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Trends in the incidence of Filariasis in rapidly urbanizing areas

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Abstract

Incidence of Lymphatic Filariasis by microfilaraemic prevalence in a study area of Kalutara district, Sri Lanka has been analysed here. Trends of annual prevalence data are parsimoniously identified by least square method. There are no marked fluctuations in microfilaraemic prevalence at the initial stage of the whole study period from 1977 to 2005. Middle period is associated with fluctuations and continuous decrease is evident at the final stage. These prevalence patterns are interpreted in terms of adverse effects of urbanisation and also in terms of beneficial effects of the mass treatment programme.

Key words: Curve fitting, Lymphatic Filariasis, Microfilaraemic prevalence, Trends

Introduction

General information

Lymphatic Filariasis (LF) is a mosquito-borne parasitic disease, which damages the lymphatic system of human being. This disease is a major health problem particularly in tropical countries, where over 120 million people are affected and many of others are at risk of getting infected (Stolk, 2005). Many programmes have been initiated to eliminate the disease worldwide, but still it threatens the social and economic development of endemic countries as a cause of permanent and long-term disabilities.

LF is mainly caused by nematode parasite *Wuchereria bancrofti*. Adult parasite worms located in lymphatic system produce microfilariae (Mf), which is the first stage of the filarial parasite life cycle. Mf then mature into infective larval stage within vector mosquito. LF is transmitted mainly through *Culex quinquefasciatus* mosquito species.

The disease is endemic in Western, North Western and Southern provinces in Sri Lanka, where nearly 10 million people are at risk (Anti Filariasis

Campaign, 1999). *W. bancrofti* transmitted by *C. Quinquefasciatus* is the main parasite-vector combination in Sri Lanka too. Though the disease prevalence is low in Sri Lanka, complete eradication has not yet been achieved.

The Global Programme to Eliminate Lymphatic Filariasis was initiated in 1998, with the main aim of control the transmission of the disease through annual mass treatment, where all possible individuals are treated without concerning whether they are infected or not (Wilma, 2005). In Sri Lanka Mass Drug Administration (MDA) was started in 2001 for Colombo district and in 2002 for entire population in endemic areas (World Health Organization, 2001).

Objective of the study

This study carries a preliminary analysis on identifying the trends of incidence of LF by presence of microfilaraemic hosts. It will be a foundation for advanced prevalence and intensity models too (Subramanian, 2004). In Sri Lankan context, this study contributes mathematical approaches regarding disease transmission using observational data of Anti Filariasis Campaign (AFC) of Sri Lanka (Tennakone & Tantirigoda, 1989). Trend analysis is worthwhile in making decisions on control strategies.

Materials and Methods

Study area

For this study two rapidly urbanizing Medical Officer of Health (MOH) areas Panadura and Kalutara of Sri Lanka have been selected. These two MOH areas belong to the Kalutara district. Though the Kalutara MOH is separated into another MOH called Beruwala at the latter stage of our study period, all the data collectively considered as Kalutara MOH for the convenience. The selected region is vulnerable to LF and it is quite dense in population with the density about 2400 individuals per sq.km.. Annual rainfall of the region is 900 mm – 1200 mm and hit by South Western monsoons during May – September. Usually, temperature lies between 26^0C – 28^0C, which is favourable for vector mosquitoes.

The data

The main factor for the cause of damage in LF is adult parasite worm. But assessing that worm burden is difficult and Mf prevalence in human hosts is used instead. This study has been carried out using the observational data taken by AFC on annual percentage of microfilaraemic humans (Mf+ percentage) in above MOH areas during the period 1977-2005.

AFC collects blood samples throughout the year by visiting the residences and then diagnose for the presence and intensity of Mf. A 20 cubic millimetre blood sample is taken from an individual by finger prick method and it has to be carried out during the night as Mf appear at night in peripheral blood. Average sample size for whole study area is about 30% of the total population during the concerned period 1977-2005.

In addition, some census data were used for analysing the facts especially in population density and urbanization. Those data were taken from the database of the Census and Statistics Department of Sri Lanka, in which survey in 2001 has been quite useful.

Analysing methods

In data manipulation, least square curve fitting criterion is used to recognise the trends in Mf+ percentages. This criterion is accounted with determining parameters of a function $f(x)$ that minimizes the sum $\sum_{i=1}^{m} |y_i - f(x_i)|^2$, where $(x_{i,} y_i)$; $i = 1,2,3,\ldots,m$ represent data points (Giordano *et al*, 2003). Thus, least square method provides the best-fit curve of a given type such as polynomial, exponential, logarithmic, etc.

A technique to have a smooth view of data patterns has been applied for Mf+ percentages. In here modified percentage of n^{th} year (MP_n) was taken by the following weighted average. $MP_n = \dfrac{aP_{n-1} + bP_n}{a+b}$; where P_n denotes the n^{th} percentage and a and b are positive constants. Choosing the values for a and b can be varied with the purpose where we set $b=2a$ to have a impact from both previous and existing percentages and at the same time to represent a larger share from the corresponding percentage of n^{th} year. These modified percentage values were subsequently used to identify the patterns, in particular the marked fluctuations in the middle part of the data stream.

In addition to above analysing criteria, a primary analysis was done for census and population data of study area with a comparison of district data. It contains the facts about total population, urban population, lands and housing units which can be used in interpreting obtained results.

Results

Results have been obtained in two aspects as overall trends and short term trends.

Overall trend

Overall trend is recognised by polynomial curve fitting under least square criterion. At a glance, graphs of Mf+ percentages show beginning of an increasing trend around mid 80's and alteration from increasing trend to decreasing trend around mid 90's. Therefore, polynomial of third degree is preferred for curve fitting since its derivative allows to have two critical points. Figure 1 verifies this claim.

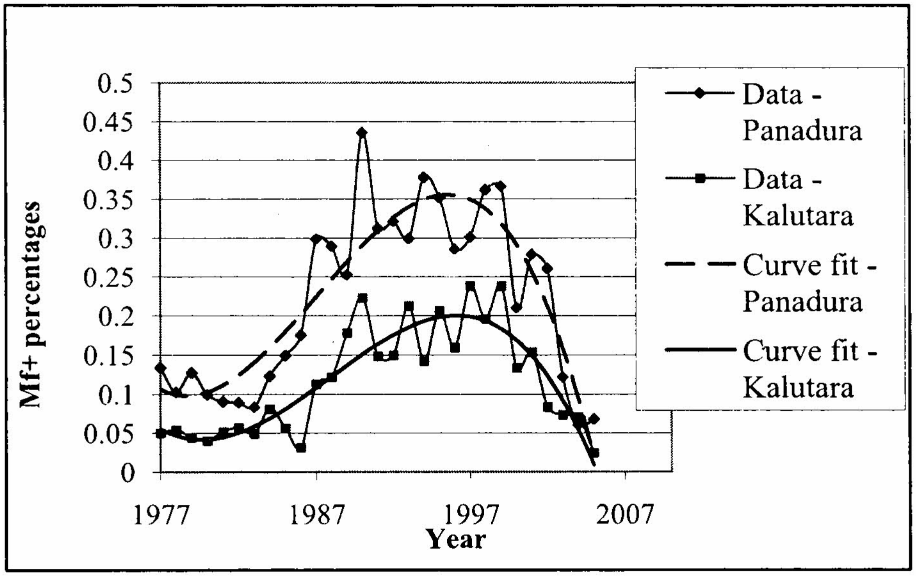

Figure 1. Third degree polynomial curve fitting for Mf+ percentage data

According to this overall trend identification, both study areas Panadura and Kalutara have shown almost similar pattern in Mf+ percentages. Since this similarity two data sets were combined to determine Mf+ percentages for Panadura and Kalutara collectively by considering total number of Mf+ individuals with respect to total sample size in each year. Figure 2 illustrates these collective Mf+ percentages. Now, more short term trends for collective area are recognised.

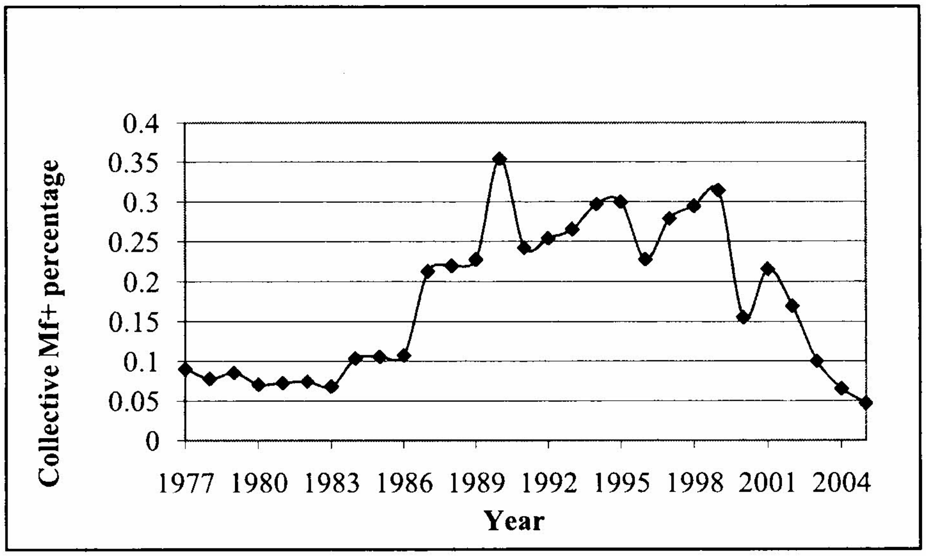

Figure 2. Collective Mf+ percentage for the whole area of Panadura and Kalutara

Short term trends

There are three major short scale patterns in the collective data stream of Mf+ percentages.

During the period of 1977 – 1983, there are no considerable fluctuations in Mf+ percentages. However, in the period of 1984 – 2000, percentages have been fluctuated after an increasing trend at the first seven years. Within this period, three local maximum occurrences can be identified in 1990, 1995 and 1999 where previous three or four years of each maximum show a gradual increment towards the corresponding maximum. To grasp a smooth view of above fluctuations, modified percentage of n^{th} year MP_n is used as described in methods section. Resultant percentages are depicted in Figure 3.

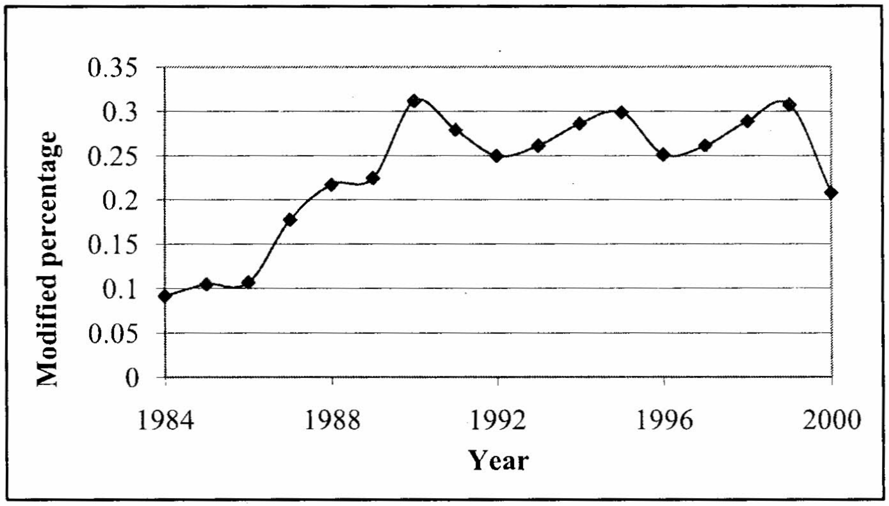

Figure 3. Modified percentages for the period 1984 – 2000

Period of last five years from 2001 to 2005 is accounted with the pattern of continuous reduction in percentages (Figure 2). It more likely follows an exponential decay which can be fitted by the exponential function $0.34e^{-0.4(t-2000)}$ where t represents the year. Least square criterion is the method used for this fit too.

Discussion

Applying polynomial curve fitting is a parsimonious way of indentifying a trend. Mathematical software or trend line tools as in Microsoft Excel can easily be used even to try more cases with different degrees. Though the higher degree polynomials are fitted well with the data, then overall behaviour is hard to detect. Therefore, principle of parsimony is important that highlights the best simple way of interpreting a phenomenon (Chan *et al*, 1998). This restricts the fact that results or interpretations become too complicated due to advanced analytical tools.

Usage of modified percentages was underpinned by the fact that identification of Mf+ case in a year may not be a result of infectious stage of that year. Moreover, the Mf+ percentage datum for a year is determined as an average figure of Mf detection by blood collection throughout that year. One can change the weights used to distinguish current and previous year and see possibilities of different outcomes in Mf+ percentages. Moreover, number of years used to determine modified version can also be increased.

Census and population data of the study area revealed the transmission potential of LF due to urbanization. An urbanized setting provides higher potential of vector mosquito abundance and easy access for mosquitoes' host seeking. Some of the relevant facts are described here taken by census survey in 2001 (Census and Statistics Department, 2005). About 92% of the district urban population belongs to Panadura and Kalutara study areas. District urban population is about 11%. District population density is 673 individuals per sq.km., where our whole study area is comprised of only 11.8% of total district land area. Study area's share of lands less than forty perches in area is 47%. That share for total housing and institutional units is 38%. All above facts reveal the dense nature of the area and the vulnerability to the disease.

Low Mf+ percentages during the initial period from 1977 to 1983 is a result of low abundance of vector mosquitoes associated with low urbanized environmental setting that reduces the disease transmission potential.

Continuous reduction of MF+ percentages at the latter part of the data stream claims that the MDA programme carried out 2002 onwards has been worked out effectively. Marked fluctuations in previous period have been disappeared and it can be considered as an evidence for the effect of MDA programme. Fitted exponential function can be used to predict the future level of Mf+ percentages. However, vector control programmes also affected to drops in Mf+ percentage levels. Proper analysis is difficult to carry out with available information to determine the effect of vector control since timing and intensity of such controls are not regular and not LF specific (unpublished AFC data).

This paper revealed the importance of prevalence modelling in order to determine endemic situation of an area. Sri Lanka is at the threshold of succeeding the elimination of LF. Therefore, more mathematical approaches are needed to analyse behaviour of transmission of LF.

Acknowledgements

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