East African Medical Journal Vol. 94 No 10 October 2017
SPATIAL AND TEMPORAL DISTRIBUTION OF NOTIFIED TUBERCULOSIS CASES IN NAIROBI COUNTY, KENYA, BETWEEN 2012 AND 2016
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ABSTRACT

Background: **Tuberculosis (TB) is an infectious disease of major public health concern globally. The disease has showed space-time variations across settings. Spatial temporal assessment can be used to understand the distribution and variations of TB disease.**
Objective: **To determine the spatial and temporal distribution of notified TB cases in Nairobi County, Kenya, between 2012 and 2016**
Design: **A cross sectional study**
Setting: **Nairobi County, Kenya**
Subjects: **Tuberculosis cases notified in Tuberculosis Information for Basic Units from 2012 to 2016**
Results: **A total of 70,505 cases of TB were notified in Nairobi County between 2012 and 2016, with male to female ratio of 3:2 and HIV coinfection rate of 38%.The temporal analysis showed a declining trend of the notified cases. The spatial clusters showed stability in most areas while others varied annually during the study period. The space-time analysis also detected the four most likely clusters or hotspots. Cluster 1 which covered the informal settlements of Kibera,Kawangware and Kangemi with 4,011observed cases against 2,977expected notified TB cases(relative risk (RR) 1.37, p<0.001). Further, Cluster 2 covered Starehe and parts of Kamukunji, Mathare, Makadara, Kibra and Dagoretti North Constituencies (RR 1.93, p<0.001; observed and expected cases were 4,206 and 2,242, respectively.**
Conclusion: **This study identified high TB case notifications, declining temporal trends and clustering of TB cases in Nairobi. Evidence of clustering of TB cases indicates the need for focused interventions in the hotspot areas. Strategies should be devised for continuous TB surveillance and evidence based decision making.**

INTRODUCTION

Tuberculosis (TB) is a major global health problem and a leading cause of death worldwide, particularly in low and middle income countries. In 2015, an estimated 10.4 million new cases of TB were reported worldwide and at least 1.4 million TB associated deaths(1). Globally, the incidence of TB disease has declined from 144 per 100,000 people in 1990 to 133 per 100,000 people in 2014. However, Sub-Saharan Africa (SSA) remains home to high TB-burden countries, which have shown a varying incidence and prevalence of TB(2). In Kenya, TB remains a major cause of morbidity and mortality and has been classified among the 30 countries with a high TB burden that together account for more than 80% of the world's TB cases by World health Organization (WHO)(1,3). A recent prevalence survey done in Kenya reported an estimated prevalence of 558 per 100,000population where Nairobi county accounted for 15% of the cases(1,4).

Worldwide the prevalence of TB is affected by various factors that include: the national economic levels, social instability, social economic factors, poverty, malnutrition, migration to the peri-urban slums, poor hygiene and the inefficiency of TB control programs(5,6). Studies found that TB can also be associated with individual differences such as genetic susceptibility, sex, education level and race(7,8). There is also an association between high incidences of TB and low socioeconomic status in most developing countries(9).The geographic distribution of TB varies across the globe as well as within countries(10).Spatial distribution analysis has been used to show variation of diseases according to regions(11,12).The distribution of TB varies among different geographical regions, with disease cases tending to congregate at particular locations(13,14).Despite Nairobi being an established hub for business and culture, it has some of the most dense and unsanitary slums, with over 100 slums and squatter settlements within the city. Urban centres like Nairobi, bear the highest brunt of the disease burden(4,15).Nairobi is among other urban communities in Kenya facing congestion, poor living conditions, and limited access to healthcare, further increasing the susceptility to TB(16) Exploratory spatial analysis is a powerful instrument in health research because its enables mapping out of cases and the detection of clusters(17,18). This information can help pinpoint areas that need intensification of interventions, preventive measures and even policy changes to prevent higher incidences of disease (12,19). There is limited published literature on spatial distribution of TB and identification of high risk areas in developing countries like Kenya (20,21). Our study sought to describe the characteristics, spatial and temporal distribution of notified TB cases in Nairobi County between 2012 and 2016.

MATERIAL AND METHODS

Study design: This was a retrospective descriptive cross-sectional study, using previously collected programmatic data.

Setting: Nairobi is the capital city of Kenya and one of the 47 semi-autonomous counties in Kenya. It comprises of ten sub-counties and seventeen administrative constituencies that are core urban centred. It has an estimated population of 3.36 million people, with most living in slums and informal settlements. Kenya was ranked sixth among the top 10 countries in SSA with large populations living in extreme poverty(22,23).

Study site: There are 225 treatment centres and 150 diagnostic sites. There are 13 Gene Xpert analysis facilities. Among them are community based, dispensaries, health centres, sub-county and county hospitals, teaching and referral hospitals and a national hospital.

Patients are seen by health workers and are part of support groups at the community level.

Study population: This study included aggregate data on all patients with TB seeking care in Nairobi health facilities from January 2012 to December 2016, whose data was available in the electronic database, Tuberculosis information for basic Units (TIBU)(24).

Data collection: The National Tuberculosis Programme utilizes TIBU data management system as a central database. This is a web based solution integrated with mobile/tablet technology developed and introduced in Kenya in 2012 with inter-sector support. Patients with TB upon diagnosis, are notified, treated and followed up with primary record captured from patient records and multi-drug register log book entered as a summary of the data entered in the registers. This is subsequently uploaded at Sub–County level into TIBU by TB coordinators TIBU has internal consistency checks and data quality audits done quarterly at the county level and biannually at the national level.

Variables and data source: The variables included age, sex, sector, HIV status, constituencies, type of TB, year of notification and treatment outcomes. The Study data was retrieved from TIBU database. The projected populations for each constituency were obtained from Kenya National Bureau of Statistics (KNBS)(25). Geo referenced maps of the study area were abstracted from an online database(26).

Analysis and statistics: Data was exported and analyzed descriptively using Stata 12 (StataCorp, Texas). The spatial and space-time scan statistic analysis was performed using SaTScan 9.4.4. A Poisson based model was used with the number of notified TB cases in an area being assumed to follow a Poisson distribution when evaluated against the population at risk. The test significance of the identified clusters was based on comparing the likelihood ratio test statistics against a null distribution obtained from a Monte Carlo simulation. Under the null hypothesis, and when there are no covariates, the expected number of cases in each area is proportional to the population size, or to the person-years in that area. The geographic size of the window was limited to half the expected number of cases and the time period was also limited to half the total time period. The number of permutation was set to 999.The significance level was set at0.05.
Maps were generated using the ArcMap 10.3 (ESRI, Redlands, USA).

Ethical approvals: This study was approved by the Moi University College of Health Sciences (MU/CHS) and Moi Teaching & Referral Hospital (MT&RH) Institutional Review Board (IREC) under approval number FAN:IREC 1868.

RESULTS

A total of 70,505 cases were diagnosed and treated for TB in Nairobi from 2012 to 2016. The characteristics of the cases are outlined in Table 1.The males were 42,927(61%) with a male to female ratio of 3:2.The median (interquartile range (IQR)) age of the cases was 32 (25 – 41) years. Those aged 25 to 34 years were 23,198(33%).Tuberculosis cases in children (0-5years) accounted for 2,623(4%) of the cases. Most of the cases were reported by public health facilities 43,913(62%) with the rest being reported by private20,243(29%) and prisons 1,722(2%) .Kasarani and Kamukunji constituencies had the highest number of cases accounting for 7,055 and 6,923 (10%) each respectively, while Embakasi East and Dagoretti South had the least cases.

Table 1

Socio-demographic characteristics of notified TB cases in Nairobi County, 2012-2016

Variables	**Number(n=70,505)**	
	n	**%**
Sex		
Male		
Female	42,927	61
	27,578	39
Age (years)		
0-4	2,623	4
5-14	2,363	3
15-24	11,299	16
25-34	23,198	33
35 – 44	16,296	23
≥ 45	12,928	18
Missing	1,798	3
Sector		
Public	43,913	62
Private	20,243	29
Prisons	1,722	2
Faith-based	4,627	7
Constituencies		
Kamukunji	6,923	10
Kasarani	7,055	10
Kibra	6,614	9
Starehe	5,997	9
Dagoretti North	4,592	7
Ruaraka	5,188	7
Ruaraka	5,188	7
Westlands	5,060	7
Langata	4,229	6
Makadara	3,849	6
Mathare	3,312	5
Embakasi Central	3,322	5
Roysambu	3,136	4
Embakasi South	2,751	4
Embakasi West	2,578	4
Embakasi East	1,904	3
Dagoretti South	1,937	3
Embakasi North	2,058	3

Clinical Characteristics

Pulmonary TB was the most common type of TB 53,498(76%) among the cases. The HIV positivity rate was 24,913(38%).The proportion of TB/HIV co-infected cases that had been initiated on antiretroviral therapy (ART) during the study period was 7,427(30%).The sputum smear examination results available at month 0 was 45% and 4% at 2/3 month. The cases treated successfully were 46,923(81%), while (5%) were lost to follow up and the rest died as shown in Table 2.

Table 2

Clinical Characteristics of notified TB cases in Nairobi County between 2012 and 2016

Characteristic	Total N	%
Type of TB (n=70,505)		
Pulmonary TB	53,498	76
Extra-pulmonary TB	17,007	24
HIV test(n=70,505)		
Done	64,846	92
Not done	5,466	8
Declined	190	0.3
Missing	3	0
HIV Status (n=64,846)		
Positive	24,913	38
Negative	39,933	62
ART (n=24,913)		
Yes	7,427	30
No	1,290	5
Missing	16,196	65
Time to ART Initiation (n=7,427)		
≤14 days	1,743	24
15-28 days	690	9
>28 days	2,207	30
Missing	2,787	38
X-ray (n=70,505)		
Done	19,378	28
Not done	51,127	73
Treatment Outcomes (n=57,697) **		
Cured	21,627	37
Death	2,695	5
Failed treatment	347	0.6
Lost to follow up*	2,261	4
Not Complete (On treatment)	1,424	3
Treatment complete	25,296	44
Transferred out	4,044	6

*Loss to follow up includes those formerly referred to as out of control(OOC)

** Treatment cohort from 2012-2015

Figure 1 shows the quarterly time series of the number of TB cases notified in Nairobi County from 2012 to 2016. There was a marked decline in the number of notified TB cases over time. The number of extra pulmonary tuberculosis cases notified remained generally constant between 2012 and 2014 followed by an increase in cases in 2015.

Fig. 1

Quarterly variations in the notified pulmonary and extrapulmonary TB cases in Nairobi County, 2012-2016

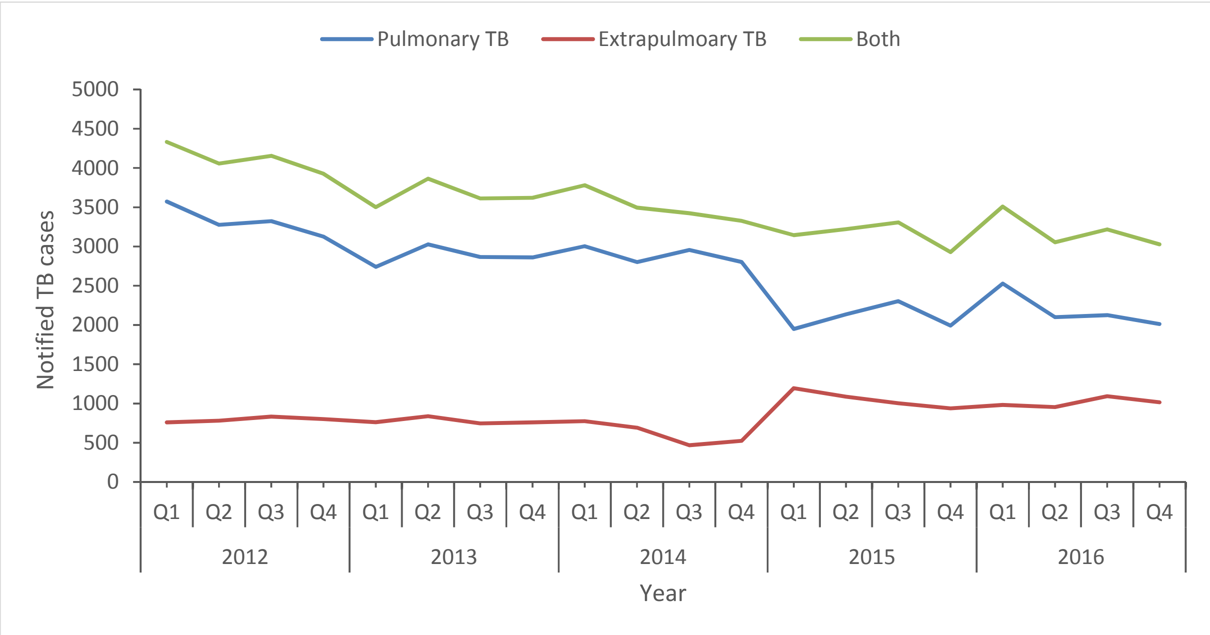
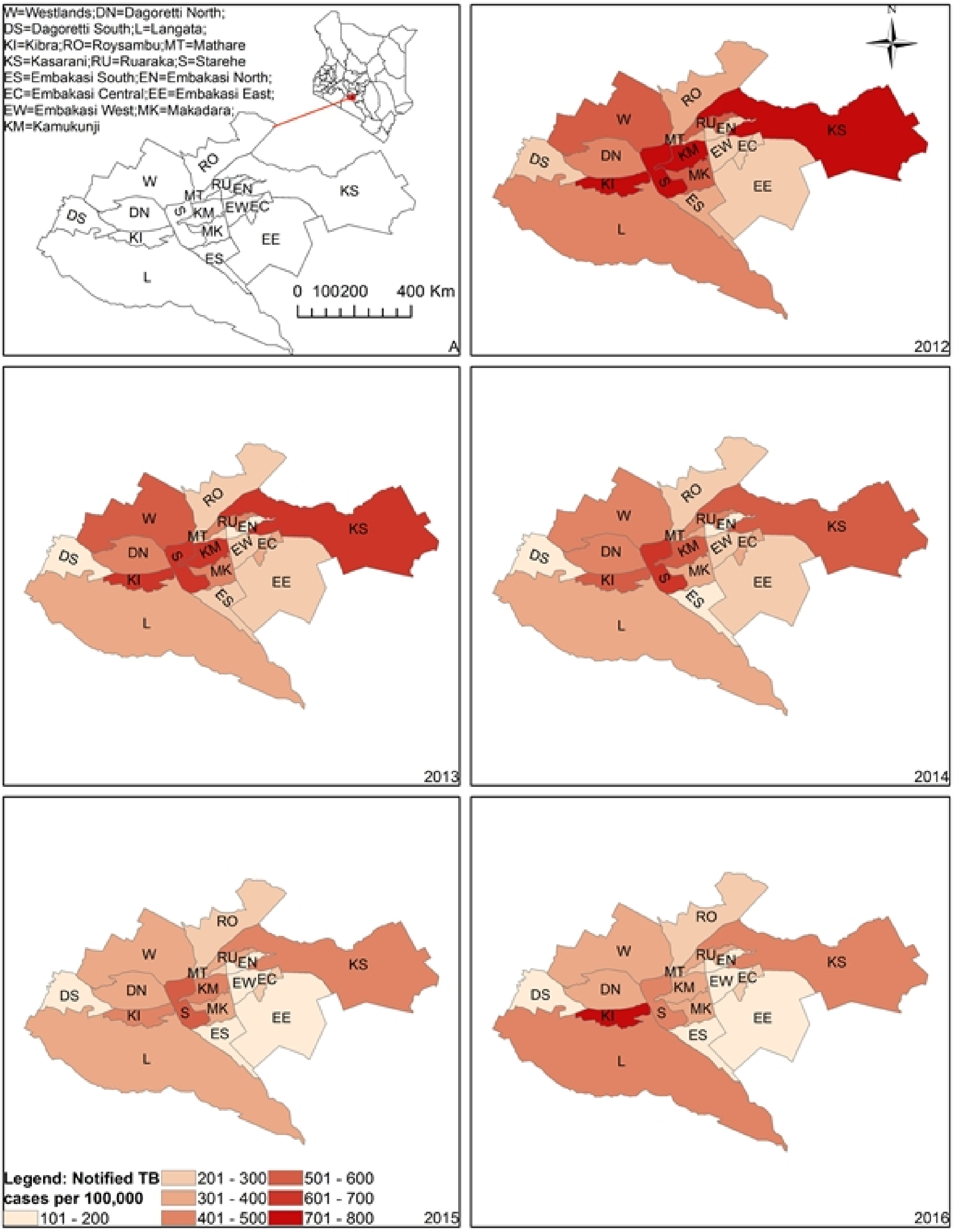


Figure 2 shows the spatial variations of the rates of notification of TB cases in Nairobi between 2012 and 2016. The annualized notified TB cases per 100,000 population at risk (PAR) ranged from 121 to 783 with the median (IQR) being 353(229 - 476) cases per 100,000 PAR as shown in Table 3.

Figure 2:
The TB case notifications variations in Nairobi County constituencies, 2012-2016



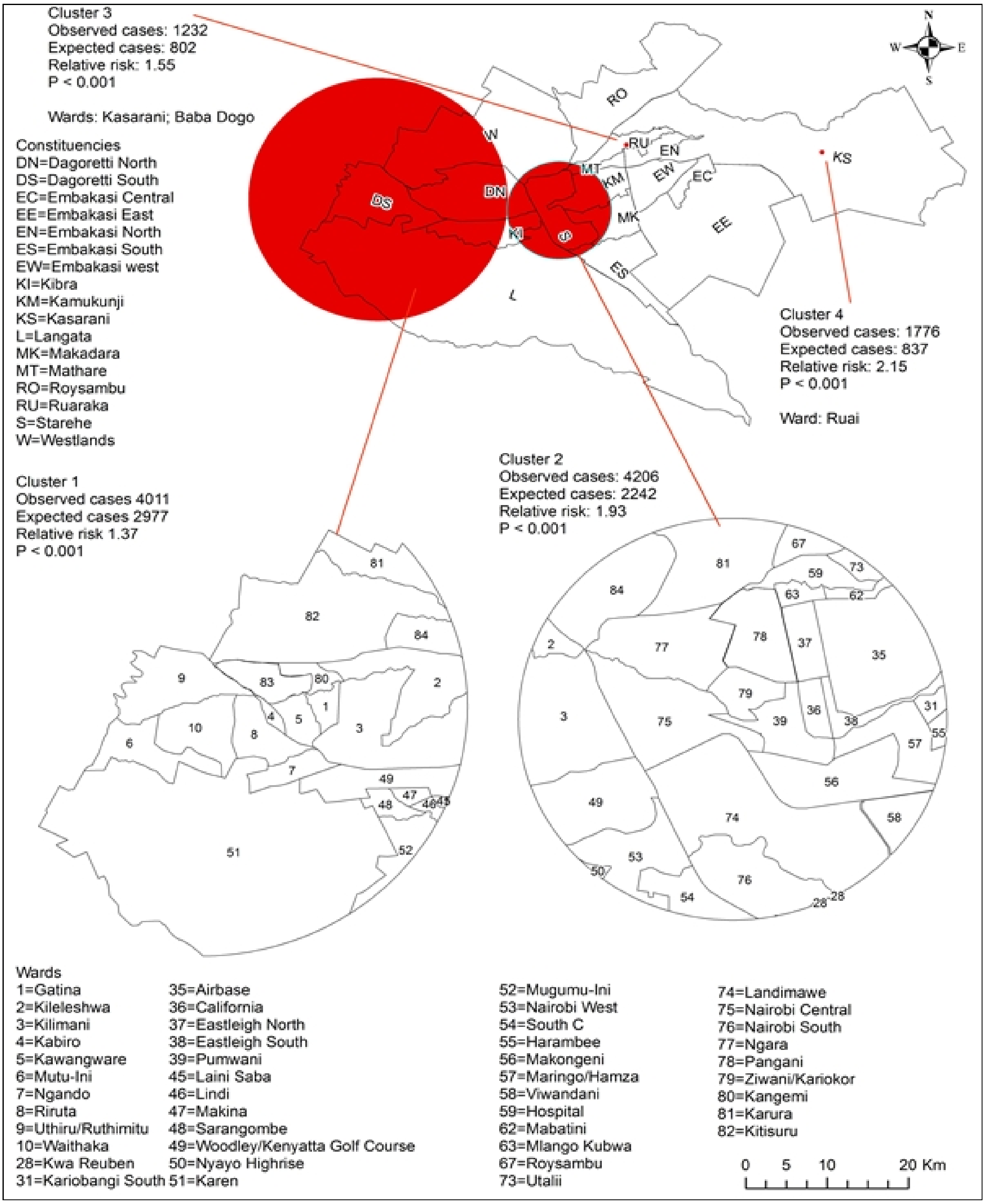
The maps in Figure 2 show that the incidence of TB varied over time during the study period. We observed high case notification rates at starehe and low rates at Embakasi North. The highest annual incidence variations in terms of constituency were; Kasarani, Kamukunji and Kibra with the lowest were Starehe,Dagoretti South, Embakasi North, Embakasi West, Embakasi East and South.

Table 3:
Case notification cases per 100,000 population at risk in Nairobi County, 2012-2016

Constituency	Notified TB cases per 100,000 population at risk				
	2012	**2013**	**2014**	**2015**	**2016**
Kibra	702	610	517	434	768
Starehe	742	658	611	509	459
Kasarani	783	610	598	480	429
Langata	472	394	366	329	405
Ruaraka	567	457	448	361	383
Kamukunji	762	611	514	453	366
Westlands	561	552	488	393	353
Dagoretti North	490	448	456	370	321
Makadara	549	450	363	309	312
Embakasi Central	226	359	318	299	256
Roysambu	312	256	247	242	210
Mathare	332	269	313	291	204
Embakasi South	382	231	178	171	174
Embakasi East	209	204	204	171	164
Embakasi west	295	250	239	193	161
Embakasi North	255	179	184	168	149
Dagoretti South	237	194	163	179	121

The spatial-temporal scan analysis results are presented in Figure 3.

Figure 3:
Geospatial clustering of notified TB cases in Nairobi County, 2012-2016



Four clusters (hotspots) were detected with the cluster year being 2012. Cluster 1 covered Dagoretti South Constituency, parts of Kibra, Westlands and Dagoretti North Constituencies. In this cluster the observed and expected rates of TB notification were, respectively, 4,011 and 2,977 per 100,000 PAR. The risk of being a notified TB cases among the population at risk in the cluster was 37% higher compared to that of the population at risk outside the four clusters (hotspots) (relative risk (RR) 1.37, p<0.001). The second cluster covered Starehe Constituency and parts of Kamukunji, Mathare, Makadara, Kibra and Dagoretti North Constituencies. Residents of these areas were 93% more likely to be notified as TB cases compared to their counterparts who lived outside the hotspots (RR 1.93, p<0.001). Two smaller hotspots were also observed at Kasarani and Ruaraka Constituencies.

DISCUSSION

Over the years we observed spatial variations in rates of notified cases of TB in Nairobi between 2012 and 2016, with the highest rates of TB cases notified from Kibra Constituency. Some constituencies (Such as Starehe) had persistently high rates of TB while some (Embakasi North, East and South) showed a stable pattern of low rates despite neighbouring constituencies (Ruaraka, Mathare, Kamukunji and kasarani) that had fairly high rates of notified cases. There were areas with high annual incidence variation particularly in three consttuencies (Kasarani, Kamukunji and Kibra).These constituencies have large informal settlements like in Kibra, Mathare slums and Eastleigh area(15).They are characterized with poor social economic status and overcrowding. Health facilities have also been set up by partners (NGOs) over the years and the introduction of better diagnostics that has enabled increased access to care and ultimately an increased case notification. There is also peri-urban migration and migration of refugees to these areas which could partly explain why there are high variations. A study done in Ethiopia with similar context suggested unusually high rate and persistence of TB which concurs with our findings (27).The lowest incidence variations were seen at Starehe, Dagoretti South, Embakasi North, East and South. Some of the areas have an effective community health strategy activities that have led to improved health status thus the low variations (28).On the contrary a part from low social economic status, this could be attributed to poor access of healthcare and low awarenes (6). Temporal trends on the notified cases showed a steady decline over the years. This was consistent with the studies done in China and Brazil which outlined, the efficiency of TB control programs and implementation of Directly Observed Treatment(DOT) as contributing factors (6,18).The possible explanations for the steady decline in our study are the introduction of Intermittent Preventive Therapy (IPT), an increase of diagnostic capacity and TB care (awareness, access to medication and compliance). This could also be due to the missed opportunities (40%) which can lead to lower reported prevalences through routine surveillance as reported previously in a prevalence survey in Kenya(4). This study showed that TB was not evenly distributed within Nairobi County. There were two major and two minor "hotspots". This study suggests that people living in the hotspots areas were at a greater risk of up to 93% of getting infected with TB compared to those living outside those regions. This study showed that most of the cluster locations in the western and northern parts of Nairobi were in areas with high population densities, poor and in equal social economic conditions, which is consistent with various studies(5,7). Low TB cases were located in the Southern Parts home to largely formal settlements. Poor access to healthcare and lack of TB control activities has contributed to an increased TB cases(8,11).

However in this study the risk factors associated with TB transmission were not assessed. Therefore inclusion of these factors in cluster analysis in the future survey might improve the understanding of their effects on the distribution of TB. Several studies have highlighted that the notification rates of TB are twice as high in males than females, which is consistent with our findings(11,14).This could be possibly explained by the bacteriological susceptibility as well as risky behaviour like alcohol intake, drug abuse and homelessness. TB related to HIV and in this study the HIV negative patients accounted for majority of the cases as evident in other studies. The children accounted for approximately 10% of the cases and the adults aged 25 to 34years were the most affected which is consistent with previous reports (1,4) Limitations of this study were, lack of data in socio-demographic factors, would have been important when relating TB to socio economic factors. This study was not a population based survey, therefore, cases occurring in the community may remain undiagnosed and unnotified. Despite the limitations the strength of this study was the large cohort of TB cases, in Nairobi. The large sample size shows its credibility and the consistent use of STROBES guidelines demonstrates its quality(27).This study recommends that health authorities need to modify its policies to enhance preventive and control measures in the hot spot areas. This was the first study done on geospatial clustering of TB in Nairobi and Kenya and acts as a baseline for future study.

CONCLUSION

The present study identified significant spatiotemporal variations in notifications of TB cases. We noted a declining trend of TB cases notifications during the study period although some hotspots consistently reported high notification rates. We recommend intensification of interventions in the hotspots as well as research to document the factors related to the observations.

FUNDING/ ACKNOWLEDGEMENT STATEMENT

This research was conducted through the Structured Operational Research and Training Initiative (SORT IT), a global partnership led by UNICEF/UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR) based at the World Health Organization The model is based on a course developed jointly by the International Union Against Tuberculosis and Lung Disease (The Union) and Médecins sans Frontières (MSFOCB). The specific SORT IT programme which resulted in this publication was led by the Department of Obstetrics and Gynaecology, University of Nairobi and the Kenya Ministry of Health Department of Disease Prevention and Control.

We would like to appreciate The National Tuberculosis Programme (NTLD-P), Kenya. Appreciation also goes to my loving husband Kiage and our babies Leo and Lulu for their immense support.

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