Covid-19 Space-time Cluster Detection Using Retrospective Analysis

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Abstract

Background: As of the 31st of January 2021, there had been 102,399,513 confirmed cases of COVID-19 worldwide, with 2,217,005 deaths reported to WHO

The goal of this study is to uncover the spatiotemporal patterns of COVID 19 in Ethiopia, which will aid in the planning and implementation of essential preventative measures.

Methods We obtained data on COVID 19 cases reported in Ethiopia from November 23 to December 29, 2021, from an Ethiopian health data website that is open to the public.

Kulldorff's retrospective space-time scan statistics were utilized to detect the temporal, geographical, and spatiotemporal clusters of COVID 19 at the county level in Ethiopia, using the discrete Poisson probability model.

Results: In Ethiopia, between November 23 and December 29, 2021, a total of 22,199 COVID 19 cases were reported.

The COVID 19 cases in Ethiopia were strongly clustered in spatial, temporal, and spatiotemporal distribution, according to the results of Kulldorff's scan. statistics

The most likely Spatio-temporal cluster (LLR = 70369.783209, RR = 412.48, P 0.001) was mostly concentrated in Addis Ababa and clustered between 2021/11/1 and 2021/11/30.

Conclusion: From November 23 to December 29, 2021, this study found three large COVID 19 space-time clusters in Ethiopia, which could aid in future resource allocation in high-risk locations for COVID 19 management and prevention.

Introduction

As of the 31st of January 2021, there had been 102,399,513 confirmed cases of COVID-19 worldwide, with 2,217,005 deaths reported to WHO.

Data collection, according to microbiology experts, is important for isolating sick persons, tracing connections, and halting the virus's spread.

Although developments in testing have made these procedures more widespread in recent months, there is still a great demand for COVID-19 screening technology that is affordable, quick, and scalable (1-2)

Africa's first regional sequencing laboratory network dedicated to SARS-CoV-2, which has been operational since September 2020, has played a critical role in this.

In the eyes of governments and leaders, genetic sequencing now has a greater understanding of the role it plays in reducing infectious disease outbreaks, something Africa has been ahead of the curve on during the pandemic.

"Genomic surveillance was very much involved with research" before the pandemic.

It was never a priority for any public health issue that was causing concern at the time.

The continent is now going forward with genomic monitoring, with governments' support and an emphasis on the network's long-term viability.

So they understand that when it comes to public health issues, surveillance should be a part of the equation. (3)

GIS (Geography Information System) is a powerful tool for visualizing and analyzing geographic attributes based on epidemiological data. (4-6)

GIS can be used in conjunction with spatial statistics to assist minimize the epidemic by providing scientific knowledge, identifying spatial correlations with other factors, and identifying transmission patterns and clustering (7-10)

Epidemiologists are now focusing their efforts on discovering space-time clusters.

There are very few research works on a large-scale study of space-time clustering, especially at the national scale, on a small scale, such as communities, counties, or provinces. (11)

Even where there is, many studies are undertaken with counties or provinces at the smallest level due to data availability. (12-13)

Analyzing the clustering of an epidemic on a national scale at the family level is critical for the creation of correct national prevention, control, and work-resumption policies.

Methods

Study area and setting

Ethiopia's GPS coordinates are 9.1450° N and 40.4897° E.

Ethiopia is the 26th largest country in terms of physical size, with a total area of 426,400 square miles.

The country has a length of 1,018 miles and a width of 980 miles.

Ethiopia has a land area of 90.5 percent and a sea area of 9.5 percent.

In other terms, Ethiopia's entire land area is 386,102 square miles and its total water area is 40,298 square miles. (14)

Ethiopia's population is over 117 million people. (15)

There are eleven regional states and two chartered cities in Ethiopia: Addis Ababa, the capital, and Dire Dawa, which was chartered in 2004. (16) (Fig 1).

Data collection and analysis

From November 23 through December 29, 2021, data was collected.

The data came from an Ethiopian health data website that is free to the general public.

After importing the data into Microsoft Excel and analyzing it with SaTscan software version 10, we used ArcGIS 10.3 to illustrate the relative risk of COVID 19 in high-risk cluster sites

Statistical analysis

To uncover COVID 19's temporal, geographical, and space-time clusters, as well as determine whether the geographic grouping was due to chance or not, we used Kulldorff's space-time scan statistical analysis (17)

The scan statistics do a cluster analysis and determine cluster size and locations using Monte Carlo Simulation, as well as compute the relative risk (RR) and generate a P-value.

Spatial analysis

With the assumption that the number of cases at each site was Poisson distributed with a known population at risk, the discrete Poisson model, as well as the number of cases (COVID 19 instances), population, and coordinates, were used as input files.

Using scan circles of various sizes, including the default value in scan statistics, the most likely spatial clusters of COVID 19 were found.

The maximum spatial cluster size was calculated using an upper limit of 50% of the population at risk.

The likelihood ratio was utilized to compute relative risk (18), and the most likely and secondary clusters were determined and reported when the P-value was less than 0.05.

The results of the investigation were displayed in tables and on maps to illustrate where the sickness had occurred at particularly high rates.

Space-time analysis

The space-time scan statistic approach uses a cylindrical window with a circular geographic foundation that is related to space and height according to time for potential clusters. (18)

COVID 19's RR was supposed to be the same inside the glass as it was outside.

The number of occurrences in areas is Poisson-distributed based on a given risk population in the Poisson probability model. (18).

To establish the test of significance, the likelihood ratio test was compared to a null distribution created by a Monte Carlo Simulation.

The permutation count was set to 999, while the statistical significance was set at P0.05.

We ran a space-time investigation for the period 2021/11/23-2021/12/29 to see if there were any recent space-time clusters of the disease.

Results

A total of 22,199 COVID 19 cases were reported from November 23 through December 29, 2021. In Ethiopia

Table 1

Spatial clustering of COVID 19 in Ethiopia from 2021/11/23-2021/12/29

Cluster Type	Coordinates /Radius	N	Cluster Regions	Observed Case	Expected Case	RR	LLR	P-value
Most likely Cluster	9.005401 N, 38.763611 E/o km	1	Addis Ababa	19772	874.23	198.72	56388.10451	0.001
Secondary Cluster 1	6.661229 N, 43.790845 E/ 604.49 km	5	Somalia, Harar, Dire Dawa, Oromia, Afar	1793	11095.49	0.088	9150.429466	0.001
Secondary Cluster 2	11.663240 N, 37.821903 E/0 km	1	Amhara	366	5449.19	0.052	4798.102396	0.001
Secondary Cluster 3	6.033103 N, 36.433828 E/319.05km	2	SNNPR, Gambela	268	3161.17	0.074	2441.304521	0.001
Secondary Cluster 4	6.661229 N, 43.790845 E/0 km	1	Somalia	0	1456.52	0	1506.498239	0.001
Secondary Cluster 5	14.032334 N, 38.316573 E/0 km	1	Tigray	0	1350.48	0	1393.301071	0.001
Secondary Cluster 6	11.485999 N, 41.245999 E/0km	1	Afar	0	460.22	0	465.057428	0.001
Secondary Cluster 7	10.780289 N, 35.565786 E/0 km	1	Benishangul Gumuz	0	268.44	0	270.075601	0.001

A total of eight statistically significant areas, comprising a total of 11 regions, were identified by spatial clustering analysis.

Addis Ababa has the highest proportion of high-risk locations, with a relative risk of more than three.

Addis Ababa. the region, 9.005401 N, 38.763611 E (LLR = 56388.10451, P 0.001) was found to be the center of the most likely cluster area (Figure 2)

With a radius of 0 kilometers, this circular area exclusively covered Addis Ababa.

The total number of COVID 19 cases was 19772, and the risk of COVID 19 was 198.72 times (RR = 198.72) higher in this location than it was elsewhere (Table 1)

Table 2

Temporal Clustering of COVID 19 cases In Ethiopia from 2021/11/23-2021/12/29

Cluster Time Frame	Observed Cases	Expected Cases	RR	LLR	P-value
2021/11/23-2021/12/1	22,199	5399.76	0	31382.578351	0.001

The temporal cluster analysis with time aggregation length of 7 days and time precision of day showed that COVID 19 cases were low from 2021/11/23-2021/12/1 (Figure 3)

The low aggregated period for COVID 19 was observed in all regions from 2021/11/23-2021/12/1 (LLR = 31382.578351, P =0.001).

During this period from 2021/11/23-2021/12/1, a total of 22,199 COVID 19 cases were reported, and the risk of

COVID 19 was (RR = infinity) very low (Table 2).

Table 3

Spatiotemporal clusters of COVID 19 in Ethiopia

Cluster Type	Cluster Time Frame	Coordinates /Radius	N	Cluster Countries	Observed Case	Expected Case	RR	LLR	P-value
Most likely Cluster	2021/11/1-2021/11/30	9.005401 N,38.763611 E /0 km	1	Addis Ababa	19772	429.95	412.48	70369.783209	0.001
Secondary Cluster 1	2020/12/1-2021/12/31	6.661229 N,43.790845 E /604.48 km	5	Somalia, Harar, Dire Dawa, Oromia, Afar	0	5638.69	0	6505.163412	0.001
Secondary Cluster 2	2020/12/1-2021/12/31	6.033103N,36.433828 E /319.05 km	2	SNNPR, Gambela	0	1606.50	0	1667.593870	0.001

Addis Ababa was the most likely spatiotemporal cluster location, and the high-risk period was from 2021/11/1-2021/11/30 (LLR = 70369.783209, P 0.001).

The area's center was Addis Ababa, which was located at 9.005401 N and 38.763611 E, with a radius of 0 km (Figure 4)

During the period 2021/11/1-2021/11/30, a total of 19772 COVID 19 cases were recorded in this location, with an RR of 412.48 (Table3.)

Discussion

Kulldorff's scan statistical analysis was used to analyze the spatial, temporal, and spatiotemporal clusters of COVID 19 in Ethiopia from 2021/11/23 to 2021/12/29.

To our knowledge, no other study of this nature has been conducted in Ethiopia.

Our research found that the distribution of COVID 19 cases in Addis Ababa was highly space-time clustered.

Addis Ababa was the epicenter of the COVID 19 outbreak.

Multiple testing problems are taken into consideration in Kulldorff's retrospective scan statistics, which is known as the most powerful method for evaluating geographical and temporal distribution utilizing routinely obtained data (19).

This approach has been used to detect disease clusters all over the world (20-23)

The results of our temporal scanning revealed that COVID 19 had a low-risk phase between November 23, 2021, and December 29, 2021.

The spatiotemporal model utilized in this work examined both time and space distributions at the same time.

The time-space scanning model, as opposed to the distinct spatial and temporal scanning models, produces a conclusion that is closer to the real-world situation.

We discovered that COVID 19 instances were concentrated in Addis Ababa from 2021/11/23-2021/12/29 when we used this model to determine the Spatio-temporal distribution of COVID 19 in Ethiopia.

COVID 19 was more prevalent in Addis Ababa during this time than in other Ethiopian districts.

The causes for the great magnitude of COVID 19 in Addis Ababa are as follows:

Addis Ababa is Ethiopia's capital city, and it has a higher level of testing and quarantine coverage than the rest of the country.

Many people, including Ethiopian long-distance vehicle drivers, traders, and others, have been traveling from Djibouti to Ethiopia via the route that connects the Amhara area, Addis Ababa, and Oromia region since the commencement of the COVID-19 pandemic, mostly owing to geographical proximity (24)

SARS-CoV 2 infection is very dangerous for certain populations.

Sentinel monitoring attempts to detect the early introduction and spread of COVID-19 are especially well-suited for such populations, especially in areas with low vaccination coverage or where layered preventative techniques are not used.

Due to their high risk of exposure or severe illness, the CDC deems the ability to monitor COVID-19 incidence in the following populations to be particularly useful:

Health care workers, residents and staff members of long-term care facilities, incarcerated people, homeless people, and workers in high-density work sites, students and staff members of kindergarten–grade 12 schools and institutions of higher education, incarcerated people, homeless people, and workers in high-density work sites (25-30)

Rising case detection rates can act as an early warning indicator that prevention methods in the facility and the larger community need to be reinforced or introduced.

Furthermore, strategic serial testing can aid in the prevention of SARS-CoV-2 transmission by quickly detecting asymptomatic cases, which are thought to account for at least 50% of SARS-CoV-2 transmission (31-32)

Further prevention and particular COVID 19 control methods should be addressed regarding the vaccine, testing, and prevention practices in other Ethiopian regions, according to our findings.

Our research also confirmed the use of spatial and temporal clustering analysis with ArcGIS and SaTScan in identifying significant COVID 19 space-time clusters in Ethiopia.

This could be utilized to develop COVID19 preventive initiatives at the county level.

However, the study's analysis was limited.

First and foremost, the data were studied at the county level, which is not the smallest administrative regionalization unit.

As a result, we can rule out several important elements.

Second, meteorological and socio-economic aspects were not taken into account in this study.

Conclusion

Using Kulldorff's retrospective scan statistic approaches, we examined the geographical, temporal, and space-time clusters of COVID 19 at the county level in Ethiopia from 201/11/23 to 2021/12/29.

The results of the space-time scanning revealed that Addis Ababa is at high risk for COVID 19.

These findings indicate that the Addis Ababa health office, Ethiopian Minister of Health, and Ethiopia Public Health Institute must implement preventive and control programs to reduce COVID 19 in Addis Ababa as soon as possible.

Declarations

Ethics approval and consent to participate:

This research is based on secondary data from Ethiopia's COVID 19, which is publically available

Consent for publication:

not applicable

Availability of data and materials:

The paper includes all data.

Competing interests:

There are no competing interests stated by the authors.

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Contributions of the Authors:

KTT was responsible for the original drafting of the manuscript's conceptualization, analysis, supervision, and development.

Methodology, Discussion, and Data Analysis were all done by KTT, ETT, AGA, and MKT.

KTT, ETT, MKT, GA, BB, KG, AT, AAA, AZ, WSB, MR, BFW, and AGA assisted with data analysis, critically revised the work, and agreed to be held accountable.

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Figures

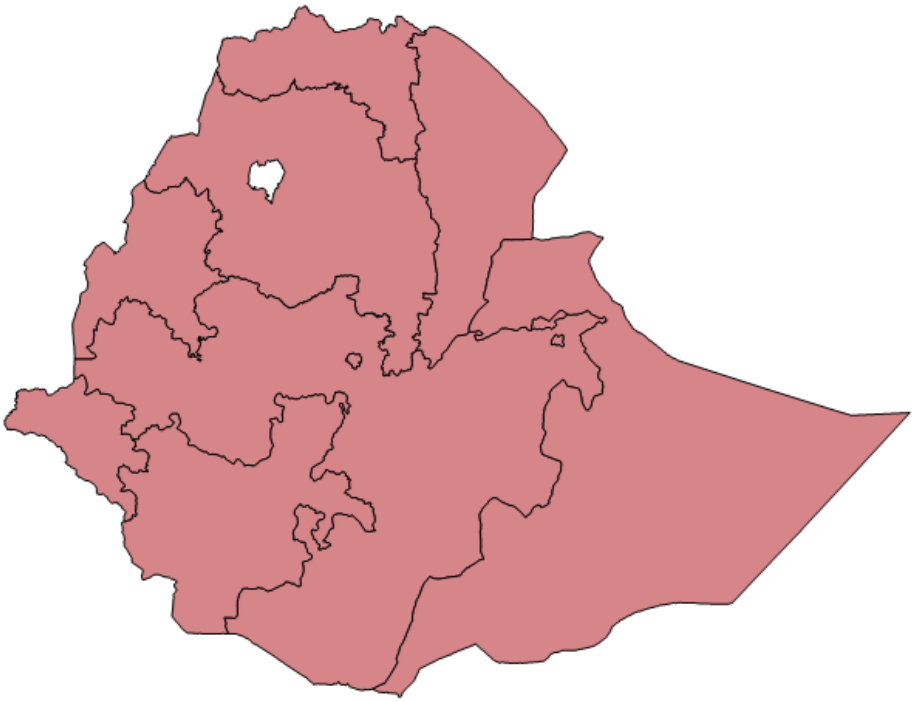

Figure 1

Study map

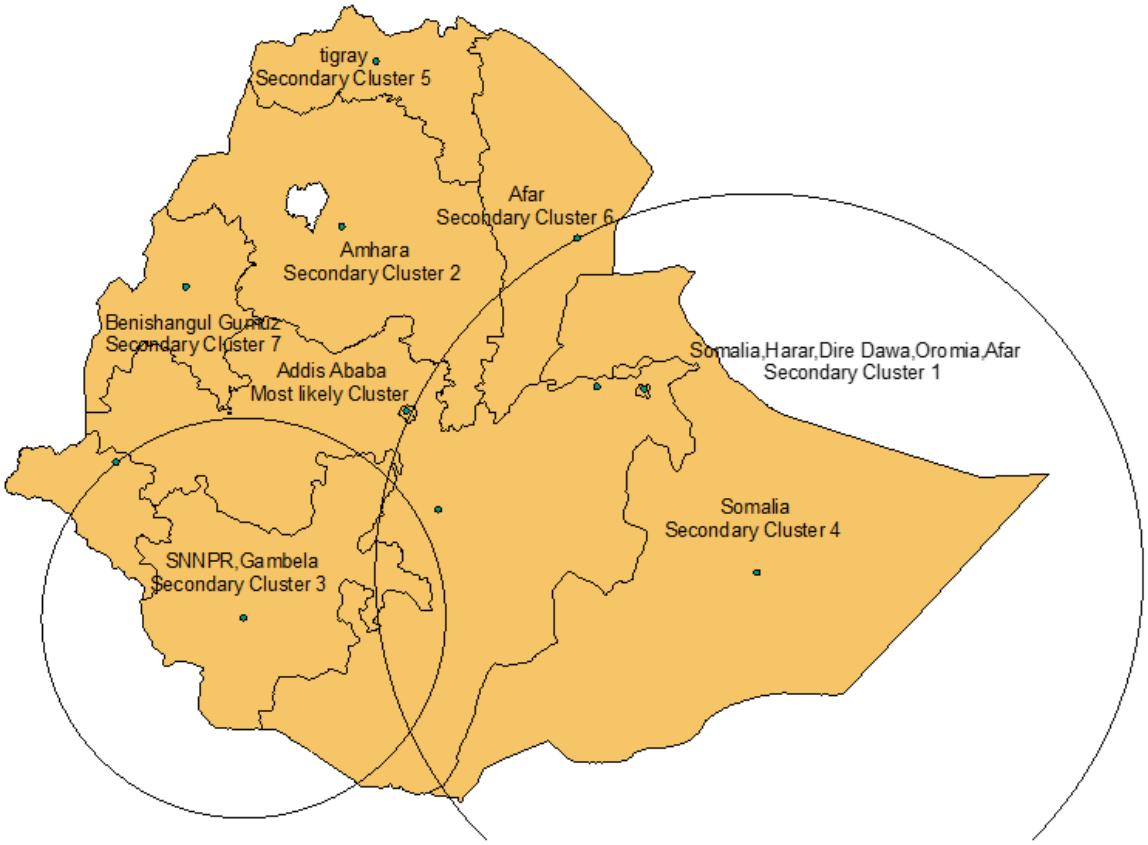

Figure 2

Spatial clustering of COVID 19 in Ethiopia

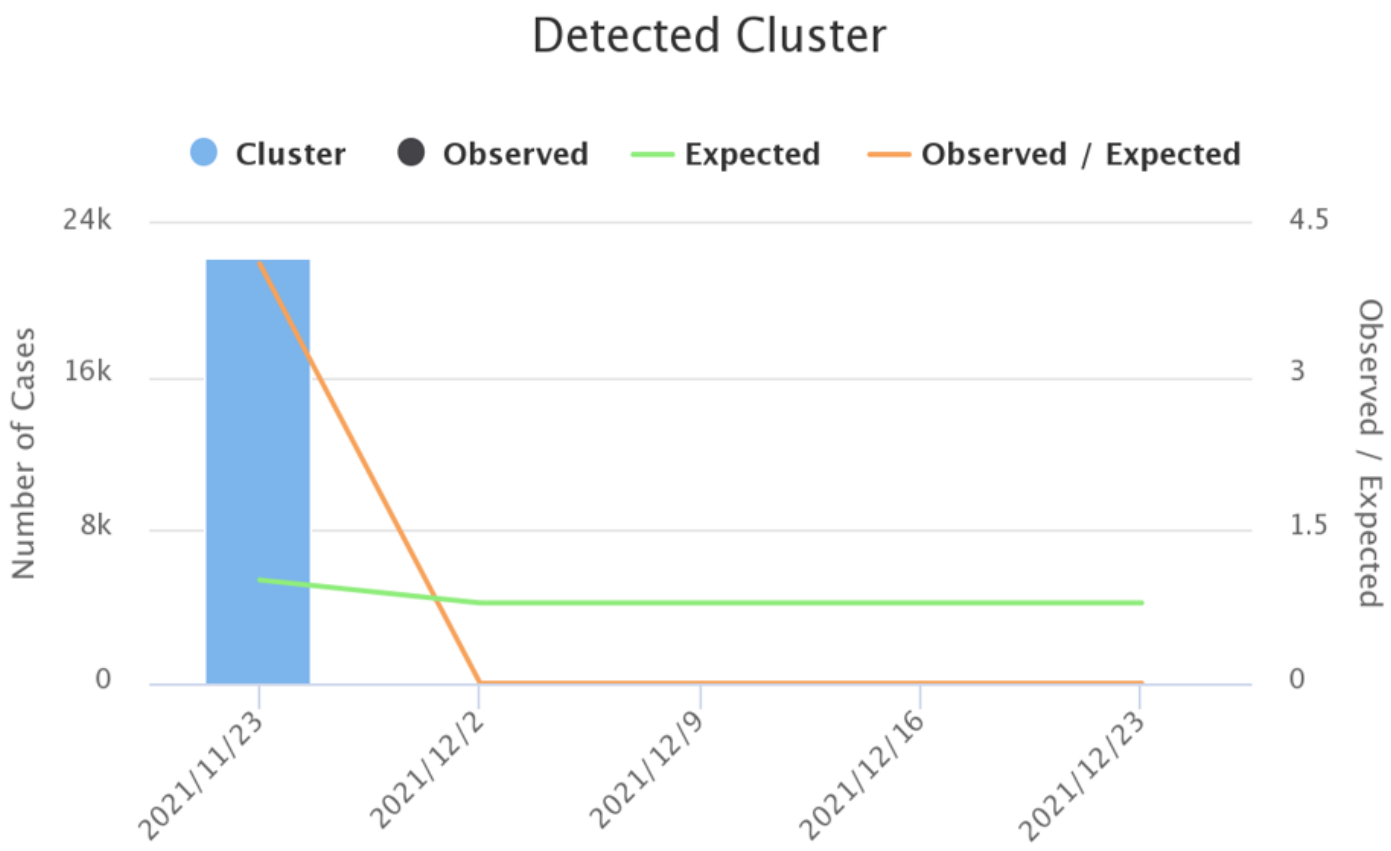

Figure 3

Temporal graph

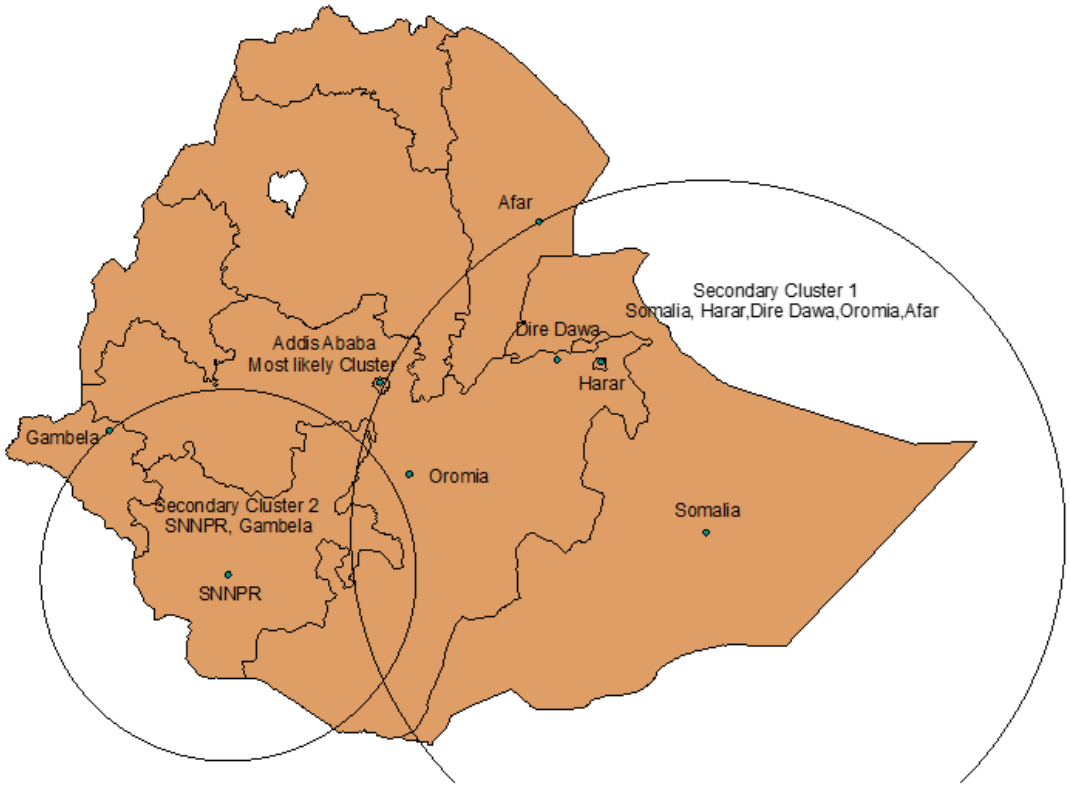

Figure 4

Spatiotemporal clusters of COVID 19 in Ethiopia