

## Enhancing malaria control using a computerised management system in southern Africa

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### Abstract

**Background:** Malaria control programmes utilising indoor residual spraying are only effective if a high coverage of targeted structures is achieved and an insecticide that is effective against the specific mosquito vector is correctly applied. Ongoing monitoring of spraying operations is essential to assure optimal programme performance and early corrective action, where indicated.

**Methods:** Successful development and application of a computerised spraying operations management system in Mpumalanga Province, South Africa during 1998 resulted in its adaptation and introduction in neighbouring Maputo Province, southern Mozambique during 2000. The structure and components of this computerised management system are described, and its' operational benefit in southern Mozambique, where community-based spray operators apply intradomestic insecticide, are reviewed.

**Conclusions:** The computerised management system allowed malaria programme management and field supervisors to monitor spraying coverage, insecticide consumption and application rates on an ongoing basis. The system supported a successful transition to community-based spraying, while assuring correct insecticide application and spraying completion according to schedule.

### Background

In 1946, South Africa introduced intradomestic spraying with residual insecticides, DDT (dichlorodiphenyl-trichloroethane) and BHC (Benzene hexachloride), to kill indoor-resting vector mosquitoes and thereby control malaria [1]. This resulted in a 75 percent reduction in the

geographic extent of the malaria-affected area, with malaria occurrence limited to summer epidemics in the low-lying northern and eastern border areas with Botswana, Zimbabwe and Mozambique [2,3]. Similar malaria control programmes were initiated in other southern African countries. In Mozambique, spraying

operations for malaria control collapsed during the 1970s due to the protracted civil war with a resulting high burden of endemic malaria throughout the country [4].

Recently there has been a resurgence of malaria in southern Africa, attributed to a number of factors, including parasite drug-resistance, mosquito insecticide-resistance, climate changes and large-scale population migration [3,5]. The HIV/AIDS epidemic has resulted in a simultaneous dwindling of resources available for public health programmes, thus placing an onus on programme managers to ensure optimal efficiency of their activities. An efficient spraying programme is characterized by application of the correct volumes of insecticide on surfaces suitable for mosquito resting [6]. This should be achieved before the onset of peak malaria transmission with a high coverage of targeted structures.

A formal spraying management system was introduced in South Africa for the first time in 1973, with activity forms being completed by the field officials responsible for each spraying team and a "hut-card" left under the eave of each sprayed dwelling. This was expanded to a set of seven different spraying record forms in 1975 under the auspices of the World Health Organization. This set consisted of a spray operator record, a daily spray-team report, a weekly report, a monthly report, a locality completion report, a sector completion report and a spraying completion report. Although this manual system was cumbersome it became entrenched, and remained essentially unaltered in South Africa for more than 20 years.

A major flaw of this data system was that field staff were not trained to use the data for programme monitoring. Thus serious programme deficiencies usually only became apparent at the end of the spraying season when the data were centrally analysed. This resulted in missed opportunities for immediate corrective action.

During 1998, Mpumalanga Province, located on the border with Mozambique in the north-east of South Africa, began to replace permanently employed spray personnel with temporary spray personnel recruited from each malaria-affected community. One hundred community-based spray personnel were appointed, each accountable to their local community, and the team was responsible for spraying almost 170,000 structures during each annual spraying round. With supervisory support limited to one field manager and six field officers, it was postulated that unless an improved spraying management system was introduced, programme performance and efficiency might deteriorate. A computerised management system was developed in Mpumalanga Province to enable malaria programme management and field supervisors to monitor, even on a daily basis when required, spraying

coverage, individual spray operator's performance, and insecticide consumption and application rates.

The success of this computerised management system resulted in it being extended to neighbouring Swaziland and also to southern Mozambique, where a malaria vector control programme was recently re-introduced through the multilateral Lubombo Spatial Development Initiative (LSDI), a partnership between the governments of Mozambique, Swaziland and South Africa. We describe the structure and components of this computerised management system, and provide operational evidence of its value in the southern Mozambique malaria control programme.

### **Description of the management information system**

The computerised spraying management system in southern Mozambique was designed prior to the first round of spraying early in 2000. The area targeted for spraying included the rural districts of Namaacha and Matutuine, and sections of the peri-urban districts of Matola and Boane in Maputo Province, covering an area of 7,962 square kilometres with an estimated 200,000 homes. The management system comprises two platforms, a spraying database and a spatial mapping platform. A Microsoft Access 2000 database was used with front-end data entry and output screens. The data entry screen mirrors the manually completed weekly spraying form, which collates data from daily spraying report forms that are submitted each week by spray operators to their supervisor (Figure 1). "Drop-down" menus ensure speed, ease and accuracy of data entry. A number of datasets have been integrated to form the basis of the spraying data base, including a comprehensive listing of place names to be sprayed, number of homes (Ministry of Health database), demographic data for each electoral area (1995 Electoral Census by the Department of Planning and Cooperation), spray operator identification codes and details of insecticides used during spraying operations. Each record is automatically allocated a unique number and all information can be linked through a relational database to a specific spray operator, team, time-period or administrative area. Additional information collected includes the number of visits made to a specific house, reasons for not spraying (where applicable), insecticide used by each spray operator and number of spray-can refills. Data is automatically backed up after each day of data entry onto an external Zip drive.

The geographic information system (GIS) platform required both spatial (roads, clinics, locality boundaries) and attribute data (locality or clinic names, population figures). The GIS software package MapInfo Professional® [MapInfo Corporation, 4 Global View, Troy, New York, 12189, USA. <http://www.mapinfo.com>] was used and

**Figure 1**  
Data entry screen of the malaria information system

maps of southern Mozambique (scale 1:250,000) were obtained from the Direcção Nacional de Geografia e Cadastro in Maputo. The South African Medical Research Council digitally captured relevant geographical and cadastral features, including roads, rivers, towns and different administrative level boundaries. The smallest administrative unit boundaries at which data was captured (localities) were drawn onto local maps by the staff of the Ministry of Health involved in the project and then digitally captured for inclusion in the GIS display. The relational database allowed the production of spraying progress maps at locality level.

Preset queries, to generate standardized management reports, were planned and designed in partnership with field supervisors and programme management staff to meet their specific needs. However, the system was designed to allow user-friendly production of customized additional reports where required.

Specific training was provided for programme supervisors on making sense of data and interpreting reports, with a spraying database manual developed for ready reference. A major emphasis in training has been on identifying operational problems and implementing timely remedial action. As field managers enter the summary data at the Namaacha Field Office on a weekly basis, necessary remedial action is taken within a week.

### Application for enhanced malaria control

The ongoing monitoring of individual spray operator's productivity, in terms of number of structures sprayed each day and volume of insecticide sprayed per structure, has facilitated early detection of operational problems, leading to prompt investigation and supportive corrective action by supervisors. A standardized aid for evaluating

individual operators' spraying quality during field visits was designed and implemented. Field managers discuss evaluation results with spray operators on-site in order to eliminate mistakes. The frequency of required supervisory corrective interventions has steadily decreased since the beginning of the programme and it is likely that some of this effect is due to the enhanced monitoring and response made possible by the computer management system.

Insecticide application rates (grams per square meter) are constantly monitored for under- and over-application. Under-application reduces insecticide residual activity and thus effectiveness, while over-application is wasteful. Where sub-optimal application rates were detected, investigation included scrutiny of insecticide preparation, nozzle condition, application pressure, distance of nozzle tip from sprayed surface, and spraying rhythm.

Spraying coverage exceeded 90% of 222,000 structures in southern Mozambique, a level that is considered more than adequate [7]. In areas where the management system repeatedly identified lower coverage than expected, investigations were conducted to determine whether this was the result of diminished community support, absenteeism or poor motivation of the specific spray operator.

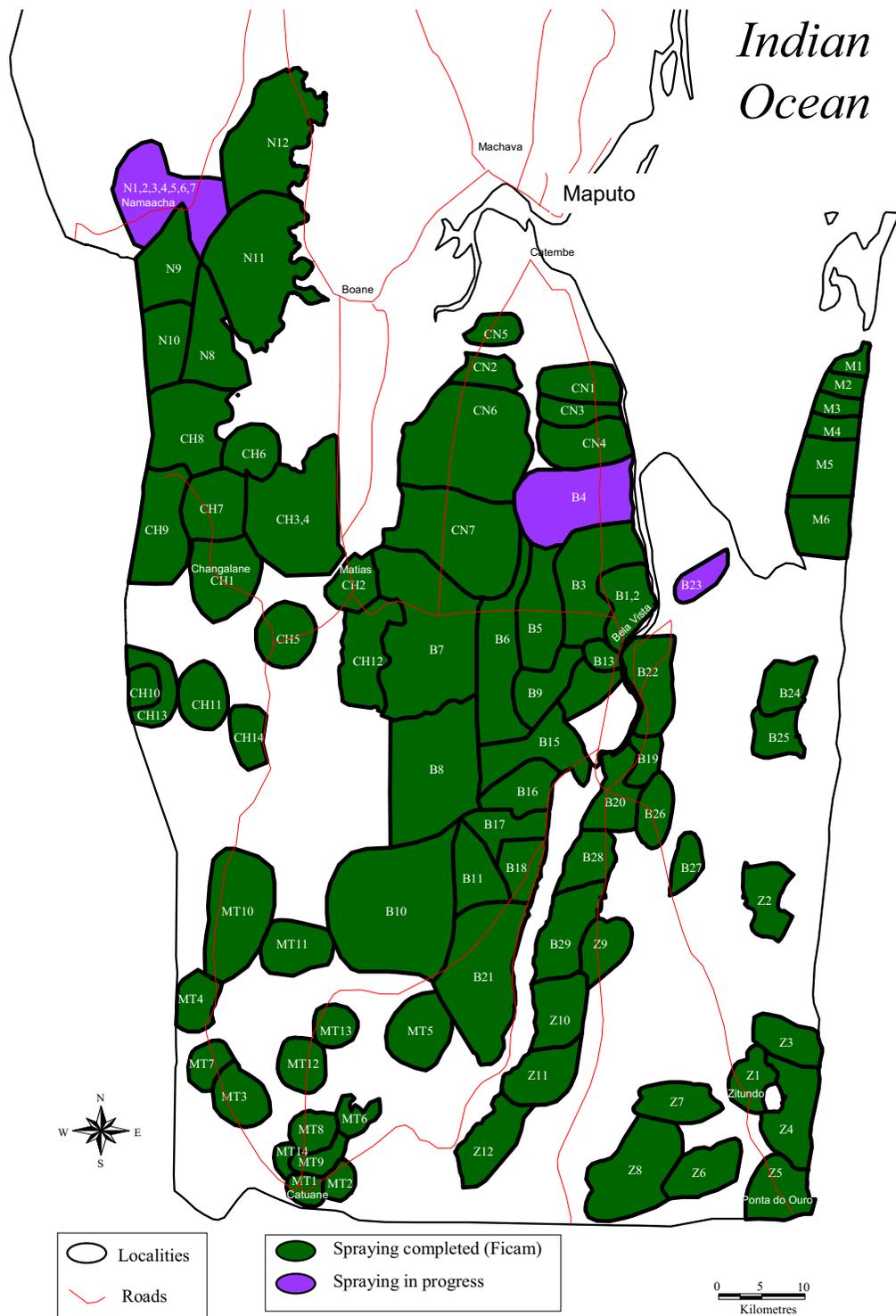
Maps depicting the coverage achieved by each team proved useful to malaria control programme management for tracking teams' progress, providing ongoing updates to senior health management and encouraging spray personnel to attain their target (Figure 2).

An additional benefit was that data captured during the first spraying round during 2000 was used to verify official data sources and provide actual household figures to replace official government estimates. This provided more precise information for malaria control planning and demographic data needed by other government agencies for planning.

### Conclusions

Competition for ever-dwindling public health resources is a major challenge for malaria control programmes in sub-Saharan Africa [8,9]. Constant monitoring and evaluation of spraying activities is obligatory where indoor residual spraying is an important component of malaria control, to ensure effective application and prevent wastage [10]. Computerised management systems are proving useful tools for providing timely information to address potentially deleterious human, social and technical factors that could negatively impact on malaria control.

The computerised management system has been in operation for three years supporting the mainly rural vector



**Figure 2**  
An example of a spraying progress map by locality in Maputo Province, Mozambique, 2003

control programme that now covers an area of 13,770 square kilometres in southern Mozambique. Not only has it supported a successful and cost-effective transition to a community-based spraying approach, but it has also ensured that spraying was completed to schedule [11]. The ability to immediately identify problems at the level of an individual spray operator and institute appropriate remedial action assured good coverage and programme efficiency. The computerised management system is a useful method for enhancing malaria control by improving application of existing tools [12].

Note: A PowerPoint presentation providing more detail on the malaria management information system and database is available at <http://www.malaria.org.za/lstdi/home.html>.

### Authors' contributions

MB, BS, CM, JLG, DD conceptualised, developed and implemented the Mpumalanga Computerised Management System prototype; MB, BS, CM, BM adapted this system for application in Maputo Province, Mozambique. All authors contributed to the review of the system and the preparation of this manuscript.

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