Assessing TB Treatment Facility Distribution and Accessibility in Akwa Ibom State, Nigeria

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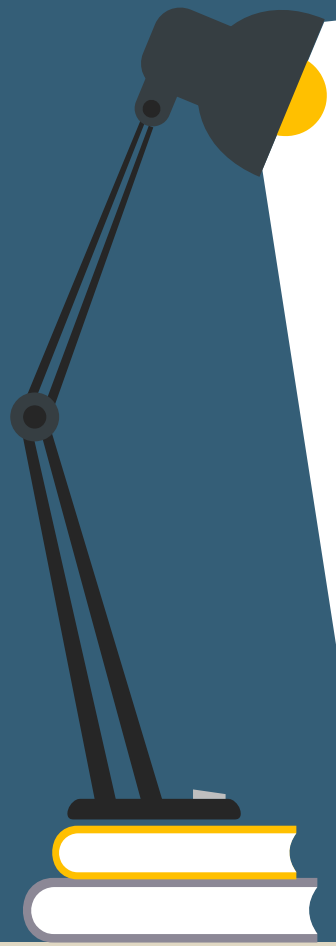
Contents



Introduction

- Nigeria is one of the largest and most populous countries in Africa.
- Nigeria is ranked seventh among the countries with the highest risk of tuberculosis by WHO (Ogbudebe et al., 2023).
- Various international organizations are implementing aid and policies for tuberculosis treatment and prevention (Erah & Ojieabu, 2009).
- However, ***Nigeria's tuberculosis problem is still unresolved*** (Asuquo et al., 2015; Ibokette et al., 2022; Ogbudebe et al., 2023).

Introduction

- Numerous studies have examined non-adherence to TB treatment in Nigeria (Oga-Omenka et al., 2021; Sullivan et al., 2017; Babatunde et al., 2015).
- *However, **research investigating TB treatment with accessibility among TB patients in high-burden regions of Nigeria has been limited**.*
- This study utilizes GIS raster analysis to ***investigate the accessibility of treatment facilities and the distribution of TB patients in Akwa Ibom State***, shedding light on this complexity and elucidating how regional differences in accessibility impact TB treatment compliance.

Frameworks

TB Wards in Nigeria's Healthcare System

- ***Provide diagnosis and initial treatment for TB***.
- Crucial for early detection and prevention of disease spread.
- Monitor and support patients throughout treatment.
- Conduct TB prevention education and outreach in communities (Ogbudebe et al., 2023).

- Challenges:
  - ***Accessibility issues*** (Oga-Omenka et al., 2021).
  - ***Distance and transportation barriers***.
  - Increased risk of ***treatment interruption*** or ***non-initiation*** (Sullivan et al., 2017).
  - Shortages of medical personnel and equipment (Babatunde et al., 2015).
  - Difficulty in diagnosis, treatment, and patient monitoring.

Frameworks

Challenges in TB Management in Nigeria

▶ **Demographic Disparities in TB Treatment**:

- ***Certain groups delay or forgo treatment post-diagnosis*** (Ogbuabor & Onwujekwe, 2019).
- Influenced by gender, age, occupation, education, and religion (Sariem et al., 2020).

▶ **Accessibility Issues**:

- ***Uneven patient distribution*** despite even TB ward distribution (Oga-Omenka et al., 2020; Ogbudebe et al., 2023).
- Concentration of cases in specific regions (Sullivan et al., 2017).

▶ **High TB Incidence Areas**:

- ***Increased travel distances and costs for patients***.
- Difficulty in maintaining treatment adherence.

Frameworks

Challenges in TB Management in Nigeria

▶ **Study Focus**:

- ***Emphasizes individual facility accessibility***.
- Importance of access for all, irrespective of location or socio-economic status.
- Special attention to ***densely populated, high-prevalence areas***.

▶ **Addressing Barriers**:

- Essential for reducing TB burden.
- Tailored efforts for demographic groups and accessibility improvement needed.

Research Design

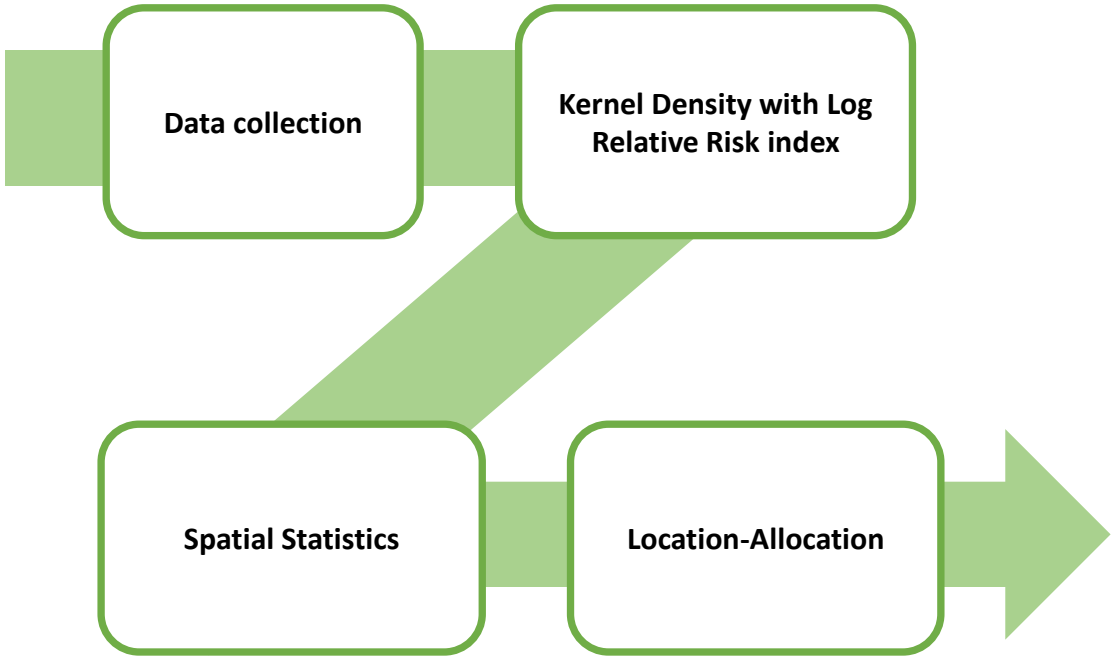
Research Design

- Research Area: **Akwa Ibom State, Nigeria**.
- Time scope: **October 2020 ~ January 2022**

- Data Resource:
  - **KNCV Nigeria Tuberculosis Foundation**

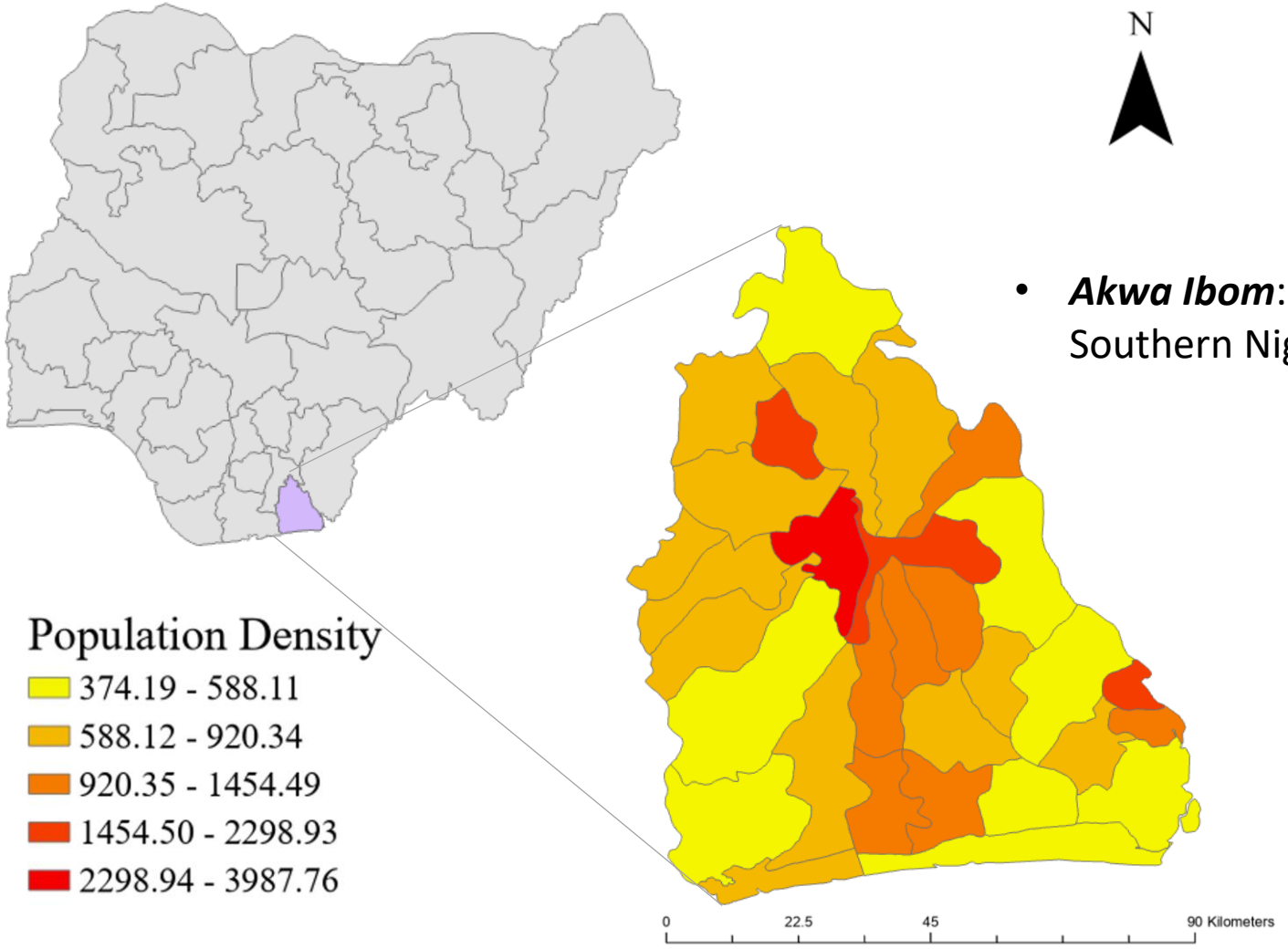
- ***Focus on accessibility rather than capacity.***
- **LRR** illustrates the supply and demand pattern and the degree of imbalance.
- **Spatial Statistics** estimates the impact of an imbalance of supply and demand on TB treatment.
- **Location-Allocation** statistically finds the optimal TB ward location.

Research Flow



Research Design

Research Area



- ***Akwa Ibom***: A hotspot for tuberculosis in Southern Nigeria (Ogbudebe et al., 2023)

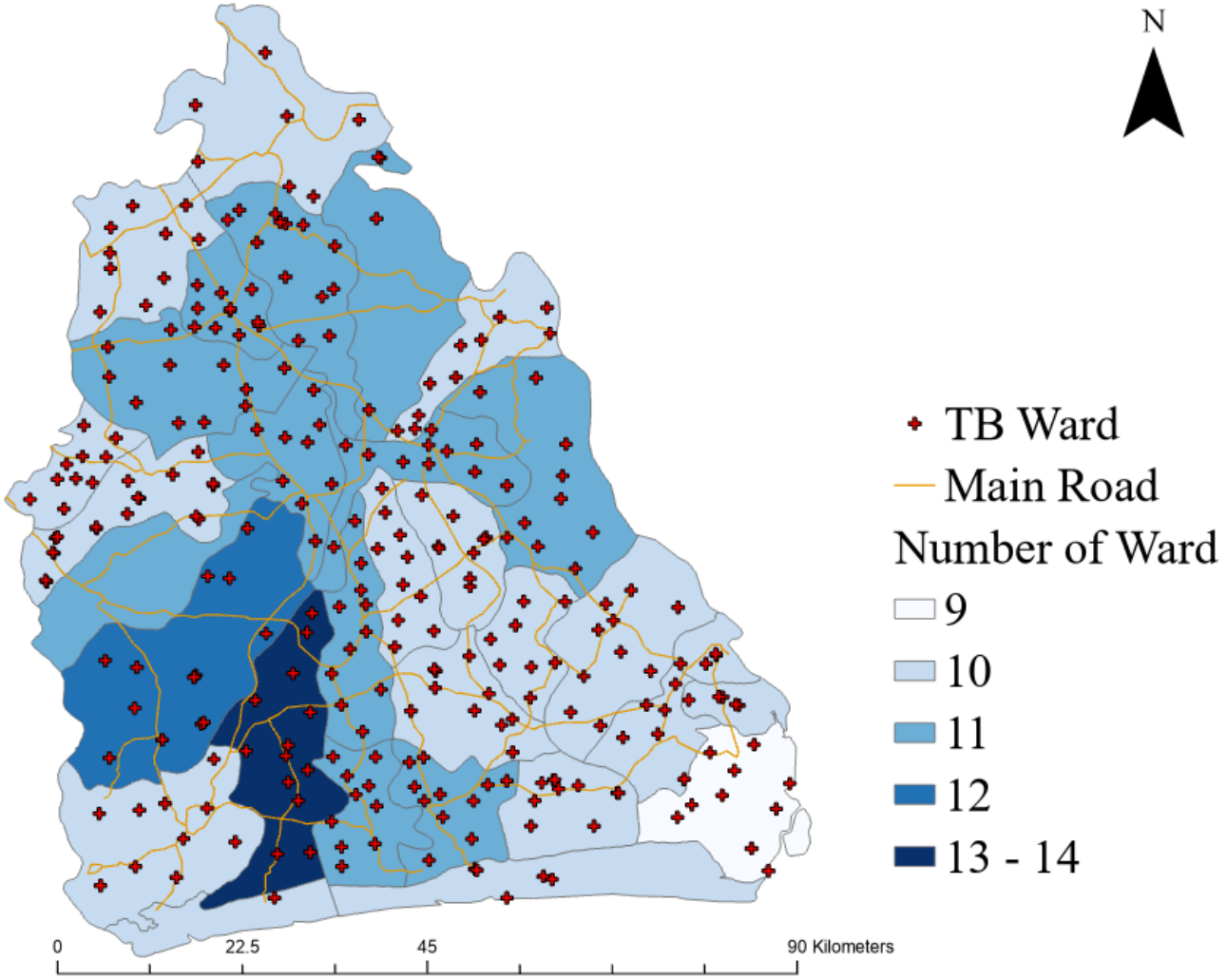
Results

Demographics of Tuberculosis Treatment Facility Demand

	TB Test cases #	TB Positive cases # (row %)	TB Treatment started # (row %)	TB Treatment Did NOT started # (row %)	Date until treatment starts Median date
Total	8638	1612(18.66%)	1401(86.91%)	211(13.09%)	2
Gender					
Male	3693	926(25.07%)	818(88.34%)	108(11.06%)	1
Female	4645	686(14.77%)	583(84.99%)	103(15.01%)	2
Age					
0~9	633	48(7.58%)	41(85.42%)	7(14.58%)	3
10~19	586	118(20.14%)	105(88.98%)	13(11.02%)	3.5
20~29	1310	308(23.51%)	276(89.61%)	32(10.39%)	1
30~39	1837	435(23.68%)	376(86.44%)	59(13.56%)	1
40~49	1446	330(22.82%)	288(87.27%)	42(12.73%)	1
50~59	1124	184(16.37%)	162(88.04%)	22(11.96%)	3
60 ~69	1038	124(11.95%)	100(80.65%)	24(19.35%)	2
70 and over	664	65(9.79%)	53(81.54%)	12(18.46%)	1

Data and Variables

TB Wards Distribution



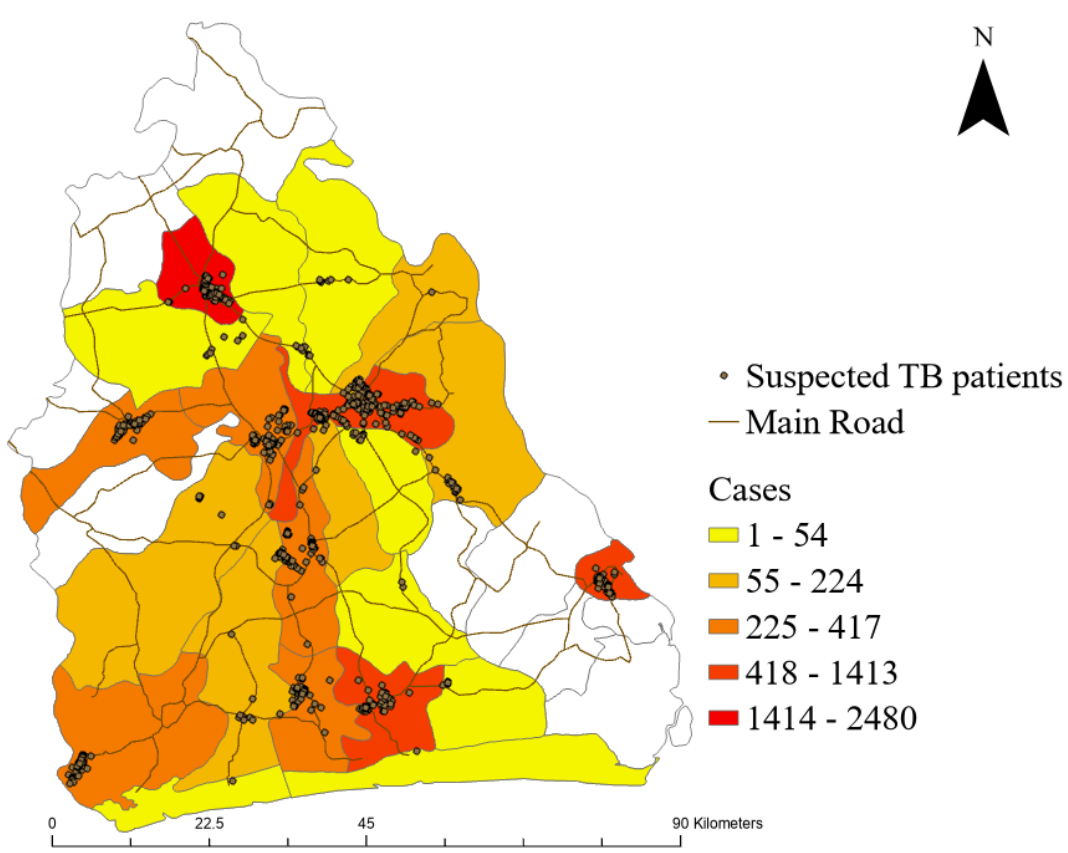
- ***Evenly spread*** along major roads for accessible TB treatment.
- ***Uniform distribution aims for equitable service*** to all residents.
- **Theoretical benefits**: Fairer healthcare, prevents regional discrimination in TB care.
- **Challenges**: ***Inefficiencies in areas with concentrated TB demand***; risk of overloading and service delays in high-incidence regions.

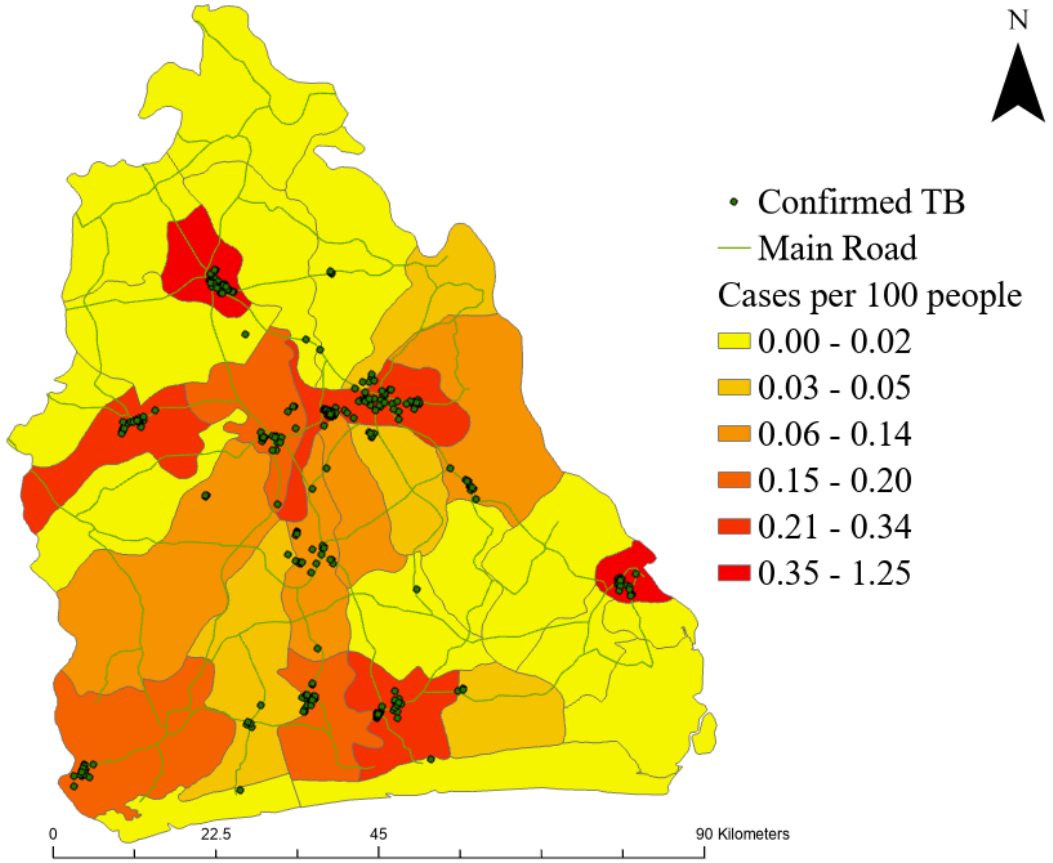
▶ ***Let's look at the demand distribution.***

Results

TB patients Distributions

***Suspected* TB patients**

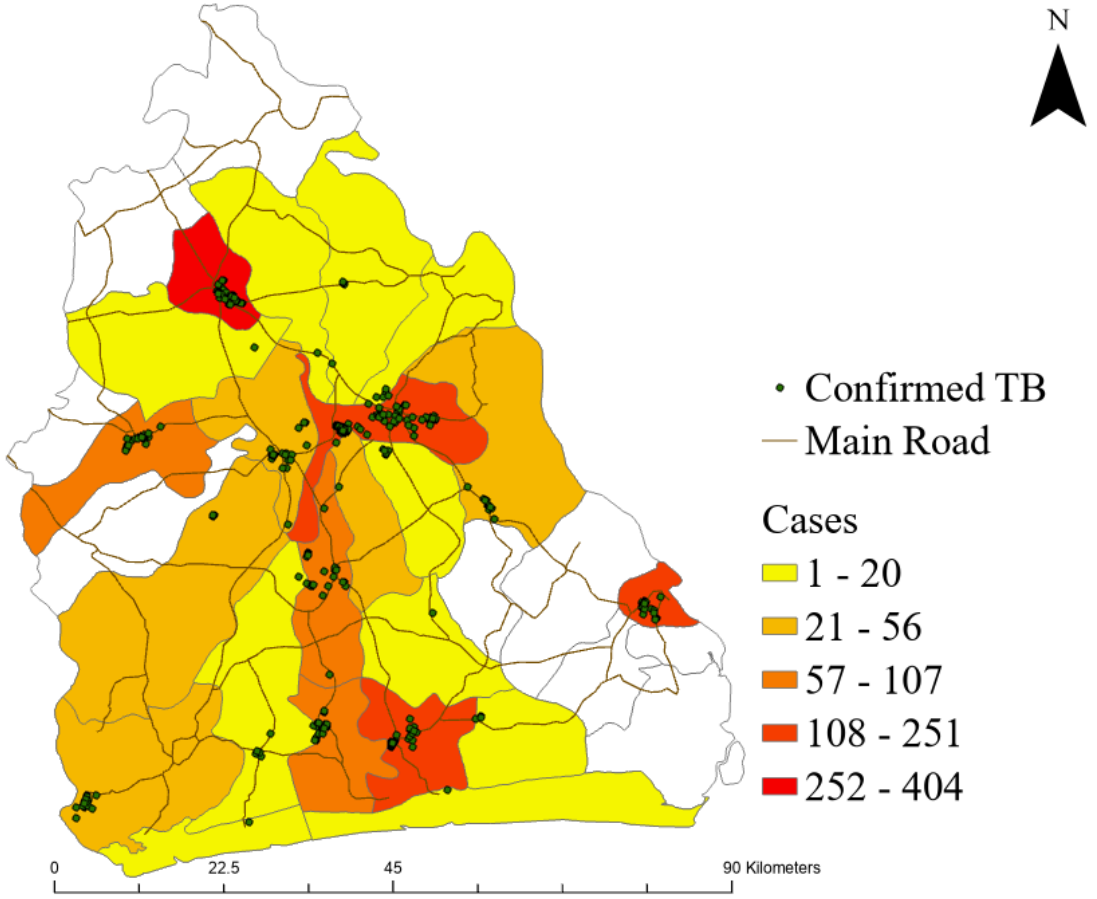


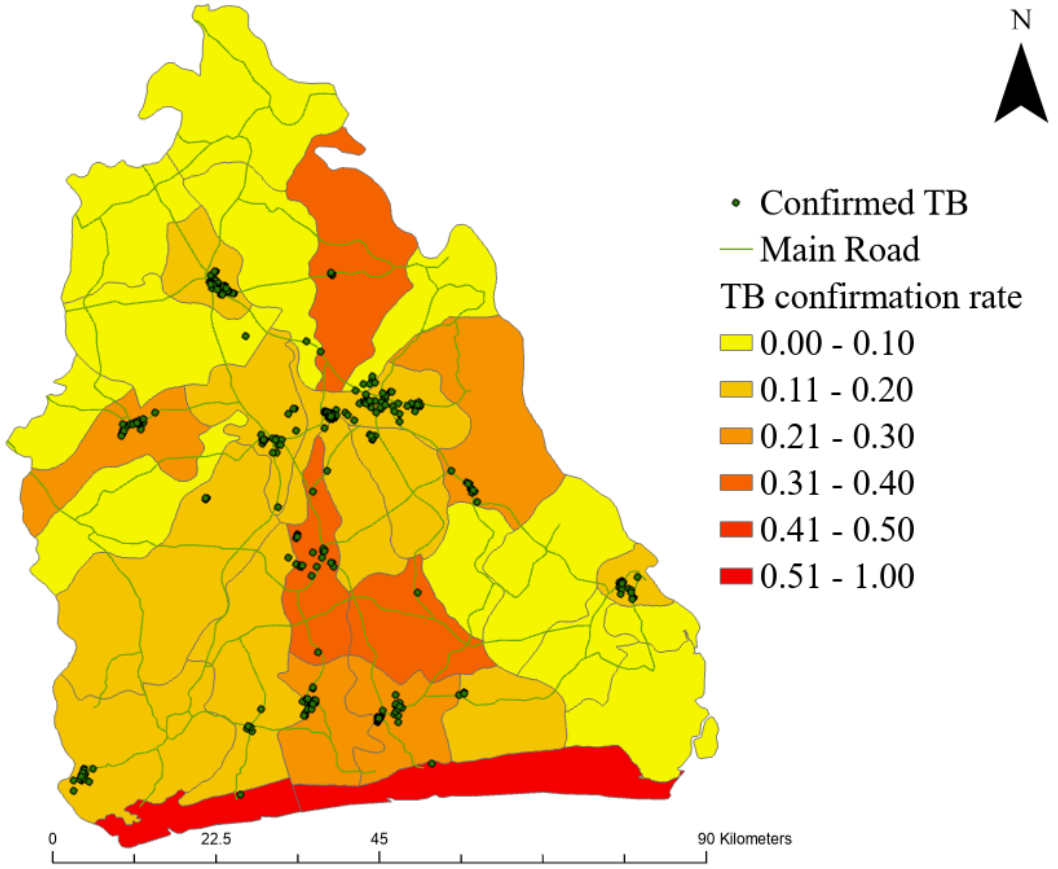


Results

TB patients Distributions

Confirmed TB cases

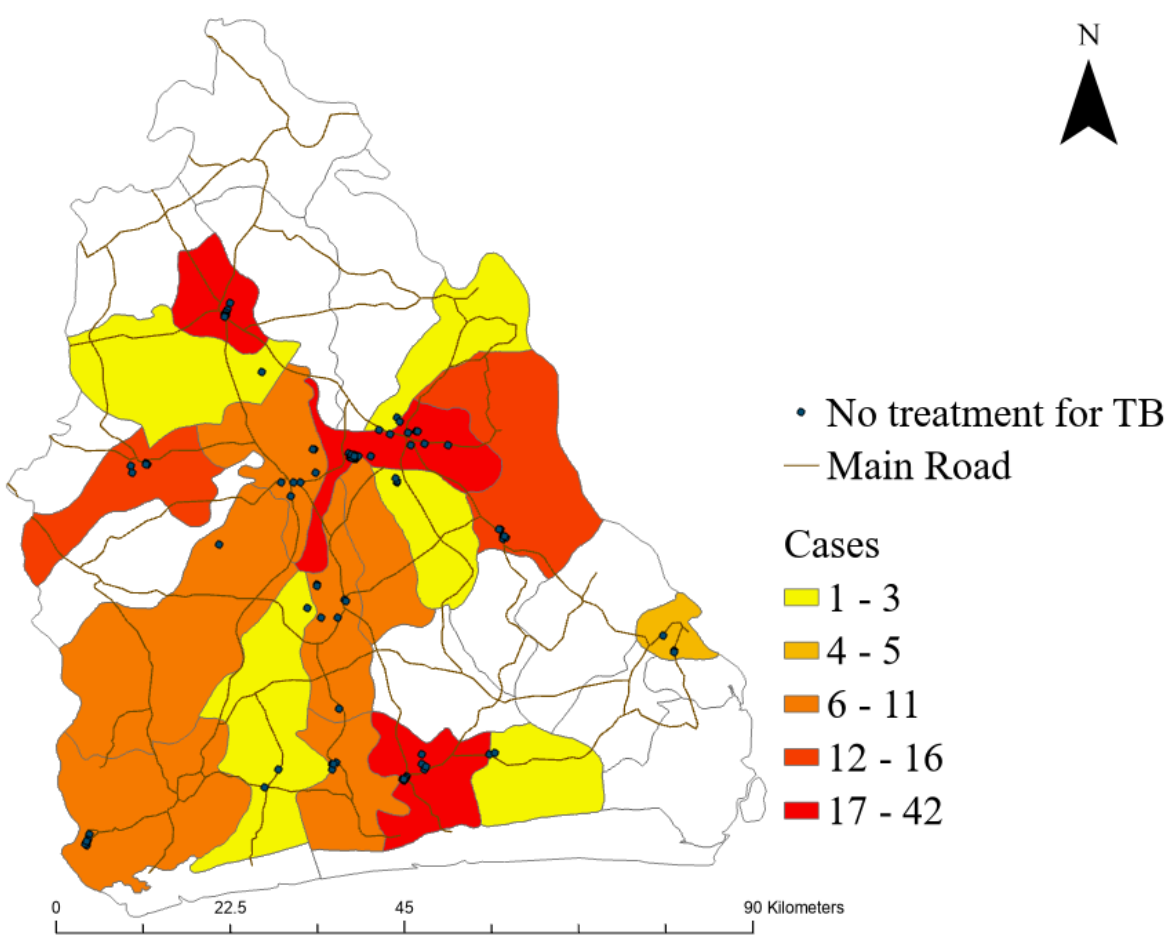


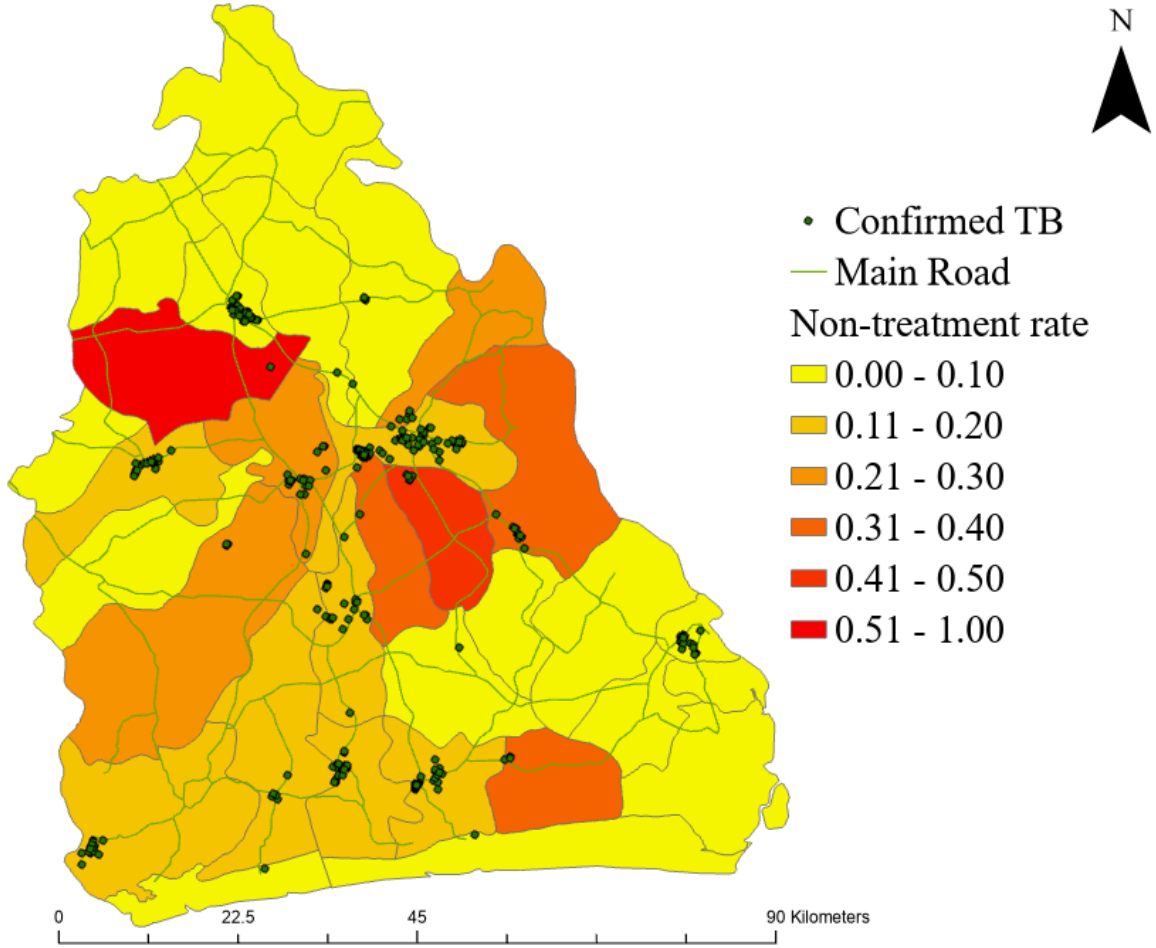


Results

TB patients Distributions

Not Treatment for TB cases

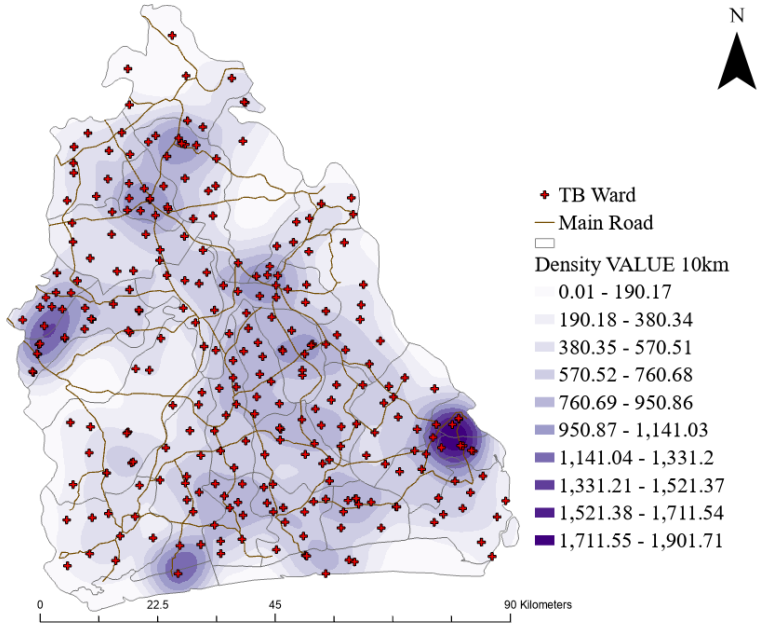




Results

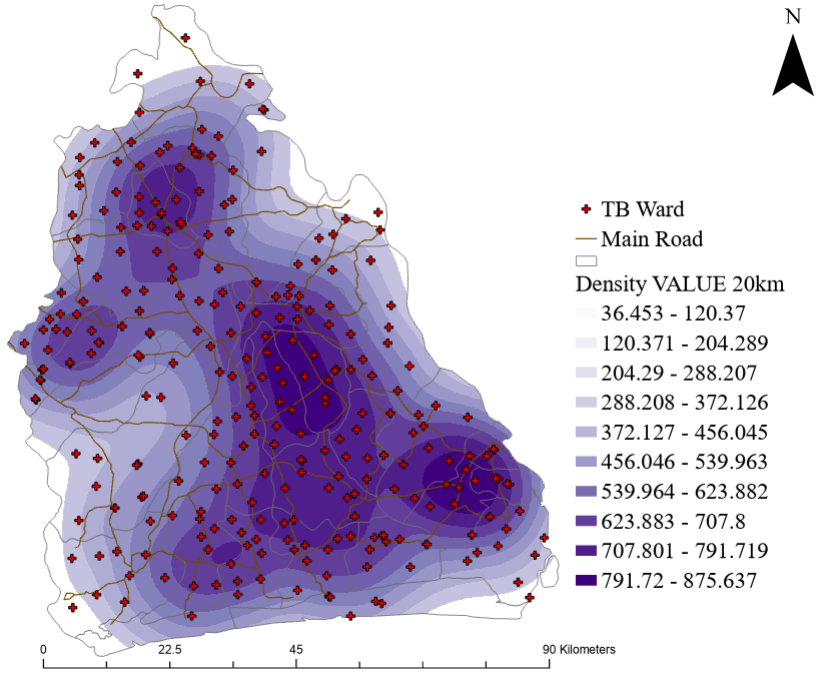
Kernel Density

Bandwidth 10km

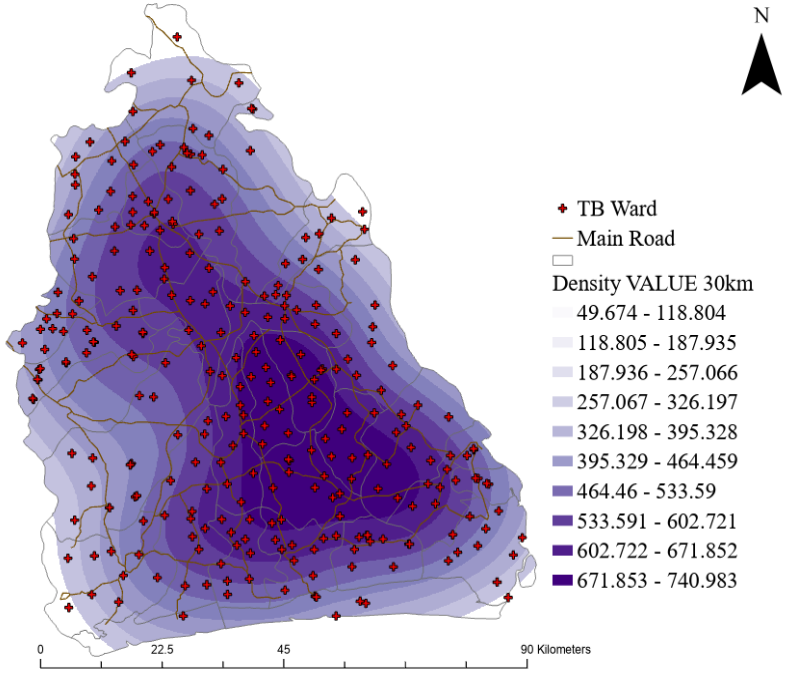


under-smoothing

Bandwidth 20km



Bandwidth 30km

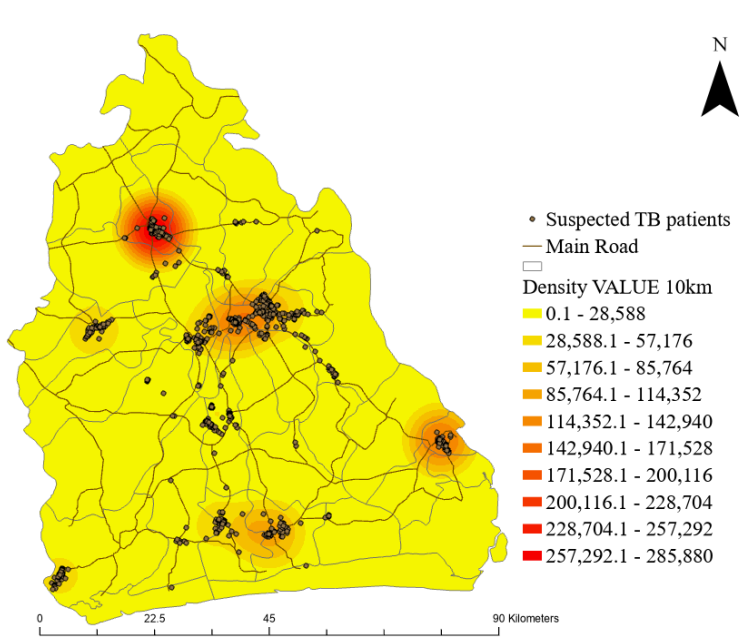


over-smoothing

Results

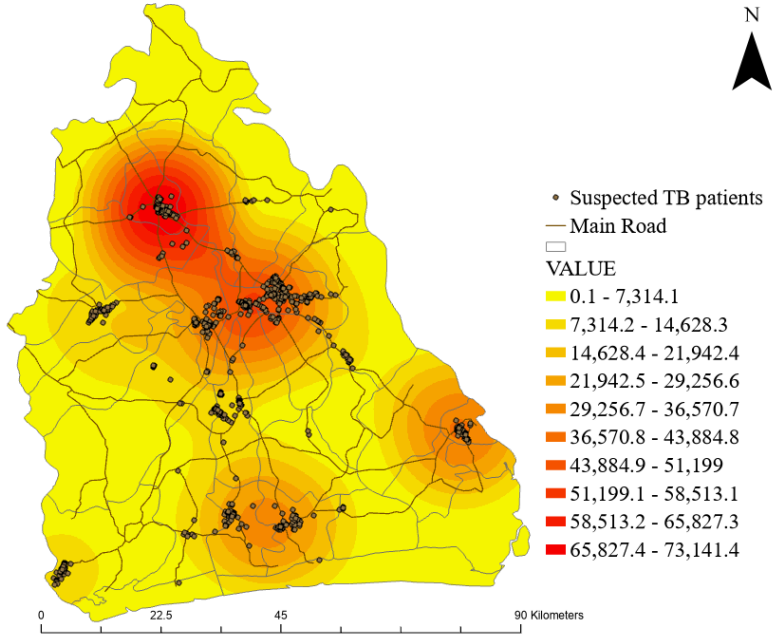
Kernel Density

Bandwidth 10km

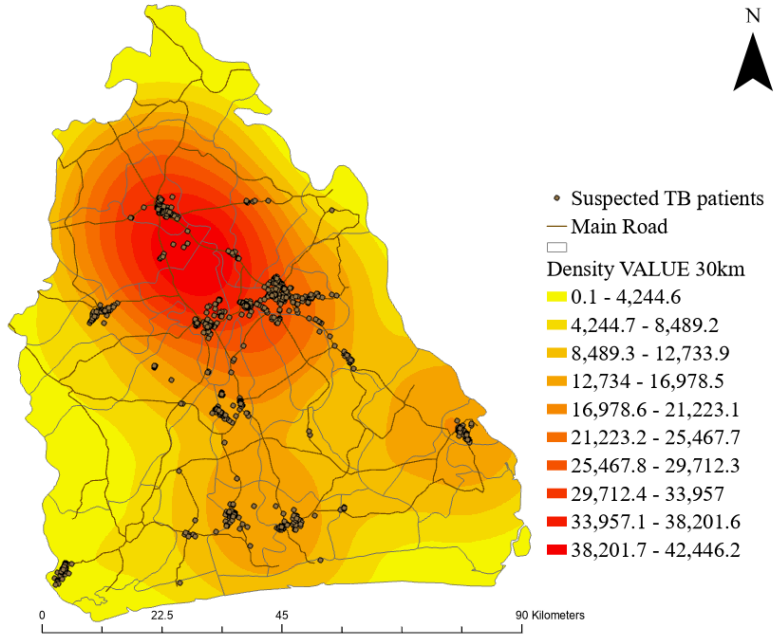


under-smoothing

Bandwidth 20km



Bandwidth 30km



over-smoothing

Results

Log Relative Risk with Kernel Density

Log Relative Risk

$$\log(\text{relative risk}(\boldsymbol{s})) = log\left(\frac{\boldsymbol{\lambda^{demand}(s)}}{\boldsymbol{\lambda^{supply}(s)}}\right)$$

$$LRR\begin{cases} > 0: Under\ Supply \\ = 0: Balanced \\ < 0: Over\ Supply \end{cases}$$

$\boldsymbol{s}$: $Surface\ (area)\ of\ a\ specific\ county$

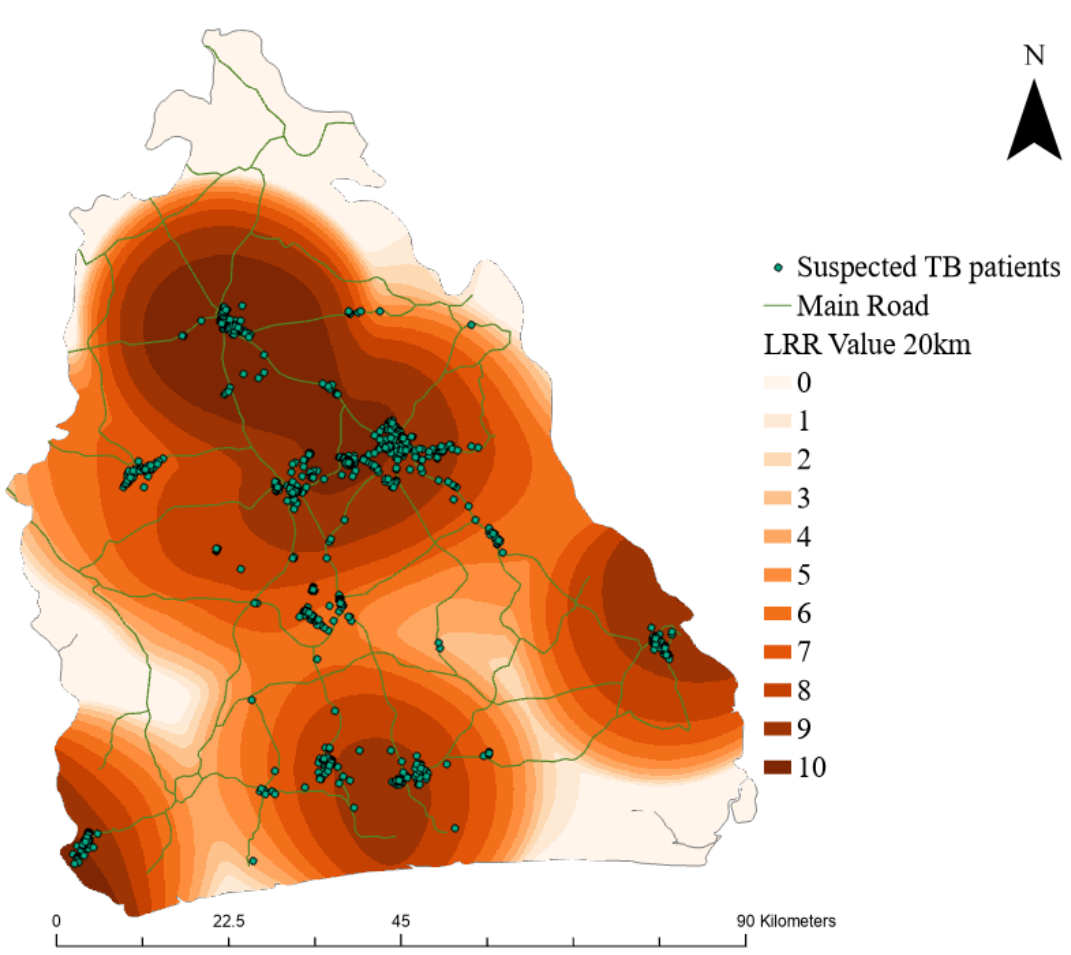
$\boldsymbol{\lambda^{supply}(s)}$: $Supply\ density\ of\ TB\ wards\ on\ surface\ based\ on\ kernel\ density$

$\boldsymbol{\lambda^{demand}(s)}$: $Demand\ density\ of\ TB\ patients\ on\ surface\ based\ on\ kernel\ density$

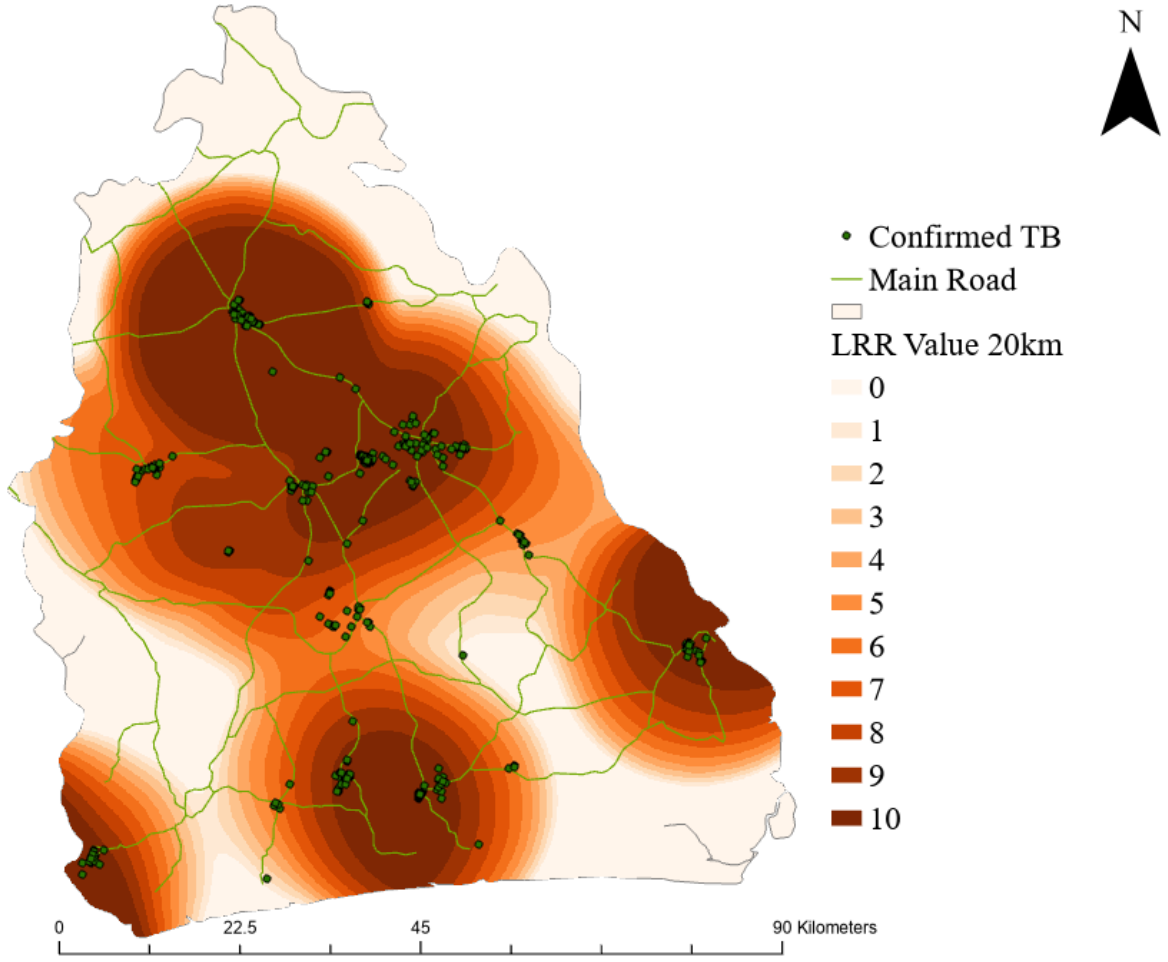
Results

Log Relative Risk with Kernel Density

Log Relative Risk of ***Suspected TB cases***



Log Relative Risk of ***Confirmed TB cases***



Results

Impact of accessibility on TB treatment

Treatment = 1
Not treatment = 0
Male = 0
Female = 1

Results of Spatial Logistic Regression for TB treatment start

logit	Model 1 Coeff (Std.Err)	Model 1 z	Model 2 Coeff (Std.Err)	Model 2 z	Model 3 Coeff (Std.Err)	Model 3 Z
_cons	-0.471 (0.331)	-1.42	-1.055 (0.392)	-2.69***	-0.490 (0.986)	-0.50
LRR	-1.497 (0.344)	-4.35***	-1.482 (0.346)	-4.28***	-2.112 (1.035)	-2.04**
Gender			-0.312 (0.151)	-2.06**	-1.602 (0.686)	-2.33**
Age			-0.011 (0.004)	-2.37**	-0.018 (0.021)	-0.85
LRR*Gender					2.041 (0.712)	2.87***
LRR*Age					0.007 (0.022)	0.33
Obs	1602		1602		1602	
Pseudo R^2	0.014		0.021		0.028	
Log likelihood	-607.606		-603.242		-598.906	

*** p<0.01, ** p<0.05, * p<0.1

- As the Log Relative Risk (LRR) increases (indicating an increase in supply shortage), the probability of not receiving treatment also increases.
- It was found that women were more likely not to receive treatment than men.
- As LRR increased, differences in treatment by gender became more pronounced.

Results

Impact of accessibility on TB treatment

Treatment = 1
Not treatment = 0
Male = 0
Female = 1

Results of Cox Regression for TB Treatment Starting Date

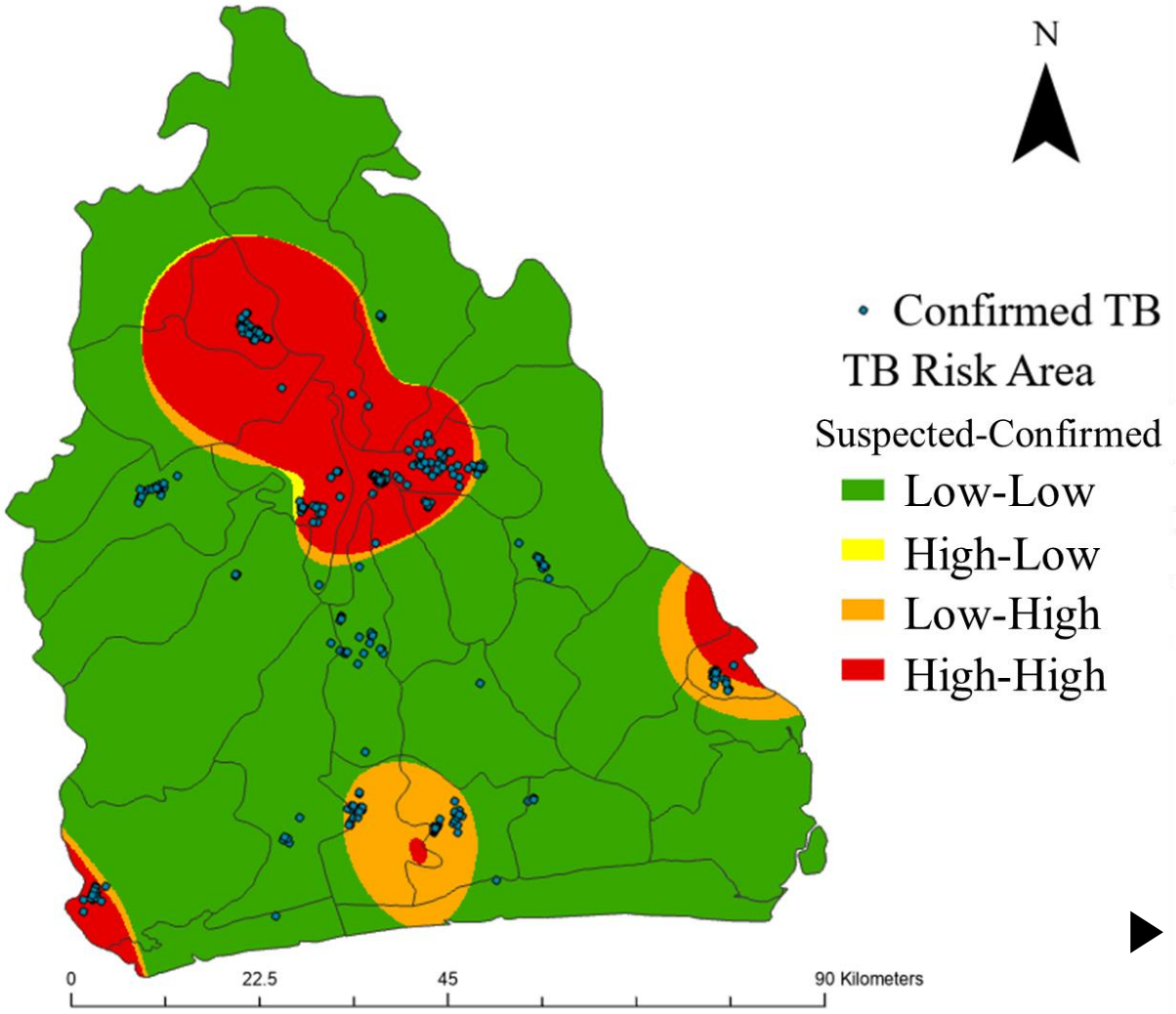
Treatment Ratio	Model 1 Haz.ratio (Std.Err)	Model 1 z	Model 2 Haz.ratio (Std.Err)	Model 2 z	Model 3 Haz.ratio (Std.Err)	Model 3 Z
LRR	-1.612 (0.293)	-2.63***	-1.650 (0.301)	-2.74***	-5.142 (2.818)	-2.99***
Gender			-0.886 (0.059)	-1.79*	-1.989 (0.733)	-1.86*
Age			-0.998 (0.002)	-0.62	-1.018 (0.011)	-1.60
LRR*Gender					-0.434 (0.163)	-2.22**
LRR*Age					-0.980 (0.011)	-1.73
Obs	1127		1127		1127	
X^2	7.19		10.53		16.97	
Log likelihood	-5783.515		-5781.846		-5778.623	

*** p<0.01, ** p<0.05, * p<0.1

- For each unit increase in LRR, the time required to initiate treatment increases by a factor of 5.142.
- Women need 1.989 times more time to start treatment compared to men.
- The increase in LRR significantly amplifies the difference in treatment initiation between men and women.

Results

Risk Area of TB cases in Akwa Ibom



- ***Zone 1 (High-High)*** faces significant challenges in both access to testing and treatment due to the high density of suspected and confirmed cases.
- ***Zone 2 (Low-High)*** competition for testing services is reduced, allowing quicker diagnoses. However, patients in Zone 2 experience relatively poor accessibility to treatment services due to the high density of confirmed cases.
- ***Zone 3 (High-Low)*** faces challenges in accessing diagnostic services due to the high density of suspected cases and potential supply shortages.
- ***Zone 4 (Low-Low)***, patients have relatively good accessibility to testing and treatment compared to other regions.

▶ ***How can we alleviate these imbalances at minimal cost?***

Results

Location-Allocation

Potential ***Optimal New TB Ward*** Location based on ***P-median***

$$\boldsymbol{Minimize} \sum_{i \in I} \sum_{j \in J} \boldsymbol{a_{ij} d_j x_{ij}}$$

$$\boldsymbol{subject\ to} \sum_{i \in I} \boldsymbol{x_{ij} = 1} \qquad \boldsymbol{for\ j \in J}$$

$$\boldsymbol{x_{ij} \leq y_i} \qquad \boldsymbol{for\ i \in I, j \in J}$$

$$\sum_{i \in I} \boldsymbol{y_i = p}$$

$$\boldsymbol{x_{ij}, y_i \in \{0, 1\}} \qquad \boldsymbol{for\ i \in I, j \in J}$$

i: *points of demand*;

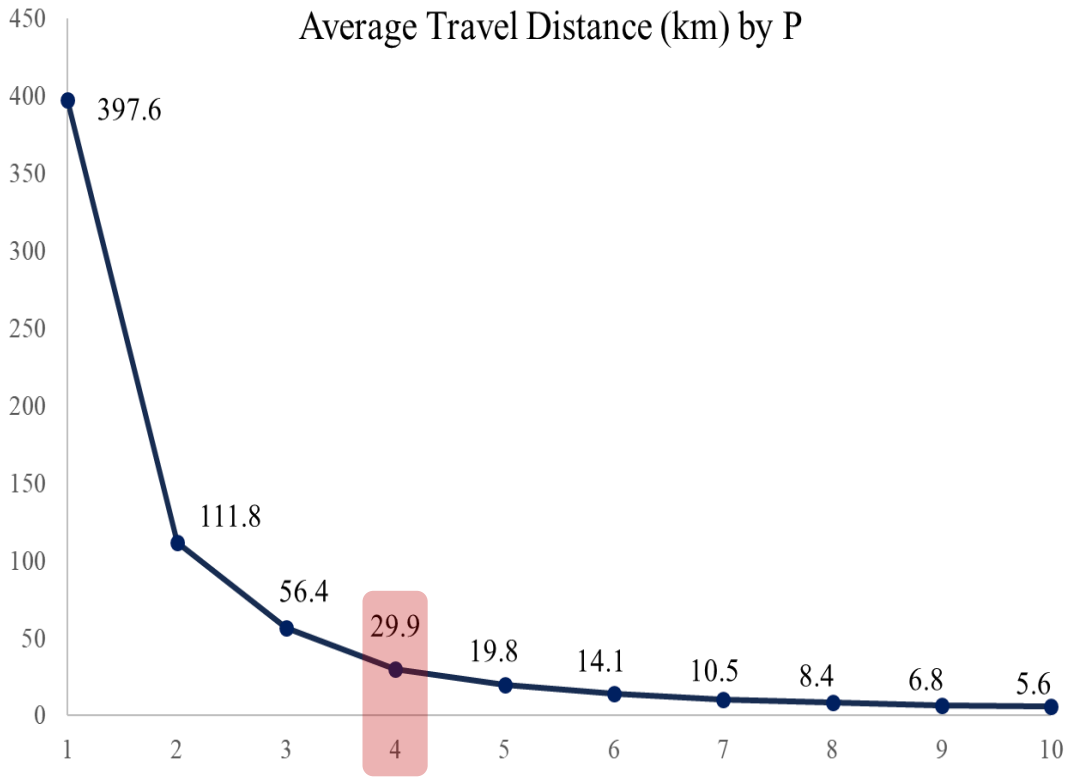
j: *points of the potential TB ward site*;

a_{ij}: *number of total demand in the service area*;

d_{ij}: *the minimum travel distance that the patient is required to treavel from point* i;

$$x_{ij} = \begin{cases} 1 & \text{if demand } i \text{ is assigned to TB ward at location } j \\ 0 & \text{otherwise} \end{cases}$$

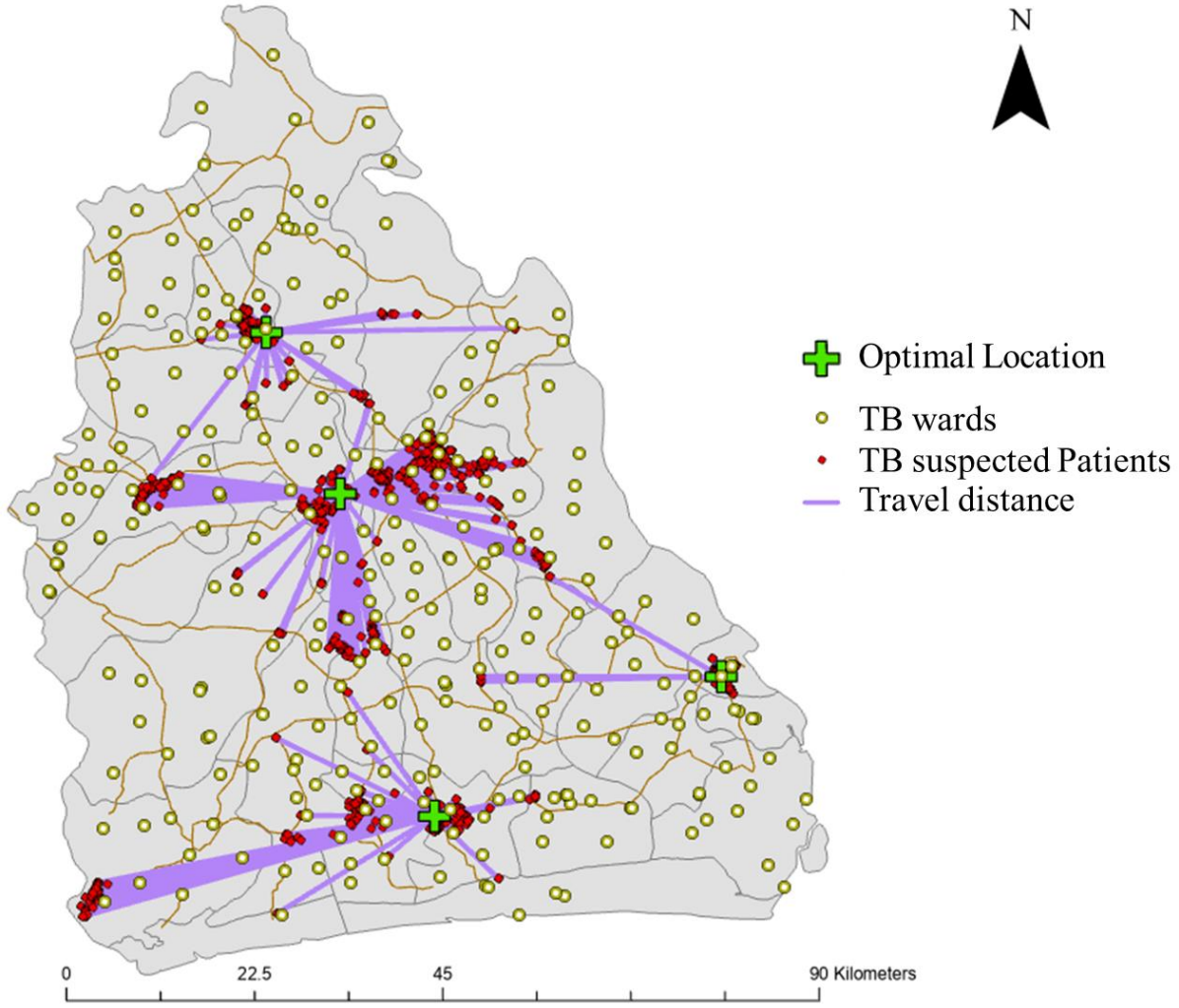
$$Y_{it} = \begin{cases} 1 & \text{if TB ward is sited at location } j \\ 0 & \text{otherwise} \end{cases}$$



Results

Location-Allocation

Potential ***Optimal New TB Ward*** Location based on ***P-median***



- **Optimal Location Allocation**: Ensures TB wards are strategically placed for ***maximum accessibility***.
- **Enhanced Accessibility**: Reduces patient travel time and distance, ***promoting better healthcare access***.
- **Targeted Impact**: ***Focuses on high-need areas***, ensuring that TB wards are located where they are most needed.
- **Cost-Effective**: ***Minimizes operational costs*** by selecting locations that effectively serve the most patients.

Conclusion

Discussion and Conclusion

- This study ***highlights the distribution of tuberculosis treatment facilities*** across Akwa Ibom State, emphasizing the importance of tuberculosis medical accessibility.
- The study results ***support the concept of demographic barriers to tuberculosis treatment initiation and timing***, as previously indicated in other studies (Sariem et al., 2020; Oga-Omenka et al., 2020; Oga-Omenka et al., 2021).
- The analysis underscores gender disparities in tuberculosis treatment initiation timing, with ***women experiencing longer delays compared to men***.
- Potential relative risk areas and ***optimal ward locations were explored through p-median***.
- This study ***focuses only on accessibility rather than the capacity of the ward***. In future research, it is ***necessary to explore more sophisticated risk areas by weighting the capacity of each ward***.
- It did ***not reflect the ward's accessibility to areas surrounding and bordering the Akwa Ibom government***.

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