Larval Source Management (LSM) in urban India

The Indian National Malaria Eradication Programme (NMEP) was launched in 1958 using indoor residual spraying (IRS) for all roofed structures, except for those in urban areas where larval source management (LSM) was recommended [2]. While malaria incidence declined overall, urban malaria increased during the 1960s especially in the states of Tamil Nadu, Andhra Pradesh, Gujarat, Rajasthan and Maharashtra, partly due to the expansion of urban slums, population movement and lack of adequate waste water disposal. This was first recognised as a specific public health problem in 1969 by the Madhok Committee. The Urban Malaria Scheme (UMS) was sanctioned in 1971 and 23 towns were initially selected, before the Scheme was expanded to 131 towns in 19 states, the population of which was 112 million in 2009 [1]. The major objective of the UMS is to control malaria through good case management and LSM, since IRS is not accepted by the majority of the urban population [2]. The UMS targets the vectors of dengue, filariasis and Japanese Encephalitis in addition to malaria vectors. This document outlines the general structure of the UMS and its impact.

Background

- **Topography:** The Indian subcontinent (Fig. 1) is characterised by nearly every major type of landscape, from grass steppes and fertile flood plains to arid desert and mountains.

- **Climate:** There are six main climatic regions: alpine, sub-tropical humid, tropical wet-dry, tropical wet, semi-arid and arid. There are four seasons: winter (January-February), summer (March-May), monsoon (rainy) season (June-September) and post-monsoon season (October-December).

![Figure 1. India](image)

- **Primary and secondary vectors:** The major vectors in urban areas are *Anopheles stephensi* and *An. culicifacies*.

- **Main type of breeding sites:** *An. stephensi* breeds mainly in man-made wells and cisterns; *An. culicifacies* breeds in agricultural grassland typically found in peri-urban areas.

- **Malaria transmission:** Transmission is low and perennial with peaks in both *Plasmodium falciparum* (which accounts for around 50% of total cases [3]) and *P. vivax*.

The larval source management program

- **Structure of the control program:** 131 towns are included in the UMS. For a town to be included in the scheme the population must exceed 50,000, the annual parasite incidence must exceed 2 per 1000 people and civic bye-laws to prevent or eliminate domestic and peri-domestic breeding places should be in place [2]. At town level, the UMS should be run by a Biologist and supervised by State and Central Health Authorities. Every target municipal area of each town is ideally divided into wards of 25.6 km² (10 mile²), which are further divided into sectors of 2.56 km² (1 mile²) [2]. Each ward should have one Inspector and one Insect Collector and each sector has one Supervisor Field Worker and up to two Field Workers (depending on the quality of the drainage system). One driver and vehicle is provided per 40 sectors [2].

- **Baseline mapping and data collection:** prior to LSM, it is recommended that geographical reconnaissance (GR) is conducted and maps showing all breeding sites prepared. All breeding sites are also numbered. Breeding places where mosquito larvicidal oil (MLO) cannot be applied (e.g. agricultural fields, ornamental tanks, coconut husk resting ponds, septic tanks) are marked for treatment with larvicides [2]. Baseline data on larval and adult densities should be collected.
before larvicide treatment. Susceptibility tests for temephos and fenthion are conducted as part of baseline data collection using the standard WHO technique [2].

- **Larviciding:** Mosquito Larvicidal Oil (MLO), pyrethrum extract, temephos, fenthion and *Bacillus thuringiensis israelensis* are recommended by the UMS for use at the discretion of individual towns [2]. The same spray teams are deployed for both MLO and larvicides [2].
- **Entomological surveillance:** It is recommended that entomological surveillance is conducted by an Insect Collector who is responsible for surveying one ward, which is divided into 12 sections each with two fixed catching stations. Larval susceptibility tests are carried out every six months [2].
  - **Larval surveillance:** It is recommended that the area around two fixed catching stations is checked for fourth instar larvae and pupae for 30 minutes per day by the Insect Collector, using 5-10 dips with a 90mm dipper. Sampling is conducted between 8am and 10am and morphological identification carried out in the afternoon [2]. Cross-checking is conducted by a Malaria Inspector and Insect Collector. Larval density is recorded in standard forms and reported monthly to the State Malariologist or State Programme Officer and the Director of the National Anti Malaria Programme (previously known as the NMEP) in Delhi [2].
  - **Adult mosquito surveillance:** Ideally, mosquito collections are conducted six days per week at four fixed and five randomly-selected catching stations between 6.30am and 8.30am. Mosquito resting places within houses are actively searched for 15 minutes and mosquitoes collected with a suction tube, which are transferred to a test-tube and morphologically identified on the same day. Mosquitoes are classified to the genus level (anophelines and culicines) and in addition numbers of *An. stephensi*, *An. culicifacies*, *Culex quinquefasciatus* and *Aedes aegypti* are recorded. Overall, each fixed catching station is visited once a week [2].

- **Funding:** Initially, the UMS was centrally sponsored by the Government of India. Since 1979-80, the costs of the UMS have been split equally between the central and state governments [2].
• Other malaria control interventions:
  Insecticide-treated nets are distributed for free to
  all age groups; IRS is used in rural areas however
  coverage remains low [3].

Impact

It is difficult to directly measure the impact of the
UMS. Critics of the Scheme have highlighted that
even now, the UMS operates only in 133 towns
and cities and in many other urban areas, the
municipality administrators are responsible for
malaria control. In many smaller urban and
industrial settings there is no malaria control
system [5].

There are also difficulties in measuring the exact
burden of malaria in India [6]. A retrospective
study using UMS and health facility data indicated
that the mean annual incidence of malaria in
Ahmedabad city, 1991-1998, was 12.2 cases per
1000 population, which far exceeds the rate
officially reported by the UMS (1.3 cases per 1000
population) [5]. Verbal autopsy data collected
between 2001-2003 indicated that 205,000
deaths (95% CI 125,000-277,000) per year could
be attributed to malaria in India [7], while WHO
estimates indicated that only 15,000 deaths (95%
CI 9,600-21,000) could be attributed to malaria in
India in 2006 [8]. Similarly, Snow and colleagues
used spatial estimates of the limits and intensity
of malaria transmission and estimated the clinical
malaria burden in India in 2007 to be 101.5
million clinical cases (95% CI 31.0-187.0 million)
[9], also higher than WHO estimates [7].

Although there was a decline in malaria in the first
5 to 6 years after the introduction of the UMS,
there has been a well-documented increase in
malaria in parts of India in recent decades, for
example in Kolkata [10, 11], Madras [12] and
Mumbai [13]. In Kolkata, health facility data for
1984-1997 demonstrated an increase in mean
annual incidence from around 40-60 cases per
1,000 during 1984-87 to 50-70 per 1,000 during
1994-97 [14]. Similarly, between 1992 and 1997,
there was a resurgence of malaria in Mumbai,
where the disease remains a significant public
health problem [13]. This has been partly
attributed to the increase in construction

activities after economic changes in 1991 and the
effect of local politics on the administration of the
Municipal Corporation of Greater Bombay [13],
together with chloroquine resistance [15].

In general, political, social, economic and
administrative problems have hampered
the implementation of the UMS in India. The
resurgence in malaria may have also been
associated with rapid urban growth and
improvements in drainage and sanitation systems
lagging behind the UMS. Environmental measures
have therefore not been implemented well, and
this, combined with the temporary effect of
biological control and larviciding, has limited the
success of the UMS in cities such as Madras [12].

Today, urban malaria remains a public health
problem in India, especially in the cities of
Mumbai, Chennai, Kolkata (Fig. 3) & Mangalore
[16]. However UMS data indicates that malaria
has declined in some towns such as Ahmedabad
and there is evidence that in other towns UMS
may have contributed to a decline in malaria [17,
18]. For example, in the area around Bharat Heavy
Electricals Ltd in the township of Hardwar,
expanded polystyrene beads, larviciding and
larvivorous fish were associated with a reduction
in the total number of confirmed reported malaria cases from 3049 in 1985 to 190 in 1995 [19].

Challenges

Malaria mortality has increased in Mumbai, Chennai, Kolkata and Mangalore among other cities, partly due to:

- Inaccessibility of many overhead storage tanks (e.g. 30% of tanks are inaccessible in Chennai) [1].
- Continuous population growth in urban areas increases pressure on water systems, increasing vector breeding [1].
- Expansion of peri-urban areas with poor infrastructure has increased the number of An. culicifacies breeding sites.
- Vertical expansion of cities creates new breeding sites since fire regulations stipulate that both ground and roof water storage tanks must be added to buildings [1].
- Water being stored in artificial containers because the water supply is intermittent [1].
- Inadequate health infrastructure and in particular a lack of man-power [1].
- Immigration from endemic rural areas to urban areas (e.g. Kolkata and Ahmedabad [1].
- Incorrect implementation of recommendations of the UMS [1, 2].

References


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