# Epidemiological Study of Malaria in an Urban Corporation Area

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### Abstract:

Introduction: Malaria response and preparedness planning requires early warning signs, determination and declaration of epidemic as it is a major public health problem in South Gujarat and country. **Objective:** To verify, investigate and supervise the malaria epidemic situation in 2015 in an urban corporation area. Method: This was a mixed-methods study conducted in the seven administrative zones of Surat Municipal Corporation (SMC)in 2015. Field visits were conducted to explore increase in number of malaria cases and factors responsible. Microscopic diagnosis of parasite in blood slides followed by calculation of malariometric indices was the main study tool. For epidemic declaration, WHO recommended threshold methods-(1) monthly mean plus twice standard deviation (SD) (2) 3rd quartile (3)Cumulative Sum+2SD; were used. Results: Among 5,084,688 population of SMC in 2015; 1,272,888 slides were examined with 8708 malaria positive, slide positivity rate (SPR) 0.65 and PF rate 16.1%. Epidemic thresholds constructed from previous year (2010-2014) data were not crossed, though maximum cases were reported during monsoon months. Migration, massive construction activities and simultaneous epidemic of influenza led to development of favourable malariogenic conditions in East, North and Southeast zones. Radical treatment and follow-up of malaria cases suffered among the highly mobile population of construction workers leading to high malaria parasite load in community. Conclusion: Urban Surat malaria cases have increased especially in South-east, North and East Zones, but not crossed epidemic threshold in year 2015. Epidemic investigation step-wise approach of identifying areas of active malaria transmission may help program managers to plan and stratify control responses in a resource- constrained setting.

Key Words: Construction Workers, Epidemic threshold, Urban Malaria

## Introduction :

Malaria is one of the major global public health problems<sup>[1]</sup>, with nearly half of the world population at risk, 216 million cases and 0.45 million deaths. India is one of the sixteen countries which together contribute 80 % global malaria burden.<sup>[2, 3]</sup> Any epidemic of vector-borne disease of malaria generates huge public attention and panic in population. Regular surveillance of the disease related situation helps in early epidemic detection and planning of prevention and control measures.<sup>[4]</sup>

A malaria epidemic can be described simply as a sharp increase in the frequency of malaria transmission that exceeds by far the inter-seasonal variation normally experienced. Early detection of Epidemic involves recognizing the beginning of an epidemic situation by measuring changes in local disease incidence.<sup>[5]</sup> Conventionally, this expected frequency for any month is considered as two standard deviations above the monthly mean calculated from previous three years data.

To summarise, epidemic detection algorithms are increasingly recommended by WHO and reputed researchers for malaria surveillance.<sup>[6]</sup> In India, the surveillance data is rarely used for epidemic detection, early warning system, planning malaria response and reallocation of resources. The present study aims to detect the epidemic situation of malaria in an urban corporation area of Gujarat. We envisage that findings will enable the program managers and policy makers to make use of routine data from surveys for planning various prevention activities.

## Method:

**Study settings:** Surat city is a large metropolitan city situated on western coast of India in the state of Gujarat.<sup>[7]</sup> The Surat Municipal Corporation (SMC) has 7 administrative zones and a separate department for vector borne disease control program (VBDCP) implementation.

Study Variables: The peripheral blood smears of suspected cases were examined microscopically for malarial parasite. The indicators recorded were blood smears collected and examined in city population, total blood slides positive for Plasmodium vivax and Plasmodium falciparum. This information was used to calculate the following malariometric indices;Blood smears examined (BSE) Annual Blood Examination rate (ABER)= (BSE/Population/10), Slide positivity rate (SPR) is proportion of positive slides out of total blood smears examined, Slide falciparum rate (SFR) is proportion of positive p. falciparum slides out of total blood smears examined, Annual Parasite Incidence (API) is proportion of positive infections in the population examined and Annual Falciparum Index (AFI) is proportion of falciparum positive and mixed infections in the population examined.<sup>[8]</sup>

**Study duration:** The data collection for this study was done from January 2015 to December 2015. Analysis and preparation of report was done in 2016. Historical data of malaria cases over 5 years (2010-2014) was used to calculate the monthly epidemic threshold to compare the trend of cases in year 2015.

**Study Methods:** This study was a mixed methods study conducted as step-wise investigation of epidemic.

First, a secondary data analysis was conducted from the information collected by malaria surveillance workers called as peripheral health workers (PHWs) in Surat city. Secondly, city areas with increasing malaria cases were identified by desk review and interviews of malaria officers of city. Thirdly, field visits to study factors responsible for increase in cases were explored. Malaria surveillance system is well developed in urban Surat and consists of active, passive and mass surveys during epidemic.<sup>[9]</sup> There are tiers of government funded health care system; (44 urban health centres and medical college as reference centres) and various private hospitals which contribute to passive surveillance of malaria in city.<sup>[9,10]</sup> The population of each urban zone is further segmented into sections of ten thousand populations (2000 households which are actively surveyed) by one designated peripheral health worker (PHW). For active surveillance, the PHWs conduct house to house fever survey in such a way that each household is visited at least twice in a month.<sup>[3,9]</sup> The VBDCP related activities of each zone is supervised by Sanitary Inspectors, Assistant Insecticide officers, Medial Officers and Medical Officer of Health. Malaria is a notifiable disease in Surat city.<sup>[11]</sup> Peripheral blood smears were collected from suspected malaria fever cases for examination by microscopy. In case microscopy was not possible within 24 hours, then rapid diagnostic kits (RDKs) were used for malaria diagnosis according to national guidelines.<sup>[12]</sup> All cases were later confirmed by blood smear examination.

The historic monthly data of malaria cases over the previous 5 years (2010-2014) was obtained. To determine the epidemic monthly threshold, following three different methods recommended by WHO were employed to calculate alert levels.<sup>[2,4, 6,11]</sup>

- (1) The monthly mean (n=5) plus twice standard deviation method. The alert threshold for each month is determined as the mean plus 2 times the standard deviation.<sup>[13]</sup>
- (2) The 3<sup>rd</sup> quartile method: the alert threshold is reached when current cases exceed the upper 3rd quartile or the "upper normal limit. For 5 years of observations, quartile 0 is the minimum, quartile 1 the second lowest, quartile 2 the median, quartile 3 the second highest and quartile 4 the maximum value of the series for any given month.<sup>[4]</sup>
- (3) The C-SUM (Cumulative Sum+2SD) mean calculated over the combined previous, current and following months' data for the past 5 years (n=15). For example the expected number of

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cases for any month would be derived from the average of 3 months (current, previous and next month) cases over last 5 years (n=15). Then the malaria cases in a particular month of 2015 were plotted on the threshold to ascertain whether an epidemic response was warranted or not.

**Ethical clearance:** As recommended by WHO ethical guidelines for public health research and surveillance, ethical waiver can be obtained for activities done under implementation of national health programs.

### **Results:**

The year wise consolidation of reports of malaria surveillance showed that in 2015, among 5,084,688 people of SMC, 1,272,888 slides were examined and 8708 had malaria positive. Plasmodium falciparum (PF) were found in1400 slides out of 8708 (16.07%). The ABER of the city was 25% (1,272,888/5,084,688 \*100); API of 1.71; SPR of 0.68 and PF 16% (table 1).Compared to this in 2014, among the 4,891,945 population of SMC, 1,286,559 slides were examined with 7110 total positive slides (P. Falciparum was positive in 1038 slides). The ABER was 26% (1,286,559/4,891,945 \*100); API of 1.55; SPR of 0.55 and PF 14.6%. Compared to 2014, there was rise of 34.9% in number of malaria cases in year 2015

Maximum cases were seen in the East followed by North and South-East zones.Out of total 8,708 malaria cases up to September in 2015, 1400 (16%) were Pf cases. The east, north and south east zones of the city constitute 70% malaria burden. Males bear 70% malaria burden of city. Compared to the year 2014, there is increase in cases of Pv and Pf malaria for all the zones except SEZ.The trend is on higher side but it does not cross the epidemic threshold level for epidemic of malaria when compared with last five years data.

Month wise Malaria surveillance data (2010 - 2015) is presented in table 2. For calculating the epidemic threshold, we used last five years malaria surveillance data (Figure 1). According to method I, the mean and twice the standard deviation of last five year data were added to calculate the level of epidemic threshold for each month.The number of cases for all the months in 2015 was below the

epidemic threshold (Figure 2).However, the year-toyear variability was marked during the monsoon season (Aug-Sep), which lead to wider 95% confidence intervals in the epidemic threshold curve during these months. According to method II, the last five year data were arranged month-wise in ascending order and middle values were used to construct the third quartile (Figure 1).In year 2015, the number of cases does not exceed the 3rd quartile for any month as shown in figure 2 also.

Using the method III, the 3-months' moving average over past 5 years called as cumulative sum (C-SUM) was compared with study year 2015. For C-SUM example, the expected number of cases for January 2015 was derived from the average of December, January and February admissions from 2010 to 2014 inclusive (n=15).

Above exercise of comparison of number of cases in year 2015 with last five year malaria cases suggests that there was no increased epidemic activity. The malaria health problem in area was below expected frequency.

For year 2015, malaria cases are below the epidemic monthly threshold; prepared on historical data of 2010-2014.

In the third part of the study, field visit was done to health centers showing increase in number of malaria cases. The findings were: 1) There was a swine flu epidemic along with malaria cases in Surat city. 2) Out of the required 488 workers nearly half posts were vacant. 3) Workers have to work for NVBDCP as well as swine flu so there was disturbance of routine activity like, anti-larval and anti-adult measures. The swine flu cases were also found in maximum numbers in the same zones where more cases of malaria were seen. 4)We also observed that it was very difficult to ensure compliance to Radical Therapy in migratory population due to non-availability of permanent address and contact details. These patients may later suffer from malaria and also serve as reservoirs of infection for other population.

#### **Discussion:**

The present study shows that the annual blood examination rate (ABER) for all the 7 zones of SMC is 20.4% well above the recommended level of 10% of

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Zone wise data	Year	Total PV	Total PF	Total Positive	Pf %	Change
Central Zone	2014	602	135	737	18.3	+41.18%
	2015	555	177	732	24.18	
West Zone	2014	319	46	365	12.6	+119%
	2015	311	101	412	24.51	
South Zone	2014	421	54	475	11.37	+20.3%
	2015	445	65	510	12.75	
South East Zone	2014	1545	282	1827	15.44	-6.4%
	2015	1523	264	1787	14.77	
South West Zone	2014	297	56	353	15.86	+30.4%
	2015	281	73	354	20.62	
North Zone	2014	1180	212	1392	15.23	+40.6%
	2015	1530	298	1828	16.3	
East Zone	2014	1708	253	1961	12.9	+57.3%
	2015	2663	422	3085	13.68	
Total	2014	6072	1038	7110	14.6	+34.9%
	2015	7308	1400	8708	16.08	

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## Table 2: Month wise Malaria surveillance data (2010 - 2015)

	2010	2011	2012	2013	2014	2015	Mean	SD
JANUARY	289	491	418	233	270	178	340.2	109.34
FEBRUARY	278	333	326	273	276	171	297.2	29.62
MARCH	351	385	398	363	320	249	363.4	30.41
APRIL	543	624	665	658	442	373	586.1	94.14
MAY	718	744	781	706	684	520	726.6	37.31
JUNE	570	875	886	820	607	723	751.6	151.38
JULY	1174	1300	1376	1114	774	1306	1147.6	232.79
AUGUST	2526	1793	1703	1489	902	1472	1682.6	585.38
SEPTEMBER	2558	2538	2048	1430	1362	1733	1987.2	577.53
OCTOBER	2116	1883	1696	895	937	1344	1505.4	558.43
NOVEMBER	1427	819	959	813	667	639	937	292.72
DECMBER	1043	584	385	415	496	390	584.6	267.66
Total					9098			



Figure 1: Epidemic Threshold calculated from five year malaria cases data using the three methods recommended by WHO

Figure 2: Line diagram of malaria cases of year 2015 compared with three methods Epidemic Threshold calculated as per WHO



total population denoting efficacy of malaria surveillance program in city.<sup>[8]</sup> SPR has been falling consistently over the last five years. The malaria cases included for present communication were reported by active as well as passive surveillance on a regular basis as per guidelines of Urban Malaria Scheme (UMS). Malaria cases increased in year 2015 but malariometric indices does not show much change or rising trend over the years suggesting the need of present epidemiological study before verifying the epidemic declaration in urban Surat (Table 1). The SPR in our study was 0.65, as compared to the national average of 0.97 which again suggests that epidemiological situation in Surat is below epidemic threshold.

On field investigation we found that migration, massive construction activities and simultaneous epidemic of influenza led to development of favourable malariogenic conditions.Unplanned expansion of city structures leads to a host of problems including weak health infrastructure, inadequate housing, poor water supply, and overcrowding leads to increase in malaria transmission in urban areas has been proven by established research.<sup>[3,7]</sup>

In the present study the PF % was 16% which was much lower than similar study done in Surat where Pf prevalence was found to be 26.1% with peak prevalence between the months of Aug-Nov.<sup>[12, 14]</sup> This difference can be explained by the fact that the latter were hospital based studies, and present study had analysed data mainly from active and passive case detection by field surveillance.

Epidemic early detection involves recognizing the beginning of an epidemic situation by measuring changes in local disease incidence. Although this surveillance mechanism offers little lead time (days to weeks) for preparation and implementation of preventive measures, it can lead to a rapid and effective response to avert or reduce peak morbidity and mortality. In current study, we used the WHO recommended and senior malaria researchers suggested field guide and epidemic threshold construction methods to estimate the situation of malaria epidemic in urban area of Surat.<sup>[13]</sup> Advantage of C-SUM method is that it smoothens artificial variations in monthly reported data that are due to late reporting and other errors inherent to the surveillance system. Another method which can be used to find epidemic threshold in which SPR exceeds by 2 times of the standard deviation observed in SPR of the preceding 3 years or 3 months of the same year. The sensitivity of Methods I(Mean + 2 SD) and III (C-SUM + 1.96 SD) were adversely affected by large year-to-year differences observed during monsoon monthsgiving a very wide 95% confidence interval and high threshold level in present study similar to other studies.<sup>[4, 6, 13, 14]</sup> According to this study, the most practical method is determination of epidemic threshold by plotting the median and third quartile of malaria incidence every calendar month of previous years.

This study also suggests that continuous vigilance and supervision of malaria surveillance is required and cases should be analysed every week to avoid missing epidemic warning signs. The vacant posts of surveillance workers or their employment in other works seriously jeopardized the malaria situation in this study leading to 34% increase in cases in year 2015. The up scaling of monitoring, supervision and involvement of less qualified local health care providers and community volunteers in malaria control program has been suggested by other important studies in this field also.<sup>[15]</sup>

### **Conclusion:**

In summary, our study suggests that epidemiological verification of malaria in an urban area should be done with epidemic threshold calculated from last five years data. This should be followed by identification of factors responsible and areas having increased cases and field visits to ensure effective surveillance by malaria workers and implementation of Urban malaria Scheme (UMS). Our study concludes that though the urban Surat does not has malaria epidemic in year 2015, control response are required due to unplanned expansion, migration and increasing trend of cases in city especially in South-east, North and East Zones.

#### **Recommendation:**

For investigation of epidemic situation in an urban area; the first step should be construction and comparison with epidemic threshold using WHO recommended methods allowing minimum bias in epidemic assessment. This should be further strengthened by field visits of health centres and areas showing increasing trend of cases. Health workers should be trained to plot malaria cases in this graph on weekly basis. When cases are in excess of the median, a report should be prepared and notification sent immediately to concerned authorities for planning epidemic response and prevention control activities. To conclude, for achieving an effective response Malaria Early Warning System must be an integral part of the national and district-based malaria epidemic preparedness plan.

#### Limitations:

The epidemic thresholds were calculated using only last five year retrospective data, considered less valid for long-term fluctuations. Historical data should have been collected right from the beginning of surveillance systems. Application of currently recommended epidemic detection algorithms in epidemic-prone settings has demonstrated that they lack required sensitivity and specificity, and the need to develop robust and reliable approaches to detection remains a significant research issue.

### Scope for future research:

There is a need to develop statistical models of malaria early warning system taking into account climatic, environmental and host factors. Use of Geographical Information Sutem, (GIS), Autoregressive Integrated Moving Average (ARIMA) andnewer modalities for malaria modelling is a significant research prospect.

### **Declaration:**

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### Conflict of Interest: Nil

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