Hyperlocal Targeting of Vaccine Hesitancy in Mali

Prepared by Fraym for Johnson & Johnson Global Public Health

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Hyperlocal Support of Vaccine Uptake: Overview

We aim to bring local understanding of uptake barriers across SSA

Goals

A **deeper understanding** of the 3C's occur locally and across entire countries to inform broad Risk Communication and Community Engagement (RCCE) efforts.

A **detailed mapping of J&J's consumer segments** and media consumption patterns across the country to close the gap between data and action.
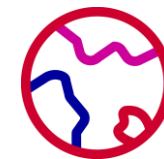
An **interactive tool to equip implementors with hyperlocal data** to overcome barriers to vaccine uptake **faster**.

Outputs

Comprehensive reports containing overviews and detailed assessments of hyperlocal patterns of vaccine confidence, convenience, complacency, consumer segmentation, and media consumption patterns across the entire country.

DATAfraym® – an interactive web-based dashboard – access, for custom data exploration, analysis, and exports, with mapping available at a 1 km^2 level of granularity.
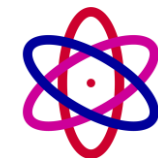
Complete datasets available regarding vaccine confidence, complacency, convenience, consumer segmentation, and media consumption patterns across the entire country, at a 1 km^2 level of granularity.

Paired with World Health Organization's 3Cs Framework, Fraym has mapped J&J's Consumer Segments to identify where vaccine uptake challenges are likely to occur

The 3Cs

Confidence: High confidence = *More* likely to take a vaccine

Convenience: High convenience = *More* likely to take a vaccine

Complacency: High complacency = *Less* likely to take a vaccine

Meet the segments: An introduction

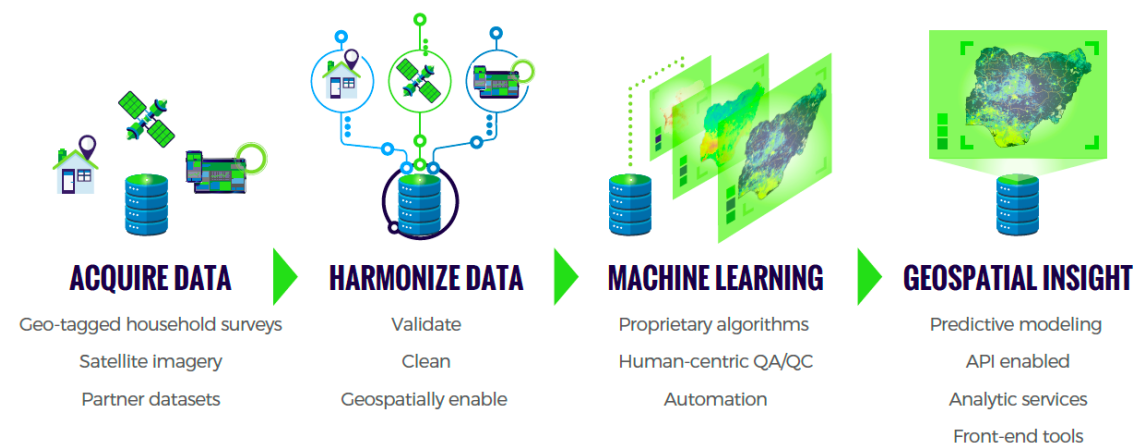|	Segment 1 Confident enthusiasts	Segment 2 Vaccine sceptics	Segment 3 COVID cynics	Segment 4 Enthusiastic pragmatists	Segment 5 Vaccine ambivalents
Summary	Convinced of COVID threat and vaccine benefits. Would be quick adopters driven by social responsibility to protect their community.	Convinced of COVID threat, but scepticism around vaccine safety and efficacy inhibits perceived benefit and quick uptake.	Strongly hesitant of COVID threat and a COVID vaccine. Mistrust in the vaccine's purpose and advocates means they will be slow to vaccine adoption, if at all.	Convinced of COVID threat and merits of a vaccine, but inhibited by practical barriers. Cost-benefit analysis of the process could cause uptake delay.	Not convinced of the threat of COVID as a disease and lack motivation to seek a vaccine, but few barriers to uptake. Could be moved by social norms and strong messaging.
% of population	24%	25%	12%	19%	20%
Likelihood to take a COVID-19 vaccine	Very High	Moderately low	Very Low	High	Moderate
Speed of uptake	As soon as possible	Wait at least 6-12 months	Never	As soon as possible	Wait at least 6-12 months
Perceived ease of getting the vaccine	Very easy	Fairly easy	Fairly easy	Not easy/not at all easy	Fairly easy
COVID disease perceptions	High perceived risk and severity	High perceived risk and severity	Low perceived risk and severity	High perceived risk and severity	Low perceived risk and severity

Consumer Segmentation

Different segments of people have different motivations and reasons to not get a COVID- 19 vaccine (barriers)

Methodology

Machine Learning for Hyperlocal Mapping

Fraym has built machine learning (ML) software that weaves together geo-tagged household survey data with satellite imagery to create localized population information (1 km^2).

1 The primary ML model input is data from high-quality, geo-tagged household surveys. Key indications of a high-quality household survey include implementing organization(s), sample design, sample size, and response rates. After data collection, *post-hoc* sampling weights are created to account for any oversampling and ensure representativeness.

2 The second major data input is satellite imagery and related derived data products, including Earth observation (EO) data, gridded population information (e.g., human settlement mapping, etc.), proximity to physical locations (e.g., health clinics, ports, roads, etc.) and biophysical surfaces like soil characteristics. As with the survey data, Fraym data scientists ensure that the software only uses high-quality imagery and derivative inputs.

3 To create spatial layers from household survey data, Fraym leverages machine learning to predict an indicator of interest at a 1 square kilometer resolution. This methodology builds upon existing, tested methodologies for interpolation of spatial data. The resulting model is used to predict the survey data for all non-enumerated areas. A similar approach was originally developed by academic researchers focused on health outcomes, which were expanded upon by USAID's Demographic and Health Surveys program since then by Fraym and others.[1]

ACQUIRE DATA	**HARMONIZE DATA**	**MACHINE LEARNING**	**GEOSPATIAL INSIGHT**
Geo-tagged household surveys	Validate	Proprietary algorithms	Predictive modeling
Satellite imagery	Clean	Human-centric QA/QC	API enabled
Partner datasets	Geospatially enable	Automation	Analytic services
			Front-end tools

Note 1: Gething, Peter, Andy Tatem, Tom Bird, and Clara R. Burgert-Brucker. 2015. Creating Spatial Interpolation Surfaces with DHS Data DHS Spatial Analysis Reports No. 11. Rockville, Maryland, USA: ICF International. Other notable, relevant work includes: Weiss DJ, Lucas TCD, Nguyen M, etal.Mapping the global prevalence, incidence, and mortality of*Plasmodium falciparum*, 2000–17: a spatial and temporal modelling study.Lancet 2019 and Tatem A, Gething P, Pezzulo C, Weiss D, and Bhatt S. 2014. Final Report: Development of High-Resolution Gridded Poverty Surfaces. University of Southampton. https://www.worldpop.org/resources/docs/pdf/Poverty-mapping-report.pdf

3Cs Model of Vaccine Hesitancy

Fraym used the *WHO Sage Working Group on Vaccine Hesitancy* backed 3Cs Model to analyze and segment vaccine hesitant populations.
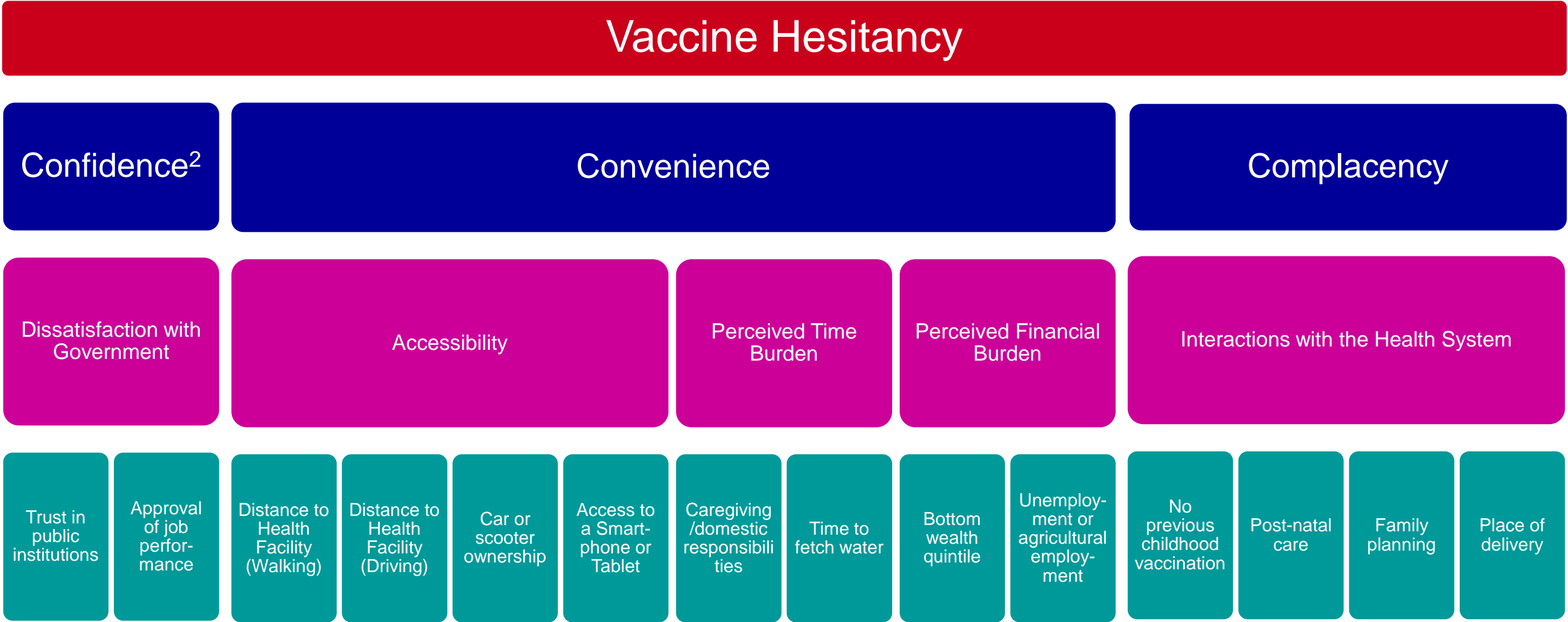
The 3Cs Model of Vaccine Hesitancy

1. **Confidence:** Trust in the effectiveness and safety of vaccines, the system that delivers them, and the motivations of policymakers.

2. **Convenience:** Physical availability, affordability, and willingness-to-pay, geographical accessibility, ability to understand, and appeal of immunization services.

3. **Complacency:** Level to which perceived risks of vaccine-preventable diseases are low and vaccination is not deemed a necessary preventative action.

Source 1: https://www.who.int/immunization/sage/meetings/2014/october/1_Report_WORKING_GROUP_vaccine_hesitancy_final.pdf
Source 2: htps://africacdc.org/download/covid-19-vaccine-perceptions-a-15-country-study/
Source 3: https://pubmed.ncbi.nlm.nih.gov/33684019/

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Indicators for the "3Cs" Model[1]

Vaccine Hesitancy				
Confidence[2]	**Convenience**			**Complacency**
Dissatisfaction with Government	Accessibility	Perceived Time Burden	Perceived Financial Burden	Interactions with the Health System
Trust in public institutions / Approval of job performance	Distance to Health Facility (Walking) / Distance to Health Facility (Driving) / Car or scooter ownership / Access to a Smart-phone or Tablet	Caregiving /domestic responsibilities / Time to fetch water	Bottom wealth quintile / Unemploy-ment or agricultural employ-ment	No previous childhood vaccination / Post-natal care / Family planning / Place of delivery

Note 1: Full indicator descriptions are available in the Appendix.
Note 2: Indicators for the confidence model are sourced from the Afrobarometer and are only available at the first administrative level.
Source: Mali Demographic and Health Surveys, World Health Organization, Malaria Atlas Project "Global maps of travel time to health facilities"

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Profiles of Vaccine Hesitant Segments

Fraym created each profile based on their unique combination of the 3Cs. The replicated Ipsos segments are not exhaustive combinations of the "3Cs" and do not add to the total population of adults in Mali.

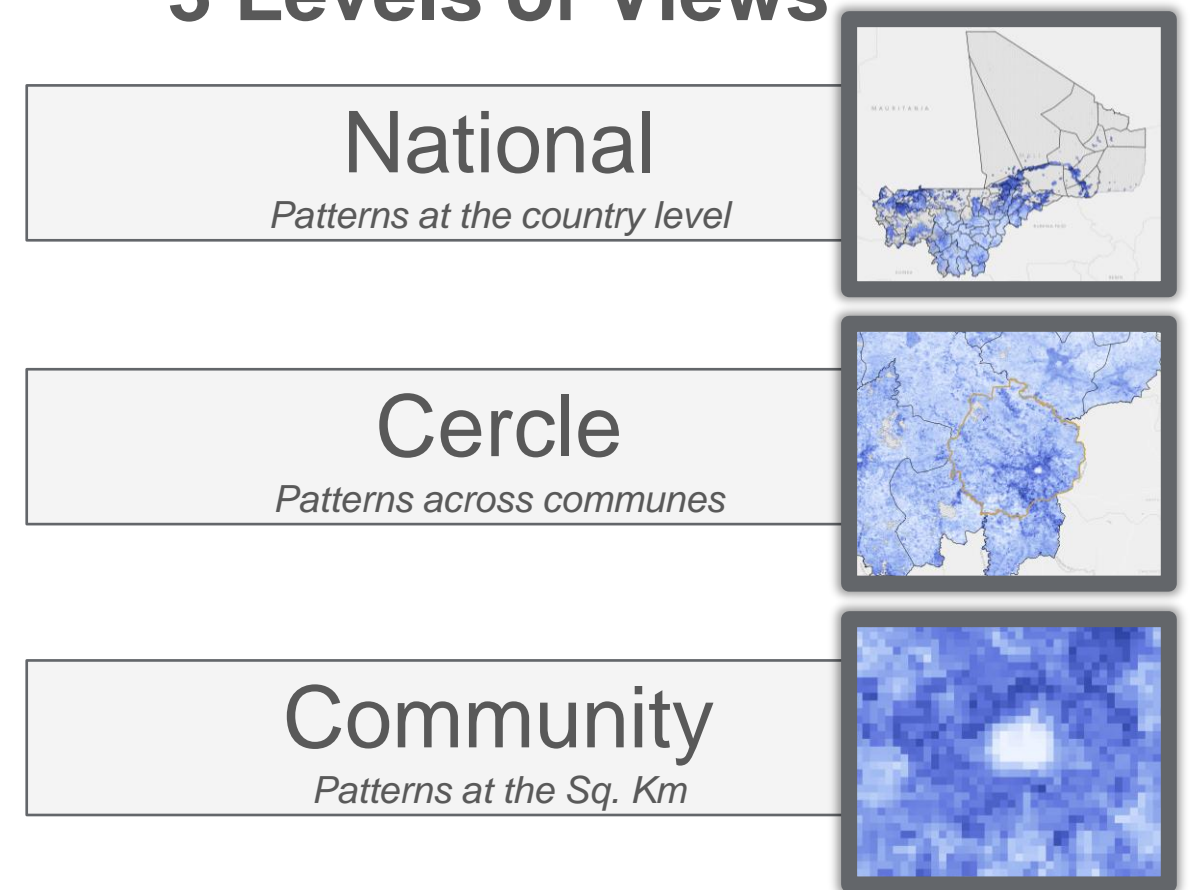| Segment Profile	Confident Enthusiasts	Enthusiastic Pragmatists	Vaccine Ambivalents	Vaccine Sceptics	COVID Cynics
Segment Description	*Convinced of COVID threat and vaccine benefits. Would be quick adopters driven by social responsibility to protect their community.*	*Convinced of COVID threat and merits of a vaccine, but inhibited by practical barriers. Cost-benefit analysis of the process could cause uptake delay.*	*Not convinced of the threat of COVID as a disease and lack motivation to seek a vaccine, but few barriers to uptake. Could be moved by social norms and strong messaging.*	*Convinced of COVID threat, but scepticism around vaccine safety and efficacy inhibits perceived benefit and quick uptake.*	*Strongly hesitant of COVID threat and a COVID vaccine. Mistrust in the vaccine's purpose and advocates means they will be slow to vaccine adoption, if at all.*
Level of Confidence	High	High	Moderate	Low	Low
Level of Convenience	High	Low	Moderate	Moderate	Moderate
Level of Complacency	Low	Low	High	Low	High
Potential Speed of Vaccine Uptake	Rapid	Delayed	Slow	Very Slow	Least Likely

How to use this analysis

Paired with WHO's 3Cs Framework, Fraym has mapped J&J's Consumer Segments to identify where vaccine uptake challenges are likely to occur.

Potential Use-Cases:

- Concentrate communication campaigns and media spending in specific geographic areas

- Target specific messages to niche audiences in prioritized geographies

- Optimize vaccine distribution

- Service & Product Delivery Planning

3 Levels of Views

National
Patterns at the country level

Cercle
Patterns across communes

Community
Patterns at the Sq. Km

Segment Mapping Use Cases

Mapping the 3Cs of Vaccine Hesitancy

Fraym created hyper-local maps of vaccine complacency and convenience and a state-level view of confidence (proxied by trust in government).

1 Fraym used the 2018 Mali Demographic and Health Survey to model vaccine complacency and convenience. To incorporate confidence, Fraym utilized state-level data from the 2019 Mali Afrobarometer.

2 Vaccine complacency indicators were created based on limited interactions with the health system as a proxy for low perceived risk for diseases and preventative actions. Vaccine convenience indicators focus on accessibility, as well as time and financial burdens associated with getting vaccinated. Fraym utilized multiple correspondence analysis (MCA) to create complacency and convenience indices and normalized index values from zero to one.[1]

3 Fraym created a confidence in government index using the 2019 Mali Afrobarometer. The index averages trust in a range of public figures—including the President, members of Parliament, the local government council, and traditional or religious leaders—through trust towards these figures and disapproval of their performance. The state-level data was normalized from zero to one. All individuals living in that state receive the same score.

Note 1: To learn more about MCA, please visit https://www.sciencedirect.com/topics/computer-science/multiple-correspondence-analysis.

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Demographics of Vaccine Segments

Fraym analyzed the demographic characteristics of each segment among adults aged 15-49.

|	Confident Enthusiasts	Enthusiastic Pragmatists	Vaccine Ambivalents	Vaccine Sceptics	COVID Cynics
Age					
15-34	58%	52%	47%	61%	55%
35-49	42%	48%	53%	39%	45%
Education					
No education	44%	85%	71%	77%	81%
Complete primary	5%	1%	4%	3%	2%
Complete secondary	0%	0%	0%	0%	0%
Higher education	2%	0%	0%	1%	0%
Regular Media Consumption[1]					
Newspaper/Magazine	10%	0%	1%	1%	1%
Television	62%	25%	36%	38%	33%
Radio	59%	34%	52%	51%	49%
Asset Ownership					
Mobile phone	100%	94%	92%	95%	92%
Television	83%	20%	42%	40%	33%
Radio	62%	68%	63%	65%	53%

Note 1: Regular media consumption is defined as listening to the radio, watching television, or reading a newspaper or magazine at least once per week.

Note 2: Categories do not add to 100% due to response options not shown.

Identifying Vaccine Ambivalents

Vaccine ambivalents are not convinced of the threat of COVID as a disease and lack motivation to seek a vaccine, but face few barriers to uptake. This group could be moved by social norms and strong messaging.
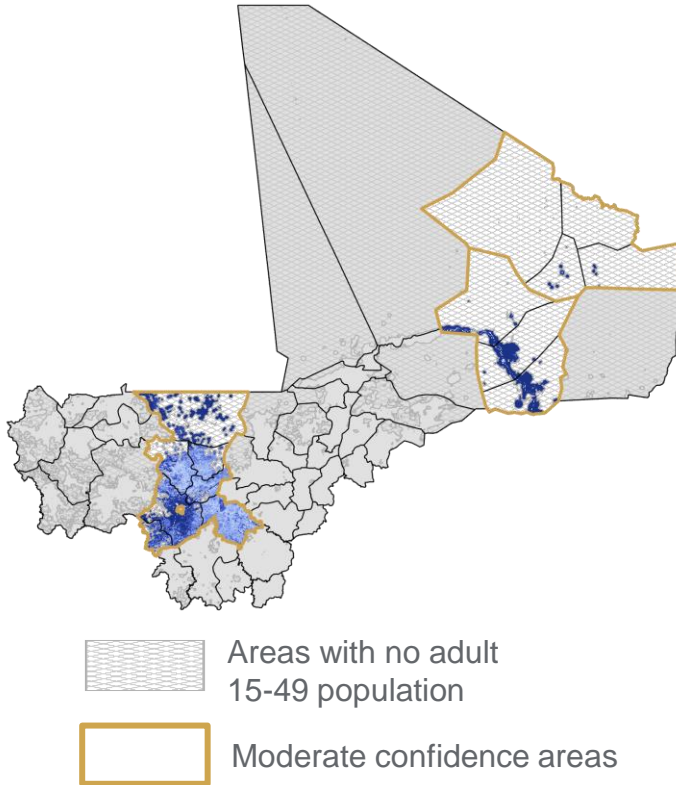
Proportion of adults 15-49 who are high complacency, moderate convenience[1]
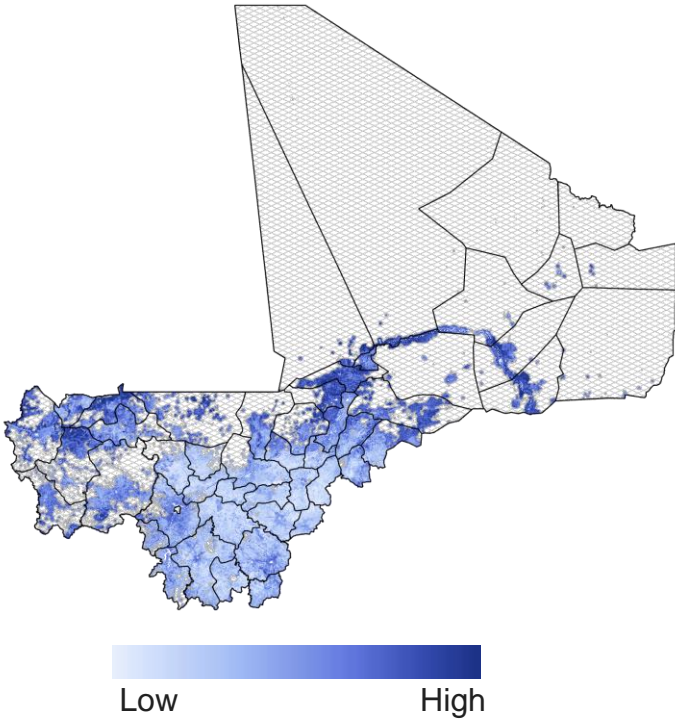
Moderate confidence areas on the state-level confidence index[2]
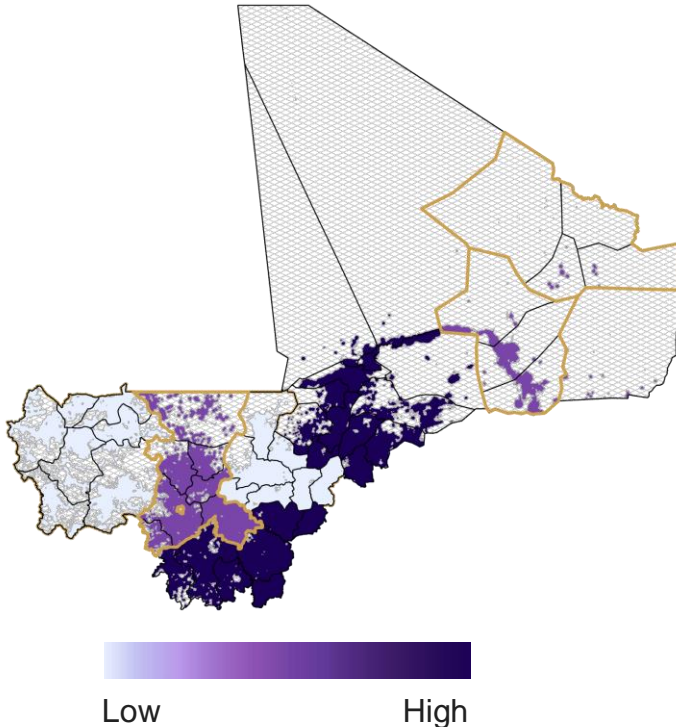
Proportion of adults 15-49 who are vaccine ambivalents

Low   High

Low   High

Areas with no adult 15-49 population

Moderate confidence areas

Note 1: High complacency adults are adults who are in the third tercile of the complacency index, and moderate convenience in the second tercile of the convenience index.
Note 2: Moderate government confidence areas are those that fall into the second tercile of the state-level confidence index. Areas that are not moderate confidence were made transparent.
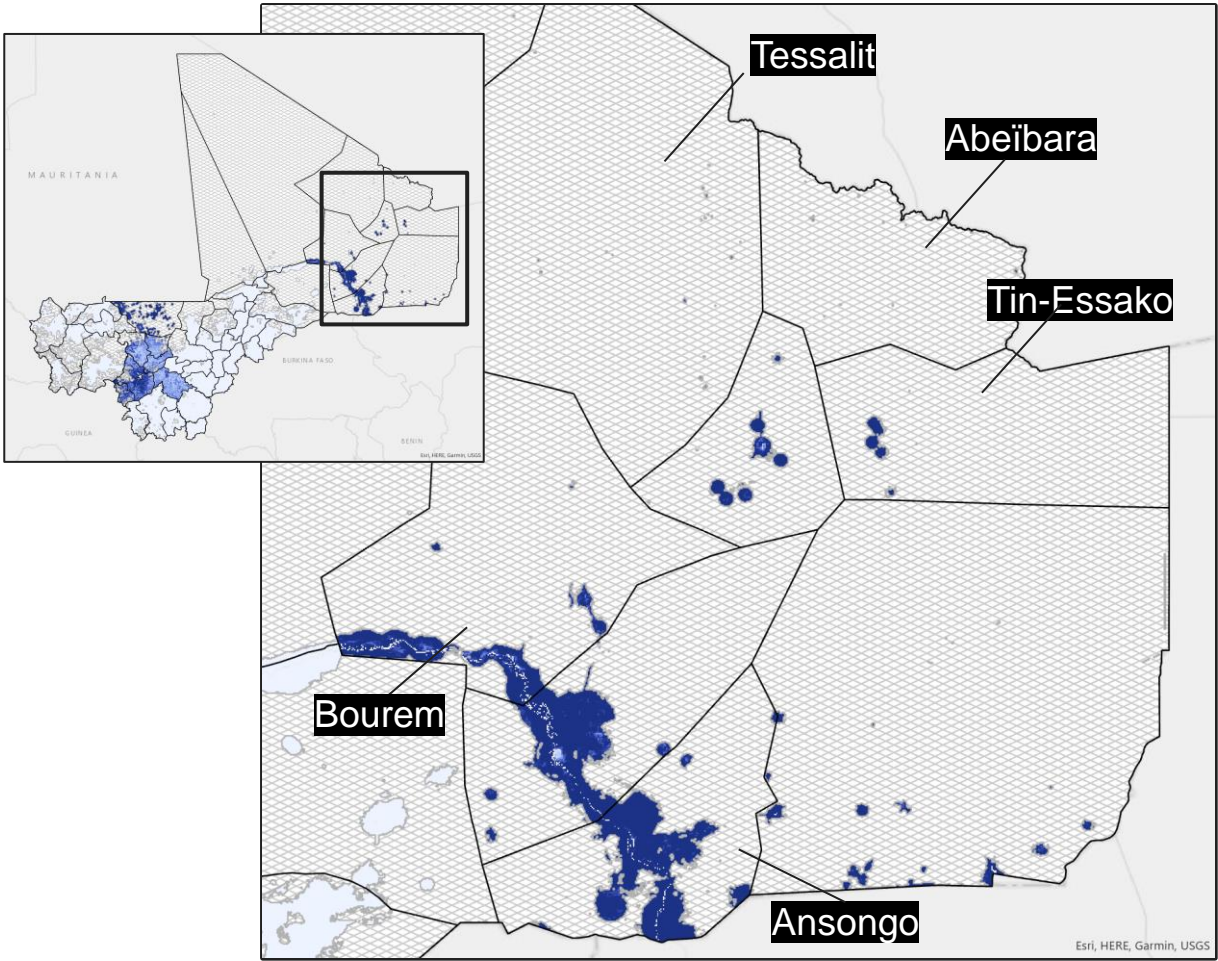**Source**: 2018 Mali DHS, 2019 Mali Afrobarometer, Fraym

Top Districts: Vaccine Ambivalents

Fraym calculated the percentage of vaccine ambivalents and aggregated them to the cercle level to identify the areas most in need *and* least likely to receive vaccines.[1]

Proportion of vaccine ambivalents

DATA*fraym*® allows users to target priority populations depending on specific programming needs. Fraym first identified the number of adults in a cercle, then found the proportion of high complacency adults. Of these high complacency adults, Fraym identified vaccine ambivalents who have moderate levels of convenience and confidence.
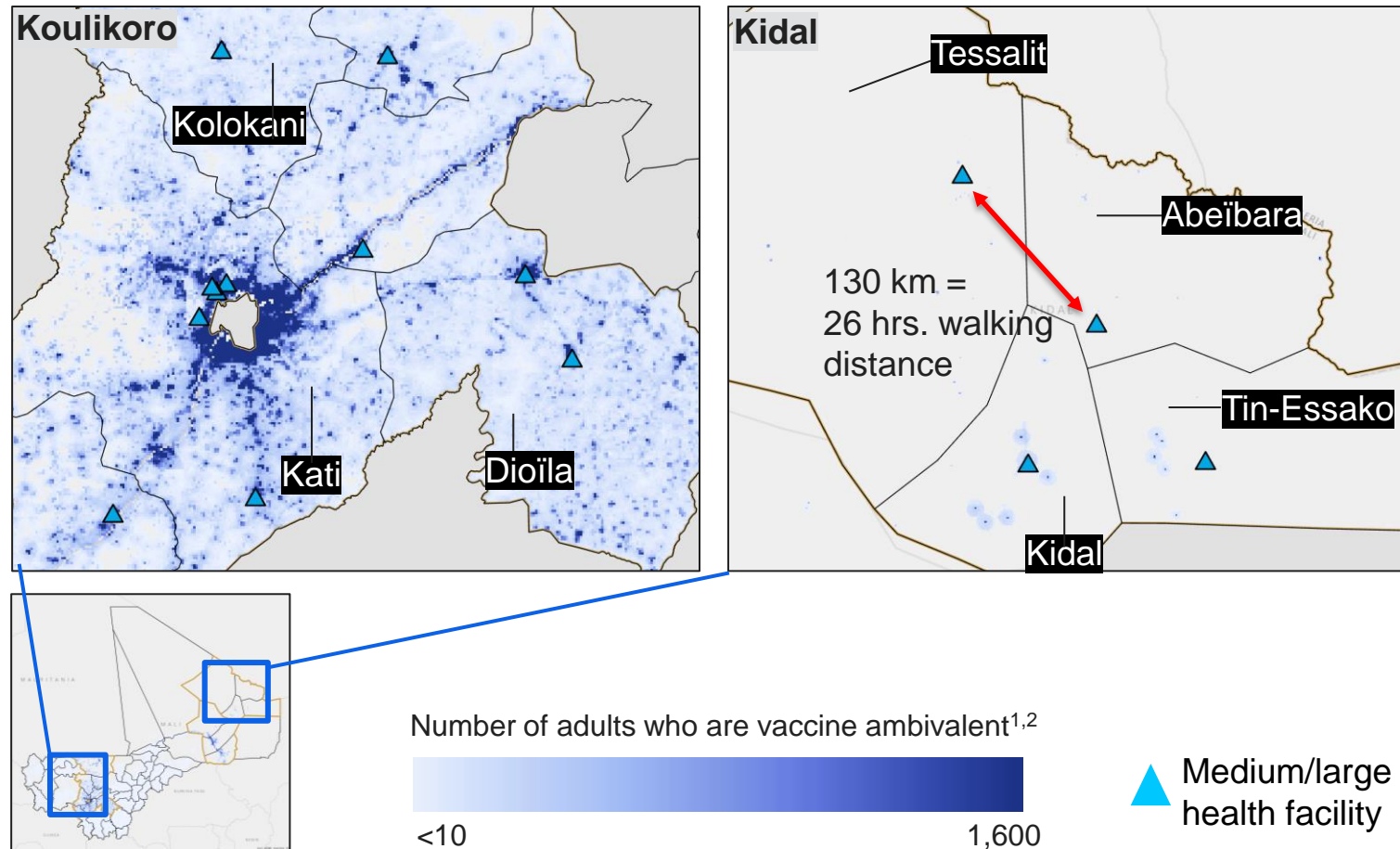
Rank (by % of vaccine ambivalents)	Region	Cercle	Adult 15-49 population	High complacency (%)	Vaccine Ambivalents (%)	Vaccine Ambivalents (# of people)
1	Kidal	Abeïbara	600	62%	23%	150
2	Gao	Ansongo	72,000	65%	23%	16,000
3	Kidal	Tin-Essako	2000	66%	22%	500
4	Gao	Bourem	40,000	47%	21%	1000
5	Kidal	Tessalit	1000	67%	21%	200

Note 1: The proportion of vaccine ambivalents was generated for every 1km^2 grid across Mali and then aggregated to the cercle level.

Vaccine Ambivalents: Hyperlocal View

Communities with high prevalence of vaccine ambivalent adults are concentrated in the north and south and also face significant accessiblity challenges to vaccine adoption.

Zoom into Koulikoro and Kidal Regions

Koulikoro — Kolokani, Kati, Dioïla

Kidal — Tessalit, Abeïbara, Tin-Essako, Kidal

130 km = 26 hrs. walking distance

Number of adults who are vaccine ambivalent[1,2]

<10   1,600

▲ Medium/large health facility

There are an estimated **246,000** vaccine ambivalents living in Mali. While higher proportions live in the sparsely populated and contentious north, larger populations of this segment live in the south.

- Rural communes in north Mali, such as in **Gao and Kidal** regions, have high rates of vaccine ambivalence. Of nearly 287,000 adults who live in these regions, **51,000 (18%)** are expected to be in this segment. Limited number of health facilities and ongoing conflict can make vaccine access even harder.

- Communes in south Mali have more vaccine ambivalent adults, despite lower prevalence. **Koulikoro** region is expected to have **192,000** adults in this segment. They are concentrated in Kati, Dioïla, and Nara Cercles.

- South Mali, such as **Koulikoro** region, can benefit from targeted outreach via **mobile phone** (92% ownership), or media campaigns via **radio** (52% listenership).

Note 1: Adults are defined as individuals aged 15-49.
Note 2: Map shows the number of adults who are high complacency and moderate convenience and are living in moderate government confidence areas.
**Source:** 2018 Mali DHS, 2019 Mali Afrobarometer, Fraym

Identifying Vaccine Sceptics

Vaccine sceptics are convinced of COVID threat, but have scepticism around vaccine safety and efficacy inhibits perceived benefit and quick uptake. Trust in the vaccine and the system that delivers it are key levers for this segment.
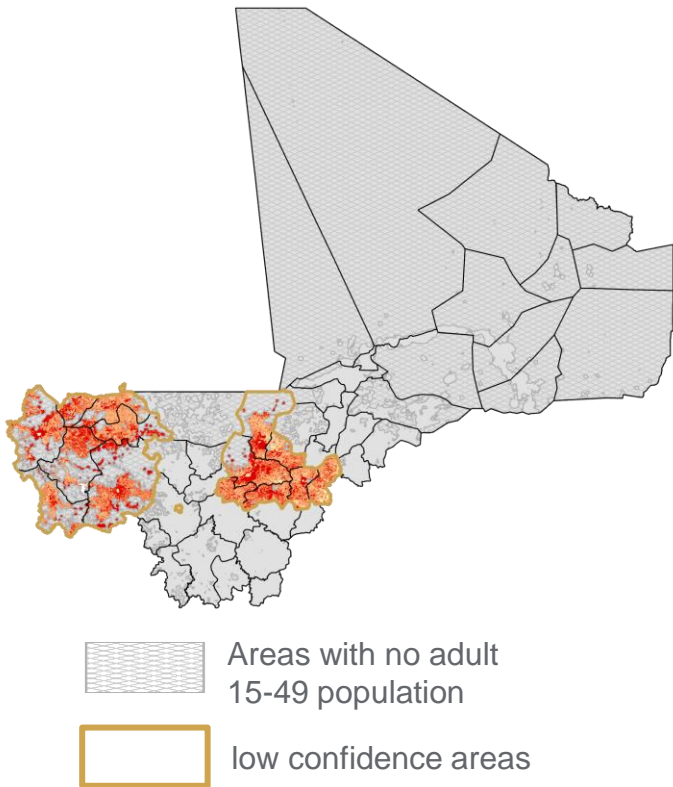
Proportion of adults 15-49 who are low complacency, moderate convenience[1]
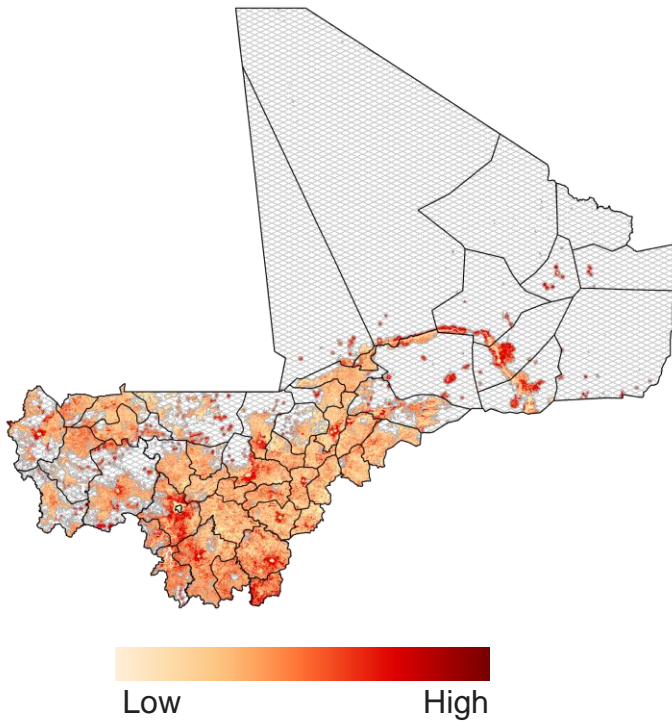
Low confidence areas on the state-level confidence index[2]
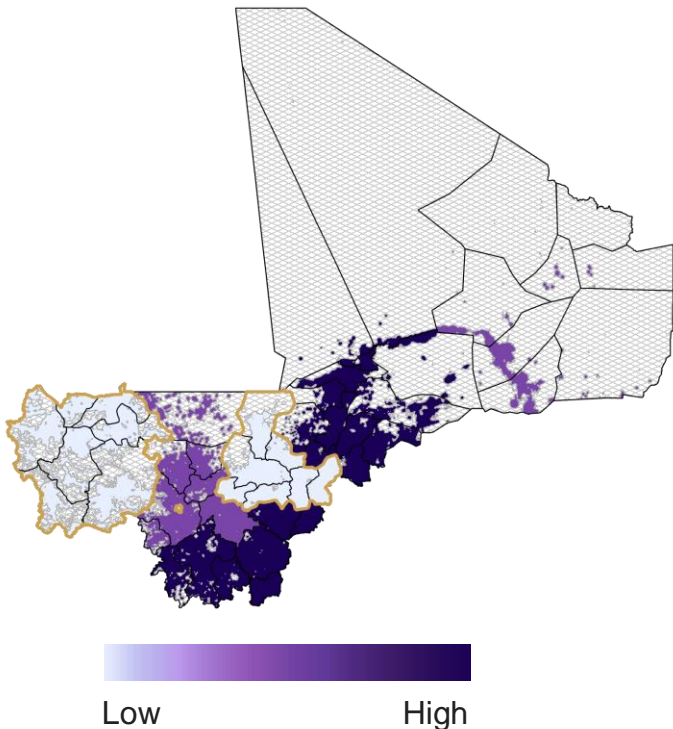
Proportion of adults 15-49 that are vaccine sceptics

Low | High

Low | High

Areas with no adult 15-49 population

low confidence areas

Note 1: low complacency adults are adults who are in the first tercile of the complacency index, and moderate convenience in the second tercile of the convenience index.
Note 2: low government confidence areas are those that fall into the first tercile of the state-level confidence index. Areas that are not low confidence were made transparent.
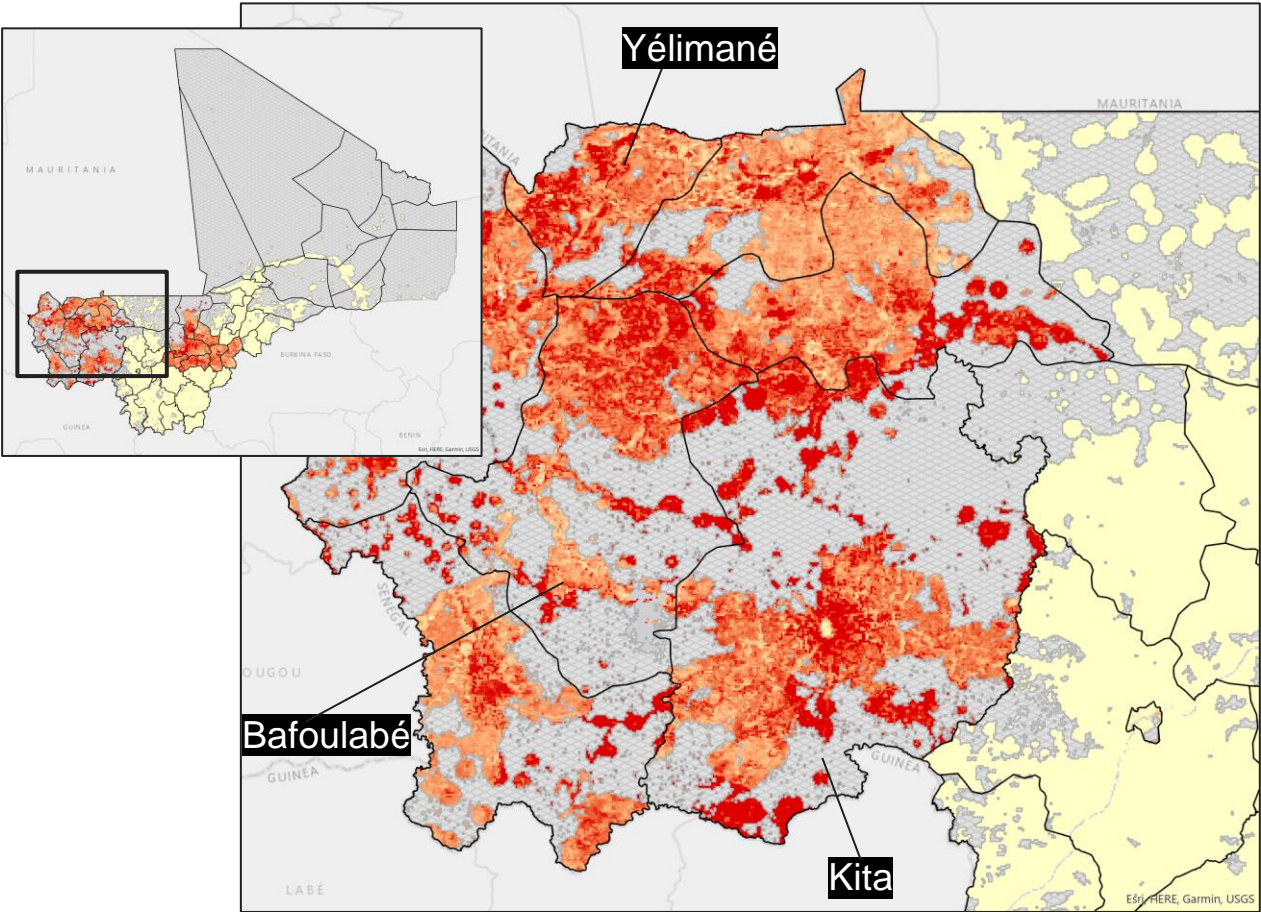**Source**: 2018 Mali DHS, 2019 Mali Afrobarometer, Fraym

Top Districts: Vaccine Sceptics

Fraym calculated the percentage of vaccine sceptics and aggregated them to the cercle level to identify the areas most in need *and* least likely to receive vaccines.[1]

Proportion of vaccine sceptics

DATA*fraym*® allows users to target priority populations depending on specific programming needs. Fraym first identified the number of adults in a cercle, then found the proportion of low complacency adults. Of these low complacency adults, Fraym identified vaccine sceptics who have moderate levels of convenience and low confidence.

Rank (by % of vaccine sceptics)	Region	Cercle	Adult 15-49 population	Low complacency (%)	Vaccine Sceptics (%)	Vaccine Sceptics (# of people)
1	Kayes	Yélimané	111,000	31%	13%	14,000
2	Ségou	Ségou	441,000	33%	13%	56,000
3	Kayes	Kita	250,000	33%	13%	31,000
4	Kayes	Bafoulabé	129,000	27%	12%	16,000
5	Ségou	Niono	246,000	23%	12%	31,000

Note 1: The proportion of vaccine sceptics was generated for every 1km^2 grid across Mali and then aggregated to the district level.

Vaccine Sceptics: Hyperlocal View

Vaccine sceptics are convinced of the COVID threat, but low confidence in the government may make vaccine outreach more challenging.

Zoom into Kita, in Kita Cercle (Kayes Region)

Number of vaccine sceptic adults[1,2]

<10   1,548

▲ Medium/large health facility
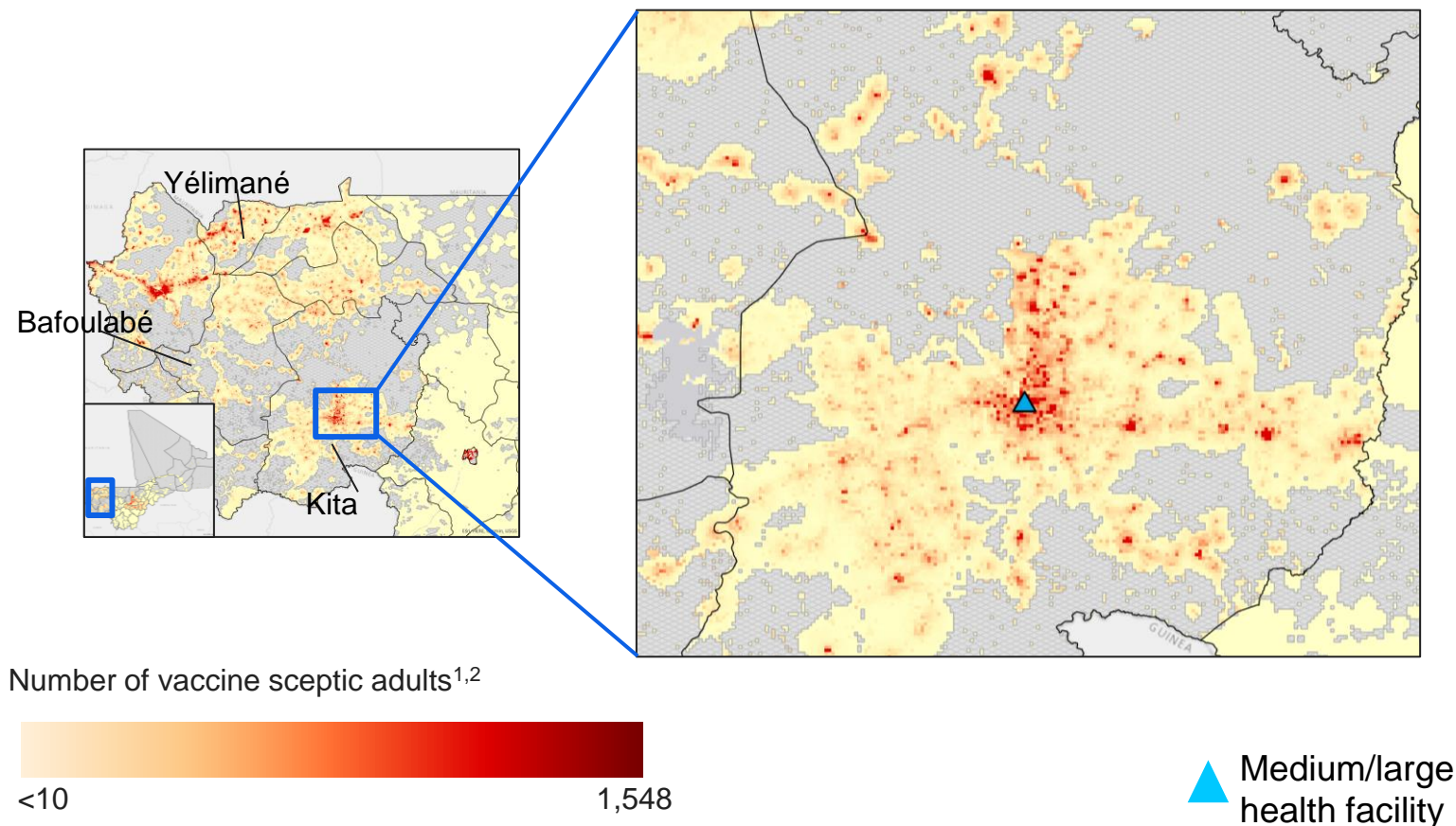
1.2 million adults live in the Kayes region, of which **139,000 (11%)** are expected to be vaccine sceptics.

- Most vaccine sceptics live in **Yélimané, Kita,** and **Yélimané** cercles. This group may take the vaccine at a slower rate given their moderate convenience and low confidence.

- There is only one medium and large health facility in each of these cercles signaling low convenience. They could benefit from **pop-up clinics** providing services to communes that are too far from established health clinics.

- Low confidence in the government pose significant challenges but nearly 95% have access to a **mobile phone** for possible media campaigns.
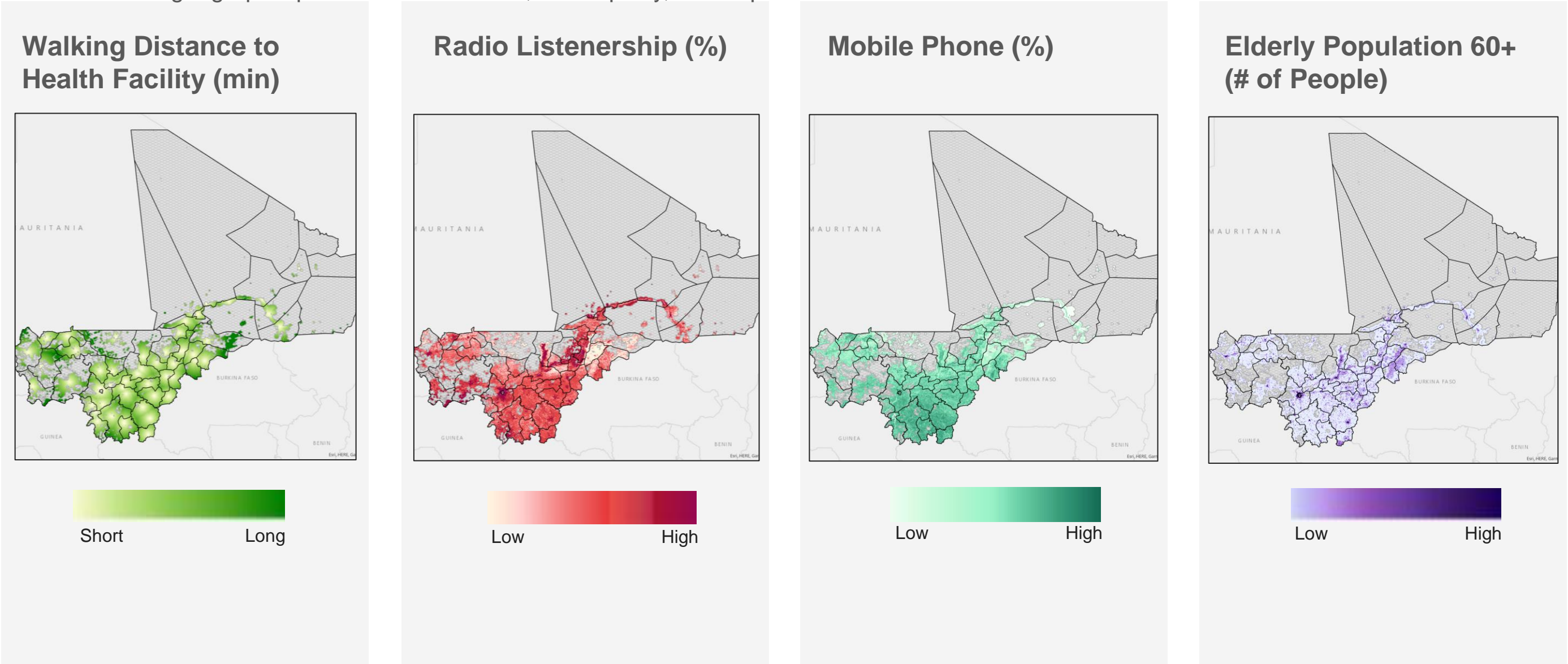
Note 1: Adults are defined as individuals aged 15-49.
Note 2: Map shows the number of adults who are low complacency and moderate convenience and are living in low government confidence areas.
Source: 2018 Mali DHS, 2019 Mali Afrobarometer, Fraym

Community-Level Context

Contextual information at the community level can help inform broad RCCE efforts. All of these data indicators are in the DATAfraym® dashboard with geographic precision at the 1km2, municipality, and department levels.

Walking Distance to Health Facility (min) — Short / Long

Radio Listenership (%) — Low / High

Mobile Phone (%) — Low / High

Elderly Population 60+ (# of People) — Low / High

Source: 2018 Mali DHS, 2020 Malaria Atlas Project

Data and Methods

Indicators for COVID-19 Vaccine Complacency

Fraym modeled COVID-19 vaccine complacency based low interactions with the health system.

Indicator	Description
Interactions with the health system: Individuals living in households with limited preventative or birth-related services.	
No previous childhood vaccination	Individual lives in a household where at least one under 5 child has not been vaccinated for polio, diphtheria, pertussis (whooping cough), and tetanus (DPT), hepatitis B, or measles.
Post-natal care	Individual lives in a household where at least one woman received a postnatal check within 2 months of giving any births in the past 0-35 months.
Family planning	Individual lives in a household where at least woman has heard of family planning at a health facility in the past 12 months.
Place of delivery	Individual lives in a household where a woman has given birth at a government hospital, government health center, or a private hospital/clinic for any births in the past 0-35 months.

Source: 2018 Mali DHS

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Indicators for COVID-19 Vaccine Convenience

Fraym modeled COVID-19 vaccine convenience with accessibility, time burden, and financial burden.

Indicator	Description
Accessibility: Geographic distance will determine how physically feasible it is to receive a vaccine. The type of health facility will determine service capacity as well as the quality of service that can be expected	
Distance to health facility (walking)	Walking time to nearest health facility using least cost distance. Travel time will determine how physically feasible it is to receive a vaccine.
Distance to health facility (driving)	Driving time to nearest health facility using least cost distance. Travel time will determine how physically feasible it is to receive a vaccine.
Car, truck, or scooter ownership	Individual lives in a household that owns a car, truck, or scooter.
Access to a mobile phone	Individual lives in a household that owns a mobile phone. If vaccine appointments are booked primarily using a smartphone or internet connection, lack of the necessary technology may make it more difficult book an appointment and receive a jab.
Time burden: Concerns about time, cost or vaccine site accessibility may deter vaccine uptake.	
Caregiving/domestic responsibilities	Individual lives in a household with a child under 5 or an adult over 60.
Time to fetch water	Individual lives in a household that must travel longer than 1 hour to fetch drinking water.
Financial burden: Lower financial resources may affect the ability to receive a vaccine, particularly if the vaccine is perceived as costly.	
Bottom wealth quintile	Individual lives in a household that is in the bottom of the DHS wealth quintile.[1]
Unemployment or agricultural employment	Individual is employed in the agriculture sector or is unemployed.

Source: 2018 Mali DHS, 2020 Malaria Atlas Project "Global maps of travel time to healthcare facilities"
Note 1: The wealth index is a composite measure of a household's cumulative living standard from the DHS survey, calculated using information on household asset ownership, housing materials, and access to water and sanitation services. The first quintile is the poorest while the fifth quintile is the wealthiest.

Indicators for Confidence in Government

Fraym created a trust in government index using state-level Afrobarometer data.

Indicator	Description
Trust towards public figures	
Trust in public institutions	Individual trusts the President, Parliament, their local government council, the ruling party, opposition parties, their traditional leaders, or religious leaders "not at all" or "just a little".
Disapproval of public figures' performance	
Disapproval of performance	Individual "strongly disapproves" or "disapproves" of the way the President, their member of Parliament, their elected local government councilor, or traditional leaders have performed their jobs over the past 12 months.

Source: 2019 Mali Afrobarometer

About Fraym

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ACQUIRE DATA
Geo-tagged household surveys
Satellite imagery
Partner datasets
Mobility data from network operators

HARMONIZE DATA
Validate
Clean
Geospatially enable

MACHINE LEARNING
Proprietary algorithms
Human-centric QA/QC
Automation

GEOSPATIAL INSIGHT
Predictive modeling
API enabled
Analytic services
Front-end tools

Thank you.

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