Spatio-temporal risk assessment to aid in planning malaria elimination in Senegal

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Background

Malaria

- Malaria is one of the **high-risk diseases** that has been targeted by **WHO**

- Rates have been **declining** since 2010, but 219 million cases of malaria were reported in 2017 making it a continued public health concern

- The **risk** of malaria **varies** significantly within the region or area and the same strategy is not necessarily appropriate for all the settings within a country

- The transmission is seasonal and tends to occur from June to November

Background

Senegal

- **West African country** home to approximately 15 million people

- Strong history of **seasonal internal migration** to look for work in agriculture or in the cities

- Cases of **malaria is decreasing**: 1.6 million cases in 2006 to just over 600 000 cases eight years later

- There is **great variation** in **malaria rates** depending on the area of the country, with lower rates in the northern region and higher rates in the southeast

Senegal: Malaria Incidence per 1000 People by Health District in 2013

Study Aim and Objectives

The focus of the current study is to **identify and analyze human movement patterns** using web-based data to aid in planning of malaria elimination in the Senegal region.

- To find the **spatial association** between the population density and distance of Senegal regions over the years;

- To find the **spatial temporal variation** in people movement over the different quarters of the year 2013-14;

- To create a **trajectory model** showing human movement across the Senegal region through call detail record data (CDR) using previously established methodologies.
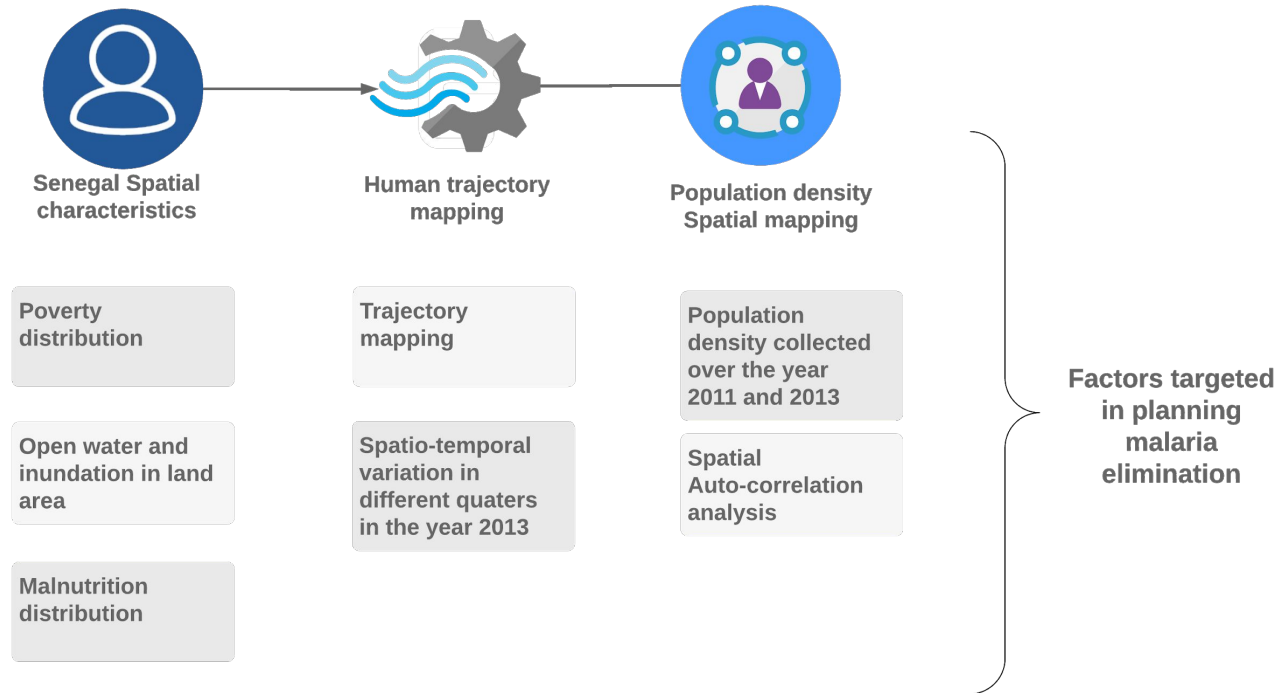
Methodology

- **Geo-spatial analysis** and **human movement trajectory mapping** to identify the spatial temporal variation of human movement over 2013

- Data:
    - population data
    - open water and land area data
    - poverty data
    - malnutrition data
    - call detail records (CDR) data

Methodological flow

Senegal Spatial characteristics

Human trajectory mapping

Population density Spatial mapping

Poverty distribution

Trajectory mapping

Population density collected over the year 2011 and 2013

Open water and inundation in land area

Spatio-temporal variation in different quaters in the year 2013

Spatial Auto-correlation analysis

Malnutrition distribution

**Factors targeted in planning malaria elimination**

Analysis Plan

- **Spatial autocorrelation,** using the **Global Moran's I statistic**, was used to depict the presence of systematic spatial variation between the population density and region of Senegal over two time points; 2011 and 2013.

- Heat distribution maps using **spatial interpolation with the kriging method** were used to explore seasonal variation over 2013 by dividing it into 3-month quarters.

- **Trajectories of individuals** were mapped for a sample of 1,000 cell phone users in January 2013 to identify common movements across Senegal.
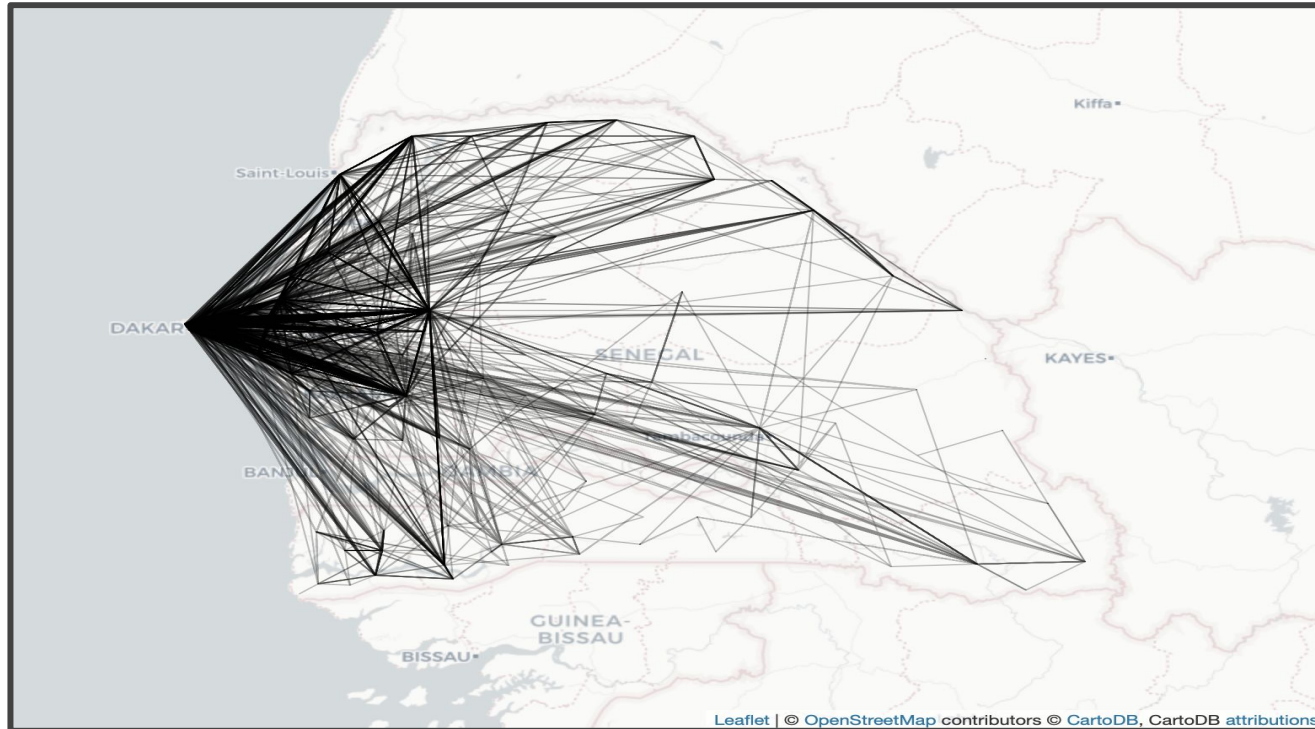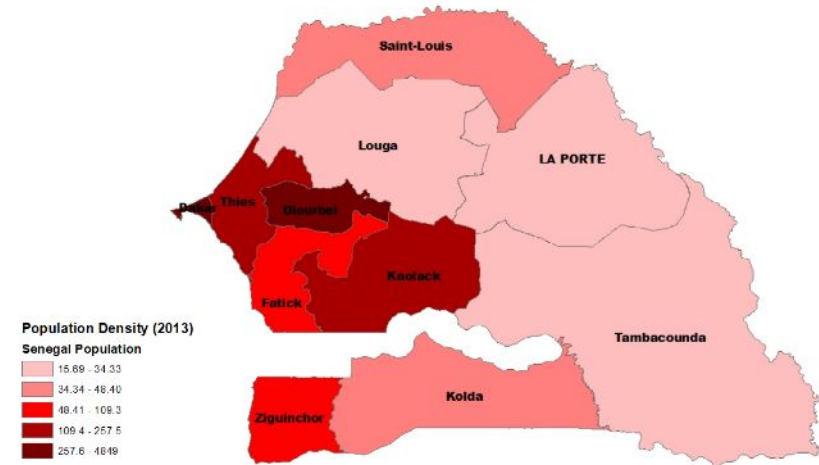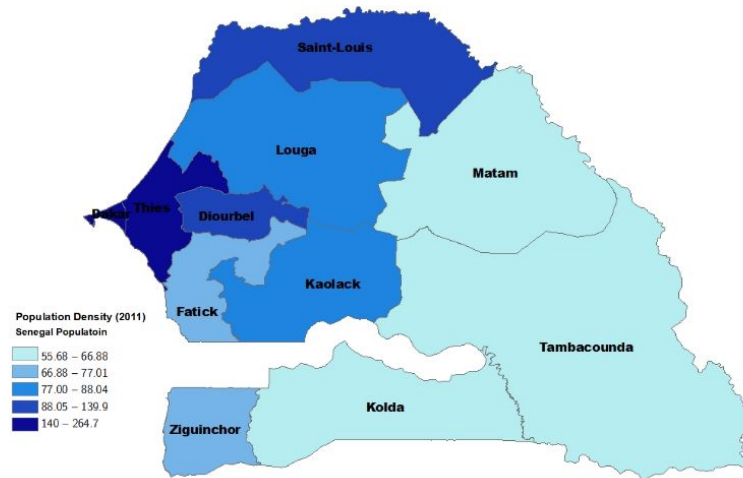
Results

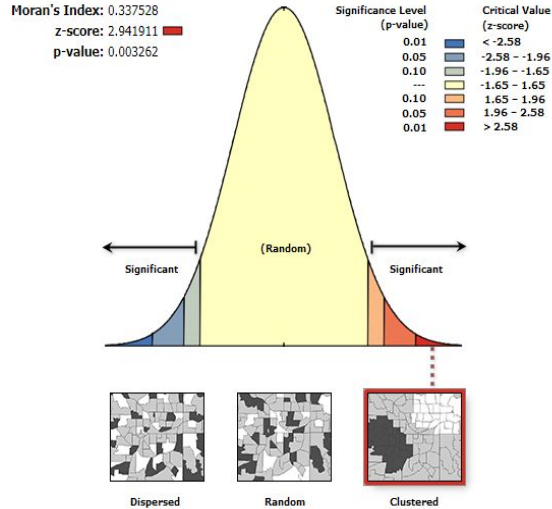# Spatio-temporal characteristics
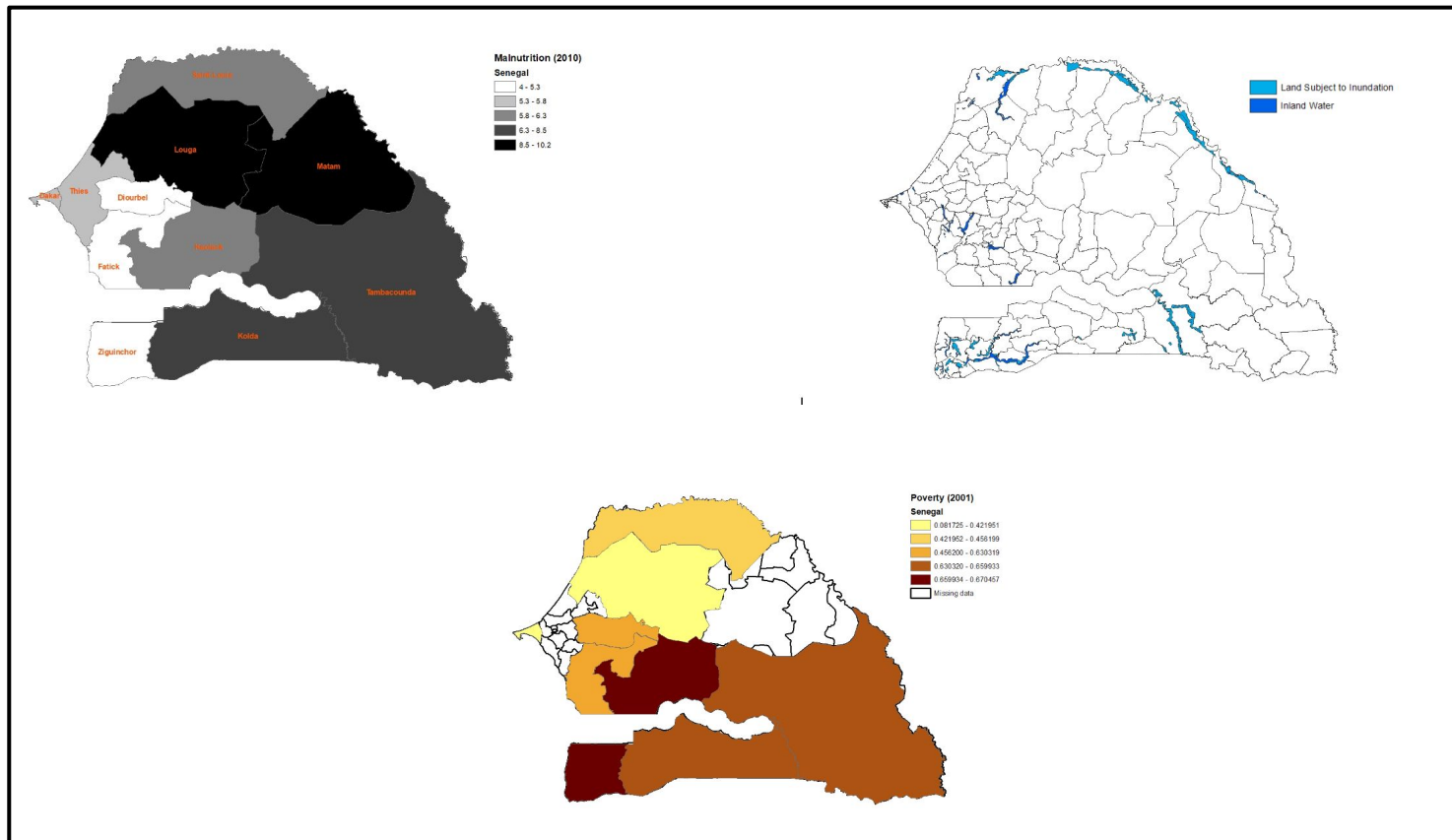
Human movement pattern

Annual population density in Senegal (2011 & 2013)

2011

Spatial Autocorrelation Report

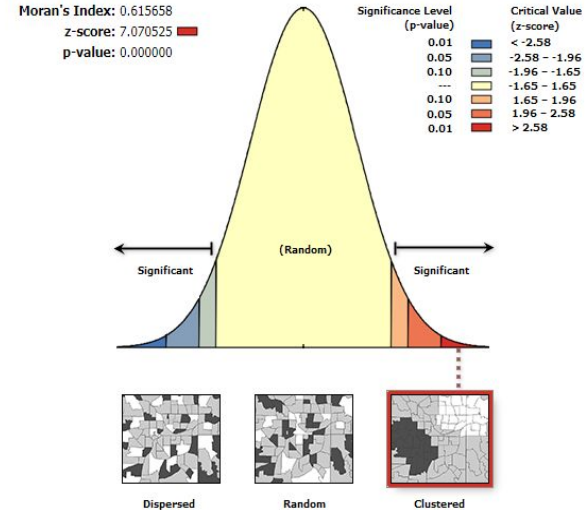Moran's Index: 0.337528
z-score: 2.941911
p-value: 0.003262

Given the z-score of 2.94191116242, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Global Moran's I Summary

Moran's Index:	0.337528
Expected Index:	-0.100000
Variance:	0.022118
z-score:	2.941911
p-value:	0.003262

2013

Spatial Autocorrelation Report

Moran's Index: 0.615658
z-score: 7.070525
p-value: 0.000000

Given the z-score of 7.07052477856, there is a less than 1% likelihood that this clustered pattern could be the result of random chance.

Global Moran's I Summary

Moran's Index:	0.615658
Expected Index:	-0.022727
Variance:	0.008152
z-score:	7.070525
p-value:	0.000000

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Spatio-temporal population distribution in different seasons

(a) January to March
(b) April to June
(c) July to September
(d) October to December
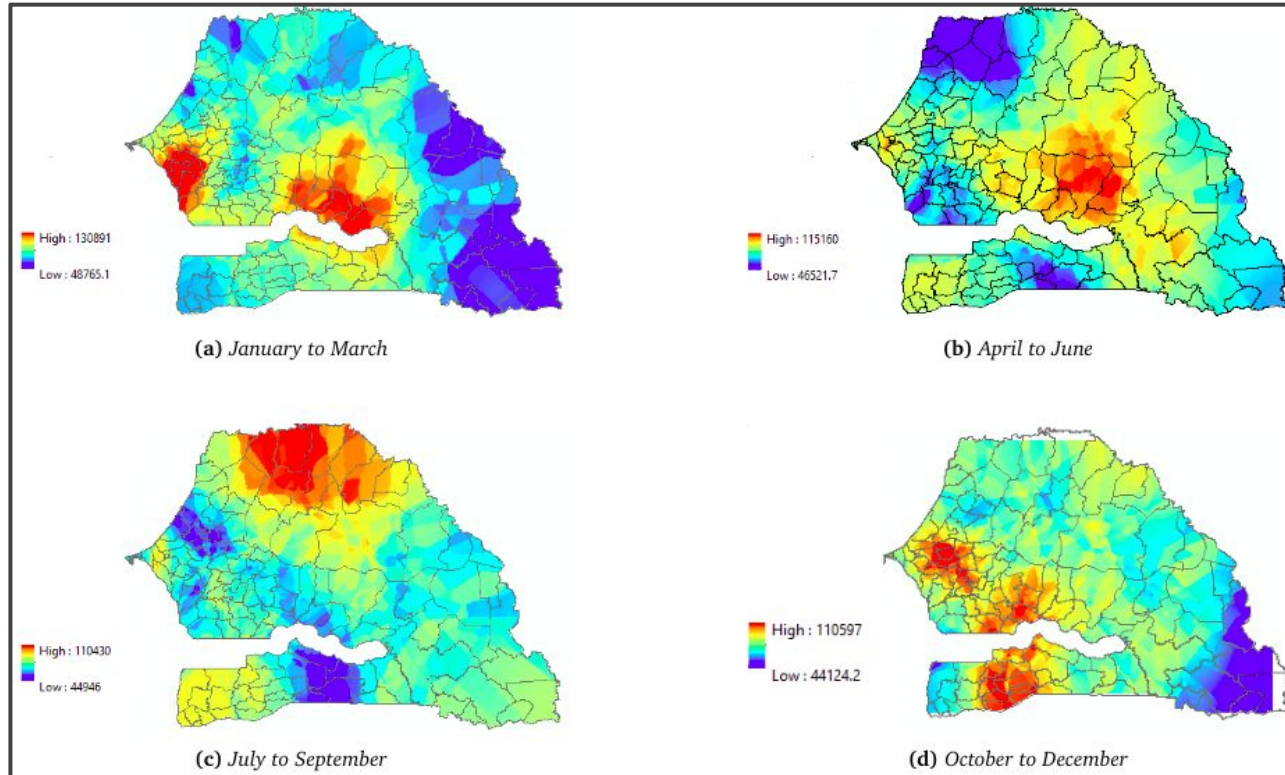
Summary

- **Spatio-temporal aspect** should be considered for planning any vector-borne diseases elimination, especially when seasonal migration occurs to or from disease-prone areas.

- **Seasonal internal migration patterns** of the Senegalese population indicates the possibility that people move to or from malarial high-risk areas, potentially hindering any gains made in malaria elimination planning.

Strengths

- Leveraged existing research on methodologies to use call record data to aid in the elimination planning for malaria, furthering scientific knowledge and **adding to the legitimacy** of using non-traditional data for public health purposes.

- Attempted to view the problem from a different angle; to that of seasonal internal migration of the population.

- The methodologies used and results obtained show promise for using call record data to study **human movement at a more frequent time scale to understand how vector-borne and infectious diseases may be spread**.

Limitations

- CDR data are **unlikely to indicate a random sample of the population**, which can hinder the generalization of the results.

- **Cultural uses cell phones**: can be used by a group of people or multiple SIM cards to be used by one person for different reasons.

- Men are more likely to be the holder of cell phones, thus movement captured by the SIM card is likely to represent the movement of men and less so for women.

- Lack of mobility flow data

- Lack of directionality of movement

Thank you!