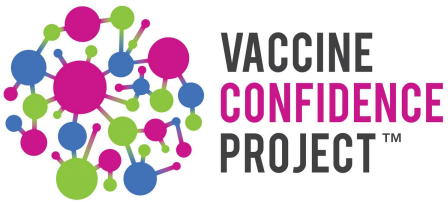
Trends in intent to accept a COVID-19 vaccine in Nigeria: a spatio-temporal modelling study

Preliminary report

Prepared by Nilmini Herath, Heidi Larson, and Alex de Figueiredo at the Vaccine Confidence Project, London School of Hygiene and Tropical Medicine, London, UK.

Funded by the Foreign, Commonwealth & Development Office



Introduction

The introduction of Covid-19 vaccines in December 2020 has presented governments and healthcare systems unprecedented challenges ranging from the rapid procurement and distribution of vaccines to encouraging mass vaccination.

Whereas much of the Western world secured priority access to vaccines through early contracts with vaccine manufacturers, many low-and-middle-income countries (LMICs) have struggled to provide Covid-19 vaccines to their populations. The current inequity in the global supply of Covid-19 vaccines is well-documented[1] and many have speculated that this inequity will both prolong the pandemic and increase the likelihood of novel SARS-CoV-2 variants, which may evade vaccines.[2] The director general of the WHO called global vaccine inequity a “moral outrage” and a recipe for seeding vaccine-escaping variants.[3] As many western countries move to provide booster vaccines to low-risk groups, many LMICs still cannot provide life-saving vaccines to their high-risk populations.[4]

In addition to this problem of low access to Covid-19 for many in various LMIC settings, a major limiting factor when vaccines become available will be the willingness of location populations to receive the vaccine. One LMIC that has experienced notable perception-based barriers to vaccines is Nigeria, where low vaccine coverage for many immunisations persist, often in very specific regions[5] and due to the deliberate spread of misinformation[6].

As of December 2021, Nigeria lags many other countries in its COVID-19 vaccination coverage, including other middle-income countries in Sub-Saharan Africa as well as regionally proximate countries such as Ghana, Côte d’Ivoire, and Sierra Leone (figure 1).

---

[1] Asundi, A., O’Leary, C. and Bhadelia, N., 2021. Global COVID-19 vaccine inequity: The scope, the impact, and the challenges. *Cell Host & Microbe*, *29*(7), pp.1036-1039.
[2] Burki, T., 2021. Global COVID-19 vaccine inequity. *The Lancet Infectious Diseases*, *21*(7), pp.922-923.
[3] https://www.aljazeera.com/news/2021/3/22/grotesque-vaccine-makers-urged-to-overcome-vaccine-inequity
[4] Hassan, F., Yamey, G. and Abbasi, K., 2021. Profiteering from vaccine inequity: a crime against humanity?. *bmj*, *374*.
[5] Mosser, J.F., Gagne-Maynard, W., Rao, P.C., Osgood-Zimmerman, A., Fullman, N., Graetz, N., Burstein, R., Updike, R.L., Liu, P.Y., Ray, S.E. and Earl, L., 2019. Mapping diphtheria-pertussis-tetanus vaccine coverage in Africa, 2000–2016: a spatial and temporal modelling study. *The Lancet*, *393*(10183), pp.1843-1855.
[6] Kapp, C., 2004. Nigerian states again boycott polio-vaccination drive. *The Lancet*, *363*(9410), p.709.

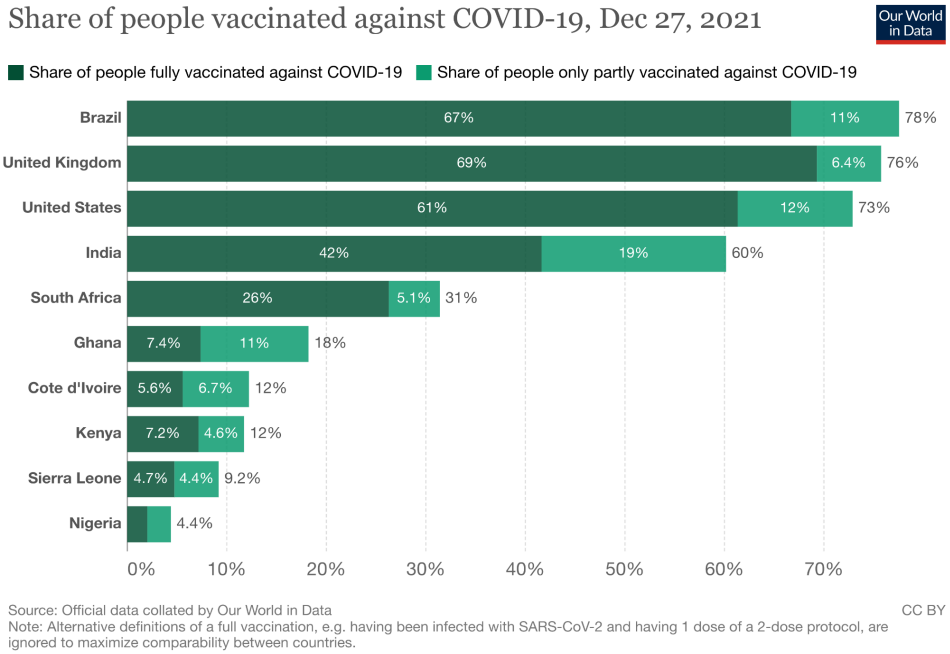


Figure 1 Nigeria lags many countries with similar economic features or geographic proximity in Covid-19 vaccine uptake (retrieved from https://ourworldindata.org/coronavirus)

In this study, we explore how intent to receive a COVID-19 vaccine evolved in Nigeria (both nationally and sub-nationally) between March 2021 (when the first Covid-19 vaccines were administered to healthcare workers[7]) and October 2021. A longitudinal survey instrument was deployed every month to about 5,000 respondents.

In this preliminary report, we provide estimates of the proportion of Nigerians who intend to vaccinate against COVID-19 and how this varies between March 2021 and October 2021 using weighted survey responses derived from Nigerian census data to obtain better estimate representativeness.

Subsequent analysis (not presented in this report) will examine the time-varying determinants of intent to vaccinate. In particular, we will examine socio-demographic, emotional, COVID-19 knowledge, trusted sources, and vaccine confidence barriers. In additional analysis, we will also

[7] https://www.afro.who.int/news/nigerian-health-workers-take-countrys-first-covid-19-vaccine

explore attitudes to (and determinants of) perceptions of childhood immunisations, in particular the DTaP, polio, and measles programmes. We will explore the extent to which vaccine confidence in the Covid-19 vaccine is related to vaccine confidence in these other immunisation programmes.

Maintaining high confidence in vaccines generally is especially important for pandemic recovery, as many countries worldwide have experienced substantial disruption to the delivery of childhood immunisation programmes[8].

Summary findings

At a national level, our data suggest that Nigeria continues to have high levels of uncertainty over intent to accept a Covid-19 vaccine, but with fairly stable intentions over time. In our final survey (November 2021) we estimate that 77% of Nigerians would either 'definitely' vaccinate or were unsure but leaning towards vaccinating. In total, only 3% of the population had received a Covid-19 vaccine as of November 2021, 48% stated a firm intent to vaccinate, 39% were unsure (with 26% unsure but leaning towards vaccinating), while only 11% would 'definitely not' vaccinate. These national-level trends were reasonably stable over time, seemingly contrasting with the broad global picture for western countries, who have generally experienced increases in intent to accept a COVID-19 vaccine over time.[9] At the state-level, we find strong regional variation in levels of intent to accept a COVID-19 vaccine. Perceptions were notably high in Kwara and Niger, as well as Kaduna, where vaccine perceptions had experienced a strong increase over time. Perceptions were relatively much lower in the Federal Capital Territory and Rivers. Methods

Data collection

A total of seven rounds of data collection took place between 3 March and 22 October, 2021, comprising a total of 38,030 interviews from 15,182 distinct participants across the 37 Nigerian states. Interviews were conducted digitally, through a questionnaire designed by the Vaccine

[8] Causey, K., Fullman, N., Sorensen, R.J., Galles, N.C., Zheng, P., Aravkin, A., Danovaro-Holliday, M.C., Martinez-Piedra, R., Sodha, S.V., Velandia-González, M.P. and Gacic-Dobo, M., 2021. Estimating global and regional disruptions to routine childhood vaccine coverage during the COVID-19 pandemic in 2020: a modelling study. *The Lancet*, *398*(10299), pp.522-534.

[9] https://www.imperial.ac.uk/media/imperial-college/institute-of-global-health-innovation/EMBARGOED-0502.-Feb-21-GlobalVaccineInsights_ICL-YouGov-Covid-19-Behaviour-Tracker_20210301.pdf

Confidence Project in collaboration with local policymakers. The number of responses collected on each day is shown in figure 2.

The surveys were conducted by our project partners, PREMISE, who are a global integrated human data collection and analytics service. Surveys are implemented on the PREMISE mobile phone application. Due to the difficulties in low-cost data gathering in Nigeria, and the imminent need for these data to inform relevant policies in Nigeria, the PREMISE platform provides a cost-efficient means of rapidly surveying thousands of respondents in Nigeria over multiple time points. However, because of the way participants are crowdsourced, collected survey data are not demographically representative of Nigeria at the sub-national or national levels. Statistical reweighting procedures are used to minimise the risk of under- or over-sampling socio-demographic groups, but we note an extremely strong bias towards male respondents and a slight bias towards younger respondents. A breakdown of responses by demographics and state is shown in table 1.

All respondents who participated in the survey were aged over 18. We excluded a small number of survey responses (228) who had duplicate submissions and we are investigating these cases further. For the purposes of reweighting against demographic data, we also excluded 237 survey responses who reported a gender other than male or female as they could not be mapped to census counts. We also excluded one observation whose age could not be determined. The questionnaire issued to respondents is provided in Appendix A3.

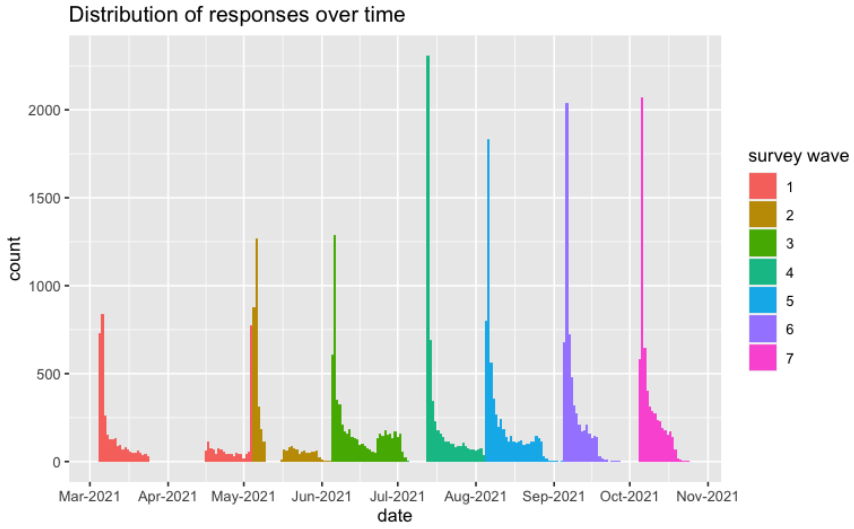


Figure 2 Distribution of survey responses over time over eight months of data collection. In each wave there were (respectively) 4902, 3708, 5831, 5398, 6278, 5927, and 5986 responses.

Region	N (all waves)	Male	Female	18-25 yrs	26-25 yrs	36-45 yrs	45+ yrs
Abia	461	371 (80%)	90 (20%)	256	157	37	11
Adamawa	644	556 (86%)	88 (14%)	221	346	68	9
Akwa Ibom	589	481 (82%)	108 (18%)	271	241	64	13
Anambra	670	513 (77%)	157 (23%)	328	275	52	15
Bauchi	438	408 (93%)	30 (7%)	188	211	39	0
Bayelsa	175	127 (73%)	48 (27%)	92	60	17	6
Benue	518	465 (90%)	53 (10%)	228	231	40	19
Borno	903	827 (92%)	76 (8%)	387	420	88	8
Cross River	402	330 (82%)	72 (18%)	246	124	26	6
Delta	832	622 (75%)	210 (25%)	375	338	91	28
Ebonyi	172	140 (81%)	32 (19%)	97	49	14	12
Edo	972	800 (82%)	172 (18%)	548	306	89	29
Ekiti	617	521 (84%)	96 (16%)	367	174	65	11
Enugu	645	478 (74%)	167 (26%)	391	234	14	6
Federal Capital Territory	1826	1303 (71%)	523 (29%)	679	822	266	59
Gombe	254	239 (94%)	15 (6%)	74	150	27	3
Imo	613	468 (76%)	145 (24%)	314	233	40	26
Jigawa	218	194 (89%)	24 (11%)	80	117	21	0
Kaduna	1624	1444 (89%)	180 (11%)	701	764	144	15
Kano	3220	2783 (86%)	437 (14%)	1379	1500	299	42
Katsina	209	192 (92%)	17 (8%)	95	91	16	7
Kebbi	104	90 (87%)	14 (13%)	70	30	4	0
Kogi	321	286 (89%)	35 (11%)	181	111	26	3
Kwara	4645	3247 (70%)	1398 (30%)	1362	2597	647	39
Lagos	5284	4044 (77%)	1240 (23%)	1762	2363	904	255
Nasarawa	513	416 (81%)	97 (19%)	204	220	76	13
Niger	1381	1264 (92%)	117 (8%)	584	705	83	9
Ogun	1591	1215 (76%)	376 (24%)	638	625	278	50
Ondo	1674	1346 (80%)	328 (20%)	860	699	105	10
Osun	1160	889 (77%)	271 (23%)	560	436	127	37
Oyo	2266	1730 (76%)	536 (24%)	737	984	490	55
Plateau	535	394 (74%)	141 (26%)	273	210	45	7
Rivers	1222	937 (77%)	285 (23%)	560	424	200	38
Sokoto	503	470 (93%)	33 (7%)	231	217	55	0
Taraba	148	126 (85%)	22 (15%)	44	65	39	0
Yobe	365	344 (94%)	21 (6%)	147	171	41	6
Zamfara	79	76 (96%)	3 (4%)	39	34	5	1

Table 1 Socio-demographic breakdown of the survey sample. We note a very strong bias towards males, with a minimum of 71% of the sample in FCT to 96% in Zamfara.

Intent to accept a Covid-19 vaccine

In this report, the quantity of interest is intent to accept a Covid-19 vaccine, which we measure via the following survey question: “if a new coronavirus (COVID-19/Coro/Cov-19) vaccine was offered to you, would you accept the vaccine for yourself?”. Respondents are presented with

four possible options that seek to elicit a precise vaccination motive: “yes, definitely”, “unsure, but leaning towards yes”, “unsure, but leaning towards no”, or “no, definitely not”. (See Appendix A3.) This response measurement has been previously used to successfully predict Covid-19 vaccine uptake in the UK[10] and we thus believe this represents a good scale on which to identify Covid-19 vaccination intentions. In May 2021, the option “I have already received at least one dose of a COVID-19 vaccine” was added to reflect the introduction of the Covid-19 vaccine to the general public.

Additional survey modules included in the questionnaire but not otherwise analysed in this report include: demographic information (sex, age, education, religion, income, ethnicity, and primary language); attitudes, behaviours, and sources of trust during the Covid-19 pandemic; Covid-19 knowledge and misinformation; perceptions of community attitudes towards Covid-19; attitudes and behaviours towards vaccines in general and routine childhood immunizations, specifically; and psychological measures. Ongoing research is using these wider survey modules to explore the determinants of Covid-19 vaccine intent, vaccine confidence more broadly, and views and perceptions towards the Covid-19 pandemic.

Survey reweighting

To make our estimates of intent to vaccinate more representative of the relevant population(s); and in particular, accounting for the heavy bias towards males, we computed survey weights at national and state levels based on age and sex distributions in 2020 inferred from the 2006 Nigerian census. (The methodology for how these population projections are calculated is available at the Spatial Data Repository from the DHS program[11].)

We compute the weights for each combination of age-group, sex, and state according to,

$$weight_{age,\,gender,\,region} = \frac{share\ of\ age\ group,\,gender,\,region\ combination\ in\ population}{share\ of\ age\ group,\,gender,\,region\ combination\ in\ sample} \quad .$$

A weight of less than one indicates an observation is from an oversampled group (so their responses are weighted downwards), while a weight greater than one indicates an observation is from an undersampled group (so their responses are weighted upwards). Throughout this

[10] de Figueiredo, A., 2021. Forecasting sub-national trends in COVID-19 vaccine uptake in the UK. *medRxiv*, pp.2020-12

[11] "Methods for Calculating 5-Year Age Group Population Estimates by Sex for Subnational Areas," available at http://spatialdata.dhsprogram.com/references/subntl_pop_est_methods_pgs_uscb_sep16.pdf

report only weighted estimates are presented, but we include unweighted estimates in the Appendix for completeness and comparison.

Results

National estimates of intent to accept Covid-19 vaccines

The intent to accept a Covid-19 vaccine has increased slightly over time in Nigeria. In March 2021, 45% of the population stated a firm intent to accept the vaccine, with only 12% stating a firm intention to reject it. In November 2021, however, a total of 51% of the population stated had either already had a Covid-19 vaccine or would definitely accept one, with 11% stating a firm intention to reject the vaccine. Interestingly, therefore, while firm intent to accept the vaccine has increased (45% to 51%) there has not been a corresponding shift away from negative perceptions (12% to 11%). Indeed, 24% of respondents were either 'unsure, but leaning towards no' or 'no, definitely not' in both March and November, suggesting that increased perceptions are due to previously unsure, but positive respondents becoming more convinced to vaccinate.

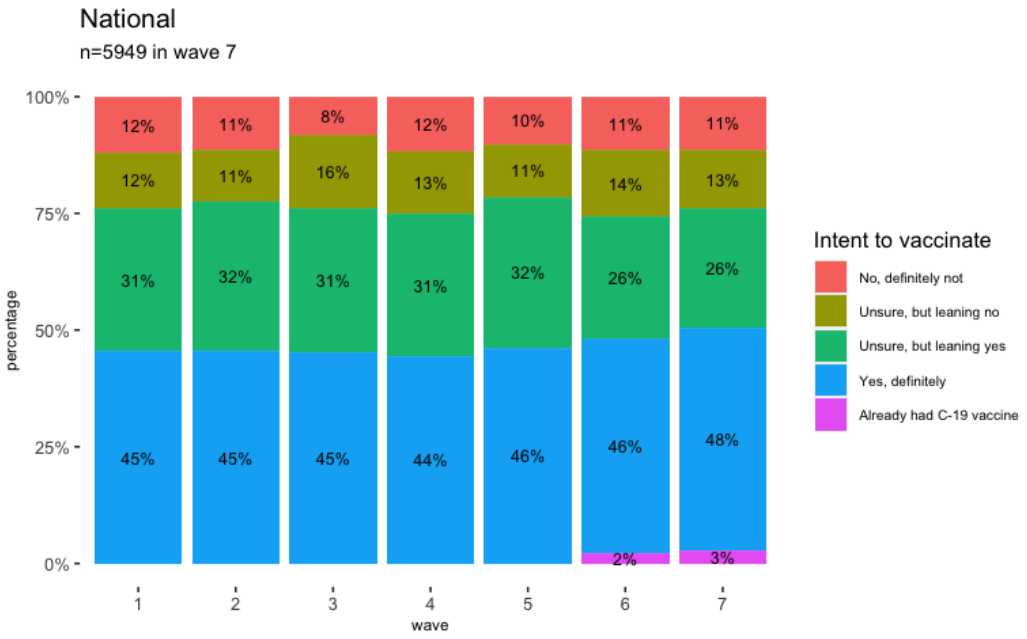


Figure 3 National intent to accept Covid-19 vaccines. Overall intention to 'definitely' accept a Covid-19 vaccine has increased in Nigeria between March and November, 2021. However, the proportion of respondents who hold overall negative intentions has remained the same. Survey wave dates are (1) 6 March - 4 May, (2) 5 May - 4 June, (3) 5 June - 4 July, (4) 5 July - 4 August, (5) 5 August - 4 September, (6) 5 September - 4 October, (6) 5 October - 4 November. 'Already had C-19 vaccine' refers to people who self-report as having had at least one dose.

It is also notable that over three quarters of the population are likely to accept the Covid-19 vaccine, but have not yet done so. This likely reflects roll-out progress, with mass vaccination (beyond health-care workers and the elderly) only starting in late October 2021.[12] It will be important to monitor the degree to which intent to vaccinate is realised as vaccine delivery widens. If those who definitely intend to vaccinate do not do so once they become eligible, this could indicate issues with access or process such as those seen in South Africa, where information access barriers prevented many from accessing the vaccine.[13]

State-level estimates of intent to accept Covid-19 vaccines

Figure 4A and B show state-level (weighted) estimates of intent to accept a Covid-19 vaccine, ordered by decreasing state sample size (see table 1) with national-level estimates for comparison.

There are a number of noteworthy trends across Nigeria. Across all states, Kwara, Osun, Niger, and Yobe have among the highest levels of respondents stating a definite intent to accept a Covid-19 vaccine (though we note a relatively small sample size in Yobe). Benue and Rivers, however, have among the highest proportions of respondents stating a definite intent to reject a Covid-19 vaccine, with this proportion becoming larger in Benue through the study period. (See figure 4A and B)

With regards to overall uncertainty over vaccinating, the Federal Capital Territory (FCT) has among the highest proportions of respondents who are unsure about their intention to vaccinate, with far lower proportions who state they would ‘definitely’ vaccinate than the national average (though this difference seems to be decreasing over time), see figure 4A.

There are also notable differences in temporal trends between some states. While the proportion who would ‘definitely’ take a Covid-19 has grown substantially over time in Kaduna (from 46% to 58%), the proportion who would ‘definitely not’ accept a vaccine has more than doubled in Rivers.

[12] https://guardian.ng/news/lagos-launches-mass-vaccination-campaign-against-covid-19/
[13] Maughan-Brown, B; Eyal, K; Buttenheim, A; Ingle, K; Brophy, T, COVID-19 Vaccine Survey 1: Preliminary Results http://www.opensaldru.uct.ac.za/handle/11090/1014

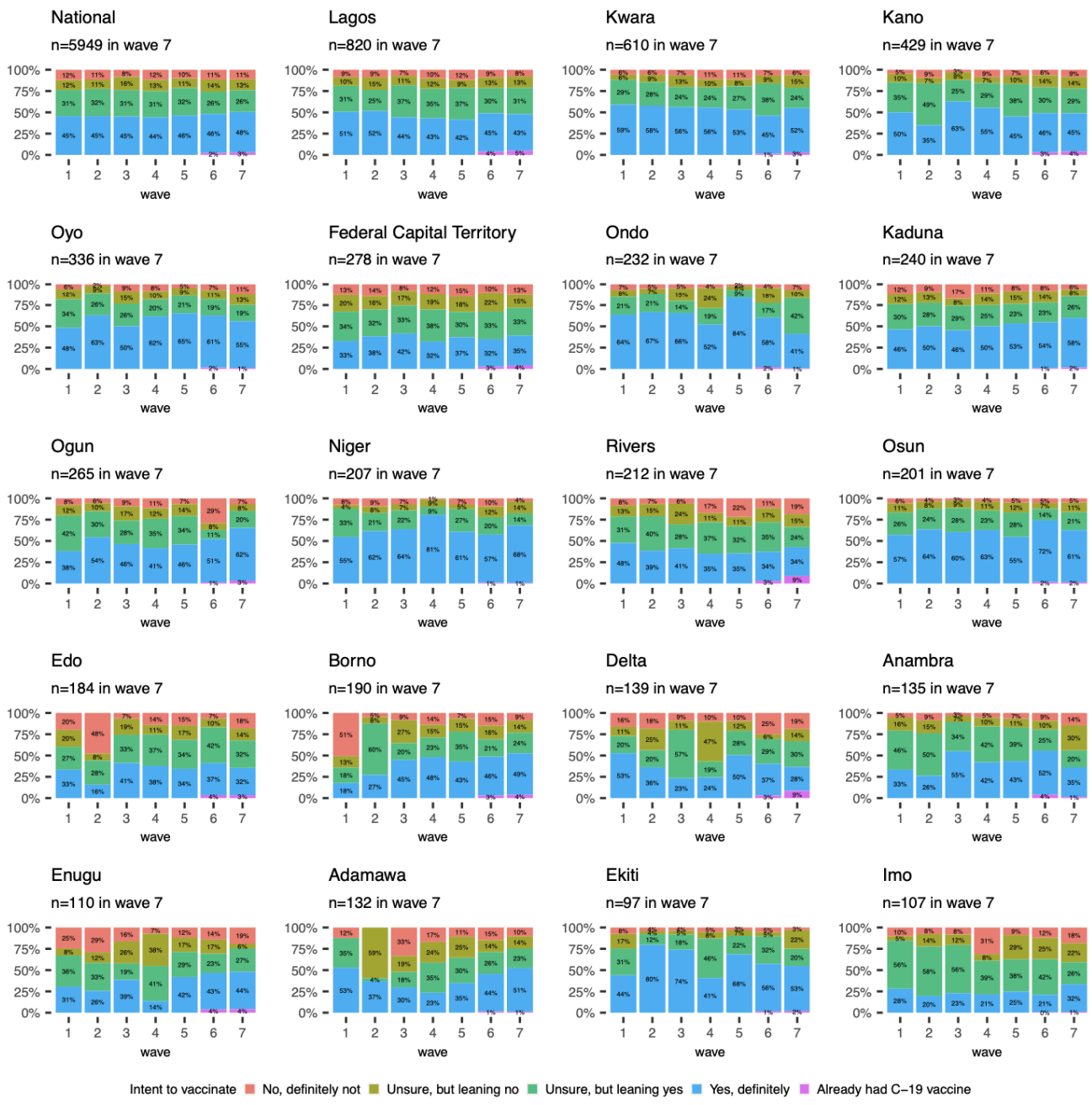


Figure 4A State-level estimates for intent to accept Covid-19 vaccines. Sub-national estimates are shown for 19 states, presented in order of decreasing sample size in the final survey wave. Survey wave dates are (1) 6 March - 4 May, (2) 5 May - 4 June, (3) 5 June - 4 July, (4) 5 July - 4 August, (5) 5 August - 4 September, (6) 5 September - 4 October, (6) 5 October - 4 November.

Figure 4B State-level estimates for intent to accept Covid-19 vaccines. Sub-national estimates are shown for 18 states, presented in order of decreasing sample size in the final survey wave. Survey wave dates are (1) 6 March - 4 May, (2) 5 May - 4 June, (3) 5 June - 4 July, (4) 5 July - 4 August, (5) 5 August - 4 September, (6) 5 September - 4 October, (6) 5 October - 4 November.

At a national level, weighting does not substantively alter our estimates of intent to accept Covid-19 vaccines. However, our weighting approach does impact findings for states with small sample sizes (as expected). Our next modelling steps will be to utilise multilevel (hierarchical) modelling tools that pool information between national and state-level data, while also drawing on geographic proximity of states, to provide more robust estimates at these levels.

Discussion

While over 75% of Nigerians surveyed would likely accept a Covid-19 vaccine if offered to them, there are notable sub-national variations in both levels to accept Covid-19 vaccines as well as trends about these levels. Overall, therefore, these findings illustrate the importance of routine monitoring of sub-national attitudes to Covid-19 vaccines to detect emerging trends and identify, explore, and address losses in vaccine confidence, which is the next step in this study.

Through identifying the main drivers of acceptance from a diverse range of putative barriers, we will be able to map barriers to uptake across Nigeria and provide contextualisation in a historical perspective. Moreover, we will be able to provide policy-relevant messages about the specific population strata who will be less inclined to vaccinate, and we can suggest means through which confidence can be rebuilt.

As Nigeria expands its COVID-19 vaccine eligibility to its entire adult population, it will be important to continue monitoring intent to vaccinate and vaccination status at the national and regional levels.

Data limitations

The ability of our partner's data collection methods to generate representative (demographically or perhaps related to other biases related to technological access/use) samples may lead to biased estimates of intent to vaccinate. As variables relating to these biases (e.g. access to technology, access to and awareness of the PREMISE app) are not measured, it will be extremely challenging to control for these particular biases.

In addition, there are some other data features that may cause unpredicted response patterns. For example, only about half of respondents completed one wave of data collection. While a reasonable cross section was secured for each wave due to continual enrollments of new contributors, it may be worth exploring an incentive structure that supports multiple wave

completion so that the same sample can be maintained over time, providing a complete longitudinal sample and tracking attitudes within the same cohort. This could be achieved using extra incentives for completion of all waves or that increase with each wave.[14] There are also some response groups who are very undersampled, and this includes gender broadly, but gender and ethnicity within specific states. While weighting approaches can improve the representativity of our estimates, an enrollment approach that specifically targeted under-represented groups may be useful to explore should future digital data collection be conducted in this context.

As vaccines continue to be rolled out across Nigeria, we will seek to validate our predictions against real-world observed state- and national-level vaccine uptake. These early estimates of vaccine uptake will provide reassurance of the robustness of our approach.

Data and knowledge-exchange

We intend on sharing this preliminary report with our project partners, such as the Africa CDC and other local policy contacts in Nigeria. In addition, we will communicate findings with the Joint Learning Network for UHC's National Coordination of Pandemic Responses collaborative as well as with other stakeholders within the FCDO.

We will immediately open up communication ties, and share further study outputs as they arise.

[14] An example of the former approach was successful in inducing immunizations in: Banerjee, A. V., Duflo, E., Glennerster, R., & Kothari, D. (2010). Improving immunisation coverage in rural India: clustered randomised controlled evaluation of immunisation campaigns with and without incentives. Bmj, 340.

Appendix

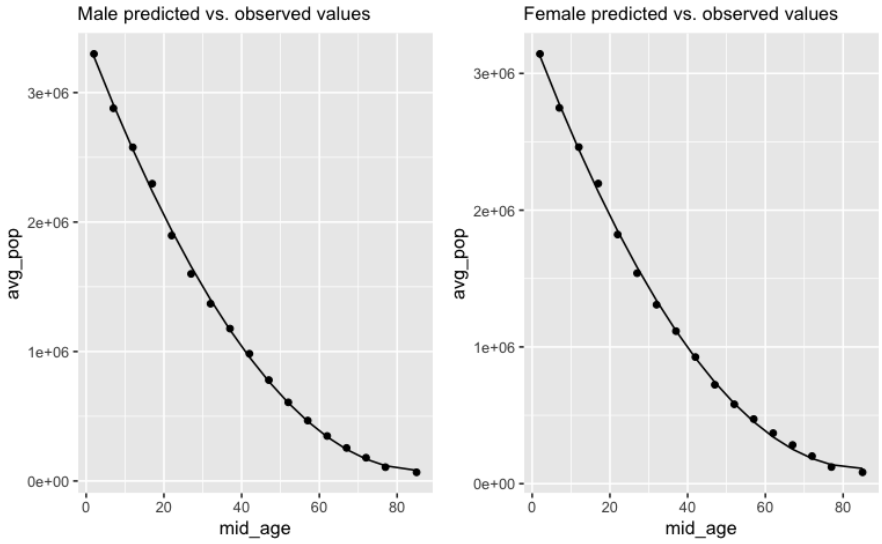
A1. Age group mapping used in weighting calculation

The census age groups don't correspond perfectly to our sample age grouping. While the census grouping is in general more granular and many categories neatly fall into our sample age grouping, four census-based population estimates by age group needed to be apportioned between the corresponding age groups in our sample.

To do this, we estimated two functions mapping age in years to the male and female population estimates using ordinary least squares regression with the model

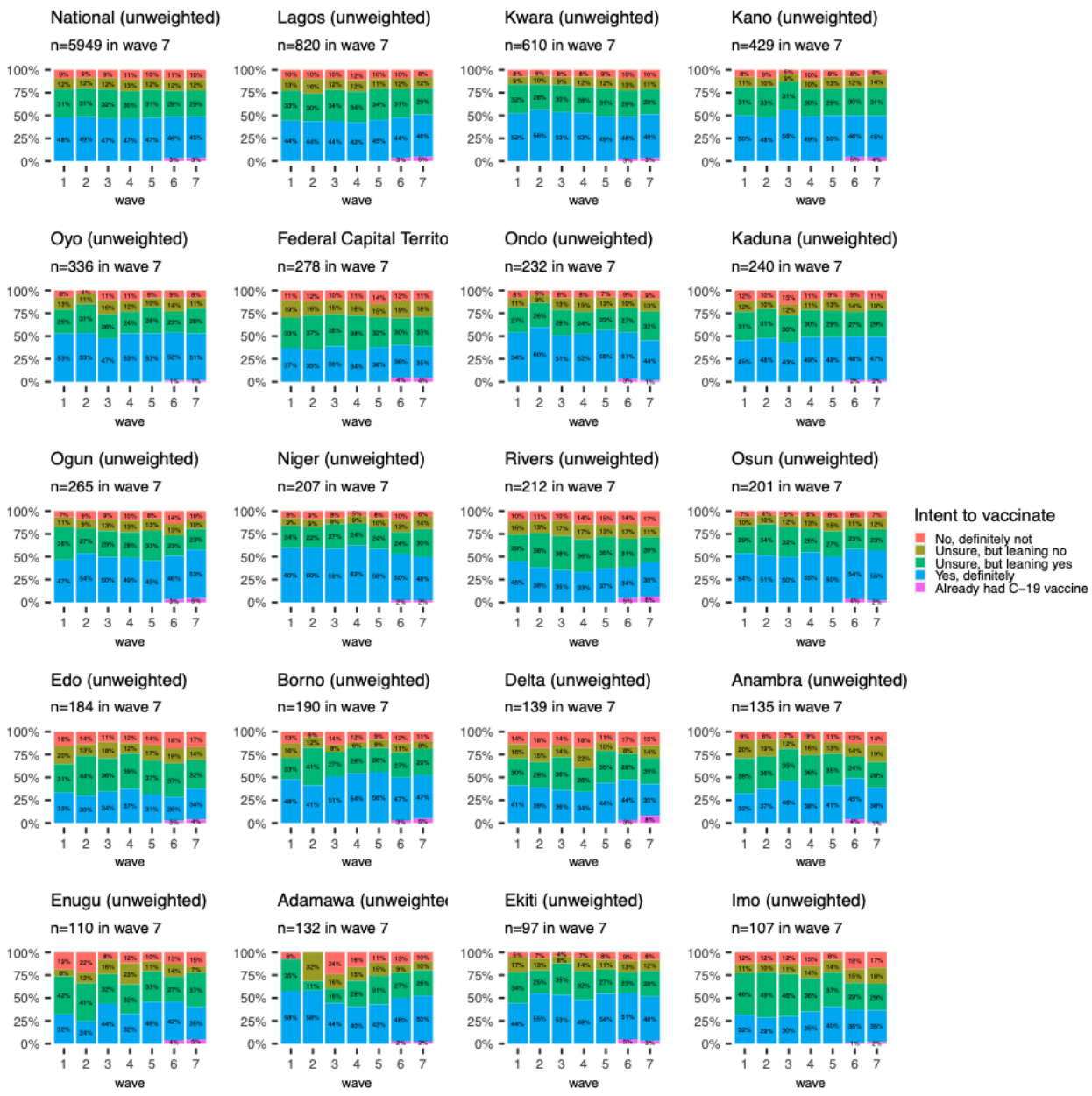
$$y_i = \alpha + \beta_1 age_i + \beta_2 age_i^2 + \varepsilon_i$$

Where i indexes the census population group, α is the intercept term, y_i is the census age group population projection for 2020, divided by 5 as age groups were in five year intervals, age_i and age_i^2 are the respectively the census age group mid-point and its square, and ε_i is the residual term. We estimated this separately for the male and female populations of Nigeria. Our model had high explanatory power with adjusted R^2 values of 0.9992 (male) and 0.9991 (female). The model fit is also shown in the following figure.



Using these estimates we calculated the predicted age in years for the male and female population groups and used this to apportion the census age groups to those of our sample.

A3. Unweighted regional estimates

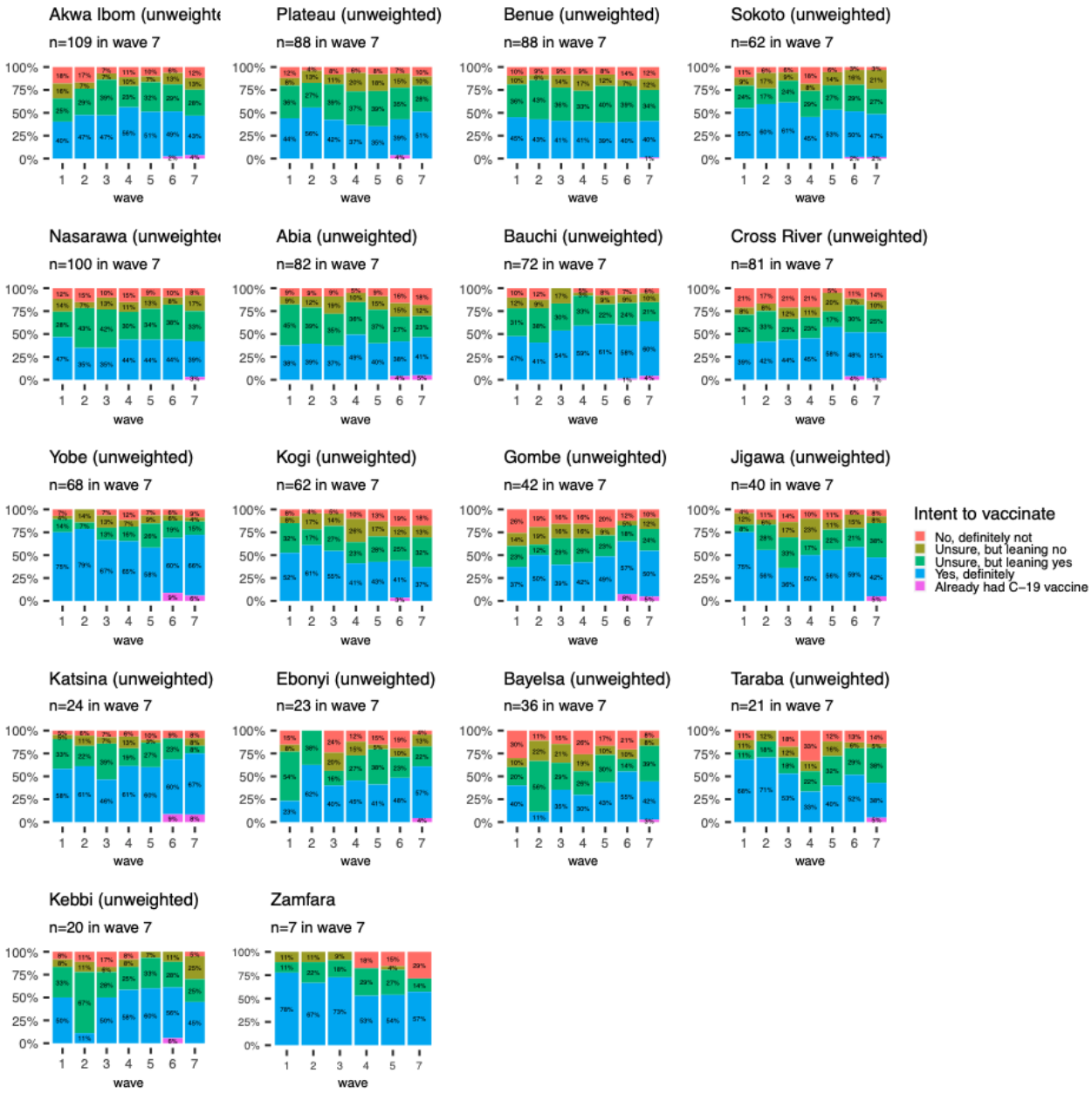


Notes:

1.Estimates are unweighted, representing proportions of responses observed in our data

2. Survey wave dates were (1) 6 March - 4 May, (2) 5 May - 4 June, (3) 5 June - 4 July, (4) 5 July - 4 August, (5) 5 August - 4 September, (6) 5 September - 4 October, (6) 5 October - 4 November.

3. Regions ordered by sample size (descending)



Notes:

1.Estimates are unweighted, representing proportions of responses observed in our data

2. Survey wave dates were (1) 6 March - 4 May, (2) 5 May - 4 June, (3) 5 June - 4 July, (4) 5 July - 4 August, (5) 5 August - 4 September, (6) 5 September - 4 October, (6) 5 October - 4 November.

3. Regions ordered by sample size (descending)

A3. Questionnaire

The questionnaire can be found in the corresponding file questionaire_nigeria_vcp_premise.pdf.