Colonial effect: language, trust and attitudes to science as predictors of vaccine hesitancy across Africa

Abstract

Vaccine safety, importance and effectiveness are at the core of vaccine hesitancy around the world and Africa has had its own share of vaccine revolts. This study uses the Wellcome Trust Global Monitor 2018 on public perceptions of vaccines in 40 African countries to examine the predictors of vaccine hesitancy. It compares levels of hesitancy along language lines, comparing French speakers with others, mostly English. Study shows that French speakers are significantly more hesitant on importance and safety while English speakers and others are more hesitant on effectiveness, an indication of the continuing influence of colonial ties. Respondents who have higher levels of trust in social actors are also more hesitant about the safety and effectiveness of vaccines, indicating the importance of non-scientists in vaccine hesitancy. Those with higher levels of education are also more likely to be hesitant about vaccines in general indicating that having more education may indeed have an opposite effect. Perceptions of science as progress is significant for all three hesitancy types and indicates that Africans with more progressive attitudes are less likely to worry about the importance, safety and effectiveness of vaccines. At country level, no predictor cuts across indicating the strong role of local social and cultural issues. These findings improve our understanding of the drivers of vaccine hesitancy in Africa and provide valuable input for future vaccine policy and health awareness campaigns.

Introduction

Resistance to vaccines and anti-vaccination groups emerged in late 18th and early 19th century over safety concerns following the introduction of the Jennerian inoculation against smallpox using cow pox. The anti-vaccination groups were formed by the religious community, scientists, journalists and politicians (Potter and Potter, 1988; Durbach, 2000; Colgrove, 2005). The scar from the inoculation was described as "mark of the beast" and vaccination as an "invasion of traditional civil liberties".

Safety concerns re-emerged in 1974 when severe neurological complications in children were linked with the Diphtheria, Tetanus and Pertussis (DTP) vaccine (Kulenkampff, et al, 1974). A link between Measles Mumps Rubella (MMR) and Autism in 1998 sparked off another wave of safety concerns (Burgess et al. (2006). More recently, safety concerns over the SARS-CoV-2 (Covid-19) vaccine have been associated with its speed of development and the rise of vaccine hesitancy during the past decade (Verger and Dubé 2020).

Africa has had its own share of anti-vaccine revolts. State governors in Northern Nigeria banned the use of the oral polio vaccine in 2003 following safety concerns during a nationwide vaccination exercise. The vials were rumoured to have been contaminated with substances capable of sterilizing women (Falade, 2014). In 1990, in Cameroun, Nigeria's neighbour to the East, young girls leapt from school windows to escape tetanus toxoid vaccination teams, also following concerns the vaccine would sterilize them (Feldman-Savelsberg, et al., 2000). Members of the Apostolic Church in Zimbabwe also expressed fears vaccines can cause death or disease (Machekanyanga, et al, 2017).

This study explores the roles of language, trust, knowledge, and attitudes to science in vaccine hesitancy on the African continent with a view to expanding the current body of literature. It explores the roles of trust in science, scientists and social actors as well as knowledge of science and health and the performance of activities which show engagement with science.

Unique to this study is the use of colonial language as a predictor variable. Colonial languages are still used as lingua franca in many African countries, splitting the continent into French and English speakers with some other less common ones as Portuguese and Spanish. African countries, post-independence, have continued to have cultural, linguistic, and economic ties with the former colonial masters and this study examines the effect these ties may have on vaccine hesitancy, given the wide difference in safety concerns between France and the United Kingdom. This is an area of research that is yet to be explored in Africa and it is hoped that it will make useful contributions to understanding differences in vaccine hesitancy across the continent.

Vaccines and public health

Vaccines have been praised as one of the great public health achievements of recent decades (MMWR, 20117). Smallpox was eradicated worldwide in 1979 with the use of vaccines and the world is closer now to the eradication of the Wild Polio Virus with confirmed cases now limited to Afghanistan and Pakistan. Mortality rates from the Covid-19 pandemic have also reduced worldwide with the use of vaccines. The world is not safe from communicable diseases until they are eradicated worldwide and the success with smallpox has shown the efficacy of vaccines and international approaches to public health. Vaccine hesitancy, described as a delay in acceptance of vaccination, or refusal, or even acceptance with doubts about its safety and benefits, remains a threat to global health campaigns (see Larson et al, 2014).

There is however no "perfect" vaccine which protects everyone who receives it and is entirely safe for everyone (WHO, 2021a). Among other adverse events, the WHO lists risk of anaphylaxis from Anthrax vaccine as 0.76 per 100,000; risk of Immune Reconstitution syndrome from BCG at 1 per 640,000 and risk of Vaccine Associated Paralysis from the oral polio vaccine as 1 per 2.9 million doses (WHO, 2021b). Following the introduction of the Covid-19 vaccine, Vaccine Adverse Event Reporting Systems (VAERS) were set up by some countries (CDC, 2022; AU 2022; UK 2022) and some of the rare adverse reactions reported so far include Guillain-Barré Syndrome, Myocarditis and pericarditis and vaccine associated deaths. Others include minor incidents such as headaches, fever, fatigue and joint or muscle pains.

While progress has been made in addressing some of these rare but serious side effects, increasing concerns have created an ever-growing number of 'anti-vaccine' groups, further driving media and public anxieties over a range of disorders linked to vaccines (Poland and Jacobson, 2011; Swales, 1992). Vaccine behaviours are however a continuum ranging from active demand for vaccines to complete refusal of all vaccines rather than a dichotomous 'pro- versus anti-vaccination' perspectives and between these extremes are parents who may accept some and reject others (Dubé et al, 2015).

Trust in science and vaccines

Trust is based on social relations (Earle, Siegrist, & Gutscher, 2007; Siegrist, 2010) and is both at the origin and the limit of social knowledge (Moscovici, 2001). A public that cannot understand what science says, must trust, as this compensates for deficiencies on a cognitive level (Neidhart, 1993). The reliance on trust in science and scientists (Nisbet and Scheufele, 2009; Brossard and Nisbet, 2007) is a dominant heuristic in reaching judgments and it is only where societal leaders effectively redefine an area of science as in conflict with something else that controversy arises. Anderson et

al's (2011) found that deference to scientific authority and specific technology knowledge are important in science, society and trust relationships.

Hendriks et al (2016) argues that trust is pivotal for scientists just as it is fundamental for public understanding of science and since laypeople are now able to rapidly access all kinds of scientific knowledge online but still have to trust scientists, such trust relationship also entails a vigilance towards the risk to be misinformed. Weingart and Guenther (2016) argue that science communication, whether internally or to the public depends on trust, both in the source and in the medium of communication. Trust, the authors argue, is endangered by the new 'ecology of communication' as science communication by scientists is tainted by special interests and the channels used to communicate, such as the social media, raise doubts about the credibility of the communication spread through them.

Larson et al (2018) define trust in healthcare as a relationship that exists between individuals, as well as between individuals and a system, in which one party accepts a vulnerable position, assuming the best interests and competence of the other, in exchange for a reduction in decision complexity. Vaccine acceptance, the authors argue, involves multiple levels of trust in the product, the healthcare professionals, the policymaker, and public health researchers. Trust in vaccine information, they argued further also involves multiple levels: the information itself, those who produce it and those who propagate it, and its perception is subjective. When communicating about vaccines specifically, Ozawa and Stack (2013) argue that the public's trust in the information source, mode of communication and consistency of messages should be carefully considered as building and sustaining trust, as well as measuring and monitoring levels of trust, may hold the key to bridging the vaccine confidence gap.

Perceptions of safety, importance, efficiency of vaccines

This study examines African publics' perceptions of the importance, safety and effectiveness of vaccines focusing on the roles of language, trust and other psychosocial and economic predictors. In Nigeria, part of anglophone West Africa, party politics and declining trust in Western countries, the donors of the oral polio vaccine, played significant roles in vaccine hesitancy (Falade, 2014). In Cameroun, part of francophone west Africa, the pro-life Catholic movement were prominent actors and opposition politicians described the vaccine as a government plot to politically disadvantage some provinces (Feldman-Savelsberg, et al., 2000). Safety concerns led to similar revolts in Uganda, Tanzania and Kenya (Clements and Drake, 2002). In Zimbabwe, greater trust in religious teachings that emphasize the power of prayers over science contributed to hesitancy.

The effect of language of communication has been neglected in past studies of vaccine hesitancy in Africa. While African countries are multilingual, the official language for politics, educational curriculum and books are largely French or English (some countries have adopted two or more official languages), but while the Anglophone countries have developed their own currencies independent of the UK, the Francophone currencies and economy remain tied to France, and some will argue, so is much of their politics, health care and other systems. The language of the media of communication in these blocks also remain French and English, with traditional media tuned to either BBC and CNN or AFP for foreign news. The public are also more likely to connect to social media platforms, now a major source of health news (Witteman and Zikmund-Fisher, 2012; Kata, 2012) in languages they understand. Cultural, linguistic and economic ties may have a role in vaccine hesitancy in Africa given the wide difference in safety concerns between France and the United Kingdom.

Harmsen et al (2013), in a Dutch study, found hesitancy as related to multiple factors including family lifestyle; parental perceptions about the body and the immune system of the child; perceived risks of disease; vaccine efficacy and side effects; perceived advantages of experiencing the disease; prior negative experiences with vaccination and social environment. Vaccines may also be resisted because of religion, pain and cost (Lyren and Leonard, 2006). Another major concern is the perception of risk that may arise from use of preservatives such as mercury and adjuvants such as aluminium, scientists are however divided on this associated risk (see Crespo-Lopez et al, 2009; Ball et al, 2001).

Scientific authorities in the medical field also have reservations about safety and efficacy of vaccines. In a review of research focused on vaccine hesitancy amongst nurses and physicians, Ahmad et al (2022) found that vaccine hesitancy amongst physicians and nurses stemmed predominantly from distrust in vaccine efficacy and safety and mistrust of pharmaceutical companies. In a review of attitudes towards vaccination in Europe, Yaqub et al (2013) found that these are shaped not just by healthcare professionals but also by an array of other information sources, including online and social media sources.

Perception of risk has also been blamed for vaccine hesitancy among doctors. A French study found that General Practitioners recommended vaccines when they felt comfortable with explaining their benefits and risks to patients or trusted official sources of information (Verger, et al. 2015) and another study of 1582 GPs, also in France, by Le Marechal, et al (2018) found that most of the GP's perceptions of serious adverse effects were not based on scientific evidence. French surveys have reported one of the highest rates of vaccine hesitancy in the world at between 25% and 70% (Ward

et al, 2019). Bocquier, et al, (2018) analysis of the 2016 survey of the French general population, showed that 26% of parents were vaccine refusers; delayers 7%; and acceptors with doubts 13%.

Ozawa and Stack (2013) argue that public trust can be built by engaging all stakeholders including parents, health practitioners, community leaders, policy makers, and the media, to recognize the value of vaccines within unique social, cultural and political contexts and information should be transparent in presenting both the risks and benefits of vaccines.

Anti-vaccination movements: same message, new media

While the functions of the anti-vaccine movements have remained the same across the decades, the campaign strategies have evolved alongside developments in the media. Before the advent of the internet, campaigns were through pamphlets, books, newspapers, magazines and journals. The internet moved the debates online and social media is now an important source of information as health news is increasingly sought from online news groups and blogs rather than official vaccine information sites (Witteman and Zikmund-Fisher, 2012; Kata, 2012).

Social media platforms such as Twitter and Reddit were used by parents in the United States and United Kingdom as top resources during the vaccine-autism controversy (Jang et al, 2019). The analysis of Twitter during the 2015 measles outbreak in California, United States, found that messages of interest were news updates, personal opinions, personal experiences, susceptibility, cues to action and severity (Meadows et al, 2019). Wilson and Wiysonge (2020) found a significant relationship between organisation on social media and public doubts about vaccine safety and a substantial relationship between foreign anti-vaccination campaigns and declining coverage. Osur, et al, (2022) found that social media remains an important source of vaccine information in Africa contributing to vaccine hesitancy among Kenyans.

Notwithstanding the lapse of time, safer and more effective vaccines and enhanced surveillance of adverse effects, resistance to vaccines remains underpinned by the same reasons as centuries ago: safety, effectiveness, and relative importance over other treatment options such as natural immunity. The activities of the anti-vaccine movements have however expanded to online fora' contributing to vaccine hesitancy and declining coverage. But contrary to the anti-vaccination leagues of the 1880's, they have adopted neutral names such as "Vaccination news" and The National Vaccine Information Centre" and have been implicated in lowered vaccine acceptance rates and increase in vaccine-preventable disease outbreaks (Kirkland, 2012; Dubé et al, 2015).

Research objectives

Safety concerns in Cameroun, Nigeria, Uganda, Kenya, Tanzania and Zimbabwe led to vaccine revolts. Safety and other concerns have also arisen with the introduction of covid-19 vaccine in Africa (Ajeigbe, et al, 2022; Ekwebelem, et al, 2022; Cooper et al, 2021). Foreign anti-vaccination campaigns, spread by social media have been associated with declining vaccine coverage in other countries contributing to vaccine hesitancy in Kenya.

The Wellcome Trust Global Monitor 2018 focuses on public perceptions of the safety, importance and efficacy of vaccines and trust in science and society. Our research questions thus evolve from these themes, examining also, the influence of shared language within Africa and with colonial masters. The survey however predates the COVID-19 pandemic and offers views into public perceptions before the crises. The research will widen the knowledge base and address the need for country specific and/or regional predictors of hesitancy in Africa. No comparable worldwide surveys have been undertaken since this effort by Welcome Trust.

Specific research questions are the following:

1. How do the hesitancy levels on importance, safety and effectiveness of vaccines in French speaking African countries compare with others and with levels of the colonial masters, France and the United Kingdom?
2. Are post-colonial cultural influences, inherent in shared language of importance to vaccine hesitancy across Africa?
3. What are the predictors of perceptions of safety, importance and effectiveness of vaccines at country level?

Data and research methods

The study examines vaccine hesitancy in 40 African countries in the WGM monitor 2018. The francophone countries in the sample (22) are Morocco, Benin, Madagascar, Mali, Mauritania, Niger, Rwanda, Senegal, Burkina Faso, Cameroon, Algeria, Burundi, Chad, Comoros, Republic of Congo, Gabon, Guinea, Ivory Coast, Mauritius, The Gambia, Togo, Tunisia. The others, mostly English speakers (18), are Egypt, Nigeria, Kenya, Tanzania, Ghana, Uganda, Malawi, South Africa, Botswana, Ethiopia, Mozambique, Zambia, Sierra Leone, Zimbabwe, Liberia, Libya, Namibia, Eswatini.

12 countries, Chad, Morocco, Democratic Republic of Congo, Mali, Algeria, Gabon, Tanzania, Kenya, Ghana, Nigeria, Zambia and South Africa were selected on language basis for comparison of frequencies and measurement invariance. The first six countries are French speaking while the others are English speaking. They were selected from the North, West, Central and Southern Africa regions.

Response variables

Q24 Vaccines are important.

Q25 vaccines are safe.

Q26 Vaccines are effective.

The answer options were recoded to a binary: acceptance (strongly agree and somewhat agree) and hesitancy (neither agree nor disagree, somewhat disagree, strongly disagree and don't know/refuse). Given the definition of hesitancy to include acceptance with doubts, somewhat agree was considered hesitancy, but the author was of the view this may be too restrictive and opted to categorise as acceptance.

Predictor variables

Demographics: age, gender, education, income and area type (rural versus urban). A binary variable was created for lingua franca, French and others.

The trust variables: Q11 'How much do you trust each of the following':

Q11A The people in your neighbourhood.

Q11B The national government in this country.

Q11C Scientists in this country.

Q11D Journalists in this country.

Q11E Doctors and nurses in this country.

Q11F People who work for Charitable organizations/NGOs.

Q11G Traditional healers.

Q12 In general, would you say that you trust science.

Q13 In general, how much do you trust scientists to find out accurate information about the world.

Q14A How much do you trust scientists working in colleges/universities in this country to do their work with the intention of benefiting the public.

Q14B How much do you trust scientists working in colleges/universities in this country to be open and honest about who is paying for their work.

Q15A how much do you trust scientists working for companies in this country to do their work with the intention of benefiting the public.

Q15B how much do you trust scientists working for companies in this country to be open and honest about who is paying for their work.

Progress, engagement and knowledge

The PREK model (Progress, Reserve, Engagement and Knowledge) was adopted from Bauer & Suerdem (2016). Reserve is the response variable thus not used as explanatory variables.

The summative scales for progress were Q17 Q18 Q19 Q16(1)

Q17 Do you think the work that scientists do benefits people like you in this country;

Q18 Do you think that science and technology will help improve life for the next generation;

Q19 Do you think that science and technology will increase or decrease the number of jobs in your local area in the next five years?

Q16(1) do you think the work that scientists do benefits most, some, or very few people in this country?

The summative scales for engagement (information seeking were Q6 Q7 Q8 Q9(1).

Q6 Have you, personally, tried to get any information about science in the past 30 days?

Q7 Have you, personally, tried to get any information about medicine, disease, or health in the past 30 days?

Q8 Would you, personally, like to know more about science?

Q9 Would you, personally, like to know more about medicine, disease, or health?

The summative scales for knowledge were Q1 Q2 Q5A Q5B Q5C Q23(1)

Q1 How much do you, personally, know about science?

Q2 How much did you understand the meaning of "science" and "scientists" that was just read?

Q5A Have you, personally, ever, learned about science at Primary School?

Q5B Have you, personally, ever, learned about science at Secondary School?

Q5C Have you, personally, ever, learned about science at College/University?

Q23(1) Before today, had you ever heard of a vaccine?

Factor analysis and Multi group confirmatory factor analysis

Factor analysis (FA) was used to reduce the responses from the 13 trust questions to latent variables (Bartholomew et al, 2008; Field, 2005). Multigroup confirmatory factory analysis (MGCFA), an extension of the Confirmatory Factor Analysis, was used to test measurement invariance, that the same underlying construct is being measured in the data set, using gender as the group variable. Models ensured increased reliability is not achieved at the expense of construct validity and goodness-of-fit indexes are reported in line with acceptable ranges (Kim et al, 2017; Bialosiewicz et al., 2013).

For factor analysis, we examined and report Cronbach alpha, percentage of variance explained, Chi square, Kaiser-Meyer-Olkin Measure of Sampling Adequacy and Bartlett's Test of Sphericity (Appendix 1). For MGCFA, we examined and report configural, metric, and scalar invariance (Appendix 2), using the Chi square statistic, Comparative Fit Index (CFI), Tucker-Lewis Index (TLI)

Root Mean Squared Error of Approximation (RMSEA), Standardized Root Mean Square Residual (SRMR), the Akaike information criterion (AIC) and Bayesian information criterion (BIC).

A three-factor solution best describes the trust variables across countries and were named: Trust in Social actors; Trust in Scientific research; Trust in Science and scientists. (Appendix 1). Percentage of variance explained by factors, factor loadings as well as factor position vary across countries while few cross loadings were observed. Loadings for trust in traditional healers was below 0.2 for South Africa and Tanzania but acceptable for the sample size (Field, pg 637)

Analysis and findings

RQ1: 1. How do the hesitancy levels on importance, safety and effectiveness of vaccines in French speaking African countries compare with others and with levels of the colonial masters, France and the United Kingdom?

Figure 1 shows vaccine hesitancy (neither agree nor disagree, somewhat disagree, strongly disagree and don't know/refuse) in six Francophone and six Anglophone African countries compared with France and the UK
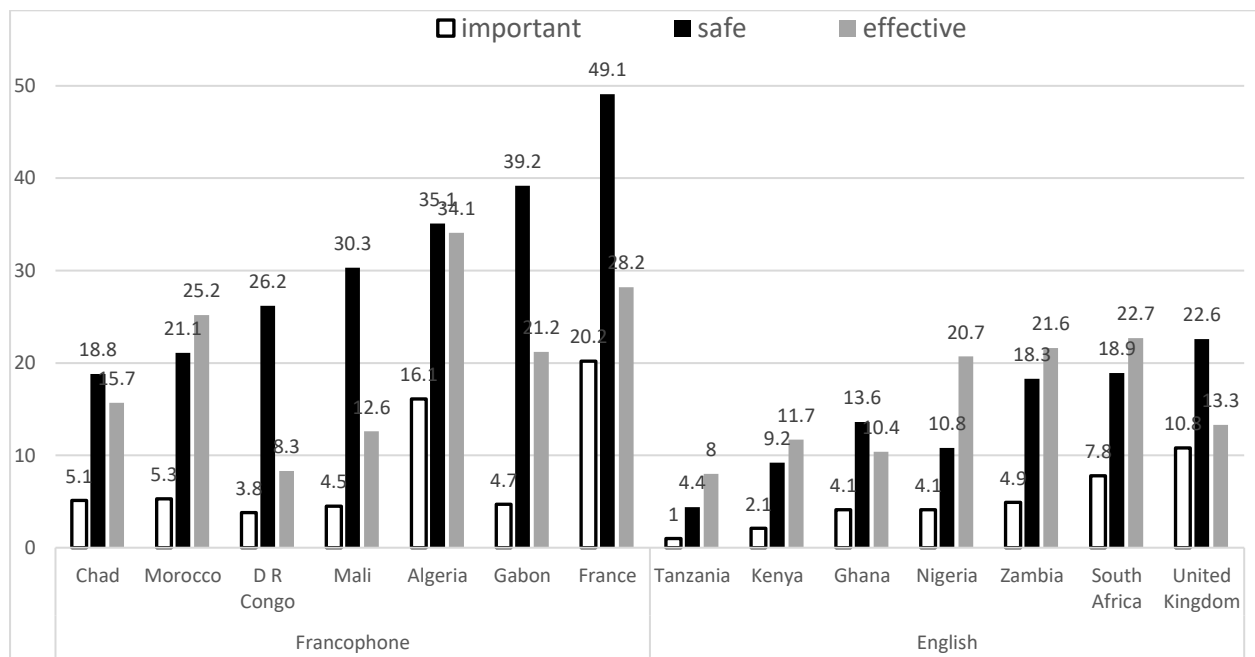
French surveys reported vaccine hesitancy at between 25% and 70% (Ward et al, 2019). The WGM survey showed 49% for hesitancy about safety, 28% for effectiveness and 20% for importance for France compared with 23%, 13% and 10% for UK. Figure 1 above shows the francophone countries mirror France with higher levels of hesitancy about safety compared with the UK and the anglophone countries.

Highest level of hesitancy about safety for the Francophone is Gabon (39.2%) and lowest in Chad (18.8%) while highest for anglophone is South Africa (18.9%) and lowest is Tanzania (4.4%). Levels of hesitancy about safety from the two countries from Southern Africa, Zambia and South Africa are higher than other English speakers and just below the level in Morocco.

Hesitancy about effectiveness in Algeria is higher than France. France is however higher than Morocco and other francophone countries. Levels for Nigeria, Zambia and South Africa are similar to Gabon and higher than Chad, DRC or Mali.

Hesitancy about importance is highest in Algeria among the African nations but lower than France. The highest level among the English speakers is South Africa followed by Zambia. Hesitancy about importance is lowest for all 12 African countries in Tanzania and Kenya, both anglophone and in East Africa.

RQ2: Are post-colonial cultural influences, inherent in shared language of importance to vaccine hesitancy across Africa?

Here, the study used the data for 40 countries and the response variables used were Q24 Vaccines are important; Q25 vaccines are safe; Q26 Vaccines are effective, and the explanatory variables were lingua franca (English or French speaking) demographics (age, gender, education, income and area type), the three latent trust factors (Trust in Social actors, Trust in Scientific research and Trust in Science and scientists) and the summative scales progress, engagement and knowledge. The trust latent factors were converted to binary/dummy variables using the visual biding function of SPSS to select the top 33.3% (1) against the rest (0).

Table 1: logistic regression output (N=21001; Hesitancy =1; Acceptance = 0) for language and other predictors of hesitancy about importance safety and effectiveness of vaccines in 40 African countries.

Important								
	B	Sig.	B	Sig.	B	Sig.	B	Sig.
Age	-0.003	0.298	-0.002	0.544	-0.005	0.112	-0.005	0.106
Gender (female)	-0.288	**0.001***	-0.3	**0.001***	-0.336	**0.001***	-0.312	**0.001***
General Educational	0.037	0.593	0.03	0.674	0.171	**0.048***	0.182	**0.035***
Area Type (Urban)	0.428	**0.001***	0.347	**0.001***	0.276	**0.001***	0.242	**0.004****
Income	0.029	0.332	0.029	0.345	0.044	0.152	0.043	0.156
Social Actors			0.012	0.875	-0.022	0.767	-0.059	0.435
Sci Scientists			0.288	**0.001***	0.17	**0.02***	0.186	**0.011***
Sci Research			0.301	**0.001***	0.201	**0.004****	0.195	**0.005****
Knowledge					-0.002	0.517	-0.001	0.663
Engagement					-0.012	**0.001***	-0.012	**0.001***
Progress					-0.024	**0.001***	-0.024	**0.001***
Language (French)							0.267	**0.002****
2 LL		5649.3		5457.2		5308.7		5299.4
R Square		0.01		0.049		0.078		0.08

Safe								
Age	-0.002	0.123	0	0.801	-0.002	0.266	-0.002	0.193
Gender (female)	-0.198	**0.001***	-0.205	**0.001***	-0.212	**0.001***	-0.161	**0.001***
General Educational	0.358	**0.001***	0.295	**0.001***	0.289	**0.001***	0.314	**0.001***
Area Type (Urban)	0.314	**0.001***	0.198	**0.001***	0.152	**0.001***	0.069	0.122
Income	0.04	**0.009**	0.036	0.021	0.038	**0.016**	0.037	**0.019***
Social Actors			0.394	**0.001***	0.345	**0.001***	0.266	**0.001***
Sci Scientists			0.018	0.634	-0.014	0.722	0.025	0.516
Sci Research			0.193	**0.001***	0.122	**0.001***	0.11	**0.002**
Knowledge					0.002	0.19	0.004	**0.016***
Engagement					0.001	0.63	0	0.981
Progress					-0.018	**0.001***	-0.017	**0.001***
Language (French)							0.625	**0.001***
2 LL		16056.1		15354.5		15143.9		14947.6
R Square		0.027		0.09		0.108		0.125
Effective								
Age	-0.009	**0.001***	-0.008	**0.001***	-0.009	**0.001***	-0.009	**0.001***
Gender (female)	-0.141	**0.001***	-0.148	**0.001***	-0.154	**0.001***	-0.193	**0.001***
General Educational	0.174	**0.001***	0.129	**0.001***	0.126	**0.007**	0.111	**0.017***
Area Type (Urban)	0.173	**0.001***	0.087	0.058	0.049	0.291	0.107	**0.022***
Income	0.014	0.37	0.011	0.496	0.012	0.446	0.014	0.409
Social Actors			0.243	**0.001***	0.209	**0.001***	0.268	**0.001***
Sci Scientists			0.113	**0.004**	0.081	**0.041***	0.055	0.17
Sci Research			0.1	**0.006**	0.047	0.208	0.057	0.124
Knowledge					0.002	0.2	0.001	0.609
Engagement					-0.002	0.164	-0.001	0.287
Progress					-0.013	**0.001***	-0.014	**0.001***
Language (French)							-0.431	**0.001***
2 LL		14775.4		14419.3		14311.7		14222.7
R Square		0.011		0.045		0.056		0.064

The averages for the 40 African countries in WGM 2018 are: important 4.3%, safe 18.7% and effective 15.5%. The averages for the 22 francophone countries are important 5.2%, safe 24.3% and effective 15.7% and for the English speakers important 3.1%, safe 11.6% and effective 15.2%. Averages for Francophone on safety doubles that of Anglophone and importance is also about double, thus strong indicators of the colonial or francophone effect.

Table 1 above shows that French speakers are more hesitant about importance and safety while English speakers and others are more hesitant about effectiveness. The study also found that those who reside in the urban areas are also significantly more hesitant about vaccine importance and its effectiveness.

The positive association of high levels of trust in scientific research with importance and safety indicates more trust leads to more hesitancy but not on effectiveness of vaccines. Trust in scientists is significant only for hesitancy about its importance. Trust in social actors is important for vaccine safety and effectiveness but not its importance.

General education and gender are significant across all three hesitancy variables but the association with gender is negative meaning men are more hesitant than women. Younger people are also significantly more hesitant about vaccine effectiveness but not its safety and importance.

Perceptions of science as progress is very significant for all three hesitancy types. The negative relationships indicate that Africans with more progressive attitudes are less likely to worry about the importance, safety and effectiveness of vaccines. The significant but negative beta for engagement (information seeking) for hesitancy about importance also indicates higher levels lead to less hesitancy.

RQ3: What are the predictors of perceptions of safety, importance and effectiveness of vaccines at country level?

Here we examine the predictors of perceptions of importance, safety and effectiveness at country levels. The explanatory response variables used were the same as for the 40 countries: demographics (age, gender, education, income and area type), the three latent trust factors (Trust in Social actors, Trust in Scientific research and Trust in Science and scientists) and the summative scales progress, engagement and knowledge.

Hesitance about Important (Table 2): The significance of variables as predictors in francophone countries varies with the largest number of variables (four) in Morocco (age, education, trust in scientific research and science as progress) and the lowest in Mali with increasing general education being negatively associated. General education is also the only variable significant in three countries, negatively associated in Chad and Mali but positive in Morocco. For Anglophone countries, significance also varies across countries and rural urban living is the only variable significant in two countries, Nigeria with negative association and Ghana with positive beta value. Both are from West Africa.

Hesitancy about safety (table 3): The significance of variables as predictors in francophone countries likewise varies with the largest number of variables (five) also in Morocco (education, trust in scientific research, knowledge, engagement and promise) and one each in Algeria (social actors) and Gabon (income). General education is positively significant in both Chad and Morocco. Zambia has the highest number of significant predictors (five) in the anglophone countries (age, gender, education, social actors and progress). The least is South Africa with positive association for social actors. Income is significant for both Kenya and Ghana while gender is significant for Nigeria, Tanzania and Zambia.

Table 2 Logistic regression output for hesitancy about importance of vaccines: 1 = strongly agree and somewhat agree; 0 = neither agree nor disagree, somewhat disagree, strongly disagree and don't know/refuse.

Important	Chad			Morocco			DR Congo			Mali			Algeria			Gabon		
	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Age	-0.04	-0.04	-0.05	0.03	**0.05***	**0.06***	-0.05	-0.04	-0.05	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.01	0.00	0.00
Gender	-0.16	-0.46	-0.67	-1.18	-0.77	-0.82	-0.08	-0.11	-0.09	-0.48	-0.36	-0.51	**0.48***	**0.51***	**0.58***	0.06	-0.14	-0.18
Education	-1.33	**-1.68***	**-2.70****	0.84	0.94	**2.01***	-0.75	-0.61	-0.18	**-1.36***	**-1.45***	-0.68	-0.05	0.08	0.08	-0.43	-0.18	-0.36
Rural/Urban	0.65	0.76	0.63	0.03	-0.24	0.02	0.38	0.31	0.41	0.30	0.48	0.71	-0.25	-0.17	-0.26	-0.06	0.07	0.10
Income	-0.15	-0.18	-0.27	-0.07	-0.21	-0.29	-0.16	-0.10	-0.13	-0.18	-0.22	-0.24	0.08	0.10	0.13	-0.07	-0.03	-0.04
Sci Research		1.35	1.19		**1.68****	**1.95****		0.86	**1.16***		0.55	0.45		0.08	0.00		0.80	0.70
Social actors		0.74	0.63		-0.35	-0.71		-0.25	-0.23		0.04	-0.04		0.06	0.05		**-1.13****	**-1.12****
Sci Scientists		17.13	17.11		0.35	0.23		0.29	0.03		-0.12	-0.28		**0.60***	**0.58****		**1.07***	**1.04***
K		-37.22	**0.07***			-0.06			-0.02			-0.04			0.00			0.02
E			-0.02			0.01			**-0.03***			-0.02			0.00			-0.01
P			-0.02			**-0.05***			0.03			-0.02			**-0.02***			-0.01
2 LL	93.63	80.36	73.62	99.28	72.63	64.04	125.78	117.84	110.40	135.41	131.66	123.42	493.35	466.90	462.54	193.56	172.72	170.64
Cha 2LL		13.27	6.73		26.64	8.60		7.94	7.44		3.75	8.24		26.44	4.36		20.84	2.08
R/Square	0.08	0.22	0.29	0.10	0.37	0.45	0.06	0.13	0.19	0.07	0.10	0.17	0.02	0.10	0.11	0.01	0.14	0.15
Cha R/Square		0.15	0.07		0.27	0.08		0.07	0.06		0.03	0.07		0.08	0.01		0.12	0.01

Important	Tanzania			Kenya			Ghana			Nigeria			Zambia			South Africa		
	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Age	-0.05	-0.07	-0.09	-0.02	-0.02	-0.02	0.02	0.02	0.02	0.02	0.02	0.02	-0.01	-0.01	-0.01	0.00	0.00	-0.01
Gender	-16.66	-17.28	-18.19	-0.85	-0.81	-0.73	0.02	-0.08	-0.07	-0.24	-0.30	-0.40	**1.23***	**1.21***	1.00	-0.44	-0.46	-0.49
Education	0.56	0.38	0.39	-1.01	**-1.10***	**-1.56***	-0.66	-0.60	-0.97	-0.19	-0.16	0.16	0.43	0.40	1.00	0.14	0.28	0.37
Rural/Urban	0.27	-0.39	-0.70	0.92	0.91	1.11	**1.56***	**1.58***	**1.58***	**-1.88***	**-1.89***	**-1.70***	-18.28	-18.30	-18.16	-0.35	-0.20	-0.24
Income	-0.14	-0.14	0.00	0.29	0.29	0.23	0.09	0.07	-0.03	0.22	0.21	0.29	0.15	0.15	0.16	-0.02	-0.05	-0.04
Sci Research		1.13	1.59		0.41	0.05		0.53	0.57		-0.15	-0.18		0.14	0.03		-0.06	-0.13
Social actors		1.35	1.89		-0.01	-0.08		0.47	0.34		-0.07	-0.05		0.06	**0.05***		0.47	0.52
Sci Scientists		-1.31	-2.06		0.63	0.52		0.17	0.33		0.39	0.10		-0.08	**-0.34***		0.27	0.16
K			0.03			0.03			**0.04***			-0.02			-0.02			-0.01
E			-0.08			-0.01			-0.03			-0.02			-0.03			-0.01
P			-0.01			-0.03			0.00			-0.02			-0.03			-0.02
2 LL	31.27	28.14	24.68	125.14	123.03	118.73	156.22	152.42	147.27	224.68	223.73	213.99	134.64	134.41	121.80	119.24	115.31	113.66
Cha 2LL		3.13	3.46		2.11	4.30		3.80	5.15		0.95	9.74		0.22	12.61		3.93	1.65

R/Square	0.18	0.26	0.36	0.09	0.10	0.14	0.07	0.09	0.13	0.07	0.08	0.13	0.10	0.10	0.20	0.01	0.06	0.07
Cha R/Square		0.08	0.09		0.02	0.04		0.03	0.04		0.01	0.05		0.00	0.10		0.04	0.02

Table 3 Logistic regression output for hesitancy about safety of vaccines: 1 = strongly agree and somewhat agree; 0 = neither agree nor disagree, somewhat disagree, strongly disagree and don't know/refuse.

Safe	Chad			Morocco			DR Congo			Mali			Algeria			Gabon		
	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Age	0.01	0.01	0.00	0.01	0.01	0.01	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.01	0.01	0.01
Gender	0.15	-0.01	0.03	-0.43	-0.33	-0.55	-0.06	-0.07	-0.10	-0.38	-0.34	-0.46	0.22	0.33	0.34	0.08	-0.12	-0.14
Education	**1.19****	**1.13****	**1.02***	**0.83****	**0.88****	**1.22****	0.21	0.20	0.12	-0.34	-0.37	-0.33	-0.02	0.08	0.16	0.05	0.08	-0.01
Area Type	0.39	0.35	0.27	-0.44	-0.53	-0.38	0.20	0.19	0.16	0.06	0.17	0.20	**-0.50***	-0.40	-0.40	**0.51****	**0.45***	0.38
Income	-0.12	-0.14	-0.14	0.00	-0.04	0.00	-0.02	-0.01	0.01	0.01	0.00	-0.01	-0.03	-0.03	-0.03	**0.17***	**0.18***	**0.16***
Sci Research		-0.64	-0.77		**0.82****	**0.72****		0.17	0.09		**0.53****	**0.42***		0.24	0.23		0.34	0.32
Social actors		**1.01***	**0.96***		-0.41	-0.59		0.00	-0.02		-0.11	-0.15		**0.40***	**0.39***		0.22	0.19
Sci Scientists		0.50	0.37		0.46	0.46		-0.05	-0.01		-0.12	-0.17		0.21	0.19		0.25	0.25
K			0.02			**-0.03***			0.00			0.00			-0.01			0.01
E			**-0.02***			**0.03***			0.01			0.00			0.00			0.01
P			-0.01			**-0.03****			-0.01			**-0.02****			0.00			-0.01
2 LL	306.7	296.4	290.1	274.7	252.1	236.9	436.9	435.6	431.0	420.6	411.2	403.2	688.1	642.7	641.7	772.3	721.4	715.8
Cha 2LL		10.28	6.31		22.62	15.15		1.29	4.63		9.39	8.05		45.37	1.04		50.94	5.58
R/Square	0.08	0.13	0.15	0.07	0.18	0.25	0.01	0.01	0.03	0.02	0.06	0.09	0.02	0.13	0.13	0.04	0.15	0.16
Cha R/Square		0.04	0.03		0.11	0.07		0.01	0.02		0.04	0.03		0.11	0.00		0.11	0.01

Safe	Tanzania			Kenya			Ghana			Nigeria			Zambia			South Africa		
	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Age	-0.01	-0.02	-0.02	0.00	0.00	0.00	0.01	0.01	0.01	-0.01	-0.01	-0.02	**0.03****	**0.03****	**0.03****	-0.01	-0.02	-0.02
Gender	-0.91	**-1.24***	**-1.24***	0.15	0.17	0.16	-0.16	-0.23	-0.13	-0.58	**-0.76***	**-0.78***	**0.63***	**0.58***	**0.56***	-0.07	-0.07	-0.07
Education	**1.14***	**1.01***	**1.48***	0.16	0.12	-0.01	-0.40	-0.32	-0.48	0.26	0.21	0.34	0.45	0.35	**0.71***	0.40	0.59	0.66
Area Type	0.71	0.44	0.55	-0.22	-0.31	-0.15	-0.07	-0.04	-0.13	-0.46	**-0.67***	-0.47	0.18	0.21	0.28	-0.38	-0.23	-0.32
Income	-0.09	-0.04	-0.06	**0.35****	**0.34****	**0.30***	**0.35****	**0.34****	**0.26***	0.14	0.13	0.15	0.11	0.10	0.10	0.16	0.13	0.14
Sci Research		0.23	0.06		0.11	-0.15		0.39	0.14		0.46	0.35		-0.23	-0.26		0.17	0.04
Social actors		0.12	-0.05		**0.74***	**0.71***		**0.71***	0.54		-0.08	-0.06		**0.56***	**0.55***		**1.05****	**1.15****

Sci Scientists		0.68	0.63		0.37	0.22		-0.03	-0.16		0.12	-0.11		0.18	0.03		-0.18	-0.30
K			-0.04			0.02			0.02			-0.01			-0.02			0.00
E			0.02			-0.01			0.01			0.01			0.00			-0.01
P			-0.03			**-0.03****			**-0.04****			**-0.03***			**-0.02***			-0.02
2 LL	139.6	128.4	122.5	394.6	382.1	370.2	442.5	429.7	403.8	420.3	409.4	391.5	384.9	370.3	361.7	214.6	195.8	190.7
Cha 2LL		11.26	5.87		12.57	11.87		12.84	25.88		10.87	17.92		14.52	8.68		18.80	5.16
R/Square	0.11	0.19	0.23	0.04	0.08	0.12	0.05	0.08	0.16	0.03	0.07	0.12	0.07	0.12	0.15	0.04	0.16	0.19
Cha R/Square		0.08	0.04		0.04	0.04		0.04	0.08		0.03	0.06		0.05	0.03		0.13	0.03

Table 4 Logistic regression output for hesitancy about effectiveness of vaccines: 1 = strongly agree and somewhat agree; 0 = neither agree nor disagree, somewhat disagree, strongly disagree and don't know/refuse.

Effective	Chad			Morocco			DR Congo			Mali			Algeria			Gabon		
	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Age	-0.02	-0.02	-0.02	0.01	0.01	0.00	-0.03	-0.02	-0.03	-0.02	-0.03	-0.02	0.00	0.00	0.01	0.01	0.01	0.01
Gender	-0.70	-0.86	**-0.97***	-0.21	-0.13	-0.31	-0.14	-0.20	-0.19	-0.29	-0.21	-0.56	0.31	0.38	0.39	0.19	0.03	0.02
Education	0.52	0.44	0.84	**0.58***	**0.64***	**1.09****	-0.41	-0.41	-0.20	0.13	0.13	0.01	-0.02	0.16	0.19	0.04	0.11	0.05
Area Type	0.31	0.34	0.44	-0.36	-0.44	-0.33	-0.17	-0.26	-0.31	-0.17	0.16	0.17	-0.35	-0.25	-0.26	0.20	0.15	0.13
Income	-0.13	-0.13	-0.09	-0.17	-0.22	-0.19	-0.02	0.02	0.06	-0.07	-0.15	-0.18	0.06	0.09	0.08	0.02	0.02	0.02
Sci Research		0.20	0.12		**0.73****	**0.65****		0.41	0.41		**0.84****	0.58		0.30	0.29		**0.55***	**0.52***
Social Actors		0.25	0.14		-0.43	-0.56		0.14	0.18		-0.06	-0.16		0.18	0.21		-0.09	-0.09
Sci Scientists		0.74	0.65		**0.54***	**0.51***		0.10	0.00		0.56	0.46		**0.66****	**0.61****		0.32	0.32
K			-0.01			**-0.03***			-0.01			0.02			0.00			0.01
E			-0.01			**0.02***			-0.01			-0.02			-0.01			0.00
P			-0.01			**-0.02***			0.00			**-0.05****			0.00			-0.01
2 LL	278.0	270.0	265.2	319.7	296.2	281.7	210.5	203.4	201.9	228.0	195.6	172.8	692.0	616.1	613.7	568.6	532.1	531.2
Cha 2LL		8.00	4.82		23.55	14.46		7.11	1.57		32.42	22.83		75.92	2.41		36.56	0.91
R/Square	0.05	0.08	0.11	0.04	0.15	0.21	0.03	0.07	0.08	0.02	0.20	0.32	0.02	0.20	0.20	0.01	0.10	0.11
Cha R/Square					0.11	0.06		0.04	0.01		0.18	0.12		0.18	0.01		0.10	0.00

Effective	Tanzania			Kenya			Ghana			Nigeria			Zambia			South Africa		
	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B
Age	0.00	0.00	-0.01	-0.01	-0.01	-0.02	0.00	0.00	0.01	**-0.03****	**-0.03****	**-0.03****	0.00	0.00	0.00	-0.01	-0.01	-0.01

Gender	-0.56	**-0.78***	**-0.92***	0.39	0.42	0.41	-0.32	-0.33	-0.31	**-0.74****	**-0.65****	**-0.61****	0.23	0.25	0.23	-0.45	-0.48	-0.52
Education	0.29	0.17	0.69	-0.05	-0.10	-0.14	-0.51	-0.53	-0.45	-0.47	-0.34	0.05	0.44	0.47	**0.58***	0.06	0.03	0.08
Area Type	0.46	0.22	0.28	0.27	0.21	0.32	**-0.65***	**-0.59***	**-0.62***	**-0.80****	**-0.69****	**-0.55***	-0.25	-0.27	-0.28	-0.15	-0.10	-0.14
Income	-0.02	0.01	0.04	**0.38****	**0.37****	**0.34****	-0.12	-0.12	-0.15	-0.03	-0.03	-0.01	0.10	0.11	0.10	-0.08	-0.10	-0.12
Sci Research		0.13	0.03		0.07	-0.13		-0.30	-0.59		**-0.49***	**-0.45***		-0.25	-0.29		0.24	0.19
Social Actors		0.51	0.51		**0.74***	**0.74***		**0.82***	**0.74***		-0.11	-0.12		-0.01	-0.03		**0.86***	**1.07****
Sci Scientists		0.24	0.01		0.16	0.01		-0.60	**-0.85***		0.34	0.25		**0.50***	0.44		-0.54	**-0.77***
K			-0.03			0.01			-0.01			**-0.03****			0.00			0.00
E			-0.01			**-0.02***			**0.02***			0.01			0.00			**-0.03***
P			**-0.03***			**-0.02***			**-0.03***			0.00			-0.01			-0.01
2 LL	273.8	254.7	243.9	464.3	452.8	443.1	367.6	360.8	346.0	650.7	641.4	622.4	458.9	450.5	446.7	237.8	227.1	218.8
Cha 2LL		19.07	10.82		11.54	9.66		6.79	14.81		9.34	19.03		8.46	3.79		10.69	8.27
R/Square	0.03	0.11	0.15	0.06	0.09	0.12	0.05	0.08	0.13	0.10	0.12	0.16	0.03	0.06	0.07	0.02	0.09	0.14
Cha R/Square		0.08	0.05		0.03	0.03		0.02	0.05		0.02	0.04		0.03	0.01		0.07	0.05

Hesitance about effectiveness (Table 4): The significance of variables as predictors in francophone countries varies but none is significant for the DR Congo data. The largest number of variables for the francophone are in Morocco. Nigeria and Ghana also have the highest number of predictors among the English speakers, with rural urban living significant to both.

Conclusions

Hesitancy average on safety for the 22 Francophone countries is more than double the average for the 18 English speaking countries. Hesitancy about importance for Francophone countries is also almost double that for English speakers. These differences mirror that observed between the United Kingdom and France, splitting Africa along colonial lines, thus strong indicators of the francophone effect. This bifurcation of Africa on vaccine hesitancy plausibly reflects the strong role of continued shared language, education and cultural ties with former colonies and shared communication in social media space now made more readily accessible with expanding internet access and the popularity and reach of social media. Language restricts the African public to news and public debates from French or English-speaking media and this has become even more important as health news is increasingly sought from online groups, blogs and social media apps rather than official vaccine information sites. Comparing where the respondent resides, study found that those who reside in the urban areas, who are more likely to have access to internet are also more hesitant about vaccine importance and effectiveness, than those in rural areas, who in Africa are largely farmers and less likely to have internet access.

With trust in institutions, those who have higher levels of trust in social actors are more hesitant about the safety and effectiveness of vaccines, not its importance. Thus, social actors play a strong role in public perceptions of safety and effectiveness and since social actors are more likely to be found in the media, unofficial vaccine information sites and everyday social communications, these findings further expand our understanding of the importance of non-scientific actors in vaccine hesitancy. With scientific actors, higher levels of trust in scientific research leads to more hesitancy on importance and safety but not effectiveness of vaccines. Trust in scientists is significant only for hesitancy about its importance. Increasing levels of general education is also significantly associated with all three hesitancy variables. These findings show that the expectation that the more you know science, the more you love it seems to have limitations and may indeed have an opposite effect with vaccine hesitancy. Study however found that Africans, in the sample population, who see science as progress; benefiting the public and improving lives, are less likely to be hesitant about the importance, safety and effectiveness of vaccines.

At country level, significance of variables as predictors varies and no predictor cuts across all 12 countries analysed indicating the strong role of local social and cultural issues. For Nigeria and Ghana, both in West Africa, the rural versus urban living is important in perceptions of effectiveness and importance of vaccines. On safety, income is important for Ghana and Kenya while general education is important for Chad and Morocco and gender for Nigeria, Tanzania and Zambia.

This research has shown the role of continent wide and country level predictors in all three types of vaccine hesitancy and going forward, it is hoped that their relevance will inform future public health policies and communication campaigns even beyond vaccines. Health policies and campaigns need to recognise continent wide

similarities, potential impact of language differences and country level cultural peculiarities for successful implementation and outcomes. It is also important to keep a longitudinal data stream as part of monitoring and evaluation process to guide the content of communication campaigns and direction of further policy. More research is also needed on the relationship between language and vaccine hesitancy, in particular, the role of media of communication in public perceptions.

The data used for this study was collected a year before the covid-19 pandemic and the subsequent introduction of covid-19 vaccines. While this is a limitation in current contexts, it also an advantage in that it provides baseline data for future comparisons.

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