

1 **Perceptions and predictors of COVID-19 vaccine hesitancy among** 2 **health care providers across five countries in sub-Saharan Africa**

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51 request to the corresponding authors.

52 **Abbreviations**

ARISE	African Research, Implementation Science and Education network
COVID-19	Coronavirus disease 2019
HCP	Health Care Providers
PPE	personal protective equipment
SSA	sub-Saharan Africa

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Abstract

The African continent has some of the world’s lowest COVID-19 vaccination rates. While the limited availability of vaccines is a contributing factor, COVID-19 vaccine hesitancy among health care providers (HCP) is another factor that could adversely affect efforts to control infections on the continent. We sought to understand the extent of COVID-19 vaccine hesitancy among HCP, and its contributing factors in Africa. We evaluated COVID-19 vaccine hesitancy among 1,499 HCP enrolled in a repeated cross-sectional telephone survey in Burkina Faso, Ethiopia, Nigeria, Tanzania and Ghana. We defined COVID-19 vaccine hesitancy among HCP as self-reported responses of definitely not, maybe, unsure, or undecided on whether to get the COVID-19 vaccine, compared to definitely getting the vaccine. We used Poisson regression models to evaluate factors influencing vaccine hesitancy among HCP. Approximately 65.6% were nurses and the mean age (\pm SD) of participants was 35.8 (\pm 9.7) years. At least 67% of the HCP reported being vaccinated. Reasons for low COVID-19 vaccine uptake included concern about vaccine effectiveness, side effects and fear of receiving unsafe and experimental vaccines. COVID-19 vaccine hesitancy affected 45.7% of the HCP in Burkina Faso, 25.7% in Tanzania, 9.8% in Ethiopia, 9% in Ghana and 8.1% in Nigeria. Respondents reporting that COVID-19 vaccines are very effective (RR:0.21, 95% CI:0.08, 0.55), and older HCP (45 or older vs.20-29 years, RR:0.65, 95% CI: 0.44,0.95) were less likely to be vaccine-hesitant. Nurses were more likely to be vaccine-hesitant (RR 1.38, 95% CI: 1.00,1.89) compared to doctors. We found higher vaccine hesitancy among HCP in Burkina Faso and Tanzania. Information asymmetry among HCP, beliefs about vaccine effectiveness and the endorsement of vaccines by the public health institutions may be important. Efforts to address hesitancy should address information and knowledge gaps among different cadres of HCP and should be coupled with efforts to increase vaccine supply.

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INTRODUCTION

The Coronavirus disease 2019 (COVID-19) caused by the novel SARS-CoV-2 continues to be a major public health challenge on the African continent and globally. As of March 8, 2022, there were at least 433 million cases of COVID-19 worldwide, and over 5.9 million associated deaths (1). On the African continent, close to 8.4 million cases and 170,300 deaths had been recorded, accounting for 3% of all global COVID-19 related mortality in the same period (1). COVID-19 however could continue to pose a threat to communities in sub-Saharan Africa (SSA) in the future, largely due to the lower availability of vaccines and hesitancy to accept vaccines by some in the population (2).

While other regions have made significant investments in vaccine rollout to curtail the further spread of COVID-19, efforts on the African continent continue to be affected by global inequity in access to vaccines (3). By the end of December 2021, only 7 African countries had achieved the target of vaccinating 40% of their population (4). While at least 68% of the global population has received at least one dose of the COVID-19 vaccine, Africa has the lowest share of the global vaccinated population with approximately 22% of the population having been fully vaccinated, and less than 1% have received a booster dose against COVID-19 (5, 6). Among African countries, coverage of at least one dose of vaccine ranged from 86% in Seychelles, 80% in Mauritius, 80% in Rwanda, 70% in Comoros and 69% in Botswana, to less than 6% in Cameroon, Madagascar, Burundi and Democratic Republic of Congo (5, 6). The potential undeterred spread of the COVID-19 pandemic and potential future mutations has serious ramifications for a continent already dealing with significant health and economic challenges, including food insecurity, high food prices, inadequate diets, and slowed economic growth (7, 8).

COVID-19 vaccine hesitancy is a global threat to achieving herd immunity (9). On the African continent, only 1 in 4 health workers is fully vaccinated against COVID-19 (10). The low levels of vaccination among health workers in Africa may be due to the lower availability of COVID-19 vaccines but also partly influenced by a hesitancy to take the vaccine. COVID-19 vaccine hesitancy among health care

119 providers could be a serious threat to efforts to combat the pandemic in Africa as health workers play an
120 essential role in the management and control of COVID-19 and have a high risk of getting infected. They
121 are also a source of information on COVID-19 for the public and exert influence on public opinion in their
122 contexts. COVID-19 vaccine hesitancy among healthcare workers could contribute to hesitancy in the
123 general public and increase patient risk of contracting COVID-19.

124 Vaccine hesitancy, defined as the delay or reluctance of people or communities to receive safe
125 and recommended vaccines, predates the COVID-19 pandemic (11, 12). Early studies in some SSA
126 countries indicated a high willingness to take COVID-19 vaccines, however, this was before the availability
127 of the vaccines (11, 13). A few studies have assessed hesitancy in COVID-19 vaccine uptake among health
128 workers in Africa (9, 14, 15). A systematic review found COVID-19 acceptance rates of 46% across Africa
129 and elevated levels of vaccine hesitancy have been reported (16, 17). However, acceptance rates as low
130 as 28% have been reported in Central Africa (16). Factors influencing attitudes towards COVID-19 vaccines
131 include fears about vaccine safety given the rapid development of vaccines, serious side effects, efficacy,
132 lack of information and distrust of science and religious reasons (16). Gaps remain in our understanding
133 of the extent of vaccine hesitancy among HCP in various contexts in SSA and the factors associated with
134 it. This study contributes to understanding these gaps.

135 Understanding vaccine hesitancy and its predictors among HCP is important to inform strategies
136 to enhance vaccination rates on the African continent (11). This study aimed to assess the magnitude and
137 determinants of COVID-19 vaccine hesitancy among HCP across five countries in SSA that are part of the
138 Africa Research Implementation Science and Education (ARISE) Network, Burkina Faso, Ethiopia, Nigeria,
139 Tanzania and Ghana.

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MATERIAL AND METHODS

Study setting

The study was part of a repeated cross-sectional survey conducted to assess knowledge and practices related to COVID-19 prevention and vaccination, and to evaluate the impact of COVID-19 on nutrition, health and other domains among adolescents, adults and HCP in 5 countries included in the ARISE Network. The ARISE network is a platform for public health research and training and includes 21 member institutions across nine sub-Saharan African countries.

Study participants for this study were HCP currently employed in health centres in the study areas. Briefly, in the baseline survey, we collected data from HCPs in urban areas of 3 SSA countries, Burkina Faso (Ouagadougou), Ethiopia (Addis Ababa), and Nigeria (Lagos). In round 2 of the survey, data were collected from these sites and additionally in rural Ghana (Kintampo) and urban Tanzania (Dar es Salaam). Further information on the ARISE sites in Burkina Faso, Ethiopia and Nigeria and their characteristics are described elsewhere (18, 19). Information on the design of the round 2 survey is described on Harvard University Center for African Studies website (https://africa.harvard.edu/files/african-studies/files/arise_covid_survey_round_2_methods_brief_final.pdf).

In the new round 2 sites of Tanzania and Kintampo, the study obtained HCP lists from medical professional associations and healthcare facilities in urban Dares Salaam and rural Kintampo. In all sites, the inclusion criteria were HCPs currently working in a healthcare setting, inclusive of all types of health facilities where COVID-19-related services were provided. We excluded dentists, pharmacists and other health providers in specialties unlikely to deliver COVID-19 related medical services. Fig 1 shows the sites included in the study.

Figure 1: Map of ARISE sites for Round 2 of the COVID-19 studies

164 **Study design**

165 This study utilized computer-assisted telephone interviews to collect data from HCP currently employed
166 in government, public and private health facilities in the study sites. Sampling frames for the study were
167 developed using databases of HCP and their telephone numbers provided by professional associations
168 and health facilities in each country. The study sites randomly selected 500 HCP to interview from the
169 provided sampling lists in each country in Round 1, with a target to recruit 300 HCP. The target sample
170 size for the round 2 survey was 300 HCP from each of the sites in the study. In round 2, participants from
171 round 1; in Ethiopia, Burkina Faso and Nigeria, who were available were first interviewed. New
172 participants were then randomly recruited from existing sampling frames to replace unavailable
173 participants in round 1 to meet study sample size requirements.

174 Study data were collected by trained research assistants using standardized survey questionnaires
175 that were adopted to the sites. Research assistants collected data on socio-demographic characteristics,
176 including age, sex, occupation of the HCP, their knowledge, attitudes, practices and perceptions of COVID-
177 19, as well as vaccine-related beliefs and hesitancy. Data collection was conducted between July to
178 December of 2021. Round 1 survey data collection was conducted from July to November of 2020. Of the
179 900 HCPs interviewed in round 1, there were 548 participants retained in round 2 of the survey indicating
180 a retention rate of 61%.

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182 **Outcome: Vaccine hesitancy**

183 We asked respondents if a COVID-19 vaccine were available, would they get it. We defined COVID-
184 19 vaccine hesitancy among unvaccinated HCPs as responses of definitely not getting the vaccine, maybe,
185 unsure, or undecided on whether to get the COVID-19 vaccine were it available, compared to responses
186 of definitely getting the vaccine. If the HCP was already vaccinated, they were classified as not vaccine-

187 hesitant. Based on these survey responses, we created a binary variable for COVID-19 vaccine hesitancy
188 (Yes/No).

189 **Statistical analysis**

190 We used descriptive and inferential statistics for the analysis. Descriptive statistics used
191 frequencies for categorical variables and means and standard deviations for continuous variables to
192 summarize socio-demographic characteristics, perceptions around COVID-19 vaccines, workplace
193 practices and key COVID-19 related practices in round 2 of the survey. We used generalized estimating
194 equation (GEE) Poisson regression models to evaluate associations between sociodemographic and other
195 characteristics with vaccine hesitancy among HCPs in Round 2 of the study.

196 We evaluated factors associated with vaccine hesitancy among HCP. We considered the following
197 possible predictors of vaccine hesitancy: age (20-29, 30-39, \geq 40 years); respondent sex (female/male);
198 occupation (doctor, nurse, other), health facility (government facility, private hospital, health outpost or
199 other), religion (Catholic or none Muslim, orthodox Christian, Protestant or other), self-perceived risk of
200 COVID-19 exposure (no risk, low risk, very high risk, high risk), perceived effectiveness of COVID-19 vaccine
201 (not effective at all, not very effective, somewhat effective, very effective), perceived safety of COVID-19
202 vaccines (very safe, somewhat safe, neither safe nor unsafe, not very safe, not at all safe), COVID-19
203 testing available in the facility where the HCP worked (Yes/No, free testing/paid testing). We also
204 considered the type of COVID-19 testing available (Antigen test, PCR), having tested positive for COVID-
205 19 previously (Yes/No), having cared for COVID-19 patients previously (never, yes and in the past one
206 month, yes but over one month ago), workplace COVID-19 policies (Yes/No), influence of vaccine
207 production in Africa on willingness to take vaccine (No, will not change my mind/Yes, will decrease my
208 chances of taking it/Yes, will increase my chances of taking it), COVID 19 control practices (score indicating
209 level of prevention measures being implemented in the workplace including wearing masks, using
210 personal protective equipment (PPE), hand washing with water and soap, social distancing, sanitizers or

211 hand washing station in health facility, cleaning and decontamination or disinfection of public areas,
212 checking high temperatures, Yes/No), believe COVID-19 vaccine is bioweapon (Yes/No) and World Health
213 Organization (WHO)/UNICEF endorsement of COVID-19 vaccine as safe and effective affect likelihood get
214 the vaccine (much more likely, more likely, no difference, less likely and much less likely)

215 Further, we also considered a score of reasons for not getting the COVID-19 vaccine (Do not think
216 it is needed, not at risk of getting COVID, vaccine not effective against COVID-19, negative media reports,
217 vaccine not safe/ developed too fast, concerned about side effects, fear of experimental vaccine, will get
218 worse quality vaccines, fear getting COVID-19 disease from the vaccine, illnesses/autism from the vaccine,
219 will cause infertility/sterilization/population control, religious reasons/church, microchipping fears, New
220 World Order, bad reaction with previous vaccinations, chronic condition e.g. diabetes, hypertension and
221 personal liberty/do not want bodily intrusion.

222 Covariates were selected for inclusion in the main model using univariate tests at $p < 0.20$. We
223 evaluated for significant associations in the adjusted models based on a significance level of $p < 0.05$. We
224 used the missing indicator approach to account for missing covariate data. Analysis was conducted using
225 SAS 9.4 (Cary, NC, USA).

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227 **Ethical approval and consent**

228 Verbal consent was obtained from study participants before they were admitted into the study.
229 Ethical approval for the study was obtained from the Institutional Review Board at Harvard T.H. Chan
230 School of Public Health and ethical review boards in each country and site, including the Kintampo Health
231 Research Centre Institutional Ethics Committee in Ghana; the Nouna Health Research Center Ethical
232 Committee and National Ethics Committee in Burkina Faso; the Institutional Ethical Review Board of Addis
233 Continental Institute of Public Health in Ethiopia; the University of Ibadan Research Ethics Committee and

234 National Health Research Ethics Committee in Nigeria; and the Muhimbili University of Health and Allied
235 Sciences and National Institute for Medical Research in Tanzania.

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RESULTS

There were 1499 HCP included in the study across the 5 SSA countries. Of the participants, 300 were from Burkina Faso, 277 were from Ethiopia, 312 were from Nigeria, 310 were from Tanzania and 300 were from Ghana. Table 1 shows the socio-demographic characteristics of the study population. The majority of respondents (59.8%) across all countries were female. In Burkina Faso, however, female participants were fewer (46%) compared to men. The mean age (\pm SD) of respondents was 35.8 (\pm 9.7) years. Most HCP in Ghana and Ethiopia were under 30 years of age, while in all other countries most respondents were in the 30-44 years age group. The majority of HCP assessed across all the countries were nurses (65.6%), with Ghana and Burkina Faso accounting for the highest proportion of nurses with 89.7% and 65.7% respectively. The majority of respondents worked in government hospitals or clinics. In Tanzania, 41.3% of HCPs worked in health posts where primary health care services were provided, while 24.3% from Ghana worked in Mission hospitals. In Ethiopia and Nigeria, most of the respondents reported Orthodox Christian religion. In Burkina Faso 49.8% were Catholic, and in Ghana and Tanzania at least 48% were Protestant or from other Christian denominations.

Table 1: Socio-demographic characteristics of HCP across 5 countries in sub-Saharan Africa

Characteristics	Burkina Faso	Ethiopia	Nigeria	Tanzania	Ghana	Total
N	300	277	312	310	300	1499
Female sex	138 (46.0)	164 (59.2)	217 (69.6)	214 (69.0)	164 (54.7)	897 (59.8)
Age of respondent in years						
20-29	28(9.3)	119(43.0)	76(24.4)	113(36.5)	155(51.7)	491(32.8)
30-44	183(61.0)	115(41.5)	125(40.1)	150(48.4)	139(46.3)	712(47.5)
\geq 45	89(29.7)	43(15.5)	111(35.6)	47(15.2)	6(2.0)	296(19.8)
Age of respondent (Mean \pm SD) years	39.9 \pm 9.1	33.7 \pm 9.7	39.7 \pm 11.7	34.6 \pm 8.6	30.8 \pm 4.7	35.8 \pm 9.7
Health care provider						
Doctor	85 (28.3)	118 (42.6)	99 (31.7)	105 (33.9)	3 (1.0)	410 (27.4)
Nurse	197 (65.7)	157 (56.7)	182 (58.3)	179 (57.7)	269 (89.7)	984 (65.6)
Clinical officer	2 (0.7)	2 (0.7)	9 (2.9)	25 (8.1)	6 (2.0)	44 (2.9)
Community health worker	8 (2.7)	0(0)	13 (4.2)	0(0)	6 (2.0)	27 (1.8)

Medical Assistant or other	8 (2.7)	0(0)	9(2.9)	1 (0.3)	16 (5.3)	34 (2.3)
Health facility type						
Government hospital/clinic	208 (69.3)	207 (74.7)	224 (71.8)	182 (58.7)	169 (56.3)	990 (66.0)
Private hospital /clinic	87 (29.0)	51 (18.4)	80 (25.6)	0(0)	12 (4.0)	230(15.3)
Health outpost/CHPS compound)	1 (0.3)	16 (5.8)	5 (1.6)	128 (41.3)	46 (15.3)	196 (13.1)
Mission hospital	4 (1.3)	3 (1.1)	3 (1.0)	0(0)	73 (24.3)	83 (5.5)
Religion						
None	1 (0.3)	2 (0.7)	4 (1.3)	1 (0.3)	0 (0)	8 (0.5)
Catholic	149 (49.8)	3 (1.1)	23 (7.4)	79 (25.6)	70 (23.3)	324 (21.7)
Muslim	106 (35.5)	21 (7.6)	41 (13.3)	78 (25.2)	40 (13.3)	286 (19.1)
Orthodox Christian	3 (1.0)	198 (71.5)	141 (45.6)	1 (0.3)	37 (12.3)	380 (25.4)
Protestant and other Christian	40 (13.4)	53 (19.1)	100(32.4)	150 (48.5)	153 (51.0)	496 (33.2)
COVID-19 testing and patient care in facilities						
Ever tested for COVID-19	142 (47.7)	215 (77.6)	168 (53.9)	128 (42.7)	42 (13.6)	695(46.4)
Ever tested positive for COVID-19	14(9.8)	68(31.5)	39(23.2)	13(33.3)	26(21.7)	160(23.3)
Ever cared for COVID-19 patients						
Never	197(66.1)	44(15.9)	164(53.3)	158(52.0)	194(70.3)	757(51.8)
Yes, in the past one month	13(4.4)	124(44.9)	51(16.6)	7(2.3)	32(11.6)	227(15.5)
Yes, over one month ago	88(29.5)	108(39.1)	93(30.2)	139(45.7)	50(18.1)	478(32.7)

274 Data shown as mean \pm SD or N (percent). Acronyms: CHPS Community Health Planning and Services

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276 Testing services were available for 85% of the respondents in Ethiopia, 67% in Nigeria, 59% in

277 Burkina Faso, 40% in Ghana and 38% in Tanzania (results not shown). Among those facilities that had

278 COVID testing services, most of the services were free. COVID-19 testing was free for the majority of

279 respondents in Burkina Faso (98%), Ethiopia (90%), Nigeria (81%) and Ghana (98%). COVID-19 testing was

280 paid for 60% in Tanzania and 19% in Nigeria, and less than 10% of the time in the other countries.

281 Availability of PCR and antigen testing for COVID-19 was comparable, with respondents reporting 28.6%

282 availability for the former compared to 25.4% for the latter. Of those HCP who had ever tested for COVID-

283 19, about 23.3% had tested positive (Table 1). Approximately 52% of HCP in the study had never cared

284 for a COVID-19 patient, and 15.5% had cared for patients affected in the previous month before the

285 survey.

286 Table 2 shows HCP prevention measures implemented in the workplace and beliefs around
 287 COVID-19. The measures that most HCPs reported as being implemented in the workplace were wearing
 288 a mask (97.4%), handwashing with water and soap (97.6%), and regular cleaning or decontamination of
 289 public areas (92.0%). The least commonly practiced measures were wearing PPE (73.3%) and socially
 290 distancing patients in waiting rooms (69.9%). The use of personal protective equipment (PPE) was least
 291 reported in Ghana (55.2%) and Tanzania (62.3%). In Burkina Faso, socially distancing patients was reported
 292 by only 44.4% of HCP, and by 65.7% in Tanzania. In Ethiopia, temperature checks were reported by only
 293 55.6% and in Tanzania by 67.1%.

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295 **Table 2: Frequency of COVID-19 preventive practices and beliefs about vaccines among HCP across 5**
 296 **countries in sub-Saharan Africa**

COVID-19 preventive practices and beliefs about vaccines	Burkina Faso	Ethiopia	Nigeria	Tanzania	Ghana	Total
COVID-19 Prevention practices						
Wearing masks	295(98.3)	275(99.3)	311(100)	279(90.3)	298(99.3)	1458(97.4)
Using personal protective equipment (PPE) such as gowns, goggles, shields, etc.	274(91.6)	231(83.7)	231(74.8)	192(62.3)	165(55.2)	1093(73.3)
Hand washing with water and soap	296(98.7)	258(93.1)	309(99.4)	299(96.5)	300(100)	1462(97.6)
Keeping sufficient distance between patients in the waiting area	131(44.4)	183(66.3)	280(90.3)	203(65.7)	243(81.5)	1040(69.9)
Presence of sanitizers or hand washing station in all service delivery points	268(89.9)	208(75.6)	301(97.1)	303(97.7)	293(98.0)	1373(92.0)
Regular cleaning and decontamination/disinfection of public areas and offices	268(89.3)	220(80.3)	286(93.2)	241(77.7)	292(97.3)	1307(87.7)
Temperature measurement (high temperatures 37 degrees Celsius)	257(86.0)	154(55.6)	279(89.7)	208(67.1)	288(96.0)	1186(79.2)
Beliefs about COVID-19 vaccines						
Vaccine trial participants have died after taking the vaccine	37(19.6)	51(22.4)	53(23.7)	20(9.5)	26(10.6)	187(17.1)
Side effects from the COVID-19 vaccine are usually mild and temporary, and should go away in a few days	253(94.4)	223(80.8)	261(86.4)	216(83.4)	278(95.5)	1231(88.2)
There is no need for a vaccine because COVID-19 is a conspiracy or a bioweapon	26(10.4)	16(6.1)	10(3.4)	8(2.9)	12(4.3)	72(5.3)

COVID-19 preventive practices and beliefs about vaccines	Burkina Faso	Ethiopia	Nigeria	Tanzania	Ghana	Total
People on the African continent are immune to COVID-19, so there is no need for a vaccine	13(4.9)	17(6.2)	5(1.7)	10(3.4)	12(4.1)	57(4.0)
It is not necessary to get a COVID-19 vaccine if you follow all safety protocols	56(19.7)	32(11.6)	16(5.3)	10(3.3)	23(7.8)	137(9.4)
There is not enough evidence that the COVID-19 vaccine prevents the occurrence and spread of COVID-19	166(65.6)	89(32.7)	143(49.3)	139(52.9)	168(61.8)	705(52.2)
The COVID-19 vaccine was developed too fast.	240(87.3)	141(53.0)	132(49.4)	234(82.1)	160(60.4)	907(66.8)

297 Data shown as N (percent)

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299 In terms of knowledge about the COVID-19 vaccine, 88.2% of the HCP indicated that the side-
300 effects of COVID-19 vaccine are usually mild. About 66.8% of the respondents across all 5 countries
301 reported that the vaccine was developed too fast. Additionally, 52% of the HCPs in all sites did not believe
302 there was sufficient evidence that the COVID-19 vaccine prevents the occurrence and spread of COVID-
303 19, with more than 60% of HCP in Burkina Faso and Ghana reporting this. About 17% of HCP believe that
304 people had died after taking the COVID-19 vaccine (more than 22% in Ethiopia and Nigeria). Across all
305 countries, a few respondents (< 10%) believed that it is not necessary to get COVID 19 vaccine if one
306 follows all COVID-19 safety protocols (20% in Burkina Faso and 12% in Ethiopia). Less than 11% of all
307 respondents believed the COVID-19 is a conspiracy or a bioweapon and 4% reported that people on the
308 African continent are immune to COVID-19.

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310 **Figure 2a: Health care provider perceptions of risk of COVID-19 exposure in 5 countries in sub-Saharan**
311 **Africa**

312

313 Almost all HCP from study countries perceived a high to very high risk of exposure to COVID-19
314 except in Burkina Faso, where about 41% of HCP perceived a low risk of exposure (Fig 2a). At least 28% of
315 all HCP believed that the COVID-19 vaccines were very safe and up to 45% thought they were somewhat

316 safe (Fig 2b). Only 1% of the HCP believed the COVID-19 vaccines were not safe at all. Approximately 8%
317 believed they were not very safe, with the highest proportion with this belief in Ghana (21.0 %). The
318 majority of respondents believed that COVID-19 vaccines were very or somewhat effective in preventing
319 the disease. In Ethiopia 32% of respondents believed vaccines were not very effective (Fig 2c).

320

321 **Figure 2b: Health care provider perceptions on COVID-19 vaccine safety in 5 countries in sub-Saharan**
322 **Africa**

323

324 **Figure 2c: Health care provider perceptions on COVID-19 vaccine effectiveness in 5 countries in sub-**
325 **Saharan Africa**

326

327 Table 3 shows beliefs about the COVID-19 vaccine, and willingness to take vaccines. At least 85%
328 of the respondents indicated that COVID-19 vaccines were available in their country and localities, except
329 in Ghana, where 45.7% reported vaccine availability at the time of the interview. The majority of HCPs
330 (84%) indicated that COVID-19 vaccine was available to them as HCPs, with 67.9% of them having been
331 vaccinated by the time of the survey, and a further 10.8% expecting to be vaccinated by the end of 2021.
332 Vaccination rates were lowest in Burkina Faso (40.3%), Tanzania (66.5%) and Ghana (69.3%). At least 86%
333 of HCP indicated that it was important for HCPs to get vaccinated. At least 77% of HCPs reported that
334 their workplaces had formulated policies on COVID-19. Most participants from Nigeria (95.2%), Ghana
335 (87.7%) and Ethiopia (75.1%) reported having workplace guidelines on COVID-19 but only 60.1% and
336 67.1% from Burkina Faso and Tanzania, respectively, had guidelines.

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340 **Table 3: Perceptions of the safety, effectiveness and availability of vaccines and willingness to get the**
 341 **COVID-19 vaccine and expected benefits in 5 countries in sub-Saharan Africa**

Characteristics	Burkina Faso	Ethiopia	Nigeria	Tanzania	Ghana	Total
Perceived safety of vaccines						
In general, I believe that vaccines are safe	153 (75.7)	210 (76.6)	292 (99.0)	250 (89.3)	279 (95.6)	1183 (88.2)
Vaccine hesitancy						
	137(45.7)	27(9.8)	25(8.1)	79(25.7)	27(9.0)	295(19.7)
Availability of COVID-19 vaccines						
Covid 19 vaccine available in country	298 (100)	237 (85.6)	306 (98.1)	306 (98.7)	137 (45.7)	1284 (85.8)
Covid 19 vaccine has been made available to you as a healthcare provider	192 (64.4)	258 (93.1)	287 (92.0)	299 (96.5)	225 (75.0)	1261 (84.2)
Have you or any of your colleagues received the Covid 19 vaccination						
Yes, I have been vaccinated	120 (40.0)	226 (81.6)	257 (82.4)	206 (66.5)	208 (69.3)	1017 (67.9)
I know someone who has been vaccinated	135 (45.0)	29 (10.5)	27 (8.7)	97 (31.3)	81 (27.0)	369 (24.6)
Workplace has formulated policies or guidelines related to COVID-19						
179 (60.1)	208 (75.1)	297 (95.2)	269 (87.7)	208 (67.1)	1161 (77.6)	
How important is it for Health care providers to get vaccinated against COVID-19						
Very important	209 (70.4)	217 (78.3)	291 (93.3)	284 (91.6)	288 (96.0)	1289 (86.2)
Somewhat important	69 (23.2)	49 (17.7)	15 (4.8)	19 (6.1)	10 (3.3)	162 (10.8)
Not very important	11 (3.7)	4 (1.4)	2 (0.6)	3 (1.0)	0	20 (1.3)
Not important at all	4 (1.4)	6 (2.2)	0	0	1 (0.3)	11 (0.7)
Don't know	4 (1.4)	0	4 (1.3)	4 (1.3)	1 (0.3)	13 (0.9)
COVID-19 vaccine's country of origin affects my willingness to take the vaccine						
74 (24.9)	107 (38.6)	56 (18.0)	68 (21.9)	91 (30.3)	396 (26.5)	
If COVID-19 vaccine had been developed or tested in Africa would that affect your willingness to take it or recommend it						
No, will not change my mind	88 (29.6)	191 (69.0)	198 (63.5)	205 (66.1)	209 (69.7)	891 (59.6)
Yes, will decrease my chances of taking it	2 (0.7)	46 (16.6)	41 (13.1)	18 (5.8)	26 (8.7)	133 (8.9)
Yes, will increase my chances of taking it	199 (67.0)	32 (11.6)	56 (18.0)	68 (21.9)	60 (20.0)	415 (27.7)
When do you think a COVID-19 vaccine will be made available to you						
Never	4 (1.4)	20 (7.2)	3 (1.0)	16 (5.2)	2 (0.7)	45 (3.0)
Already received the vaccine	119 (40.1)	226 (81.6)	257 (82.4)	206 (66.5)	208 (69.3)	1016 (67.9)
Before the end of 2021	88 (29.6)	15 (5.4)	21 (6.7)	12 (3.9)	26 (8.7)	162 (10.8)
During the first six months of 2022	7 (2.4)	9 (3.3)	3 (1.0)	7 (2.3)	9 (3.0)	35 (2.4)
During the last six months of 2022	2 (4.7)	1 (0.4)	3 (1.0)	4 (1.3)	2 (0.7)	12 (0.8)
2023 or later	37 (12.5)	4 (1.5)	2 (0.6)	9 (2.9)	9 (3.0)	61 (4.1)
Don't know	39 (13.1)	2 (0.7)	21 (6.7)	50 (16.1)	44 (14.7)	156 (10.4)
Would you recommend that my friends and loved ones get the COVID-19 vaccine						
57 (19.2)	26 (9.4)	11 (3.5)	33 (10.7)	6 (2.0)	133 (8.9)	
Are you doing any activities to boost your community's confidence in taking the vaccine						
Community outreach/education	214 (72.1)	228 (82.3)	185 (59.3)	261 (84.2)	193 (64.3)	1081 (72.3)
Other	0(0)	0(0)	23 (7.4)	0(0)	9 (3.0)	32 (2.2)

Characteristics	Burkina Faso	Ethiopia	Nigeria	Tanzania	Ghana	Total
Willing to participate in a vaccine clinical trial if available	181 (60.9)	136 (49.1)	102 (32.7)	69 (22.3)	141 (47.0)	629 (42.1)

342

343 Approximately 26.5% of HCPs indicated that the origin of the vaccine influenced their willingness
344 to take COVID-19 vaccines, and 27.7% of all respondents indicated that if a vaccine were developed and
345 tested in Africa, this would increase their willingness to take it. This was more so in Burkina Faso, where
346 67% of HCP indicated a greater willingness to take African vaccines. Among unvaccinated HCP, the
347 majority indicated a willingness to take the vaccine if it was availed to them (Suppl Fig 1). However, in
348 Tanzania, 48.1% of unvaccinated HCPs reported unwillingness and 18.3% were undecided on whether to
349 take the COVID-19 vaccine. Reasons for unwillingness to take the COVID-19 vaccines across the countries
350 include not thinking the vaccine was effective, concern about side effects, concern that vaccine
351 development was too fast, fear of receiving poor quality vaccines and negative media reports. These
352 concerns were most frequently reported in Burkina Faso (Fig 3). Finally, HCPs reported that the most
353 prescribed treatments for COVID-19 were antibiotics/azithromycin (47.2%) and multivitamins (33.4%)
354 (Supplementary Fig 2). Close to 20% of the cases were not prescribed any medications.

355

356 **Figure 3: Frequent reasons (%) for not getting COVID-19 vaccination in 5 countries in sub-**
357 **Saharan Africa**

358

359 COVID-19 vaccine hesitancy affected 19.7% of the HCPs (Table 3). Reported hesitancy was highest
360 in Burkina Faso (45.7%) and Tanzania (25.7%) compared to other countries. The lowest levels of vaccine
361 hesitancy were reported in Nigeria at 8.1% and Ghana at 9.0%.

362 Table 4 shows factors associated with COVID-19 vaccine hesitancy among HCP in the study. We
363 found that there were site-specific differences in the risk of COVID-19 vaccine hesitancy among HCP. In
364 Ethiopia (RR:0.52, 95% CI: 0.29,0.95) HCP had lower vaccine hesitancy, and in Tanzania, there was a trend
365 towards having higher vaccine hesitancy (RR:1.49, 95% CI: 0.99,2.25, $p=0.06$) among HCP compared to
366 Burkina Faso. Age was associated with vaccine hesitancy, with HCPs aged 45 years or older less likely to
367 be vaccine-hesitant (RR:0.65, 95% CI: 0.44,0.95) compared to those aged 20-29 years. Nurses were more
368 likely to be vaccine-hesitant (RR 1.38, 95% CI: 1.00,1.89) compared to doctors. Respondents reporting that
369 COVID-19 vaccines are very effective (RR:0.21, 95% CI:0.08, 0.55) were less likely to report vaccine
370 hesitancy. For each reason given by HCP for not wishing to receive COVID-19 vaccination, the risk of being
371 vaccine-hesitant increased (RR 1.78, 95% CI:1.62, 1.95). Finally, HCP reporting that the World Health
372 Organization or UNICEF endorsement of the COVID-19 vaccine as safe and effective would make them
373 more likely (RR 0.51, 95% CI:0.35, 0.74) or much more likely (RR 0.69, 95% CI:0.52, 0.92) to receive the
374 vaccine were less likely to be vaccine-hesitant.

375 **Table 4: Factors associated with COVID-19 vaccine hesitancy among health care providers in round 2 of the ARISE COVID study in 5 countries**

	Unadjusted RR (95% CI)	Adjusted RR (95% CI)
Country		
Burkina Faso	Ref	ref
Ethiopia	0.21(0.14,0.32) ***	0.52(0.29,0.95)*
Nigeria	0.18(0.12,0.27) ***	0.67(0.37,1.23)
Tanzania	0.56(0.43,0.74) ***	1.49(0.99,2.25)
Ghana	0.56(0.43,0.74) ***	0.65(0.36,1.17)
Male sex	0.86(0.68,1.09)	0.90(0.69,1.18)
Age		
<30 years	Ref	ref
30-44 years	1.19(0.92,1.54)	0.80(0.59,1.08)
45 years+	0.97(0.69,1.36)	0.65(0.44,0.95)*
Occupation		
Doctor	Ref	ref
Nurse	1.18(0.90,1.54)	1.38(1.00,1.88)*
Other occupation	1.03(0.62,1.70)	1.52(0.88,2.63)
Religion		
Catholic or none	Ref	ref
Muslim	3.10(2.10,4.60)***	1.00(0.58,1.72)
Orthodox Christian	3.18(2.13,4.74) ***	1.16(0.68,1.99)
Protestant or other	1.98(1.33,2.95) **	1.16(0.71,1.89)
Health centre type		
Government hospital/clinic	Ref	ref
Private hospital/clinic	1.12(0.42,1.51) *	0.96(0.70,1.33)

	Unadjusted RR (95% CI)	Adjusted RR (95% CI)
Health outpost/CHPS compounds or other	0.58(0.41,0.84) **	0.73(0.47,1.13)
Perceived risk of COVID-19 disease		
Low risk	1.30(0.48,3.53)	0.94(0.33,2.69)
No risk	0.65(0.24,1.75)	0.93(0.33,2.61)
Very high risk	0.58(0.21,1.59)	1.08(0.38,3.07)
High risk	Ref	ref
Effectiveness of COVID-19 vaccine		
Very effective	0.05(0.02,0.12)***	0.21(0.08,0.55)*
Somewhat effective	0.31(0.18,0.53)***	0.87(0.46,1.63)
Not very effective	0.91(0.52,1.58)	0.97(0.53,1.80)
Not effective at all	Ref	ref
Workplace policy score (number of policies)	0.75(0.68,0.82)***	0.98(0.88,1.09)
Reasons for not vaccinating (number of reasons)	2.03(1.90,2.16)***	1.78(1.62,1.95)***
Believe the COVID-19 vaccine is a bioweapon	2.89(1.99,4.20)***	0.94(0.62,1.42)
Believe vaccines are safe	0.30(0.22,0.40)***	0.71(0.50,1.02)
WHO/UNICEF endorsement of the COVID-19 vaccine as safe and effective affects likelihood get the vaccine		
Much more likely	0.19(0.13,0.26)***	0.51(0.35,0.74)***
More likely	0.40(0.31,0.52)***	0.69(0.52,0.92)*
No difference	Ref	ref
Less likely	0.50(0.27,0.90)*	0.92(0.47,1.83)
Much less likely	0.84(0.31,2.29)	1.53(0.51,4.56)

376 Acronyms: COVID-19; Coronavirus disease 2019, RR: relative risk, CI: Confidence interval, * <0.05, **<0.01, ***<0.001

377

DISCUSSION

378 We assessed perceptions and predictors of COVID-19 vaccine hesitancy among HCP in Burkina
379 Faso, Ethiopia, Ghana, Nigeria and Tanzania. We found that the majority of HCP had been vaccinated by
380 the time of the survey and that almost a fifth of the HCPs across the sites were hesitant to receive the
381 COVID-19 vaccine. There were differences in vaccine hesitancy by site. The age of a HCP, their profession
382 and perceptions about COVID-19 vaccine effectiveness were significant predictors of vaccine hesitancy in
383 this study. Older HCP reported lower levels of vaccine hesitancy, while nurses and HCP who believed that
384 COVID-19 vaccines were not effective were more likely to be vaccine-hesitant.

385 Our findings show consistency with some findings from previous studies. In a study of vaccine
386 hesitancy among HCPs in South Africa, being an older HCP or a physician and perceptions of the benefits
387 and risks of vaccination were associated with lower vaccine hesitancy [13]. However, the study also found
388 additional factors that influenced vaccine hesitancy among HCPs including beliefs that vaccines are
389 incompatible with religion and willingness to be vaccinated to protect others [13]. Similarly, another study
390 in Ethiopia found that older age (>40 years) and being a medical doctor were associated with a lower risk
391 of vaccine-hesitancy. In Nigeria, a study found that HCP who were younger, single and with lower income
392 had more vaccine hesitancy, while being a nurse or doctor was associated with lower hesitancy [17]. In
393 Ghana, being female and having a low income have also been associated with increased COVID-19 vaccine
394 hesitancy [18]. These findings suggest there may be information asymmetry for example among different
395 cadres of HCPs and lower perceived risks among some population sub-groups (20). Women additionally
396 face greater concerns about the effects of COVID-19 vaccines on their fertility (21). In this study, we did
397 not observe greater hesitancy among female HCP.

398 Older age may be associated with lower vaccine hesitancy since age is a risk factor for COVID-19
399 infection, and that older people are more vulnerable to more severe disease possibly due to more co-
400 morbidities. This could be a factor influencing decisions by older HCPs to be vaccinated. In an Africa-wide

401 survey, respondents indicated that vaccine hesitancy was lower among those with a higher perceived risk
402 of infection [19]. Additionally, HCP who perceive that vaccines are effective may face fewer personal
403 barriers and may be more willing to take the vaccine. Other factors reported by studies include concerns
404 about vaccine safety, serious side effects and efficacy of vaccines, with limited information also being a
405 key factor (16). Additionally, perceptions of lack of COVID-19 vaccine benefits, distrust of the government
406 and the ability of science to provide safe and effective vaccines and concerns about vaccine safety were
407 associated with greater vaccine hesitancy [14].

408 The differences between our findings and those from previous studies may be because we
409 included 5 countries in our study and have a larger sample size and variability of responses than previous
410 studies. Our findings are able to account for differences in contextual factors across the countries and
411 determine overall influential factors affecting vaccine hesitancy across countries.

412 In our study, there were differences in vaccine hesitancy among HCP by country, with Burkina
413 Faso and Tanzania reporting the highest levels of hesitancy and Ghana and Nigeria showing low levels of
414 hesitancy. Previous studies have also shown variations in acceptance rates from as low as 28% in Central
415 Africa, and up to 48-49% in West and East Africa (16), suggesting that there may be context-specific
416 factors influencing attitudes towards COVID-19 vaccines. Country-specific factors such as differences in
417 availability and access to vaccines, the burden of COVID-19 cases, and variation in mitigation measures
418 put in place could account for differences across countries. Reported rates of vaccine hesitancy have been
419 higher in other studies. A study conducted early in the COVID-19 emergency in Nigeria found higher rates
420 of vaccine hesitancy among HCPs (50%) [17]. In a South African study, 41.0% of HCPs were vaccine-
421 hesitant [13] and in Ghana, three out of five HCP were hesitant early in the pandemic (22). Levels of
422 vaccine hesitancy of 41%-45.9% have also been reported among HCP in South Africa and Ethiopia [7].
423 These studies were conducted early during the COVID-19 pandemic before vaccines had been available.
424 Additionally, low rates of COVID-19 vaccine acceptance by the general population on the African continent

425 have been reported [20]. Our observations of lower levels of vaccine hesitancy may be partly influenced
426 by changing attitudes and beliefs towards the COVID-19 vaccine across the continent as the pandemic has
427 progressed, due to increased cases and mortality, increased information and greater availability of COVID-
428 19 vaccines.

429 We observed higher levels of COVID-19 vaccination among HCP across our study, compared to
430 previous reports on the African continent. Two-thirds of HCP interviewed across the 5 countries had
431 already received the COVID-19 vaccination at the time of the survey; however, vaccination rates were low
432 in Burkina Faso. Health care providers were prioritized to receive the COVID-19 vaccine initially when the
433 vaccines were not readily available. It is therefore expected that more HCP had received the vaccine. The
434 WHO, however, reported that approximately 25% of HCPs were fully vaccinated against COVID-19 on the
435 African continent by November 2021 [8]. The differences observed between this study and previous
436 studies could be due to the fact our study is more recent, and vaccines may have been relatively more
437 available during our study. Additionally, we only assessed vaccination status in a few selected health
438 centers in the study sites, and our estimates are not nationally representative. Further, four of our survey
439 sites were in urban areas, where vaccination rates are higher. Reasons for lower vaccination in some of
440 our study sites could have been due to challenges with the availability of the COVID-19 vaccines, and this
441 is consistent with the situation across the African continent. Reasons for the limited availability of COVID-
442 19 vaccines on the African continent have included global architecture and restricted vaccine supply
443 chains and limited availability of donations promised by donors through the COVAX facility for low- and
444 middle-income countries by the end of 2021 [21].

445 Another possible reason for the higher vaccination rates and lower vaccine hesitancy we observed
446 in our study could be because perceptions about the COVID-19 vaccine were mainly positive in our study.
447 There was a high willingness among the unvaccinated to get vaccinated across three of our five sites.
448 While some COVID-19 misinformation was reported, the proportion of participants reporting

449 misinformation was low, with few HCPs believing that COVID-19 is a conspiracy or bioweapon; that people
450 of African descent are immune to COVID-19; that people have died from taking the vaccine; and that the
451 COVID-19 vaccine was unnecessary. Many in the study correctly believed that the side effects of the
452 COVID-19 vaccine are usually mild and temporary. The low levels of misinformation overall could have
453 contributed to lower levels of hesitancy among HCPs.

454 While most of the HCP who had not been vaccinated were willing to take the COVID-19 vaccine,
455 in Tanzania, willingness to take the COVID-19 vaccination was low. The main reasons for this were
456 perceptions that the vaccine was not effective, concerns about side effects and the belief that the vaccine
457 was developed too fast. The concerns about side effects and safety have also been reported in other
458 studies from similar settings and among the general population (20, 23, 24).

459 Beliefs regarding the safety and effectiveness of the COVID-19 vaccine are important
460 considerations for HCP uptake. The majority of HCP in this study believed that COVID-19 vaccines are safe
461 and effective in preventing the disease. In this study, HCP rightly perceived a high risk of exposure to
462 COVID-19 across all countries, an observation likely due to HCP attending to patients which puts them at
463 a higher risk of exposure to the disease. In contrast, most of the HCP believed that there is insufficient
464 evidence that the COVID-19 vaccine prevents the occurrence and spread of COVID-19. This observation
465 could reflect sentiments that although Europe, America and Asia had greater availability of vaccines, their
466 reported declines in morbidity lagged as vaccine rollout continued in these contexts. Finally, there were
467 concerns about how quickly the vaccine had been developed in this study since drug development usually
468 takes many years to go through the various pre-clinical and clinical stages. In addition, at least a quarter
469 of respondents indicated that the origin of the vaccine influenced their willingness to take COVID-19
470 vaccines, and a similar proportion indicated that if a vaccine were developed and tested in Africa, this
471 would increase their willingness to take it. Potential concerns about vaccine safety and efficacy may be
472 partially addressed in the future by encouraging local production of vaccines on the African continent.

473 Our study had limitations. Being a telephone survey, it would not have been equally available to
474 all health workers, and it was affected by non-response in some countries. We instituted replacements
475 using randomly allocated individuals from existing sampling frames and HCP lists to mitigate against this.
476 Additionally, 4 of our 5 study sites were urban, and therefore findings may not be attributable to HCPs in
477 rural areas.

478 In conclusion, in this study, we found low COVID-19 vaccine hesitancy across most countries, with
479 higher vaccine hesitancy among HCP in Burkina Faso and Tanzania. We also found that factors associated
480 with hesitancy include age, occupation, beliefs about vaccine effectiveness and endorsement by global
481 public health institutions. Efforts to increase vaccine uptake will have to address vaccine hesitancy by
482 tackling information and knowledge gaps among different cadres of health workers, along with efforts to
483 increase vaccine supply.

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505

506 **Authors' contributions**

507 IM and LNA conceived and designed the study, analyzed the data, and drafted the manuscript. WWF
508 was the principal investigator for the parent study, conceived the study, designed the study, interpreted
509 the data, and guided revisions of the manuscript. EP, TA, VB, CJ, DW, FM, OM, NA,AC, FW, BL, ECH, AI,
510 SA, KPA,YB, JK, AO, AS, AS, SV, MMS, SV, ES, TB and RT designed the study, interpreted the data and
511 revised the manuscript. All authors read and approved the final manuscript.

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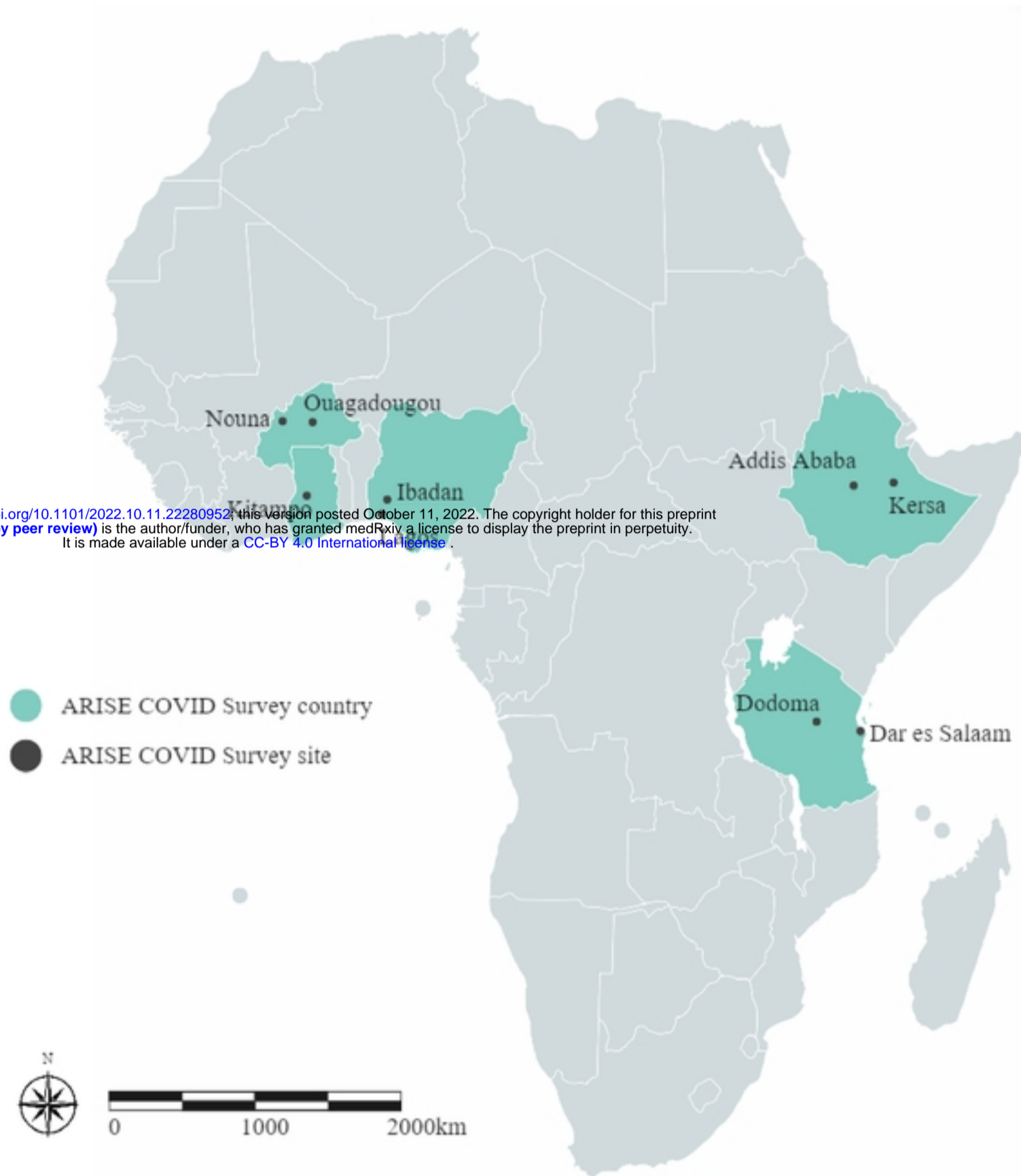


Figure 1. Map of study sites included in the ARISE COVID-19 Round 2 Survey, 2021

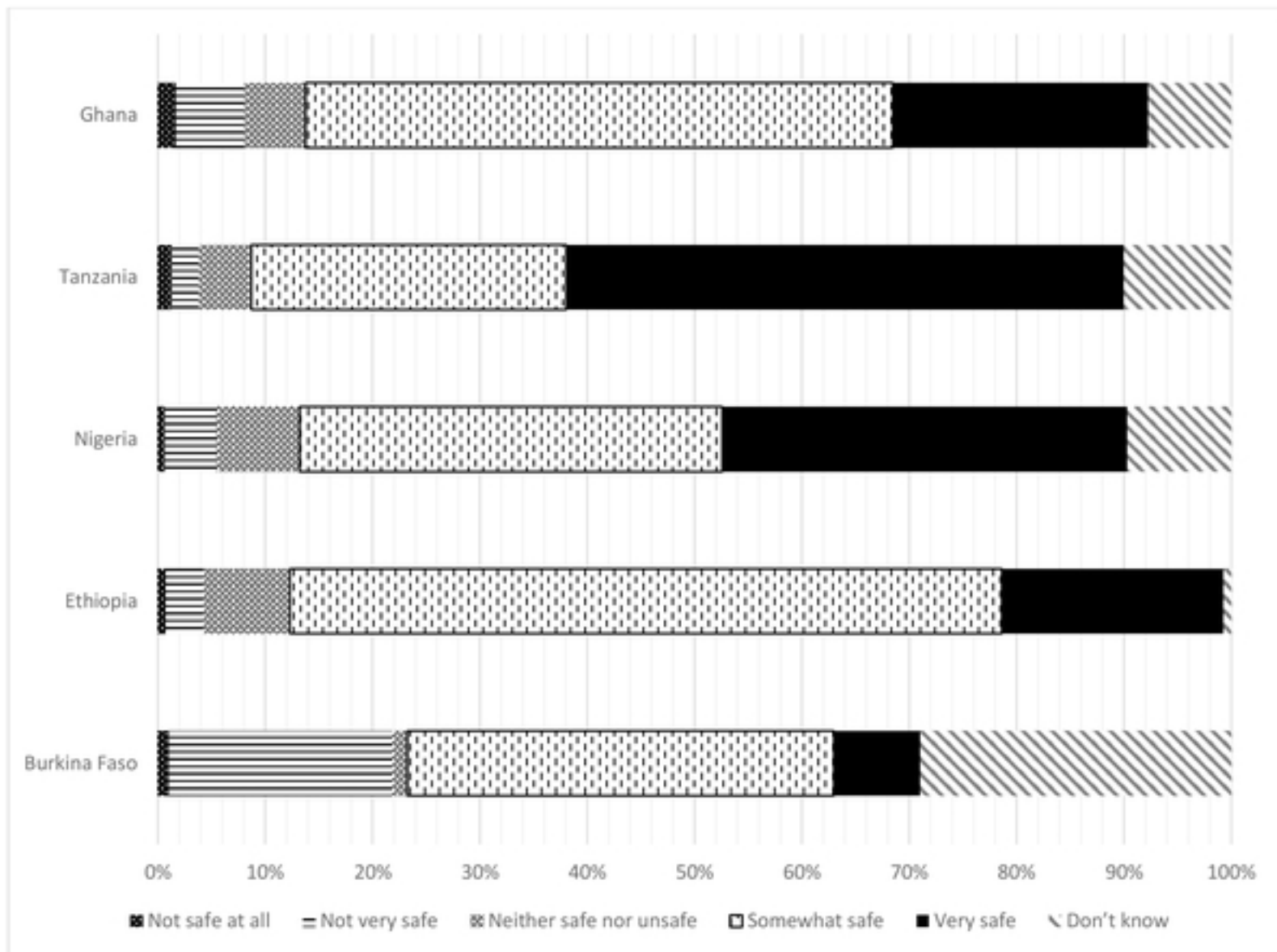


Figure 2b: Health care provider perceptions on COVID-19 vaccine safety in 5 countries in sub-Saharan Africa

Figure2b

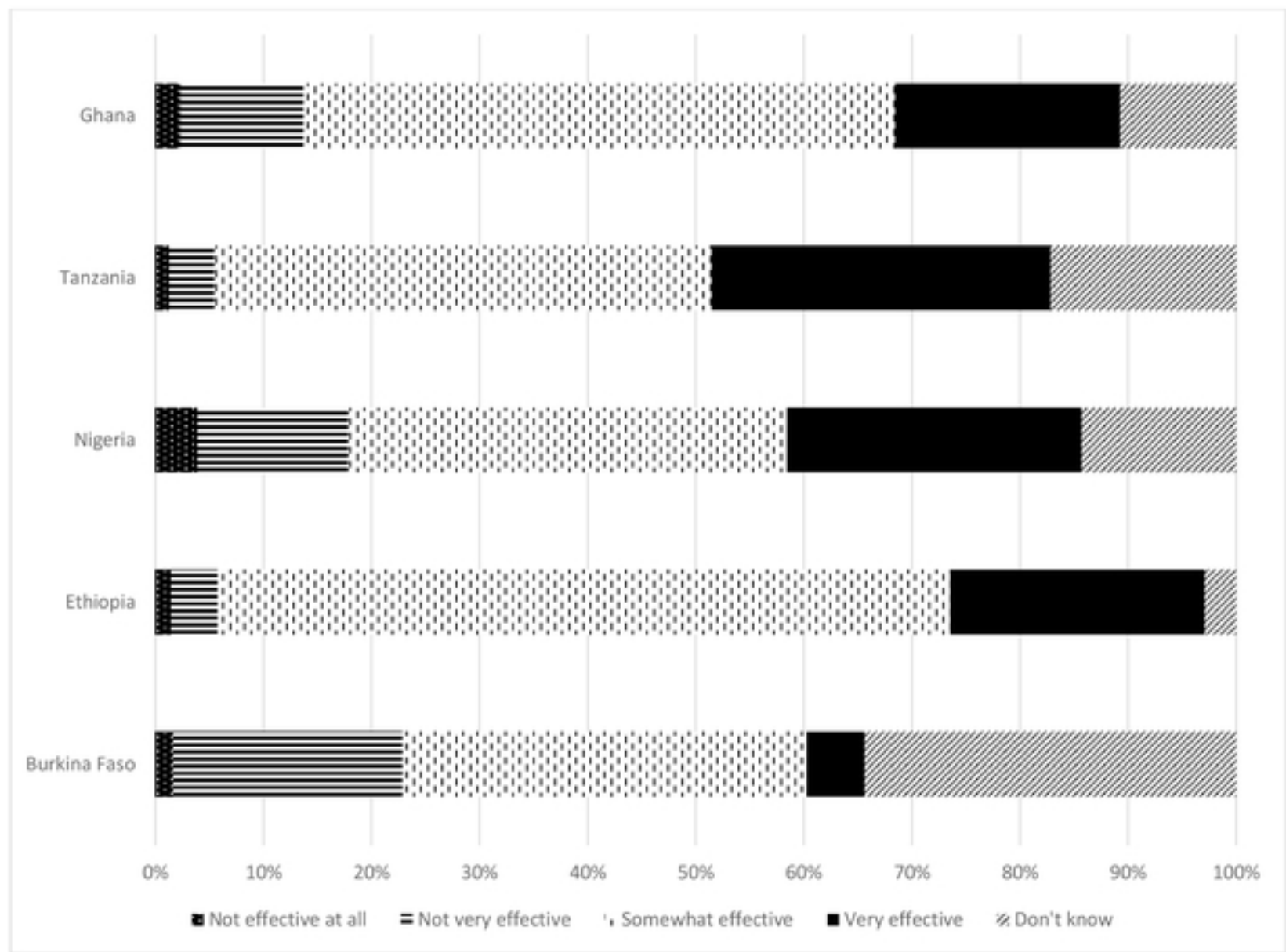


Figure 2c: Health care provider perceptions on COVID-19 vaccine effectiveness in 5 countries in sub-Saharan Africa

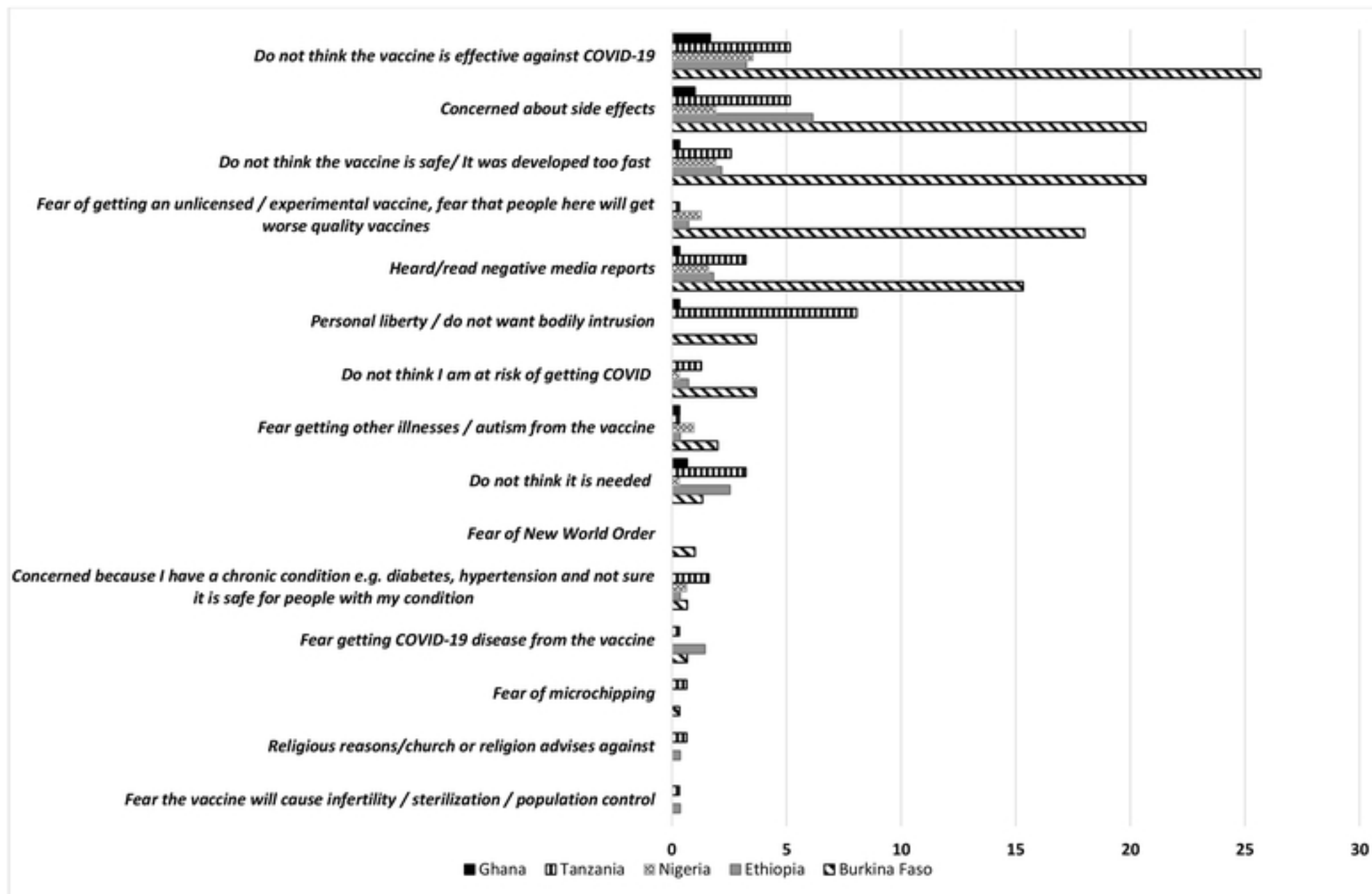


Figure 3: Frequent reasons (%) for not getting COVID-19 vaccination in 5 countries in sub-Saharan Africa

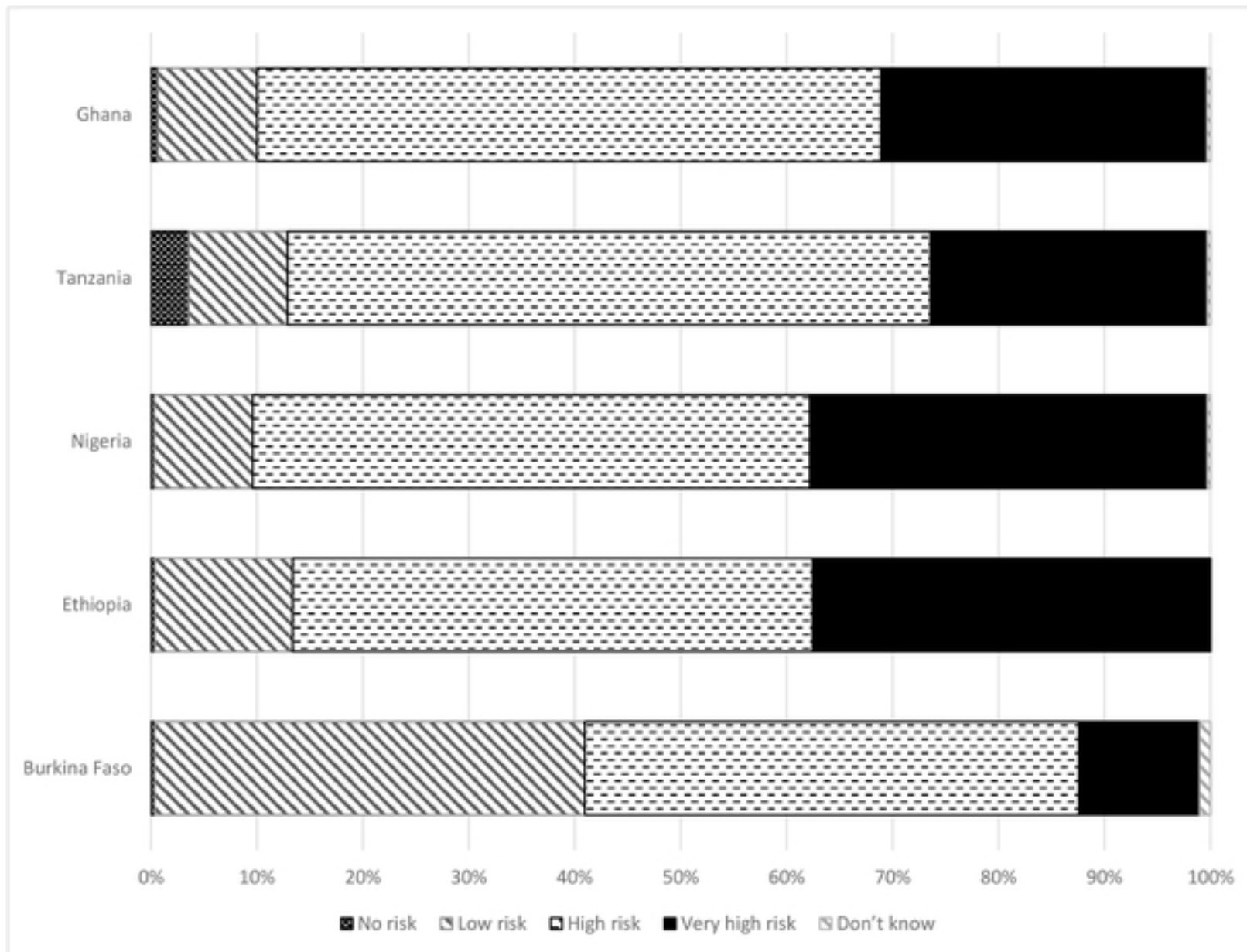


Figure 2a: Health care provider perceptions of risk of COVID-19 exposure in 5 countries in sub-Saharan Africa

Figure2a