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DETECTING LOCAL DENGUE CLUSTERS USING SATSCAN METHOD FOR IMPLEMENTING PREVENTIVE MEASURES IN GUNTUR DISTRICT, ANDHRA PRADESH

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Abstract:
Guntur District, India is a high dengue transmission area that is subject to dengue epidemics. SaTScan methodology was used by the dengue control programme to detect local dengue clusters to assist disease control planning. The third season for case cluster identification overlapped with the first season of implementing an outbreak identification and response system in the area. SaTScan™ software using the Kulldorf method of retrospective space-time permutation and the Bernoulli purely spatial model was used to identify dengue clusters using definitively confirmed individual cases in seven towns over three dengue seasons. Following passive case reporting at health facilities during the 2011 to 2015 seasons, active case detection was carried out in the communities, this assisted with determining the probable source of infection. The distribution and statistical significance of the clusters were explored by means of Monte Carlo replication of data sets under the null hypothesis with replications greater than 999 to ensure adequate power for defining clusters and exploring the clustering of cases assisted with the planning of public health activities, including mobilizing health workers and resources. Where appropriate additional indoor residual spraying, focal larviciding and health promotion activities, were all also carried out.

Background

Dengue is the most dangerous disease of humans. Over three billion people live in dengue areas and the disease causes over 500 million cases with one to three million deaths per year [1,2]. An estimated one hundred million people in Africa are at risk of dengue epidemics [3]. In common with most vector-borne infectious diseases, dengue is heterogeneous in its distribution in time and space [4-6], and incidence can vary greatly between districts, towns and villages. This heterogeneity is affected by patterns of dengue vector distribution, human-vector contact, human host behavioral factors, house construction, and dengue prevention methods used [5,7-10]. Characterization of dengue heterogeneity may allow prioritization of risk areas and allow focused control interventions. The ability to identify localized dengue clusters in remote highland areas of east Africa facilitated early intervention in the absence of early warning systems, as these dengue "hotspots" remained constant in epidemic and non-epidemic years [11]. A number of models have been developed for describing dengue spatial distribution and seasonality [12-15] transmission [8,16-18], mosquito distribution [19,20] and risk factors associated with dengue [21-23]. However many dengue endemic environments are resource limited and tools to assist decision support need to take account of these limitations.

Dengue remains a public health problem in Andhra Pradesh, in the low altitude area of Andhra Pradesh Dengue risk is low compared to other hyperon endemic areas of southern India and naturally acquired immunity does not develop in the local population [26].

The burden of dengue is well described in this region as definitive diagnosis using rapid diagnostic tests (RDTs) and mandatory reporting of dengue cases is universally practiced in the public health system, which manages the vast majority of dengue cases [27,28]. All confirmed dengue cases are entered into a computerized dengue surveillance system.

This paper reports on the analysis of dengue notification data from 2011–2015 from Guntur District to determine local clustering of cases and how that was used to direct local control efforts and enhance the district outbreak identification and response system [29].

Methods

Study area

Guntur district is in the Capital Region of Andhra Pradesh located in banks of Krishna river at the longitude and Latitude between 16’390” N and 80’0088” E. at a mean sea level of 26 m. It sprawls an area of 168.5Km2 in that 88.50Km2 is classified as an urban area. Guntur is governed by two administrative bodies namely the Guntur Municipal Corporation (GMC) and Guntur Metro City both are eventually comes under Capital Region Development Authority (CRDA), GMC is responsible for public health activities. The GMC comprises 58 wards that cover the most significant part. The study area is spread at 88.5 *km*2 and has population 7, 73,568. The Indian red-chilies capital city Guntur remains hot in summer, humid in monsoon season. Average

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temperatures of Guntur are 28.5°C. In summers, the heatwave in Guntur is immense and adequate precautions have to be taken before going out in the afternoons. Rainfall season in Guntur is between June to September and the average rainfall recorded is 830 mm.

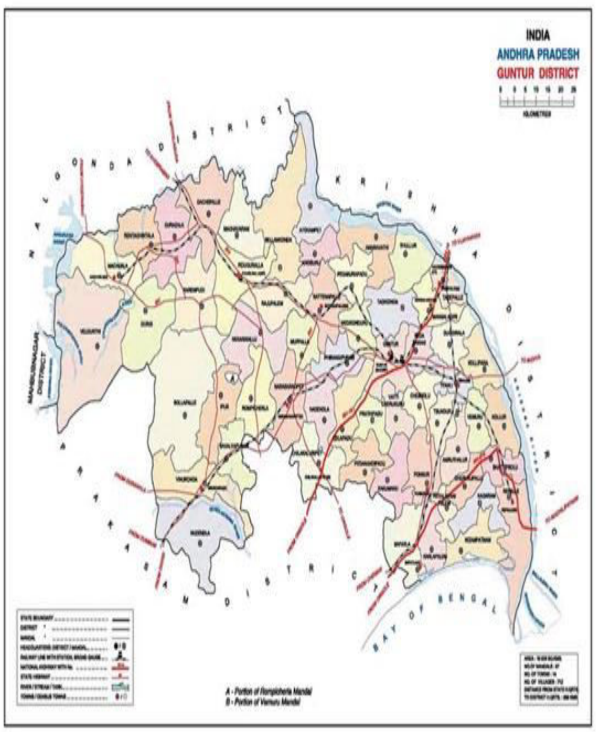

Fig:1

Active dengue case investigation

Dengue case investigators followed up all dengue cases reported at local health facilities for these towns as part of dengue control program activities for the 2012/2013/2014 and 2014/2015 seasons. A dengue case is defined as a person diagnosed either by positive rapid test or blood slide. An investigator would identify the probable source of infection by confirming the travel history of the patient recorded on the notification

Spatial and temporal clusters

SaTScan™ software, version 5.1.3, using the Kulldorf method of retrospective space-time permutation and the Bernoulli purely spatial model [34,35], was used by dengue control programme operational staff to detect dengue clusters in individual towns in the three seasons under investigation and over the combined time period. Individual dengue cases were used and recorded against source of infection households. Households who did not seek health care for dengue or tested negative during active case detection were used as controls for the Bernoulli method. More than one case can be reported per household. A household in these areas is typically defined as a family unit with a single land owner.

The circular scan statistic is isotopic with respect to the rotation of the geographical area http://www.satscan.org. This method has previously been validated for plotting and understanding local dengue time-space-clusters [21,36-39].

Observed cases in a cluster were compared to the distribution of expected cases if spatial and

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temporal locations of all cases were independent. The model adjusts for entirely spatial or entirely temporal clusters. With spatial adjustment, time remained dormant and during temporal analysis seasons were considered. The distribution and statistical significance of the clusters were explored by means of Monte Carlo replication of data sets under the null hypothesis with replications greater than 999 to ensure adequate power for defining clusters http://www.satscan.org. Clusters were prioritized for public health action according to their statistical significance. Hard copy town maps showing cluster areas were distributed to dengue field staff investigating cases allowing the coordination of intervention efforts within communities.

Results

Dengue incidence

Four hundred and twenty-two dengue cases were notified during the three seasons from 341 households across the seven towns. Dengue incidence differed significantly between the towns during the three seasons p = 0.005) (Figure 2).

Case clustering

SaTScan analysis detected number of clusters during the study period produced two space-clusters over the three-season period using the Bernoulli model, one in the northern (log likelihood ratio = 12.308, p = 0.003) and one in the south eastern part of town (log likelihood ratio = 12.187, p = 0.003) (Figure 3A). Three additional space-clusters were observed; in Goba (log likelihood ratio = 12.226, p = 0.001), Mbuzini (log likelihood ratio = 22.372, P = 0.001) and Thambokulu (Figure 4A) (log likelihood ratio = 22.372, p = 0.001). Only two towns, Albertsnek (test statistic = 5.548, p = 0.007) and Thambokulu (test statistic = 3.668, p = 0.004), had spacetime clusters and both were during the 2014/2015 season (Figure2)

Cluster detection to guide control activities

The third season for case cluster identification, 2014/ 2015, overlapped with the first season of implementation of an outbreak identification and response system in the

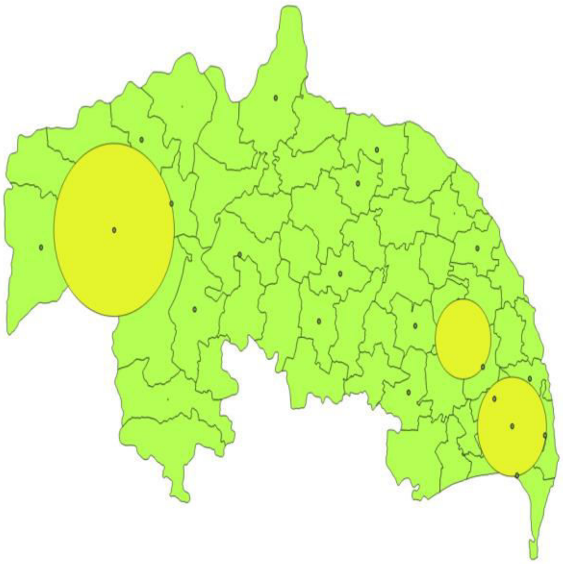

Figure 2
Spatial dengue case clusters, Guntur district. A. 2011-12,

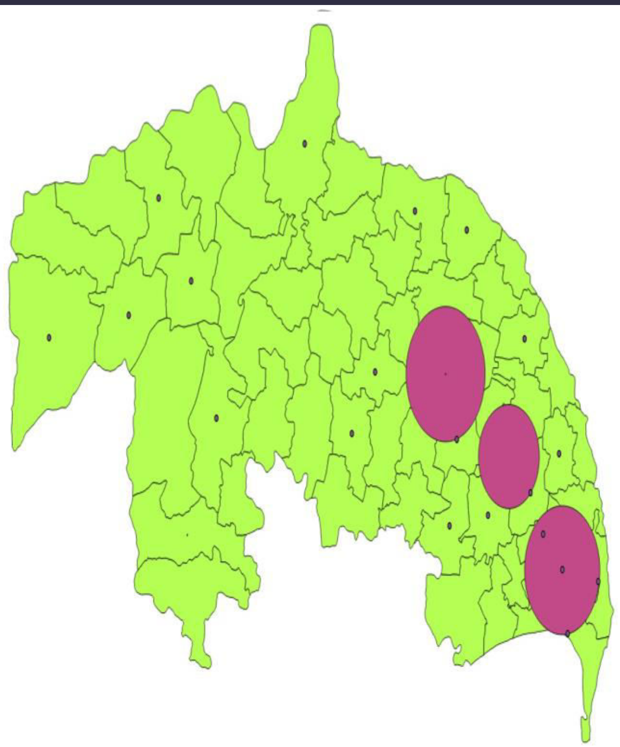

Figure 3
Space time dengue case cluster,

The timely planning of public health activities especially logistics, including active case detection, early diagnosis and treatment of positive cases in the areas of the clusters, additional indoor residual spraying, focal larviciding and health promotion activities.

Discussion

Application of the SaTScan method successfully identified dengue clusters and clearly demonstrated dengue risk heterogeneity at local level. Four towns in this study experienced spatial clusters and two produced space-time clusters in the 2004/2005 dengue season, the latter resulting in targeted local control efforts. The high rates of treatment-seeking behavior at primary health care level in Guntur combined with the use of passive notification and active case detection, strengthens disease surveillance and provides good quality data for cluster identification. SaTScan cluster identification has also proven valuable for targeting control strategies in the Kenyan highlands [21]. Over a ten week period during a 2002 epidemic, spatial targeting of vector control interventions reduced the abundance of *Anopheles* mosquitoes. The investigation of causes for clusters within the areasreported here was not explored. The hypo-endemic nature of dengue in these areas does predict the unstable patterns Guntur area [29]. triggered outbreak declarations during this season (Table 1). Analysis demonstrated clusters in both towns during this season. Real time cluster detection, monitoring as cases occur, triggered at the same time as the binomial outbreak identification thresholds [29].

The physical plotting of cases by household during this season (2014/2015) as part of the cluster identification activities at district level and on hard copy maps provided a visual distribution of risk in the towns and assisted with of disease occurrence and more specifically outbreaks that can be clustered. The proximity of these

areas to higher dengue risk areas such as allows for the import of Guntur and eventually local transmission. Spatial clustering of infectious disease is enjoying renewed interest, particularly in areas of limited resources. Statistical methods have been used to investigate spatial clustering of dengue [41] encephalitis [19] and sleeping sickness but the application to dengue has been limited [42].
Gaudart *et al* [43] compared the oblique decision tree model, a complex statistical technique with Kulldorff's SaTScan™ cluster technique, which was used in this study. Gaudart *et al* [43] produced similar results using both methods in a village in West Africa to identify dengue risk clusters. This investigation confirmed the usefulness of the Kulldorff's scan statistic [44-46]. Due to the circular isotopic technique of Kulldorff's SaTScan™ it is a useful tool to detect clusters but has limitations on detecting irregular shaped clusters due to its fixed scan window [47,48].

The towns in the Guntur district are under cluster surveillance were included in a dengue outbreak identification and response system based on formal case reporting [29]. There was strong concordance between recognized local clustering and outbreak identification in specific mandalas, with Guntur and Amaravati both reporting dengue outbreaks in the same season as the time-space clusters. This synergy allows mutual validation of the two systems in confirming outbreaks, which demand additional resources, and cluster identification that could better target these resources within the affected town.

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