

# Analysis of spatial patterns of multiple malnutrition types in West Africa:

## four country case studies

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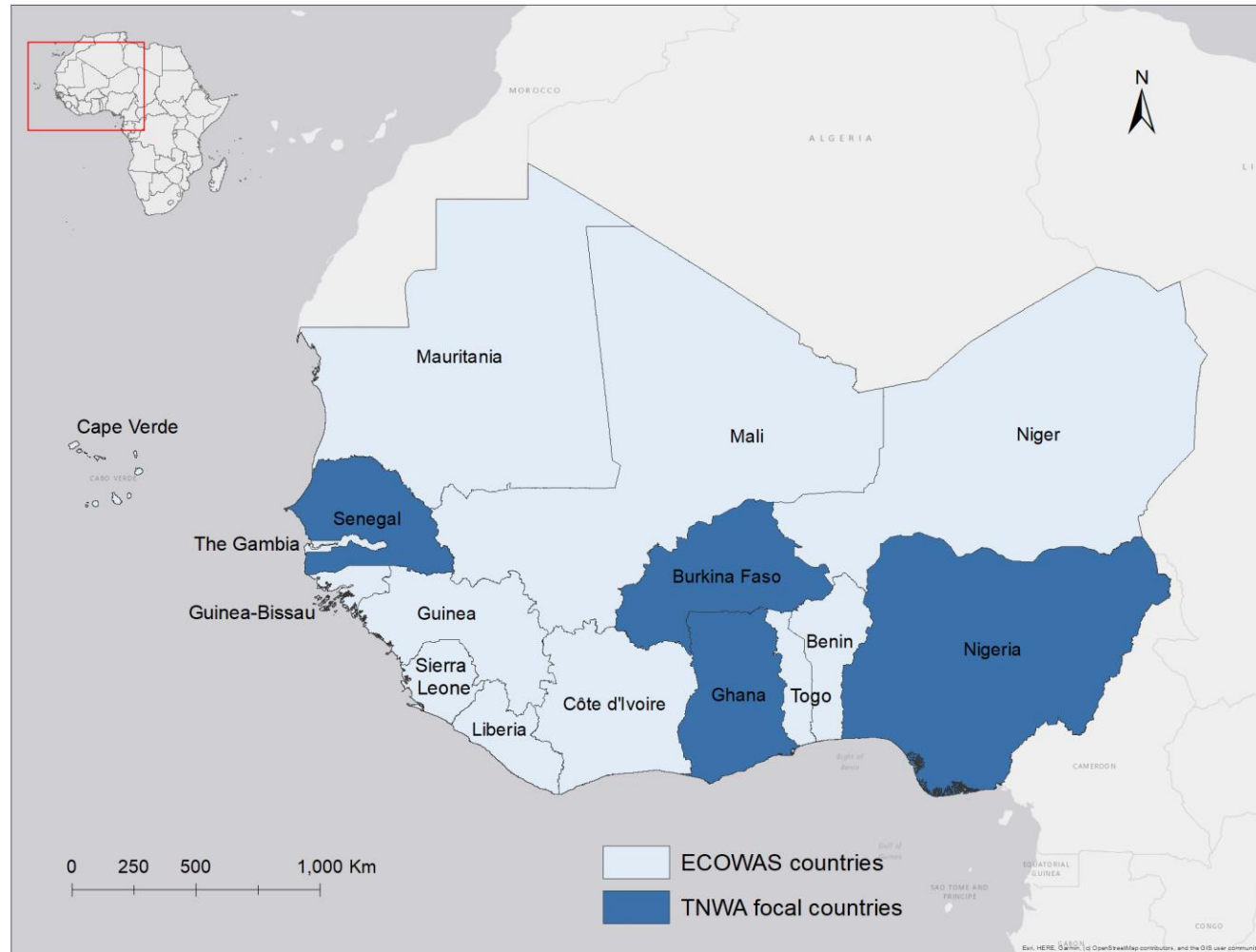
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# Overview

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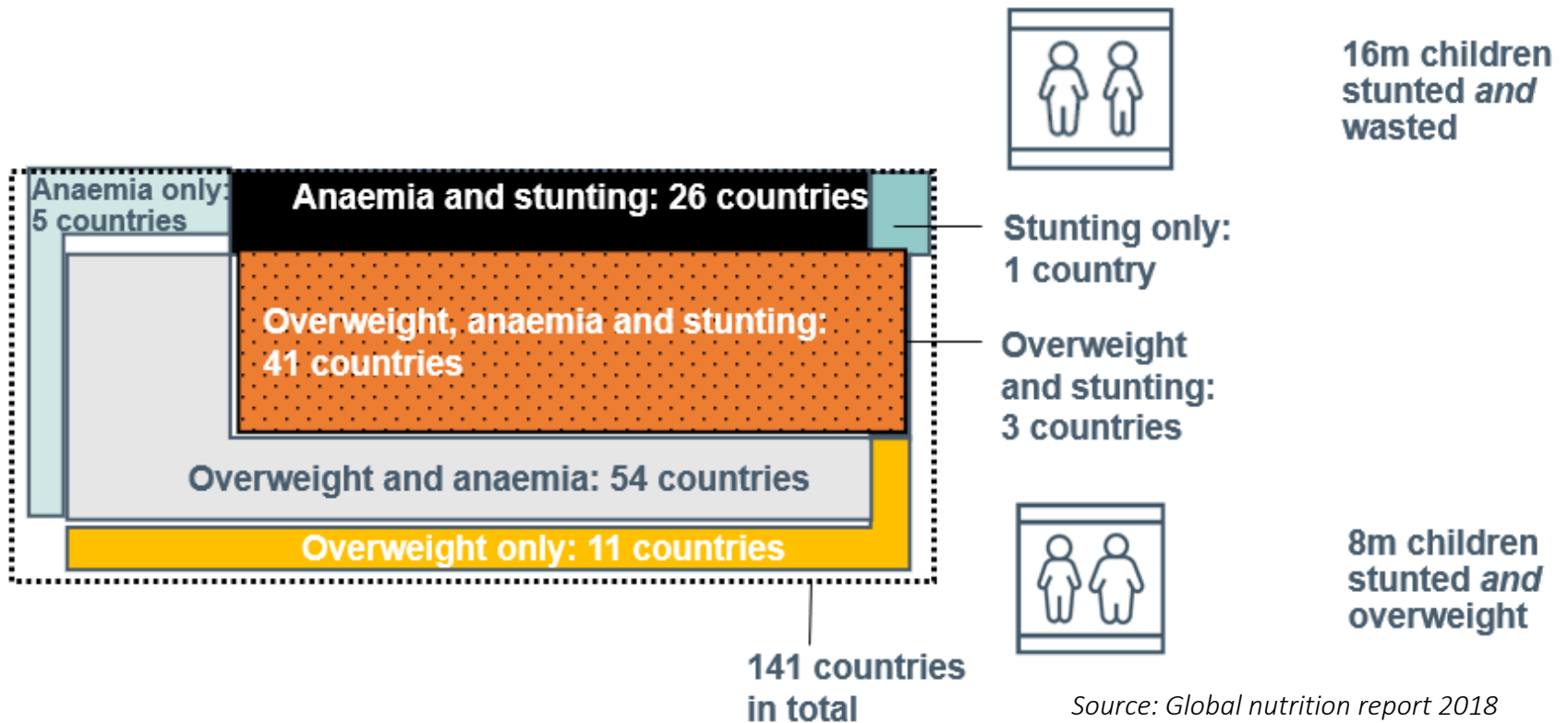


# 1 – Background

# The “new nutrition reality”: persistent high rates of undernutrition and rising rates of overweight/obesity

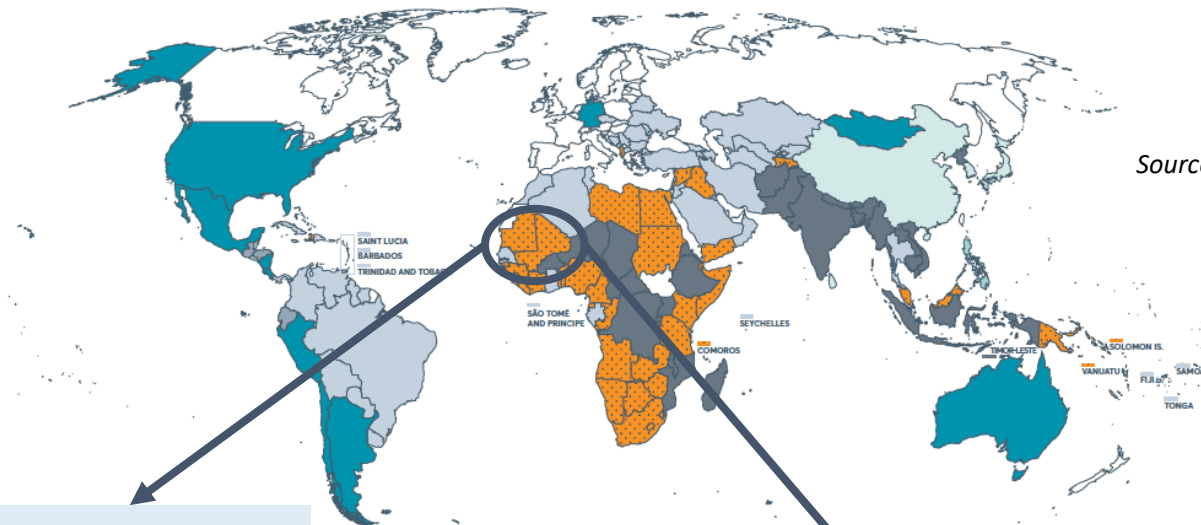
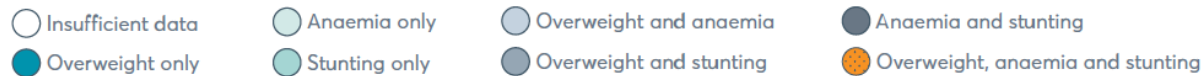


# Number of countries facing single or multiple malnutrition burdens among children



The co-existence of different types of malnutrition has become a norm: 88% of countries face overlapping burdens in their children and adult women.

Map of countries with overlapping forms of childhood stunting, anaemia and overweight in adult women, 2017 and 2018

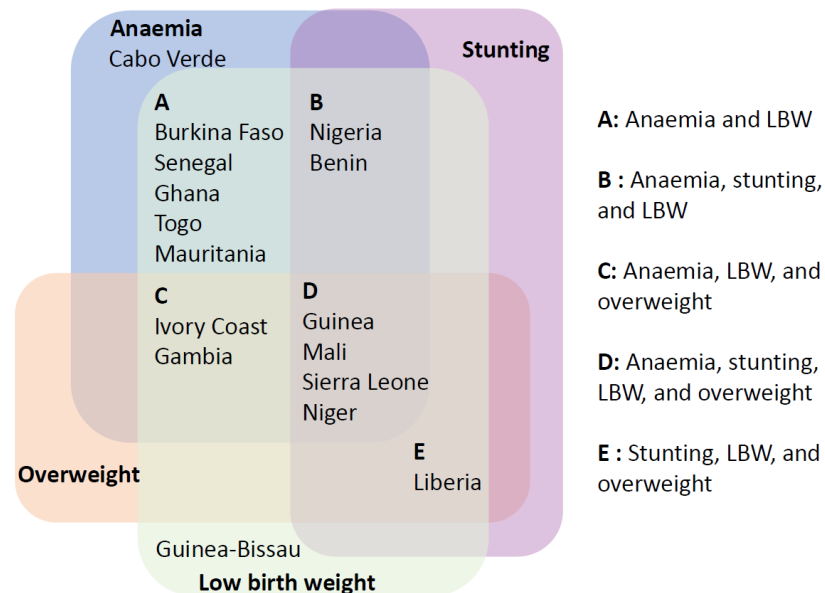


Source : Global Nutrition Report 2018

Stunting in children under five years old coexists with anemia and overweight in adult women.

Multiple burdens in children under five years of age

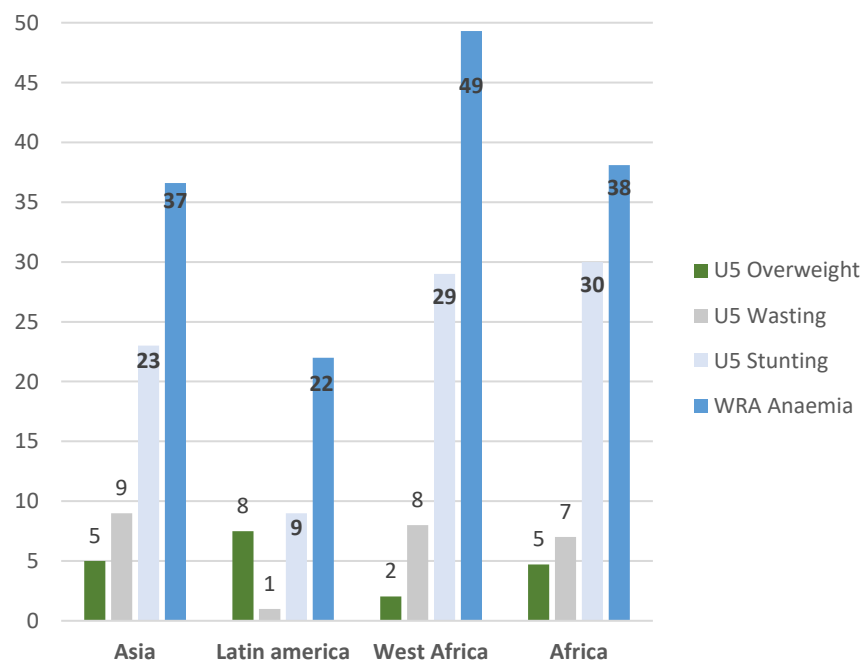
West Africa is one of several regions facing an increasing double burden of malnutrition.



Source : Transform Nutrition West Africa 2019

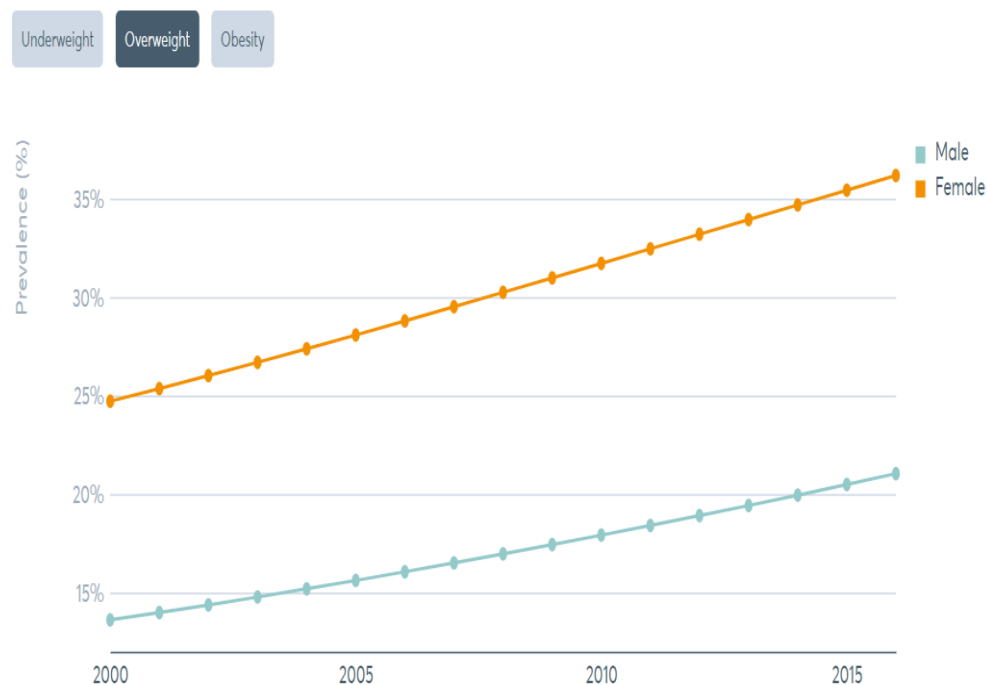
- West African countries, while still trying to tackle undernutrition, also are seeing rising rates of overweight/obesity, particularly in women of reproductive age (WRA).
- Several of these countries face a triple burden of childhood stunting with overweight and anemia in adult women, as well as multiple malnutrition burdens in children under five years of age.

### Malnutrition rates by region



Source: Transform Nutrition West Africa, inception report 2018

### Rates of overweight rates among men and women in West Africa



Source: Global nutrition report 2020

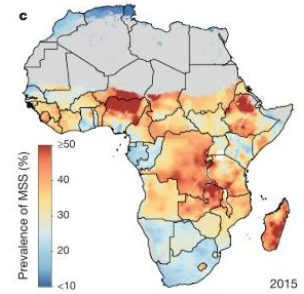
## 2 – Objectives

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# Prior research

**Prior work** that examined spatial patterns of multiple malnutrition burdens/types in sub-Saharan Africa has:

- Mapped current and expected prevalence of single malnutrition types among children under five (U5) at sub-national level in sub-Saharan Africa (*Osgood-Zimmerman et al. 2015*).
- Examined spatial correlations between overweight and anemic Women of Reproductive Age (WRA) and stunting among U5; associations between urbanicity and presence of double burden in the same individual and the same household in 30 SSA countries (*Jones et al. 2016*).
- Analyzed spatial patterns of childhood malnutrition and contextual factors in Burkina Faso (*Chuang 2019*) and Nigeria (*Gayawan 2019*)
- Examined the spatial correlation between childhood anemia and malnutrition in Burkina Faso and Mozambique (*Adeyemi 2019*)



Source: *Osgood-Zimmerman et al. 2018, Prevalence of stunting in children under five*

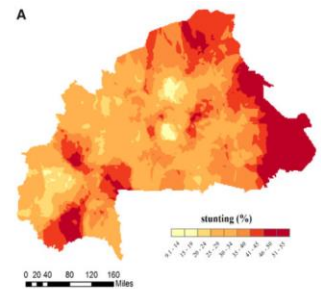


Fig. 1. (A) Stunting patterns in provinces of Burkina Faso. (I

Source: *Chuang et al. 2018. Contextual Factors and Spatial Patterns of Childhood Malnutrition in Provinces of Burkina Faso*

# Main objectives

- Improve the evidence gap on multiple malnutrition burdens in 4 West African countries: Burkina Faso, Ghana, Nigeria, Senegal
- Support policy/program development and guidance towards double duty action

## Contributions of this study

- Uses the most recent DHS surveys of 4 West African countries to ensure comparability in methods and good data quality.
- Analyzes spatial clustering of malnutrition types in 4 West African countries and examines multiple combinations of malnutrition types that occur in the same location, the same individuals and the same households (mother-child pairs).
- Identify drivers of spatial clustering of multiple malnutrition burdens to improve understanding of the spatial patterns of co-occurrence of various malnutrition types.

# 3 – Methodology

*(Analysis steps are presented only briefly here; please consult the more detailed [methodology](#) section at the end of this slide deck for more details)*

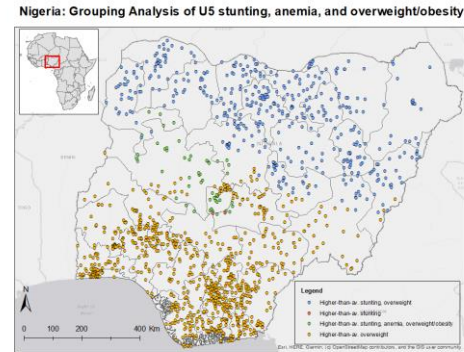
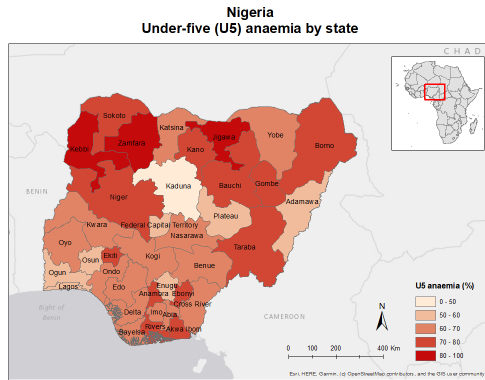
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# Methodology – *Analysis steps (1/2)*

To address the evidence gap on multiple malnutrition burdens and support policy/program development, this study examined, in Burkina Faso, Nigeria, Ghana, and Senegal:

1. Prevalence levels of different types of malnutrition in Women of Reproductive Age (WRA) and Under-Five children (U5) at national and subnational level (**Choropleth maps**)
2. Co-occurrence of multiple malnutrition types in the same locations, the same households (mother-child pairs), and within the same individuals (**Choropleth maps**)
3. Where multiple types of malnutrition cluster spatially (**hotspot analysis/spatial interpolation maps and grouping analysis**)
4. Which drivers (e.g., poverty) drive spatial clustering of co-occurrence of multiple malnutrition types (**Spatial regression analysis**)

# Methodology – Analysis steps (2/2)

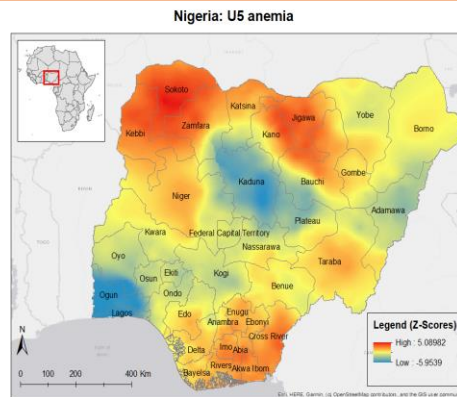


Choropleth maps

Hotspot analysis  
(results not shown)  
& Spatial  
interpolation

Grouping analysis

Spatial regression  
analysis



# Methodology – *Data and indicators used for this analysis*

Country	Survey year used	Finest geographic subdivision at which the survey is representative
Burkina Faso	2010	Region (n=13)
Ghana	2014	Region (n=10)
Nigeria	2018	State (n=37). Senatorial district (n=3) for Kano and Lagos.
Senegal	2019	Region (n=14)

Indicator	Definition
U5 stunting <sup>1</sup>	Height for age z-score (HAZ) < -2 standard deviations (SDs)
U5 anemia <sup>1,3</sup>	Haemoglobin (Hb) < 11.0 g/dL (110 g/l)
U5 overweight/obesity <sup>1</sup>	Weight-for-height z-score (WHZ) > 2 SDs
WRA thinness/underweight <sup>2,3</sup>	Body Mass Index < 18.5 kg/m <sup>2</sup>
WRA anemia <sup>2,3</sup>	Hb < 12.0 g/dL (120g/L)
WRA overweight/obesity <sup>2,3</sup>	Body Mass Index equal to or over 25 kg/m <sup>2</sup>

<sup>1</sup> U5 : Under-five years of age

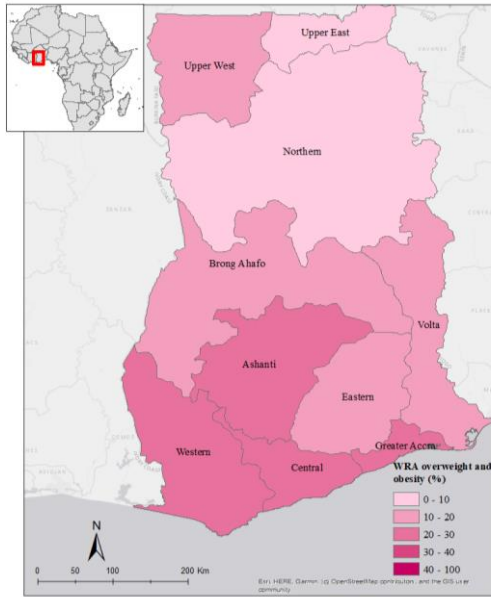
<sup>2</sup> WRA : Women of Reproductive Age

<sup>3</sup> Data on anemia in children under five years of age and WRA malnutrition not collected in Senegal's 2019 DHS

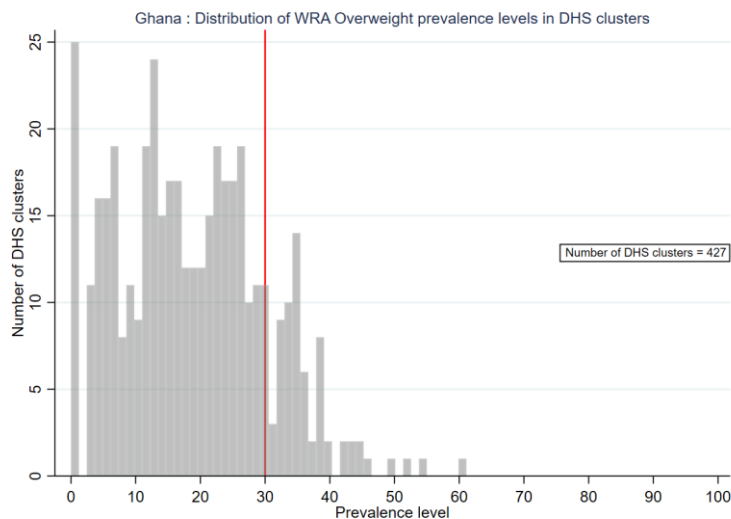
## 4 – Results

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# How to understand these results? ([methodology](#) section for details)



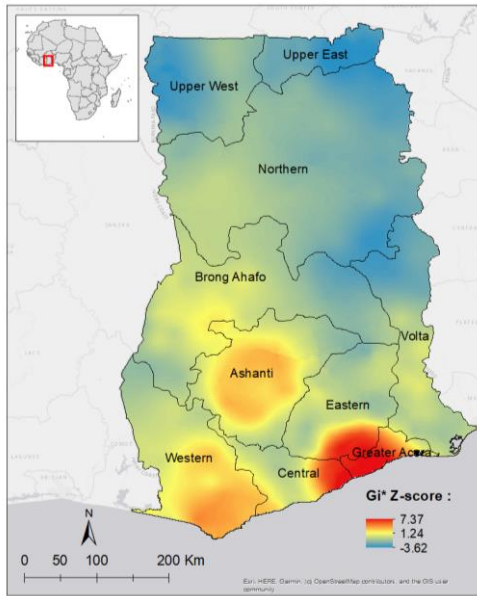
**Choropleth map:** Representation of the prevalence levels of a certain type of malnutrition using different colors. Each color represents a specific prevalence level. The legend indicates the prevalence level that corresponds to each color.



**Distribution graph:** Representation of the number of DHS clusters that have a certain level of the malnutrition type of interest. The red vertical line represents the threshold indicating a severe public health problem. This helps understand the extent of a problem and allows to see the prevalence levels in the clusters on which the hotspot analysis is based.

# How to understand these slides? ([methodology](#) section for details)

- **Hotspot:** Area with higher-than-normal prevalence level of the malnutrition problem of interest. The prevalence levels found are higher than what should be expected from a random distribution of events. These areas need particular attention.
- **Coldspot:** Area with lower-than-expected prevalence levels of the malnutrition problem of interest. Analyzing the situation in these areas could help understand how to resolve the problem in areas with higher values.



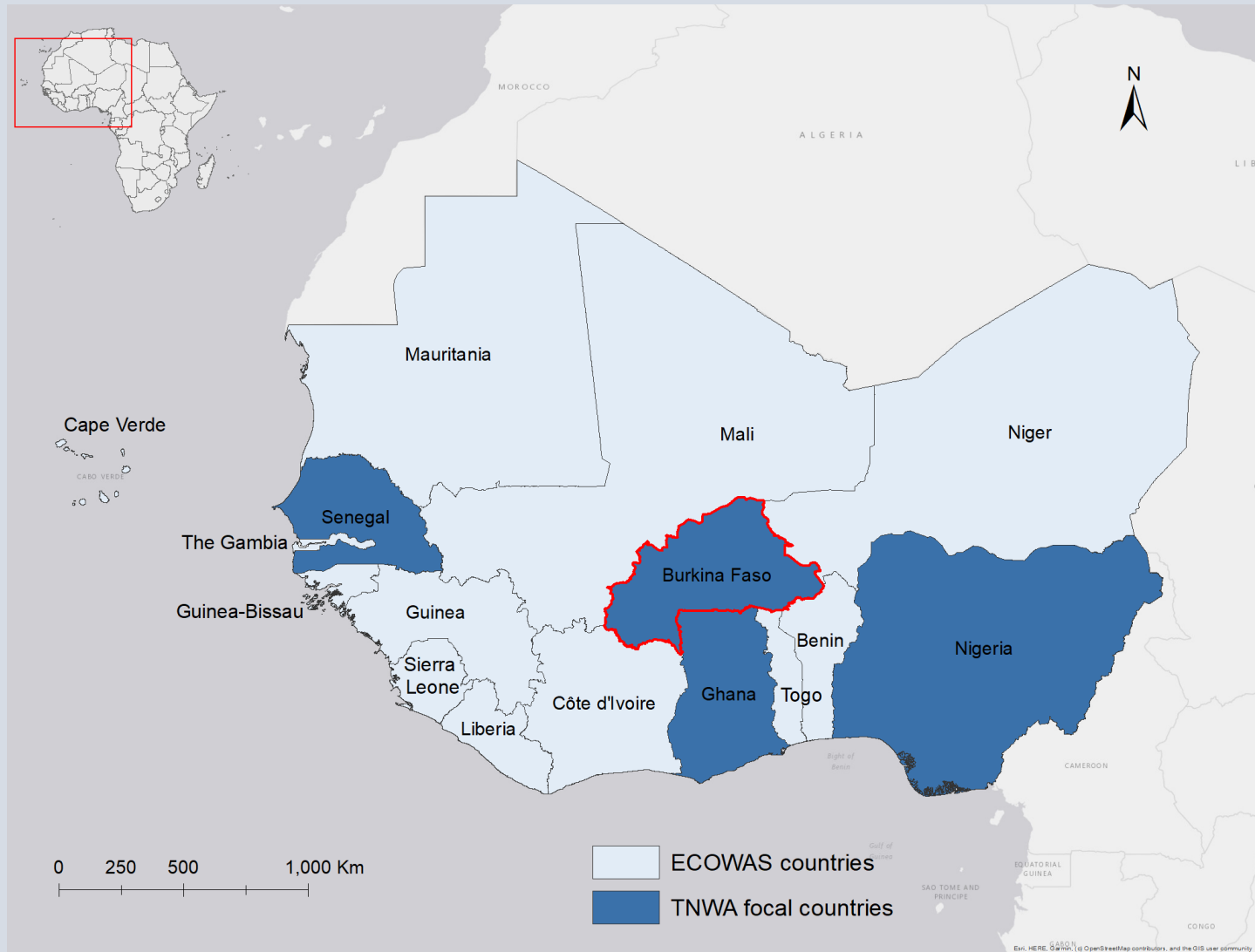
**Spatial interpolation:** These maps result from the spatial interpolation of the hotspot analysis results.

**Red areas** represent hotspots and **Blue areas** represent coldspots.

**Yellow to orange** areas represent areas in which no significant spatial clustering was found. This means that the distribution of the malnutrition in these areas is random.

- **Grouping analysis:** allows to look at how several types of malnutrition are distributed in the same area. Areas with similar prevalence levels of several types of malnutrition are grouped together, allowing to see which types of malnutrition are associated.

# Burkina Faso



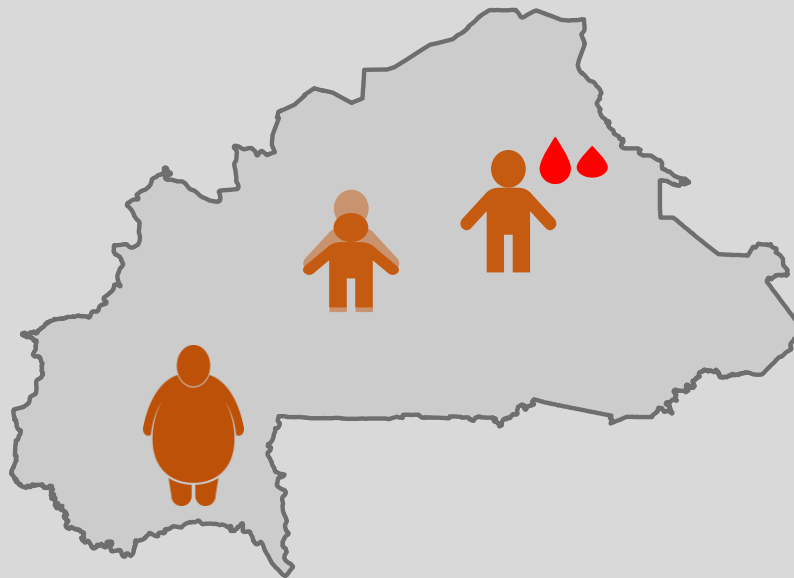
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# Results for Burkina Faso

Single malnutrition types in Children under five years of age (U5) and Women of reproductive Age (WRA)	Grouping Analysis
<ul style="list-style-type: none"> <li>• <a href="#">U5 stunting</a></li> <li>• <a href="#">U5 anemia</a></li> <li>• <a href="#">U5 overweight</a></li> <li>• <a href="#">WRA underweight/thinness</a></li> <li>• <a href="#">WRA anemia</a></li> <li>• <a href="#">WRA overweight/obesity</a></li> </ul>	<ul style="list-style-type: none"> <li>• <a href="#">Stunting, anemia and overweight among U5</a></li> <li>• <a href="#">Stunting, anemia and overweight among WRA</a></li> </ul>
Co-occurrence of different types of malnutrition in U5 and WRA	Regression Analysis
<ul style="list-style-type: none"> <li>• Within regions:               <ul style="list-style-type: none"> <li>- <a href="#">Stunting, anemia, and overweight/obesity among U5</a></li> <li>- <a href="#">Thinness, anemia, and overweight/obesity among WRA</a></li> </ul> </li> <li>• Within households (mother-child pairs):               <ul style="list-style-type: none"> <li>- <a href="#">U5 stunting &amp; WRA anemia</a></li> <li>- <a href="#">U5 anemia &amp; WRA overweight/obesity</a></li> <li>- <a href="#">U5 anemia &amp; WRA anemia</a></li> </ul> </li> <li>• Co-occurrence of multiple malnutrition types within the same individual:               <ul style="list-style-type: none"> <li>- <a href="#">Stunting and anemia (U5)</a></li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <a href="#">U5 anemia and WRA anemia</a></li> <li>• <a href="#">U5 anemia and WRA overweight/obesity</a></li> <li>• <a href="#">U5 anemia and U5 stunting</a></li> </ul>

# Single malnutrition types for U5

Stunting - Anemia - Overweight/obesity

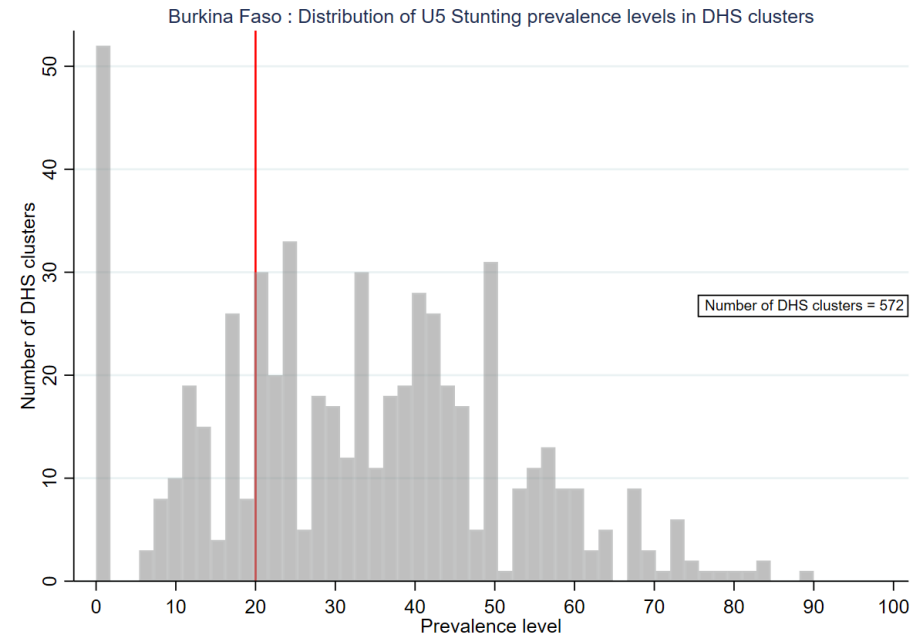


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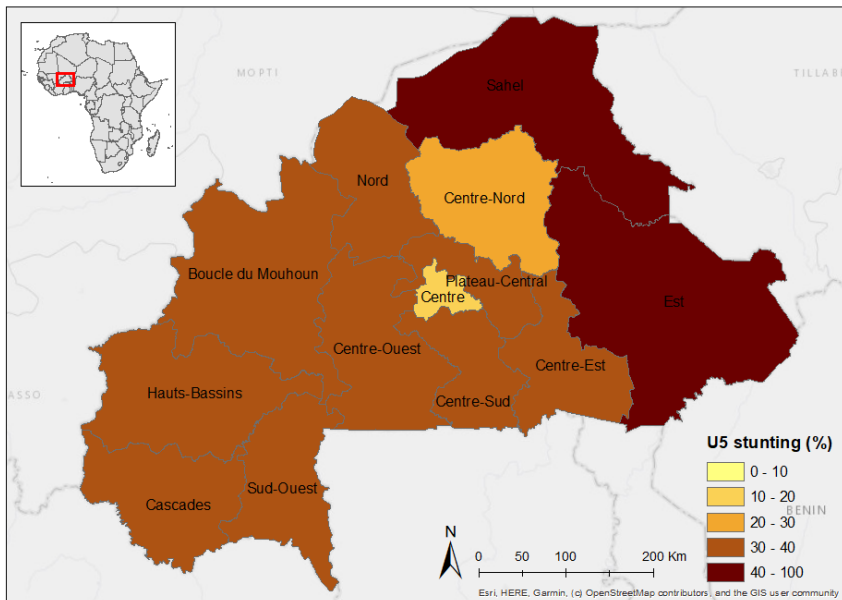


## U5 Stunting

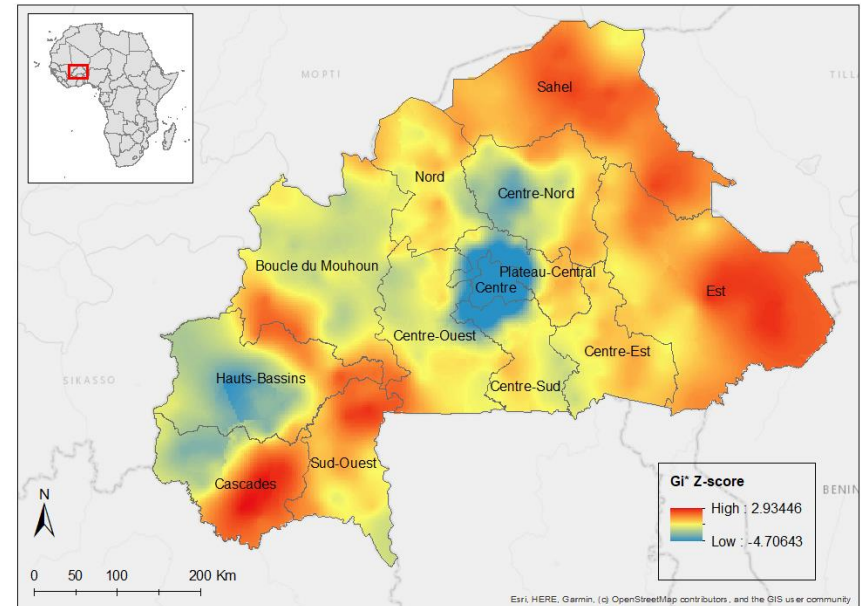
U5 stunting is over 30% in most of the country, and over 40% in Sahel and Est regions. Pronounced **hotspots** of U5 stunting are found in these two regions, as well as in Cascades and Sud-Ouest regions, and on the border of Hauts-Bassins and Boucle du Mouhoun, with **cold spots** in Centre and Centre-Nord as well as in the rest of Haute Bassins.



Burkina Faso – U5 stunting by region



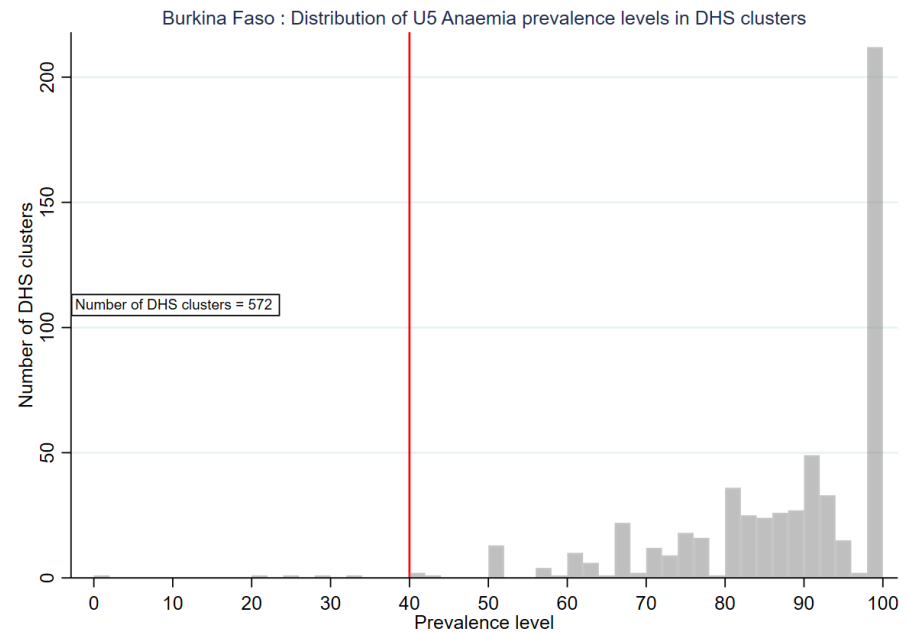
Burkina Faso – Hotspots/coldspots of U5 stunting



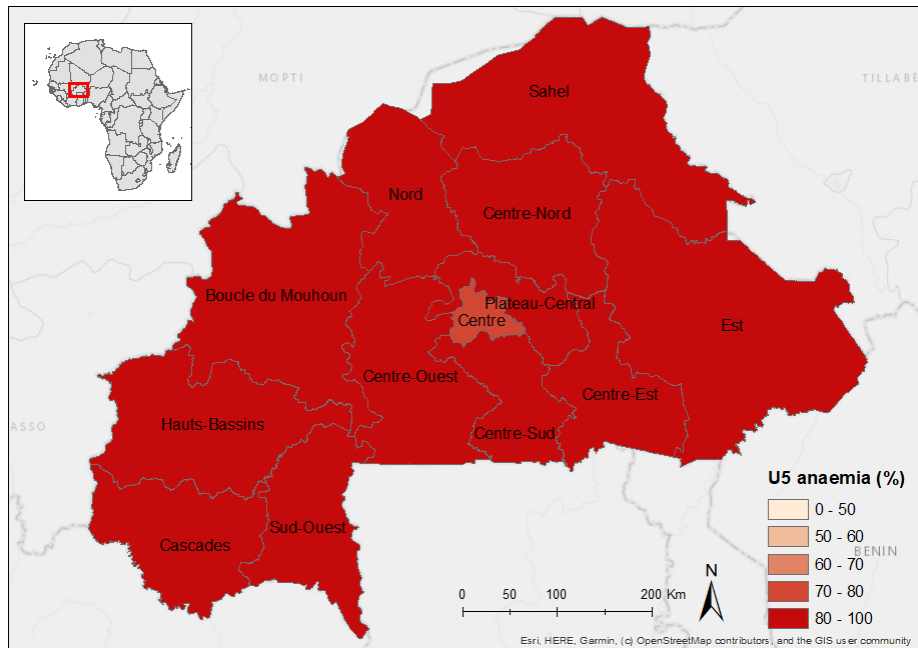


## U5 anemia

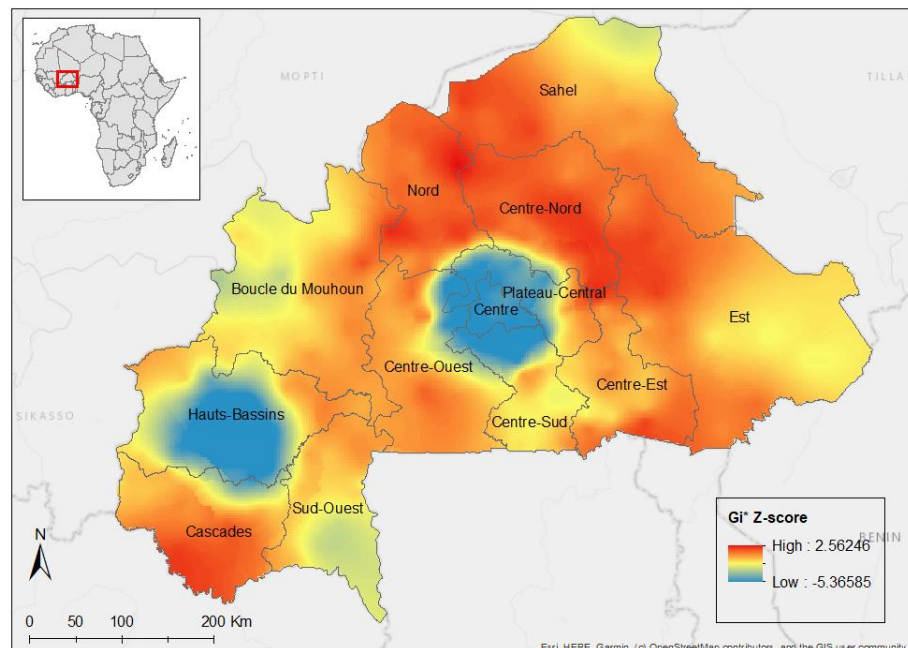
U5 anemia is very high across the country: over 80% in all regions except around the capital in Centre. The spatial interpolation reflects this but shows particular **cold spots** in Haute-Bassins and around Centre regions and **hotspots** in most of the rest of the country.



Burkina Faso – U5 anemia by region



Burkina Faso – Hotspots/coldspots of U5 anemia

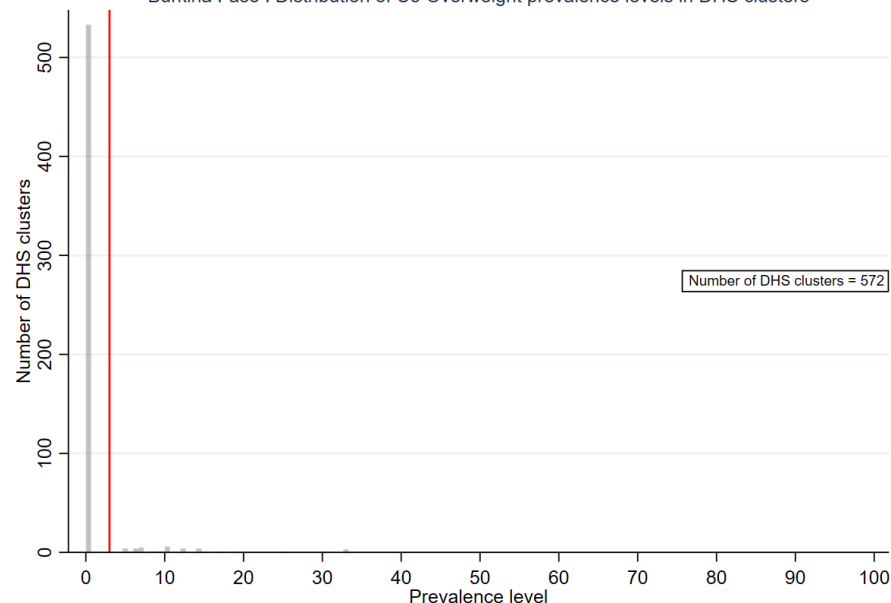




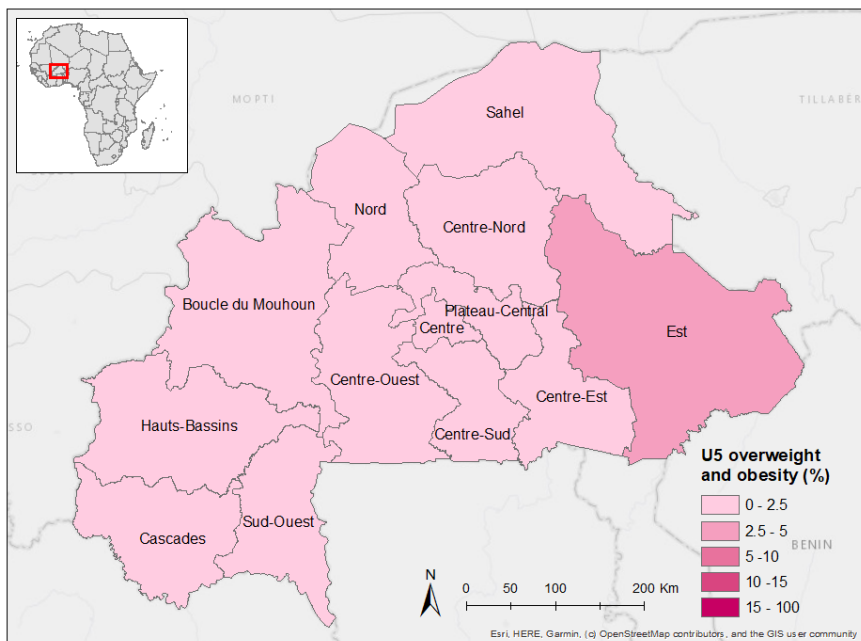
## U5 overweight/obesity

U5 overweight/obesity rates are under 2.5% in most of the country, except in Est region where rates are under 5%. The spatial interpolation reflects this, with a clear **hotspot** in Est region as well as Sud-Ouest and Cascades to a lesser extent.

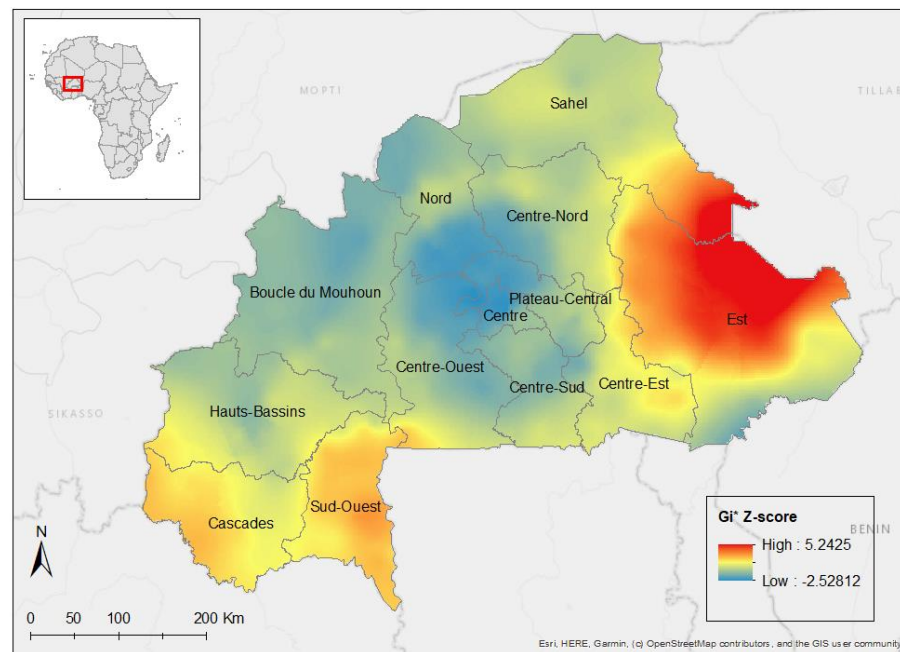
Burkina Faso : Distribution of U5 Overweight prevalence levels in DHS clusters



## Burkina Faso – U5 overweight/obesity by region

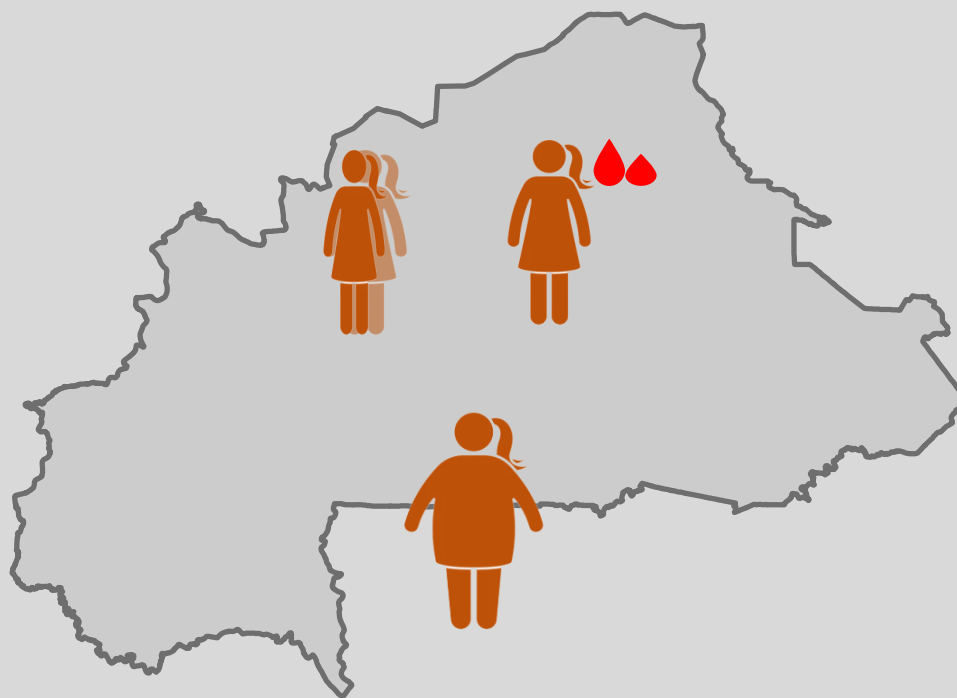


## Burkina Faso – Hotspots/coldspots of U5 overweight/obesity



## Single malnutrition types for WRA

Underweight/thinness - Anemia - Overweight/obesity

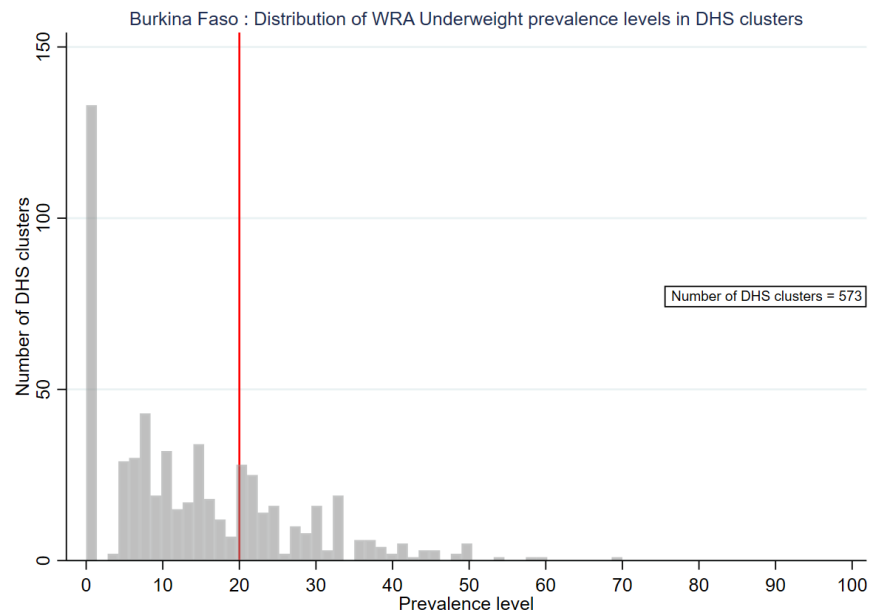


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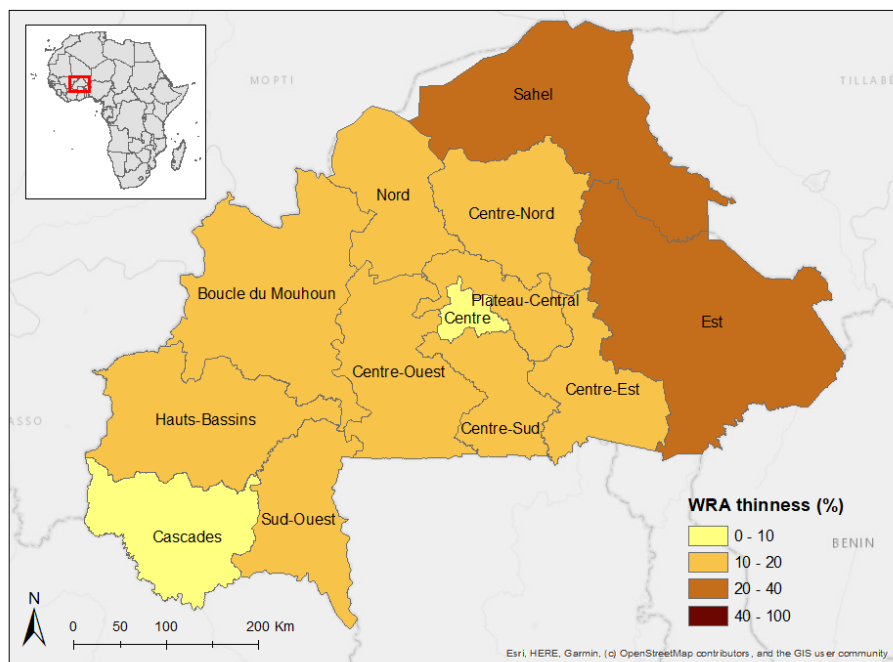


## WRA underweight/thinness

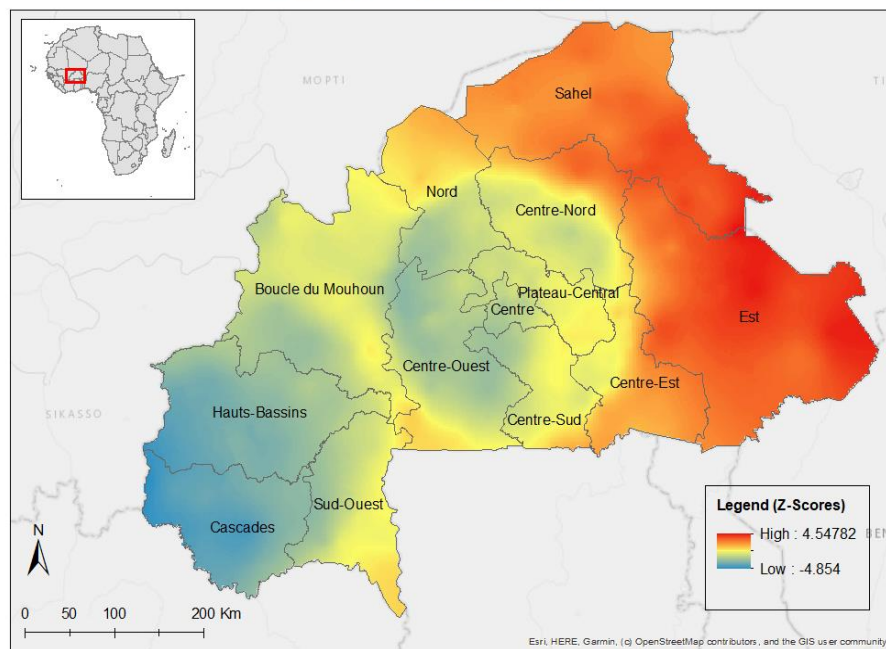
WRA thinness is 10-20% in most of the country, with rates between 30% and 40% in Sahel and Est regions. The spatial interpolation map reflects this, but shows more nuance, with **cold spots** in the southwest and center of the country.



Burkina Faso – WRA underweight/thinness by region



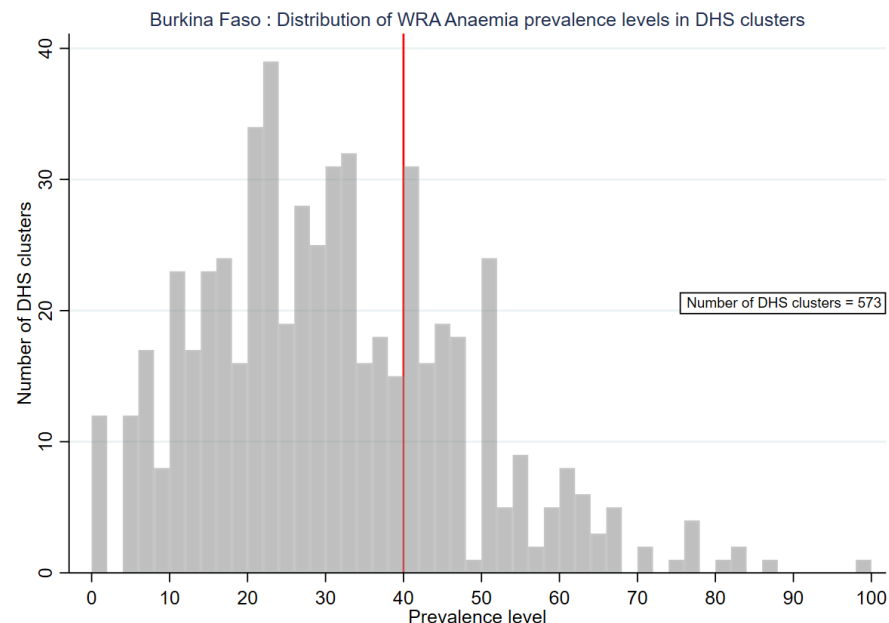
Burkina Faso – Hotspots/coldspots of WRA underweight/thinness



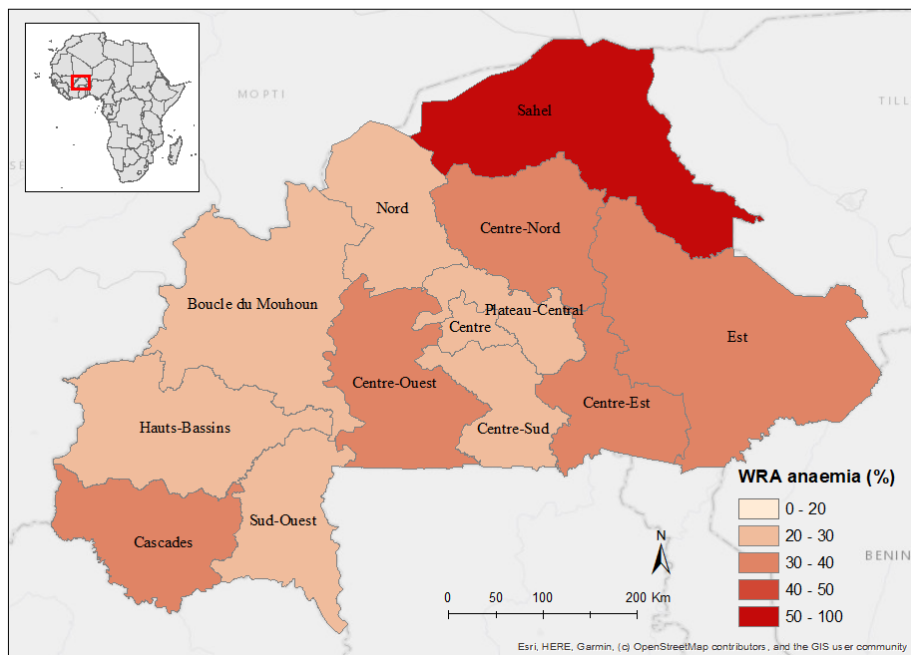


## WRA anemia

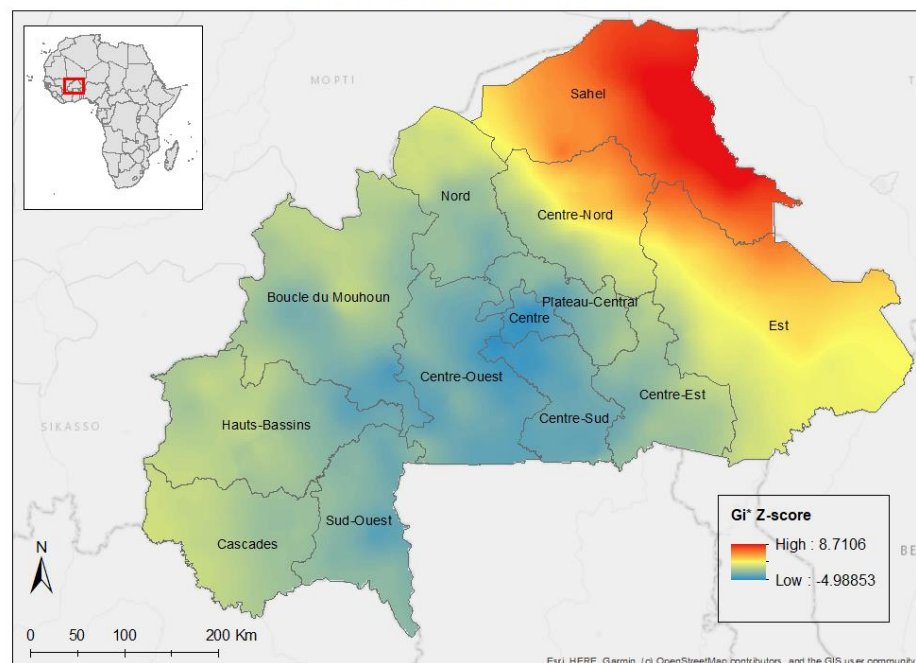
WRA anemia is particularly high in Sahel region (over 50%). This is reflected in the spatial interpolation that shows **hotspots** in this region and **cold spots** in most of the rest of the country.



Burkina Faso – WRA anemia by region



Burkina Faso – Hotspots/coldspots of WRA anemia

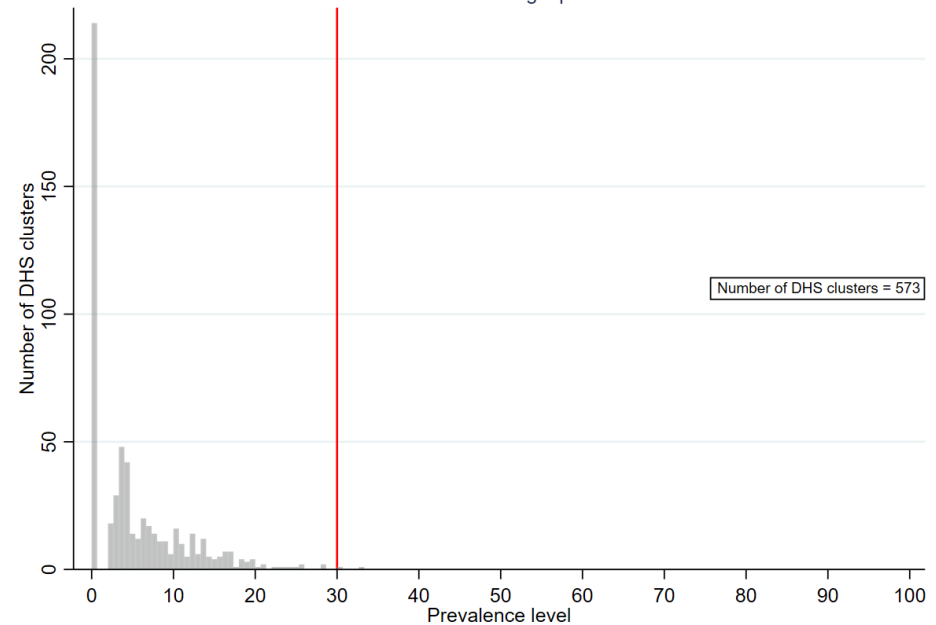




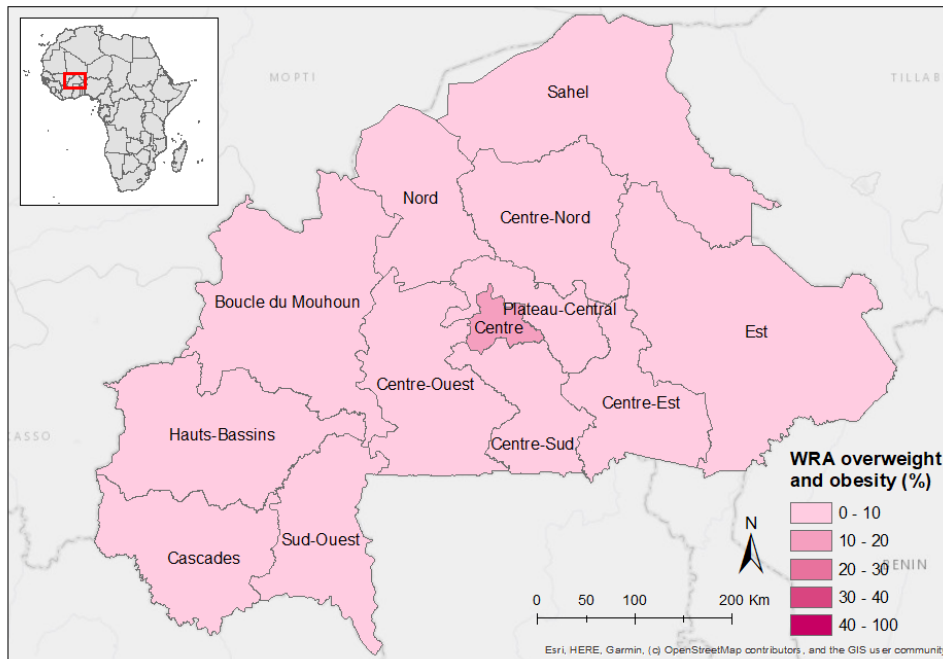
## WRA overweight/obesity

WRA overweight and obesity is under 10% in all regions except Centre, where the capital city Ouagadougou is located. There, overweight/obesity prevalence is 13%. The hotspot analysis detect two hotspots in the center and south-eastern part of the country.

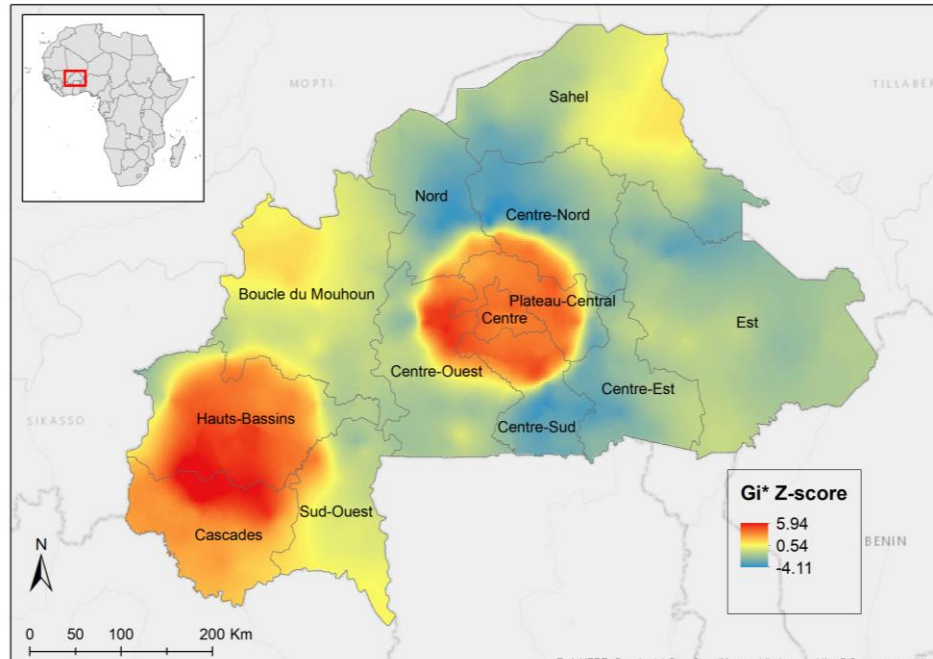
Burkina Faso : Distribution of WRA Overweight prevalence levels in DHS clusters



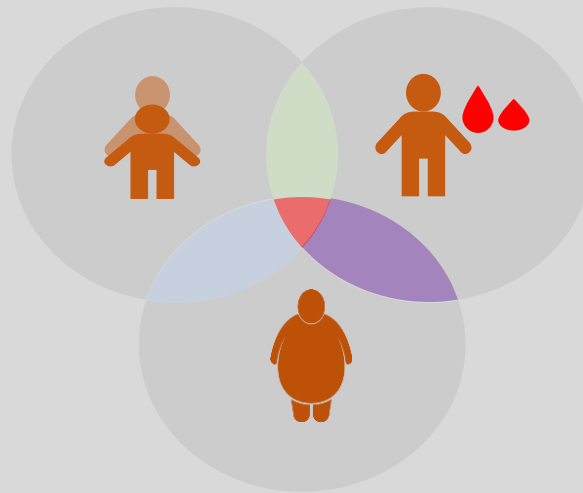
Burkina Faso – WRA overweight/obesity by region



Burkina Faso – Hotspots/coldspots of WRA overweight/obesity



# Co-occurrence of malnutrition types within the same location

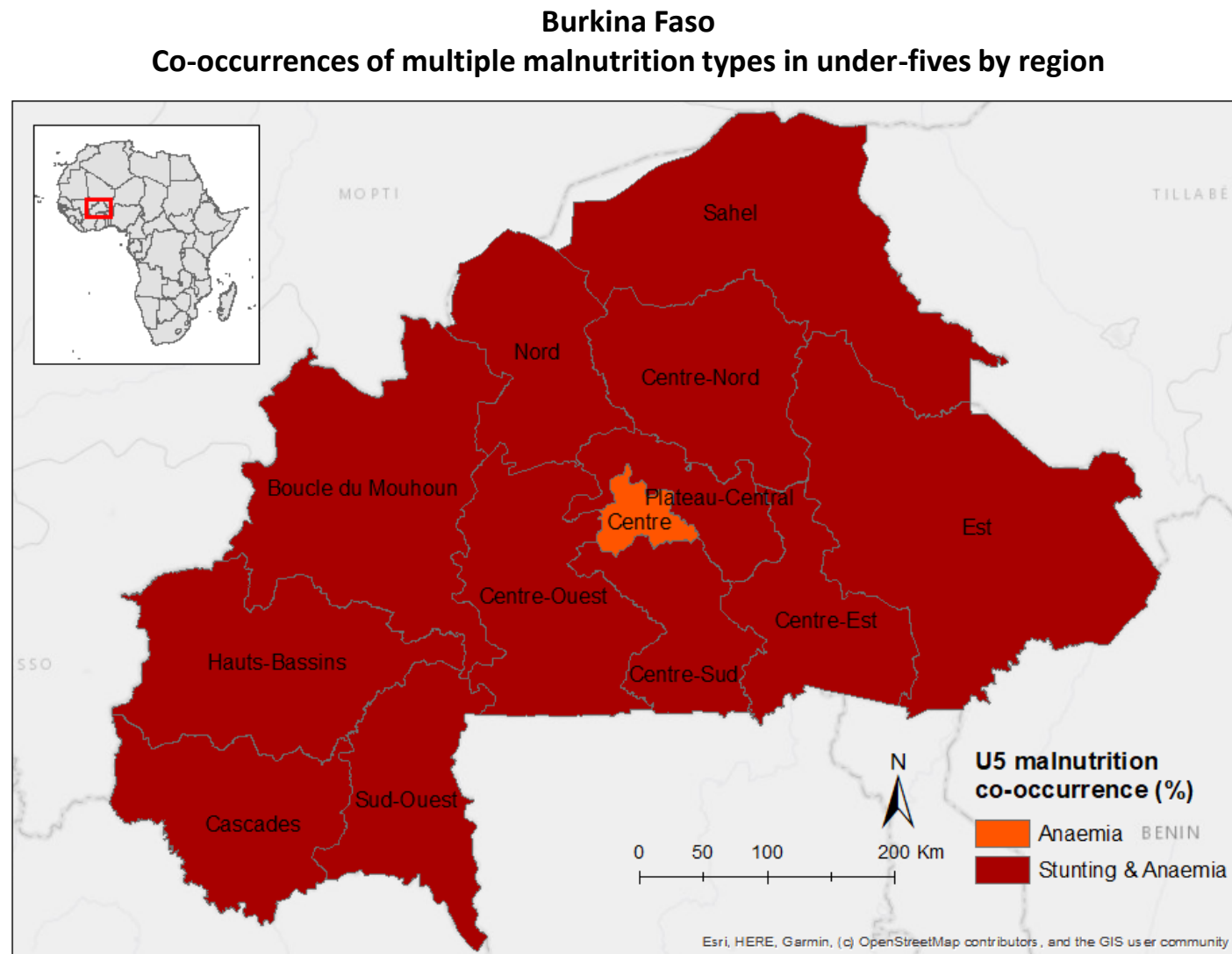


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## Co-occurrence in the same regions (U5)

U5 stunting over 20% and anemia over 40% exists in the entire country except in Centre, where only anemia rises above the threshold. There was no co-occurrence of these malnutrition types with overweight/obesity (over 30%).

**Thresholds used:** Stunting: 20% and up; Anemia: 40% and up; Overweight/obesity: 3% and up.



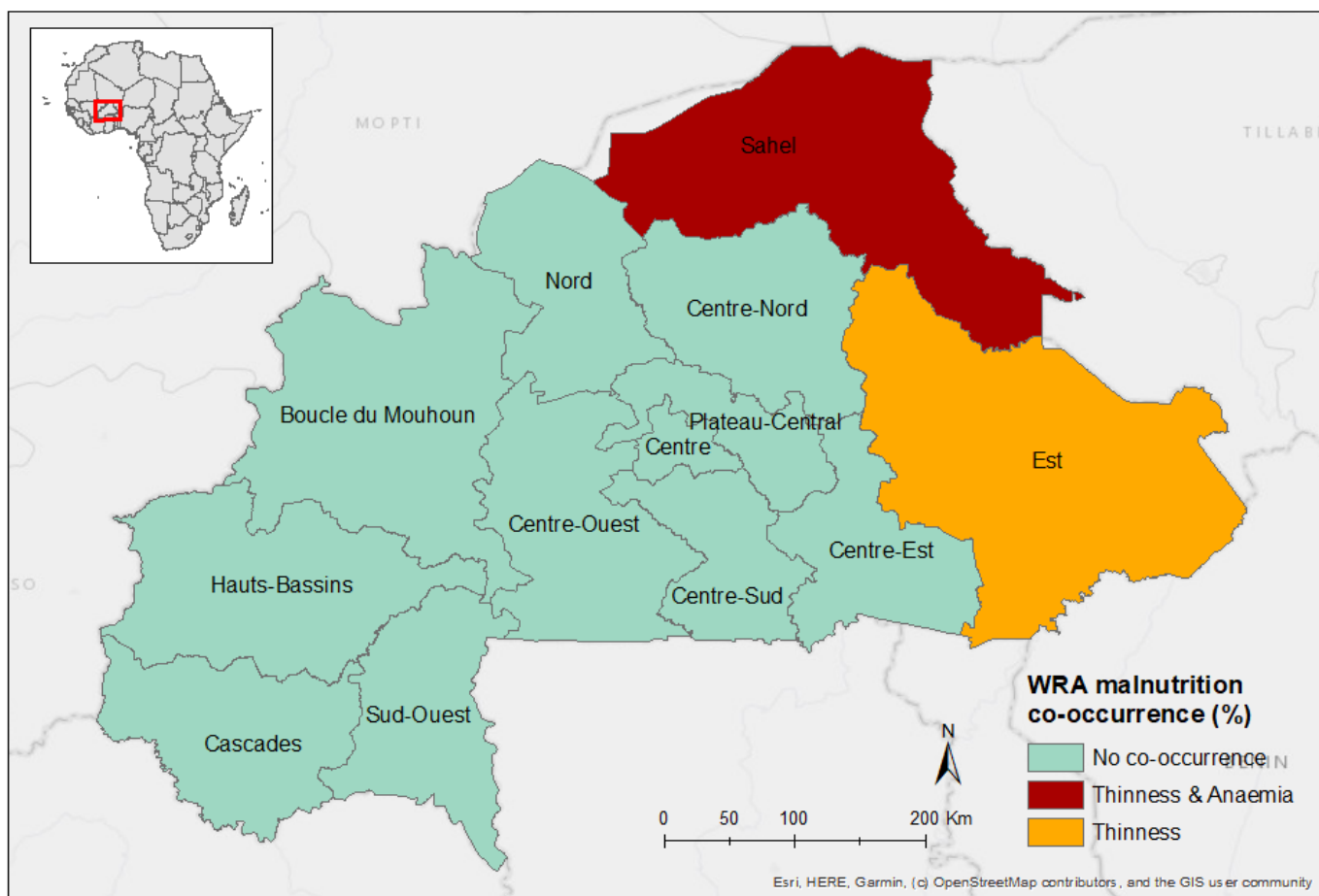
## Co-occurrence in the same regions (WRA)

WRA underweight/thinness over 20% and anemia over 20% exists in the Sahel. Est region experiences thinness over 20% but not anemia above the identified threshold, with the rest of the country still experiencing these burdens but not beyond the identified thresholds. There was no co-occurrence of these malnutrition types with overweight/obesity (above 30%).

**Thresholds used:** Thinness: 20% and up; Anemia: 20% and up; Overweight/obesity: 30% and up.

### Burkina Faso

#### Co-occurrences of multiple malnutrition types in WRA by region



## Co-occurrence of malnutrition types within the same household (mother-child pairs)



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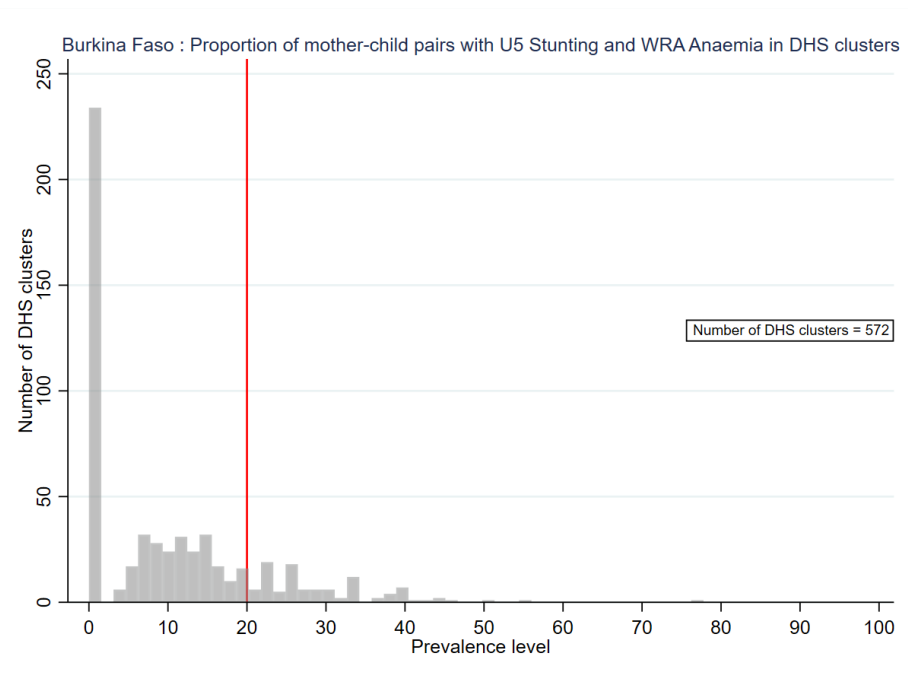
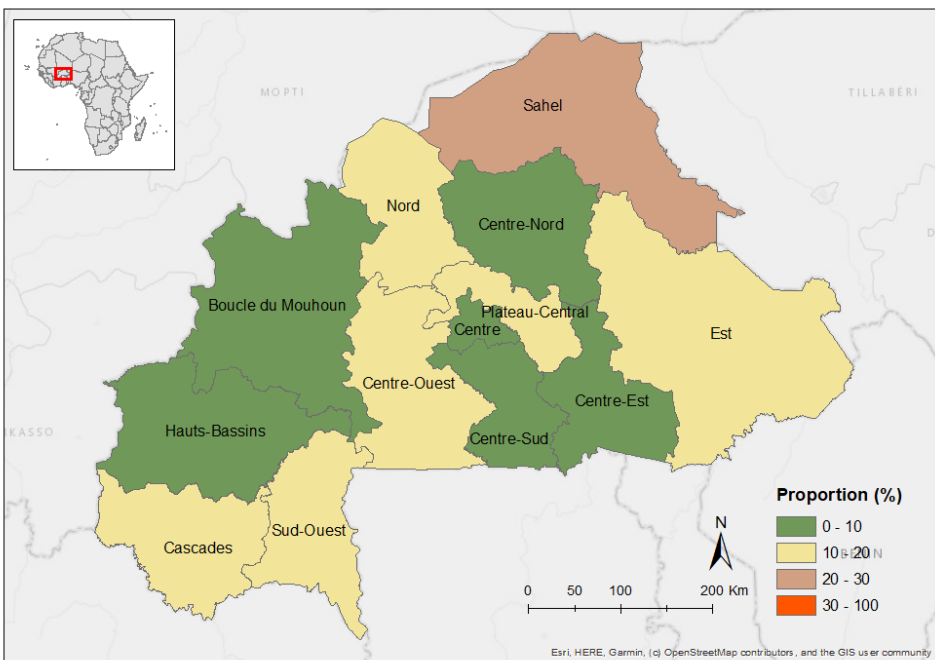
## Anemic mothers with stunted children



Anemic WRA with stunted children have the highest prevalence in Sahel region (20-30%).

However, no spatial clustering was detected for this double burden.

### Burkina Faso – Anemic mothers with stunted children by region

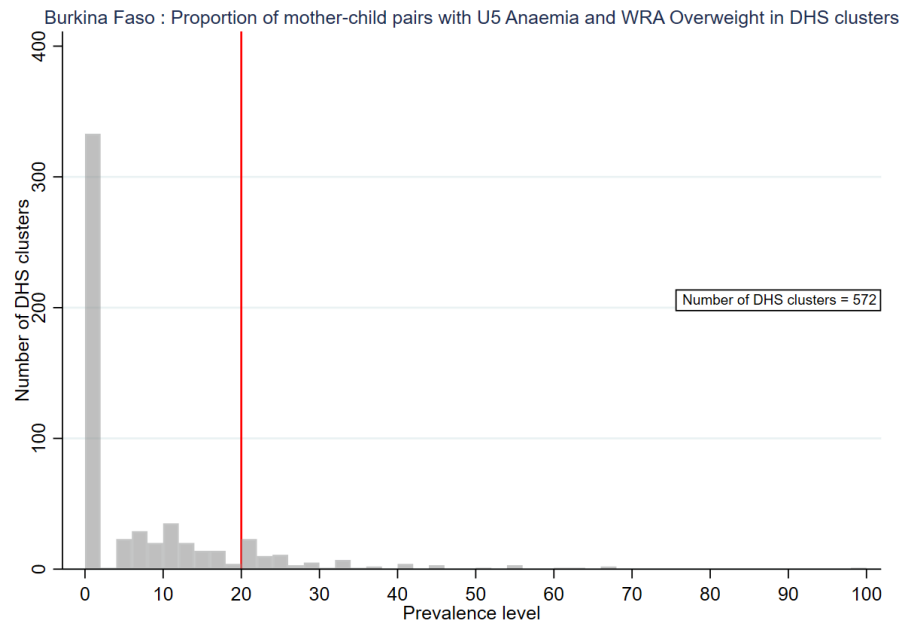




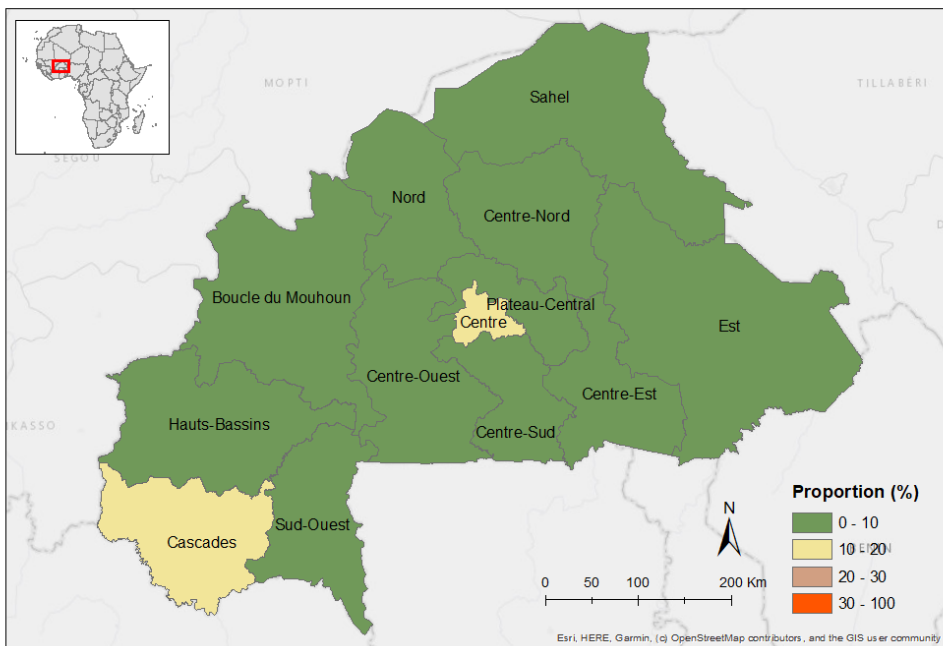
## Overweight/obese mothers with anemic children



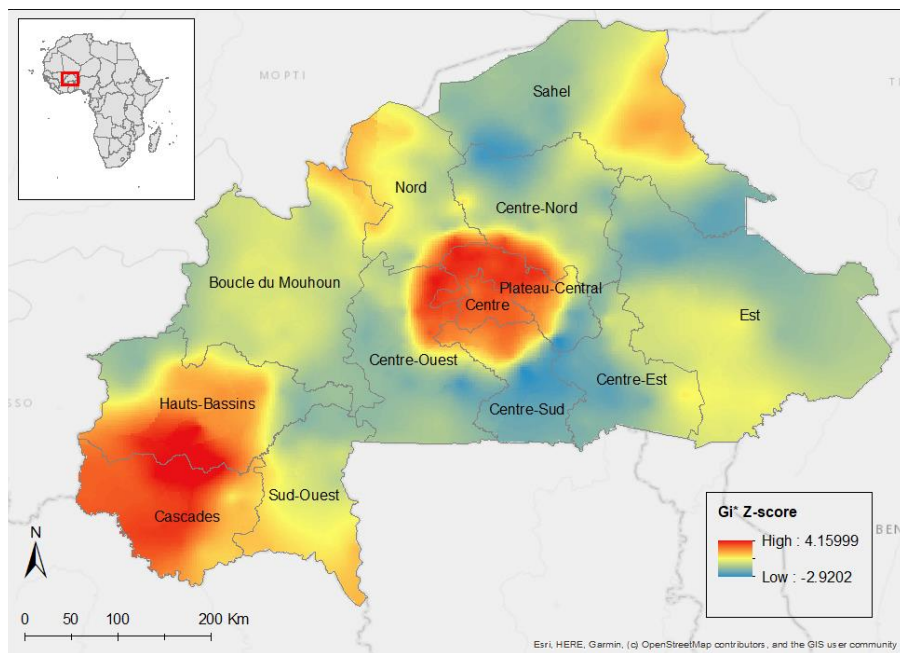
Highest prevalence of overweight WRA with anemic children were found in Centre and Cascades regions (10-20%), with prevalence of this double burden under 10% in the rest of the country. The spatial interpolation reflects this, in that there are particular **hotspots** in the center of the country and in Cascades into Hauts-Bassins regions.



### Burkina Faso – Overweight/obese mothers with anemic children by region



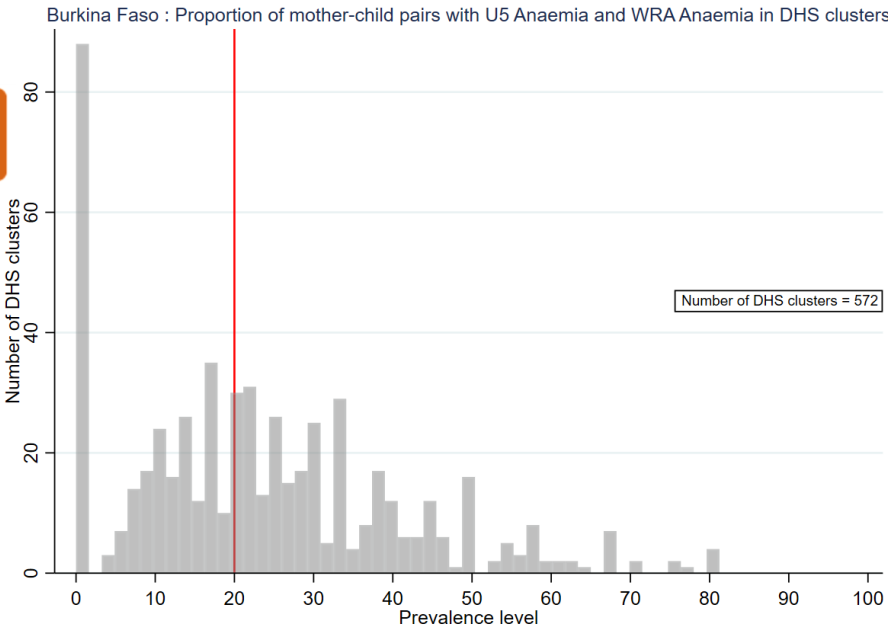
### Burkina Faso – Hotspots/coldspots of overweight/obese mothers with anemic children



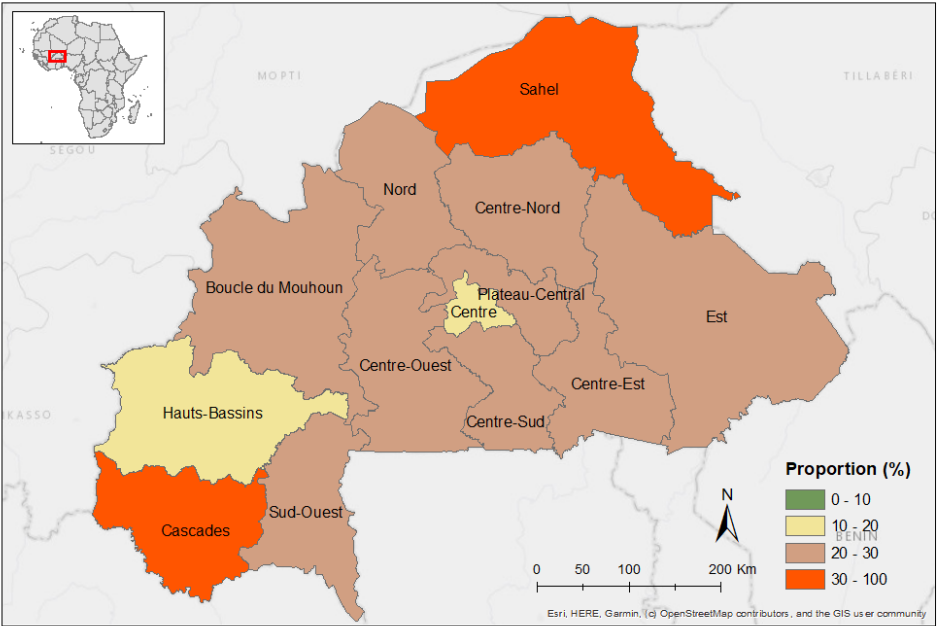


# Anemic mothers with anemic children

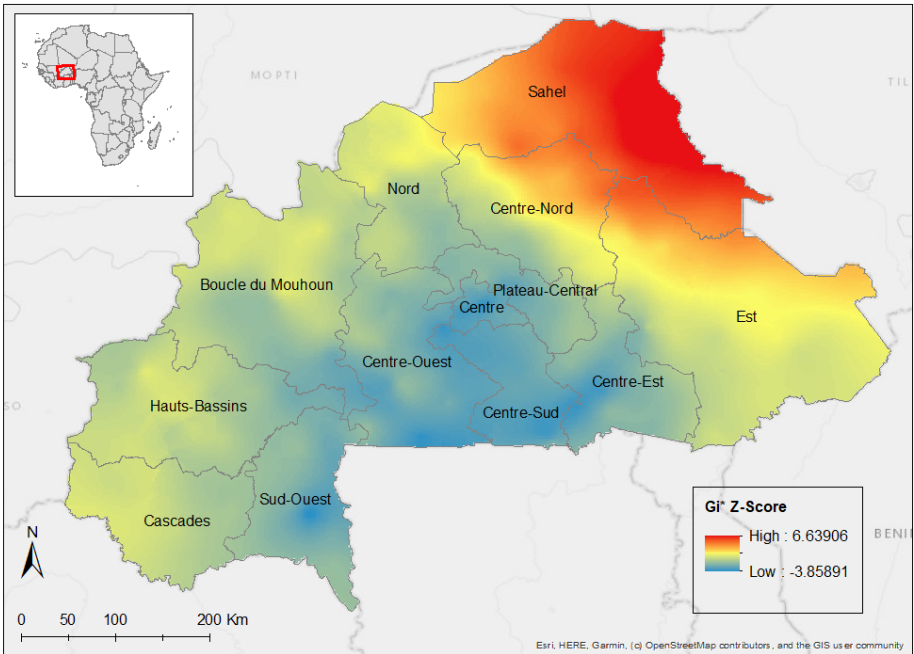
Rates of mothers and children who are both anemic are highest (over 30%) in Sahel and Cascades regions, with Sahel experiencing a **hotspot**.



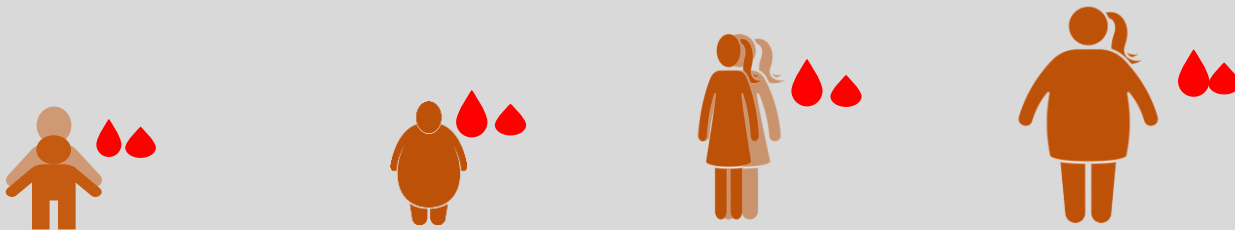
Burkina Faso – Anemic mothers with anemic children by region



Burkina Faso – Hotspots/coldspots of anemic mothers with anemic children



# Co-occurrence of multiple malnutrition types within the same individual (U5, WRA)



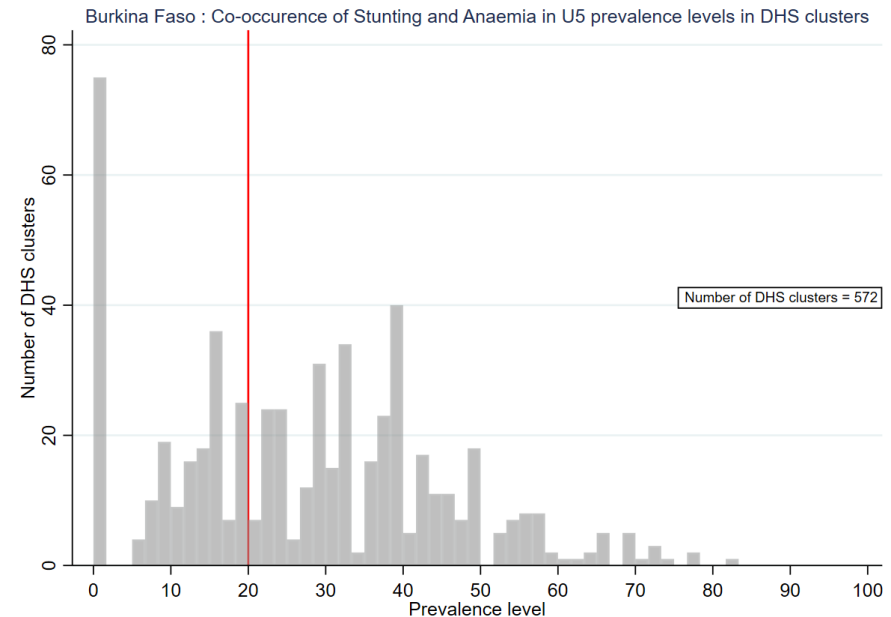
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## Stunted and anemic U5

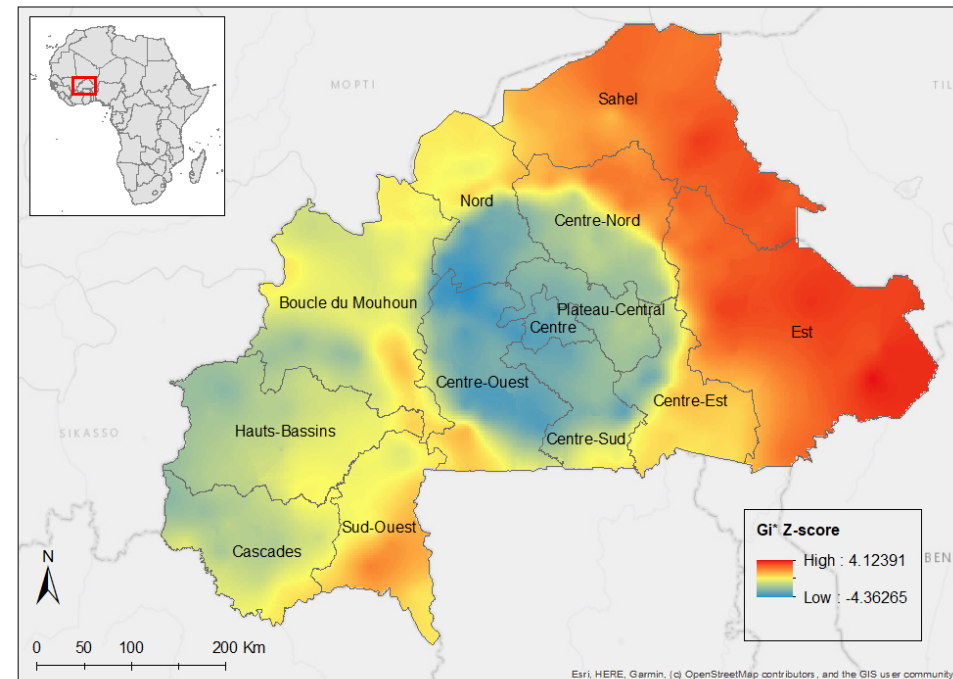
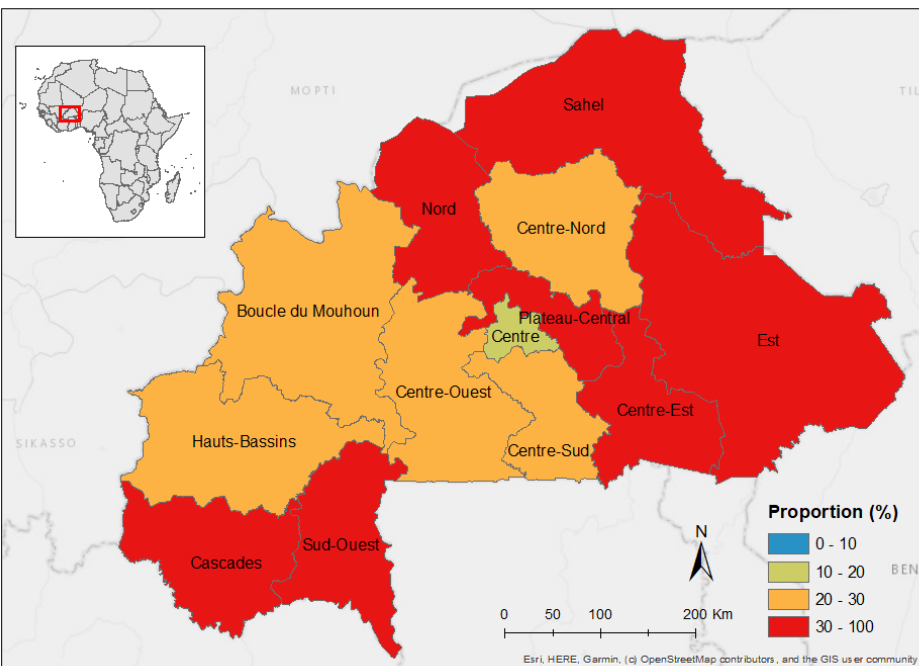


U5s experiencing both stunting and anemia are over 30% in about half of the country, and over 20% in the rest, apart from Centre (10-20%). The spatial interpolation shows particular **hotspots** in Sahel and Est and Sud-Ouest, with **cold spots** in the center of the country.



Burkina Faso – Stunted and anemic U5 by region

Burkina Faso – Hotspots/coldspots of stunted and anemic U5

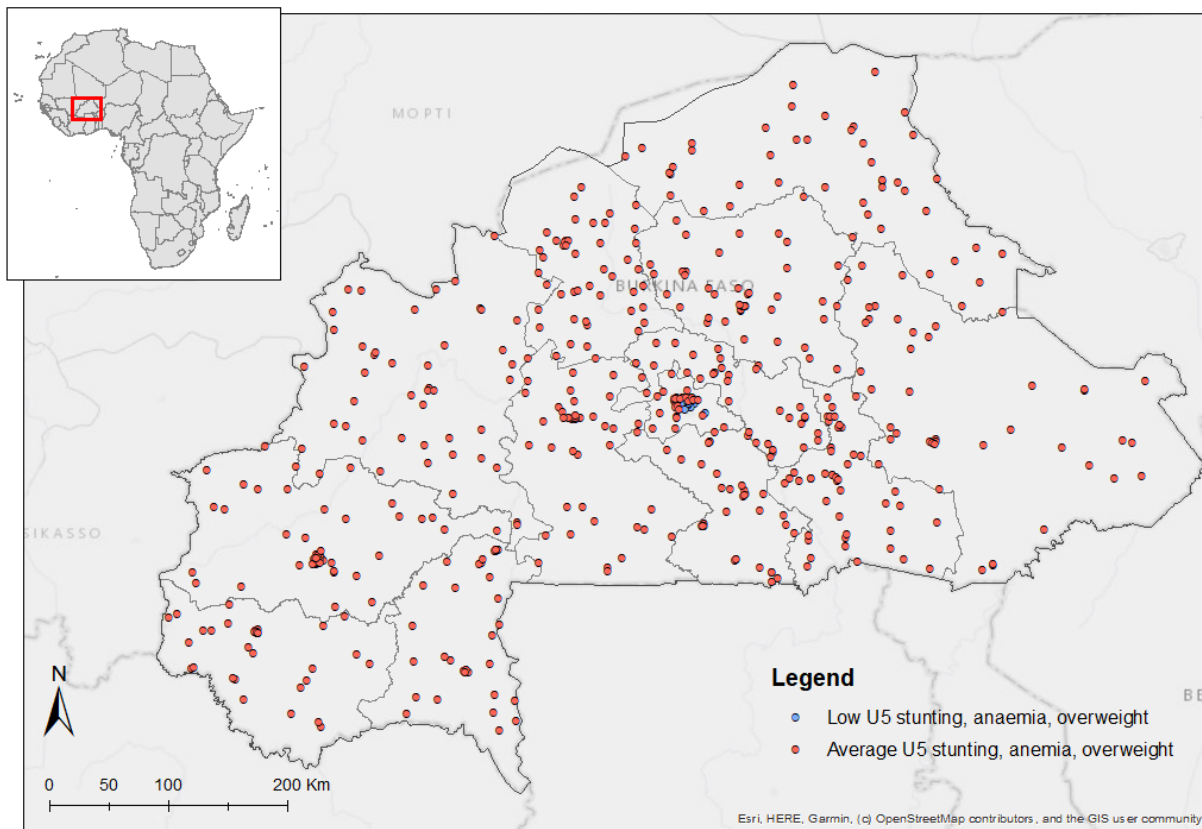


# Grouping analysis of U5 and WRA malnutrition

(back to [Results for Burkina Faso](#))

## Burkina Faso

### Grouping Analysis of U5 stunting, anaemia, and overweight/obesity



### Grouping analysis – U5



The grouping analysis of U5 malnutrition types showed two types of clusters in Burkina Faso with the **blue group** located in/around the capital Ouagadougou, characterized by lower-than-average stunting, anemia, and overweight/obesity levels.

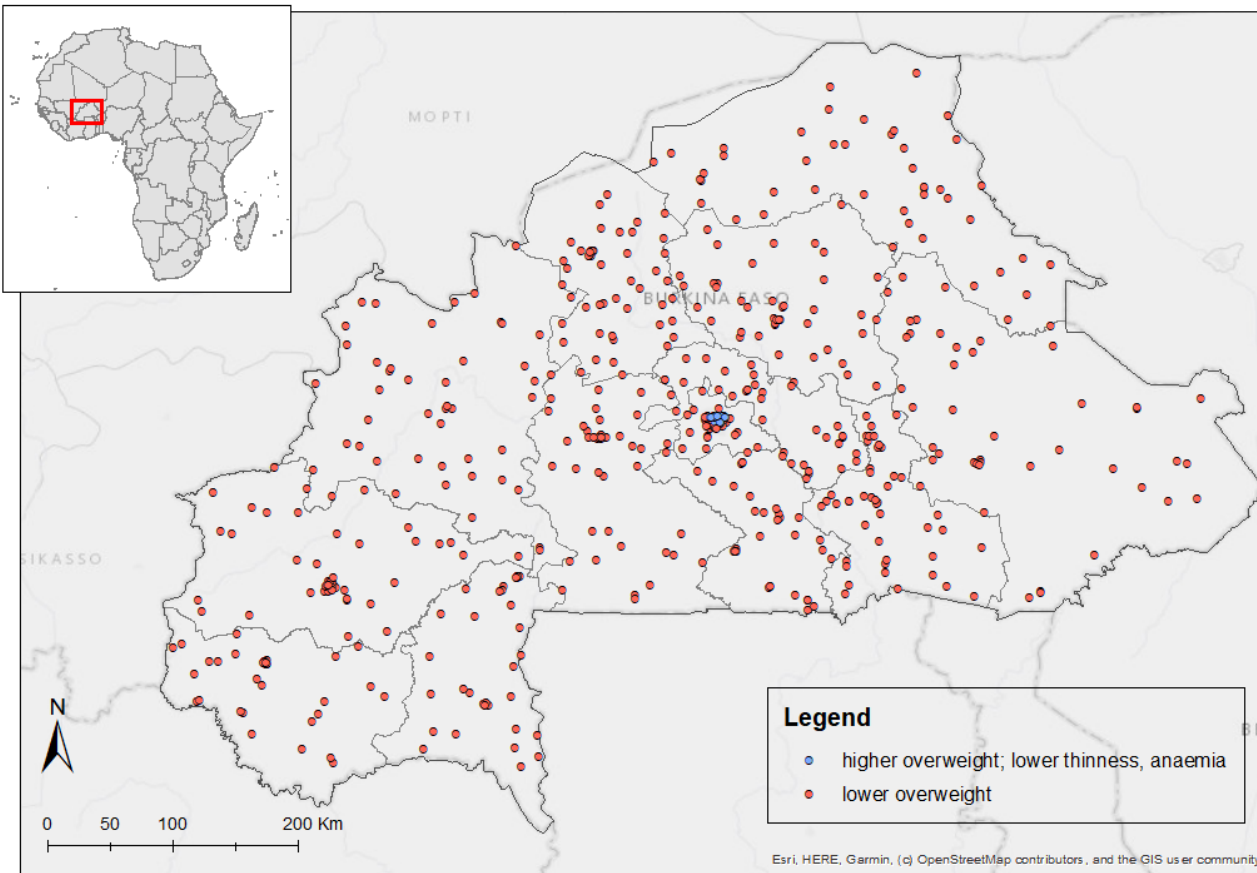
### Average prevalence of U5 malnutrition type by group – Burkina Faso

Malnutrition type	Country average <i>n</i> =537	Group 1 <i>n</i> =13	Group 2 <i>n</i> =524
U5 stunting	32 ± 19	<b>11 ± 11</b>	32 ± 19
U5 anemia	87 ± 15	<b>46 ± 21</b>	88 ± 13
U5 Overweight/Obesity	0.68 ± 3.03	<b>0.0 ± 0.0</b>	0.7 ± 3.1

Values are mean ± standard deviations. Numbers in **bold** are statistically significantly different from the mean.

## Burkina Faso

### Grouping Analysis of WRA thinness, anaemia, and overweight/obesity



Average prevalence of WRA malnutrition type by group – Burkina Faso

### Grouping analysis – WRA



The grouping analysis of WRA malnutrition types showed two types of clusters in Burkina Faso. One group (**blue**), mainly located in/around the capital Ouagadougou, is characterized by higher-than-average overweight/obesity and lower-than-average levels of thinness and anemia. The group (**red**) experiences lower-than-average levels of overweight/obesity.

Malnutrition type	Country average <i>n</i> =541	<b>Group 1</b> <i>n</i> =15	<b>Group 2</b> <i>n</i> =526
WRA anemia	31 ± 17	<b>19 ± 11</b>	31 ± 17
WRA Thinness	14 ± 12	<b>4.7 ± 6.0</b>	14 ± 13
WRA Overweight/Obesity	5.2 ± 5.9	<b>20 ± 5.4</b>	<b>4.8 ± 5.4</b>

*Values are mean ± standard deviations. Numbers in **bold** are statistically significantly different from the mean.*

# Spatial regression analysis of U5 and WRA malnutrition

(back to [Results for Burkina Faso](#))

# Factors associated with hotspots of anemic mothers with anemic children

## *Summary of findings*

- **Indicator of interest:** an area (cluster) that is a hotspot of anemia in mother-child pairs i.e. in that area, the proportion of mother child pairs in which both the child and the mother suffer from anemia is significantly higher than what should be expected given the distribution of anemia in Burkina Faso.
- Identifying the factors associated with these hotspots improves understanding of the problem and provides insights into which interventions could efficiently address the existing multiple malnutrition burdens.
- The anemia from which these mothers and their children suffered was associated with the past incidences of malaria.
- Clusters with high proportions of educated mothers, who had an income generating activity, delivered in health facilities and had their child vaccinated for measles had a reduced risk of being a hotspot.
- Older children had a higher risk of being in a mother-child pair experiencing anemia.
- High livestock density in an area was associated with a high risk of being a hotspot of anemia in mother-child pairs.

# Factors associated with hotspots of anemic mothers with anemic children

*Results of regression model*

Log likelihood = -72.045929

Number of obs	=	540
LR chi2(24)	=	237
Prob > chi2	=	0.000
Pseudo R2	=	0.622

Hotspot	Odds Ratio	Std. Err.	z	P>z	[95% Conf.Interval]
Spatial lag	1.20	0.04	6.16	0.000	(1.13 - 1.27)
Density of livestock	1.04	0.01	3.24	0.001	(1.02 - 1.07)
Proportion of mothers with an income generating activity	0.97	0.01	-4.68	0.000	(0.96 - 0.98)
Average number of adults in households	0.37	0.14	-2.68	0.007	(0.18 - 0.77)
Average children age	4.64	3.39	2.1	0.036	(1.11 - 19.42)
Irrigated cropland area	0.83	0.06	-2.67	0.008	(0.72 - 0.95)
Proportion of mothers educated	0.96	0.02	-2.55	0.011	(0.93 - 0.99)
Proportion of births in medical facilities	0.97	0.01	-3.35	0.001	(0.96 - 0.99)
Measles vaccination coverage	0.95	0.01	-3.58	0.000	(0.92 - 0.98)

Sensitivity	70%
Specificity	98%
Positive predictive value	84%
Negative predictive value	96%
Correctly classified	95%

# Factors associated with hotspots of overweight/obese mothers with anemic children

## *Summary of findings*

- **Indicator of interest:** an area (cluster) that is a hotspot of overweight/obese mothers with anemic children.
- The anemia in the case of this double burden was less associated with malaria than the anemia from which children suffered in mother-child pairs where both mother and child were anemic.
- Risk factors for a hotspot of this double burden in mother-child pairs included richer households, high prevalence of open defecation practice and problems for mothers to get access to medical facilities.
- Protective factors from being a hotspot were higher prevalence level of appropriate breastfeeding, better coverage of full DPT vaccination, and antenatal visits for pregnancies.

# Factors associated with hotspots of overweight/obese mothers with anemic children

## *Results of regression model*

Log likelihood = -83.215366

Number of obs	=	540
LR chi2(24)	=	481
Prob > chi2	=	0.000
Pseudo R2	=	0.743

Hotspot	Odds Ratio	Std. Err.	z	P>z	[95% Conf.Interval]
Spatial lag	1.11	0.04	2.61	0.009	(1.03 - 1.19)
Proportion of rich households	1.03	0.01	2.56	0.011	(1.01 - 1.05)
Appropriate breastfeeding prevalence	0.97	0.01	-2.45	0.014	(0.95 - 0.99)
Full DTP vaccination coverage	0.96	0.01	-3.05	0.002	(0.93 - 0.98)
Problem getting access to medical facilities	1.02	0.01	2.29	0.022	(1 - 1.03)
Length of growing period	1.05	0.01	4.00	0.000	(1.03 - 1.08)
Antenatal visit for pregnancy coverage	0.98	0.01	-1.76	0.078	(0.96 - 1)
Open defecation practice prevalence	1.03	0.01	2.58	0.010	(1.01 - 1.05)
Vitamin A supplementation coverage	0.98	0.01	-1.69	0.092	(0.97 - 1)

Sensitivity	88%
Specificity	97%
Positive predictive value	94%
Negative predictive value	95%
Correctly classified	95%

# Factors associated with hotspots of stunted and anemic children

## *Summary of findings*

- **Indicator of interest:** an area (cluster) that is a hotspot in which U5 suffer simultaneously from anemia and stunting.
- Risk factors of being a hotspot of U5 stunting and anemia included a higher number of children per women, a higher proportion of women smoking, and a higher proportion of women who were educated and had an income generating activity.
- A higher average number of adults in the households was also a risk factor of significantly higher prevalence of stunting and anemic children.
- Protective factors from being a hotspot were rural areas with a higher coverage of polio full vaccination and older mothers.

# Factors associated with hotspots of stunted and anemic children

## Results of regression model

Log likelihood = -92.636666

Number of obs	=	513
LR chi2(24)	=	279
Prob > chi2	=	0.000
Pseudo R2	=	0.601

Hotspot	Odds Ratio	Std. Err.	z	P>z	[95% Conf.Interval]
Spatial lag	1.13	0.03	4.99	0.000	(1.08 - 1.18)
Length of growing period	0.92	0.01	-6.95	0.000	(0.9 - 0.94)
Average number of children per mother	2.76	1.11	2.51	0.012	(1.25 - 6.09)
Proportion fo households with handwashing facilities	0.99	0.01	-1.66	0.096	(0.98 - 1)
Prevalence of appropriate breastfeeding	0.98	0.01	-1.75	0.081	(0.96 - 1)
Average age of mothers	0.49	0.08	-4.3	0.000	(0.36 - 0.68)
Proportion of mothers smoking	1.10	0.02	4.45	0.000	(1.06 - 1.15)
Proportion of mother educated	1.03	0.01	2.14	0.032	(1 - 1.06)
Open defecation practice prevalence	1.03	0.01	3.08	0.002	(1.01 - 1.05)
Proportion of mother with an income generating activity	1.53	0.27	2.4	0.016	(1.08 - 2.16)
Full polio vaccination coverage	0.97	0.01	-2.5	0.012	(0.94 - 0.99)
Distance to big cities (500k population)	9.22	3.90	5.25	0.000	(4.02 - 21.13)
Rural area	0.06	0.04	-3.96	0.000	(0.01 - 0.24)
Average number of adults in households	2.67	0.71	3.69	0.000	(1.58 - 4.49)
Improved cooking fuel use coverage	1.04	0.03	1.66	0.097	(0.99 - 1.1)
Tube well use for drinking water	1.03	0.01	3.73	0.000	(1.01 - 1.04)

Sensitivity	74%
Specificity	98%
Positive predictive value	89%
Negative predictive value	95%
Correctly classified	94%

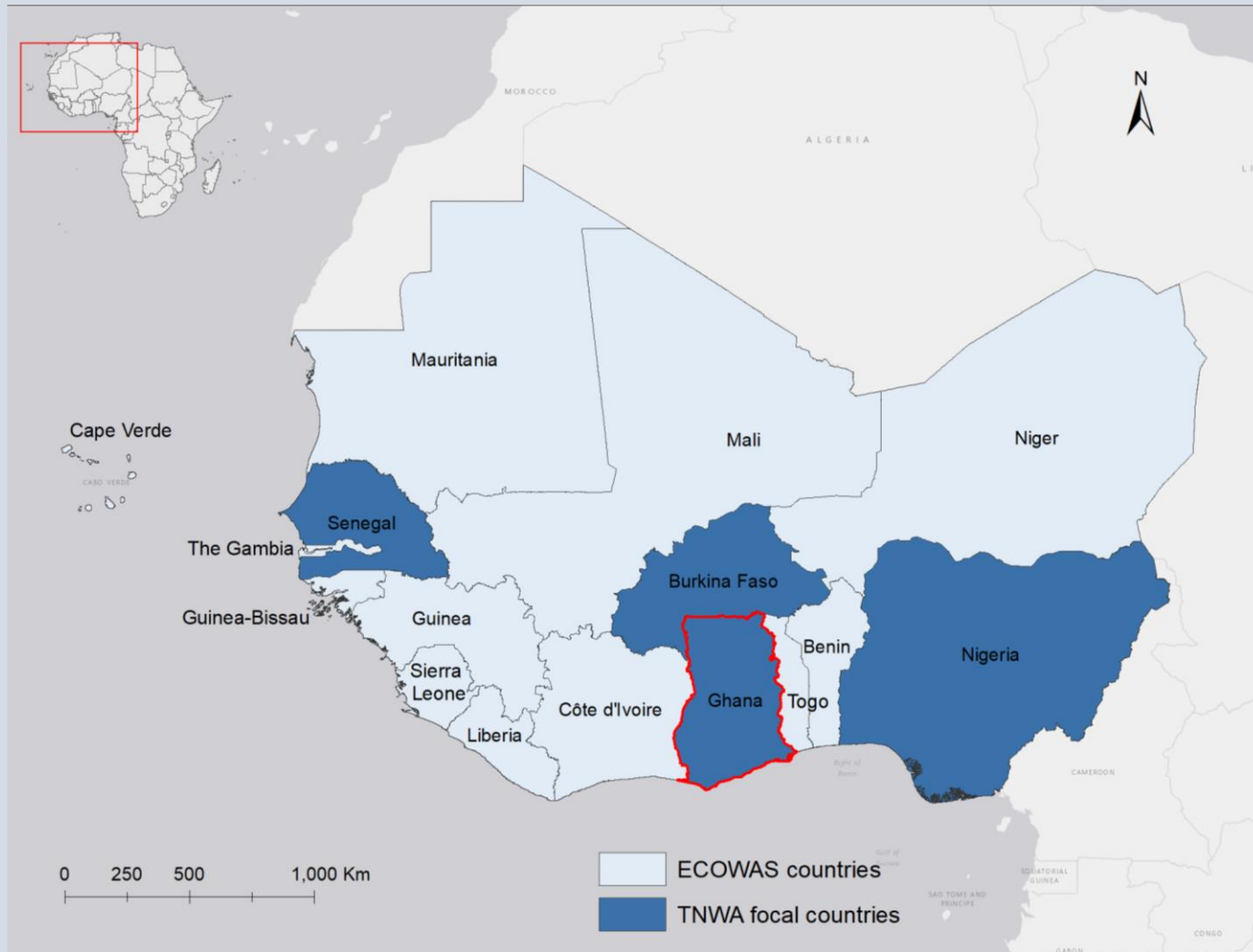
# Conclusions / Recommendations for Burkina Faso (1/2)

- U5 stunting and anemia rates are (very) high throughout the country except in Centre region, with stunting hotspots in the east and southwestern parts of the country, and cold spots in more populated areas. Similarly, anemia rates show hotspots in a majority of the country and cold spots around Ouagadougou and Bobo Dioulasso.
- WRA underweight/thinness and anemia are also high, with Sahel and Est regions particularly affected (20-40%) with regards to underweight/thinness, and Sahel particularly affected with regards to anemia (over 50%).
- The hotspot analysis shows hotspots of stunting and anemia occurring in the same U5 child in Sahel and Est regions and a cold spot for this double burden in the center of the country.
- Factors associated with these hotspots are a higher number of children per woman, and a higher proportion of women who were educated and had an income generating activity. It appears that the co-occurrence of anemia and stunting within the same child is associated with a lack of focus on him/her, the mother being occupied, having other children and also the fact he/she lives in an extended family.

## Conclusions / Recommendations for Burkina Faso (2/2)

- The double burden within mother-child pairs in which the child is anemic and the mother is overweight/obese were detected primarily in and around Centre and Cascades and Hauts-Bassins.
- Factors associated with this double burden were the fact that the area included richer households, had a high prevalence of open defecation, and challenges for mothers to access medical facilities.
- The mother-child pair double burden in which both child and mother were anemic had a hotspot primarily in Sahel. It was found that high livestock density increased the risk of such a hotspot; older children had a higher risk of being in a mother-child pair with such a double burden.

# Ghana



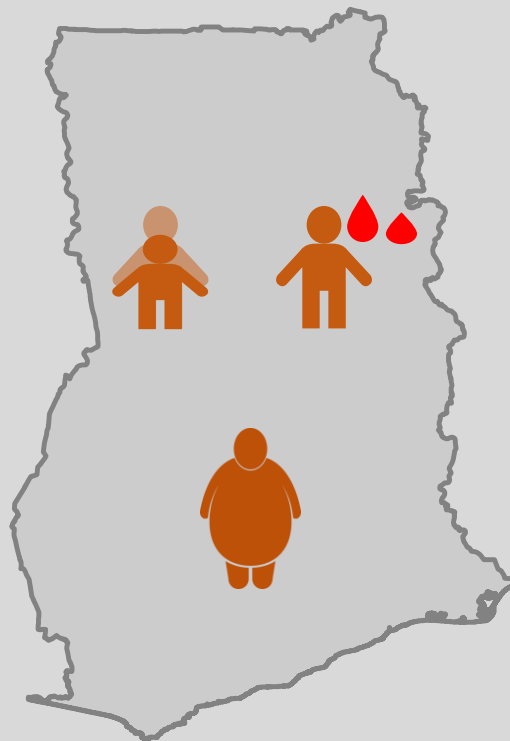
(back to [overview](#))

# Results for Ghana

Single malnutrition types in Children under five years of age (U5) and Women of reproductive Age (WRA)	Grouping Analysis
<ul style="list-style-type: none"> <li>• <a href="#">U5 stunting</a></li> <li>• <a href="#">U5 anemia</a></li> <li>• <a href="#">U5 overweight</a></li> <li>• <a href="#">WRA underweight/thinness</a></li> <li>• <a href="#">WRA anemia</a></li> <li>• <a href="#">WRA overweight/obesity</a></li> </ul>	<ul style="list-style-type: none"> <li>• <a href="#">Stunting, anemia and overweight among U5</a></li> <li>• <a href="#">Stunting, anemia and overweight among WRA</a></li> </ul>
Co-occurrence of different types of malnutrition in U5 and WRA	Regression Analysis
<p>Within regions:</p> <ul style="list-style-type: none"> <li>• <a href="#">Stunting, anemia and overweight among U5</a></li> </ul> <p>Within households (mother-child pairs):</p> <ul style="list-style-type: none"> <li>• <a href="#">U5 anemia &amp; WRA anemia</a></li> <li>• <a href="#">U5 stunting &amp; WRA anemia</a></li> <li>• <a href="#">U5 anemia &amp; WRA overweight/obesity</a></li> </ul> <p>Individuals simultaneously experiencing:</p> <ul style="list-style-type: none"> <li>• <a href="#">Stunting and anemia (U5)</a></li> </ul>	<p>Within households (mother-child pairs):</p> <ul style="list-style-type: none"> <li>• <a href="#">U5 anemia &amp; WRA anemia</a></li> <li>• <a href="#">U5 anemia &amp; WRA overweight</a></li> </ul>

# Single malnutrition types for U5

Stunting - Anemia - Overweight/obesity



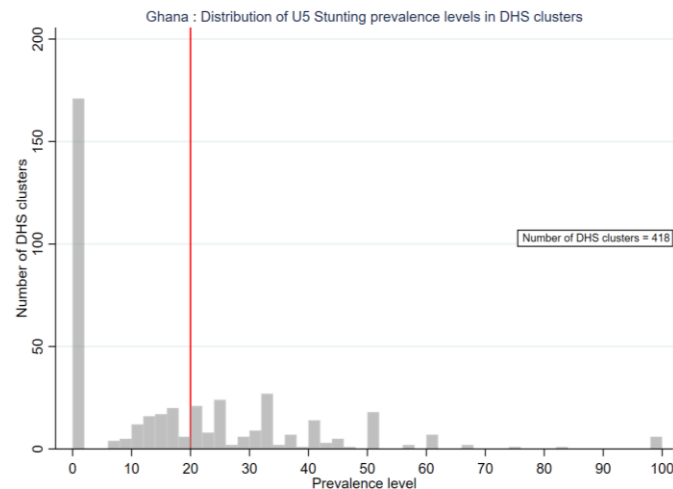
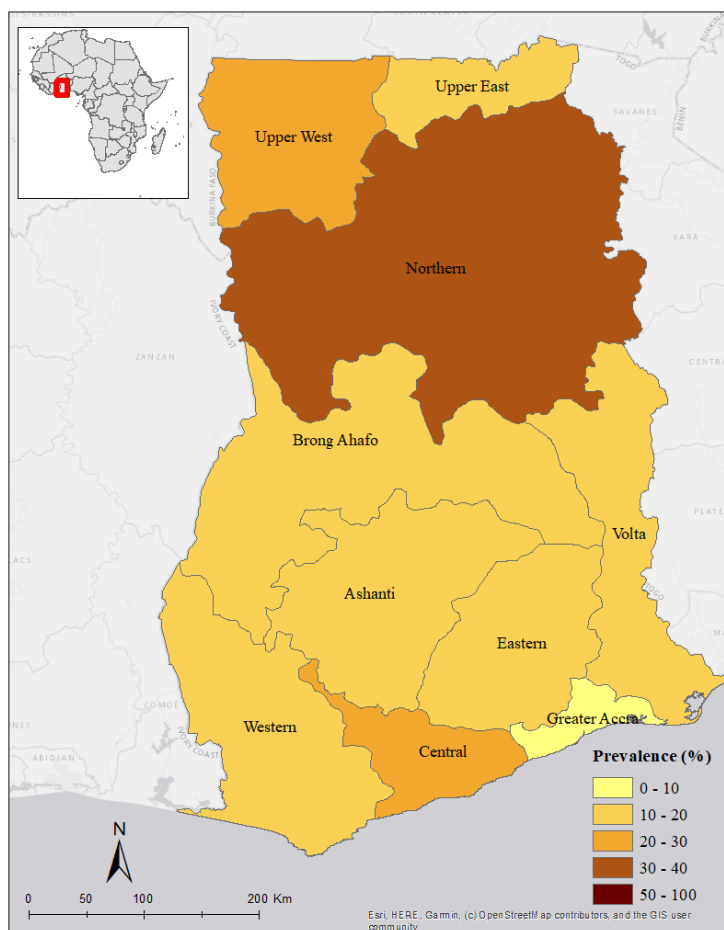
(back to [Results for Ghana](#))



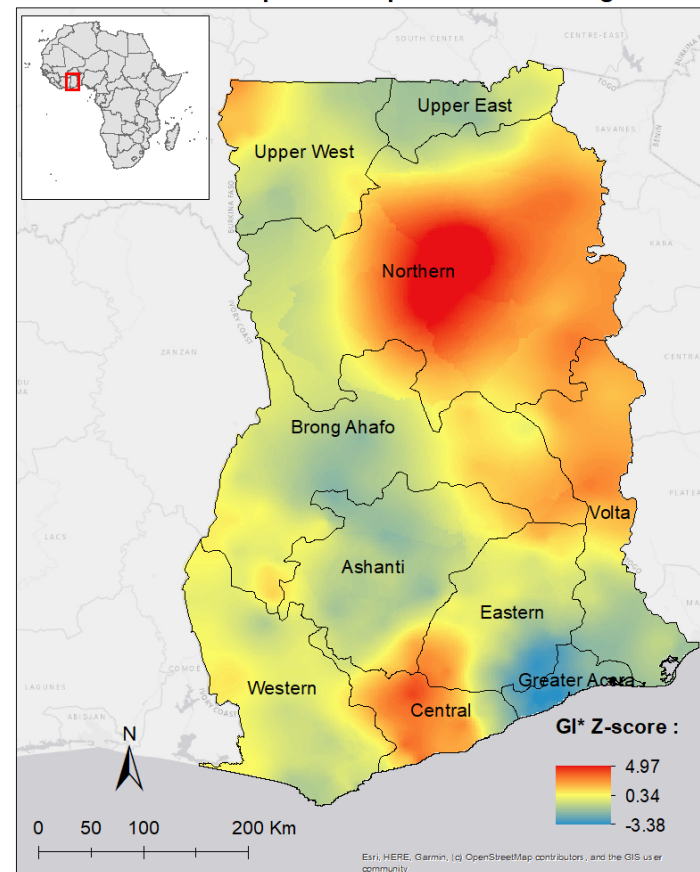
## U5 Stunting

There is high prevalence (above 30% of U5) of stunting in northern and central regions, confirmed by the hotspot analysis that shows a concentration of high prevalence clusters in these regions.

Ghana : U5 stunting by region



Ghana : Hotspots/coldspots of U5 stunting

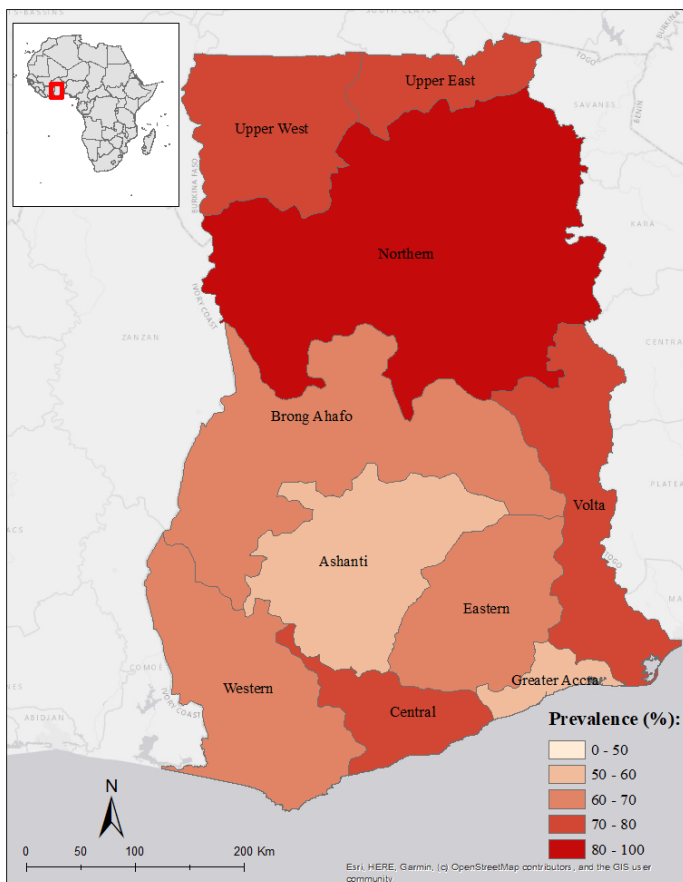




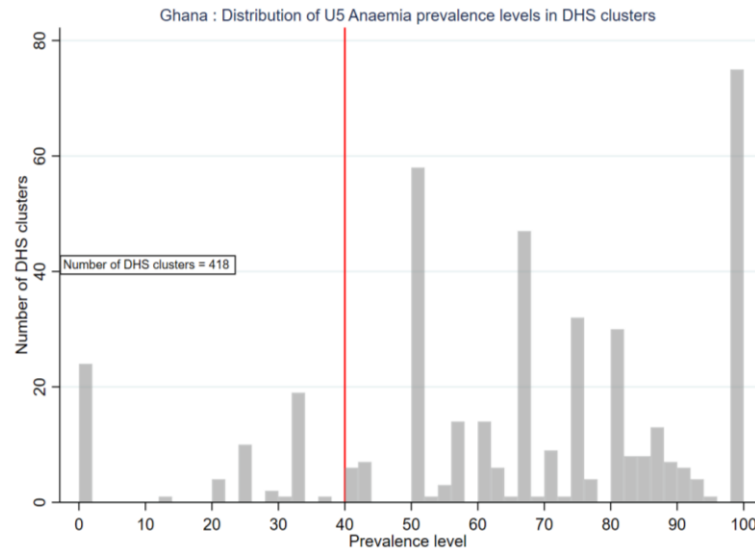
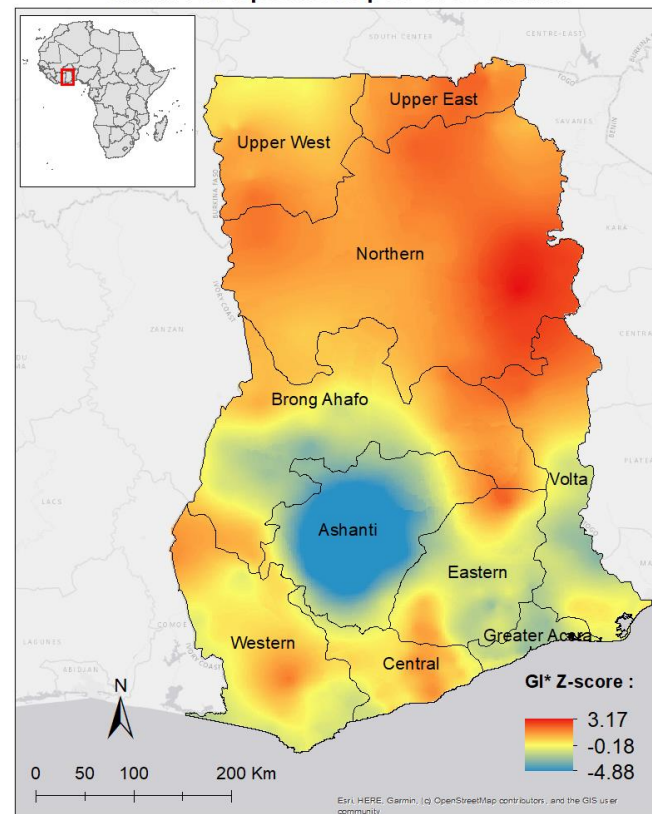
## U5 anemia

Overall, a high prevalence level of anemia in U5 is found throughout Ghana, with significant **coldspots** in Ashanti region and to a lower extent in Greater Accra. Highest prevalence levels are found in northern regions.

Ghana : U5 anemia by region



Ghana : Hotspots/coldspots of U5 anemia

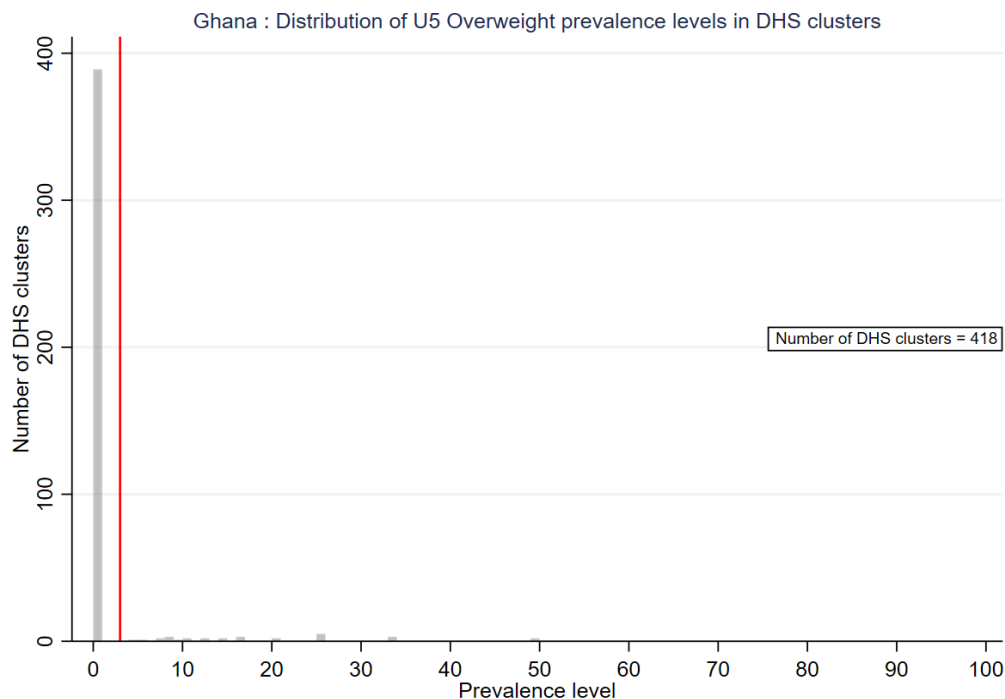
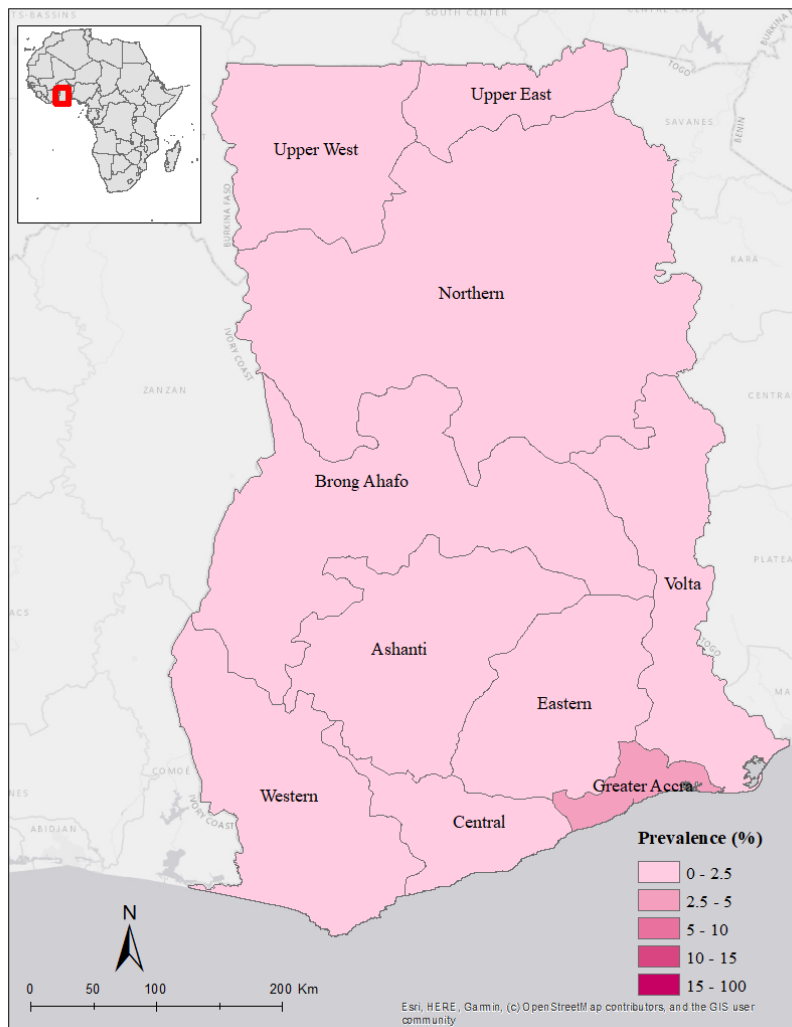




## U5 Overweight/Obesity

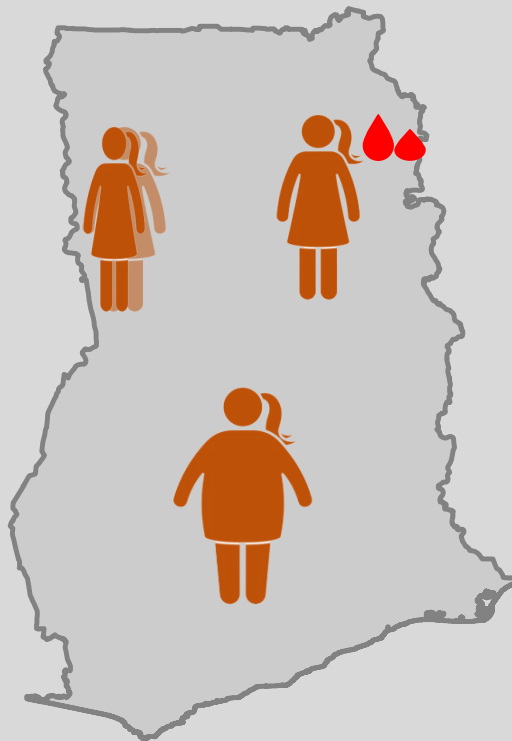
Overall, there is a very low prevalence level of overweight/obesity i.e below 2.5% of U5 in almost all regions except Greater Accra (3%); no significant clustering detected with the hotspot analysis.

### Ghana : U5 overweight/obesity by region



## Single malnutrition types for WRA

Underweight/thinness - Anemia - Overweight/obesity



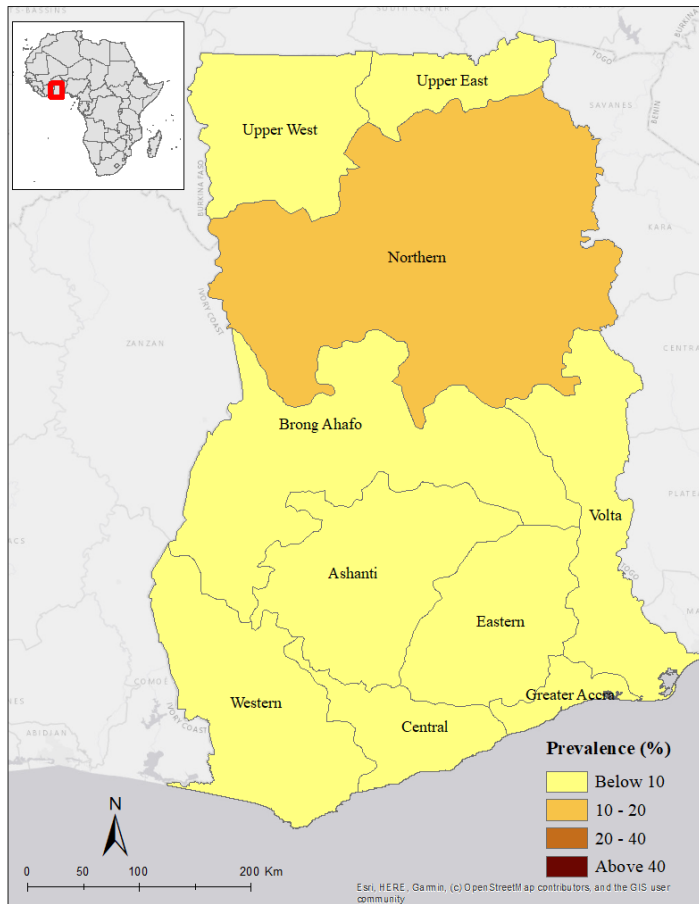
(back to [Results for Ghana](#))



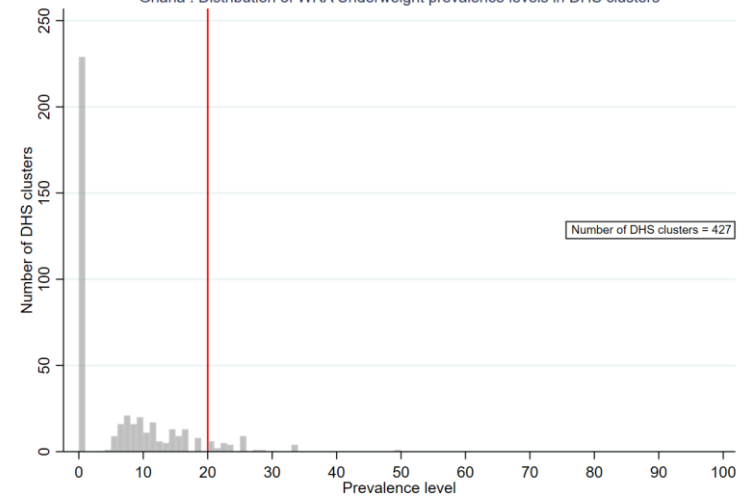
## WRA Thinness / Underweight

Overall, there are low prevalence levels of thinness/underweight (10% in Northern region) in Ghana. However, significant clustering is detected in the north-east and (surprisingly) in some areas of the central regions (Brong Ahafo, Ashanti and Eastern) with the hotspot analysis.

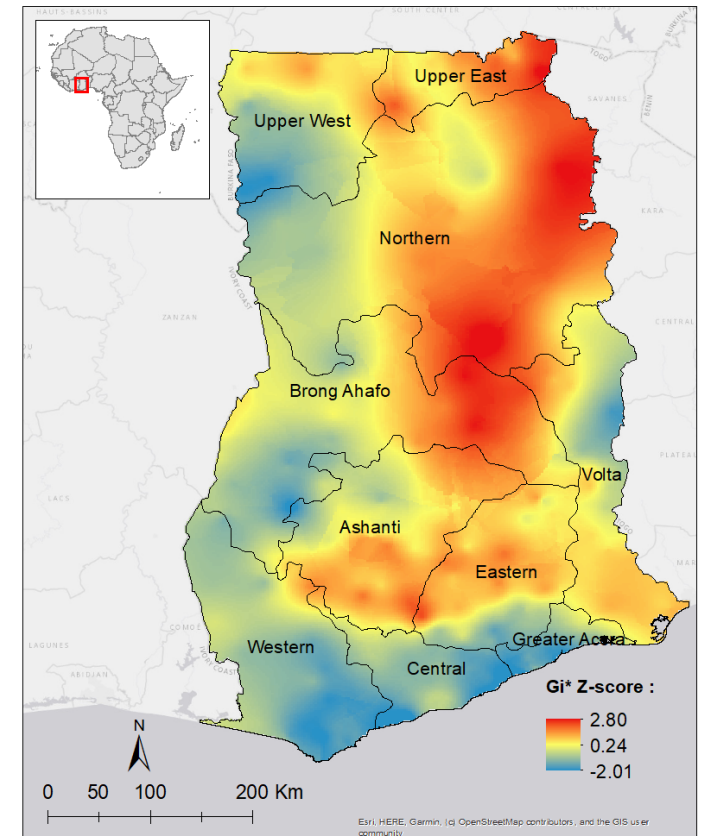
Ghana : WRA thinness/underweight by region



Ghana : Distribution of WRA Underweight prevalence levels in DHS clusters



Ghana : Hotspots/coldspots of thinness/underweight in WRA

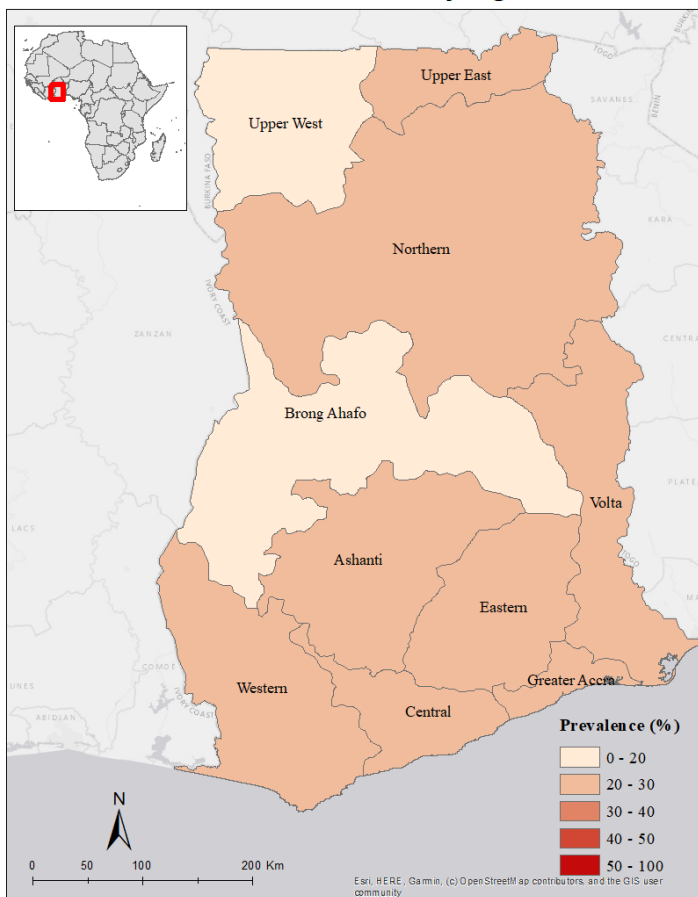




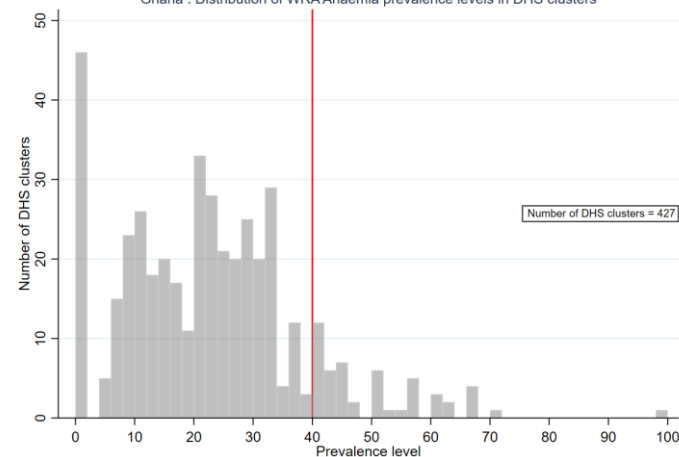
## WRA anemia

Overall, low to average anemia prevalence levels are found in WRA. However, significant clustering is detected in the East and South, which requires monitoring of anemia in these regions. Similar to U5 anemia, areas with significantly lower prevalence levels were identified in the Ashanti and Eastern regions.

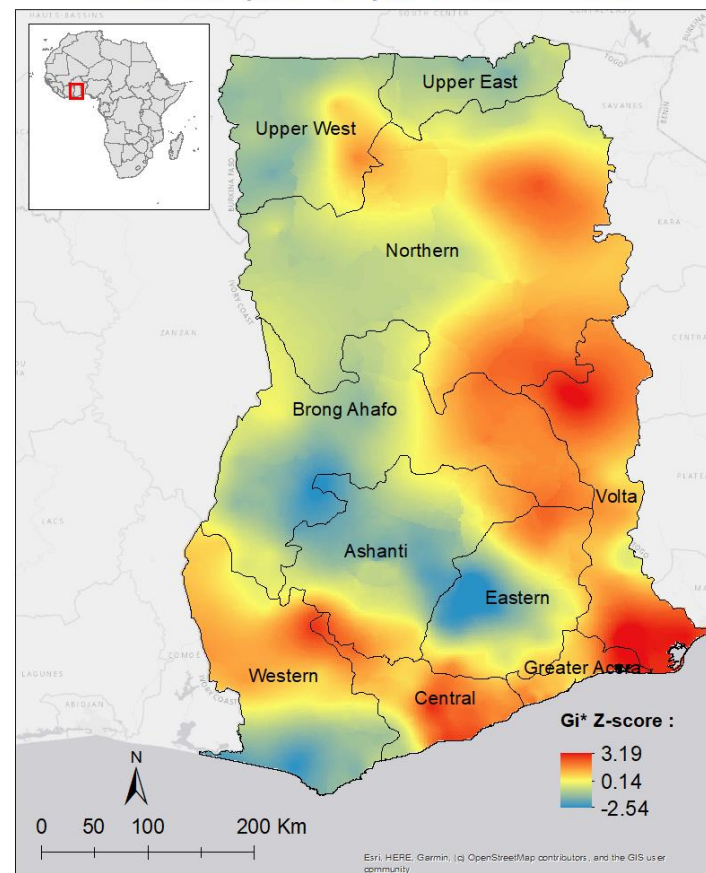
Ghana : WRA anemia by region



Ghana : Distribution of WRA Anaemia prevalence levels in DHS clusters



Ghana : Hotspots/coldspots of anemia in WRA

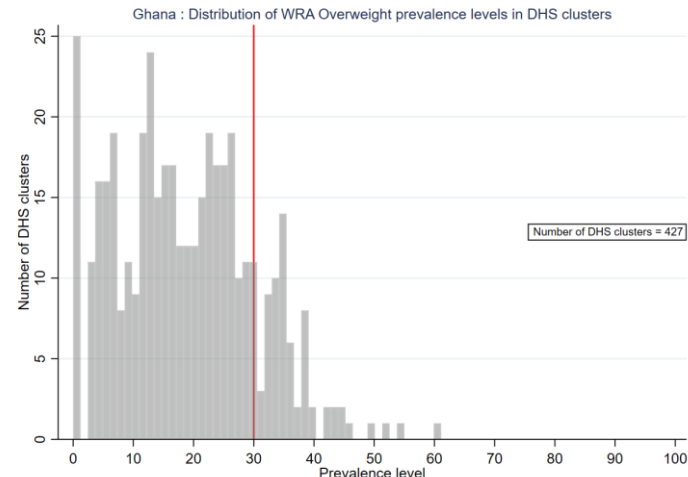
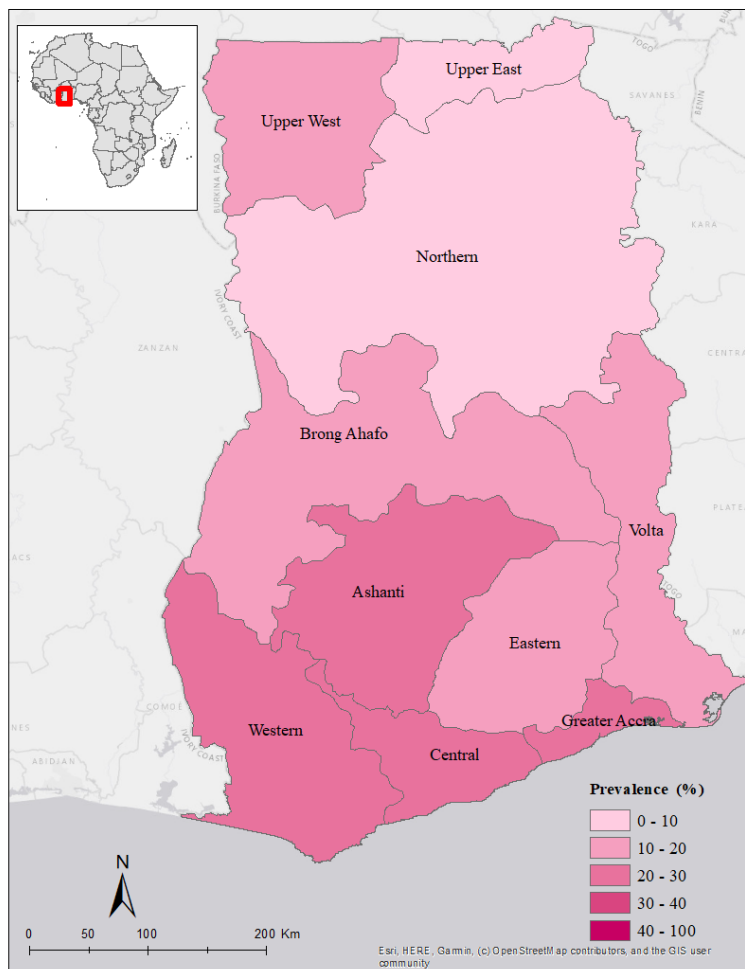




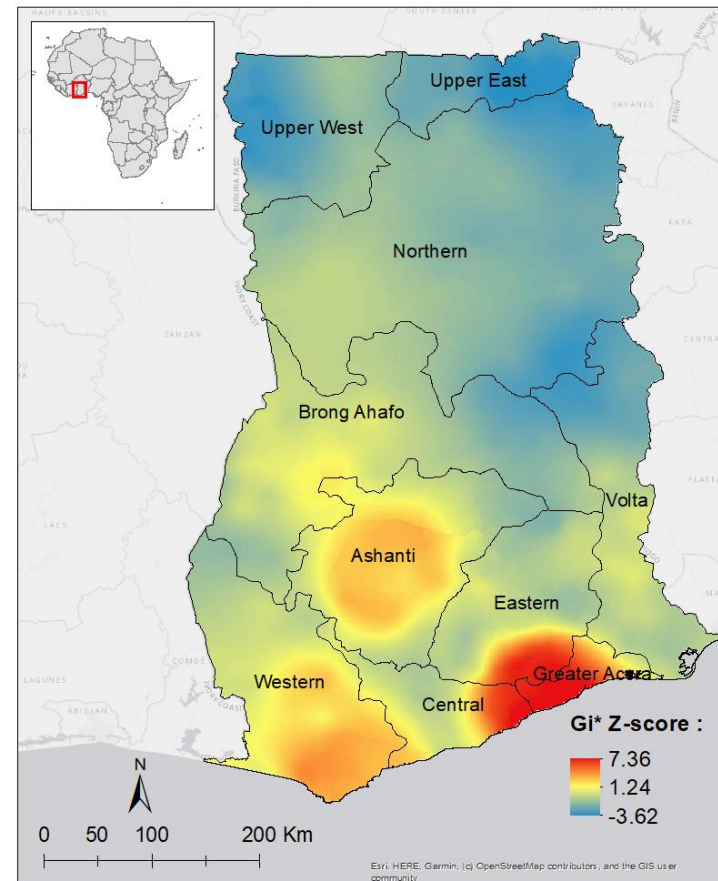
## WRA Overweight/Obesity

The prevalence level is above 20% in the Southern regions, but the **hotspot** identified the Greater Accra region as having areas with particularly high overweight/obesity prevalence levels.

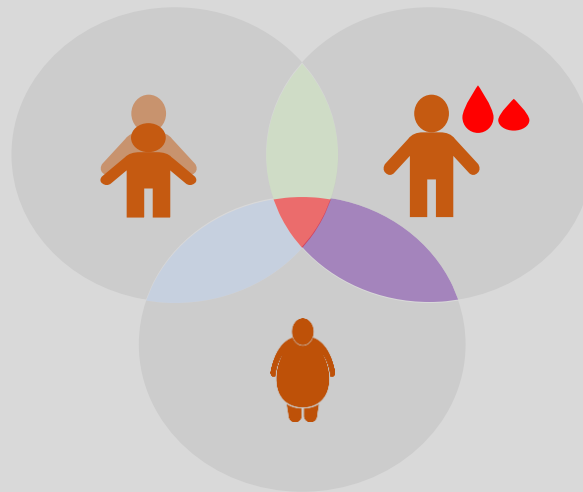
Ghana : WRA overweight/obesity by region



Ghana : Hotspots/coldspots of overweight/obesity in WRA



# Co-occurrence of malnutrition types within the same location



(back to [Results for Ghana](#))

## Ghana

### Co-occurrence of multiple malnutrition types in under-fives by region

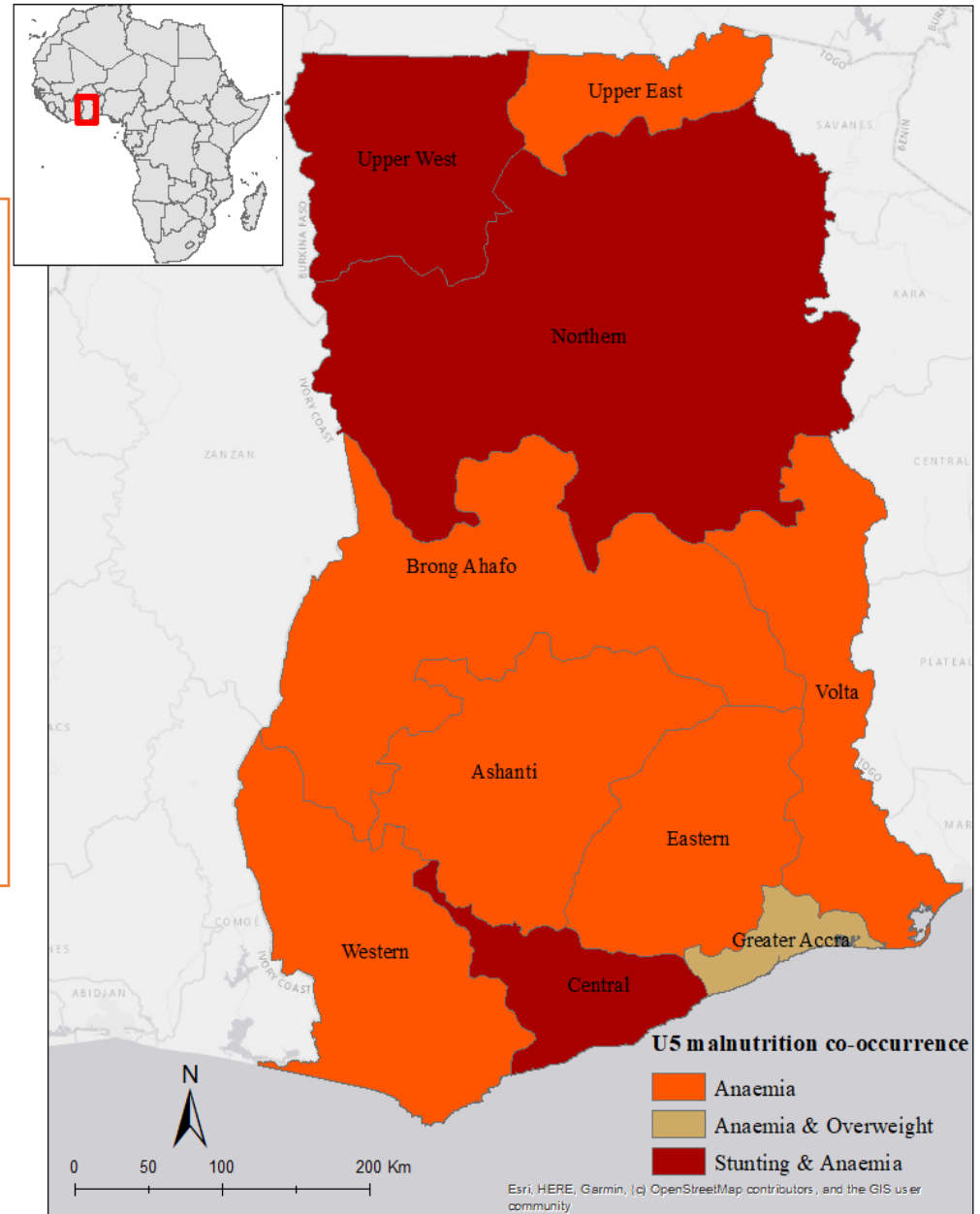
#### Co-occurrences in the same regions (U5)

Most regions have a single burden of anemia in U5. The Central, Upper-West and Northern regions are facing burdens of U5 stunting and anemia. The Greater Accra region is facing a double burden of anemia and overweight in U5.

#### Thresholds used:

- Stunting: 20% and up
- Anemia: 40% and up
- Overweight/obesity: 3% and up

*No region in Ghana faced a burden of thinness/underweight, anemia or overweight/obesity in WRA, as the prevalence levels for these forms of malnutrition were lower than the trigger levels.*



## Co-occurrence of malnutrition types within the same household (mother-child pairs)



(back to [Results for Ghana](#))



# Anemic mothers with anemic children

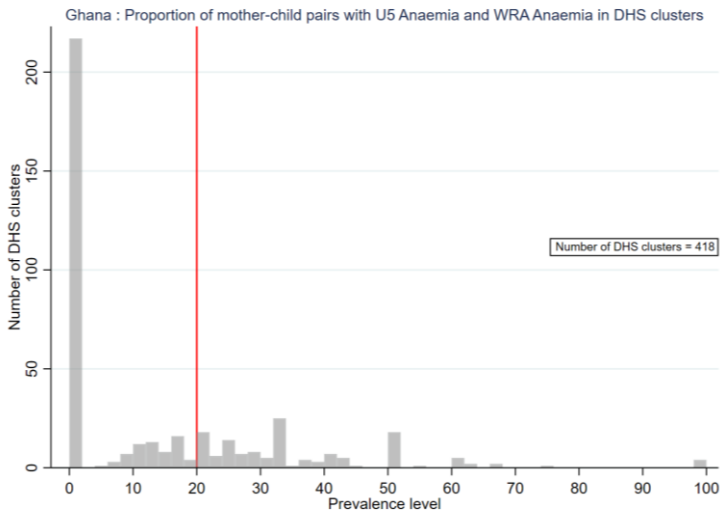
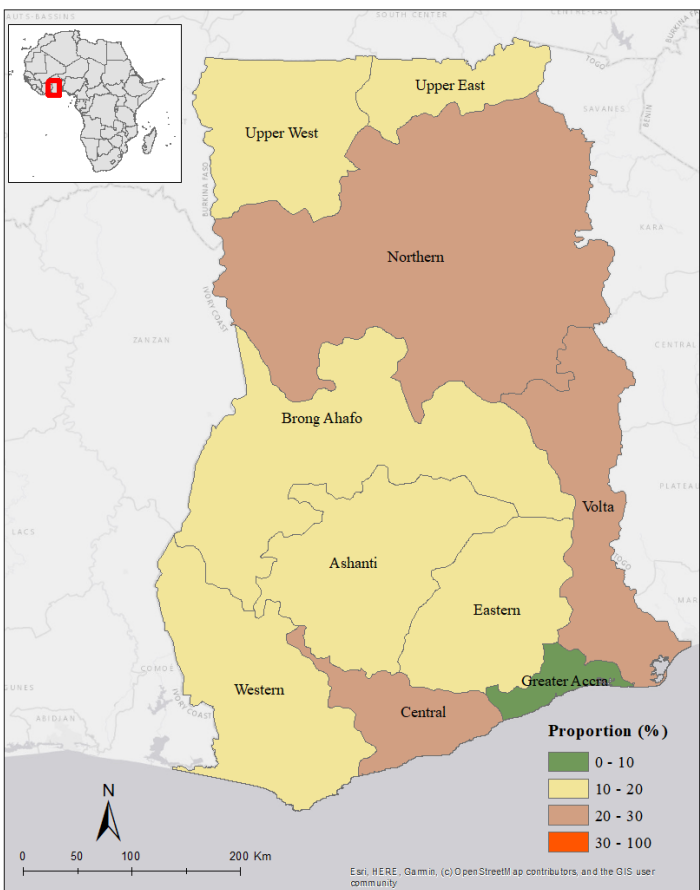


In the Northern, Central and Volta regions, at least one mother-child pair out of 5 experiences anemia, in both the mother and the child.

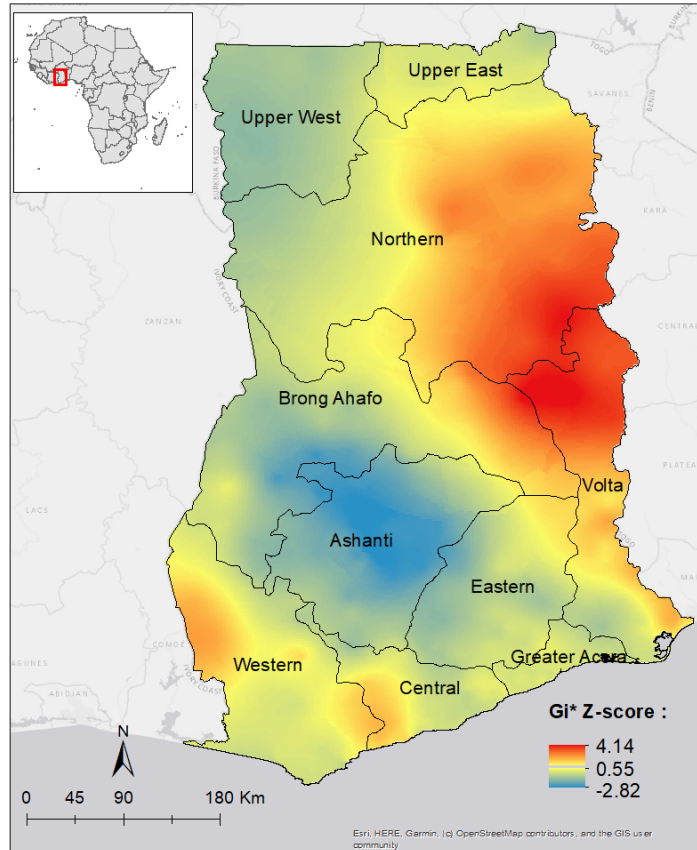
A significant clustering of areas with a high proportion of mother-child pairs with anemia was detected in the East.

The Ashanti region, which was found to have significantly lower prevalence levels of U5 anemia and WRA anemia, is also the region with the fewer proportion of mother-child pairs with anemia.

Ghana : Anemic mothers with anemic children by region



Ghana : Hotspots/coldspots of anemic mothers with anemic children



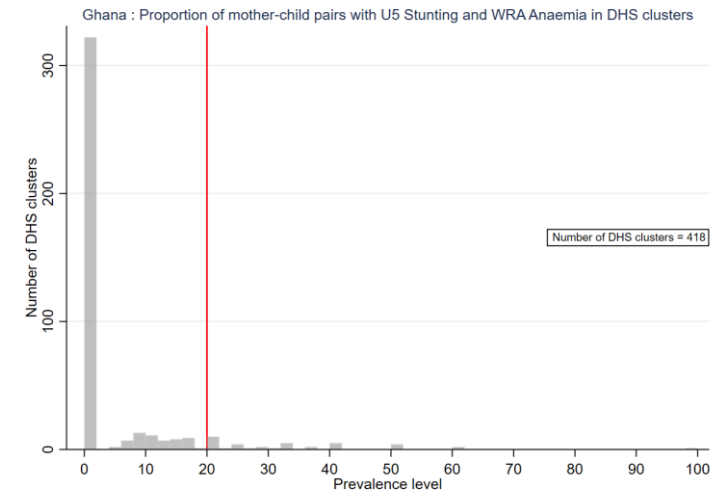
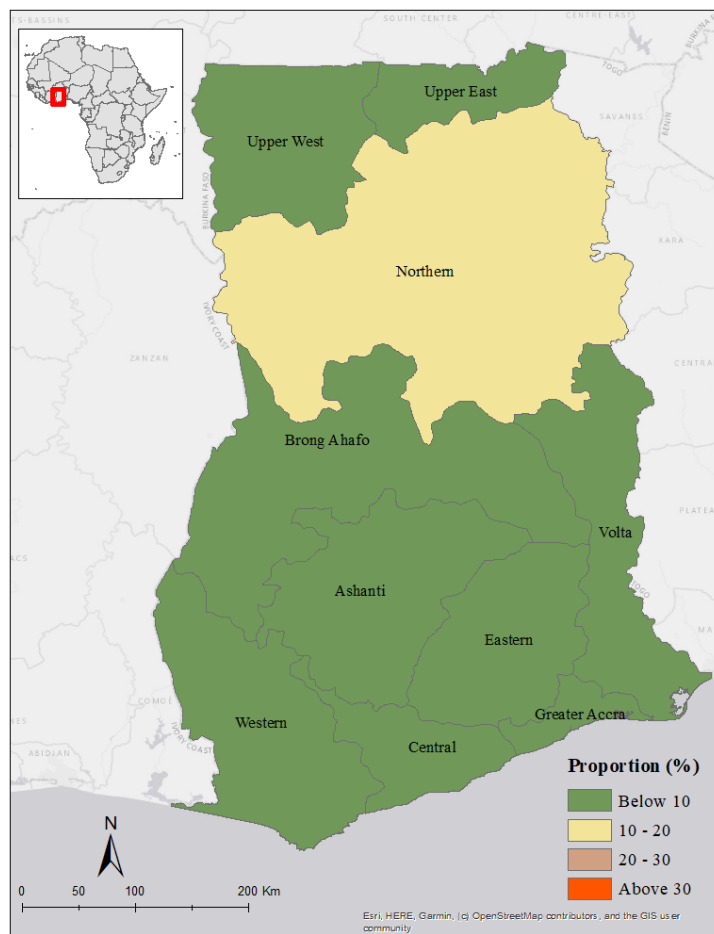


## Anemic mothers with stunted children

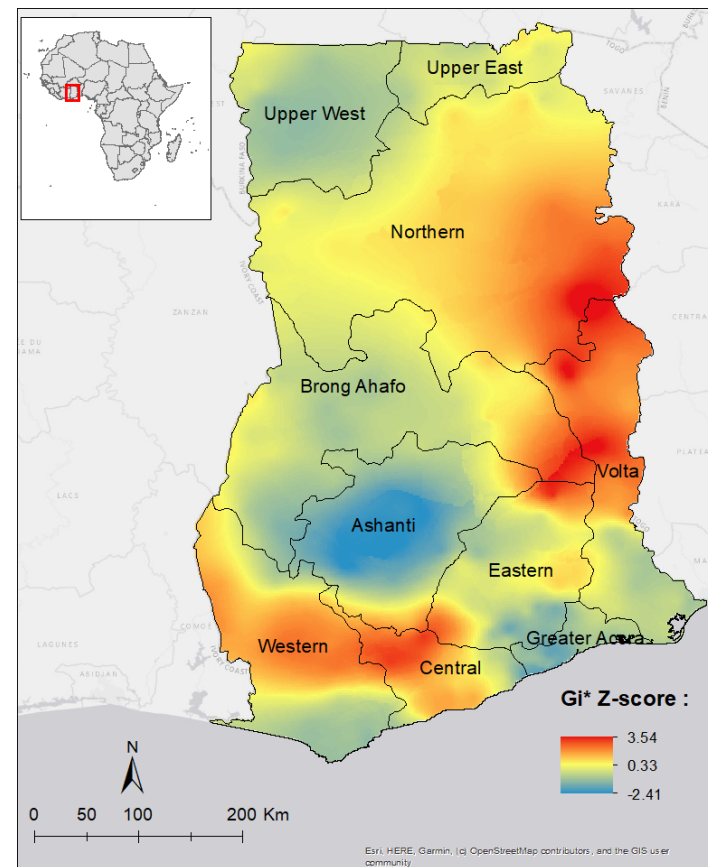


Overall, the proportion of mother-child pairs with a stunted child and an anemic mother is low. However, significant clustering of high prevalence areas was detected in the East and in the Western and Central regions.

**Ghana : Anemic mothers with stunted children by region**



**Ghana : Hotspots/coldspots of anemic mothers with stunted children**

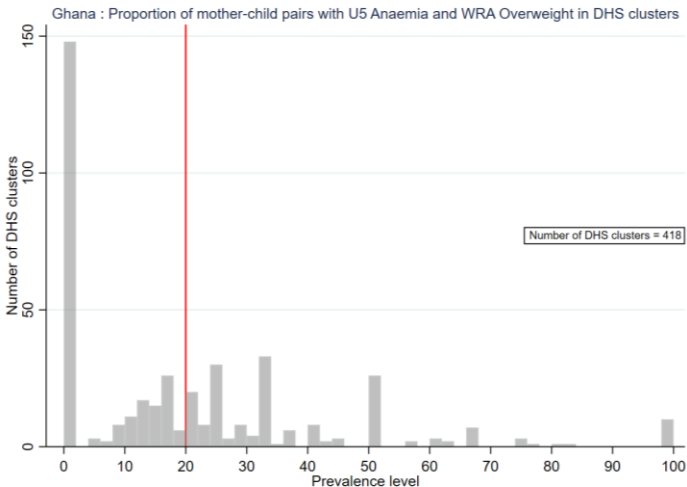




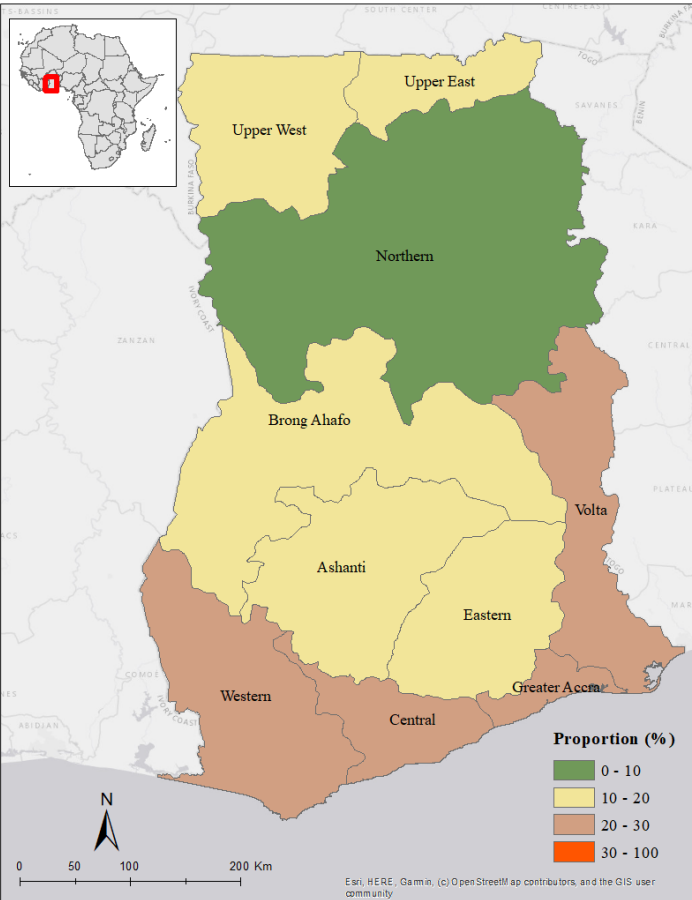
# Overweight/obese mothers with anemic children



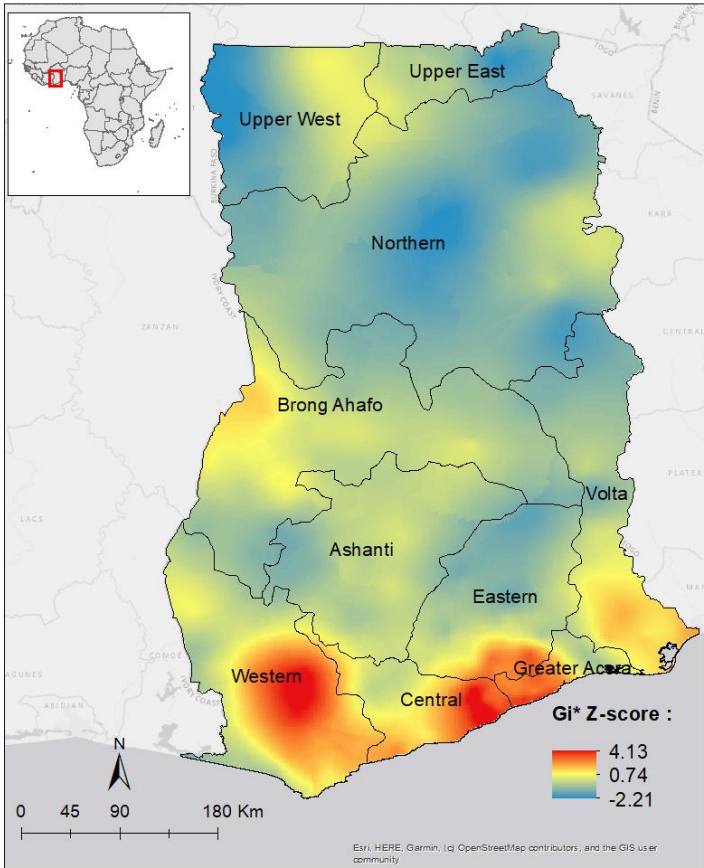
There is a higher proportion of mother-child pairs that experience a double burden of malnutrition (child anemic and mother overweight or obese) in the Volta, Greater Accra, Central and Western regions. This is confirmed by the hotspot analysis.



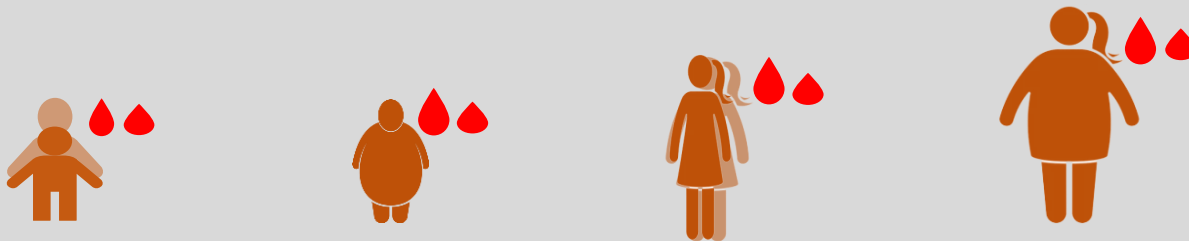
Ghana : Overweight/obese mothers with anemic children by region



Ghana : Hotspots/coldspots of overweight/obese mothers with anemic children



# Co-occurrence of multiple malnutrition types within the same individual (U5, WRA)



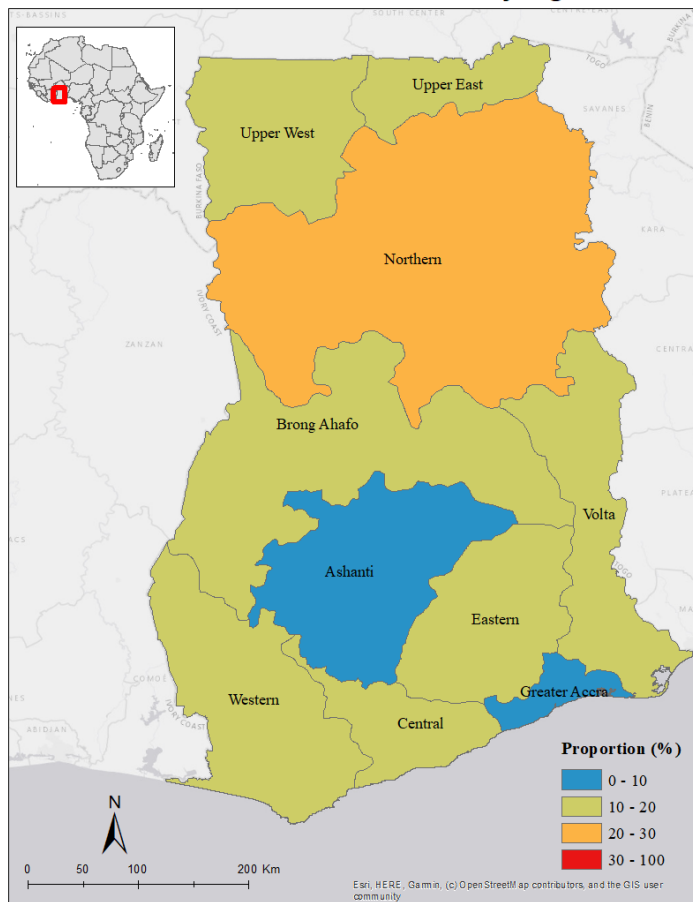


## Stunted and anemic children

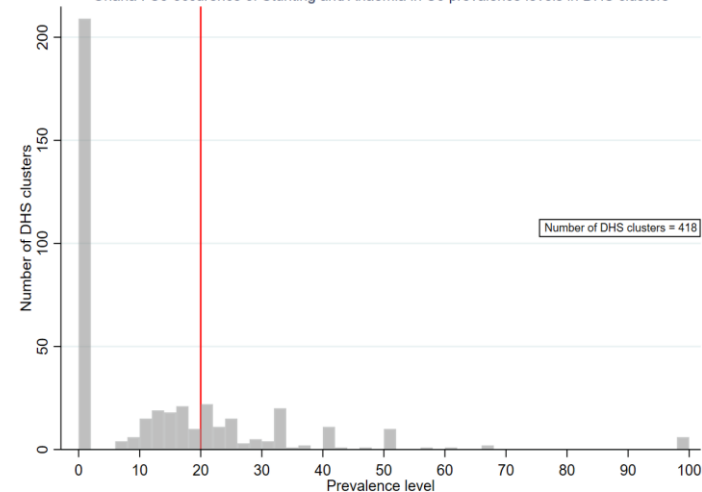


A significant clustering of areas with a high proportion of children both stunted and anemic was found in the Northern region (27% of U5 children in this region). A similar pattern was found in the Central region, to a lesser extent (16% of U5 in this region).

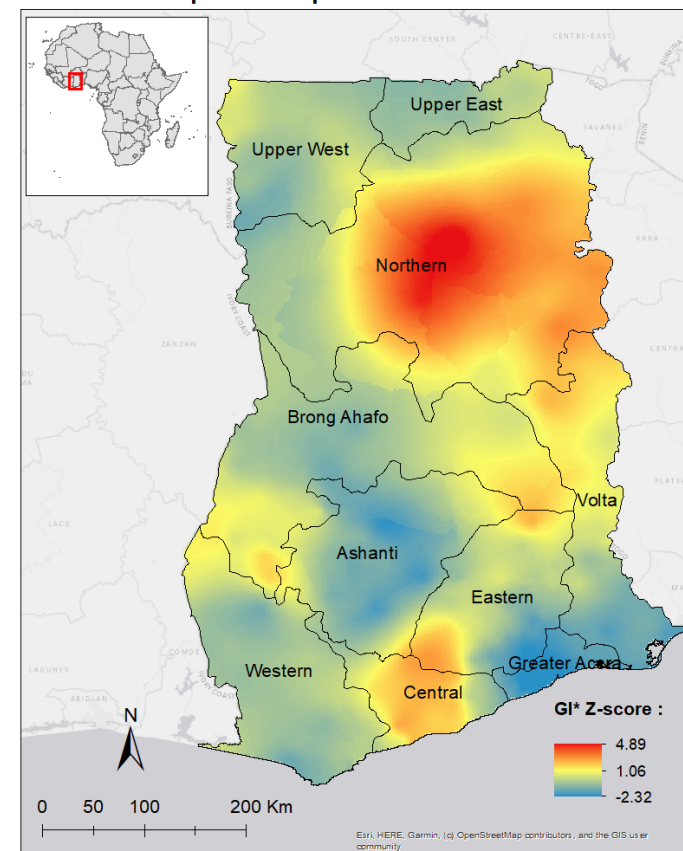
**Ghana : stunted and anemic U5 by region**



Ghana : Co-occurrence of Stunting and Anaemia in U5 prevalence levels in DHS clusters



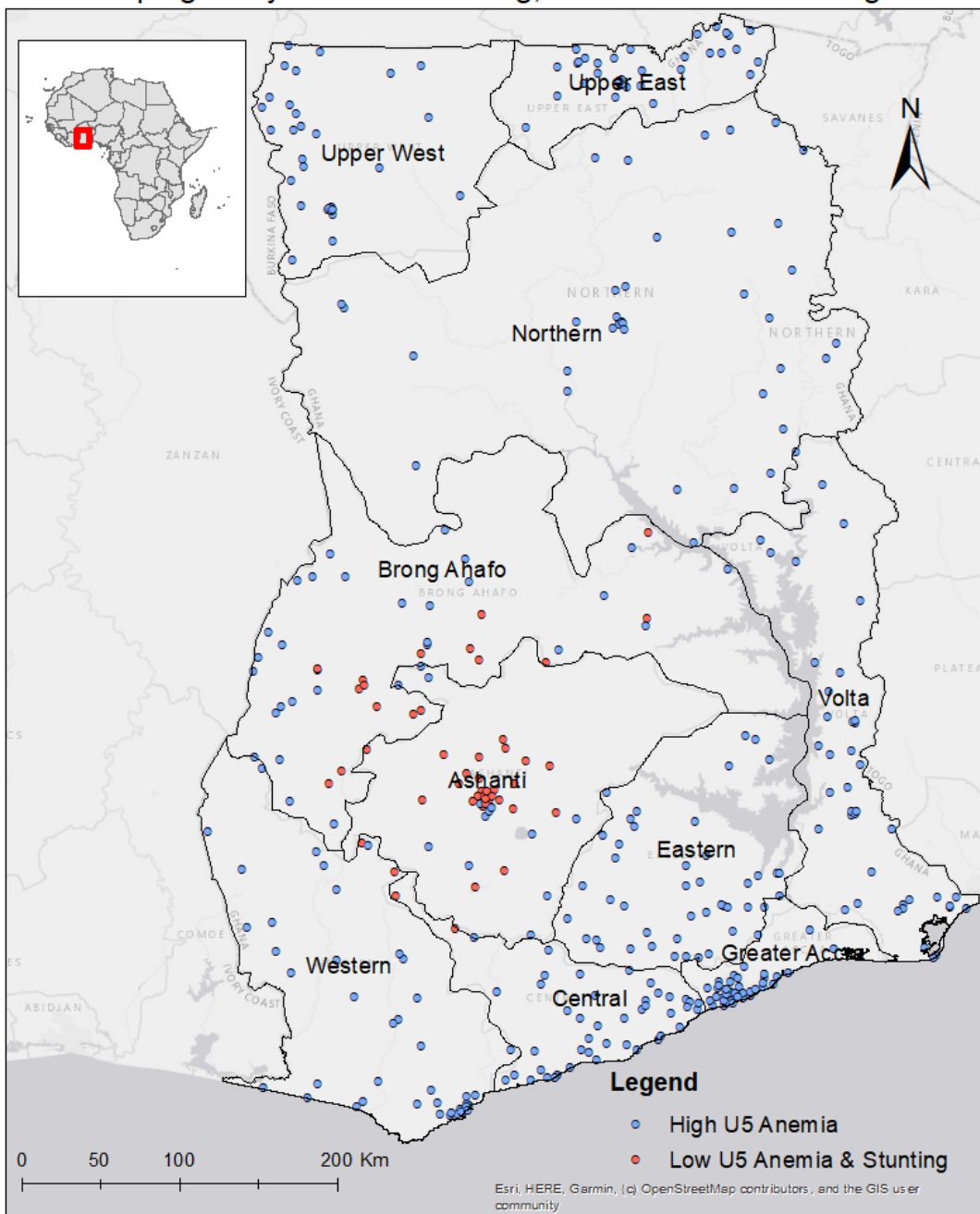
**Ghana : Hotspots/coldspots of stunted and anemic U5**



# Grouping analysis of U5 and WRA malnutrition

(back to [Results for Ghana](#))

## Ghana Grouping analysis of U5 Stunting, Anaemia and Overweight



## Grouping analysis – U5



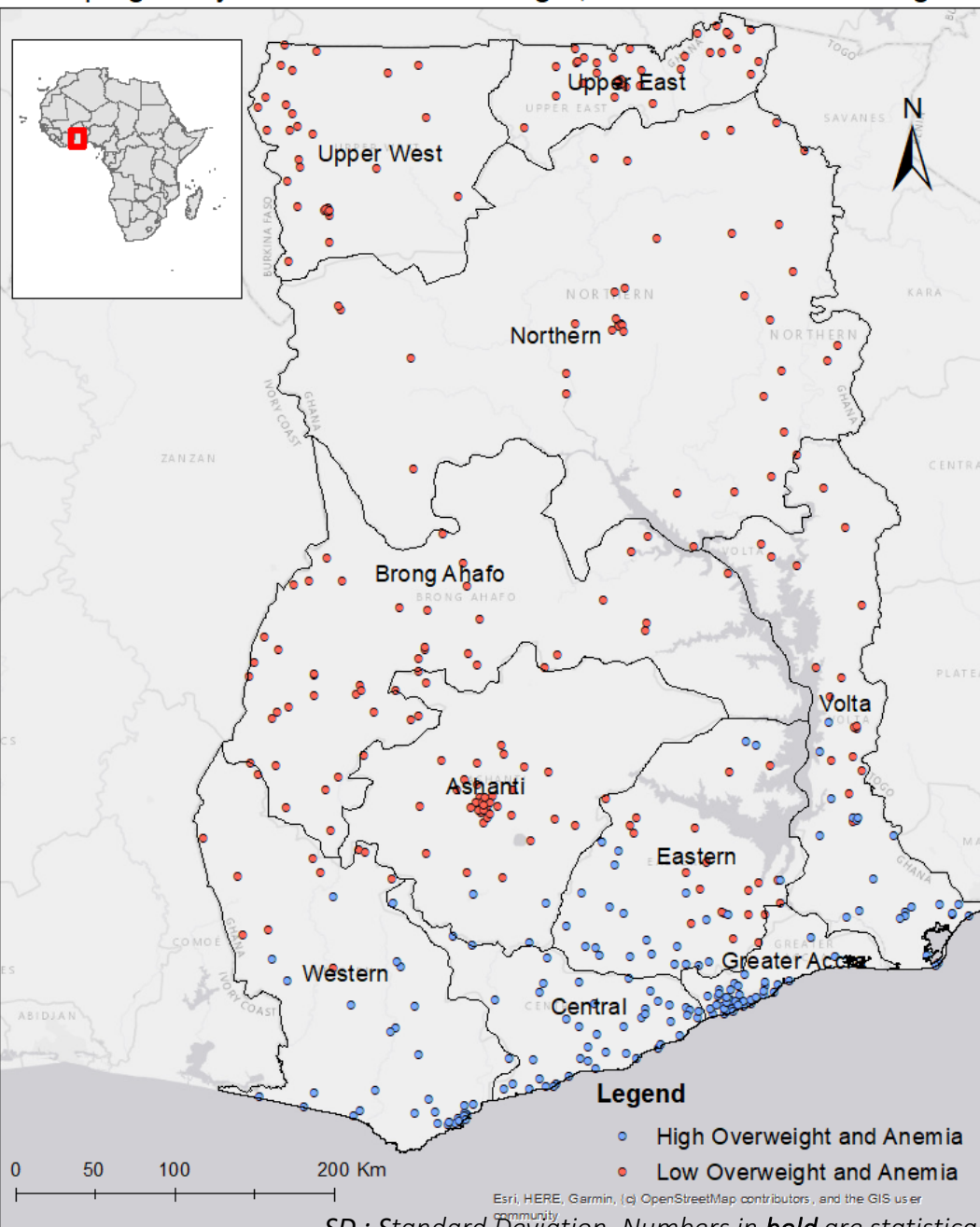
The grouping analysis of U5 malnutrition shows that, in Ghana, there are two groups of areas. The areas identified by the **blue** dots (clusters) are characterized by high levels of anemia in children under the age of five. The areas identified by the **red** dots (clusters), located in the Ashanti and Brong Ahafo regions, are characterized by low levels of anemia (significantly lower than the national average) and stunting.

Malnutrition type	Mean $\pm$ SD
<b>Overall (n=414)</b>	
U5 anemia	66 $\pm$ 27
U5 Stunting	18 $\pm$ 20
U5 Overweight/Obesity	1.3 $\pm$ 5.8
<b>Blue group (n = 359)</b>	
U5 anemia	69 $\pm$ 25
U5 Stunting	19 $\pm$ 20
U5 Overweight/Obesity	1.3 $\pm$ 5.4
<b>Red group (n=55)</b>	
U5 anemia	43 $\pm$ 26
U5 Stunting	11 $\pm$ 18
U5 Overweight/Obesity	1.8 $\pm$ 7.7

***n*** ***bold*** are statistically significantly different from the mean.

# Ghana

## Grouping analysis of WRA Underweight, Anaemia and Overweight



## Grouping analysis - WRA :



The grouping analysis on WRA malnutrition detected two types of clusters in Ghana. The first group of clusters (**blue**) is mainly located in the south and is characterized by high levels of anemia and overweight in Women of Reproductive Age. The second group of clusters (**red**), located in the upper part of the country is characterized by lower levels of anemia and overweight.

Malnutrition type	Mean $\pm$ SD
<b>Overall (n=414)</b>	
WRA anemia	22 $\pm$ 15
WRA Thinness	5.9 $\pm$ 7.7
WRA Overweight	19 $\pm$ 11
<b>Blue group (n = 172)</b>	
WRA anemia	25 $\pm$ 15
WRA Thinness	5.4 $\pm$ 7.6
WRA Overweight	23 $\pm$ 11
<b>Red group (n=242)</b>	
WRA anemia	21 $\pm$ 14
WRA Thinness	6.2 $\pm$ 7.8
WRA Overweight	15 $\pm$ 11

SD : Standard Deviation. Numbers in **bold** are statistically significantly different from the mean.

# Spatial regression analysis of U5 and WRA malnutrition

(back to [Results for Ghana](#))

# Factors associated with hotspots of anemic mothers with anemic children

## *Summary of findings*

- **Indicator of interest:** an area (cluster) that is a hotspot of anemic mothers with an anemic child. i.e. in that area, the proportion of mother child pairs in which both the child and the mother suffer from anemia is significantly higher than what should be expected given the distribution of anemia in Ghana.
- Anemia in these areas was found to be related to malaria, as a highly significant association was found between past incidence of malaria in the area and a hotspot of U5 and WRA anemia.
- The size of the households in which these mother-child pairs lived, and practice open defecation in the area seemed to be positively associated with the probability that both the mother and the child suffered from anemia.
- Mother-child pairs in which the child was a girl and the mother had problems accessing a medical facility had a higher probability of both mother and child suffering from anemia.

# Factors associated with hotspots of anemic mothers with anemic children

## *Results of regression model*

---

Log likelihood = -43.79

---

Number of obs	=	414
LR chi2(24)	=	0
Prob > chi2	=	0.000
Pseudo R2	=	0.67

Hotspot	Odds Ratio	Std. Err.	z	P>z	[95% Conf.Interval]
Spatial lag	1.14	0.05	2.94	0.003	(1.04 - 1.25)
Average size of hoouseholds	1.34	0.05	2.95	0.003	(1.1 - 1.7)
Open defecation practice	1.02	0.00	2.25	0.024	(1.002 - 1.03)
Women working	1.02	0.01	1.86	0.062	(0.999 - 1.001)
Problem having access to medical facility	1.03	0.12	2.15	0.031	(1.002 - 1.05)
Proportion of girls in mother-child pairs	1.03	0.14	2.18	0.030	(1.002 - 1.06)
Proportion of rich households	0.99	0.00	-3.69	0.000	(0.98 - 0.99)

Sensitivity	80%
Specificity	99%
Positive predictive value	88%
Negative predictive value	98%
Correctly classified	97%

# Factors associated with hotspots of overweight/obese mothers with anemic children

## *Summary of findings*

- **Indicator of interest:** an area (cluster) that is a hotspot of overweight/obese mothers with anemic children .
- The anemia associated with this double burden in mother-child pairs is not associated with malaria.
- High rates of full DTP vaccination and piped water usage, bigger distance to cities of over 250,000 people were found to be protective factors from a hotspot of this double burden occurring in mother-child pairs.
- A high proportion of rich households and being a rural area seemed to be positively associated with being a hotspot of this double burden.
- Children belonging to mother-child pairs with a double burden of U5 anemia and WRA Overweight have a higher probability of having a minimum dietary diversity.

# Factors associated with hotspots of overweight/obese mothers with anemic children

## Summary of findings

Log likelihood = -93.830656

Number of obs	=	414
LR chi2(24)	=	256
Prob > chi2	=	0.000
Pseudo R2	=	0.577

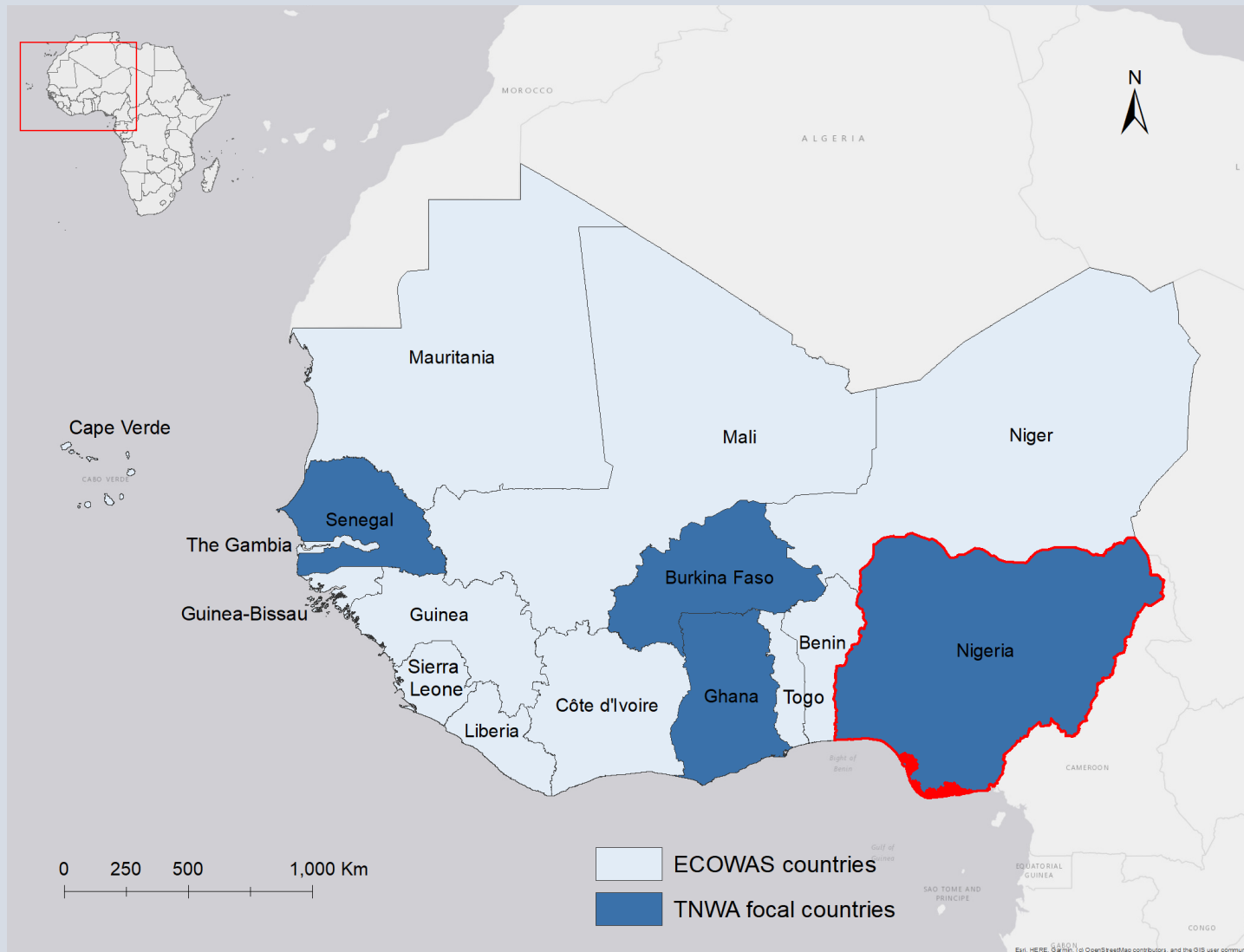
Hotspot	Odds Ratio	Std. Err.	z	P>z	[95% Conf.Interval]
Spatial lag	1.08	0.02	4.68	0.000	(1.04 - 1.11)
Proportion of rich households	1.03	0.01	3.78	0.000	(1.01 - 1.05)
Average incidence of malaria during previous years	10.1	.24	0.99	0.322	(0.10 - 983)
DPT full vaccination coverage	0.98	0.01	-2.54	0.011	(0.96 - 1)
Piped water usage	0.99	0.01	-2.08	0.038	(0.98 - 1)
Rural area	1.02	0.01	3.62	0.000	(1.01 - 1.04)
Minimum dietary diversity	1.03	0.01	4.02	0.000	(1.01 - 1.04)
Average distance to big cities (250K population)	0.17	0.06	-4.72	0.000	(0.08 - 0.35)
Length of growing period	0.95	0.01	-6.97	0.000	(0.94 - 0.96)

Sensitivity	72%
Specificity	96%
Positive predictive value	83%
Negative predictive value	92%
Correctly classified	90%

# Conclusions / Recommendations for Ghana

- In Ghana, most regions have a single burden of anemia in U5. The Central, Upper-West and Northern regions are facing burdens of U5 stunting and U5 anemia.
- The Greater Accra region is facing a double burden of anemia and overweight in U5 children.
- In the Northern, Central and Volta regions, at least one mother-child pair out of 5 is experiencing anemia in both the mother and the child.
- The Volta, Greater Accra, Central and Western regions have hotspots of a double burden of malnutrition (child anemic and mother overweight or obese) in mother-child pairs.
- In mother-child pairs where both children and mothers suffer from anemia, incidence of malaria in the area is the main factor associated with this.
- Interventions preventing malaria should help address the high proportion of mother-child pairs in which both mother and child suffer from anemia.
- This is not the case for mother-child pairs suffering from a double burden of U5 anemia and overweight, which is not associated with malaria but seems to affect rich households in rural settings.

# Nigeria



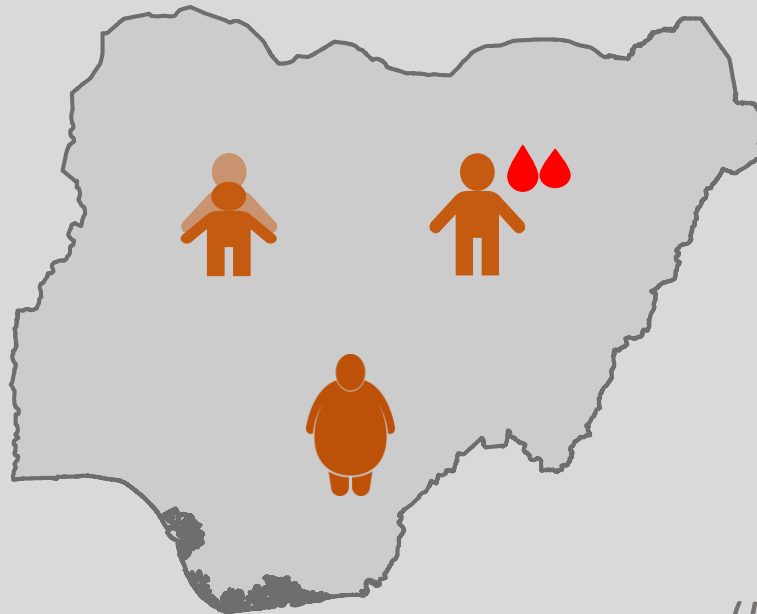
(back to [overview](#))

# Results for Nigeria

Single malnutrition types in Children under five years of age (U5) and Women of reproductive Age (WRA)	Grouping Analysis
<ul style="list-style-type: none"> <li>• <a href="#">U5 stunting</a></li> <li>• <a href="#">U5 anemia</a></li> <li>• <a href="#">WRA underweight/thinness</a></li> <li>• <a href="#">WRA anemia</a></li> <li>• <a href="#">WRA overweight/obesity</a></li> </ul>	<ul style="list-style-type: none"> <li>• <a href="#">Stunting, anemia and overweight among U5</a></li> <li>• <a href="#">Stunting, anemia and overweight among WRA</a></li> </ul>
Co-occurrence of different types of malnutrition in U5 and WRA	Regression Analysis
<ul style="list-style-type: none"> <li>• Within regions:               <ul style="list-style-type: none"> <li>- <a href="#">Stunting, anemia, and overweight/obesity among U5</a></li> <li>- <a href="#">Thinness, anemia, and overweight/obesity among WRA</a></li> </ul> </li> <li>• Within households (mother-child pairs):               <ul style="list-style-type: none"> <li>- <a href="#">U5 anemia &amp; WRA anemia</a></li> <li>- <a href="#">U5 stunting &amp; WRA anemia</a></li> <li>- <a href="#">U5 stunting &amp; WRA underweight/thinness</a></li> <li>- <a href="#">U5 anemia &amp; WRA overweight/obesity</a></li> <li>- <a href="#">U5 stunting &amp; WRA overweight/obesity</a></li> </ul> </li> <li>• Within the same individual:               <ul style="list-style-type: none"> <li>- <a href="#">Stunting and anemia (U5)</a></li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>• <a href="#">U5 anemia and WRA overweight/obesity</a></li> <li>• <a href="#">U5 anemia and U5 stunting</a></li> </ul>

# Single malnutrition types for U5

Stunting - Anemia - Overweight/obesity

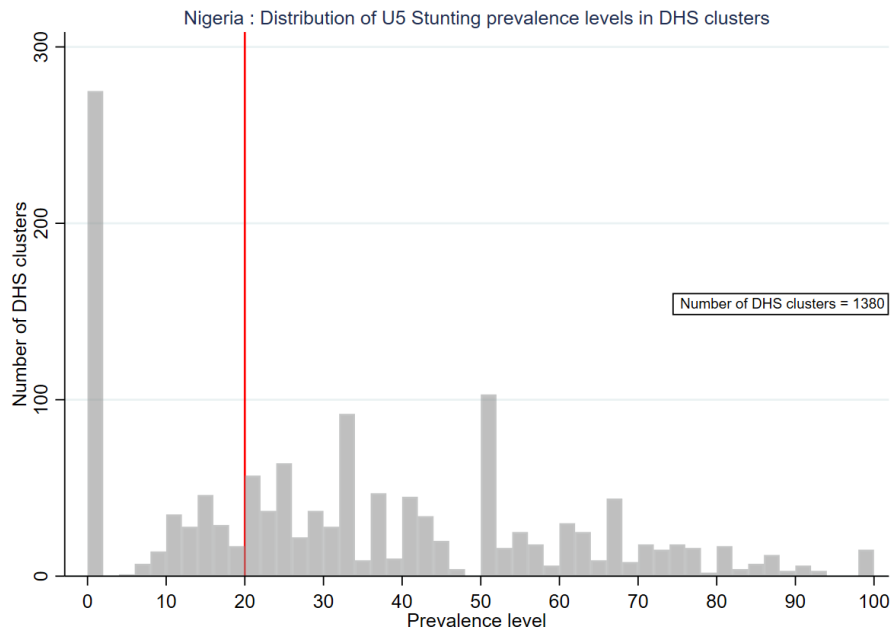


(back to [Results for Nigeria](#))

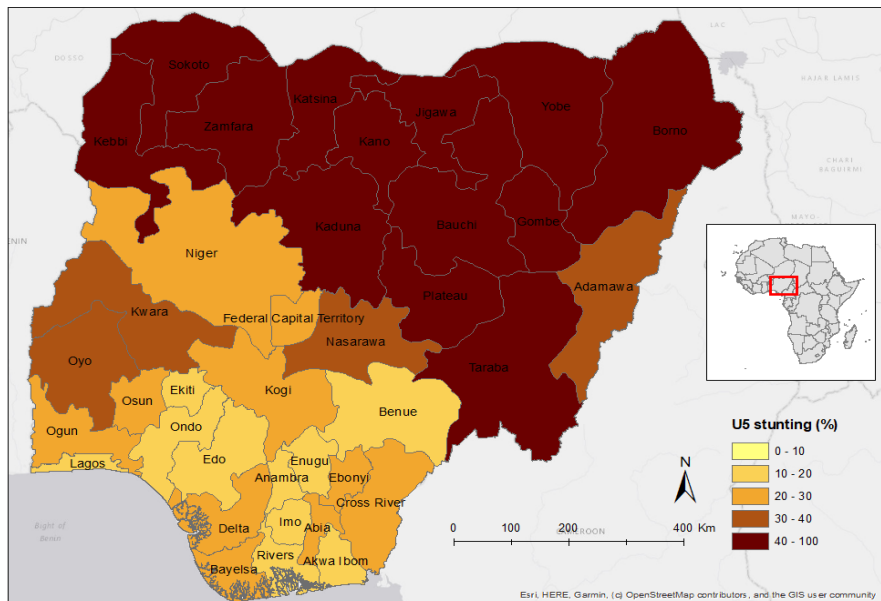


## U5 Stunting

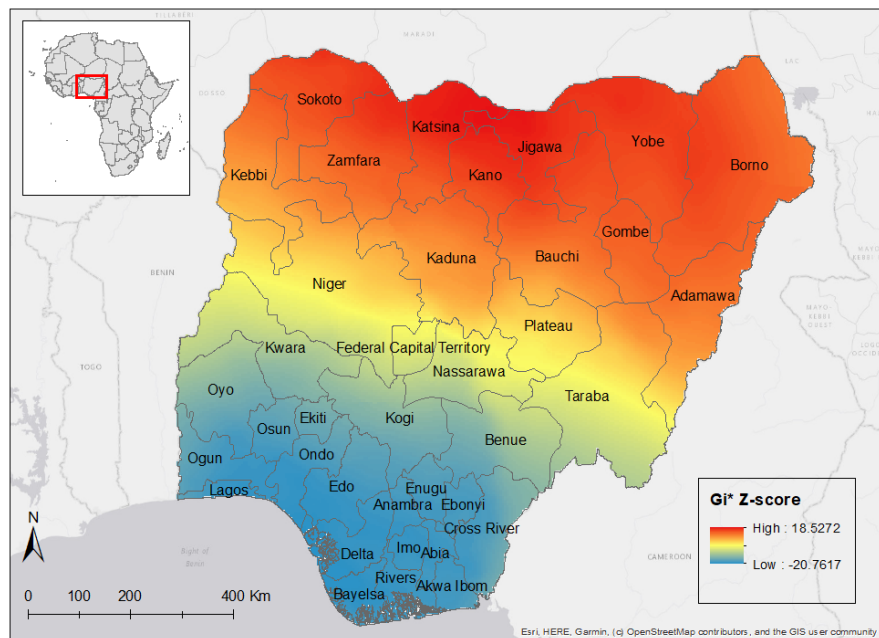
There is a high prevalence of U5 stunting (above 40% of U5) in northern states, confirmed by the hotspot analysis that shows **hotspots** in the north and **cold spots** in the south of the country.



## Nigeria – U5 stunting by region



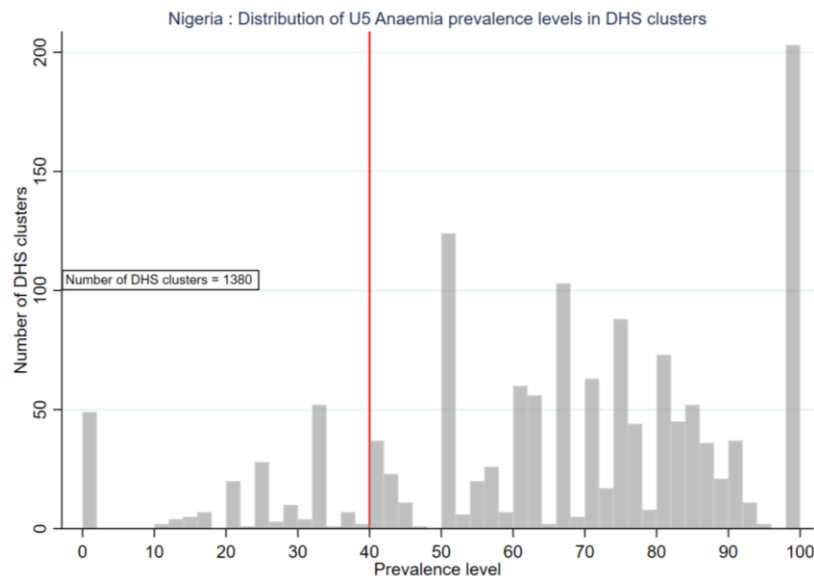
## Nigeria – Hotspots/coldspots of U5 stunting



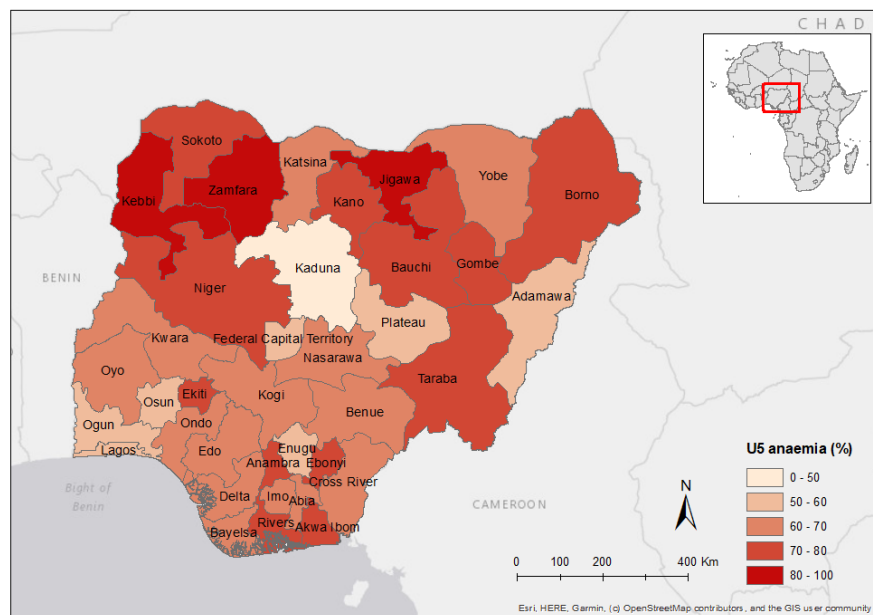


## U5 Anemia

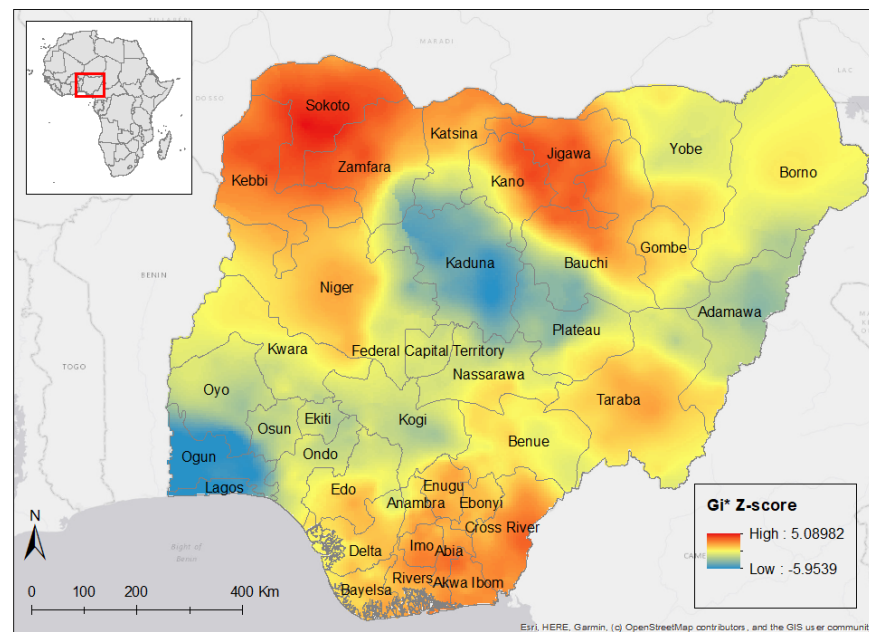
U5 anemia prevalence is over 60% in the majority of states, with rates over 70% and 80% in several states in the northern and southeastern part of the country. The hotspot analysis reflects these high burdens in the **hotspots**, with **cold spots** in Kaduna and the very southwestern part of the country (Lagos).



Nigeria – U5 anemia by region

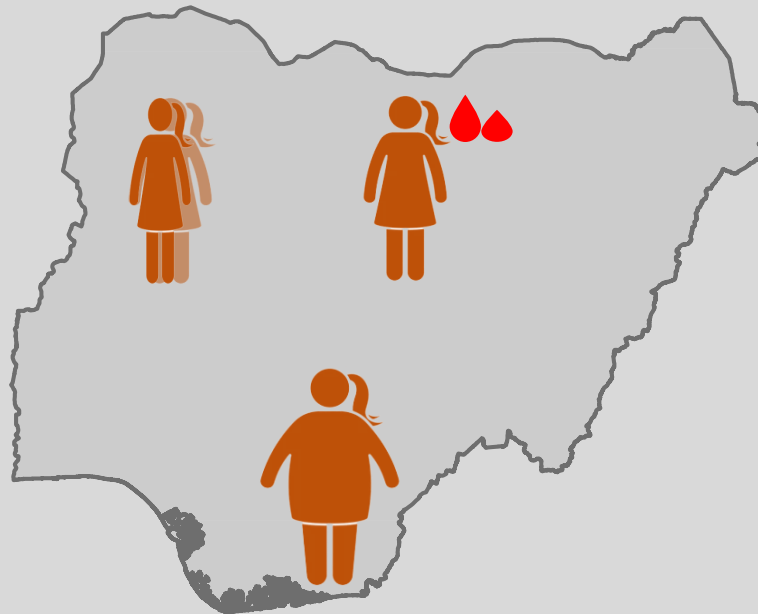


Nigeria – Hotspots/coldspots of U5 anemia



## Single malnutrition types for WRA

Underweight/thinness - Anemia - Overweight/obesity



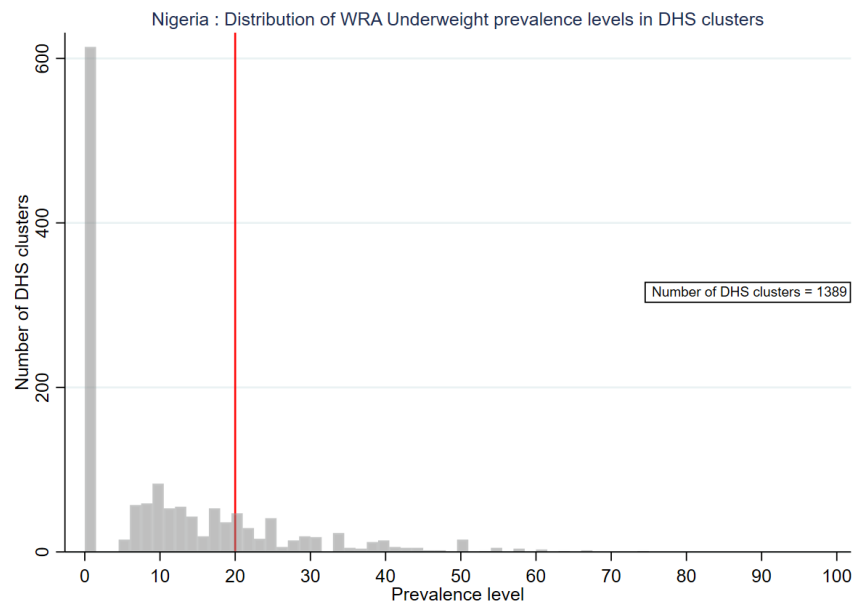
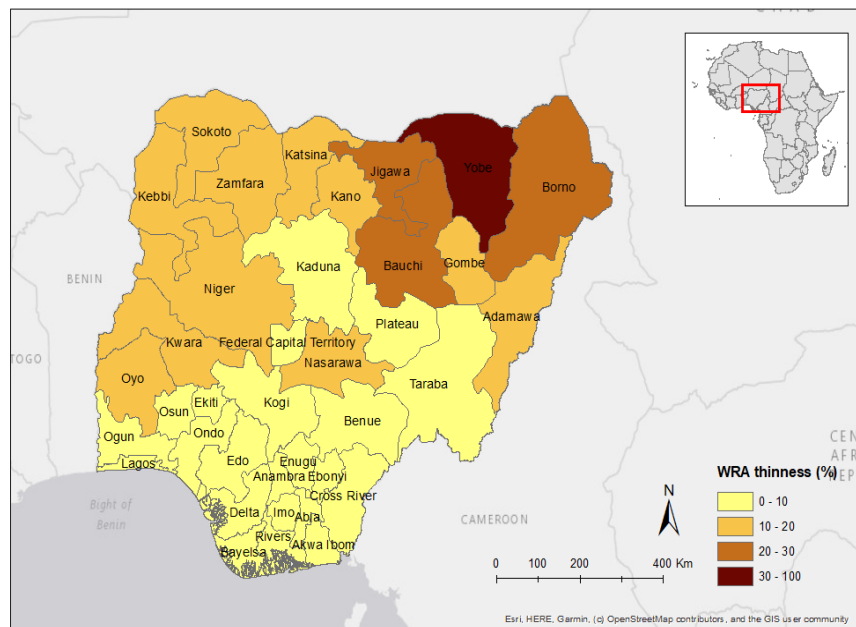
(back to [Results for Nigeria](#))



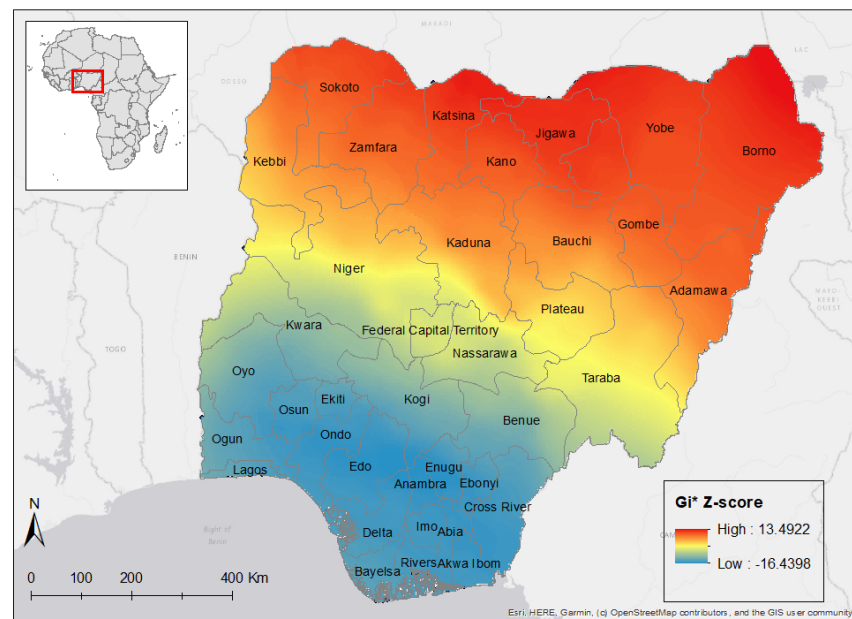
## WRA underweight/thinness

WRA underweight/thinness is under 20% in most states, although Jigawa, Borno, and Bauchi states have prevalence of 20-30% and Yobe state has a prevalence of over 30%. The hotspot analysis shows **hotspots** in the northern part of the country and **cold spots** in the south of the country.

Nigeria – WRA underweight/thinness by region



Nigeria – Hotspots/coldspots of WRA underweight/thinness

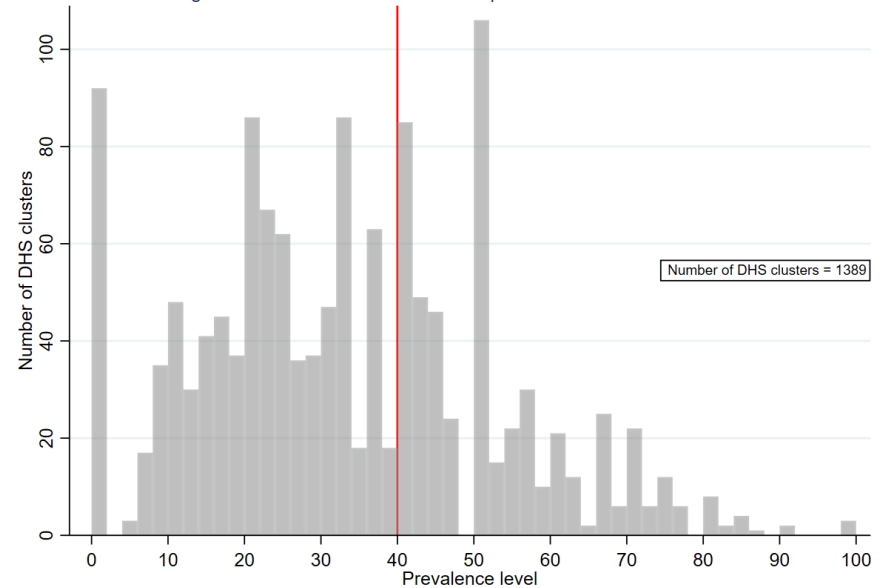




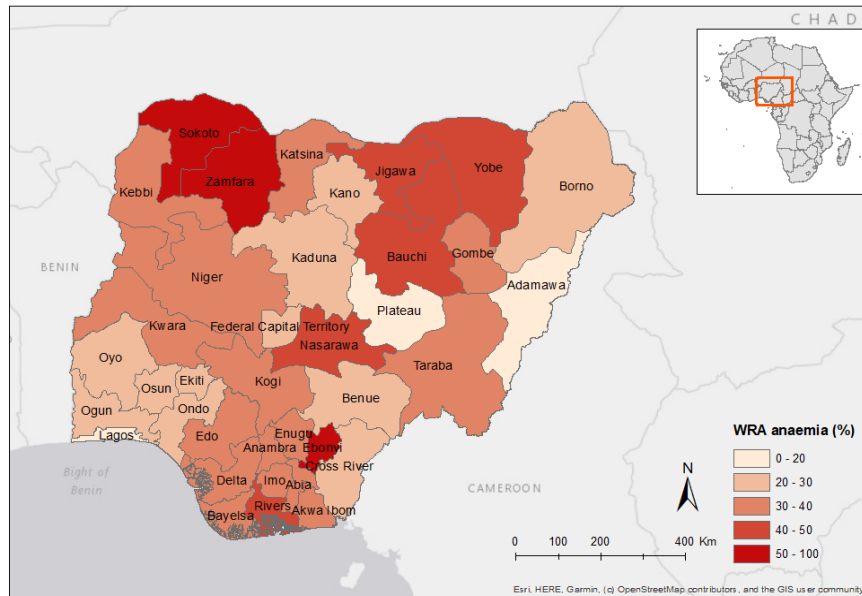
## WRA anemia

WRA anemia prevalence is over 30% in many states, but particularly high in Sokoto, Zamfara, and Ebonyi states (over 50%), as well as in Jigawa, Yobe, Bauchi, Nasarawa, and Rivers (over 40%), which translates into significant **hotspots** in the North and the south. Similar to U5 anemia, there are **cold spots** in the central and western states.

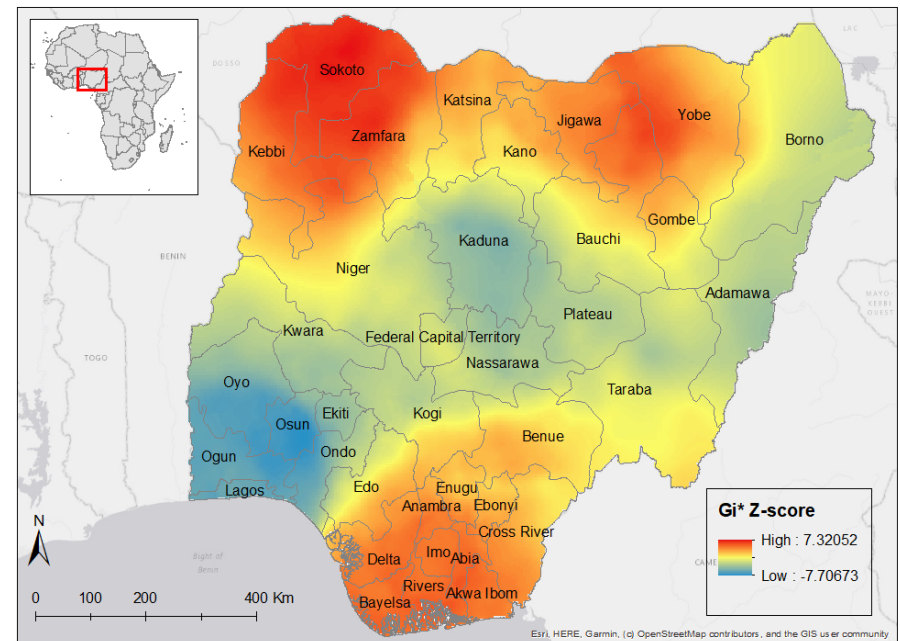
Nigeria : Distribution of WRA Anaemia prevalence levels in DHS clusters



Nigeria – WRA anemia by region



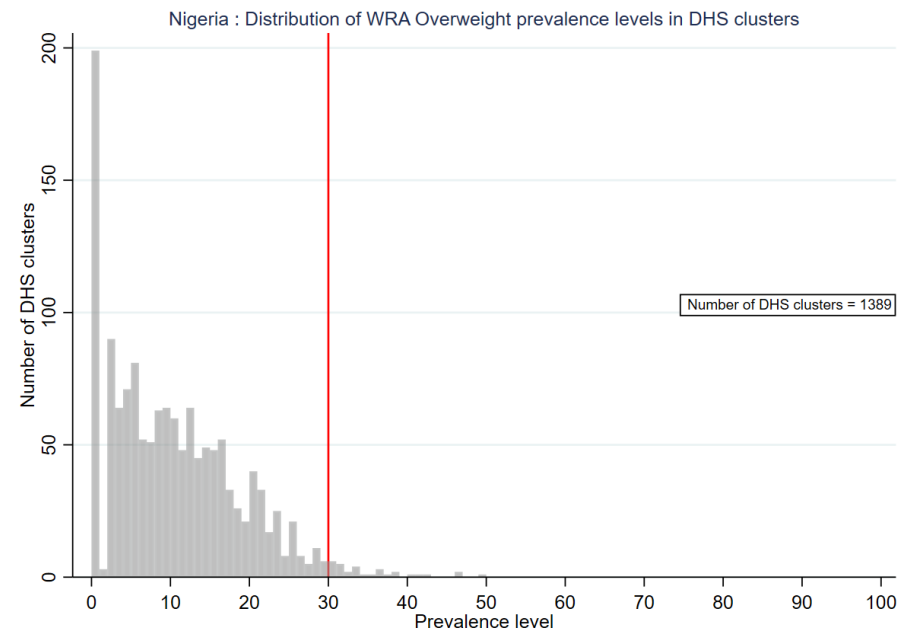
Nigeria – Hotspots/coldspots of WRA anemia



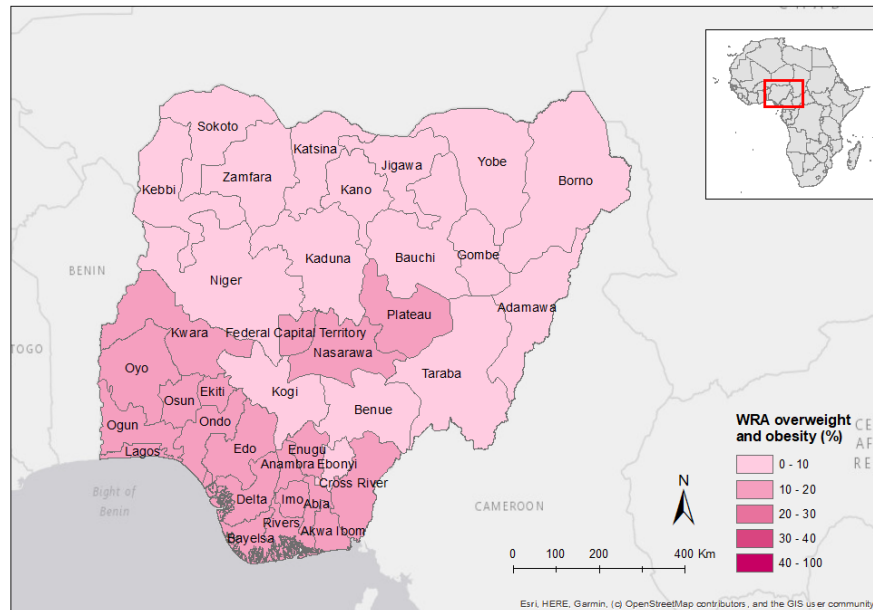


## WRA overweight/obesity

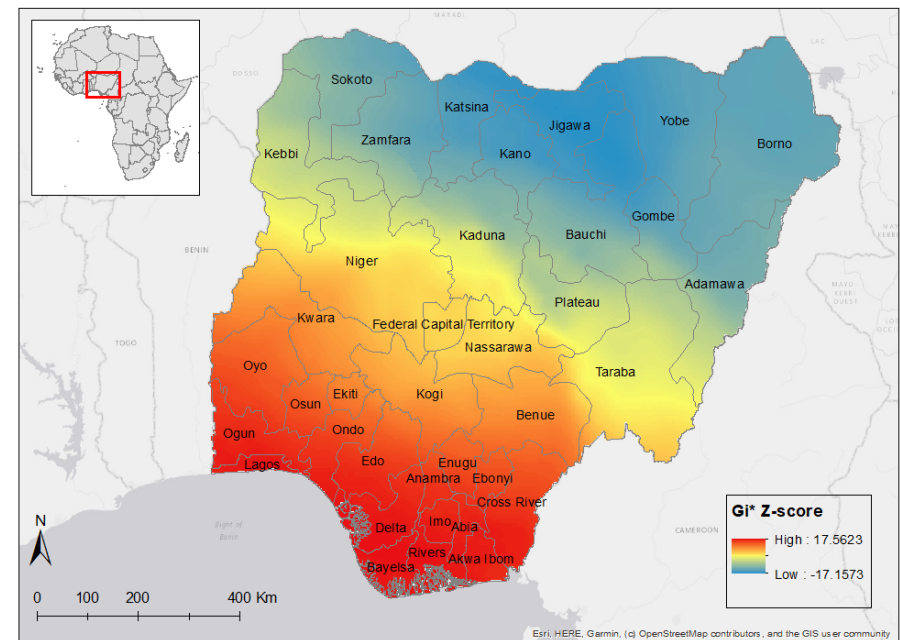
Prevalence level is lower than 20% overall, but there are some differences between southern and northern states, with southern states experiencing **hotspots** of overweight/obesity and northern states experiencing **cold spots**.



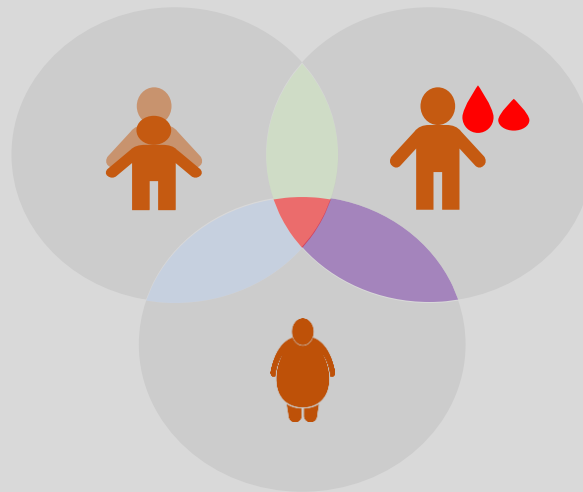
### Nigeria – WRA overweight/obesity by region



### Nigeria – Hotspots/coldspots of WRA overweight/obesity



# Co-occurrence of malnutrition types within the same location



(back to [Results for Nigeria](#))

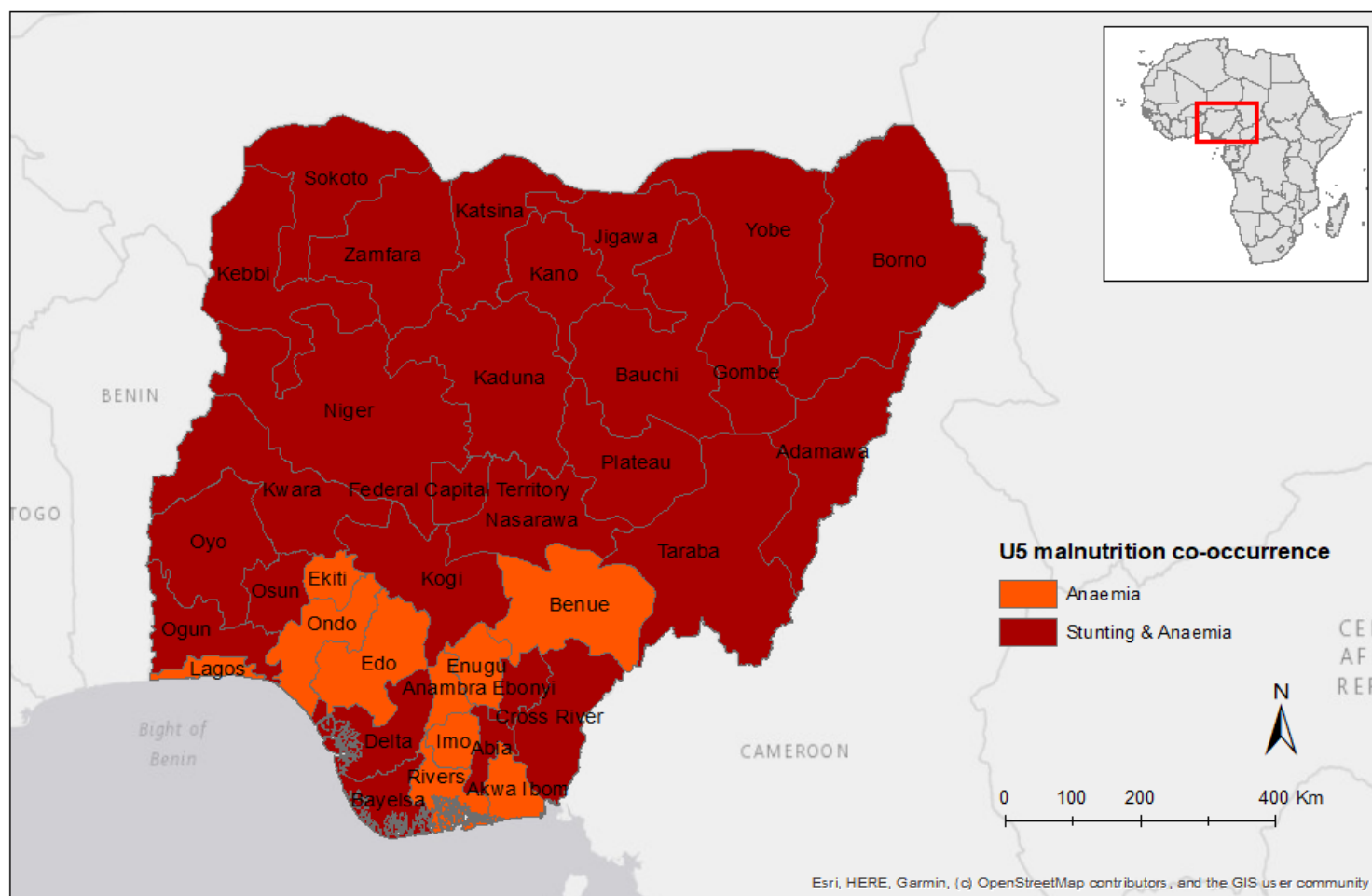
## Co-occurrences in the same states (U5)

Most states have both U5 stunting and U5 anemia, apart from several states in the south that have U5 anemia only. No co-occurrence was found with these malnutrition types and overweight/obesity (of above 3%) in the same state.

**Thresholds used:** Stunting: 20% and up; Anemia: 40% and up; Overweight/obesity: 3% and up

### Nigeria

#### Co-occurrences of multiple malnutrition types in under-fives by region



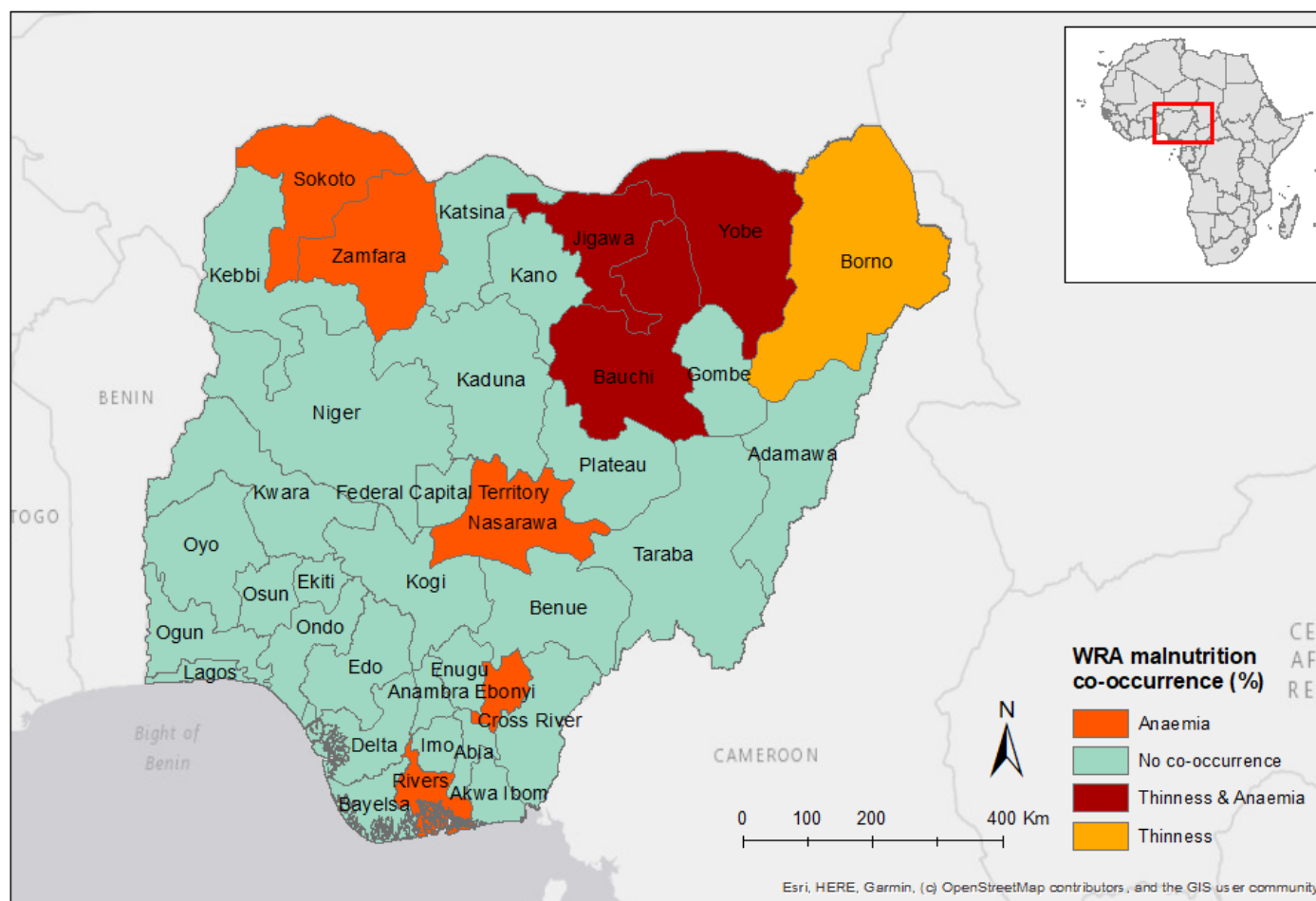
## Co-occurrences in the same states (WRA)

For WRA, there is mostly no co-occurrence of malnutrition types, although several, mostly in the north, face anemia, thinness & anemia, and thinness only. No co-occurrence was found of these malnutrition types with overweight/obesity (of over 30%) in the same state.

**Thresholds used:** Thinness: 20% and up; Anemia: 20% and up; Overweight/obesity: 30% and up

### Nigeria

#### Co-occurrences of multiple malnutrition types in WRA by region



# Co-occurrence of malnutrition types within the same household (mother-child pairs)



(back to [Results for Nigeria](#))



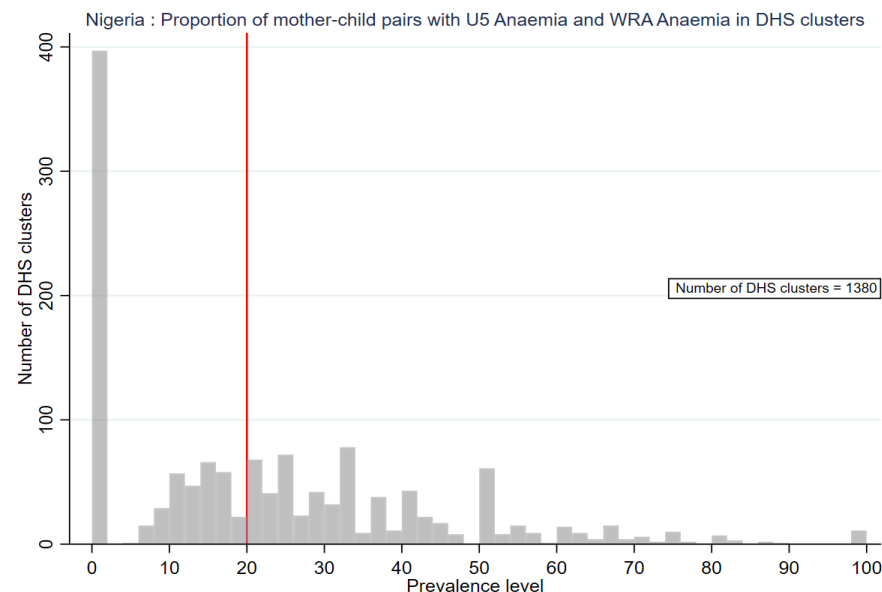
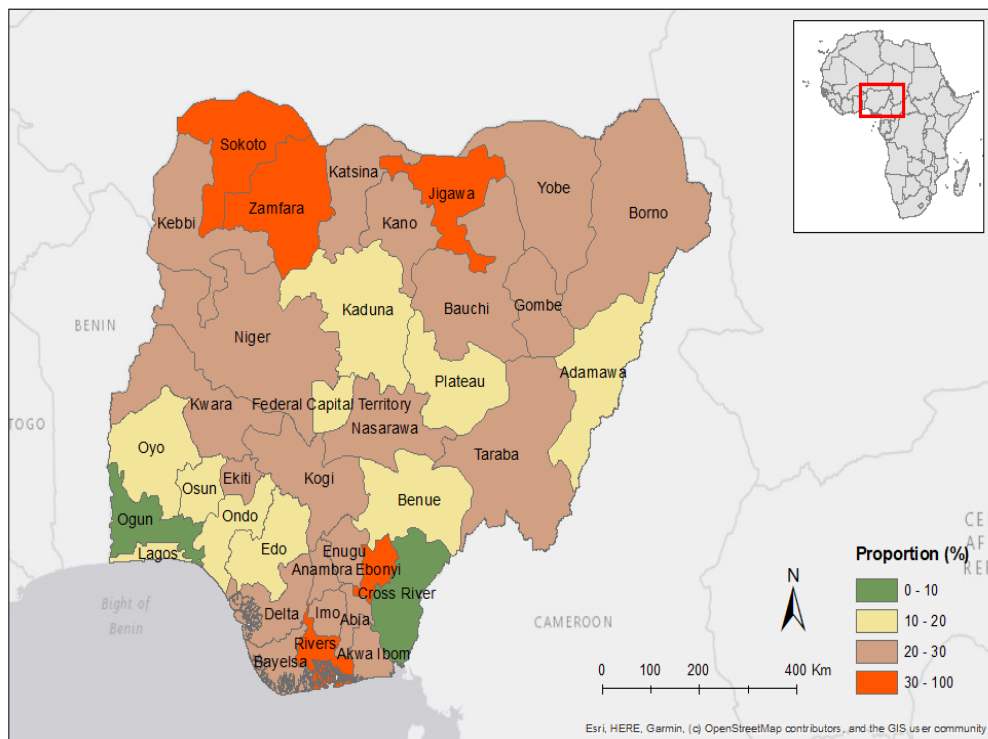
## Anemic mothers with anemic children



In the majority of states, over 20% of mother-child pairs experience anemia, with some variation across the country.

However, no significant spatial clusters were detected.

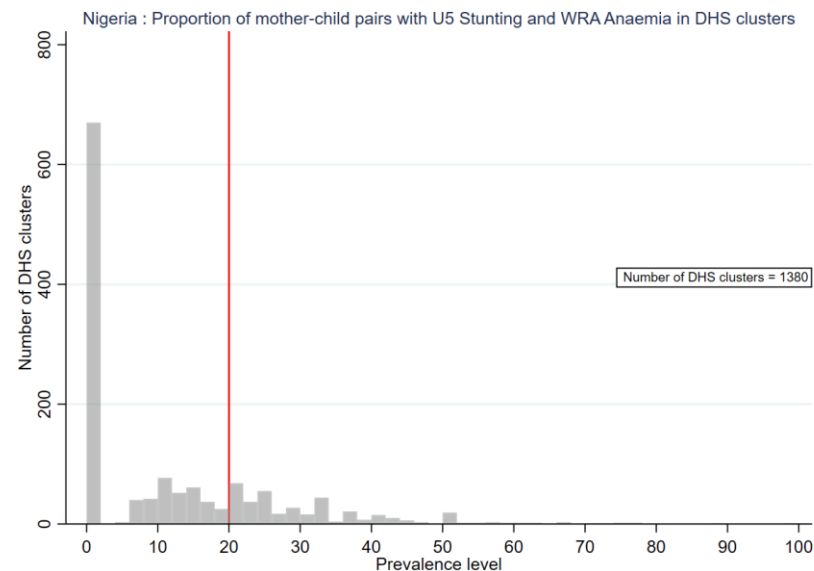
### Nigeria – Anemic mothers with anemic children by region



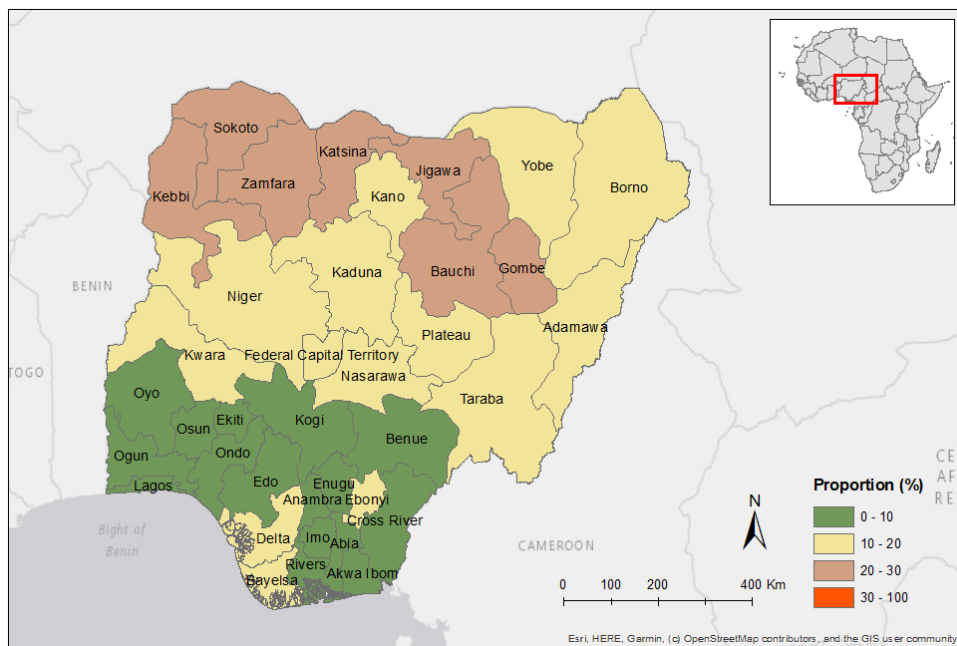
# Anemic mothers with stunted children

In the majority of states, less than 10% of mother-child pairs experience U5 stunting with WRA anemia, except in northern states where between 10-30% of pairs experience this co-occurrence.

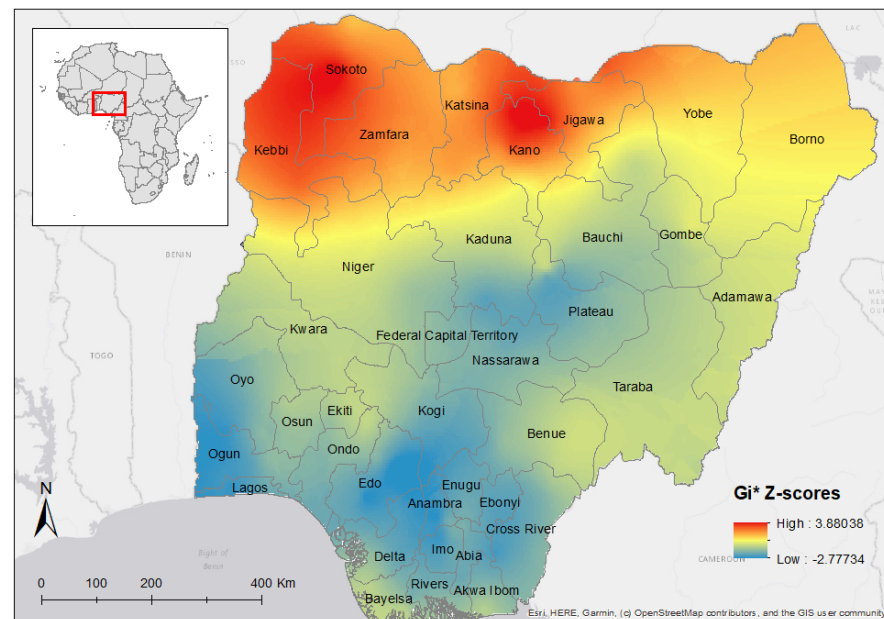
The hotspot analysis shows **hotspots** in the northwest and **cold spots** in the central and southern parts of the country.



## Nigeria – Anemic mothers with stunted children by region



## Nigeria – Hotspots/coldspots of anemic mothers with stunted children



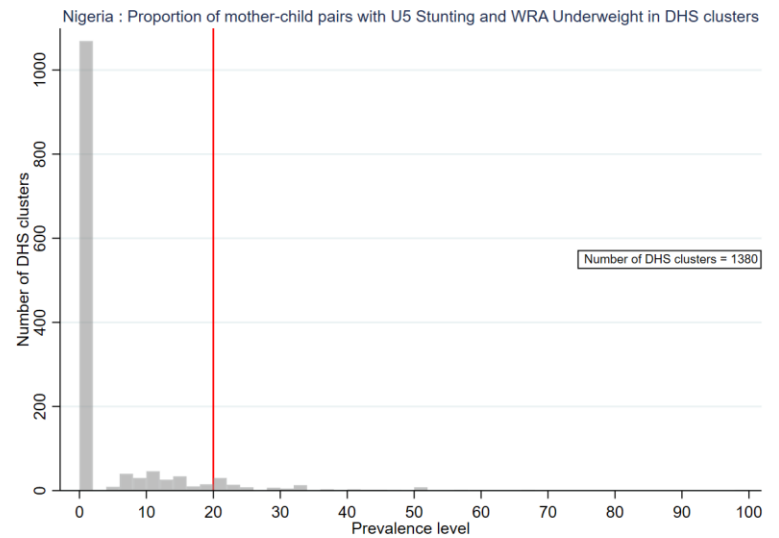


## Underweight/thin mothers with stunted children



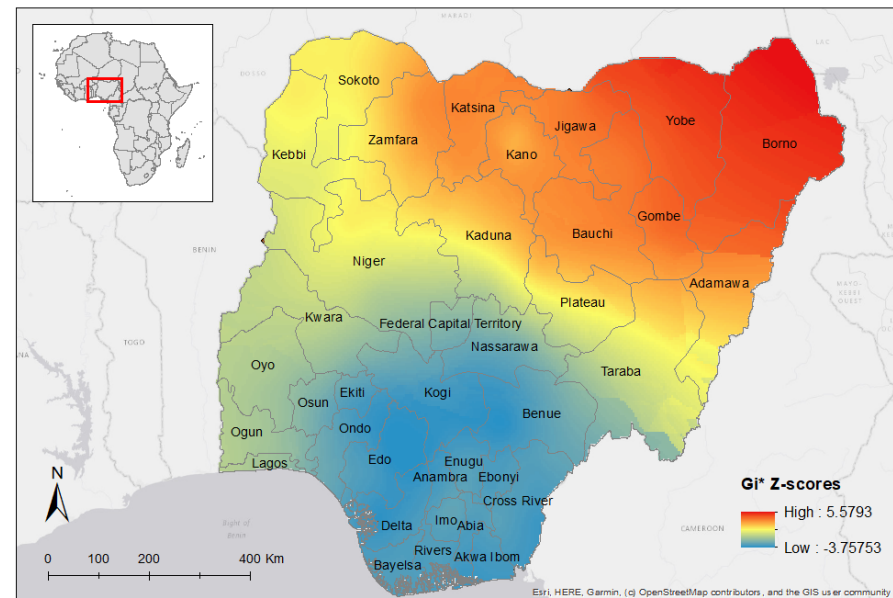
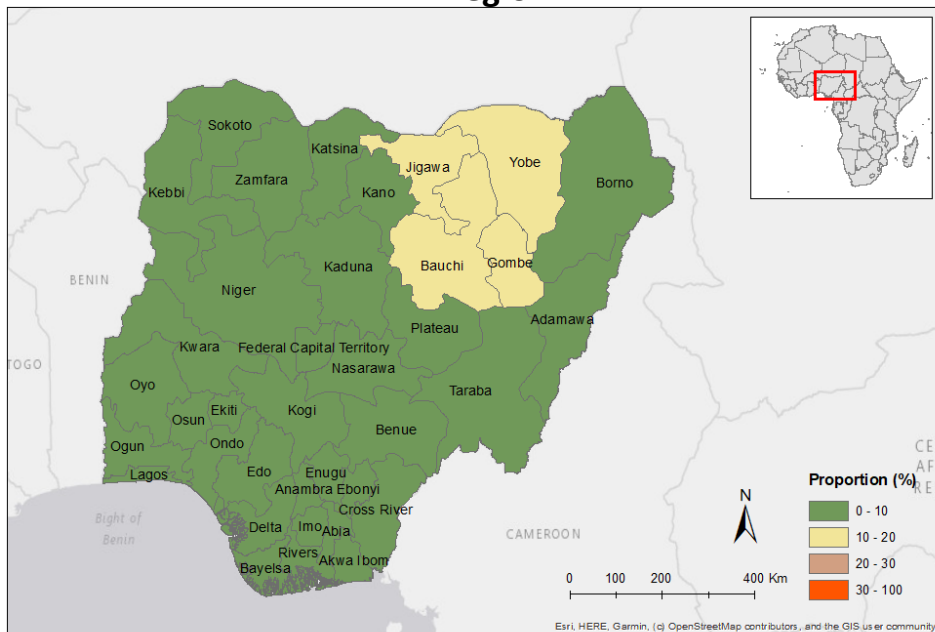
Proportion of mother-child pairs with a stunted child and an underweight/thin mother is 10-20% in 4 northern states (Jigawa, Yobe, Gombe, and Bauchi).

The hotspot analysis confirms this, with **hotspots** in these 4 states but also across Borno, Kano and Katsina, and **cold spots** in the southern states.



## Nigeria – Underweight/thin mothers with anemic children by region

## Nigeria – Hotspots/coldspots of underweight/thin mothers with stunted children

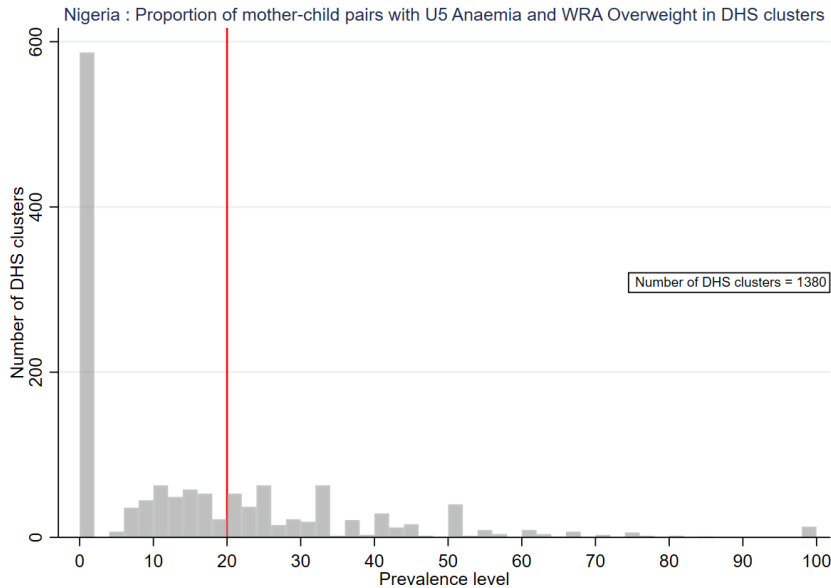




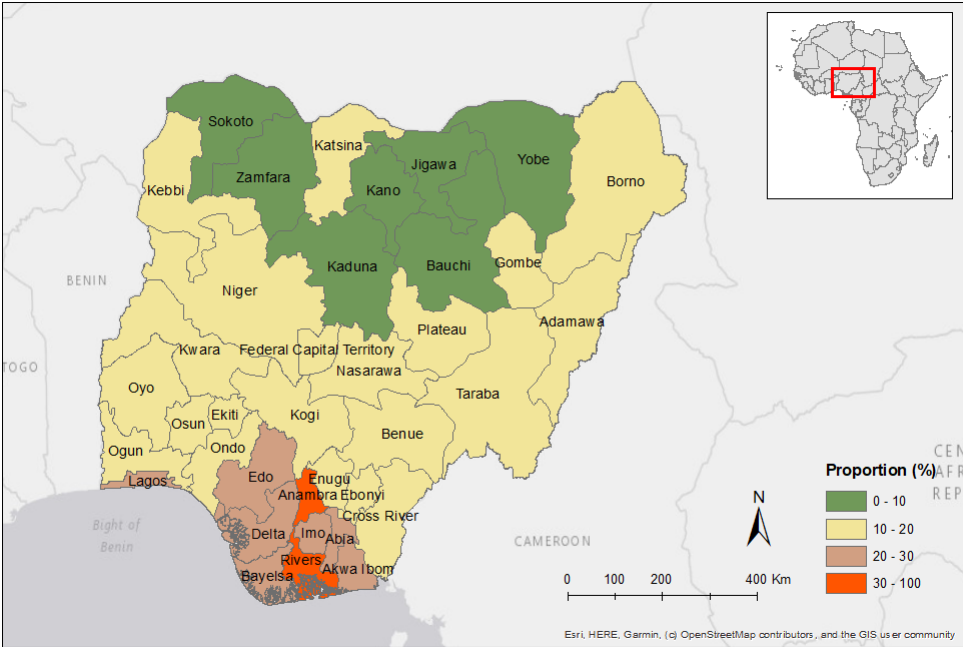
# Overweight/obese mothers with anemic children

In the majority of states, 10-20% of mother-child pairs experience U5 anemia with WRA overweight, but this is more pronounced in southern states (20% and up).

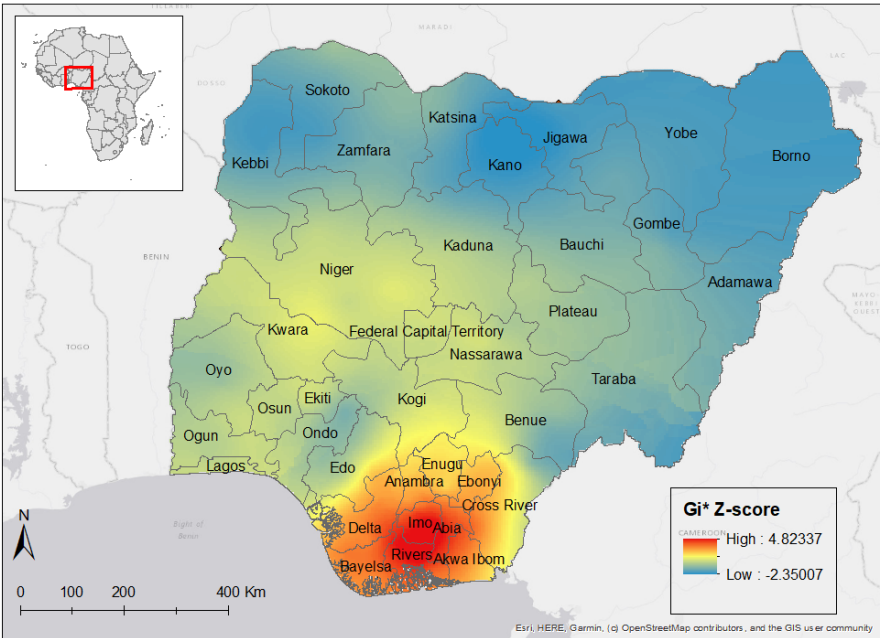
The hotspot analysis similarly shows a pronounced **hotspot** of mother (overweight)-child (anemic) pairs in the south.



Nigeria – overweight/obese mothers with anemic children by region



Nigeria – Hotspots/coldspots of overweight/obese mothers with anemic children





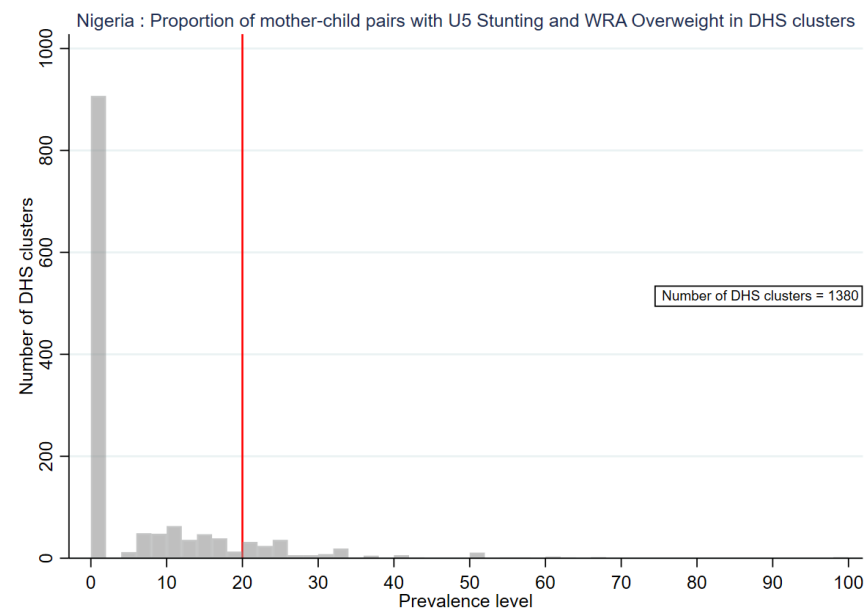
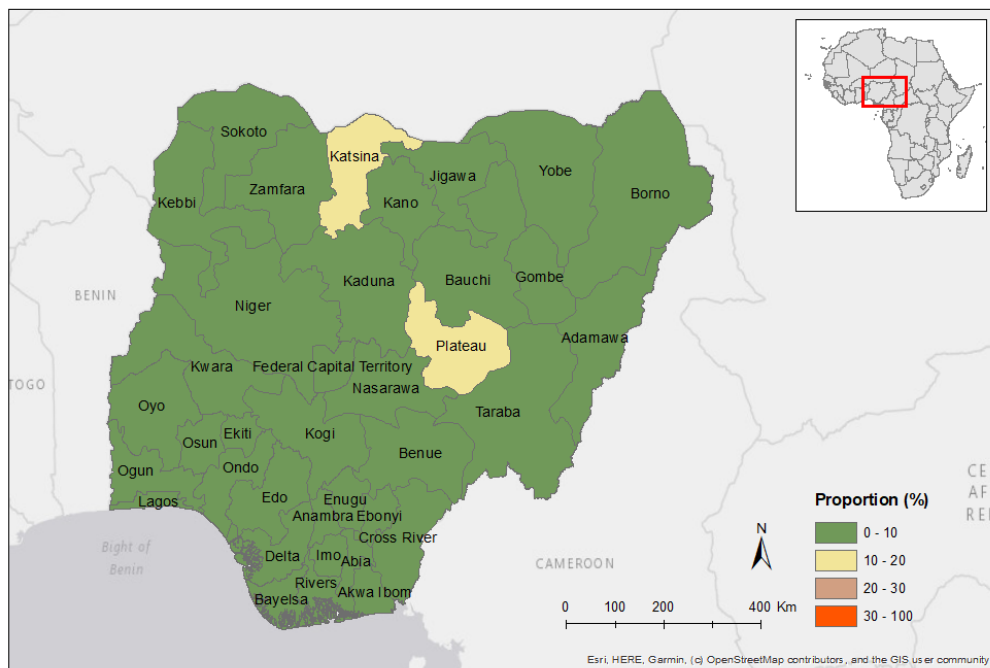
## Overweight/obese mothers with stunted children



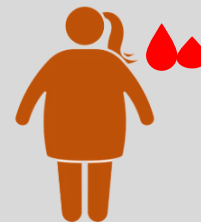
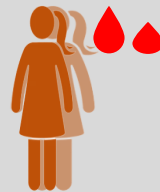
The proportion of mother-child pairs with a stunted child and an overweight/obese mother is 10-20% in Katsina and Plateau.

No significant spatial clusters were detected for this double burden in mother-child pairs.

### Nigeria – Overweight/obese mothers with stunted children by region



# Co-occurrence of multiple malnutrition types within the same individual (U5, WRA)

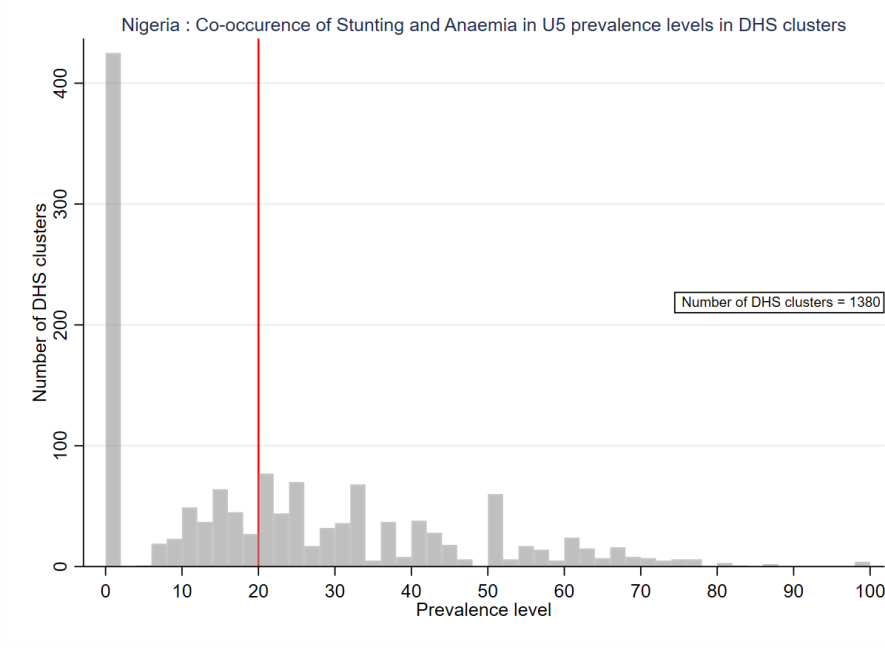




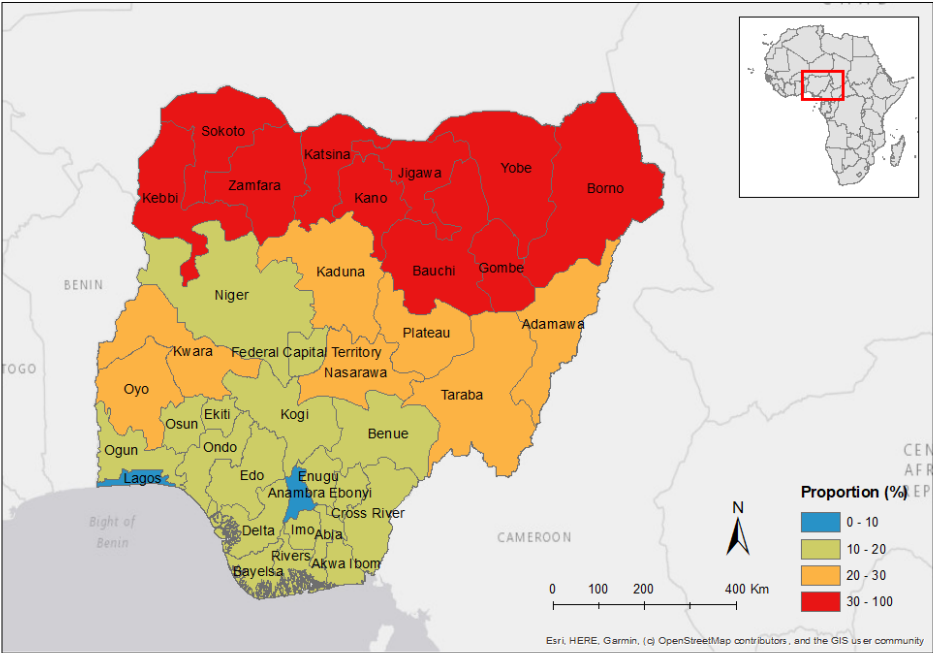
# Stunted and anemic children



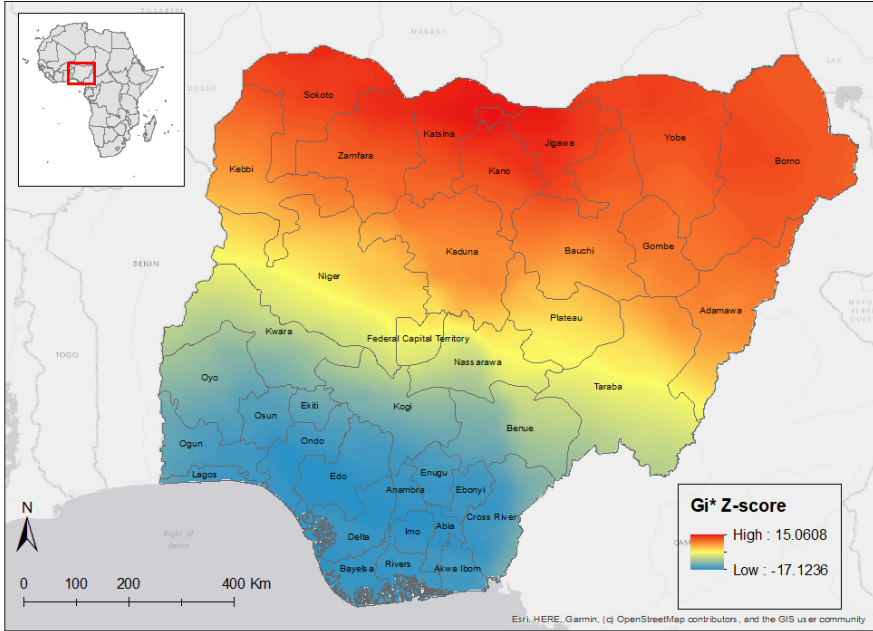
The proportion of U5s who were simultaneously stunted and anemic increased from south to north, with levels in the north exceeding 30%. The hotspot analysis reflects this, with **hotspots** in the north and **coldspots** in the south.



Nigeria – Stunted and anemic U5 by region



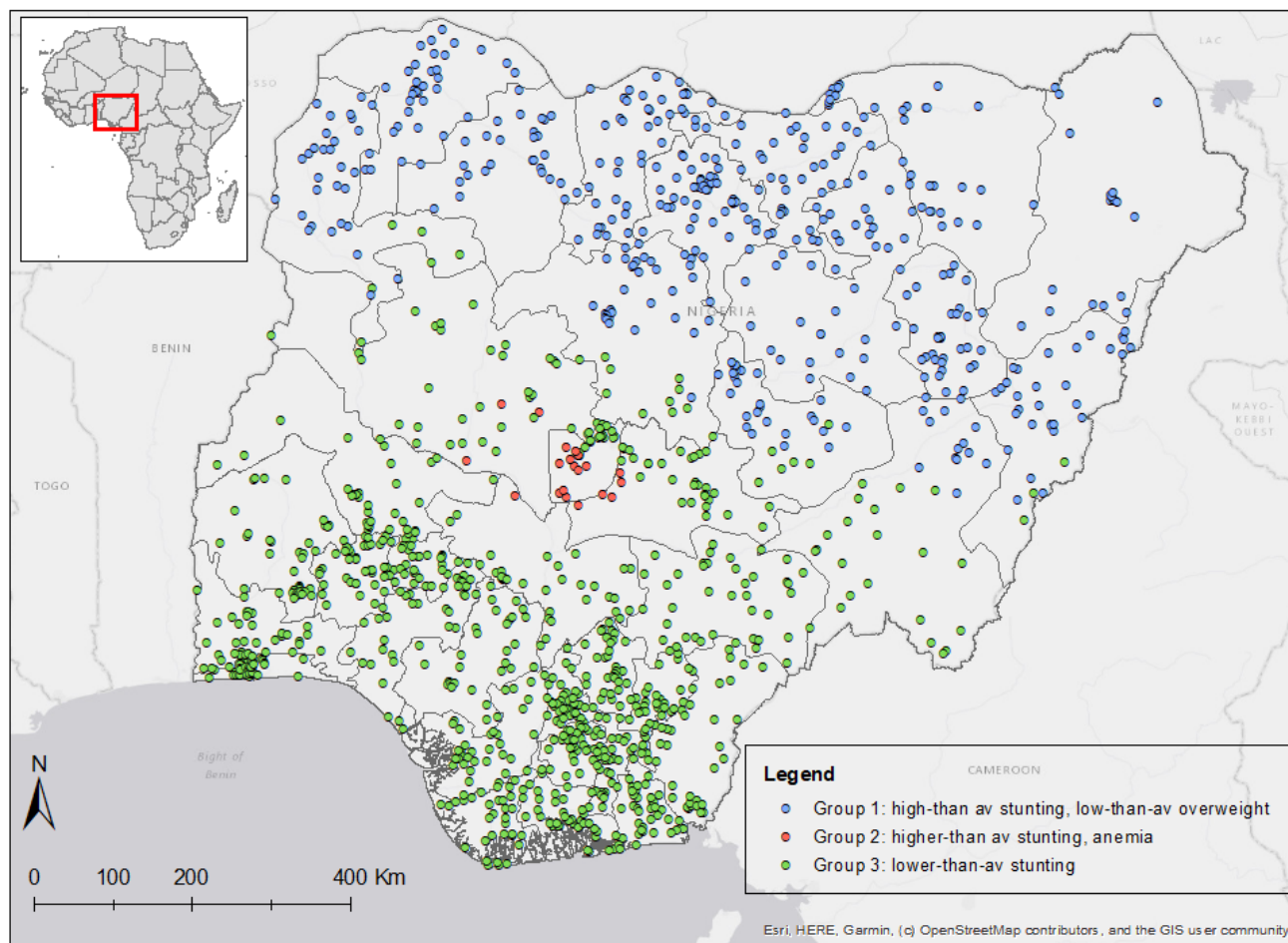
Nigeria – Hotspots/coldspots of stunted and anemic U5



# Grouping analysis of U5 and WRA malnutrition

(back to [Results for Nigeria](#))

## Nigeria: Grouping Analysis of U5 stunting, anemia, overweight/obesity



### Grouping analysis – U5



Grouping analysis shows 3 groups representing high stunting (52%) and low overweight/obesity prevalence in U5 (0.40%) (**blue**) in the northern half of the country, high stunting and anemia levels (42.3% and 80%, respectively) around FCT (**red**), and stunting (22.4%) in the southern part of the country (**green**).

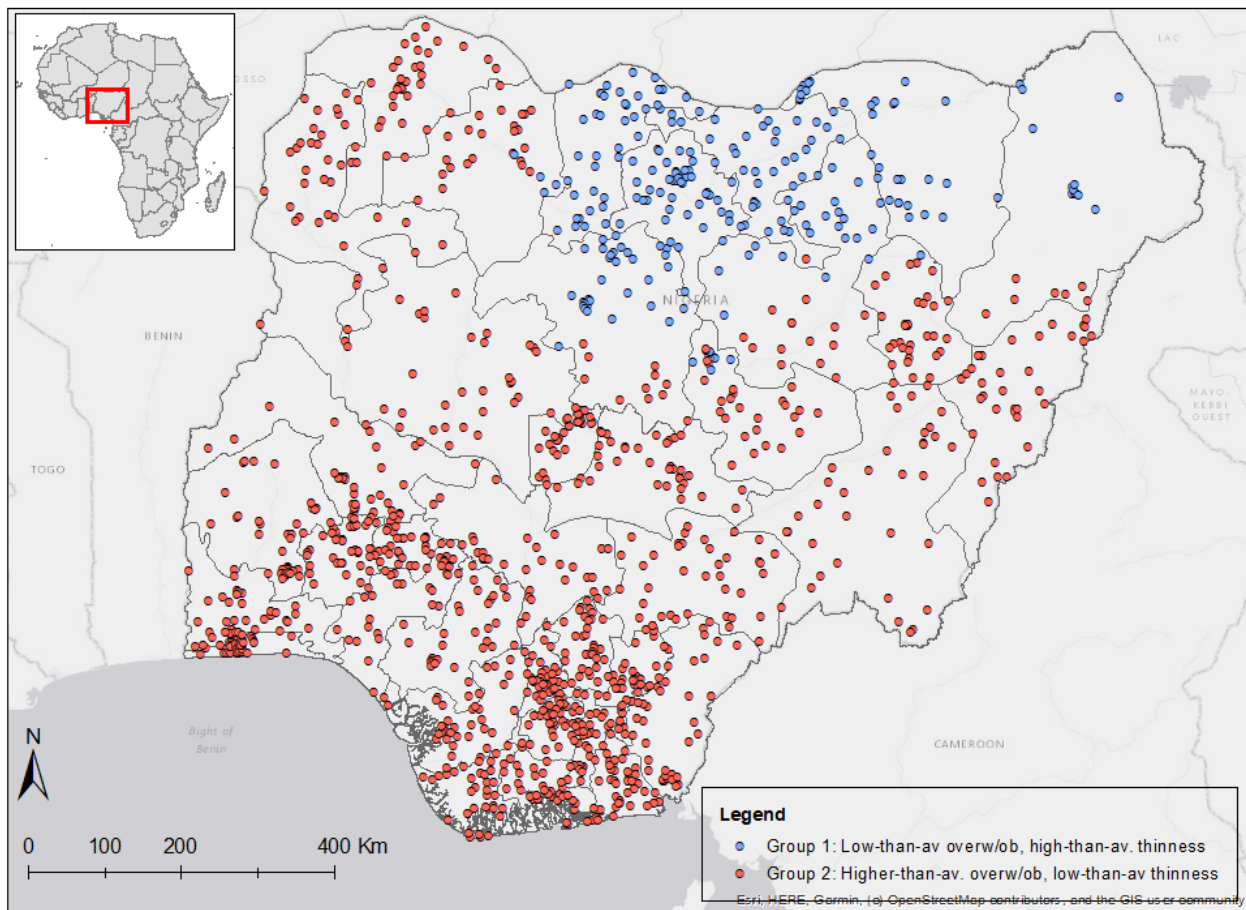
Despite this, anemia is also still high in the north (~67%) (**blue**) and stunting and anemia are still high in the south (**green**) (~22% and 65% respectively).

Average prevalence of malnutrition type by group (U5)

Malnutrition type	Country average $n=1348$	<b>Group 1</b> $n=456$	<b>Group 2</b> $n=21$	<b>Group 3</b> $n=871$
U5 stunting	$33 \pm 26$	<b><math>52 \pm 23</math></b>	<b><math>42 \pm 14</math></b>	<b><math>22 \pm 21</math></b>
U5 anemia	$66 \pm 26$	$67 \pm 24$	<b><math>80 \pm 16</math></b>	$65 \pm 26$
U5 overweight/ obesity	$0.58 \pm 2.9$	<b><math>0.40 \pm 2.1</math></b>	$0.00 \pm 0.0$	$0.68 \pm 3.2$

Values are mean  $\pm$  standard deviations. Numbers in **bold** are statistically significantly different from the mean.

## Nigeria: Grouping Analysis of WRA thinness, anemia, overweight/obesity



### Grouping analysis – WRA



WRA grouping analysis shows the opposition of two groups. Areas in the north (**blue**) are characterized by higher-than-average thinness (19.6%) and low overweight/obesity (4.8%) prevalence levels. While in the rest of the country, higher-than-average overweight/obesity (11.9%) and lower-than-average underweight / thinness (~8.5%) prevalence levels are found (**red**).

### Average prevalence of malnutrition type by group (WRA)

Malnutrition type	Country average <i>n</i> =1359	Group 1 <i>n</i> =248	Group 2 <i>n</i> =1111
WRA thinness	11 ± 13	<b>20 ± 15</b>	<b>8.5 ± 11</b>
WRA anemia	33 ± 19	34 ± 19	33 ± 20
WRA overweight/ obesity	11 ± 8.3	<b>4.8 ± 4.9</b>	<b>12 ± 8.3</b>

*Values are mean ± standard deviations. Numbers in **bold** are statistically significantly different from the mean.*

# Spatial regression analysis of U5 and WRA malnutrition

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# Factors associated with hotspots of overweight/obese mothers with anemic children

## *Summary of findings*

- **Indicator of interest:** an area (cluster) that is a hotspot overweight/obese mothers with anemic children.
- The anemia associated with this double burden in mother-child pairs is not associated with malaria in Nigeria.
- Higher proportions of appropriate breastfeeding practices and households with handwashing stations, higher average number of children by mother, younger children, and bigger distance from big cities were found to be protective factors from being a hotspot of this double burden in mother-child pairs.
- On the other hand, higher proportion of mothers educated, older mothers and being a rural area were risk factors for being a hotspot of pairs in which the child is anemic and the mother overweight/obese.

# Factors associated with hotspots of overweight/obese mothers with anemic children

## *Results of model regression*

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Log likelihood = -455.96358

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Number of obs	=	1,349
LR chi2(24)	=	868
Prob > chi2	=	0.000
Pseudo R2	=	0.488

Hotspot	Odds Ratio	Std. Err.	z	P>z	[95% Conf.Interval]
Spatial lag	1.08	0.01	9.13	0.000	(1.07 - 1.1)
Proportion of appropriate breastfeeding	0.99	0.00	-4.47	0.000	(0.98 - 0.99)
Mean preceding birth interval	0.98	0.01	-2.8	0.005	(0.97 - 0.99)
Proportion of households with handwashing stations	0.99	0.00	-4.94	0.000	(0.98 - 0.99)
Mean age of children	0.66	0.11	-2.53	0.011	(0.47 - 0.91)
Mean age of mothers	1.06	0.03	2.11	0.035	(1 - 1.12)
Proportion of mothers educated	1.05	0.00	9.9	0.000	(1.04 - 1.06)
Distance to big cities (250k population)	0.12	0.03	-9.3	0.000	(0.08 - 0.19)
Proportion of deliveries in medical facilities	0.99	0.00	-2.66	0.008	(0.99 - 1)
Rural area	2.24	0.41	4.35	0.000	(1.56 - 3.21)

Sensitivity	80%
Specificity	86%
Positive predictive value	77%
Negative predictive value	88%
Correctly classified	84%

# Factors associated with hotspots of anemic and stunted U5

## *Summary of findings*

- Indicator of interest: an area (cluster) that is a hotspot of simultaneous anemia and stunting in children under five years of age.
- Risk factors of being a hotspot include bigger households (average size) and higher diarrhea prevalence levels.
- Higher coverage of vitamin A supplementation and antenatal visits during pregnancy, a better proportion of children that achieved minimum dietary diversity, and older educated mothers with an income generating activity were protective factors from being an area with proportions of stunted and anemic children that are too high.
- Rural areas were less likely to be hotspots of U5 anemia and stunting.

# Factors associated with hotspots of anemic and stunted U5

*Results of regression model*

Log likelihood = -380.29611

Number of obs	=	1,349
LR chi2(24)	=	997
Prob > chi2	=	0.000
Pseudo R2	=	0.567

Hotspot	Odds Ratio	Std. Err.	z	P>z	[95% Conf.Interval]
Spatial lag	1.08	0.01	8.88	0.000	(1.06 - 1.09)
Vitamin A supplementation coverage	0.99	0.00	-3.43	0.001	(0.98 - 0.99)
Average size of households	1.17	0.06	3.28	0.001	(1.07 - 1.29)
Minimum dietary diversity of children	0.99	0.00	-2.28	0.023	(0.99 - 0.999)
Average age of mothers	0.93	0.03	-2.61	0.009	(0.88 - 0.98)
Proportion of mothers educated	0.98	0.00	-7.7	0.000	(0.97 - 0.98)
Antenatal visit for pregnancy coverage	0.98	0.01	-4.31	0.000	(0.97 - 0.99)
Proportion of mothers with an income generating activity	0.83	0.03	-4.98	0.000	(0.77 - 0.89)
Diarrhea prevalence	1.02	0.01	3.22	0.001	(1.01 - 1.03)
Rural area	0.49	0.11	-3.13	0.002	(0.31 - 0.76)
Use of improved cooking fuel coverage	0.98	0.00	-3.67	0.000	(0.98 - 0.99)

Sensitivity	81%
Specificity	93%
Positive predictive value	86%
Negative predictive value	90%
Correctly classified	88%

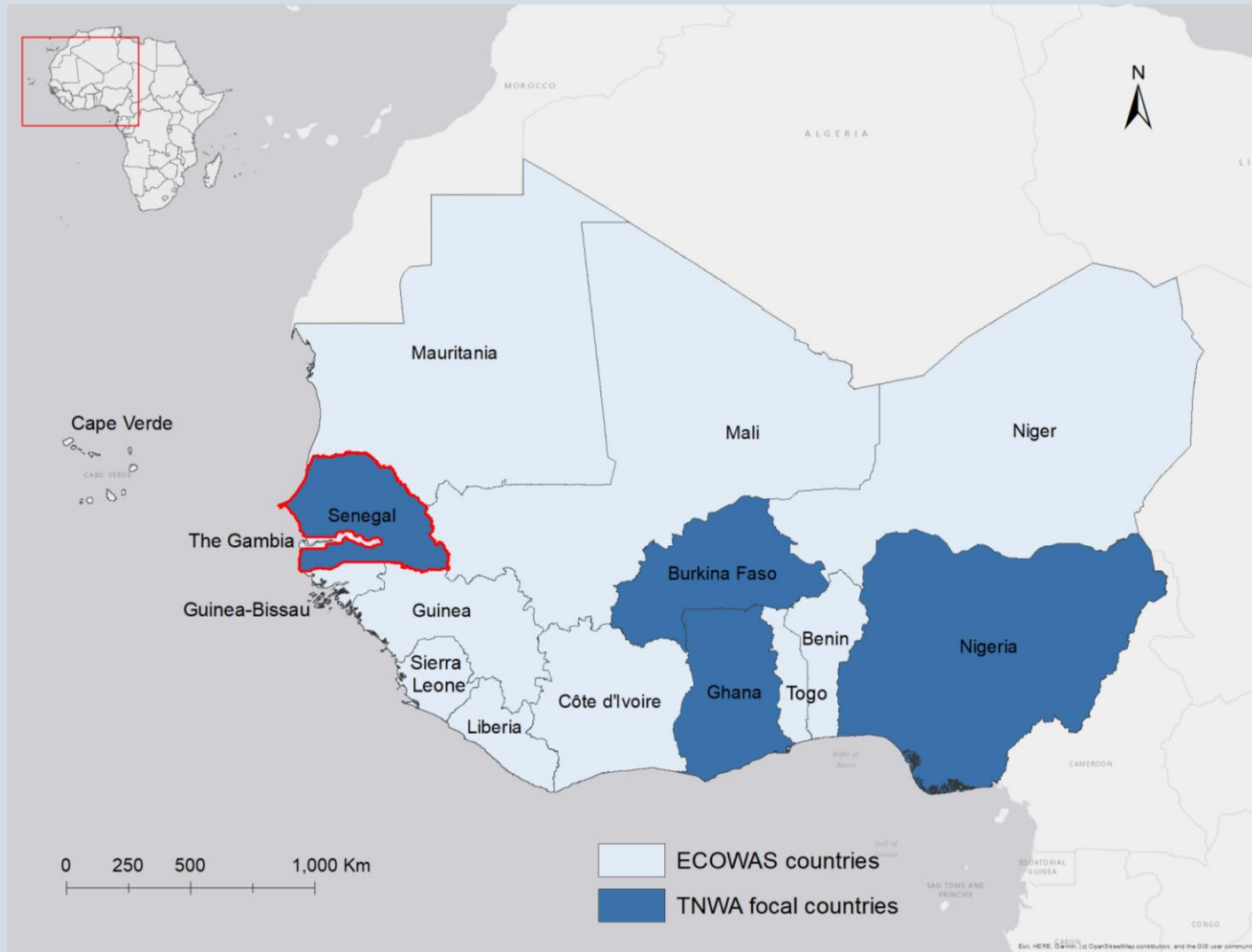
# Conclusions / Recommendations for Nigeria (1/2)

- Most states experience both U5 stunting (above 20%) and U5 anemia (above 40%), apart from several states in the south that experience U5 anemia only (above the 40% threshold).
- For WRA, there is mostly no co-occurrence of malnutrition types within the same states, although several states, mostly in the north (Jigawa, Bauchi, Yobe), face thinness and anemia (using 'high' thresholds of 20%)
- There is a significant clustering of overweight/obese mothers with an anemic child in the south
- There is a significant clustering of anemic mothers with a stunted child in the north
- U5 stunting and WRA thinness in mother-child pairs is concentrated in 4 northern states (Jigawa, Yobe, Gombe, and Bauchi)
- There is a significant clustering of children suffering from stunting and anemia in the north and women suffering from overweight and anemia in the south

## Conclusions / Recommendations for Nigeria (2/2)

- The **grouping analysis** for U5 shows high stunting and low overweight in the north and low stunting in the south.
- For WRA, the grouping analysis shows a clear division between the northeast and the rest of the country whereby the northeast has higher WRA thinness and lower overweight, and the opposite occurs in the rest of the country.
- The **regression analysis** shows that the co-occurrence of anemia and stunting among U5 is positively associated with poverty, household size and child diarrhea. It is negatively associated with rurality.

# Senegal



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# Results for Senegal

Single malnutrition types in Children under five years of age (U5) and Women of reproductive Age (WRA)	Grouping Analysis
<ul style="list-style-type: none"><li>• <a href="#">U5 stunting</a></li><li>• <a href="#">U5 overweight/obesity</a></li><li>• <a href="#">U5 anemia</a></li><li>• <a href="#">WRA anemia</a></li></ul>	<ul style="list-style-type: none"><li>• <a href="#">Stunting, anemia and overweight among U5</a></li></ul>
Co-occurrence of different types of malnutrition in U5 and WRA	Regression Analysis
<ul style="list-style-type: none"><li>• Within regions:<ul style="list-style-type: none"><li>- <a href="#">Stunting, anemia, and overweight/obesity among U5</a></li></ul></li><li>• Within households (mother-child pairs):<ul style="list-style-type: none"><li>- <a href="#">U5 anemia &amp; WRA anemia</a></li></ul></li><li>• Within the same individual:<ul style="list-style-type: none"><li>- <a href="#">Stunting and anemia (U5)</a></li></ul></li></ul>	

## Note

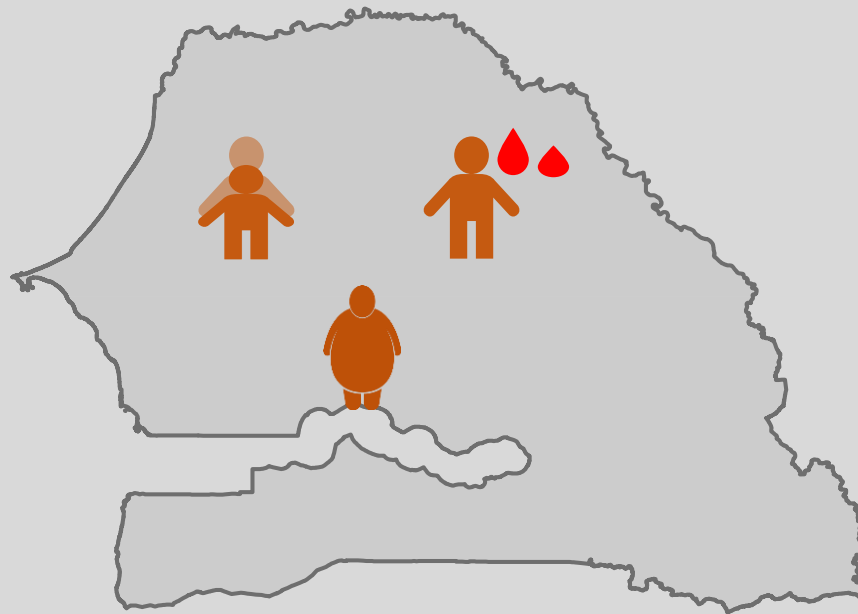
Findings on Senegal are limited as the 2019 DHS did not include data collection on U5 anemia or on several WRA malnutrition types (underweight/thinness, anemia, and overweight/obesity).

The DHS 2017 which was more complete (included data on U5 and WRA anemia) was also used to build several choropleths maps. However, geographic coordinates from the 2017 DHS were not available.

Therefore, it was not possible to conduct the hotspot analysis and regression analysis on co-occurrences.

# Single malnutrition types for U5

Stunting - Anemia - Overweight/obesity



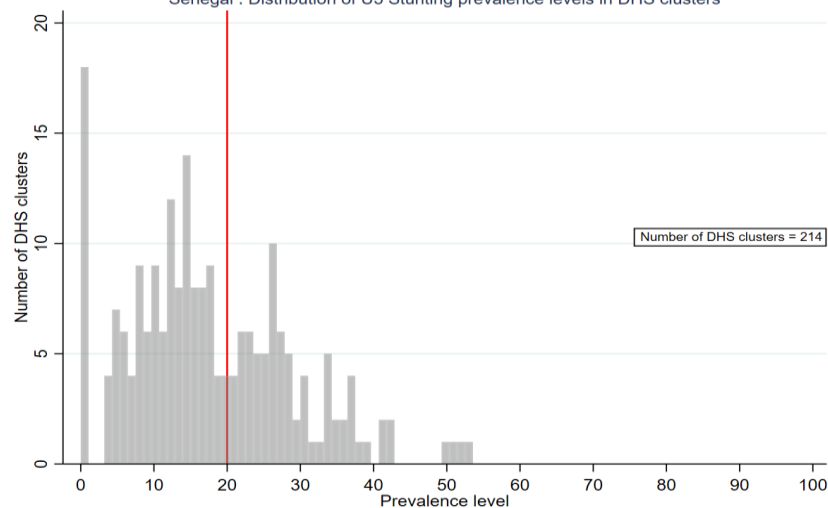
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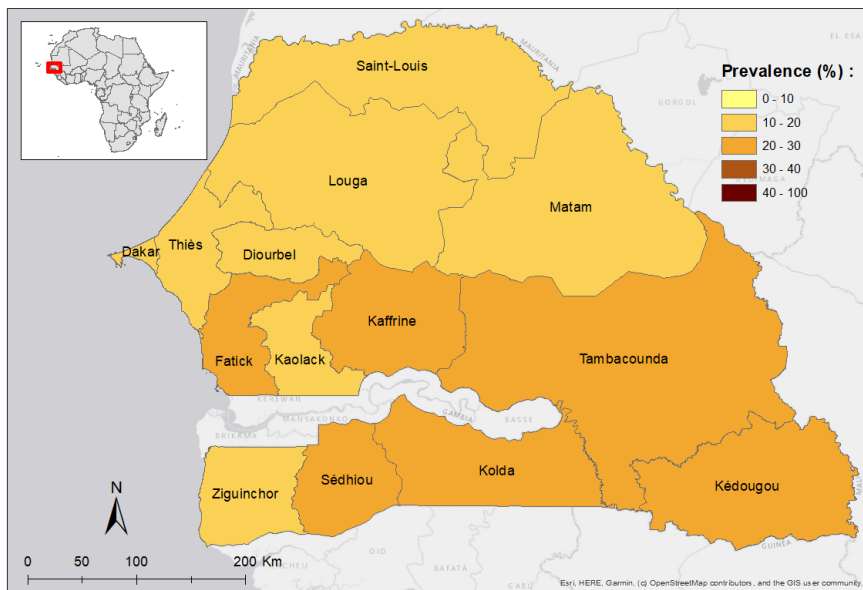
## U5 Stunting

Prevalence of stunting in children under 5 years of age is under 30% in the entire country but is more pronounced in the south. **Coldspots** are detected in the western part of the country, in Dakar, the capital city and its surrounding areas.

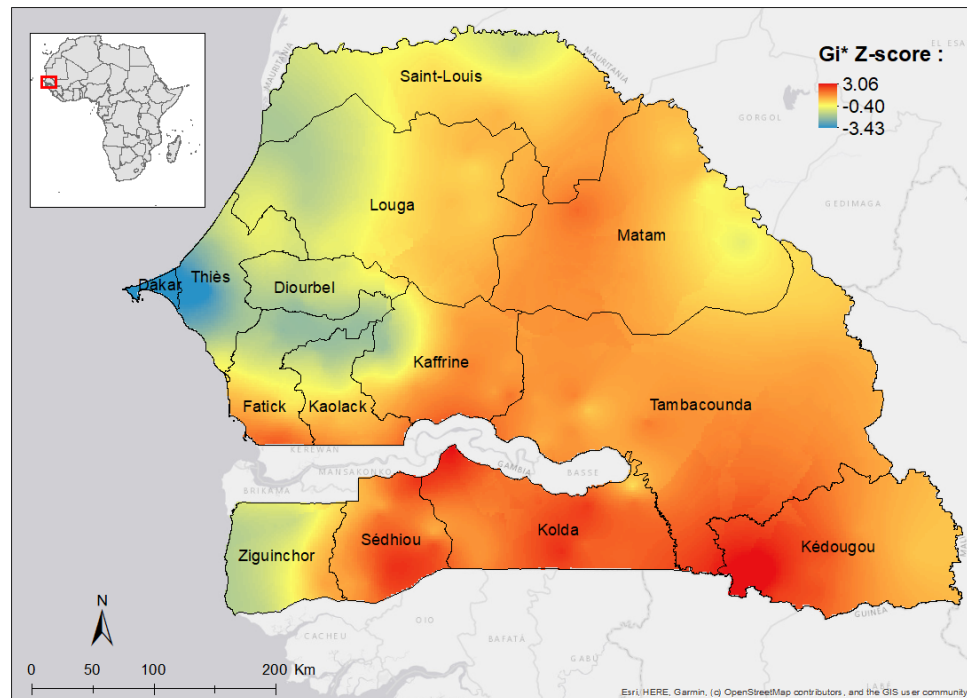
Senegal : Distribution of U5 Stunting prevalence levels in DHS clusters



Senegal – U5 anemia by region



Senegal : Hotspots/coldspots of stunting among U5

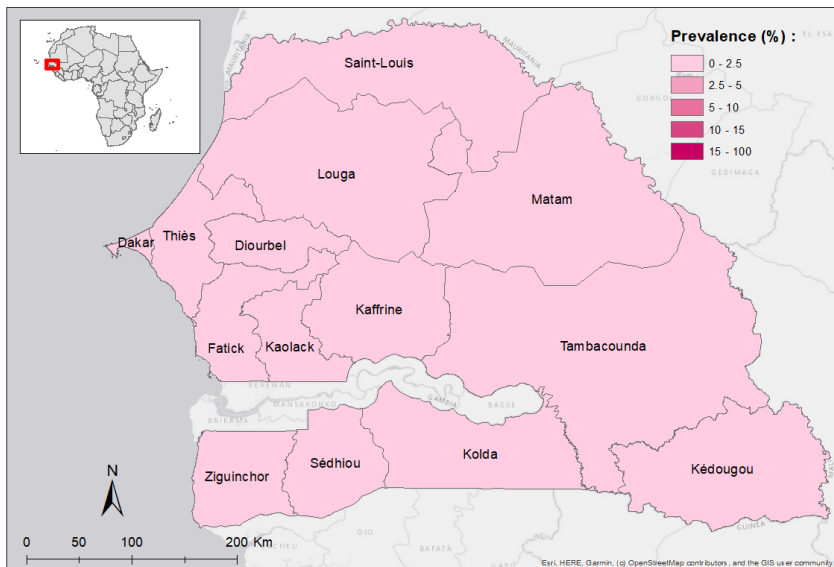




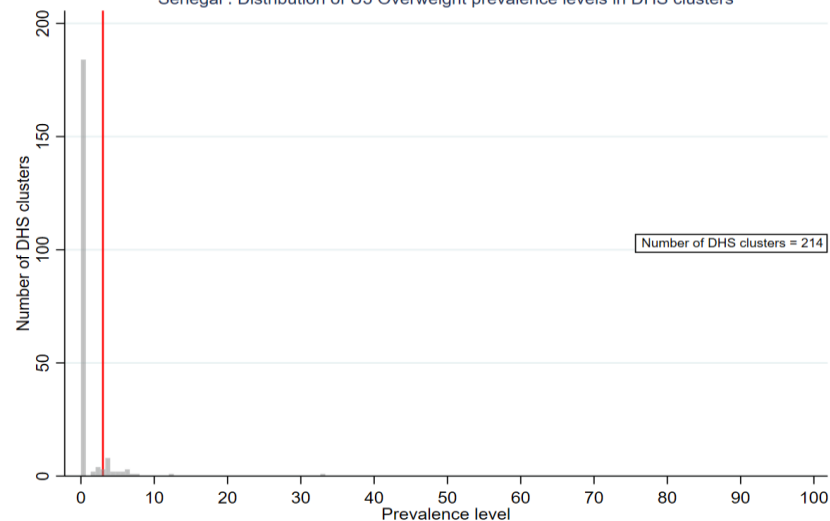
## U5 Overweight/Obesity

Overall, very low prevalence level of overweight/obesity i.e below 2.5% of children U5 in all regions. However, a significant **hotspots** were detected in Dakar and Thiès, requiring particular to be address to this problem in these regions.

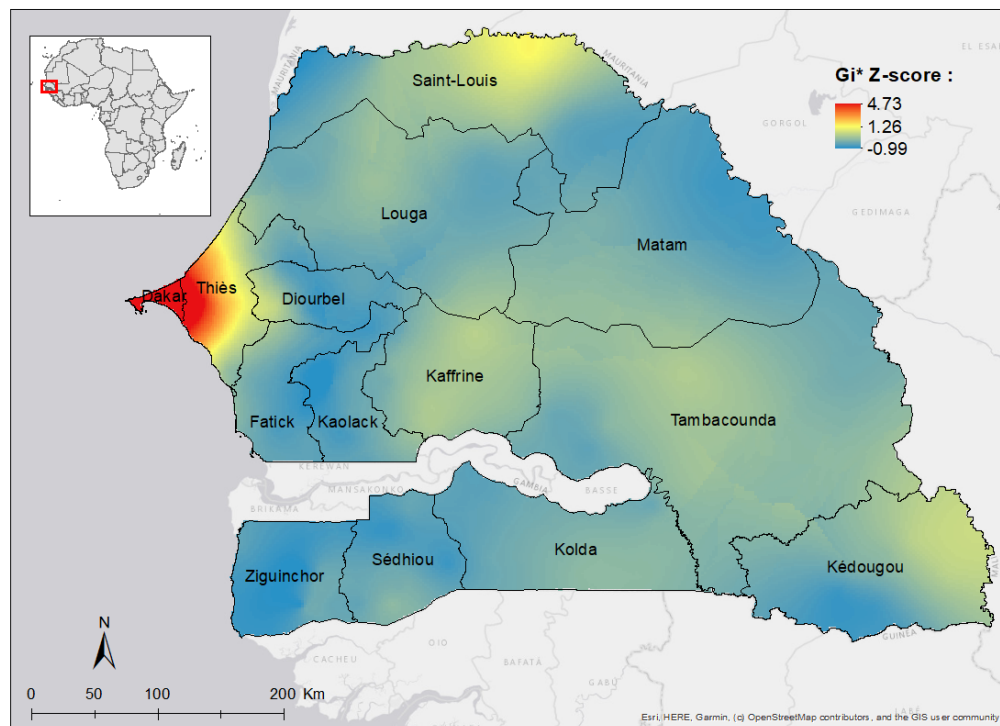
Senegal – U5 overweight/obesity by region



Senegal : Distribution of U5 Overweight prevalence levels in DHS clusters



Senegal : Hotspots/coldspots of overweight/obesity among U5

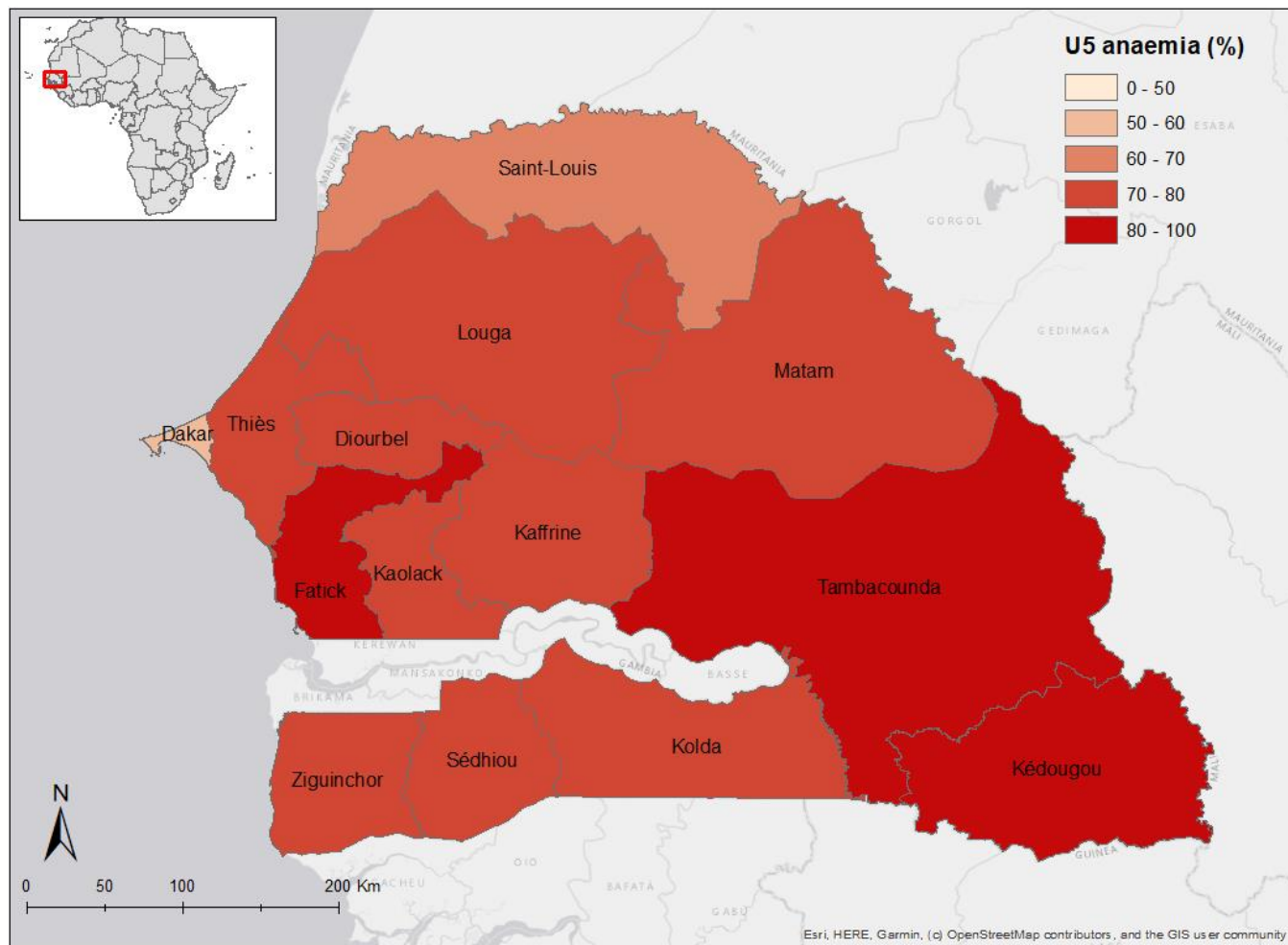




## DHS 2017 - U5 Anemia

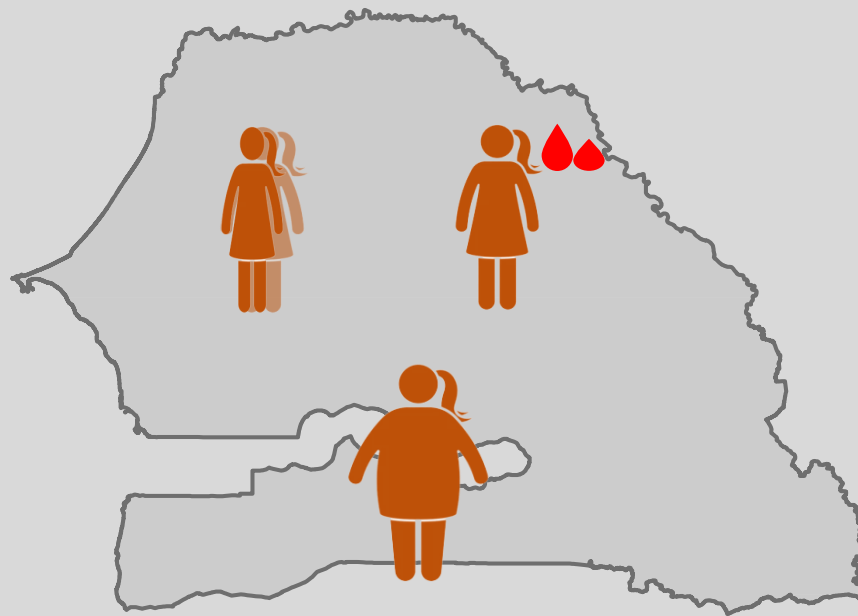
U5 anemia was a burden faced by all regions in Senegal as the prevalence level was higher than 50% in all regions and the situation is more critical in the southeastern part of the country.

Senegal (2017) – U5 anemia by region



# Single malnutrition types for WRA

Underweight/thinness - Anemia - Overweight/obesity



## Note

*Only choropleth maps are shown when DHS 2017 is used; this is because geographic coordinates were not available for this survey year, which precluded carrying out more thorough analyses.*

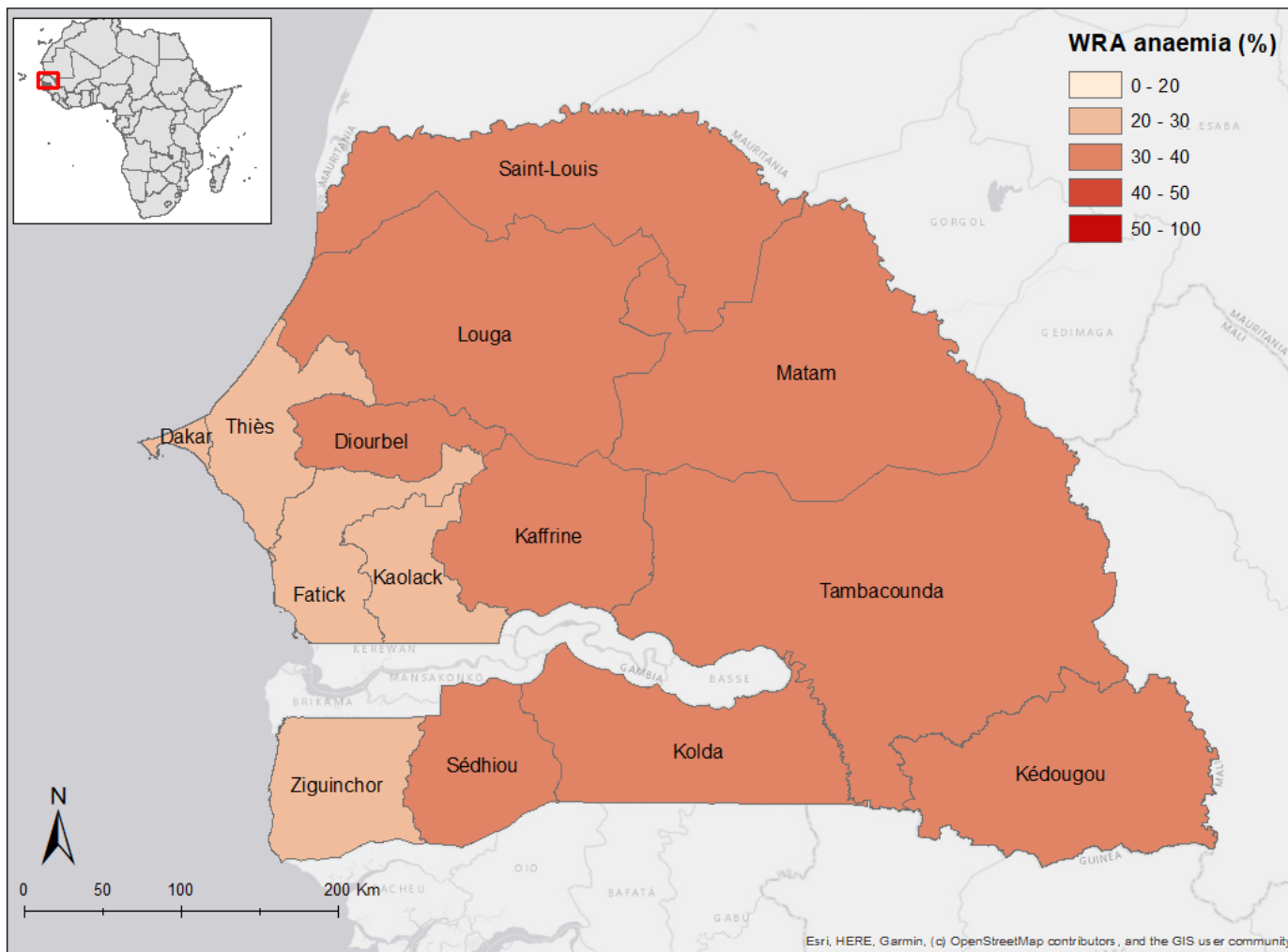
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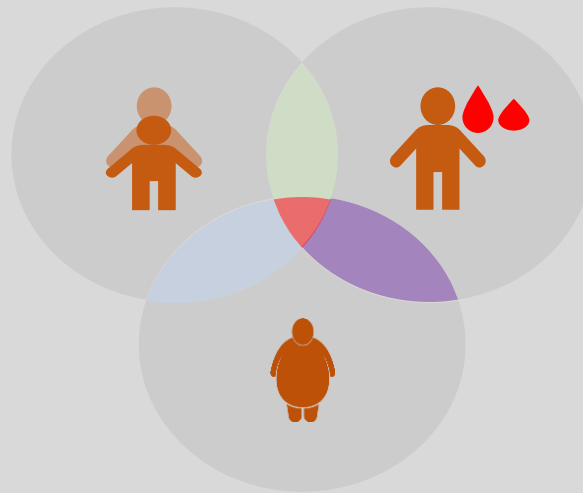
## DHS 2017 - WRA Anemia

Most of the regions have a prevalence of WRA anemia higher than 30% except for the western regions that have lower prevalence levels.

### Senegal (2017) – WRA anemia by region



# Co-occurrence of malnutrition types within the same location



## Note

*Only choropleth maps are shown when DHS 2017 is used; this is because geographic coordinates were not available for this survey year, which precluded carrying out more thorough analyses.*

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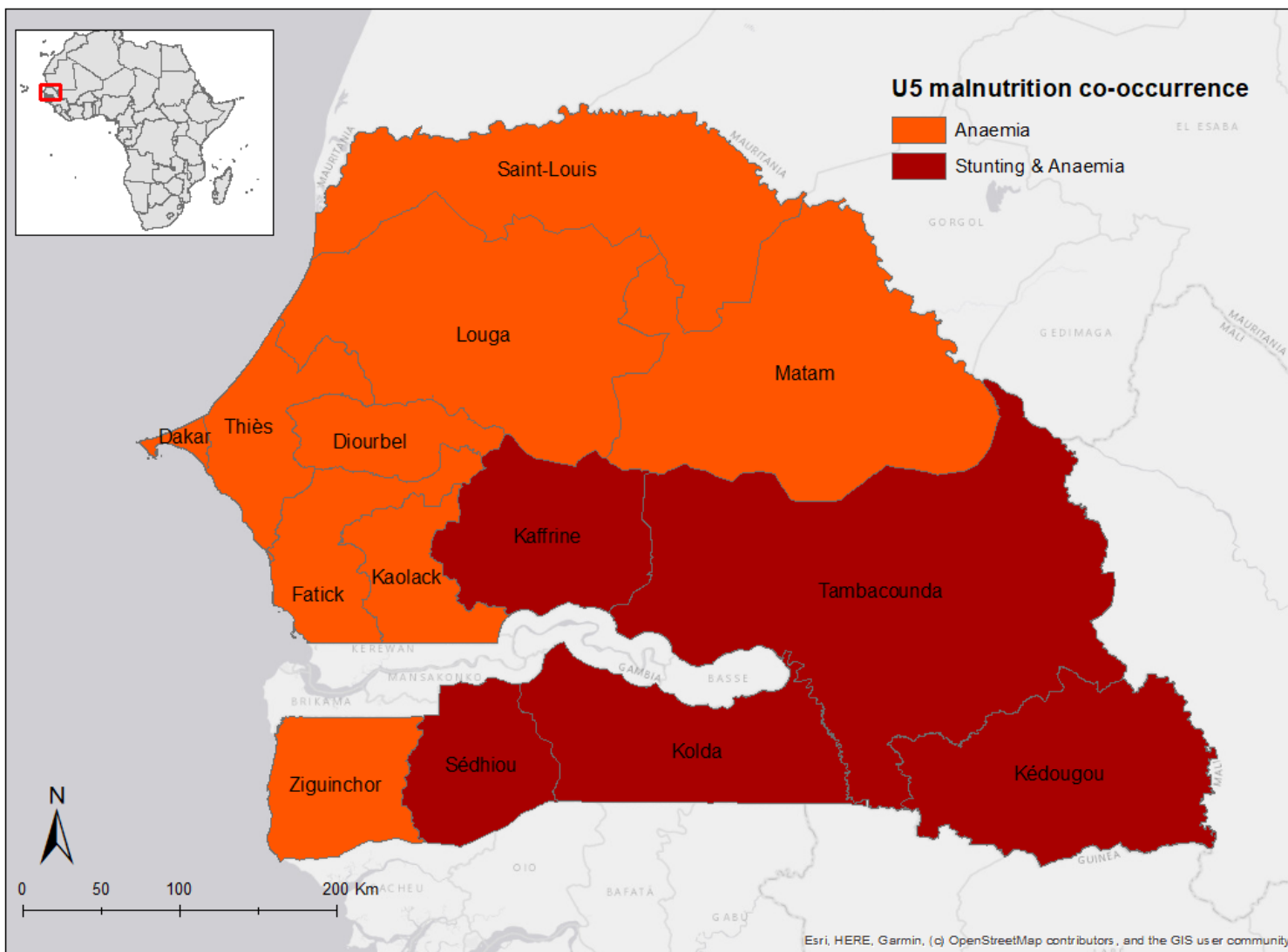
## DHS 2017 - Co-occurrences in the same regions (U5)

Most of the regions face a single burden of anemia in U5 except the southern regions and Kaffrine.

Thresholds used: Stunting: 20% and up; Anemia: 40% and up

### Senegal (2017)

#### Co-occurrences of multiple malnutrition types in under-fives by region



# Co-occurrence of malnutrition types within the same household (mother-child pairs)



## Note

*Only choropleth maps are shown when DHS 2017 is used as geographic coordinates were not available for this survey, which didn't allow to conduct more thorough analyses.*

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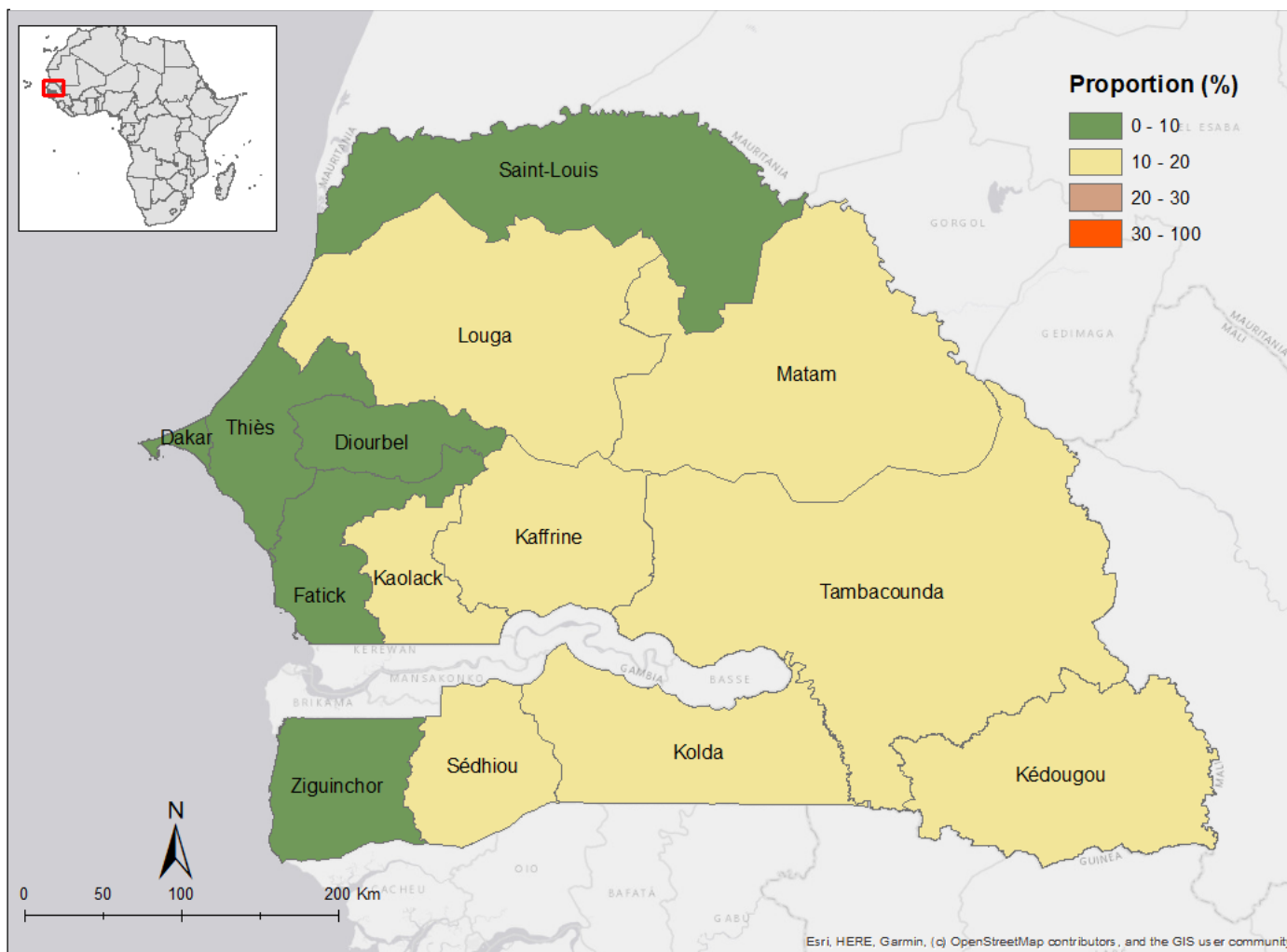


## Anemic mothers with anemic children



In the majority of regions, more than 10% of mother-child pairs experience anemia in both the mother and the child. Western regions and Saint-Louis have lower prevalence levels of this co-occurrence.

### Senegal (2017) – Anemic mothers with anemic children by region



# Co-occurrence of multiple malnutrition types within the same individual (U5, WRA)



## Note

*Only choropleth maps are shown when DHS 2017 is used as geographic coordinates were not available for this survey, which didn't allow to conduct more thorough analyses.*

*(back to [Results for Senegal](#))*

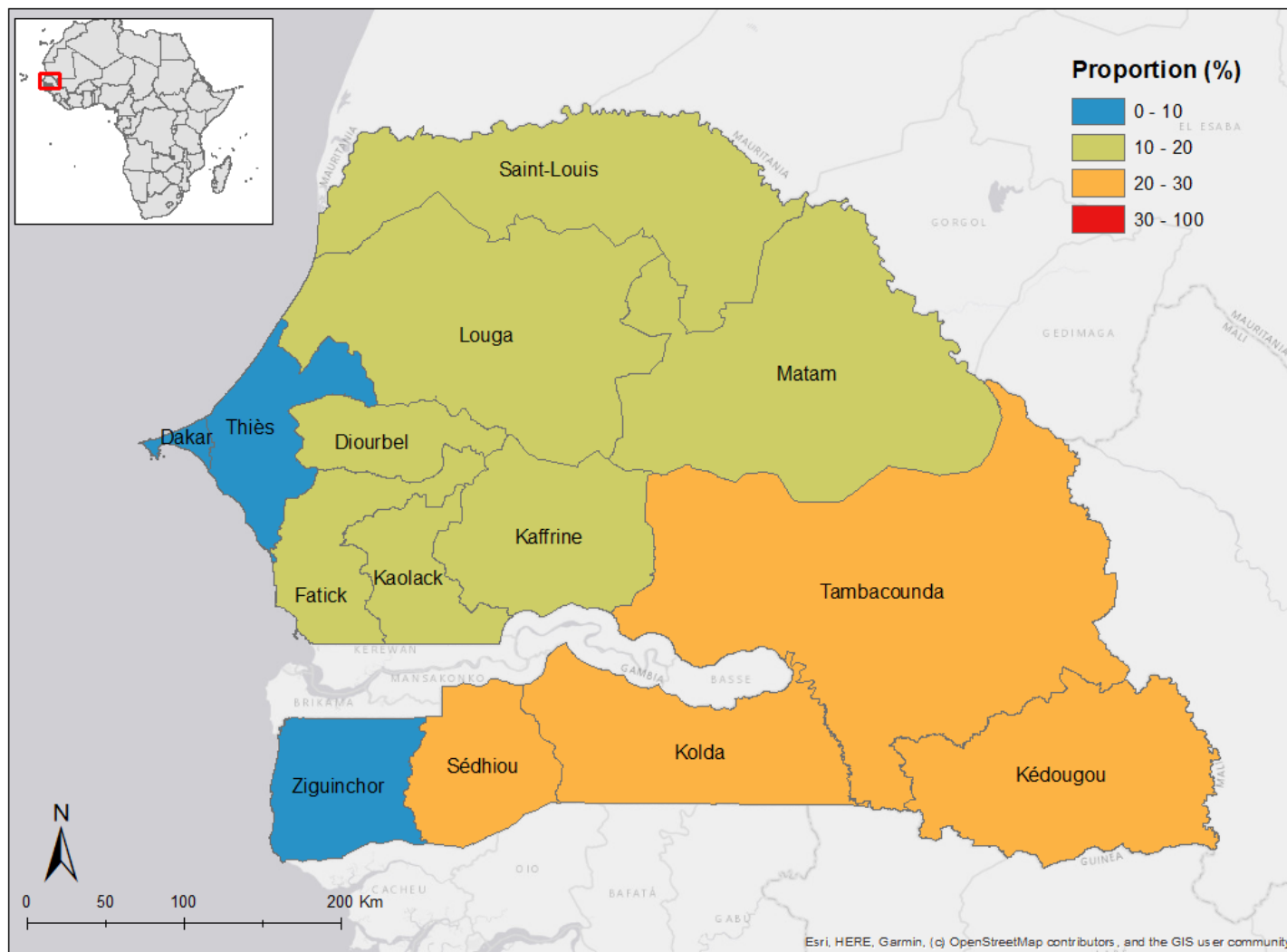


## Stunted and anemic children



The proportion of U5 who were simultaneously stunted and anemic increased from north to south, with very low levels in Dakar, Thiès and Ziguinchor.

### Senegal (2017) – Stunted and anemic U5 by region



## Grouping analysis of U5 malnutrition

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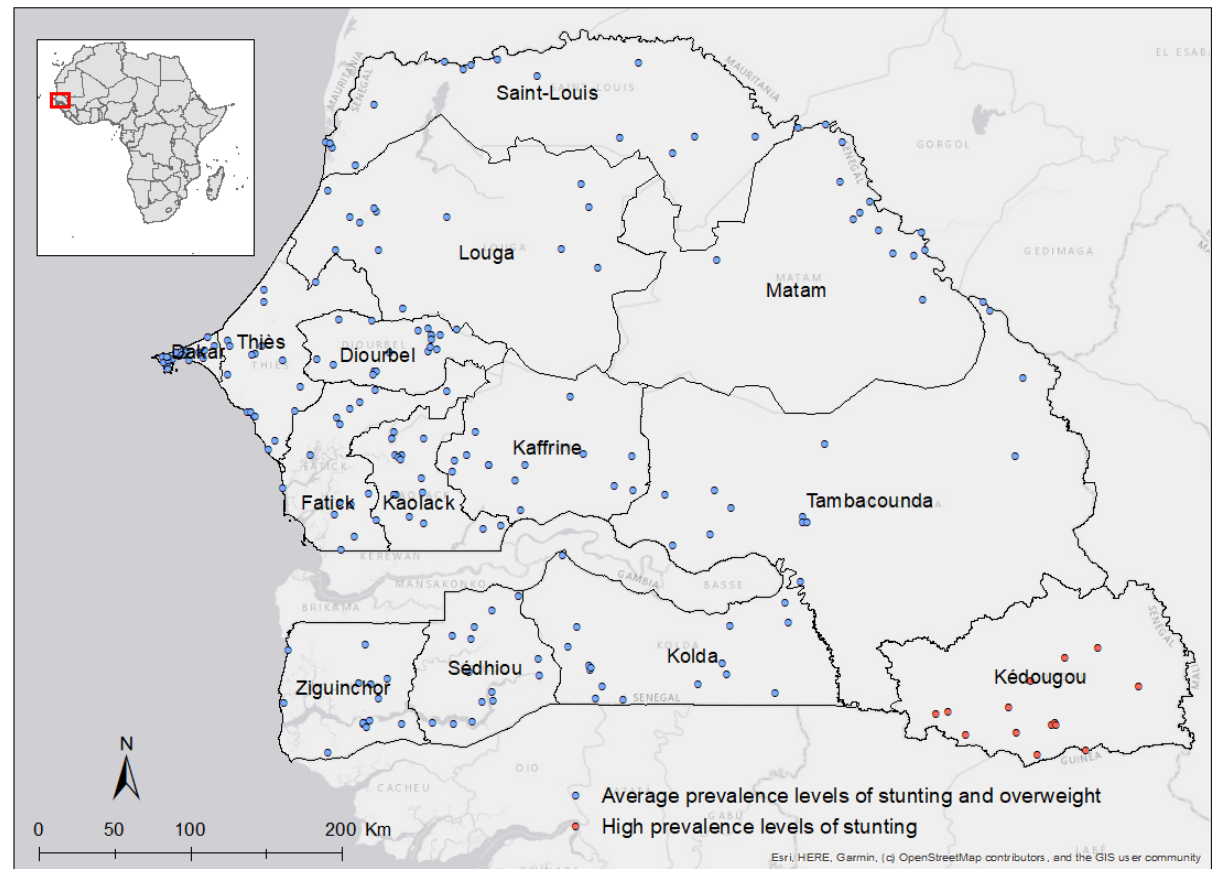
## Senegal : Grouping analysis of U5 stunting and overweight/obesity

### Grouping analysis – U5



The grouping analysis considering stunting and overweight shows that clusters (in **red**) located in Kedougou have significantly higher prevalence levels of stunting in children under the age of five.

The **blue** group of clusters have a prevalence level equal to the national average. Closer attention needs to be brought to stunting in Kedougou.



Malnutrition type	Country average <i>n</i> =214	Group 1 <i>n</i> =200	Group 2 <i>n</i> =14
U5 stunting	18 ± 11	17 ± 11	<b>24 ± 11</b>
U5 overweight/ obesity	0.7 ± 2.8	0.77 ± 2.9	0.4 ± 1.5

Values are mean ± standard deviations. Numbers in **bold** are statistically significantly different from the mean.

# Conclusions / Recommendations for Senegal

- Limited findings as there was no data collection on U5 anemia and WRA malnutrition types (underweight/thinness, anemia or overweight/obesity) during the 2019 DHS survey round.
- **U5 stunting:** significant clustering of high prevalence areas in the southern part of the country was detected, particularly in Kédougou where almost 1 child out of 4 was stunted (prevalence level of 24%) .
- **U5 overweight/obesity:** despite low prevalence rates of overweight/obesity in U5, a hotspot was detected in Dakar and its closest neighboring region Thiès.
- In 2017, U5 anemia was a burden faced by all regions in Senegal as the prevalence level was higher than 50% in all regions and at least 1 child out of five suffered simultaneously of stunting and anemia in the 4 regions in the southeastern part of the country.
- It is therefore important to ensure that data on anemia are collected to monitor the situation.
- In addition, data on women are not regularly collected, making it impossible to analyze the type of malnutrition faced by this population and by mother-child pairs.

## 5 – Discussion

## 5. Discussion / Comparison across countries (1/3)

- In all four countries, the multiple malnutrition burden (MMB) of stunting and anemia was most prevalent in U5.
- Only U5 in the Greater Accra Region of Ghana experienced, in addition to this MMB, a high burden of anemia and overweight.
- Among WRA, some regions/states of Burkina Faso and Nigeria stood out as having the highest prevalence of underweight/thinness and anemia.
- In terms of MMBs within households, anemia affecting both mother and child pairs was found in Ghana, Nigeria and Burkina Faso (in at least one out of five mother-child pairs in some regions/states).
- Ghana and Nigeria also had high prevalence of a U5 anemia and WRA overweight/obesity MMB in mother-child pairs (at least one pair out of five in the southern regions/states).
- With regards to MMBs within the same individual, U5 who experienced both stunting and anemia were found in (eastern) Burkina Faso, (northern) Nigeria, and (northern) Ghana.

## 5. Discussion / Comparison across countries (2/3)

- Contextual factors for these MMBs varied between countries, but when both a mother and her child suffered from anemia, it was more likely to be malaria related.
- Findings suggest that, in Burkina Faso, hotspots of children with an MMB of stunting and anemia were related to mothers having higher levels of education and having an income-generating activity or living in larger households.
- In Nigeria, however, the complete opposite was found, as the high proportion of educated mothers or those who had an income generating activity decreased the risk of having a hotspot of this MMB. Rather, this MMB was associated with poor feeding and water, sanitation and hygiene (WASH) practices.
- When an overweight/obese woman had an anemic child, rather than being malaria related, in Burkina Faso, Ghana, and Nigeria, the anemia was linked with poor WASH practices; in Burkina Faso, it was also associated with poor feeding practices.
- In Ghana, the MMB of overweight/obese mothers with anemic children was also more common in rural areas, wealthier households, and households with more highly educated women.

## 5. Discussion / Comparison across countries (3/3)

- The contextual factors associated with MMBs identified fall into three categories:
  - modifiable factors (e.g., feeding and WASH practices),
  - modifiable factors - that should not be modified (e.g., high level of education of mothers or household wealth being risk factors for overweight/obese mothers with anemic children),
  - and non-modifiable factors (e.g., age of mothers, sex of children).
- While all categories contribute to a better understanding of which factors may drive the occurrence of these MMBs, the modifiable factors are those that can inform future intervention development.
- Non-modifiable factors may help identify key target groups.
- A limitation of this study is the use of the DHS datasets only, as these do not include data on potentially important factors such as food consumption, the food environment, or lifestyle behaviours (e.g., physical activity).
- Primary data collection on these factors, for identified MMBs hotspots, is needed to inform double duty actions.

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- Elodie Becquey, Senior Research Fellow, IFPRI
- Wahid Quabili, Senior Research Analyst, IFPRI

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## 6 – Detailed methods

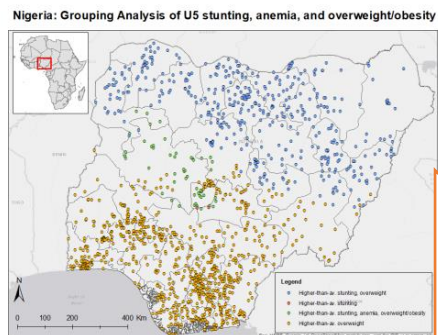
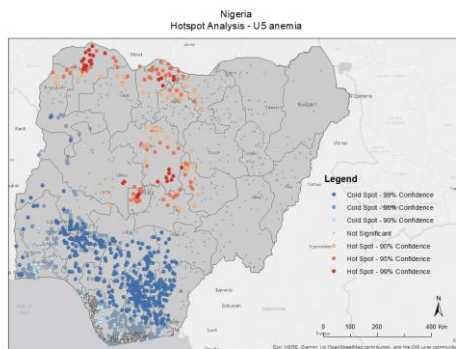
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## 6. Methodology – Analysis steps (1/2)

To address the evidence gap on multiple malnutrition burdens and support policy/program development, this study examined, in Burkina Faso, Nigeria, Ghana, and Senegal:

1. Prevalence levels of different types of malnutrition in Women of Reproductive Age (WRA) and Under-Five children (U5) at national and subnational level (**Choropleth maps**)
2. Co-occurrence of multiple malnutrition types in the same locations, the same households (mother-child pairs), and within the same individuals (**Choropleth maps**)
3. Where multiple types of malnutrition cluster spatially (**hotspot analysis/spatial interpolation maps and grouping analysis**)
4. Which drivers (e.g. poverty) drive the spatial clustering (**Driver analysis**)

## 6. Methodology – Analysis steps (2/2)



Choropleth maps

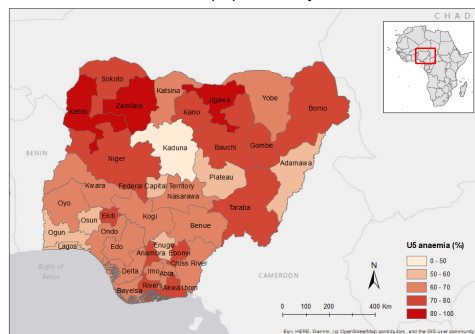
Hotspot analysis

Spatial interpolation

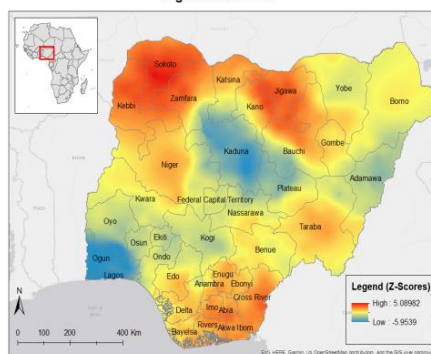
Grouping analysis

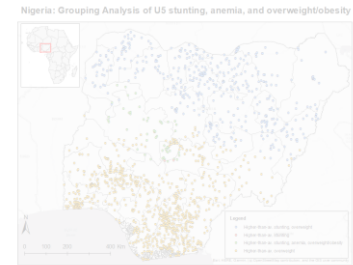
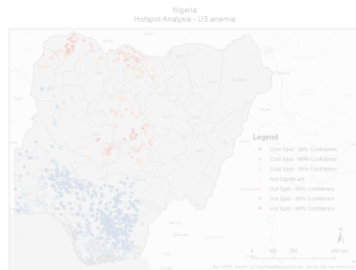
Driver analysis

Nigeria  
Under-five (U5) anaemia by state



Nigeria: U5 anaemia





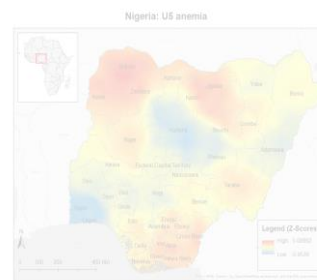
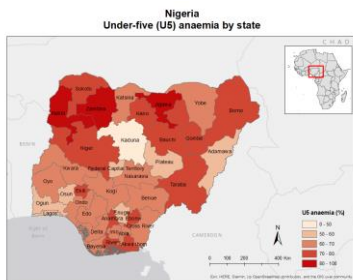
Choropleth  
maps

Hotspot  
analysis

Spatial  
interpolation

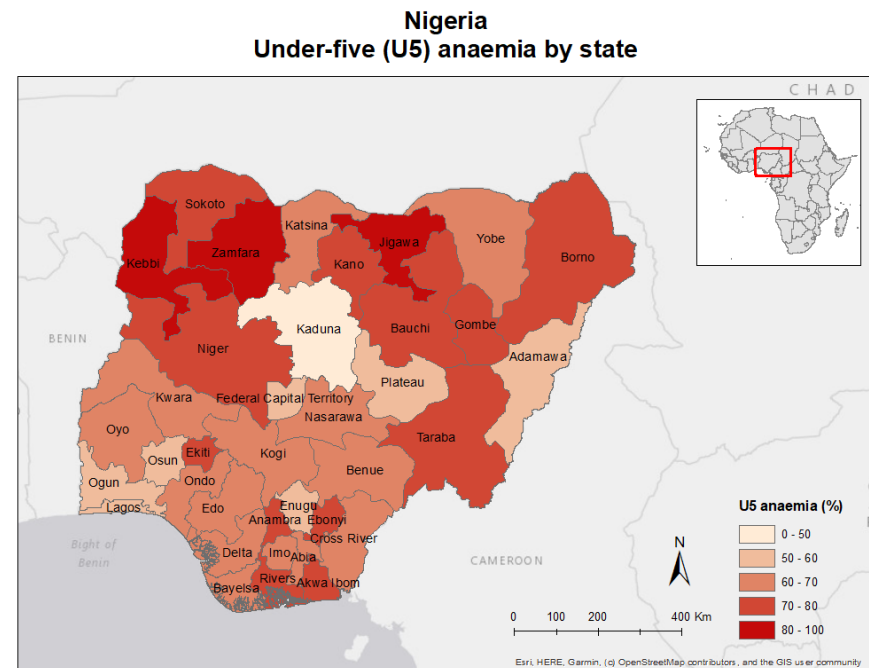
Grouping  
analysis

Driver analysis



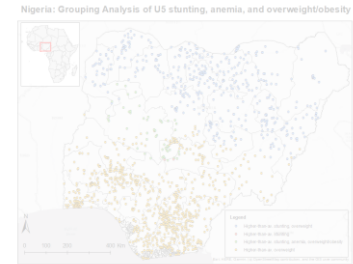
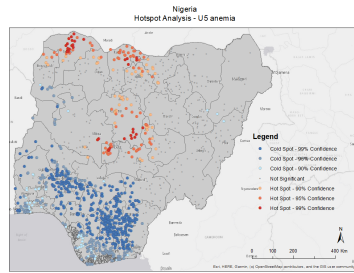
## 6.1 Analysis: Choropleth maps thresholds

- **Choropleth maps** are thematic maps with pre-defined areas according to a color scheme
- **Choropleth maps** developed here provide a representation of prevalence levels of single malnutrition types and co-occurrence of multiple malnutrition types (in the same location, the same household, and within the same individual)
- **Maps were *not* developed if:**
  1. Co-occurrence did not exist
  2. Maps for which the proportion of individuals or mother-child pairs experienced a co-occurrence of less than 10% (except for Senegal for which all the U5 malnutrition maps were shown).



# 6.1 Analysis: Choropleth map and thresholds used

Indicator	Publish thresholds	Adjusted thresholds
U5		
Anemia	<=4.9%: no public health problem 5-19.9%: mild public health problem 20-39.9%: moderate public health problem >=40% severe public health problem <sup>a</sup> (De Benoist & Mclean, 2008)	Below 50 50 – 60 60 – 70 70 – 80 Above 80
Stunting	<2.5%: Very low 2.5% – <10%: Low 10% – <20%: Medium 20% – <30%: High >=30%: Very high <sup>c</sup> (De Onis et al., 2019)	Below 10 10 – 20 20 – 30 30 – 40 Above 40
Overweight/obesity	<2.5%: Very low 2.5% – <5%: Low 5% – <10%: Medium 10% – <15%: High >=15%: Very high <sup>c</sup> (De Onis et al., 2019)	
WRA		
Anemia	<=4.9: no public health problem 5-19.9: mild public health problem 20-39.9 moderate public health problem >= 40 severe public health problem (WHO, 2010) <sup>b</sup>	
Thinness/underweight	5-9%: low prevalence (warning sign, monitoring required) 10-19%: medium prevalence (poor situation) 20-39%: high prevalence (serious situation) >=40% very high prevalence (critical situation) <sup>a</sup> (De Benoist & Mclean, 2008)	
Overweight/obesity	≥ 30%	Below 10 10 – 20 20 – 30 Above 30



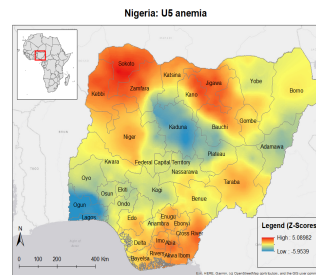
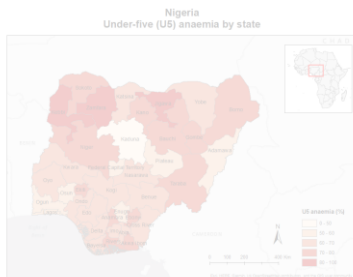
Choropleth  
maps

Hotspot  
analysis

Spatial  
interpolation

Grouping  
analysis

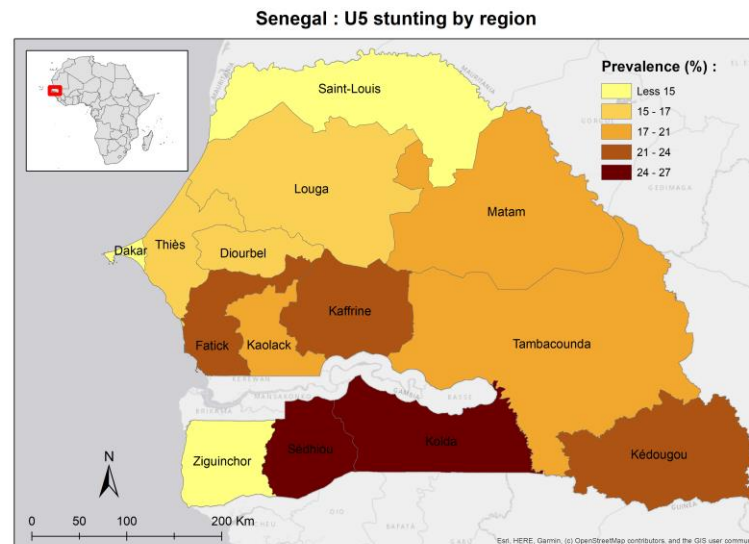
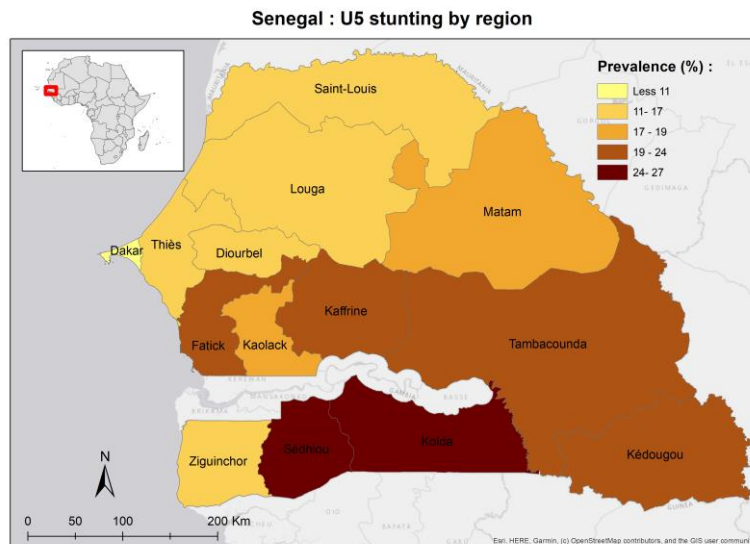
Driver analysis



## 6.2 Analysis: Why hotspot analysis?

- Mapping prevalence levels (choropleth maps) only shows potential clusters (high or low prevalence areas), but the type of classification method used affects the type of clusters you see (see example below)

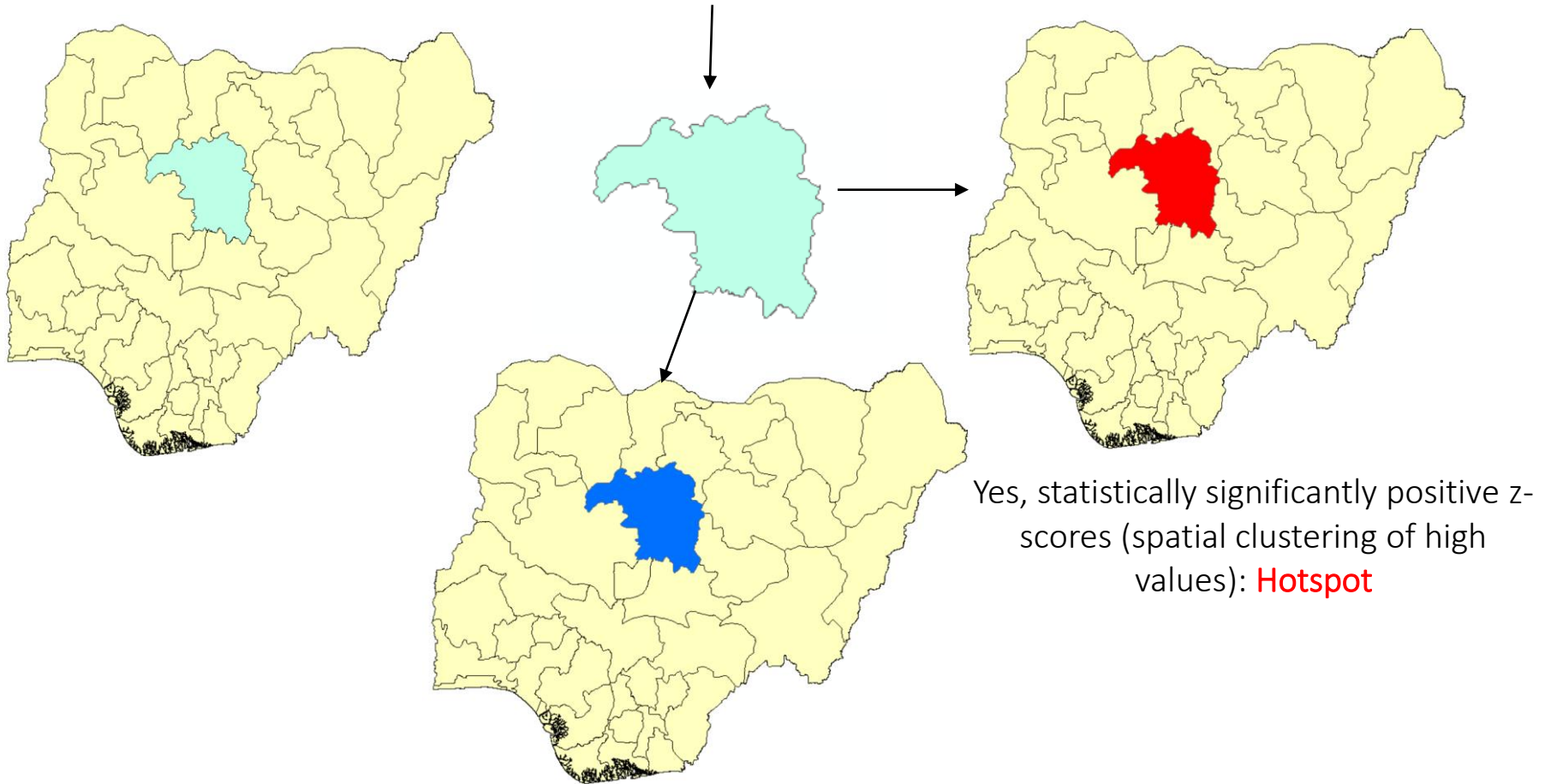
Senegal U5 stunting	
Jenks (natural breaks) classification method	Quantile classification method



- Using local statistics such as Getis-ord  $G_i^*$  (used in hotspot analysis) allows one to calculate the probability of clusters occurring by chance, providing greater confidence in the results

## 6.2 Analysis: Why hotspot analysis?

Is the prevalence level in this area significantly different from what is happening in the rest of the country?



Yes, statistically significantly positive z-scores (spatial clustering of high values): **Hotspot**

Yes, statistically significantly negative z-scores (spatial clustering of low values):  
**Coldspot**

## 6.2 Analysis: Hotspot analysis and spatial interpolation

- **Hotspot analysis:** identifies statistically significant spatial clusters (hot spots, areas of high occurrence, and cold spots, areas of low occurrence) using the Getis-Ord\* statistics
- The  $G_i^*$ -statistic tells us whether high values or low values (but not both) tend to cluster in a study area. Thus, it's often used to identify whether hot spots or cold spots exist.

The formula of the  $G_i^*$  statistic for a cluster (i) at a distance (d) is :

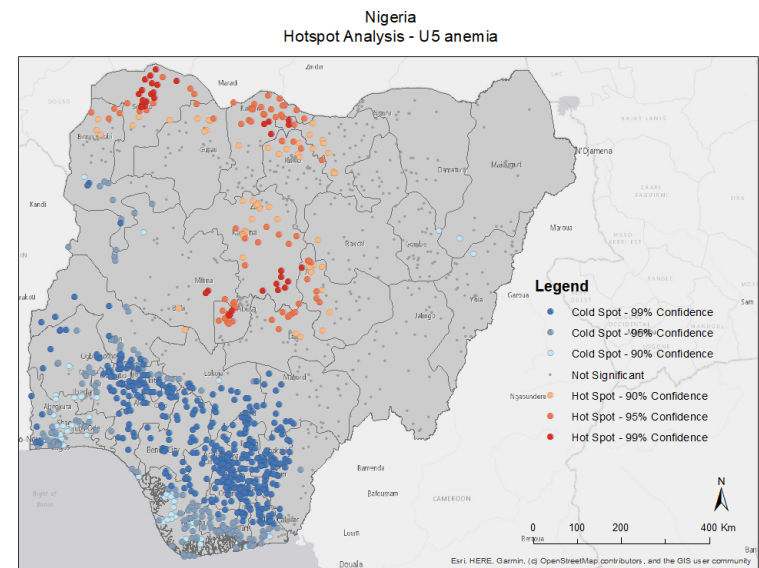
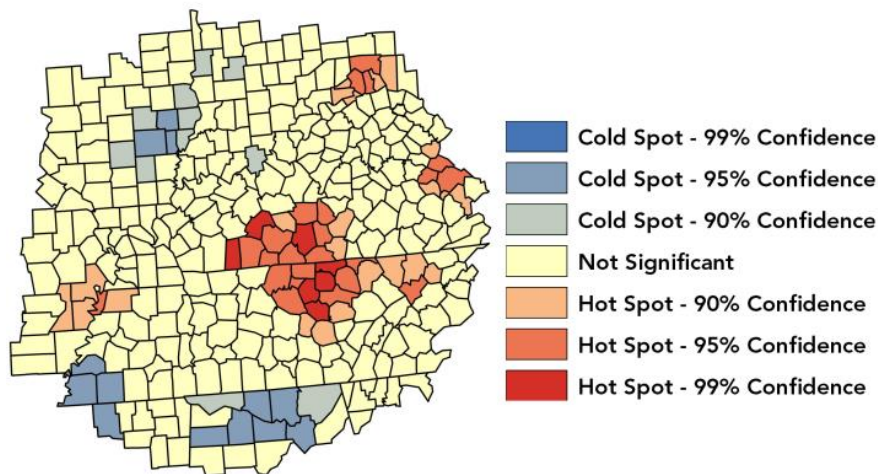
$$G_i^* (d) = \frac{\sum_j w_{ij} (d) x_j}{\sum_j x_j}$$

Explanation : The value for each neighbor (  $x_j$  ) is multiplied by the weight for the target-neighbor pair (  $w_{ij}$  ), and the results summed,

Then the sum is divided by the sum of the values of all neighbors (  $x_j$  ) , that is , all the clusters in the data set

## 6.2 Analysis: Hotspot analysis and spatial interpolation

- **Choice of distance:** The 'optimal fixed distance' generated via the Optimized HotSpot Analysis was used as the beginning distance in Incremental Spatial Autocorrelation; approx. one eighth of the country length was used as the 'distance increment'; distance bands (n=30) were used.
- A high value (**red**) for the  $G_i^*$ -statistic indicates that high values—values higher than the mean for the study area—tend to be found near each other.
- A low value (**blue**) for the  $G$ -statistic indicates that values lower than the mean tend to be found together.

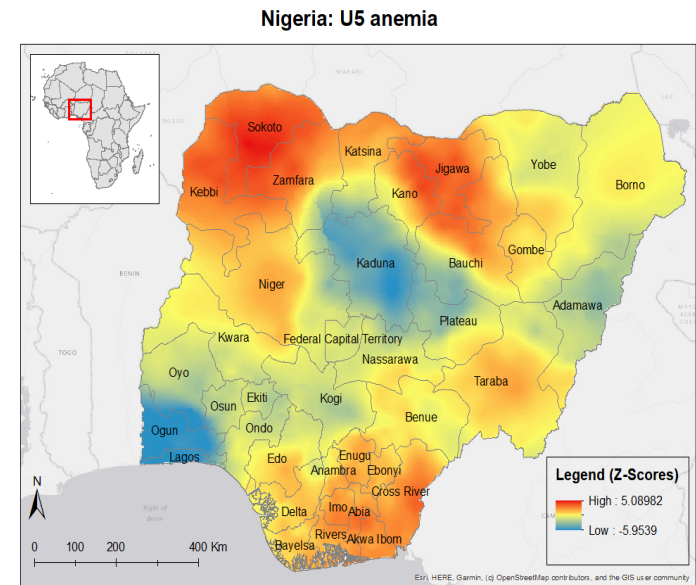


Source: Yelena Ogneva-Himmelberger,  
Clark University, Introduction to GIS, Fall  
2016

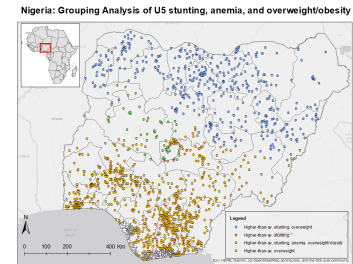
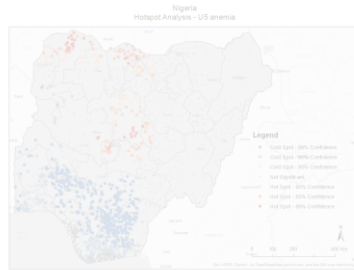
## 6.2 Analysis: Hotspot analysis and spatial interpolation

**Spatial interpolation:** Cluster-level point data from hotspot maps (points with z-values) used to carry out spatial interpolation, which assigns values to pixels that did not previously have a value via a method called Empirical Bayesian Kriging in ArcMap (to get full area coverage)

- **Kriging:** geostatistical procedure that generates an estimated surface from a scattered set of points with z-values. The Kriging tool in ArcMap effectively involves an interactive investigation of the spatial behavior of the phenomenon represented.
- **Empirical Bayesian Kriging** is an interpolation method that accounts for the error in estimating the underlying semivariogram through repeated simulations.



- **Analysis units :** DHS clusters from the most recent DHS survey in each country. Clusters were representative at national and first administrative subnational level.
- **Exclusions :** All single burdens and co-occurrences were considered but only those for which statistically significant spatial clusters were found were included.



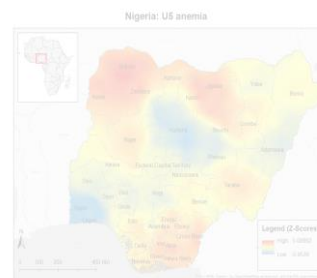
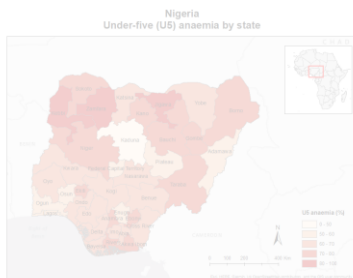
Choropleth  
maps

Hotspot  
analysis

Spatial  
interpolation

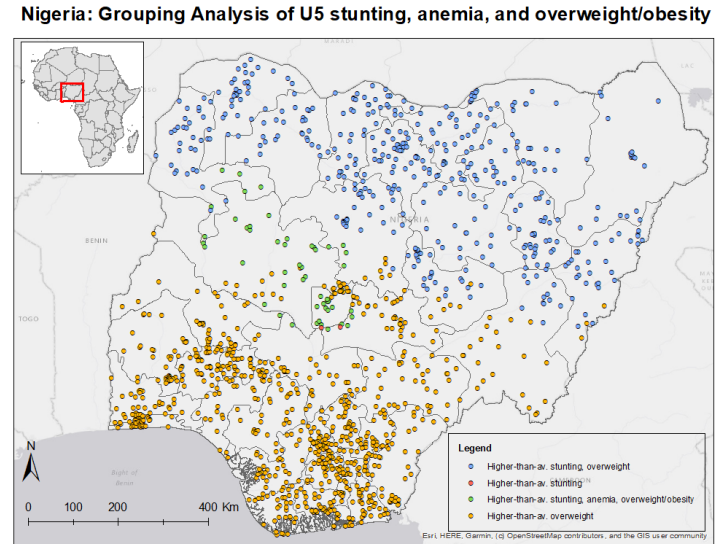
Grouping  
analysis

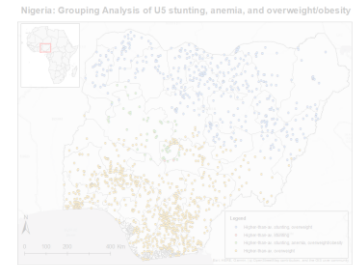
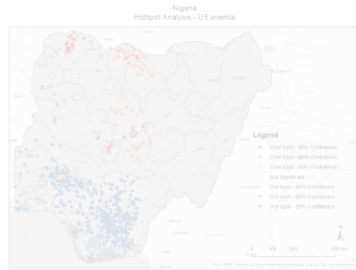
Driver analysis



## 6.3 Analysis: Grouping analysis

- Grouping analysis uses unsupervised machine learning to identify natural groupings within a dataset, according to set spatial constraints, i.e. it will look for a solution where all the features within each group are as similar as possible, and all the groups themselves are as different as possible.
- Allows to see which malnutrition types are associated (in the same location):
  - For U5 : stunting, anemia, and overweight/obesity
  - For WRA : thinness, anemia, and overweight/obesity
- Grouping was only carried out for all three U5 single malnutrition types (1) and all three WRA single malnutrition types (2) to maintain map interpretability.





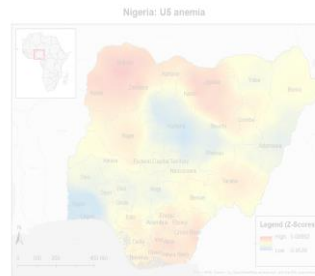
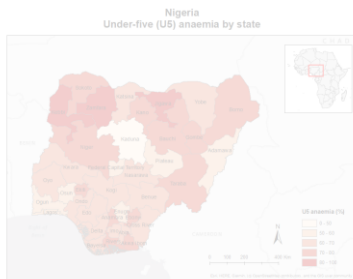
Choropleth  
maps

Hotspot  
analysis

Spatial  
interpolation

Grouping  
analysis

Driver analysis



## 6.4 Analysis: Drivers

- Conducted only for malnutrition types for which significant spatial clustering was found using **hotspot analysis**
- **Unit of analysis:** DHS clusters
- **Dependent variable:** Binary variable related to the presence of hotspot – 1: Cluster is a hotspot – 0: Cluster is not a hotspot
- Potential explanatory variables identified through literature review and final model identified using backward stepwise regression
- **Model:** Spatial logistic regression, odd ratios reported, and confusion matrix evaluated
- **Spatial dimension included** using a spatial lag computed using distance weights and row-standardized weight method in Geoda Software (Chuang et al 2017)
- **Sensitivity:** Proportion of true hotspots identified by the model
- **Specificity:** Proportion of “non” hotspots identified as so by the model