KEMRI/Walter Reed Project, Kenya

Spatial epidemiology of Tuberculosis in High Burden Counties of Kisumu and Siaya, Western Kenya in 2013

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Disclaimer

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Background (1/2)

- Kenya has a large Tuberculosis (TB) disease burden and is ranked 15th among the high burden countries that collectively contribute about 80% of the world's TB cases.
- The occurrence of TB in Kenya is characterized by geographical variations across the country. Nyanza region in western Kenya has the highest TB burden with an estimated prevalence of 500-600 cases per 100,000.
  - A HIV prevalence of ~20%
- Effective management of TB and reduction of TB incidence rates relies on knowledge of where, when and to what degree the disease is present.

Background (2/2)

- Disease mapping is an activity widely used to identify patterns of diseases and to develop new ideas about the causative factors of disease.

- TB occurrence is linked to various factors that influence its distribution geographically (including high population density and overcrowding, poverty, urbanization).

- Understanding of spatial patterns coupled with a knowledge of the demographic, SES characteristics and HIV allows more efficient targeting of valuable health resources.

Research Questions

1) What is the spatial variability of TB disease at a small area level within the high burden region of Kisumu and Siaya Counties, Western Kenya?

2) What are the factors associated with the spatial distribution of TB disease in Kisumu and Siaya Counties?

Methods (1/2)

- Descriptive retrospective study conducted using 2013 health facility data on notified TB cases from the Kenyan National TB Control Program database (TIBU).
- Cases linked to the lowest formal administrative unit (sub-location) based on the physical address provided in the registers.
- Individual data points at the sub-location level were further aggregated at the county ward level (~30,000 people) to eliminate bias associated with smaller denominators in calculating rates.
- The ArcGIS software was used to visualize and generate choropleth maps which helped to identify geographical disparities of TB disease.

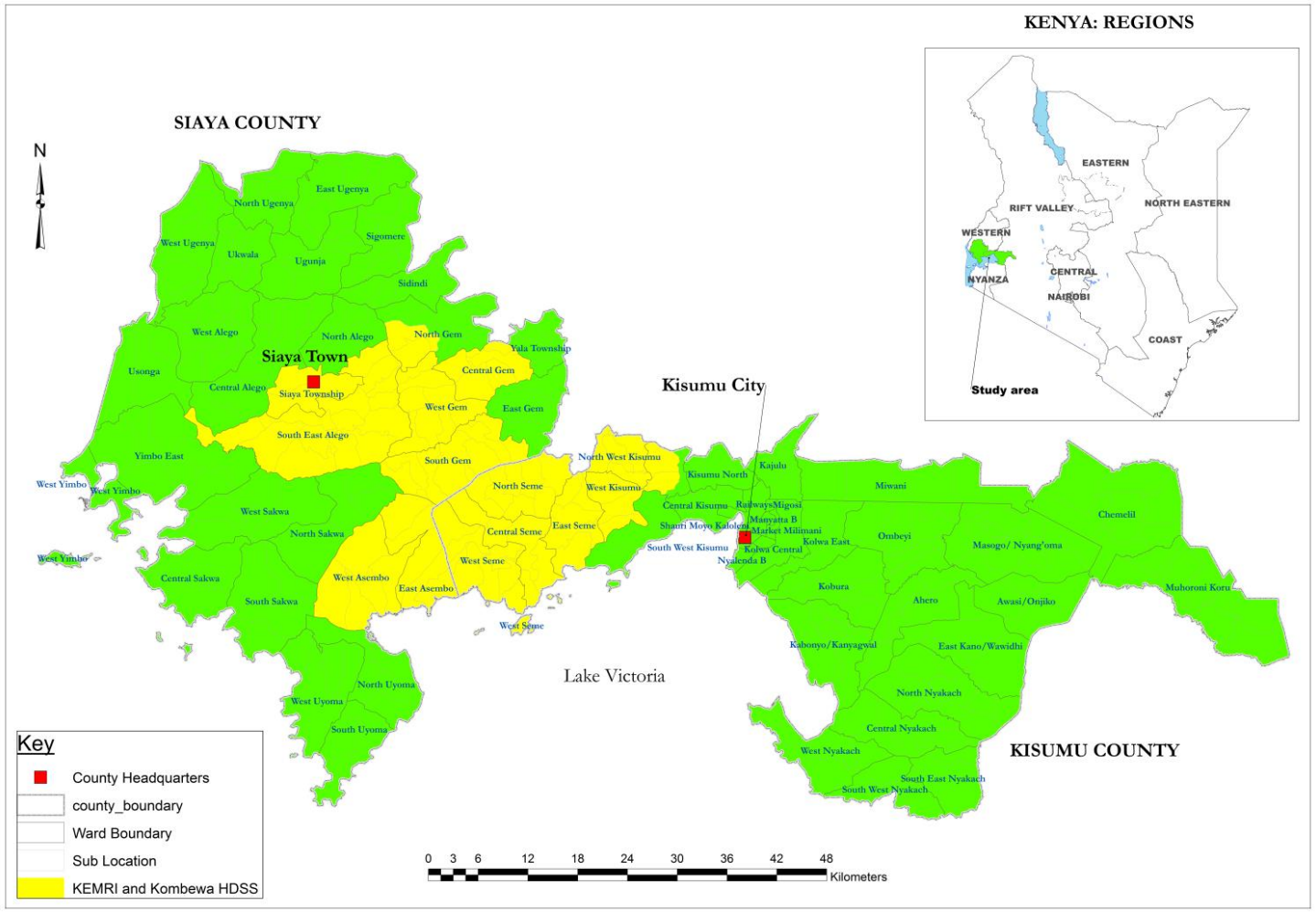
Methods (2/2)

- Spatial analysis techniques employed to describe the pattern of TB and reveal TB clusters and hotspots within the study area.

- Data tested for normality and the appropriate non-parametric tests used to correlate TB rates with other variables.
  - Population density (crowding)
  - Urbanization (Urban vs Rural)

- Visual correlation of TB occurrence and presence of informal settlements and slums.

Study Area


KENYA: REGIONS
EASTERN
NORTH EASTERN
RIFT VALLEY
WESTERN
NYANZA
CENTRAL
NAIROBI
COAST
Study area
SIAYA COUNTY
N
Siaya Town
Siaya Township
Kisumu City
Lake Victoria
KISUMU COUNTY
East Ugenya
North Ugenya
West Ugenya
Ukwala
Sigomere
Ugunja
Sidindi
West Alego
North Alego
North Gem
Yala Township
Usonga
Central Alego
Central Gem
West Gem
East Gem
South East Alego
Yimbo East
South Gem
North West Kisumu
West Yimbo
West Sakwa
North Seme
West Kisumu
North Sakwa
Central Seme
East Seme
West Seme
Central Sakwa
West Asembo
East Asembo
South Sakwa
North Uyoma
West Uyoma
South Uyoma
Kisumu North
Kajulu
Miwani
Central Kisumu
Kolwa East
Ombeyi
Chemelil
Shaurri Moyo Kaloleni
Kolwa Central
Masogo/ Nyung'oma
South West Kisumu
Nyalenda B
Kobura
Ahero
Awasi/Onjiko
Muhoroni Koru
Kabonyo/Kanyagwal
East Kano/Wawidhi
North Nyakach
Central Nyakach
West Nyakach
South East Nyakach
South West Nyakach
Key
County Headquarters
county_boundary
Ward Boundary
Sub Location
KEMRI and Kombewa HDSS
0 3 6 12 18 24 30 36 42 48
Kilometers

Results

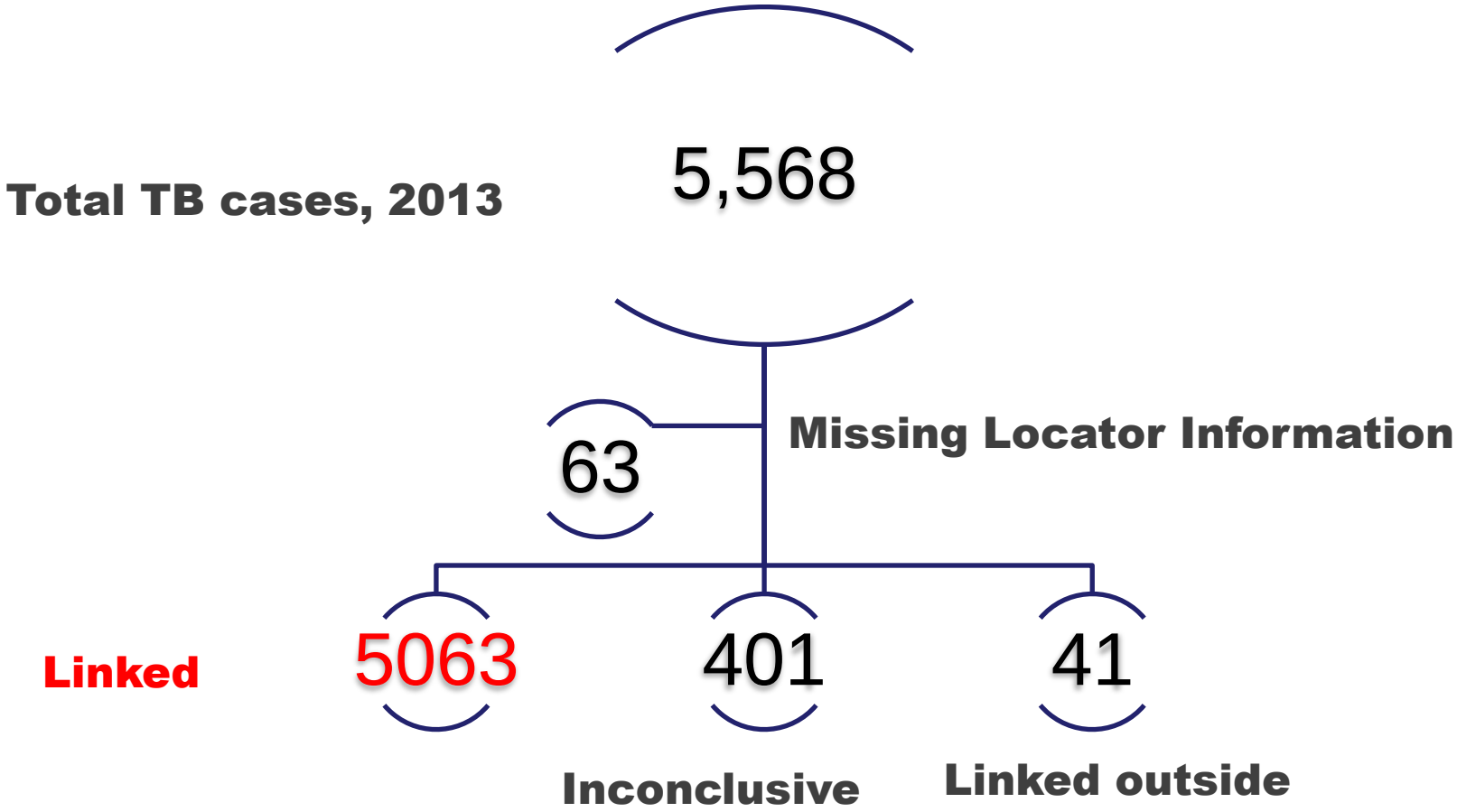

Total TB cases, 2013
5,568
63
Missing Locator Information
Linked
5063
401
41
Inconclusive
Linked outside

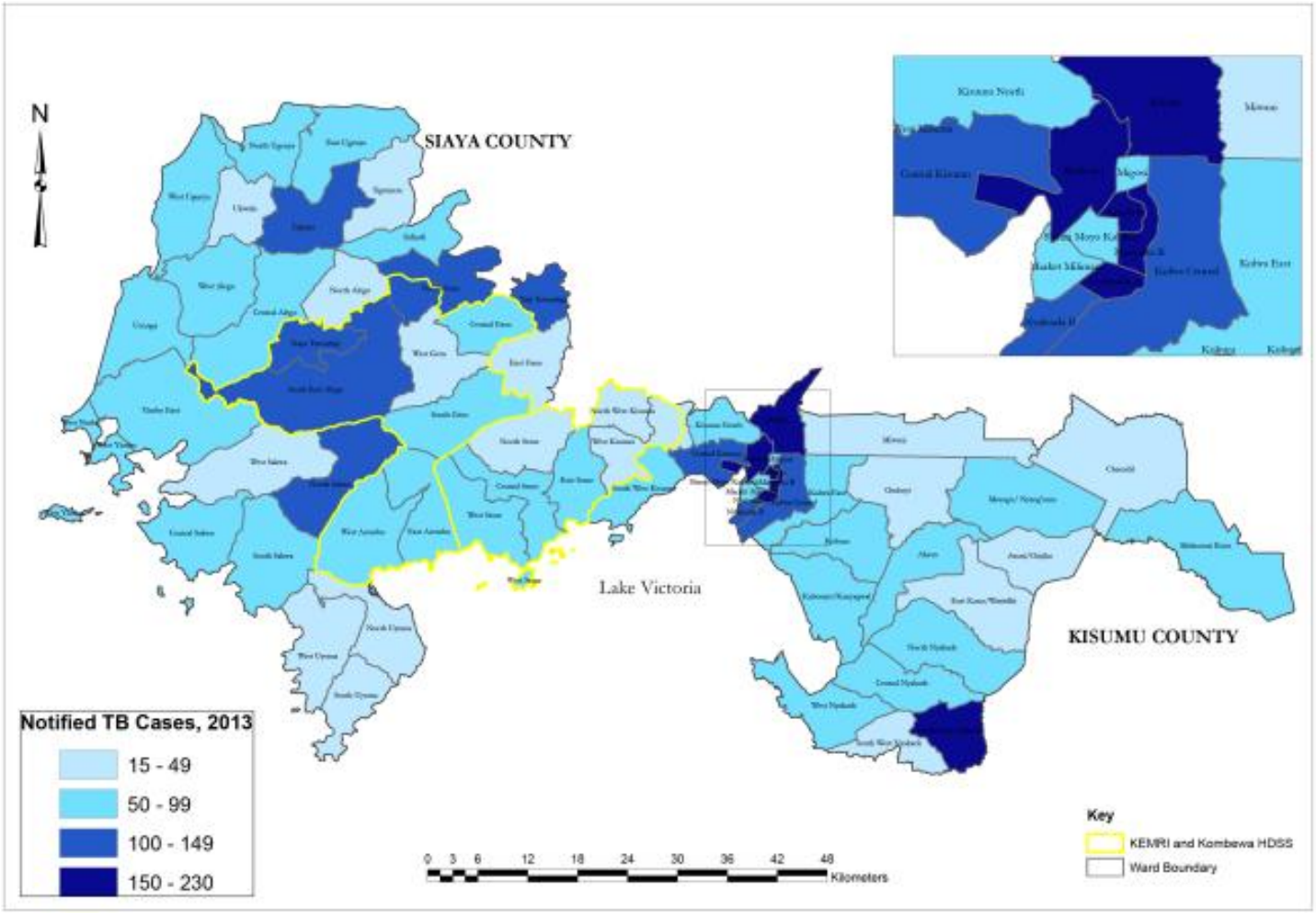
Table 1: Characteristics of cases

Characteristics	% (n/N)
Age at registration	
<=14	8.3 (419/5063)
15-24	15.5 (786/5063)
25-34	34.5 (1748/5063)
35-44	21.4 (1084/5063)
45-54	11.1 (563/5063)
>55	9.2 (463/5063)
Sex ǂ	
Male	46.2 (2,342/5063)
Female	53.8 (2,721/5063)
Type of TB	
Extra pulmonary	16.1 (815/5063)
Pulmonary	83.9 (4248/5063)
Sub-county of residence¥	
Siaya County	38.9 (1,970/5063)
Kisumu County	61.1 (3,093/5063)
HIV Status	
Negative	31.2 (1,578/5063)
Positive	66.5 (3,367/5063)
Unknown	2.2 (118/5063)

Distribution of notified cases

- TB cases were found in every ward (average 77 cases per ward).
- The highest number of TB cases (**n = 230**) was reported in Nyalenda A ward; the lowest number of TB case (**n = 15**) was reported in South Uyoma ward.
- The notified TB rate for the entire study area was 278 cases per 100,000 population.
- Geographically, the notified TB rates varied considerably **from 76 per 100,000** in South Uyoma to **813 per 100,000** in Nyalenda A.

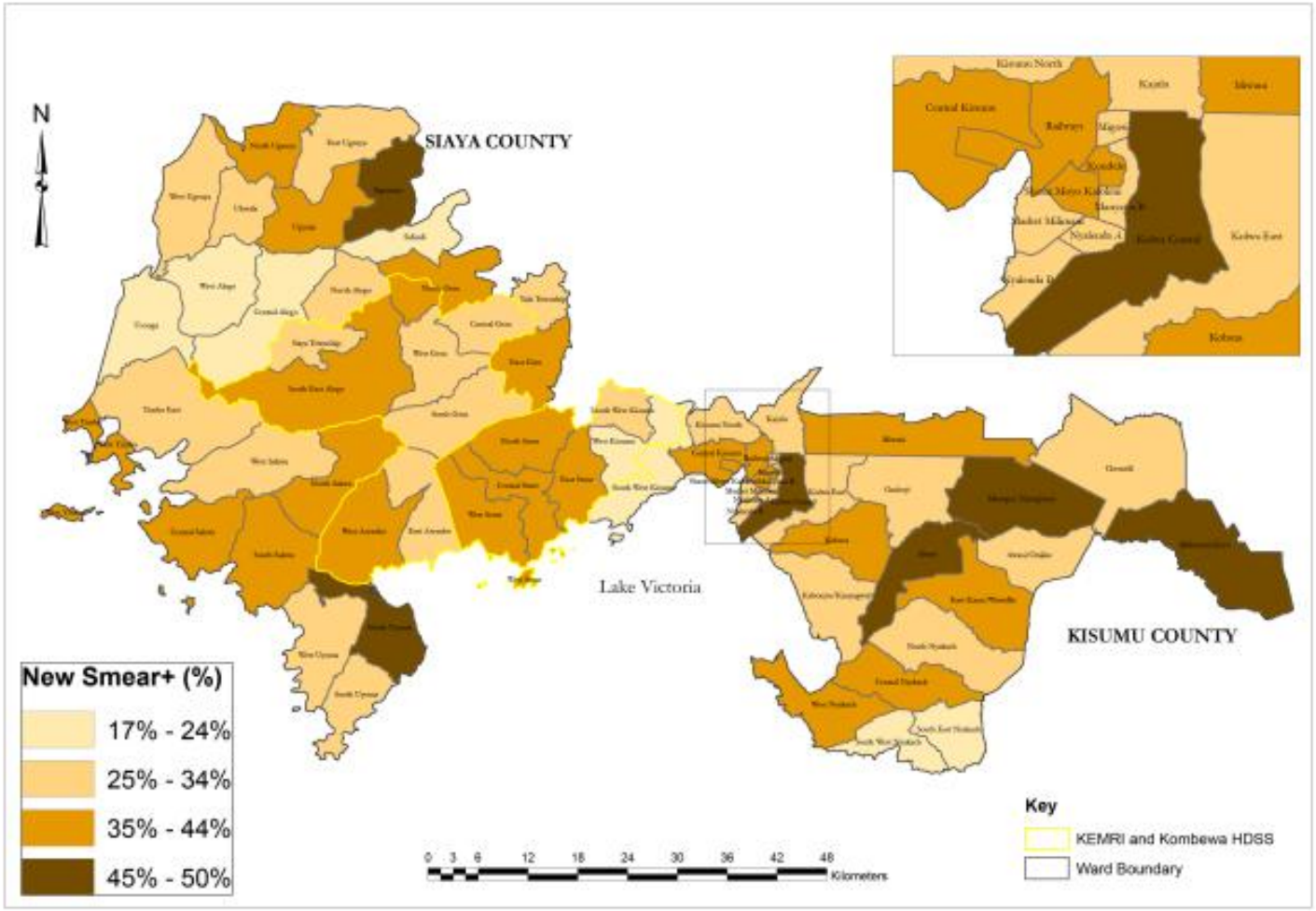
Distribution of Notified TB cases



Distribution of New Smear Positives

- There were a total of 4,486 (88.6%) new TB cases in the study area in 2013.
- A total of 1,701 (37.9% of total reported cases) cases had a positive sputum smear; 1,788 (39.8%) had a negative sputum smear while 997 (22.8%) did not have any sputum smear examination done.
- The percentage of new smear positives per county ward varied from **17%** in Sidindi ward (11/63) to **50%** in Muhuroni/Koru (35/70).
- The rate of new smear positives for the entire population was recorded at 99 per 100,000.
- Rates of smear positives varied geographically a the county ward level from **23 per 100,000** in West Uyoma to **245 per 100,000** in Shauri Moyo Kaloleni.

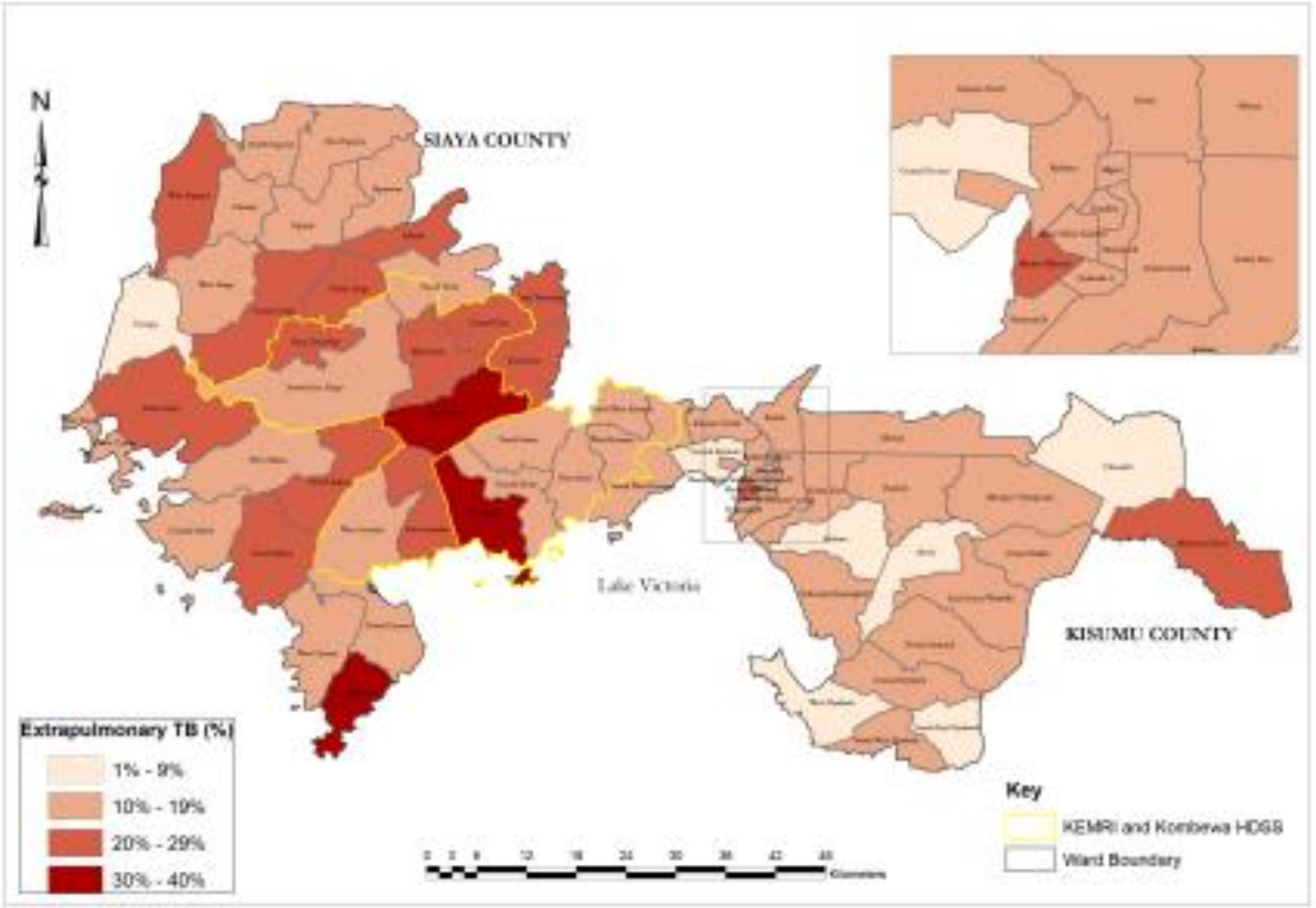
Distribution of New Smear Positives



Distribution of Extrapulmonary TB

- A total of 815 cases with extrapulmonary TB were reported.
- Variation in occurrence of EPTB from **1%** (1/70) Kobura Ward to **40 %** (9/15) in South Uyoma.
- Geographical variations from **2 per 100,000** in Kobura Ward to **128 per 100,000** in Manyatta B Ward.

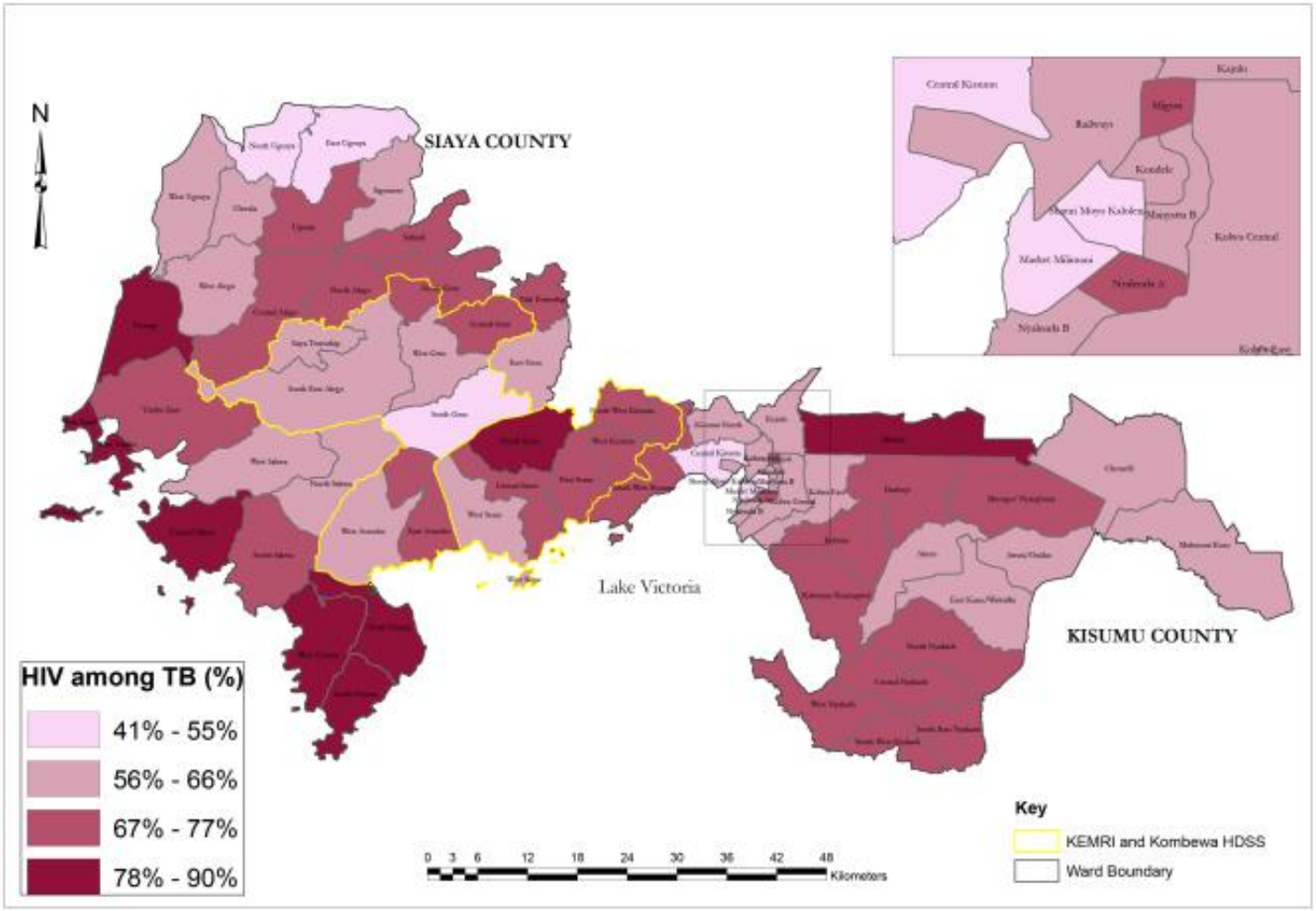
Distribution of Extrapulmonary TB



TB/HIV Co-infection

- A total of 4,945 (97.6%) of reported TB cases had known HIV status recorded.
- The estimated HIV prevalence among TB cases with known status was 68.1% (3,367/4945).
- Percentage of HIV-coinfection varied at the ward level from **41%** (21/51) in East Uyoma to **90%** (26/29) in North Uyoma.
- The overall rate of HIV among newly reported TB patients was 273 per 100,000.
- There was variation of *rates of co-infection with HIV* at the ward level from **61 per 100,000** in Miwani ward to **548 per 100,000** in Nyalenda A ward.

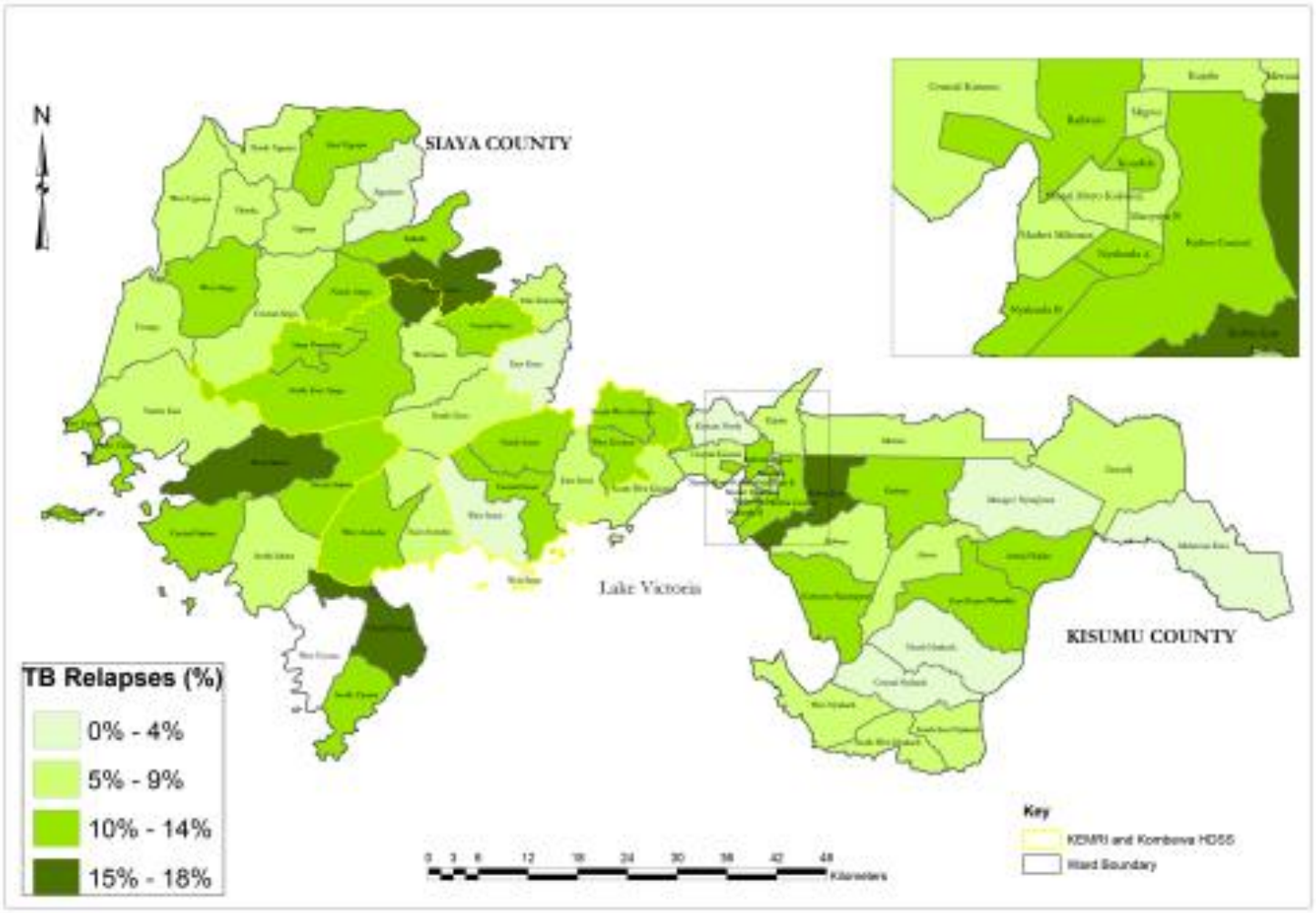
Distribution of TB-HIV Co-infection



TB Treatment Failures and Retreatment

- TB treatment failure and initiation of retreatment accounted for 9% (440/5,063) of all TB patients reported in the study area in 2013.
- Geographically, the percentage of TB relapses and treatment failures varied from **0%** Central Nyakach (0/53) to **18%** (4/22) in West Uyoma.
- The rate of TB retreatment for the entire study area was recorded at 24 per 100,000.
- At the ward level, the rates of TB retreatment s varied significantly from **0 per 100,000** central Nyakach to **102 per 100,000** in Nyalenda A.

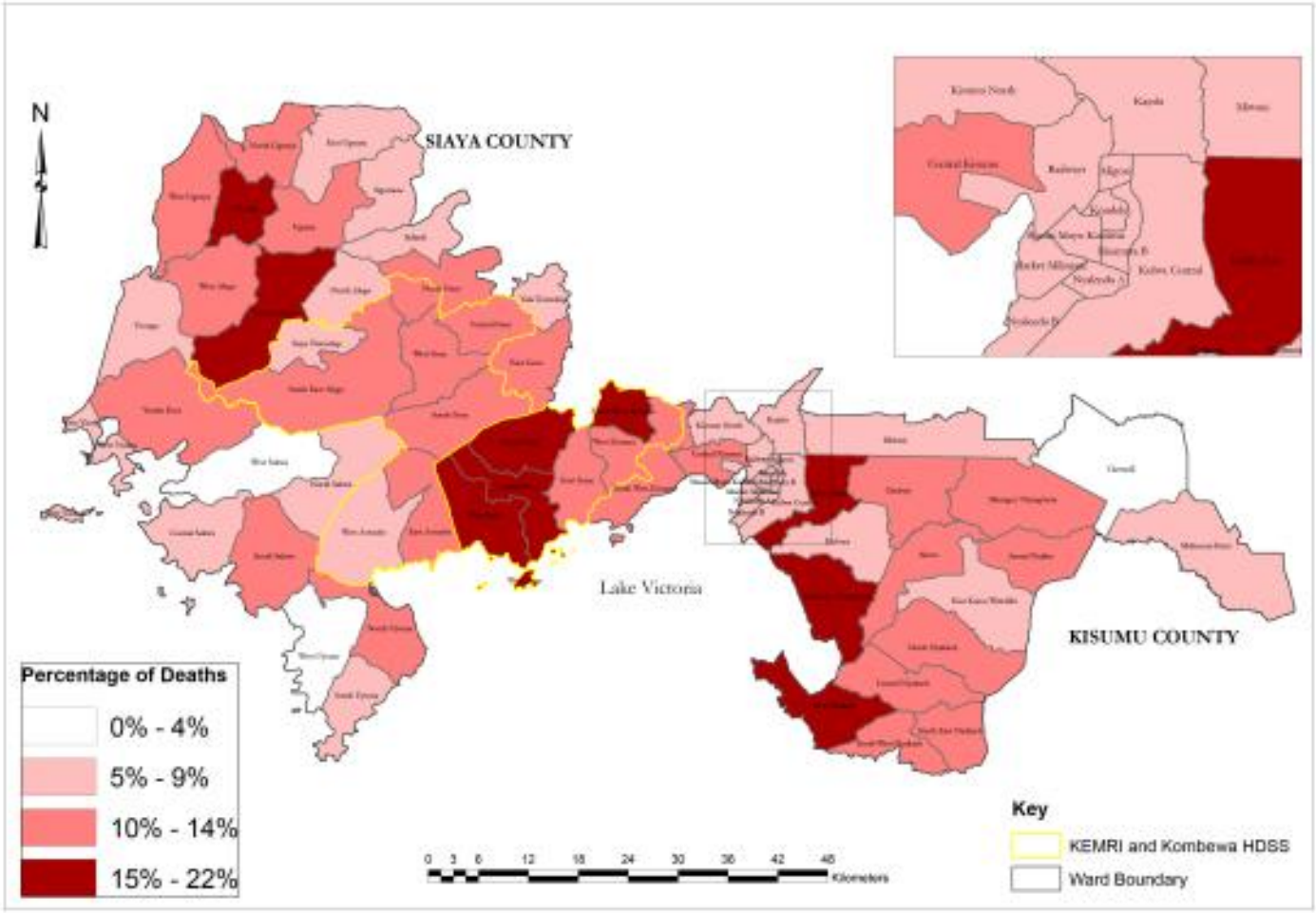
Distribution TB Treatment Failure/Retreatment



Mortality Among TB Cases

- Reported deaths among the TB patients for the year 2013 stood at 9.8% (495/5,063).
- Percentage of reported TB deaths varied geographically at the ward level from **0%** (0/22) in West Uyoma Ward to **22%** (10/45) in North Seme Ward.
- Mortality rate among the TB cases was 27 deaths per 100,000.
- Geographical variations noted between Siaya County (24 deaths per 100,000) and Kisumu County (30 per 100,000).
- At the ward level, the mortality rates varied from **0** deaths per 100,000 in West Uyoma Ward to **68 per 100 000** in South East Nyakach.

Distribution of deaths among TB Cases



Detection of TB Clusters and Hot spots

Global Moran's index

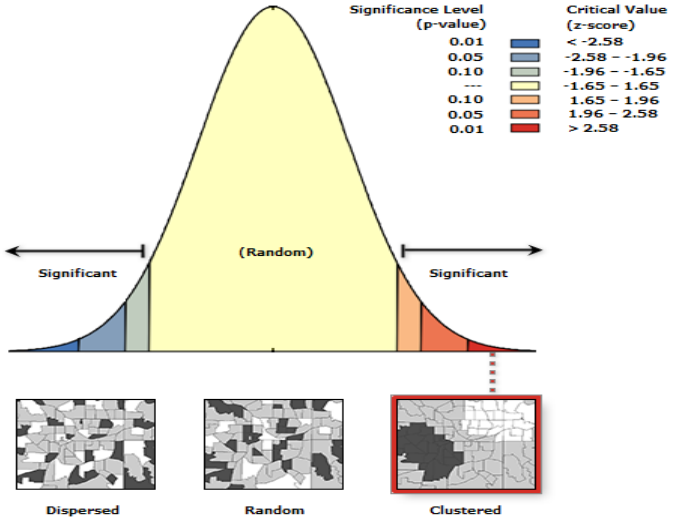
- There was a positive and spatial autocorrelation of TB prevalence in the study area (Moran's I=0.423, p-value <0.001) implying spatial clustering of TB values as illustrated

Local Indicator of Spatial Association (LISA)

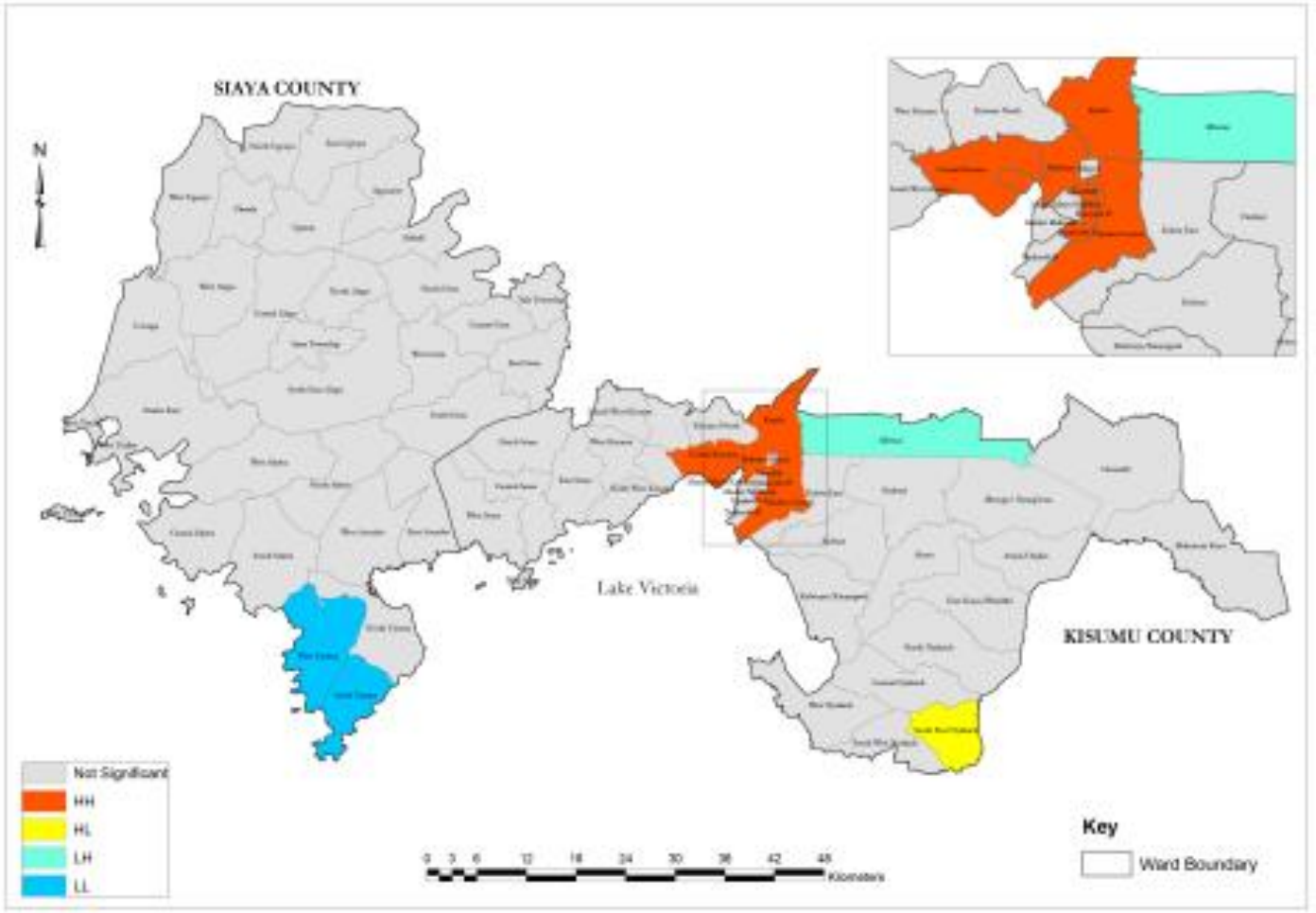
- LISA was used to localize specific clusters and determine the degree of spatial autocorrelation at the local level.
- A High-High (HH) cluster means a ward of high value is surrounded by wards with high value while a Low-Low (LL) cluster means a ward of low value is surrounded by wards with low value.

Hot spot detection (Getis and Ord's local statistic)

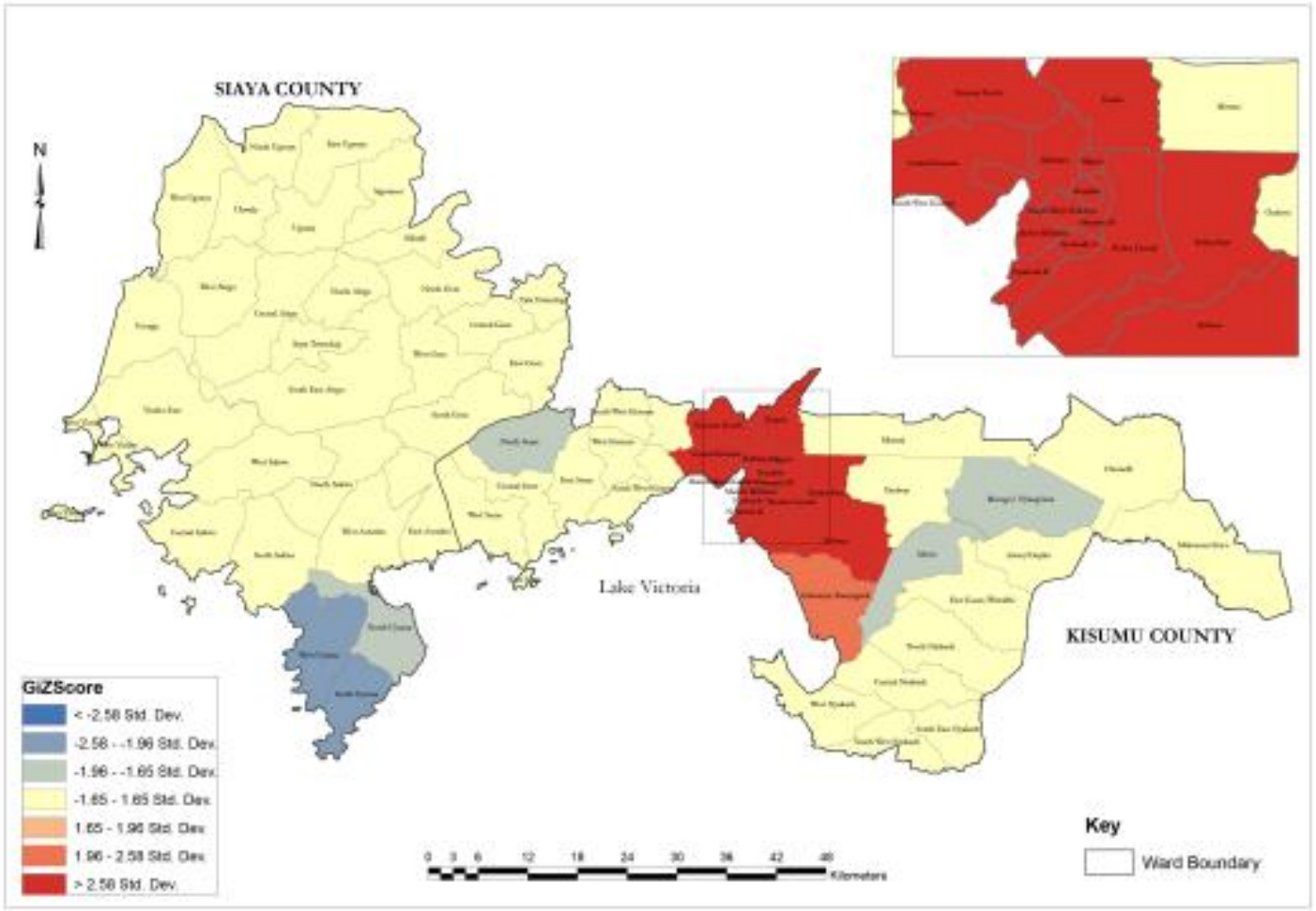
- Hot Spot Analysis is a spatial cluster detection method which identifies statistically significant spatial concentrations of the high and of low values associated with a set of geographic features.



TB Clusters and Outliers (LISA)



TB Hot spots and Cold spots



Geographic Correlation of TB (Statistical)

- Spearman's correlation was run to assess the relationship between TB rate and population density.
  - Positive correlation between population density and the rate of TB, (rs=0.5739, p= 0.0001.)
- Two-sample Wilcoxon rank-sum (Mann-Whitney) test was performed to compare TB means in the urban and rural area. There was a statistically significant difference between the TB rates in urban areas as compared to the rural areas.
  - TB Mean of 2.2 in the rural area vs 3.9 in the urban area
  - Wilcoxon rank-sum p=0.0001

Discussion

- The study showed that the spatial distribution of TB was non-random and clustered with significant Moran's I values for 2013.
- LISA analysis detected significant spatial clusters for high incidence of TB.
- Information on identified TB hotspots and clusters could be used for targeted screening and intensive case finding with a goal of reducing TB incidence.
- This information could also be utilized in *allocating resources* on a needs basis to *improve diagnosis*, *treatment and care* in high burden areas, *program evaluation* thereby ensuring efficient utilization of limited resources to reduce burden and decrease mortality.

Conclusion

- TB occurrence in the high burden counties of Siaya and Kisumu varied significantly at the small area (ward) level.
- The occurrence of TB was positively correlated with urbanization and population density (crowding); this correlation was statistically significant.
- Varied TB outcomes geographically

Limitations of the study

- Our data relies on passive surveillance by the Ministry of Health and we cannot exclude the possibility that some facilities may not have submitted their data to TIBU for various reasons.
- Routine notification systems may miss individuals with TB if individuals do not seek care, thereby remaining undiagnosed, or are diagnosed by providers that do not report cases to the national system.
- Some reported cases could not be geocoded to residence due to inconclusive or missing physical location data in TIBU.
- It is possible that cases could be miscoded to a geographical area, especially for physical addresses that are near the borders of two or more sub-locations.
- Only cases from facilities within Siaya and Kisumu Counties were included in this study. It is possible that individuals residing in the study area sought care from facilities outside the area and had TB diagnosed (and reported) from facilities outside of the study area.
- Lack of socioeconomic and environmental data at the mapping level was an additional limitation of this study

Study recommendation

- GIS technology can be incorporated into existing MoH TB control programs in Siaya and Kisumu Counties.
- Information to assist in decision-making for TB prevention and control programs; technology can also be used to monitor impact of various interventions.
- Priority of TB interventions should target regions with highest disease burden for efficient resource utilization.
- This type of analysis relies heavily on correctly linking cases to their respective geographic locations, training of staff on the importance of accuracy and completeness of patient locator information.

Utility of HDSS

- Existence of HDSS within the study area could be useful in validating locator information.
- HDSS data can validate the government population estimates used in defined geographic areas (denominators).
- The HDSS monitors deaths and Causes of Death through Verbal Autopsy. Could provide cause specific mortality data for TB patients.
- Next steps to link TB cases to the HDSS. Preliminary linkage within the Kombewa HDSS has yielded a 68% match rate

Further Study

- Effectiveness of TB control measures in specific high burden areas could be assessed by monitoring longitudinal change in TB prevalence over time.
  - A space-time analysis with 2013 as the baseline could be utilized for program evaluation.
- Analysis at the facility level to aide with training, improved patient care, allocation of resources
- More detailed individual level investigations are needed in the identified TB clusters and hotspots to evaluate the most important determinants of disease distribution.
  - Individual level studies

Acknowledgment

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Thank you!

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