USE OF ROUTINELY COLLECTED PAST SURVEILLANCE DATA IN IDENTIFYING AND MAPPING HIGH-RISK AREAS IN A MALARIA ENDEMIC AREA OF SRI LANKA

AR Wickremasinghe[1], DM Gunawardena[2] and STC Mahawithanage[3]

[1]Department of Community Medicine and Family Medicine, Faculty of Medical Sciences, University of Sri Jayawardenepura, Nugegoda; [2]Anti Malaria Campaign, Badulla; [3]Malaria Research Unit, Department of Parasitology, Faculty of Medicine, University of Colombo, Sri Lanka

Abstract. Stratification of malaria endemic areas on eco-epidemiological criteria is an important step in planning and implementing malaria control programs. The uses of stratification of malaria endemic areas lead to better targeting of control measures such as residual insecticide spraying in countries where unstable malaria transmission occur. In this study, two methods that can be used for stratification of malaria endemic areas in Sri Lanka using routinely collected surveillance data over a period of 9 years are described. In the first method, the median Annual Parasite Incidence (API) was used as the criterion to classify an area as at risk for malaria while in the second method, the API and the Falciparum Rate (FR) were used as the criteria. Risk maps were produced by plotting the results of the analyses on maps generated by EPIMAP. The potential uses of risk maps are discussed.

INTRODUCTION

Malaria has prevailed in Sri Lanka for many years and continues to be a major public health problem and leading cause of hospital admission in the country. Of the 18 million of the country's population, 60% live in areas where malaria transmission takes place. Annually, 0.1 to 0.3 million malaria cases are reported and two thirds of the country including the dry zone is endemic for malaria. During 1997, 1.3 million blood smears were examined for malaria parasites of which 16.4% were laboratory confirmed as positive for malaria parasites.

Malaria in Sri Lanka can be described as unstable with perennial transmission which fluctuates every 4-5 years. The rural under privileged communities, which are mainly dependent on agricultural livelihood, are greatly affected from this devastating disease which is a hindrance to the general development of the country (Ministry of Health, 1997).

A large amount of resources in terms of personnel and financial are spent for malaria control in Sri Lanka. In 1994, 9% of the total health budget and two thirds of public health expenditure were spent on malaria control. It has been estimated that the cost of preventing a single malaria infection is Sri Lankan rupees (SLR) 1,097.00 (approximately US$16) to the government (Gunawardene *et al*, 1998). The cost of malaria to the health services of Sri Lanka is largely the cost of prevention, especially the purchase of insecticides and, much of the rest, on case detection and treatment to reduce the transmission.

Malaria control in Sri Lanka was decentralized in 1989. Strategies for malaria control in Sri Lanka follow the guidelines advocated by the WHO in 1992 (WHO, 1993) and are applied to entire country (Ministry of Health, 1990). These strategies focus primarily on anti-parasite measures which emphasize on early

Correspondence: Dr AR Wickremasinghe, Department of Community Medicine and Family Medicine, University of Sri Jayewardenepura, Gangodawila, Nugegoda, Sri Lanka.
Tel: +94-1-598014; Fax: +94-1-598014
E-mail: arwicks@sltnet.lk

case detection and prompt treatment of malaria as well as chemoprophylaxis of at risk groups, especially pregnant women, security personnel and migrants. The use of selective control measures, including vector control measures to reduce malaria transmission, is also stressed and requires timely and reliable data.

The malaria eradication campaign started in 1958 in Sri Lanka, though abandoned later, was successful in establishing a sound infrastructure for malaria control. An efficient surveillance system in which there was a continuous data flow from the periphery was established and is still in existence today. In this study we demonstrate how past surveillance data can be made use of in stratification of malaria risk areas and in planning and implementing malaria control measures.

MATERIALS AND METHODS

Study setting

Sri Lanka is divided into provinces and each province is divided into districts. The districts are further divided into Divisional Secretary (DS) Divisions, each of which consists of a number of Grama Niladhari (GN) areas. A GN area is the smallest administrative unit in the country and typically comprises 2-3 villages having a population that may range from a few hundred to a few thousand.

The Moneragala district of Sri Lanka is situated in the dry zone of the south eastern part of the country (Fig 1) and comprises 9 DS Divisions. There is perennial transmission of malaria in the Moneragala district which is of the unstable type. The incidence of malaria shows an annual seasonal variation and fluctuations from year to year in different areas. The Wellawaya DS Division lies in the south western part of the Moneragala district.

Sources of data

Data on the incidence of malaria in the Moneragala district of Sri Lanka were obtained from the Regional Malaria Officer of the Moneragala district from 1991 to 1998. These data were sent by field workers of the Anti-Malaria Campaign who were posted in different institutions on a monthly basis and included the number of blood smears examined, the number positive, the species and the age and sex break down. Data were compiled village wise.

Population data were obtained from the Grama Niladharis who administer a Grama Niladhari (GN) area.

Computation of malariometric indices

The Annual Parasite Incidence (API) was calculated as the number of malaria infections per 1,000 population per year for each GN area. As the villages in a GN area are known, village-wise data obtained from the Regional Malaria Officer were coded into GN area data. Each GN area has, on the average, 2-3 villages.

The falciparum rate (FR) was calculated as the percentage of falciparum infections of all malaria infections for each GN area.

Classification of risk areas

The classification of GN areas as risk areas for malaria transmission was done using 2 methods as described below:

Let x_{ij} be the API of the j^{th} GN area for a particular district for the i^{th} year where i = 1991, ..., 1998.

Let m_i be the median API of the GN areas for a particular district for the i^{th} year where i = 1991, ..., 1998.

Let y_{ij} be the falciparum rate of the j^{th} GN area for a particular district for the i^{th} year where i = 1991, ..., 1998.

Method 1: Based on the median API of the GN areas, each GN area was classified as a potentially high risk area if the API was above the median API for a particular year.

Let r_{ij} be the risk estimate of the j^{th} GN area for the i^{th} year based on API.

$$r_{ij} = \begin{cases} 0 & \text{if } x_{ij} < m_i \\ 1 & \text{otherwise} \end{cases}$$

where i = 1991, ..., 1998

Method 2: Based on the API cutoff value of 80 and falciparum rate cutoff value of 30, each GN area was classified as a potentially high risk area for a particular year.

Let r_{ij} be the risk estimate of the j^{th} GN area for the i^{th} year.

$r_{ij} = 0$ if $x_{ij} < 80$ and $y_{ij} < 30\%$

1 otherwise

where i = 1991, ..., 1998

Risk of malaria transmission

The overall risk of malaria transmission, R, based on the analysis of 9 years of past surveillance data is defined as:

$R = \Sigma r_{ij}$

Based on the overall risk of malaria transmission, the GN areas were further classified as follows:

If ($R \geq 5$) then the area is a high risk area

If ($3 \leq R \leq 4$) then the area is of moderate risk

If ($R \leq 2$) then the area is of low risk

Mapping

The overall risk of malaria transmission was mapped using EPIMAP. Base maps of the GN areas in the district were digitized and the malaria risk displayed.

Table 1
Annual risk estimates for GN areas of Wellawaya DS Division for 1998 using method 1.

GN Area	Population	Positives	API	r_{ij}
Anapallama	1,768	193	109.1	1
Andawelayaya	1,952	-	-	-
Balaharuwa	2,565	362	141.1	1
Budduruwagala	1,605	111	69.2	0
Debara Ara	1,338	94	70.3	0
Dimbulamure	1,627	0	0.0	0
Ethiliwewa	1,912	384	200.8	1
Galbokka	890	39	43.8	0
Handapanagala	1,210	264	218.2	1
Kitulkote	1,042	334	320.5	1
Kotikanbokka	1,466	0	0	0
Kurugama	1,528	0	0	0
Maha Aragama	1,375	-	-	-
Neluwagala	1,735	-	-	-
Nugayaya	1,370	96	70.1	0
Pubuduwewa	2,172	-	-	0
Randenigodayaya	1,160	-	-	0
Randeniya	1,914	160	83.6	0
Siripuragama	1,645	-	-	-
Siyambalagune	1,337	-	-	-
Sudupanawela	2,163	92	42.5	0
Thelulla	895	1,019	1,138.5	1
Telulla Colony	2,314	-	-	-
Uva Kudaoya	1,868	592	316.9	1
Veherayaya	1,714	285	166.3	1
Veherayaya Colony	2,432	-	-	-
Warunagama	4,379	377	86.1	0
Wellawaya	1,642	230	140.1	1
Yalabowa	1,560	73	46.8	0

Median API for the district = 87.5

RESULTS

The API and FR for GN areas in the Wellawaya health area of the Moneragala district for 1998 are given in Tables 1 and 2. In Table 1, the risk of acquiring malaria in the Wellawaya health area in 1998, r_{ij}, was classified as 1 if the API for the GN area was above the median API for the district which was 87.5. In Table 2, the risk of acquiring malaria in 1998, r_{ij}, was classified as 1 if the API was over 80.0 or the FR was greater than 30%. In 1998, 9 GN areas were classified as high risk areas using method 1 whereas 11 GN areas were classified as high risk areas using method 2.

The above procedure was carried out for all GN areas in each DS Division of the district from 1991 to 1998 using the 2 methods described above. After obtaining the risk estimates for each year, the overall risk of malaria transmission in the GN area was calculated as described above separately for each of the methods. The results are shown in Table 3 and Fig 1.

Table 2
Annual risk estimates for GN areas of Wellawaya DS Division for 1998 using method 2.

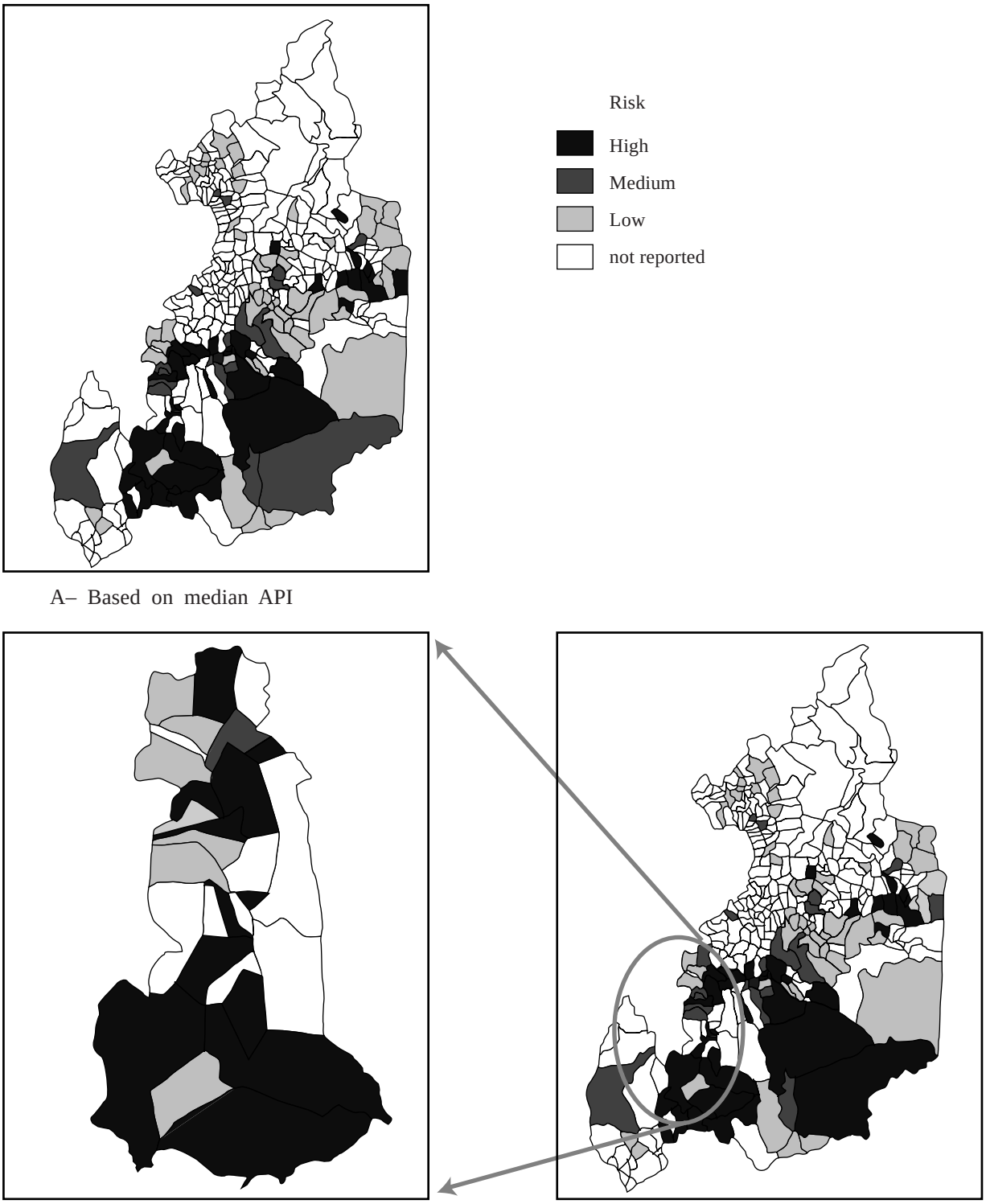
GN Area	Population	Positives	API	Pf	FR	r_{ij}
Anapallama	1,768	193	109.1	4	2.1	1
Andawelayaya	1,952	-	-	-	-	-
Balaharuwa	2,565	362	141.1	31	8.6	1
Budduruwagala	1,605	111	69.2	3	2.7	0
Debara Ara	1,338	94	70.3	10	10.6	0
Dimbulamure	1,627	0	0.0	0	0	0
Ethiliwewa	1,912	384	200.8	37	9.6	1
Galbokka	890	39	43.8	0	0	0
Handapanagala	1,210	264	218.2	13	4.9	1
Kitulkote	1,042	334	320.5	63	18.9	1
Kotikanbokka	1,466	0	0	0	0	0
Koorugama	1,528	0	0	0	0	0
Maha Aragama	1,375	-	-	-	-	-
Neluwagala	1,735	-	-	-	-	-
Nugayaya	1,370	96	70.1	2	2.1	0
Pubuduwewa	2,172	-	-	-	-	-
Randenigodayaya	1,160	-	-	-	-	-
Randeniya	1,914	160	83.6	4	2.5	1
Siripuragama	1,645	-	-	-	-	-
Siyambalagune	1,337	-	-	-	-	-
Sudupanawela	2,163	92	42.5	2	2.2	0
Thelulla	895	1,019	1,138.5	205	20.1	1
Telulla Colony	2,314	-	-	-	-	-
Uva Kudaoya	1,868	592	316.9	129	21.8	1
Veherayaya	1,714	285	166.3	21	7.4	1
Veherayaya Colony	2,432	-	-	-	-	-
Warunagama	4,379	377	86.1	9	2.4	1
Wellawaya	1,642	230	140.1	8	3.5	1
Yalabowa	1,560	73	46.8	1	1.4	0

Table 3
Classification of GN areas by the 2 different methods.

District	Risk status	Method 1 No. of GN areas	Method 2 No. of GN areas
Moneragala	High Risk	32	32
	Moderate Risk	18	22
	Low Risk	55	51
	Non malarious	214	214

DISCUSSION

Many organized efforts have been made to combat malaria in Sri Lanka since the early part of the 19th century with few successes and many failures. The strategies to combat malaria have also changed focus and direction with time. The eradication strategy in the 1950s and 1960s, which produced promising results early on in the campaign could not be sustained, and has been superseded by a control strategy, the objective of which is to reduce



A– Based on median API

B– API>80 or FR>30
Enlarged Wellawaya DS Vivision

Fig 1–Malaria risk in Moneragala district of Sri Lanka.

the morbidity and mortality due to malaria so that it will no longer be a public health problem.

The mainstay of malaria control today, as based on the Global Strategy for Malaria Control, is early detection and prompt treatment and vector control especially in countries with unstable malaria transmission (WHO, 1993). Vector control strategies emphasize on less reliance on chemical methods and, whenever such methods are used, to target them appropriately based on stratification of malaria endemic areas on eco-epidemiological criteria (WHO, 1995). In this study we have demonstrated how routinely collected data can be used for this purpose.

The two methods that have been used in this study have, as expected, produced results which differ only marginally. The choice of the criteria used for defining risk areas will depend on the objectives of malaria control programs and the resources available for malaria control. The criteria used in the 2 methods described in this manuscript are important in terms of malaria transmission in Sri Lanka. As both parasite species *ie*, *P. vivax* and *P. falciparum*, are prevalent in Sri Lanka and the FR is about 30%, morbidity due to malaria per se is important and, hence, the use of the median API for the district. Likewise, as *P. falciparum* itself is important in terms of morbidity, mortality and spread of drug resistance, the FR was used in the second method. It is also possible to have different criteria of stratification for different regions in a country.

The Roll Back Malaria Initiative (RBMI) of the World Health Organization which was launched in the latter half of 1998 envisages to reduce malaria morbidity and mortality by 50% by 2010. Key strategies of RBMI include evidence based decision making, multiple prevention and well coordinated action. This example illustrates the use of routinely collected surveillance data to design and implement evidence based control measures in accordance with the RBMI principle.

A number of lessons can be learnt from this illustration that are applicable to other diseases as well. Firstly, the ability of the use of routinely collected surveillance data in mapping risk areas. It should be emphasized that the output of such analyses depends on the quality of data. Although routinely collected data is not devoid of limitations, it can be used efficiently for such purposes as such data can indicate disease trends in general.

Secondly, the analysis of routinely collected data can be used to design and implement appropriate intervention strategies by disease control programs. In Sri Lanka, the cost of residual insecticides is the largest component of the costs of malaria control. With emphasis on the reduction of the use of residual insecticides in countries with low to moderate degrees of endemicity, based on stratification of malaria risk areas on eco-epidemiological factors, such analyses provide an useful guide to targeting control measures in an affordable and cost effective manner.

Thirdly, these analyses provide a scientific basis for evidence based decision making, a key strategy in the Roll Back Malaria Initiative. Such analyses can be useful in generating interest and convincing policy makers on the need for, and options available for, control of disease.

This type of analysis can also be extended to monitor and evaluate control programs. This analysis could be extended for a number of years and the success and failures of programs could be highlighted. It can also be used to select suitable control options depending on the characteristics of the particular area. For example, in areas where accessibility is constrained or limited, the choice of control option may be the one which has the longest duration of action. Likewise, strategies such as the rotational use of insecticides may be designed and implemented, using these tools.

An important use of risk mapping for epidemiological purposes is the identification of high risk areas for further study. In this example only 2 variables, namely the API and FR, have been considered. The FR is an im-

portant indicator of falciparum transmission in the area, especially drug resistant malaria, and is useful for the application of control measures and their subsequent monitoring and evaluation. The model presented here could easily be extended to include other parameters such as presence of development projects and conflicts, presence of indigenous transmission of drug resistant malaria, etc as well. Analysis using GIS can be useful preliminary analyses to generate hypotheses. For example, high risk areas can be focused and subjected to microepidemiological studies to identify ecological risk factors for malaria transmission.

When such analyses are performed, efforts should be made to disseminate the findings to the concerned authorities and the persons who collected the raw data. It is necessary to inform the authorities so that appropriate action may be taken in a timely manner. Informing the persons who collect the raw data would have a hidden impact. People who collect the raw data will then realize the importance of the exercise which in turn will lead to improved quality of data. This, in itself will be a tremendous achievement and, in turn will lead to analyses that would be more accurate and more useful.

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