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Anopheles Stephensi Transmitted Urban Malaria in India

Prof (Dr) R S Sharma

Former HOD & Additional Director, Centre for Medical Entomology & Vector Management National Centre or Disease control Delhi-110054

Abstract: *Anopheles stephensi transmitted urban malaria programme was started in 1971 in the country and initially it covered 23 towns. It was extended to 5 more towns in 1972. At present urban malaria programme is functioning 131 towns covering a 135 million populations. The criteria for urban malaria towns are API more than 2 and above having ABER al least 10%. During National Malaria Eradication Programme in 1958 all rural areas were covered with DDT and drastic decline in malaria cases. But urban areas showed increasing trend and reporting 10 to 12 % malaria cases of the country. Under the urban malaria programme the main thrust is to attack the vector mosquitoes with an aim to interrupt the malaria transmission. Thus Anti larval measures were recommended in urban areas to control vector Anopheles stephensi. From the malaria case load of 0.1 million during the year 2005 declining trend of malaria cases was observed till 2014 The total caseload is though steady at around 0.1 million cases annually since 2005 in in Urban towns. There, has shown a declining trend since 2014. When interpreting API, it is important to evaluate the level of surveillance activity indicated by the annual blood examination rate. When there is low levels of surveillance as in the in urban areas, the Slide Positivity Rate (SPR) may be serve as a better indicator. From 2005 to 2020 SPR was seen gradually reducing from 2.25 to 0.06 and The SPR has also shown a gradual decline from 2.25 in 2005 to 0.06 in 2020. The reported Pf cases declined from 14905 (11.02%) in 2005 in 2005 to 1938 (0.49%) cases in 2020. The Pf % has gradually increased from 11.02 in 2005 to 0.49 in 2020. The maximum cases (2, 20,062) occurred in 2009. The maximum number of deaths (213) occurred was reported iin 2009 during Mumbai when an epidemic was reported in Mumbai Corporation. After 2017, indicates the overall trends of malaria endemicity is declining in the Urban towns.*

I. Introduction

The world's urban population is expected to increase upto 5.7 billion by the end of this decade 2030, accounting for 60% of the total population.1 This rapidly increasing urbanization has been recognized as a major development, social, and health concern, leading to the 2016 launch of the United Nations (UN) New Urban Agenda as part of the 2030 Agenda for Sustainable Development2. The World Health Organization's (WHO) Strategic Advisory Group for malaria eradication (SAGme) has identified rapid urban population growth as one of the key megatrends influencing the vision of a malaria-free world. 3 Among the fastest-growing regions in Sub-Saharan Africa (SSA), which also accounts for over 94% of the current global burden of malaria. 4 In this region, the proportion of the population living in urban areas increased from 31% (457 million) to 47% (680 million) between 2000 and 2020. By 2050, 58% of the population in SSA will be urban. In some of the SSA countries (about 10 countries) a coordinated global response is identified under the "High burden to high impact" (HBHI) approach, 44% of the population (244 million) was urban in 2020 – a percentage that is projected to rise to 50% (363 million) by 2030. Similarly, the Indian urban population increased from 18 % (1960) to 35% (2020). The urban malaria problem is therefore not simply a medium- to long-term concern, but one that needs urgent attention now for elimination5.

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Before the launching of the NMCP malaria was a problem in Bombay (now Mumbai)12 and a few more towns but its control was managed largely by source reduction and biological control12. Historically, port cities of India were having problem of malaria, subsequently the anthopogenic activities like digging of wells piped water supply introduction of canal irrigation supported *an, stephensi* establishment in other cities e.g. Delhi, Lucknow, and Hyderabad. Similarly invasion of *Aedes aegypti* was observed. Unplanned urbanization and deficient water supply prompts water storage practices, malaria in urban settings favoring creation of more mosquitogenic conditions, thereby resulting in increased transmission of vector-borne diseases15.

In 1953, the Indian National Malaria Control Programme (NMCP) was started. Encouraged by the results, and the fact that insecticide resistance in vector species may evolve and become an obstacle. In 1958 control program was converted to the National Malaria Eradication Programme (NMEP). By 1964, malaria was eradicated from 88% of the area and it was in the advanced stage of spraying in the remaining parts. At that time, focal outbreaks that occurred in 1965 and increased in later years, could not be contained due to the shortages of DDT. As a result, large areas in the consolidation and maintenance phases were reverted to the attack phase. Besides, the infrastructures in general health services was not adequate and mature enough to take up surveillance and vigilance. This produced a large number of secondary cases due to the re-introduction and relapse of malaria. Added to this was the problem of urban malaria, the control of which was the responsibility of local bodies. Malaria cases increased in towns and started diffusing to the rural areas, due to inadequate staff and the shortages of mosquito larvicidal oil (MLO)**.7,8,9,10**. Later, it turned out, that while it was technically feasible to eradicate malaria from 91% of the population, the strategy of indoor spraying of DDT to interrupt transmission did not succeed in 9.0% of the population, despite more than 12-14 years of regular spraying.

II. IMaterial and methods

Urban Malaria, as a specific problem in India, was first recognized in 1969, after an in-depth review of the situation of malaria in India was done by Madhok Committee.11 However, the main malaria vector in urban areas of India is *An. stephensi,* which was first recognized in the early part of the 20th century. Many of the local bodies carrying out anti- larval operations earlier failed to continue the same due to a paucity of funds. During that time, malaria in urban areas was not considered a major problem because the epidemics recorded earlier in Bombay, Delhi, Lucknow, etc. could immediately be contained. Large-scale migration of population, creation of slum clusters, construction activities, and water storage practices have contributed to the establishment of malaria foci. Urban malaria control is therefore based on source reduction, larviciding, minor engineering interventions, legislative measures, building bye-laws, and breeding potential and human factors. Historically urban malaria was a problem in port cities and later invasion of *An. stephensi* in towns along the rivers or excessive digging of wells introduced in other towns i.e. Delhi, Lucknow, and Hyderabad. Control strategy will comprise of (i) Parasite control & (ii) Vector control. Parasite control: Treatment is done through passive agencies viz. hospitals, dispensaries both in private & public sectors, and private practitioners. In megacities, malaria clinics are established by each health sector/ malaria control agency viz. Municipal Corporations, Railways, Defence services

Vector Control : Malaria control guidelines provide the control of vectors by source reduction, filling and leveling, channelizing, de-silting, de-weeding, periodical cleaning of drains, solid waste disposal, sanitation, empty water container once in a week, recurrent anti-larval measures like Temephos and biological control i.e. application of Guppy and Gambusia fishes and bio-larvicides (Bacillus thuringiensis ; minor engineering works; Pyrethrum, malathion thermal fogging, indoor residual spraying in peri-urban settlements; anti-parasitic measures, malaria clinics for diagnosis and early treatment; information, malaria month, education and communication (IEC) campaigns16.

The control of urban malaria lies primarily in the implementation of urban bylaws to prevent mosquito breeding in domestic and peri-domestic areas, or residential blocks and government/commercial buildings, construction sites. Use of larvivorous fish in the water bodies such as slow-moving streams, lakes, ornamental ponds, etc. is also recommended. Larvicides are used for water bodies, which are unsuitable for use of larvivorous fish. Awareness campaigns are also undertaken by Municipal Bodies/Urban area authorities. Legislative control: There are general guidelines by the National Vector Borne Disease Control Programme (NVBDCP) for the adoption of municipal bylaws and building bylaws but their implementation is wanting in almost all towns. Framing and introducing model civic bye-laws and building bye-laws introduced in urban areas for prevention and control of vector breeding is an important strategy under UMS. Model Civic Bye-laws: Promulgation and implementation with provision to prevent /eliminate mosquito breeding like Municipal Corporation of Greater Mumbai, NCT Delhi, Chandigarh, Bhopal, Agartala, Navi Mumbai Municipal Corporation, Thane, and Goa. Building Bye-laws: Provision to prevent mosquitogenic conditions on the exterior of the buildings and clauses in the contract to keep curing tanks free of mosquito breeding during the construction phase and dismantling of the same before issuance of occupancy certificate like Navi Mumbai 14,17.

III. Results

Disease burden:

A total of 10-12 % of the total country cases of malaria are reported from urban areas. Maximum numbers of malaria cases are reported from Chennai, Vishakhapatnam, Vadodara, Kolkata, Mumbai, Vijayawada, Ahmadabad, etc. Cities and towns in the states of Gujarat (Ahmadabad Municipal Corporation (AMC) and 17 towns), Maharashtra (Municipal Corporation of Greater Mumbai (MCGM) and 14 towns), Tamil Nadu (Chennai Municipal Corporation (CMC) and 11 towns), and West Bengal (Kolkata Municipal Corporation) together have been contributing the most in the total malaria cases. The total caseload is though steady at around 0.1 million cases annually since 2005 in UMS towns. There, has shown a declining trend since 2014. When interpreting API, it is important to evaluate the level of surveillance activity indicated by the annual blood examination rate. At low levels of surveillance in urban areas, the Slide Positivity Rate (SPR) may be a better indicator. The SPR has also shown a gradual decline from 2.25 in 2005 to 0.06 in 2020. The reported Pf cases declined from 14905 in 2005 to1938 cases in 2020. The Pf % has gradually increased from 11.02 in 2005 to 0.49 in 2020. The epidemiological profile and indicators of all UMS towns are given in Table-1. Fig 3 shows the trend of malaria cases and deaths of UMS towns. The maximum cases (2,20,062) in 2009. The maximum number of deaths (213) was reported in 2009 when an epidemic was reported in Mumbai Corporation. After 2017, indicates declining overall endemicity of malaria in the UMS towns.

IV. Gaps and Challenges

Since the malaria problem in towns/cities is not perceived as a major threat, no structured health care delivery system like the primary health care system as in rural areas has been established. Funds are also allocated for larvicides/adulticides only and the operational costs of malaria control activities are met by the State/Urban Local Bodies.

The coverage by anti- larval measures, however, is limited and does not extend to the entire towns/city limits. The source reduction drives in domestic areas are hampered by denial of entry to public health personnel for security reasons, limited community mobilization and multi-sectoral collaboration, and the absence of appropriate civic legislations.

Surveillance, integrated vector management (including promotion of alternative measures like insecticide-treated mosquito nets), awareness campaigns, inter-sectoral partnerships, capacity building through training, Monitoring & Evaluation, enactment and enforcement of legislatures to prevent mosquito breeding in domestic and peri-domestic areas or workplaces, government/commercial buildings, construction sites, etc. are the responsibility of multiple authorities and often not implemented in a coordinated manner. No proper

resource allocation is also made for most of these components, even though these are extremely critical to achieving the desired health objectives of health and well-being in urban areas.

Presently, because of increasing constraints, as mentioned below, many urban towns/cities are facing a huge risk of malaria:

Urbanization and Population Growth: Uncontrolled poorly managed urbanization pose several innate issues like resource availability, alteration in health seeking behaviour, insecurity, congregations due to availability of areas, i.e Delhi and NCR region is one of the examples where the growth of city has engulfed several villages as they were earlier and they could not be modified in urban planning. Therefore, at several urban setups and find similar transition and rural areas are converted into urban. The housing pattern socio ecological factors remained the same. On the other hand the proportion of the urban population to the total population has increased in the last few decades. This may be due to finding better livelihood, education, health facilities in urban areas people are more attracted to urban setups. Due to which the support management population exceeds the supply. As a result of which some time uncertainty in basic amenities occurs i.e. water storing habit due to intermittent water supply. This has been triggered by the rural "push" (for earning a livelihood and "urban pull" (for availing both medicare/ education opportunities) phenomenon. The increasing population growth is unable to match with the civic facilities leading to increased malaria vector breeding including invasion by Aedes aegpyti the vector of dengue fever, and Chikungunya. This haphazard and unplanned growth of towns results in the creation of "urban slums" that has poor sanitation and living condition, promoting vector mosquito-breeding potential for malaria, filarial, and dengue fever/ Dengue hemorrhagic fever.

Spatial Spread: Inclusion of other vector species: Due to population pressure all towns & megacities are expanding and new settlements in peri-urban areas have come up. These peri-urban situations have low infrastructure which leads to the inclusion of An. culicifacies (malaria vector in rural areas) along with the vector of urban malaria An. stephensi. Urban towns are expanding under population pressure spatially. There is the growth of sub-cities, for example, Gurgaon sub-city, Greater Noida, Dwarka in National Capital Territory of Delhi, Navi Mumbai and Greater Mumbai, etc. These projects lack infrastructure, water supply, solid waste removal resulting in heavy vector breeding potential. Vertical growth further complicated the problem with its water storage problem.

Vertical spread: Mega towns are now expanding vertically creating new avenues of bre
eding. For example, firefighting exigencies require the building of two storage tanks one at the ground and the other at the top with the high breeding potential of *An. stephensi.*

Drinking water supply: Intermittent water supply developed storage practices in artificial containers which generated breeding sites for vector mosquitoes. : In urban towns, the increasing population pressure has burst the water supply system at its seams. Regular water supply has now been replaced by intermittent supply (Delhi), and in towns located in water scarcity areas, supplies are restricted to 2 to 3 times a week (Hyderabad & Chennai). Water storage practices in artificial containers have generated the breeding potential of *Ae. stephensi*, vectors of urban malaria, and *Aedes aegypti*, the vector of DF/ DHF.

Haphazard growth of towns: Haphazard and unplanned growth of towns has resulted in the creation of "urban slums" with poor housing and sanitary conditions, promoting vector mosquito-breeding potential for malaria, filarial, and dengue fever/ Dengue hemorrhagic fever

Health Impact Assessment (HIA): Development project activities without health impact assessment have resulted in malaria outbreaks in the short term and endemic malaria with foci of *P. falciparum* resistance strains in long term.

Inadequate health Vector-Borne Disease infrastructure: With the rapid growth of population in urban towns, existing staff strength has not correspondingly increased, and is therefore inadequate for service delivery.

Immigration: particularly population from disease-endemic areas to urban cities/towns viz. Delhi, Mumbai Kolkata, and Ahmadabad. Poor disease surveillance: It is very difficult to eliminate malaria in urban areas by 2030 due to passive surveillance and control of other **VBDs**.

V. Road map for urban malaria elimination

Malaria elimination activities should be implemented on a war footing in urban areas. The country should prepare Urban malaria elimination framework and everyone should participate in fighting against malaria. Now the responsibility of urban malaria implementation lies with state and Municipal Corporations. All the 131 UMS towns should prepare the roadmap for Malaria elimination. Mumbai Corporation contributing maximum cases of Maharashtra state, Mangaluru and Udupi cities reported about 72% of malaria of Karnataka state, Chennai Corporation also contributed 65-70% malaria cases of Tamil Nadu state. So if malaria elimination is to be achieved in such high burden cities will require active case detection, effective supervision of anti-larval measures, and complete radical treatment. Weekly entomological surveillance will also play an important role to sustain the malaria elimination process. Urban malaria cases increased from 26015 (2018) to 31735 (2019). Malaria deaths also decreased from 131 towns in 2020, compared with 2016. The slide positivity rates also decreased from 0,68% (2018) to 0.06 (2020). In India, this is the beginning of malaria elimination, and everyone must join hands to achieve the goal of 'Urban malaria-free India' by 203018.

VI. Future Vision for malaria elimination and other VBD in Urban areas

National Urban Health Mission (NUHM):

• Approved on May 1, 2013, as a sub-mission of the National Health Mission (NHM) to strengthen the primary health care system in cities & towns

• Target Population: 29.95 Crore urban population (Census 2011) ¬ 942 cities/ towns with population above 50,000 (29.69 Crore)

- 64 District Headquarter towns with population between 30,000 – 50,000 (0.26 Crore)
- Special focus on ¬ People living in listed, unlisted slums and other low-income neighborhoods ¬ All other vulnerable populations such as homeless, rag-pickers, street children, rickshaw pullers, and other temporary migrants
- Core Strategies: • Strengthening of Infrastructure
- Creation of new facilities
- Rationalization and strengthening of the existing urban primary health structures (UFWCs, UHPs, Urban RCH Centres, Dispensaries)

But implementation of NUHM is still not fully functioning due to the non-availability of human resources and financial allocations. Given the aforesaid, it is apparent that earlier *An. stephensi* was the sole vector and the matching infrastructure was provided to control this species18. With the expansion of urban areas, even rural villages have now become urban villages, carrying the high breeding potential *for An. culicifacies*, which require different control strategies.

More than that here is an upsurge in the number of dengue and Chikungunya cases in an urban situation due to changing dynamics of vector-borne diseases. Imported cases of filaria are being reported in the metro- cities and need to be taken care of to interrupt active transmission and to avoid the precipitation of problem in the future.

In addition to malaria, control of dengue, chikungunya, and filariasis require different control strategies and additional human resources with matching budgetary provisions. Vector control activities should be evidence-based on entomological surveillance and sub paradigm specific comprising more than one control strategy placed

synergistically in an integrated vector management mode (IVM).

Emphasis should be on source reduction, environmental and engineering methods of control, i.e. appropriate solid waste disposal and drainage, use of larvivorous fish in rain-filled stagnant waters along roadsides/ railway lines, abandoned cellars at construction sites and quarry pits, and excavated pits of brick kilns, use of insecticide-treated bed nets/curtains in slums and use of larvicides at sites which cannot be drained. All activities should be supported by legislative measures.

The urban malaria scheme needs to be addressed now as Urban VBDs Control Scheme. The community intervention through their active involvement for prevention and control of VBDs is very essential, particularly, in source reduction, in and around their premises. The emphasis should be on inter-sectoral linkages with the non-health sector (all development projects) to ensure health impact assessment, Communication for Behaviour Impact (COMBI) – approach for community participation for the sustainability of source reduction, application of larvicides and proper health-seeking behavior, and training of health/non-health sector in Health Impact Assessment of development projects. The proposed strategy not only fulfills these gaps but will be more cost-effective and sustainable.

VI. Discussion

Inadequacy in urban planning and interventions led to epidemics of communicable diseases *e.g*. malaria, LF, Zika, dengue, chikungunya, etc. There was no active surveillance in urban areas and the private sector flourished and masked the outbreaks. Data of the towns under the UMS indicated that the malaria situation was fast deteriorating and required immediate remedial measures. The existing tools and strategies were failing in the containment of malaria. NVBDCP has further reduced the towns from 131 to 28 as the most malarious towns (Fig. 2) and also Programme's thrust in control of urban malaria. These towns have a migratory labor population and fall in the belt of industrial development. Important disease vectors in these towns are *An. stephensi* and *An. culicifacies* (malaria), *Aedes aegypti* [dengue & dengue hemorrhagic fever (DHF); Zika and Chikungunya]; and *Culex quinquefasciatus* (lymphatic filariasis), and mosquito nuisance is very high and unbearable in most situations.

So far urban malaria has received low priority for elimination and its control is organized by the local governments with token financial support from the NVBDCP. Urban malaria control requires human resource development, sound planning, and strengthening of interventions, particularly taking note of the growing urbanization of rural India, industrialization, and expansion of cities and peri-urban areas.

VII. Recommendations

- Malaria is in elimination mode in the country. Urban malaria is already a problem and is likely to increase as urbanization continues. To avert an increase in disease burden, concerted action needs to be taken quickly.
- In urban areas, there is a need to target the most vulnerable sections of society who suffer a double burden of insufficient protection from malaria transmission due to inadequate housing and living conditions, and limited financial resources. These factors restrict their access to appropriate preventive and curative services.
- Inter-sectoral interventions are the key to successful urban malaria control and must include close collaboration between water supply, urban planning, commercial, and health and community players.
- Existing health and governance structures in urban environments need to invest in programs to manage urban malaria effectively using established methods and tools for mosquito control and malaria prevention, diagnosis, and treatment.
- National Health Mission (NHM) encompassing both the National Rural Health Mission (NRHM) and National Urban Health Mission (NUHM) highlighted financial and technical support to achieve the objectives of malaria elimination and preventing mortality and morbidity due to VBDs with improved surveillance and source reduction with the help entomological surveillance. 12 NUHM should be

operationalized technical and financial support for LF, Malaria, Kala-azar elimination, and prevention and control of Aedes borne diseases in urban settings in the country.

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Table-1. Epidemiological profile of urban malaria from 2005 to 2020

Year	BSE	Cases	Pf	Pf%	Deaths
2005	102423064	135249	14905	11.02	96
2006	105782505	129531	17278	13.34	145
2007	112448027	102829	18038	16.82	125
2008	113334073	113810	18963	13.42	102
2009	114699850	166065	31134	18.75	213
2010	115159555	220062	7587	18.75	31
2011	130316971	142502	13910	9.77	147
2012	130329138	82554	8236	9.98	69
2013	131279000	65568	5463	8.33	26
2014	133857000	142376	10343	7.2	21
2015	148181952	28821	2679	9.29	17
2016	107953339	23374	1873	8.01	16
2017	117940161	9292	756	8.13	20
2018	116965378	26015	1721	6.59	6
2019	137391947	31735	1606	5.06	2
2020	141759779	17038	1938	0.49	1
2021	142595106	26747	7961	0.59	0

Fig- 1. Urban malaria towns in different state

State wise	No. of towns in UMS
Andhra Pradesh	8
Bihar	4
Gujarat	18
Haryana	17
Karnatka	8
MP	6
Mahrashtra	15
Manipur	1
Nagaland	1
Orissa	3
Punjab	13
Rajashthan	6
Tamil Nadu	12
UP-	14
West Bengal	1
Tripura	1
Delhi	1
Chandigarh	1

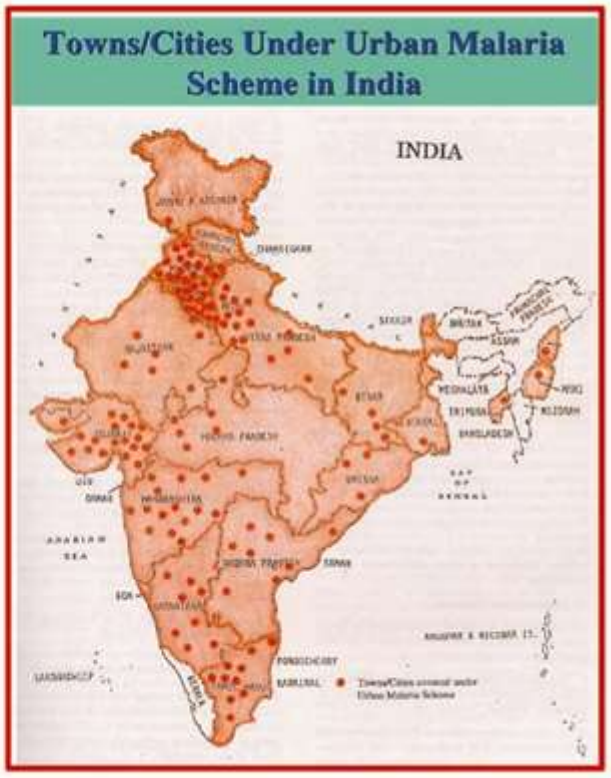

Fig -2. High risk Towns /Cities under Urban Malaria Scheme

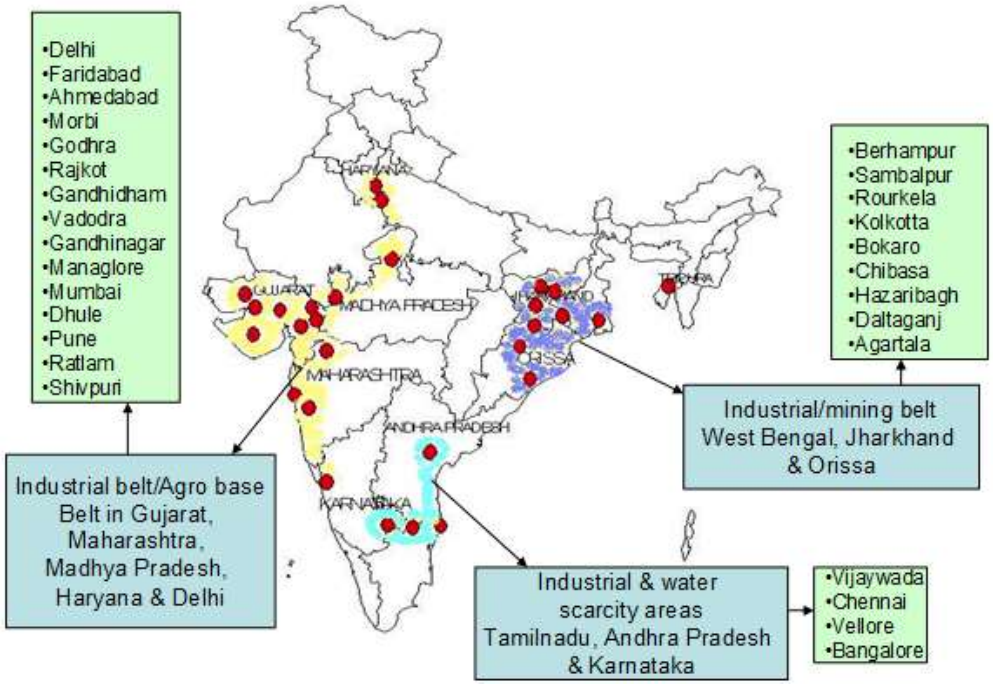

Fig 3. Trend of urban malaria cases and deaths in India