INTEGRATED MALARIA MANAGEMENT CONSORTIUM

Working to reduce the incidence of malaria, and other insect spread diseases.

IMMC

About

Development and deployment of integrated malaria management (IMM).

Surveillance, data collection, data analysis, a cyberenvironment (CE) for modeling and management information.

CONTENTS

4. Performance Metrics and Management Information
    1. Complex biology is matched by complex cost behavior
    2. A lot of good data is far better than a little perfect data
    3. Performance (outcome) metrics
    4. Performance (activity and cost) metrics
    5. There are three separate phases in the IMM process
        1. Graphic: The plan organize, implement and feedback cycle
        2. Graphic: The cycle ongoing not a one off
        3. Graphic: Intervention cost down, and socio-economic value up
    6. There are several different analysis cycles
    7. Purpose of surveillance and data collection
        1. Schematic: Data Flow Data Analysis Schematic
5. Surveillance, Data Collection and Data Logistics
    1. Different types of surveillance and data collection
    2. Spatial information
        1. An important source of performance improvement
        2. Getting baseline information from satellite imagery
            1. Example: Monrovia, Liberia
            2. Example: Houses in Monrovia, Liberia
            3. Example: Stone Town, Zanzibar with analysis grid
            4. Example: Stone Town, Zanzibar with analysis grid
            5. Example: Near Robertsfield airport, Liberia
        3. Ground truthing
    3. Techniques for data collection
    4. Scouting or surveillance work
    5. Data collection about malaria prevalence and malaria incidence
    6. Rapid local analysis for immediate decision making
6. Data Logistics
    1. Many approaches to data logistics
    2. Getting data from data collection to an organized data store
7. Data Store, Cyberenvironment and Data Analysis
    1. Local, rapid use of data and data analysis
        1. Local daily data analysis
        2. This analysis complementary to the cyberenvironment data analysis
    2. High volume complex multi-variable analysis
        1. Cyberenvironment for Integrated Malaria Management (CE for IMM)
8. Management Information and Performance Metrics
    1. The IMM Consortium (IMMC)
        1. About the Integrated Malaria Management Consortium (IMMC)
        2. IMMC Capabilities
    2. About Costs and Value
        1. Projected Costs
        2. Projected value
    3. Management Information for Integrated Malaria Management
        1. Cyberenvironment is key element for management information

    2. Management information is important and ubiquitous
    3. Making the information clear
        1. Example: Kwa Zulu Natal,
        2. Example: Bioko Island in Equatorial Guinea
    4. Performance metrics ... relating cost to results
    5. The use of standard costs
9. Performance Considerations, Strategic Issues
    1. Strategy for sustainability
    2. Strategy of cooperation and collaboration
    3. Strategy to supplement local capacity
        1. Support philosophy
        2. Community Focus: The Role of Mosquito and Vector Control Districts
        3. Community focus: field surveillance and data collection
        4. Community level analysis, feedback and action
        5. Training and operational support
    4. A strategy to assist wherever malaria is a burden
    5. Strategy for environmental protection
        1. Knowledge of pesticides and biological agents
    6. Strategy to minimize the risk of resistance
        1. Prevent human reinfection ad infinitum
        2. Resistance of mosquitoes to pesticides

Annex Contents

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Integrated Malaria Management Consortium

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Development and deployment of integrated malaria management (IMM).

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September 2007

Introduction

The Integrated Malaria Management Consortium (IMMC)

IMMC is a program of the University of Alabama, Birmingham (UBA) and the National Center for Supercomputing Applications (NCSA), two organizations that have world class credentials in malaria epidemiology and entomology and supercomputing applications.

IMMC also includes ADAPCO, a leading company with expertise in the use of pesticides and all aspects of vector control; West Coast Aerial Applicators with US and African experience in aerial operations and pesticide application, the Millennium Institute and the Transparency and Accountability Network (Tr-Ac-Net) with expertise in bio-economic modeling, cost accounting and management information.

An additional strength is IMMC's cooperation with Africa based organizations including local telecenters, local non-governmental organizations (NGOs), local community based organizations (CBOs), local faith based organizations (FBOs), local scientific research institutions (such as ICIPE and KMRI in Kenya), local Universities and other educational organizations, and local businesses.

The goal of mosquito and malaria control interventions

The overall goal of malaria control interventions is to reduce the prevalence of malaria and reduce mortality and morbidity associated with malaria. An associated goal is to achieve the maximum of malaria prevalence reduction for the least use of scarce resources.

The justification for this is that this will improve the quality of life and the economic performance of the area.

The overall goal is to help make malaria a rare disease. The starting point is one or several pilot locations, deploying a replicable methodology that can be used in other geographic locations equally effectively. Optimum malaria control interventions are based on malaria transmission dynamics, multiple simultaneous and complementary activities that reflect best available knowledge of ecology, medical science, entomology, molecular biology, sociology, economics and communications.

The interventions simultaneously aim to:

1. Reduce the parasite in the population,
2. Reduce re-infection of the population and lower the prevalence of malaria parasite in the mosquitoes, and
3. Reduce mosquito populations near homes.

A generic concept of cost and performance metrics

The basic idea that there is a relationship between cost and results is fundamental to an economic rational for decision making. This has important implications.

One of the realities is that the relationship between cost and results is complex. The idea that more cost results in more result is fatally flawed, though this is a common metric that has been used in the international relief and development sector for decades.

Results are a function of some activity. The relationship between the activity and the result should be optimized in order to get the best results.

Activities have costs, and the cost is a function of the techniques that are used to carry on the activity. Typically there can be many ways to carry out an activity, ranging from high-tech, high investment to low tech and labor intensive. The cost resulting from choices about how to carry out an activity depend on costs of technology and costs of labor, both of which are very variable depending on when and where.

In the area of international relief and development, the goal of a sustainable improved socio-economic situation is rarely achieved because of any single result. A set of intermediate results produce the final result that is the ultimate goal. The relationship between a set of intermediate results and the final result is also complex.

The complexity is part technical, and part a result of the vagaries of the human specie. While human beings do behave some of the time in an economic manner, there is also another dimension that is not incorporated into the simple rules describing economic behavior.

The IMM cost and value model for performance has been simplified so that it can be easily understood. At the most summary level the metrics are how much has been or resources have been used, and how much of ultimate value has been achieved. These are computed both for a period (such as a year) and on a cumulative basis using balance sheet concepts that are reasonably well understood by accountants. The entity that is best used for this is a geographic area, such as a community mosquito and malaria control district.

At the intermediate level the IMM performance metrics relate to specific activities, specific results and the cost of the resources used to achieve these results. The cost and the result are measures that can be "accounted for" at a clerical level ... but the understanding of how the results inter-relate to achieve the ultimate goal and results that have ultimate value is complex and replete with multiple variables.

To put the cost and value metrics in perspective. The value of success is huge. The population at risk of malaria in Africa is around 500 million. There is a high risk of mortality for young children and serious complications for pregnant women, a vulnerable group that represents perhaps 10% of the total population of 50 million. Around 50% of the population are children 16 and under. Perhaps 10% of the population are elders no longer able to work. This leaves 40% of the population who are potentially economically active adults, or some 200 million.

Malaria is a debilitating disease. If 50% of economically active adults are unable to work for 5 weeks a year, that represents (200 million X 50% X 5) 500 million weeks of lost economic activity. If a week of African adult labor is worth just $10 a week, the lost economic product is $5 billion. If the African adult labor for a week is $100, the lost economic product is $50 billion ... not an inconsequential sum.

The international corporate community involved with foreign direct investment in Africa has recognized the high corporate cost of malaria reflected in high absenteeism and reduced productivity. The cost of reducing the impact of malaria on their employees and their families is less than the cost of lost productivity due to their illness.

The corporate community in industries like tourism benefit from reduced malaria, both from the impact of malaria on their staff and from the negative PR associated with being located in a malarial area.

These corporate impacts are potentially much larger than the economic product calculated by reference to a $100 a week economically active adult. It is not easy to know what the total might be, but the lost economic product in Africa due to malaria of $100 billion is not unreasonable. Clearly this justifies a major effort to mobilize resources to help solve the malaria crisis.

As regards cost, the challenge is to use whatever resources are available in the best possible way. The starting point has to be to understand how much funds have been used in the past, for what activity and for what (intermediate) result, how funds are being used now, and how funds are planned to be used in the future.

What will immediately become apparent is that there is a wide range of costs for the same intermediate result, reflecting different operational modalities and operational efficiency. A first step is to ensure that all intermediate results are obtained using the most cost effective modalities.

A basic technique that can be used to measure cost performance is a system of standard costs, with routine variance analysis.

Setting

The problem being addressed

The problem being addressed is the lack of quality management information about malaria control interventions needed to assess performance and plan for the optimum use of resources.

The prevailing situation

In the few years since 2000, there has been a large increase in the disbursement of funds to support malaria control interventions in Africa. The African HIV-AIDS crisis helped to focus international attention on the broader crisis of African health, and especially the issues of malaria and tuberculosis. The international community has responded with support for the new Global Fund for HIV-AIDS, Tuberculosis and Malaria (GFATM), the United States has responded with the President's Malaria Initiative (PMI), and together with others this represent more than $1 billion a year of funding for malaria control initiatives.

Existing management systems are insufficient to ensure adequate financial control and the achievement of optimum performance in use of these funds. Some of the existing systems serve well as internal controls for the organization, some serve well as the basis for internal assessment of results ... but there is no broad uniformity of approach that enables the critical scientific data to be shared and analyzed in the most effective way, and little management information or easily accessible data that ensures that the best decisions are being made to achieve optimum results.

Background and history

The Integrated Malaria Management Consortium (IMMC) program for surveillance, cyberenvironment and modeling and management information builds on the successful integrated pest management (IPM) approach that has been the basis of success for a long time and continues in use to ensure the preemption of vector borne epidemic disease where early detection and rapid reaction are critical. The ability to control malaria using a combination of interventions was demonstrated by Gorgas during the building of the Panama Canal a century ago, and the basic concepts remain valid today.

Malaria has been eliminated in many locations that were endemic a century ago, but the scourge of malaria remains critical in Africa where WHO reports more than 3 million people die annually, of which 1 million are young children. A big part of this problem is that there are inadequate resources in the African health sector to control mosquitoes and malaria, and with insufficient resources, it is impossible to break the vicious cycle of malaria transmission. Instead of making the situation better, some of the limited interventions over the past years have contributed to making the situation worse by accelerating resistance in both the mosquito and the malaria parasite.

Since 2000, African and international health leadership has recognized the challenge and the resources committed to malaria control have been expanding significantly. However, the data about program effectiveness and performance remains weak, and while there are indications of success, the evidence basis for much of the reporting of success is poor.

Over the last 50 years the concept of mosquito abatement efforts to control vectors that transmit malaria, filariasis, yellow fever, dengue etc as well as pest species have progressively shifted to adult control. Availability of equipment, the use of residual pesticides (notable DDT), strategies based on single intervention techniques (eradication of malaria/yellow fever vector and later parasite) have shifted the focus from the optimum solutions.

In time emphasis shifted from field work seeking out the sources of mosquitoes and limiting the use of pesticides to only those places where and when needed to a routine attack with little regard for specific information about mosquitoes or to methods that only provided for limited utility in providing artificial barriers. The introduction of hypertoxic residual pesticides aided in losing sight of the importance of larval ecological information to manage mosquito populations even when they were used in low concentrations and carelessly applied many times over broad areas. First residuals were used as larvicides because they provided many answers to logistical questions, and they were effective at low concentrations. Then came the era of aerial application of thermal fogs and mists. Even though it is a confirmed fact that these application techniques will eventually cause resistance if continually used or misused, the ease of application took precedence over sound entomological data. These often times indiscriminate use of pesticides violate the first principal of Integrated Pest Management (IPM) or Integrated Mosquito Management (IMM) of effective control based on the principal of attacking the pest/vector when it is most concentrated, least mobile and most accessible.

Structure of the malaria sub-sector

The malaria sub-sector has many organizations involved. This shows something of the scale or the sector and the complexity that is involved in getting wide acceptance of any common approach to the best practices, and what is most cost effective.

Some of the organizations involved include:

1. Funding organizations like:
    1. The President's Malaria Initiative in the United States,
    2. The malaria component of the Global Fund for AIDS, Tuberculosis and Malaria,
    3. The international corporate community operating in Africa,
    4. The philanthropic community such as the Bill and Melinda Gates Foundation,
    5. The official relief and development sector organizations (see below).
2. Governmental organizations engaged in malaria control activities like:
    1. Ministries of Health, and their malaria control activities
    2. Hospitals and clinics providing malaria case management
3. Organizations in the official relief and development assistance sector like:
    1. WHO

2. UNICEF
3. World Bank
4. Bilateral development assistance agencies like:
    1. USAID/PMI
    2. DFID (UK)
    3. CIDA (Canada)
    4. SIDA (Sweden)
    5. GTZ (Germany)
    6. etc.

4. International non-governmental organizations engaged in malaria control activities like:
    1. RTI - Research Triangle Institute,
    2. PSI – Population Services International.
    3. Merlin,
    4. MSF.

5. Academic and Research Institutions like:
    1. North American and European Universities
    2. African Universities
    3. African organizations like ICIPE, KMRI, etc.

6. Community organizations like.
    1. Mosquito and vector control districts in the USA
    2. Community based organizations
    3. Faith based organizations ... churches
    4. Local governance organizations

How IMMC can facilitate improved performance

The IMMC ... the Integrated Malaria Management Consortium ... is organized to provide the critical need for scientific data, data analysis and management information in the global effort to reduce the impact of malaria and to be a cost effective service for all the participants in the challenge of reducing the impact of malaria on people and society.

IMMC is structured to provide to ANY or ALL the participants in the mosquito and malaria control sector a cost effective way to handle data and optimize the results being achieved with the resources they are managing.

IMMC is designed to address the problem of data analysis and lack of management information that constrains performance. The IMMC work is intended to provide more facts about performance so that spin and opinion become less of a factor.

IMMC is designed to help where help is needed. This help can be in various forms from training to full scale operational interventions.

The IMMC surveillance, data analysis (cyberenvironment) and management information offers something of value to all the participating organizations:

1. Funding organizations

More ability to make decisions about allocating resources based on results achieved rather than on promises and incomplete performance information.

2. Governmental organizations
   Also more ability to make decisions based on what is best to do with the limited resources available
3. International NGOs
   International NGOs are much involved in implementing malaria control programs, but performance is constrained by project design that is goal driven rather than be results based and evidence based.
4. Academic and research institutions
   Academic and research institutions know a lot, but the knowledge is not easy to use in a practical way, and its value is discounted because of this.
5. Community organizations
   Community organizations can be strengthened in Africa so that they become a big part of the solution, including becoming the core for a network of mosquito and vector control districts.

How scientific data and management information helps

A combination of scientific data and management information helps by making it possible for non-scientific decision makers to understand the implications of their decisions and for scientists and researchers to understand the cost and value implications of their work. Though scientific data and management information are completely different in the approaches that optimize their value, they both describe the same realities, and the analysis deals with the same sets of detailed data.

Scientific data tends to have the most value when the analysis can look at a very large dataset with many variables and over a significant time period. When the behaviors from the past are understood, it then becomes possible to make improved predictions about the future.

Management information, on the other hand, has the most value when it is quick, clear, easy to understand and relevant to the decisions that need to be made now. It is sometimes characterized as the least amount of information that ensures that the right decisions are being made.

It is expected that IMM management information will show that there are significant opportunities to improve the cost effectiveness of the many initiatives that are presently funded and operational.

Anticipated outcomes

The present initiatives to combat malaria are well funded compared to recent past years. There is a commitment on the part of the donors to get optimum results and to be transparent and accountable.

It is not yet clear whether or not the strategy is delivering optimum results, or that there is an adequate level of transparency and accountability. As fund flows have increased, there have been many reports that funds have not been used effectively to combat malaria. It remains difficult to get an accounting where there are indications that funds have not been used effectively.

But even where there are clear data about activities being undertaken, there is not much associated cost accounting easily accessible for public review, and it is not easy to discern progress being made towards sustainable reductions in the burden of malaria.

Accordingly IMMC is seeking to satisfy a critical need to have robust performance metrics that will make it possible for interested people and organizations to be able to see data that relates costs to results, both in terms of the intermediate activities associated with specific interventions and at the community level as a whole.

IMM Interventions

Three areas for intervention, an integrated approach

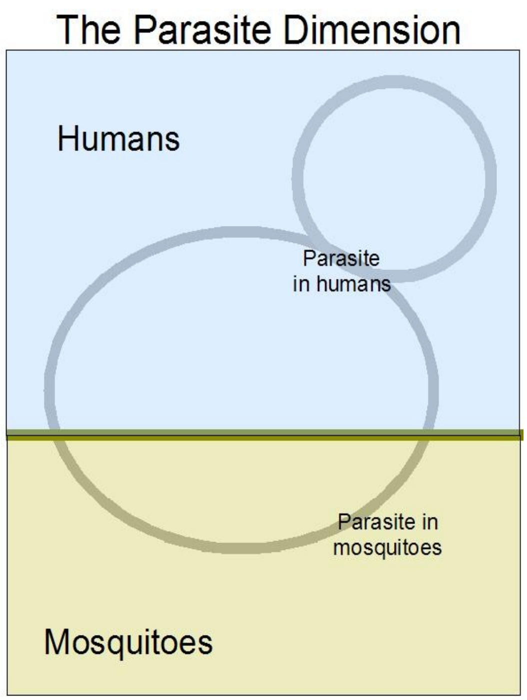
The integrated approach originally used successfully by Gorgas during the construction of the Panama Canal had a focus on the human, the habitat and the mosquito. A similar set of interventions is the basis of IMM. There are many possible interventions and variants of these interventions.

They fall into three main areas:

1. Medical
2. Personal protection
3. Mosquito (vector) control

The reason there are three areas of intervention relates to the basic biological science where there are interactions between the human, the parasite and the mosquito vector. The following schematics help to show the complex dynamic in a simple understandable form.

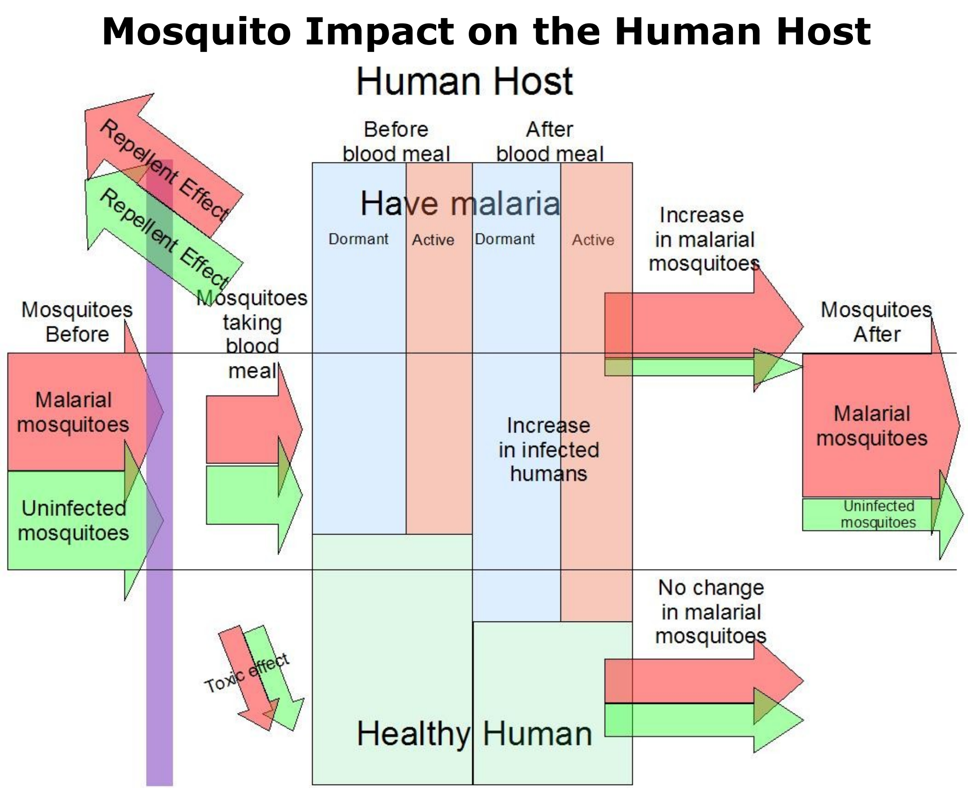
The first is a reminder that the parasite moves from human to mosquito to human to mosquito to human in the course of its life cycle. The parasite may remain dormant in the human host for a long time. The parasite becomes active from time to time and causes bouts of malaria.



When a mosquito bites, takes a blood meal, there are several possible consequences:

1. the mosquito is non-malarial and the human host is non-malarial in which case the mosquito remains non malarial,
2. the mosquito is malarial and the human host is malarial in which case the bite does not change the situation,
3. the mosquito is non-malarial and the human host is malarial in which case the mosquito becomes malarial
4. the mosquito is malarial and the human host is non-malarial in which case the host becomes malarial

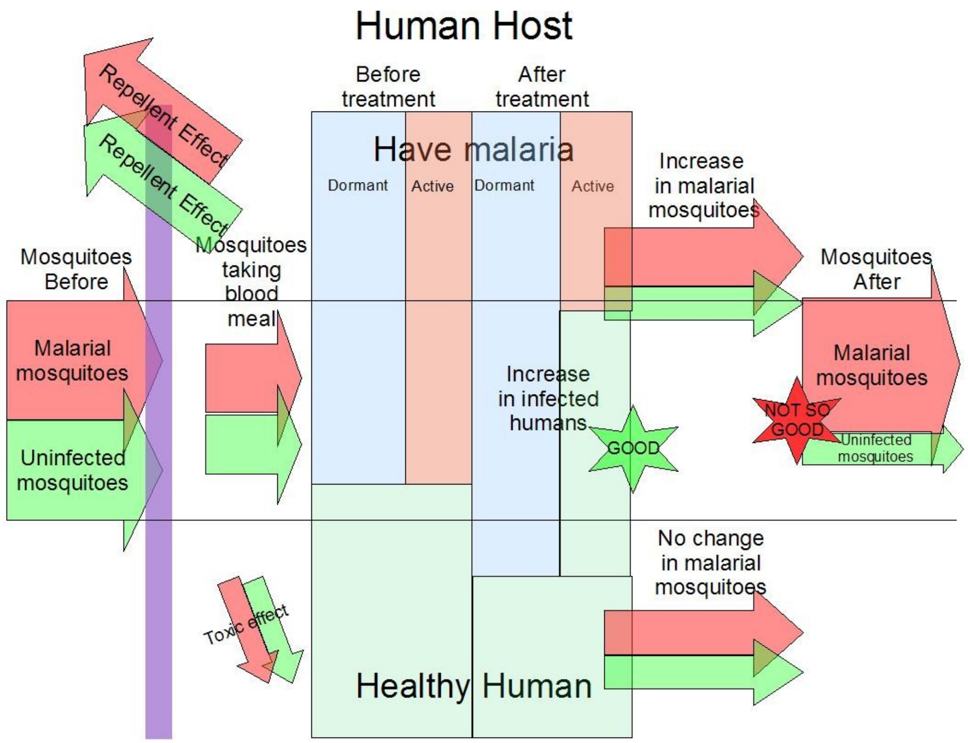
The following schematic shows the dynamic of the mosquito / human host interaction in a simplified way.



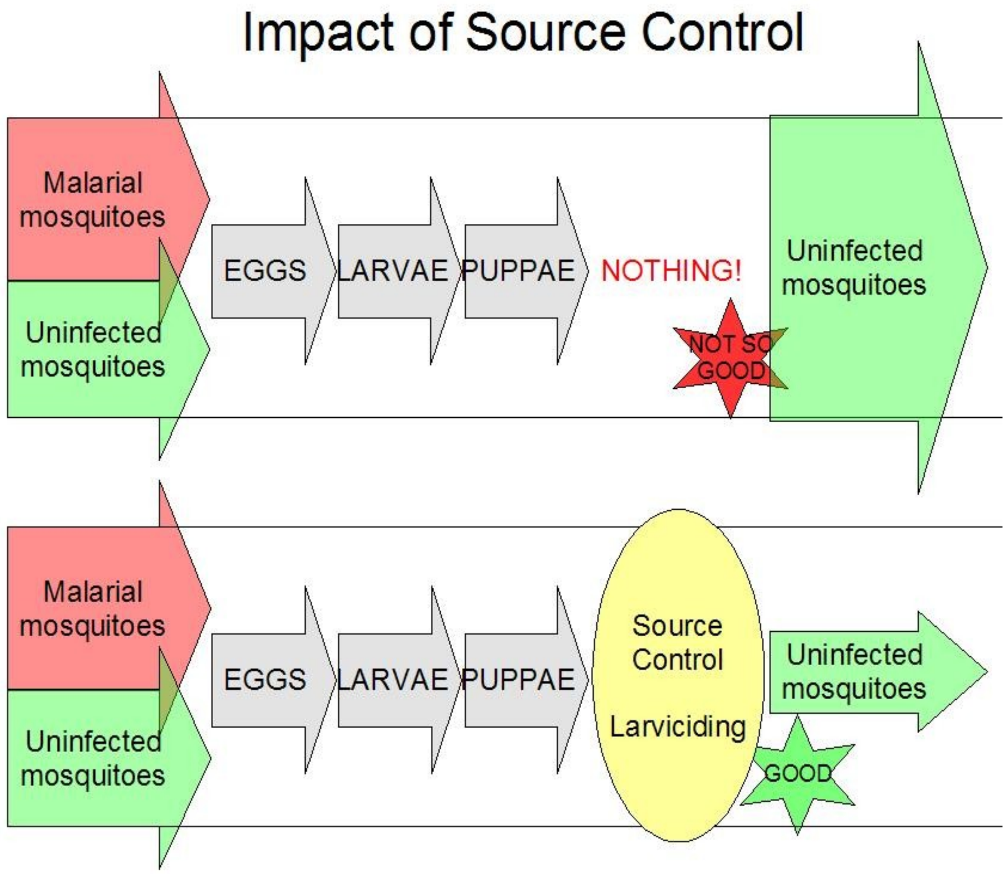
With an abundance of mosquitoes and a high prevalence of malarial mosquitoes the prevalence in the human host increases. Efforts to limit contact between the mosquito and the human host helps, but is not easy to do with a high degree of effectiveness for all the times the mosquitoes may be looking for a blood meal.

With medical treatment, the malaria in the human host can be reduced. This has a favorable impact on the mosquito human interaction, but it is small for the population taken as a whole. There is little impact on the mosquito population and the prevalence of malarial mosquitoes.

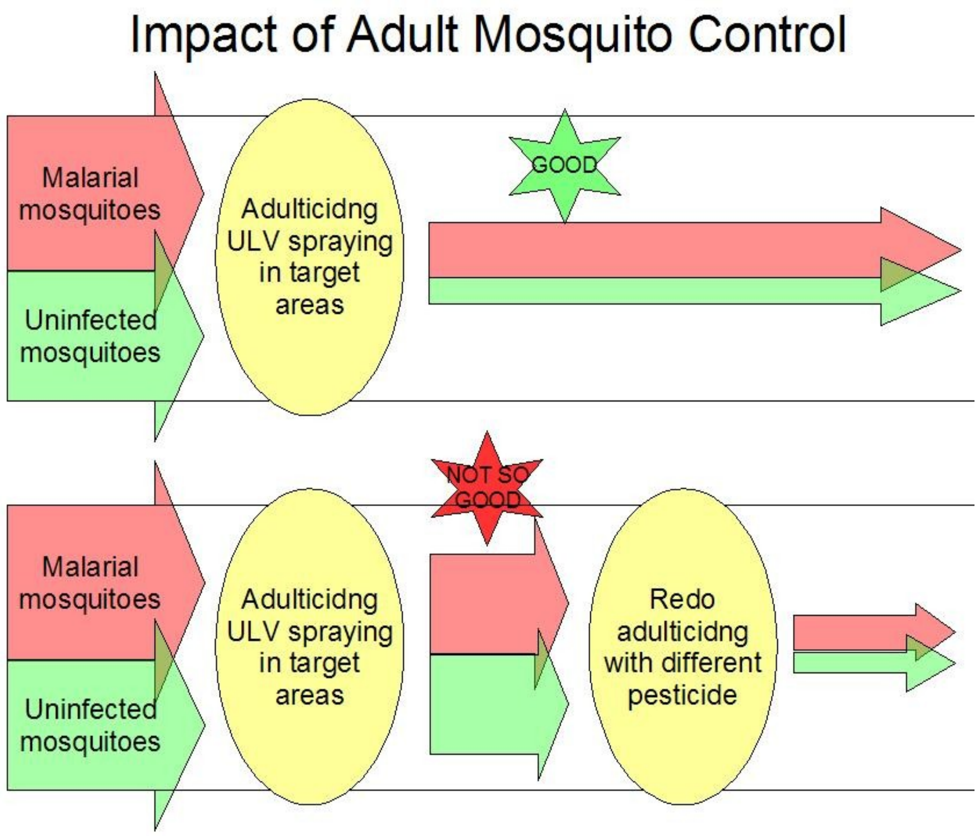
Case Treatment Impact on the Human Host in a malarial setting



The malaria population can be very favorably impacted by source control. The following schematic shows how the population of mosquitoes can be substantially reduced by active source control. With no source control the mosquito population stabilizes at a level that is governed by general environmental considerations, of which the weather is one of the most important. With source control the population of mosquitoes can be reduced significantly.



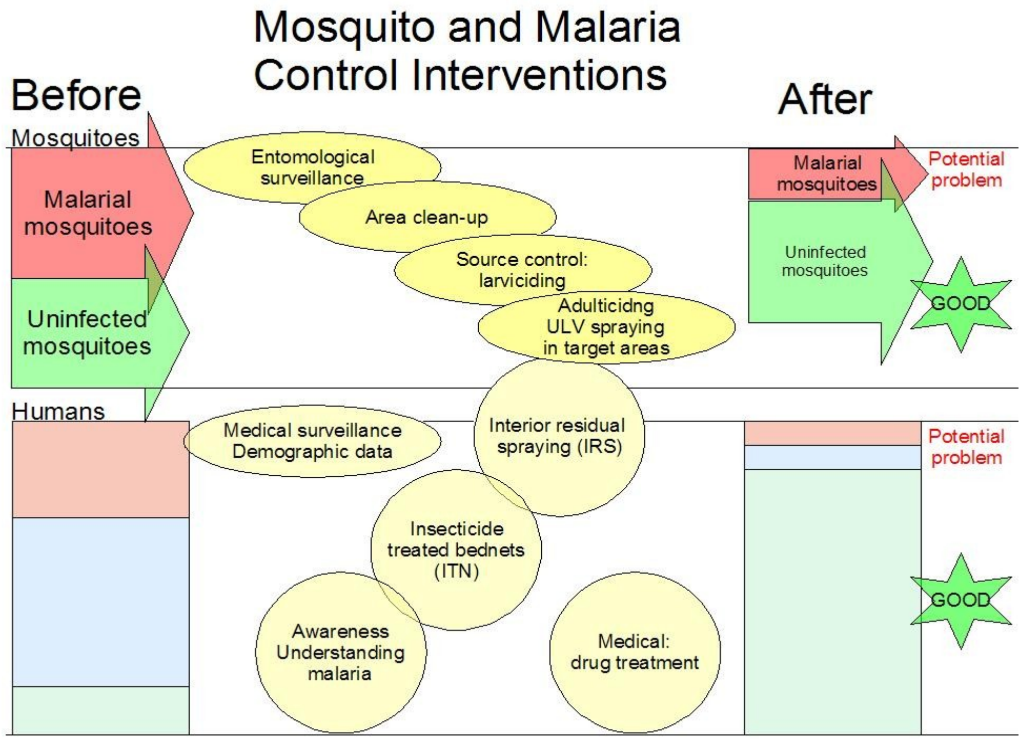
When there is an abundance of adult mosquitoes, the use of adulticiding will reduce the mosquito population. The following shows two situations. In the first case the adulticiding is successful and mosquitoes are killed and the population is reduced. In the second case there is resistance to the first chemical used, so the procedure is repeated using a different chemical treatment.



The cost and intermediate result of adulticiding suggests that this should be a significant part of integrated malaria control interventions. On its own adulticididng is going to have little impact on the ultimate goal because there will be rapid reestablishment of the mosquito population and because there will also be rapid reinfection of the mosquitoes with the parasite. The use of adulticiding might, however, be a very powerful factor in accelerating the impact of other interventions, specifically the medical treatment and the larviciding, and in combination give an optimized performance.

The following graphic summarizes in a simplified way the various interventions involved in integrate mosquito and malaria management. The primary goal of reduced malaria burden in society is shown in green, in the human section ... before and after. The related goals, the reduction of parasite in the human host and the reduction of parasite in the mosquito population are also shown. Between before and after there are a portfolio of possible mosquito and malaria control interventions.

Interventions and Before After Change



Best performance is for the costs of the interventions to be the lowest possible for the maximum of improvement or progress towards the ultimate goal of reduce malaria burden in the community.

The science of each of these interventions is quite well known. Rather little is yet known about the optimum way to combine these interventions for best performance.

The interventions

In outline, excluding the surveillance and data collection elements, they are:

1. Medical:
    1. treatment of active malaria cases
    2. treatment to reduce the prevalence of the malaria parasite in the human host
    3. prophylactic medication
2. Personal protection:
    1. creating awareness about malaria
    2. use of insecticide treated bednets (ITN)
    3. use of interior residual spraying (IRS)

        4. use of insecticide treated clothing (ITC)
3. Mosquito (vector) control:
    1. source control:
        1. remediation of breeding habitats
        2. area clean up
        3. larviciding
            1. manual ground
            2. vehicle mounted ground
            3. aircraft
    2. mosquito control:
        1. Ultra low volume (ULV) adulticiding
            1. manual ground
            2. vehicle mounted ground
            3. aircraft

In addition there needs to be the scientific data and management information dimension that includes:

1. Surveillance,
2. Data collection,
3. Data logistics,
4. Data analysis (cyberenvironment for IMM),
5. Management information, and
6. Feedback to operational and strategic decision makers.

Medical

Medical treatment using drug therapy for active malaria.

Malaria is a deadly disease for children and pregnant women, and some types of malaria are also deadly for everyone. Malaria in all its variations is a debilitating disease for everyone. Accordingly, the treatment of malaria is a priority for medical personnel.

The popular low cost drug Chloroquine is not longer effective in most situations because of a build up of resistance to this drug. More recent drugs like Fanzidar are also showing signs of widespread resistance. A more recent therapy using ACT is more powerful and there is less resistance, and it is an effective therapy. The cost of ACT is many times more than Chloroquine or Fanzidar, and out of reach economically in most communities in Africa without subsidy.

Medical treatment of active cases is a high priority in the health sector, but the issue of resistance is a major concern. Where there is perpetual reinfection, and the treatment is limited to the existing drug therapies, there is absolutely going to be resistance development, and most likely quite rapidly.

Medical treatment using drug therapy to reduce parasite prevalence

Medical treatment that addresses the active malaria bout should be supplemented by medical treatment that addresses the parasite that is simply hosted in the human subject. A bite from a non-malarial mosquito is not the start of transmission when the source of a blood meal is not host to the malaria parasite. The bite is a nuisance, but the bite is not dangerous.

Medical treatment to reduce the prevalence of the malaria parasite in the human host is a key part of an integrated malaria management regime. Medical treatment that helps to eradicate the disease is very much more cost effective than medical treatment that only addresses a presently active bout of malaria, that will reactivate in a matter of weeks, and perhaps many times in a single year.

Personal protection

Community awareness and personal protection

Increased individual and community awareness of mosquitoes and their role in the transmission of malaria, and the importance of treatment is very important. The community needs to know:

1. about how malaria is transmitted, and
2. about ways to control the mosquito population,
3. about how use of bednets can reduce incidence of malaria,
4. about the advantages of interior residual spraying,
5. about the ways to keep mosquitoes away from the house, and
6. about the recognition and treatment of malaria.

With better knowledge of these matters, the community becomes empowered to take control of many of the factors that have an impact of the malaria status of their community.

In order for a malaria management program to be successful and sustainable there is a critical need to get the community involved and running as much of the program as possible. In a situation where the malaria level has been reduced almost to zero, it is possible that everything can be done in the community with little external inputs with the exception of data logistics and the IMM cyberenvironment modelling. If interventions are needed, there should be the implementation capacity available for the required interventions to he deployed as needed, together with the necessary funding.

Personal protection using insecticide treated bednets (ITN)

For the past several years personal protection using an insecticide treated bednet has been a widely used intervention. There are several styles of bednet and a variety of chemicals are used. Not all the the chemicals being used have been approved for use by the WHO and/or UNICEF.

The main goal in many of the programs has been to get young children who are at the highest risk of dying as a result of a malaria bout to sleep under a bednet and be protected. The result of these efforts seems to have been positive in that it seems that less children are dying of malaria in the critical first year, or even two or three, but it is less clear that children as a whole are growing up to adulthood. The possibility is that children survive initially, but subsequently die because malaria is so prevalent in the society at large.

Another group being targeted for bednet use are pregnant women who are also highly vulnerable to malaria. Again, the reports suggest that sleeping under a bednet reduces the incidence of malaria for the person involved, but this does not translate into less malaria in the community as a whole, and is probably unsustainable for the individual when they are no longer in the vulnerable group of pregnant women.

The cost of a bednet varies from around $2.00 to around $10.00, but it is not clear that these numbers relate to the same item, and the data are not easily to be found that show the makeup of costs. A "per year" cost of using a bednet is sometimes stated to be around $4.00 per person per year.

Personal protection using interior residual spraying (IRS)

Personal protection using interior residual spraying (IRS) of the home is a proven way of reducing the impact of the mosquito vector on people in the home. There are several ways in which IRS impacts on the mosquito and malaria:

1. By the repellent effect which helps to keep mosquitoes out of the home,
2. By the toxic effect which kills the mosquito when they try to rest on the treated surfaces, as they would do after a blood meal. This operates along the following lines:
    1. In the event that the mosquito was not malarial before the blood meal the human subject will not become infected, but if the mosquito is malarial before the blood meal the human subject will be at risk of infection,
    2. If the human subject is host to the parasite before the blood meal, then the IRS toxicity will stop the mosquito transmitting the parasite to others.

The use of DDT as the chemical agent for IRS is the most cost effective. DDT has a high repellent effect, is toxic to mosquitoes and remains effective for a long time. The effectiveness of DDT lasts perhaps as much as twice as long as other chemical agents. There are some mosquitoes that are resistance to DDT, but this resistance does not seem to apply to the repellent effect. In terms of cost effectiveness DDT appears to be several times better than other chemicals, being a less costly chemical, requiring less frequent application, and having a bigger impact on the malaria prevalence in the community.

IRS should, of course, be conducted with trained personnel who know and practice safety. The environment should be monitored to confirm that there is no undesirable environmental impact.

Personal protection using insecticide treated panels

One of the behaviors associated with some insecticides is a repellent effect, which keeps mosquitoes away and stops them taking blood meals. The technique has been used on an experimental basis with success.

Personal protection using other techniques

Exposure to mosquitoes can be reduced by many different techniques. Some of the approaches are expensive and therefore limited to the wealthier members of society.

Living in air-conditioned space and using sprays to ensure that any mosquitoes are killed is effective and used by wealthy families and in international class hotels. Burning insecticide treated coils keeps mosquitoes away from possible blood meal targets. Wearing clothing that covers the legs and arms helps keep mosquitoes from reaching a blood meal.

Mosquito (vector) control

Community awareness and environment clean up

Community awareness and clean up of the environment is a first stage in reducing the mosquito population. Eliminating standing water of all types will reduce the breeding places and help keep the mosquito population near the human population under control.

Source control

Source control reduces the population of locally produced mosquitoes that are responsible for transmission of vector-borne pathogens and associated nuisances to human and animal populations. Killing mosquitoes at their sources, when they are in the larval stages and concentrated, immobile and accessible is the key to a cost effective program. The interventions focus on reducing the incidence of adult females, both vector and nuisance species to tolerable levels. Other measures supplement this primary intervention.

The objectives of source management in the aquatic habitat are as follows:

1. To locate and eliminate larvae within the management area.
2. To reduce or eliminate adult mosquitoes in known areas of aggregation and / or concentration.

Larval elimination is the most effective and reliable way to control a mosquito population especially when directed at the young larval stages before they become more dispersed in the environment. The application of insecticide when the larvae are most concentrated in the habitat also reduces the amount of insecticide needed which has the dual effect of reducing potential environmental contamination as well as reducing costs.

Abatement plans for Anopheles, Culex and Aedes mosquito species depend on the pattern of annual and seasonal (dry and rain) rainfall and the incidence and distribution of the immature stages of the mosquitoes. In the IMM program data about weather are collected and included in the IMM cyberenvironment model.

Anopheles and Culex species have time limited estivation and/or latency capabilities in the adult, larval or egg stages and cannot remain dormant during dry periods, it is imperative to locate and manage the water filled harborages that provide sustainable habitats during these times. These "seed populations" are the sources for the enormous increases in population densities that occur when the rainy season begins and aquatic habitats become numerous.

Eggs of the Aedes species are capable of surviving for long periods of time on soil withstanding dry conditions and hatch into larvae when flooded. Some container inhabiting aedine species survive in artificial or natural containers and natural precipitation or man-made means provide water for hatching.

The population density of mosquitoes is directly related to weather conditions, especially precipitation (irrigation), temperature and relative humidity. Monitoring these key climatological conditions can provide the necessary information to predict which sites will be producing mosquito larvae and when. These parameters coupled with a knowledge of sub-surface water (water table) can provide additional information on where and when to begin mosquito larval applications.

A mosquito abatement area must be large enough to encompass the sources of mosquito vectors and pests it is to manage. The boundaries of mosquito control operations should be established by the affected communities taking mosquito science into account. In most circumstances a distance of 500 meters from human habitation is a default guideline. Larval habitat surveys should be done within this area to locate any larval breeding sites that would be a source of mosquitoes. The flight range of an An. Gambiae mosquito is considered to be 500 meters, though some will travel longer distances, especially with a favorable wind.

Source control using larvicide treatments

Larvicide treatment is very effective if the insecticide application units:

1. apply insecticides to the exact sites where larvae are present as determined by the surveillance and data collection teams, and
2. everything to do with insecticides is carried out in accordance with the safety rules for humans, animals and the environment.

Surveillance data will identify places where mosquitoes breed that can be eliminated by habitat modification. Poor design of structures and the area where construction has taken place often create excellent habitats for breeding mosquitoes. These situations need to be identified and modifications made, in the main to eliminate standing water.

The personnel engaged in working with chemical and biological agents must be trained and supervised to sanitise the specific larval sites. It is optimum when the teams apply an insecticides only to that portion of the habitat occupied by the larvae while they are in their most concentrated phase (early larval instars). The insecticide prescribed must also be chosen as indicated by the environment. Protection of the environment and human health is paramount.

Source control through habitat modification and area clean up

Surveillance data will also identify locations of breeding places that result from a variety of wastes, such as automobile tires and discarded containers of all types that collect water. All of these potential breeding places can be cleaned up and will results in a reduction in malaria producing sources.

It is often said that every "hoof mark in Africa" is a potential breeding place for mosquitoes, and to the extent that this is a challenge, it may not have much impact on the success of an integrated malaria management program because the combination of interventions can be used to limit the impact of an out of control mosquito population increase on the overall health situation.

Mosquito population control using ULV spraying of adulticides

While mosquito population control is best controlled by controlling at the larval stage before they fly and disperse, modern ultra-low volume (ULV) spray technology makes it very cost effective to control flying mosquitoes. Chemicals such as Dibrom are used extensively in the United States for mosquito and vector control and the modern spray techniques available are very effective and very low cost. The cost can be as low as $2.50 per acre treated, and the per-capital cost very low depending on the population density.

Also important is that the impact of ULV spraying is very fast. If an area is correctly sprayed tonight, the mosquito population will be significantly lower next morning, usually a reduction of more than 80%. If the reduction is less than this, there is a resistance problem that needs to be addressed, and changing to a different family of insecticides and respraying will probably deliver a reduction in the mosquito population.

In areas where mosquitoes have a very favorable habitat, a permanent reduction in the mosquito population is going to be difficult. It is possible that source control referred to above can help bring the population of mosquitoes under control permanently, but a substantial mosquito population is likely for the long term.

The challenge is not to reduce the population of mosquitoes, but to reduce the population of malarial mosquitoes, and to break the currently perpetual cycle of parasite transmission from human host to human host through the mosquito vector. The role of ULV is to reduce the population of mosquitoes long enough for the other interventions to have an impact on the permanent situation.

The optimum way of doing this depends a lot on the behavior of all the interacting systems, and the data will be analyzed in order to understand these interconnections.

Performance Metrics and Management Information

Complex biology is matched by complex cost behavior

Each of the mosquito and malaria control interventions has a unique cost behavior. Because of the complex biological system and limited knowledge, the results are difficult to predict with great certainty. However, the IMM approach facilitates that data about the cost and outcome from all specific interventions becomes a part of a cumulating dataset.

These interventions used in an appropriate combination provide effective, economically efficient and environmentally friendly mosquito abatement that will aid in reducing the morbidity and mortality associated with malaria and other mosquito-borne diseases. The interventions will also reduce the nuisances and pest problems associated with mosquitoes as they relate to both man and domestic animals.

The key characteristic of integrated malaria management is that ALL possible interventions are included in the analysis framework in order to be in a position to recommend and use the interventions that are likely to give the best results at least cost.

These will be described in more detail in the following sections. After that there is a section that addresses the work of data collection and surveillance and then the data logistics required to move data to where it may be stored and complex analysis undertaken (the cyberenvironment). Subsequently there is a section that addresses the management information needs of decision makers for integrated malaria management.

A lot of good data is far better than a little perfect data

A key concept for success in the context of integrated malaria management is that the goal is not to have perfect data, but to have useful data to facilitate good decisions that results in a cost effective reduction in the prevalence of malaria.

Performance (outcome) metrics

In the IMM approach, scientific data and management information look to the following outcome metrics:

1. Number of cases of active malaria
2. Prevalence of malaria parasite in the human population
3. Abundance of mosquitoes
4. Prevalence of malaria parasite in the mosquito population
5. Reduction in mortality associated with malaria
6. Reduction in morbidity associated with malaria

The socio-economic benefits associated with success in controlling malaria include:

1. less absence from work
2. industries like tourism less adversely affected

Performance (activity and cost) metrics

In the IMM approach, scientific data are compiled and analyzed to understand what it is that gets the best possible outcomes, and what is the underlying science that is driving the process. In addition, the IMM approach to scientific analysis has an element of cost analysis so that optimization does not ignore the financial and economic parameters.

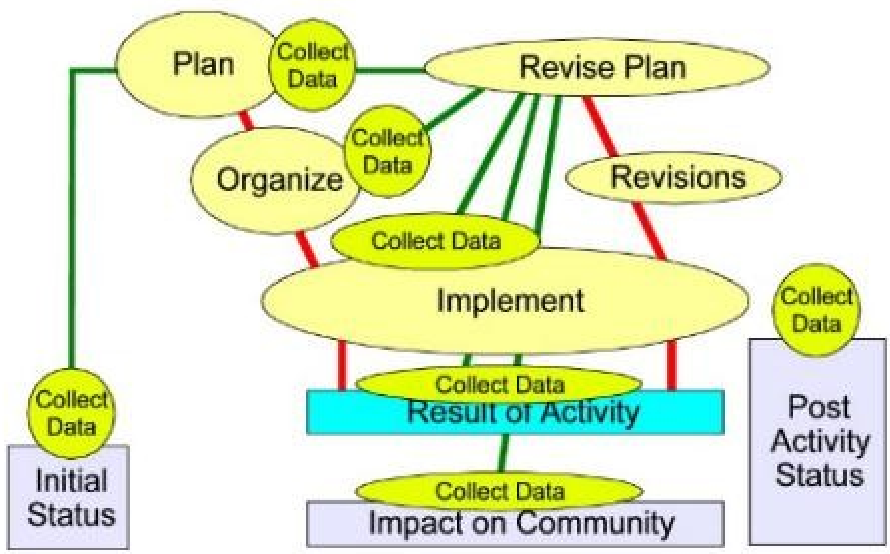
In parallel, data about activities and costs are compiled so that there can be a quick, albeit crude, understanding of how much is being spent and the outcomes that are being realized. These data have the most value when the information can be used to improve immediate operations and used to improve the allocation of resources wherever resources are being used for malaria control interventions.

There are three separate phases in the IMM process

The three separate phases of the IMM approach are:

1. Surveillance, data collection, data analysis that determines what to do
2. Intervention operations ... and how much did it cost
3. Surveillance, data collection, data analysis that determines the results that were achieved in this time period and at what cost ... and what to do next.

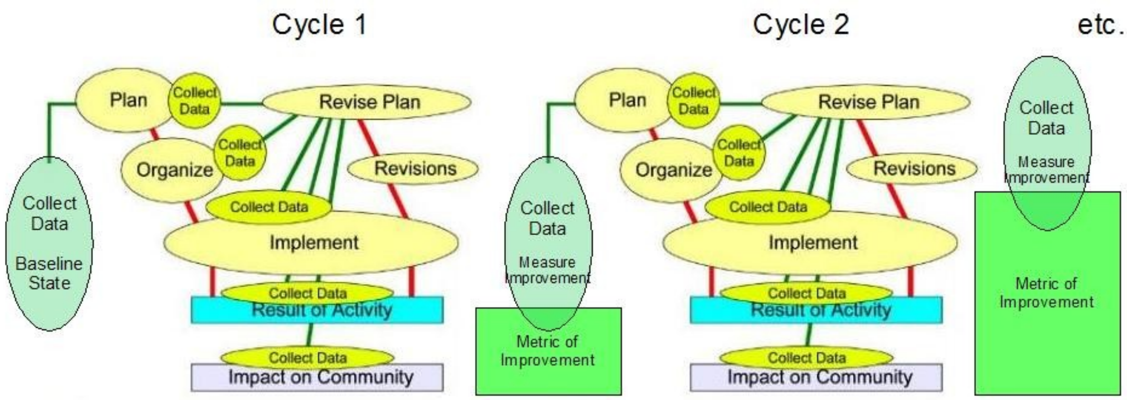
These are reflected in the following schematic which shows how high performance operations integrates data collection, analysis, planning, action, more data collection, more planning, more action in a perpetual process.



The ultimate measure of success is whether the change between the initial status and the post activity status has a value that (substantially) exceeds the costs.

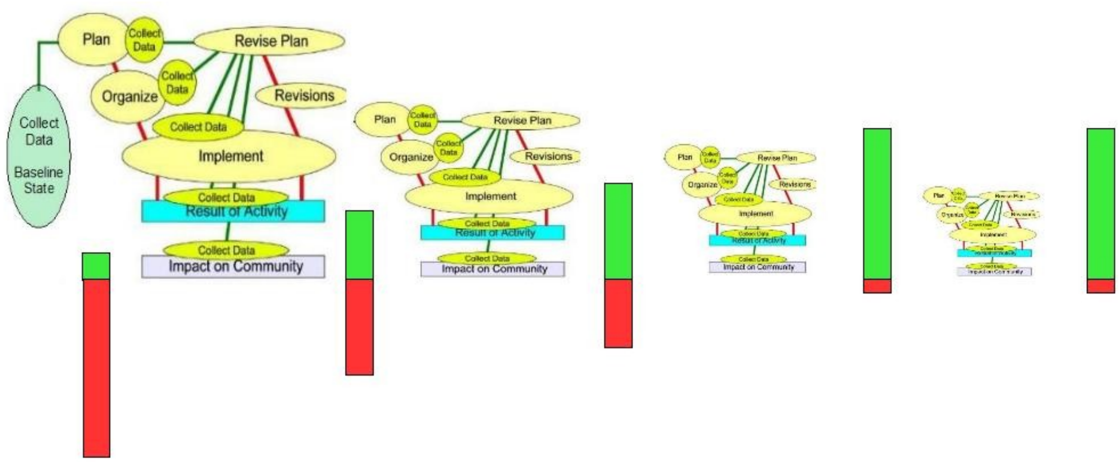
There is no simple relationship between funds disbursed, interventions used, results of these activities and the ultimate impact on the community. At the present there is no understanding of how a comprehensive portfolio of control interventions can best be optimized. However, there are some things that seem to apply, and data needs to be compiled so that there is better understanding.

There is some knowledge, and there is some experience. One reality is that the planning, implementation, review cycle is ongoing, not just a single cycle.



In this schematic the activities that are implemented produce their own results or outcomes, and in turn these have an impact on the community. The metric of improvement is mainly that of impact on the community and the constituents of the community. Does the impact on the community justify the expenditure on the activities, and are the activities costing the right amount given the situation and experience elsewhere.

Over multiple cycles the aim is for the scale of the interventions to diminish and for the impact on community to get better and better, and the bad things to get smaller.



This is the essence of success and sustainability. In the long run the value of a good status in the community should be sufficient to pay for the cost of the essential ongoing activities that are needed to maintain the improved status.

There are several different analysis cycles

At a practical level, the analysis of data needs to be done so that the results are available "in time" for the best possible decisions to be made. Thus, for example, the following needs to be done in a matter of days, or even hours:

1. A decision to do larviciding should be made in time for the larviciding intervention to be effective before the larvae become flying adult mosquitoes,
2. Identification of resistance should be made in time so that the chemical or biological agents can be changed to address the resistance issue,
3. The following interventions were done yesterday / last night ... have the expected results been achieved?

On the other hand, some scientific data analysis that is initiated now may still be ongoing in several years time. The daily, weekly or monthly accumulation of data is perpetual, and eventually the data analysis might yield real clarity about the mechanisms that drive the optimization of malaria control interventions. Periodic feedback will improve the knowledge base for decisions and improve the management models.

EXPAND

EXPAND

EXPAND

EXPAND

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EXPAND

Purpose of surveillance and data collection

The purpose of surveillance and data collection is to learn what is going on in the best possible way. Surveillance data are the foundation for analysis of performance in conjunction with basic cost information derived from the financial accounting system.

Surveillance data serves not only to provide some metrics of performance, but is also vital to help understand the scientific behaviors that are going on and how best to make interventions toward the goal of reducing malaria prevalence.

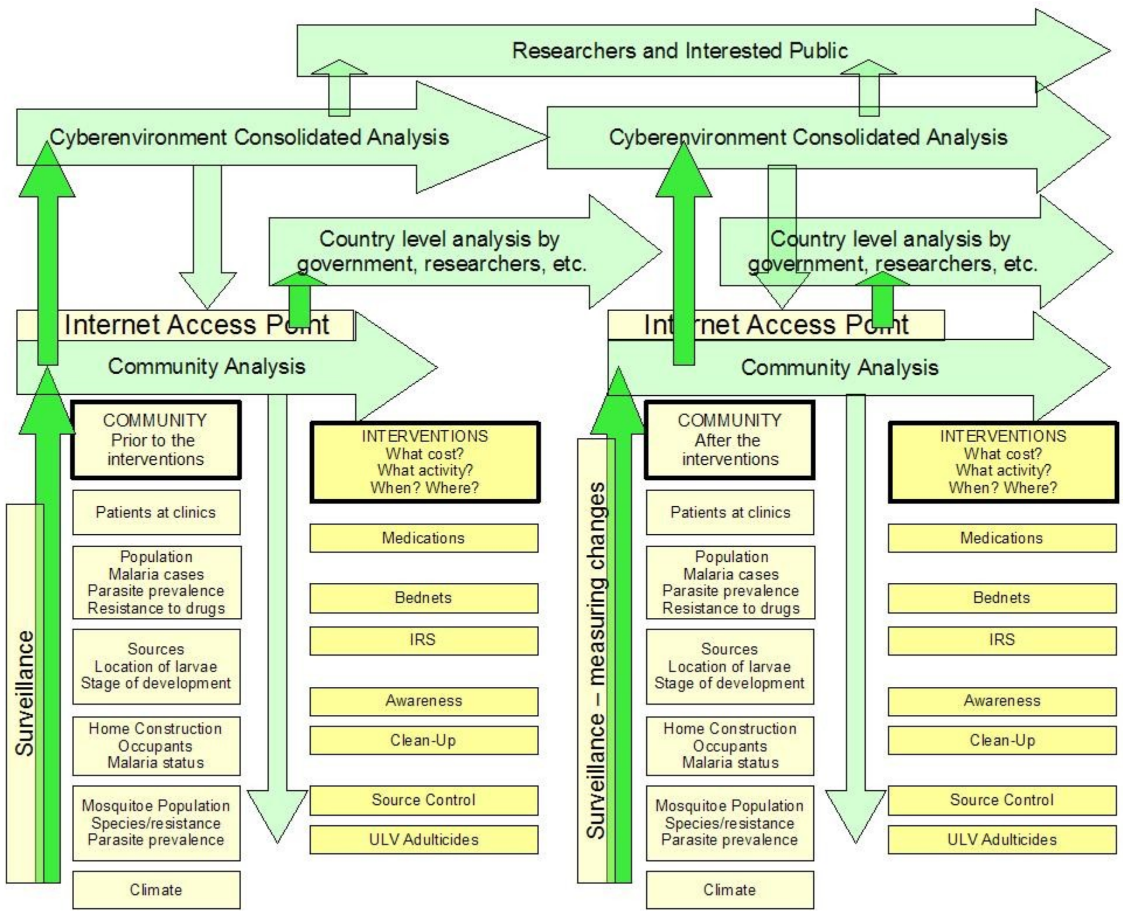
Data are the most cost effective when they are used in multiple ways. In the IMM case data are used:

1. Primarily:
    1. to inform the local malaria control community using rapid local analysis and local management information techniques ... such as a wall map and colored pins, and to update a local mirror of the centralized data, and
    2. to update the IMM cyberenvironment and data analysis system for cross area comparison, alternative intervention comparison, time series analysis, etc.

2. Secondarily:
    1. to update responsible government authorities about results,
    2. to update the mosquito and malaria research community about results, and
    3. to update the local malaria control communities about results

Moving data is easy and very low cost when there is economical access to the Internet, otherwise it is more of a challenge. In general data flows need to be in electronic form so that they can be transmitted using the Internet. The following data flow graphic shows the broad flows of data starting with surveillance activities:

Data Flow – Data Analysis Schematic



Data flows from surveillance and data collection to a place where community activities can be coordinated and data used at that level for operational analysis and decision making ... and the same data used in the cyberenvironment in an electronic form transmitted from an Internet access point. Data flows are shown in bright green.

There are also analysis actions and flows shown in light green. Data flowing into community analysis can be used almost immediately to make timely decisions about operational activities. A more in depth analysis can later confirm these decisions were the most appropriate, and give future guidance.

Data and analysis from the cyberenvironent are freely and easily available to the wide community of researchers and interested public.

Data flows start from surveillance and field data collection. These relate to all the key performance parameters that are included in the integrated malaria management protocols.

Data flows also included the operational details about the interventions including information about costs, the nature of the activities and data such as when and where the activities were carried out.

The availability of an Internet access point facilitates data transfer. Cooperation with the local telecentres and other organizations with Internet access is an important way to minimize costs and to develop a local capacity for the future.

Surveillance, Data Collection

Different types of surveillance and data collection

There are several different types of surveillance and data collection:

1. Building the knowledge base about the area,
    1. Use of satellite imagery can reduce the time and cost of establishing a basic understanding of the area,
    2. Combining this with ground truthing can validate the interpretation of the satellite imagery and give a sound basis for planning interventions and the associated continuing surveillance,
    3. Use of basic data collection techniques to add specific information needed for IMM interventions and the associated variable data updates ... but planned based on the initial knowledge obtained from satellite imagery. Note that this can help reduce the data collection time and costs by as much as 90%.
2. Getting data that changes rapidly ... within a daily cycle,
    1. Entomological data,
        1. About the adult mosquito population,
        2. About the larval habitats,
        3. About the weather conditions.
    2. Daily data about interventions,
        1. What interventions ...
            1. quantity and cost,
            2. expected and actual results.
3. Getting data that changes more slowly ... within a monthly cycle or a yearly cycle.
    1. Monthly summary of entomological data,
        1. About the adult mosquito population,
        2. About the larval habitats,
        3. About the weather conditions,
    2. Monthly summary about interventions,
        1. What interventions ...
            1. quantity and cost,
            2. expected and actual results.
    3. Epidemiological data,
        1. About the cases in the clinics,
        2. About the cases in the population at large,
        3. About the prevalence of malaria parasite in the human host.
    4. Socio-economic data,
        1. About the socio-economic condition of the community,
        2. About the socio-economic condition of the population.

Any technique for surveillance and data collection that works and is cost effective can be used. The use of labor intensive techniques can be more reliable than the use of more high tech approaches simply because the underlying infrastructure is not universally available. Paper based data collection in combination with local data entry into an electronic file may be the best way to optimize the data collection.

Data that are already being collected may be a good foundation for the data collection being described here. Maybe there is everything that is needed already being collected ... or maybe there are some elements that are missing or not in an appropriate format.

The progress of technology for data capture will be monitored carefully, and included in tests where appropriate and there is the potential for more cost effective and more sustainable data collection.

Spatial information

An important source of performance improvement

Mosquito and malaria control has a strong spatial characteristics that have a very large impact of control results. Accordingly spatial information and mapping are a very important part of cost effective high performance integrated malaria management.

Some of the characteristics that need to be taken into consideration include the following:

1. Where are people that are host to the malaria parasite located: where do these people live, where do they work, where do they congregate together, where do they travel to,
2. Where are the sources of mosquitoes,
3. Where do the mosquitoes travel and other details of their behavior including when they travel and how they behave relative to homes, people and animals,
4. Where are infected mosquitoes located,
5. What mosquito and malaria control interventions have been done: when and where.

In addition to mapping that shows the simple spatial dimension of the data, there also needs to be an ability to understand the changes that occur over time about a specific place and a specific characteristic of the data.

The ultimate measure of performance is how much has been spent in order to achieve an improvement, and to a great extent money spent well today will only result in sustainable value sometime in the future. However it is also possible to relate the money spent well today with various intermediate results, that in turn will produce the sustainable long term value.

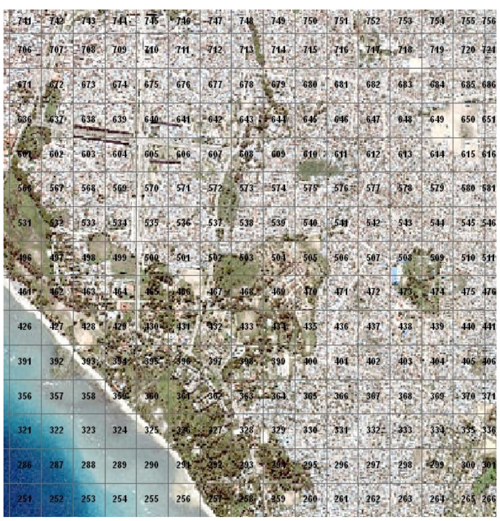
Getting baseline information from satellite imagery

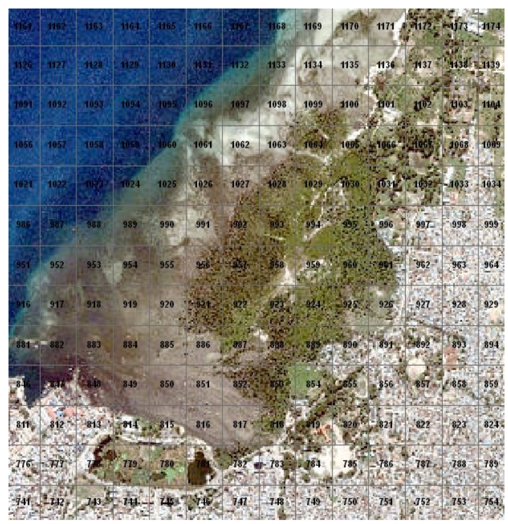
The use of satellite images is relatively new, and the techniques can be very powerful. It is important, however, to use them in ways that are cost effective and valuable.

Satellite imagery can be used for desk review and analysis in ways that are very time saving and cost effective. The following images were accessible using Google Maps and show respectively the whole of the Monrovia are in Liberia, and a small section of the built up area of Monrovia where individual houses can be identified.

On the all Monrovia image, the area within the yellow line is 50,000 acres, and the dark brown area is about 15,000 acres of tidal marsh right in the middle of the city where mosquitoes breed prolifically.

The following images are of Stone Town and its outskirts in Zanzibar. They are images supplied by QuickBird incorporating data from the visible and near-infra-red (NIR) spectra. A grid-based matrix has been overlaid.





These remote sensing and aerial/satellite images are the basis for a rapid build of data about the area, and a framework for rigorous spatial analysis. These images can also be used to develop an initial hypothesis about the profiles of mosquito and malaria prevalence in the area.

The first phase of surveillance is to validate some of the hypothesis derived from the remote sensing. This ground truthing is used both in the immediate process of establishing a baseline and data about the starting state, but also to initiate a process of determining what the optimum interventions strategy would be.

The techniques for doing this surveillance are established, and involve building statistically valid samples relative to each square of the grid.

The following is another example of the use of aerial imagery for planning. The area of potential high mosquito population is identified and a possible area to be treated laid out. With modern GPS equipment it is possible for the aircraft navigation system to be programmed so that spray is accurately delivered to the target area taking into account airspeed and wind over the ground.

Ground truthing

The early work of surveillance combines use of satellite imagery with ground verification of the conclusions derived from study of the images. This process of validating conclusions drawn from study of images should be taken very seriously because it has the potential to save both money and lives on a very large scale.

There has been work done that suggests that the effectiveness of anti-malaria and anti-mosquito interventions could be improved substantially by making planning assumptions based on what can be deduced from study of satellite images. Hardly any use of this is going on at the present time on the large scale interventions that have been funded by the international community.

Techniques for data collection

The cost effectiveness of data collection can be enhanced by doing data collection in the best possible way. The following are some of the techniques that can be used. Some of these are incorporated in the design of the field data collection forms, whether in a paper form or electronic form.

1. Much of the data needed for efficient data processing and analysis is "permanent" and does not need to be updated
2. Other data changes frequently and this information needs to be collected and turned into electronic form as efficiently as possible.
3. In addition there needs to be administration information to facilitate checking and holding data collection staff accountable.

4. Preprinted data collection sheets facilitate the work of the data collectors, and make it possible for the data collectors to correct erroneous permanent data.
5. Use of GPS information can be helpful in ensuring that data being collected relate to the specific location identified in the paper-work,
6. Use of emerging technologies like the SemaPedia system may be useful in helping to get accurate data entry and easy access to associated information.

Scouting or surveillance work

Scouting or surveillance work is the foundation for meaningful data and performance metrics. Data is not easily improved after it is collected. The importance of a sound process for data collection cannot be over-emphasized. Mosquito abatement scouts or surveillance teams must be trained to sample and monitor mosquito sources, mosquito populations and weather conditions using a variety of sampling tools in order to provide accurate information for targeted mosquito control interventions.

Accordingly, the scouting or surveillance crew(s) must be sufficiently staffed, trained and organized to be able to:

1. With respect to source control:
    1. find ALL of the potential larval habitats and locate specific locations of all larvae in all sites,
    2. report the occurrence of larvae early in their development while they are still very concentrated (near oviposition site),
    3. record information that will enable data analysis to be done, including the preparation of maps that can be used by the insecticide application teams,
    4. inform the program coordinator in time for application to attack larvae before dispersal and certainly before emergence,
    5. do post-treatment checks to verify that all of the aquatic habitats are free from larvae, and if not to report back the information,
2. With respect to adult mosquito control:
    1. use a variety of surveillance tools to monitor the incidence of adult mosquitoes either directly by landing/light traps, gravid traps, egg raft traps and oviposition traps.
3. With respect to meteorological data:
    1. collect data about rainfall, temperature, humidity, barometric pressure, and wind velocity and direction.

Data collection about malaria prevalence and malaria incidence

The critical goal of the program is to reduce the prevalence of the malaria parasite in the population and the incidence of malaria.

Data collection about malaria prevalence and malaria incidence is needed for two purposes:

1. To facilitate the treatment of people with malaria so that their health can be improved,

2. To help reduce the pool of malaria parasite in the human host so that the level of transmission of the parasite from person to mosquito to person can be reduced,
3. To help measure the effectiveness of various medical treatments,
4. To provide a key metric of performance and a way to measure the value of the program's multiple interventions.

Rapid local analysis for immediate decision making

The local area coordinator uses the scouting surveillance data to plan for appropriate intervention activities. The plan is based on data analysis taking into consideration the mosquito species, whether a dangerous vector or a simple nuisance, the potential production by site, etc. and organizes the sites into a priority list for treatment.

The idea of rapid decision making based on local information is critical to the success of community centric sustainable development and to the success of a malaria control program. A reasonable decision made at the right time is likely to be much more valuable that a perfect decision that can never be made, because the time to make it has past.

In this circumstance, the detailed analysis of the situation and the recommendation concerning the optimum decision is used to help inform the local decision maker so that better decisions can be made in the future.

In the case of a mosquito and vector control operation in the United States, todays surveillance information is reviewed as soon as it is possible, and by 2.30 in the afternoon a decision is made as to what interventions are going to take place overnight. Very rapid identification of a problem and very rapid response is both the best for the public health outcome as well as also being the most cost effective.

Data Logistics, Data Store, Cyberenvironment and Data Analysis

Data Logistics

Many approaches to data logistics

The challenges associated with data collection continue through all phases of data processing, storage and transmission. There is too little communications infrastructure, it is unreliable and it is expensive.

Getting data from its original collection to the data store reliably and at low cost is a challenge. Technology is changing rapidly and it is becoming easier to communicate from remote locations.

The IMMC will cooperate with existing entities to make the best possible communication channel, with the goal of having rapid local analysis for immediate decision making, and a perpetual data store that will be facilitate long term analysis for scientific purposes and periodic analysis to feed a management information system.

The management information system provide oversight information to confirm the immediate decisions were consistent with an optimization strategy, and the give the management team information and progress and guidance about strategic direction that will optimize performance.

All available paths for communications will be taken into consideration, including using local telecentres, local organizations, and others to facilitate access to computer systems and to the Internet.

Part of the data flow has to be rapidly available for decisions that need to be made from day to day. While some information can reasonably be reviewed once a month, a lot of the data are needed for decisions that are made every day.

Getting data from data collection to an organized data store

This is a challenge, but technically possible. Modern information and communications technology (ICT) is very powerful but it requires a certain level of infrastructure and a reasonable cost structure. Universal access to the Internet does not yet exist, and often access is very expensive.

In some places there are organizations that have established their own private networks. Some of these networks are operated by private corporations (such as oil industry companies) and by multilateral institutions such as the World Bank. These networks have the technical capacity to carry the data flow that supports IMMC activities.

In some places there are international NGOs that have set up some form of Internet access and international data communication capability.

In some places there are telecentres that have some level of data communication capacity. The telecentres have an almost universal desire to help but are challenged because of the available communications infrastructure and their precarious financial condition. The telecentre network with their community based operations are the natural local partner for data communication.

The very rapid evolution of ICT means that it is likely that cell-phone data entry will be available almost universally within a short period of time. The exact manner that data will be transmitted will need to be determined for each community, and the local program.

Cooperation with African telecentres

There have been many initiatives to help organizations of many types establish telecentres in Africa to help close the "digital divide". Most of these telecentres have great difficulty surviving after the external financing ends, but they have real value both the the local community and the world community.

Real value for a local community is derived from something of value happening in the community. Reducing the burden of malaria has real value in the community, and the use of the capacity of a telecentre to help with data processing and Internet access related to the data about malaria and the control interventions going on could be a very useful piece of the process, and remunerated accordingly.

Local, rapid use of data and data analysis

Local daily data analysis

Some decisions need to be taken rapidly, and simple, rapid data analysis is sufficient for good decisions to be made without a lot of sophisticated analysis.

The mosquito life cycle is measured in days, and interventions are effective when they are done at the right time, and of no value when delayed.

In a typical mosquito abatement district setting it is usual to find a wall map and colored pins indicating issues of concern. This works very well to pinpoint problems and plan immediate interventions.

This analysis complementary to the cyberenvironment data analysis

The local rapid data analysis is complementary to the cyberenvironment data analysis. Exactly the same underlying data are used in the two analysis sets, but for very different purposes, albeit towards the same long term goal. What the local analysis does is to help operational decision makers to function as effectively as possible based on the information that is available now.

The same data incorporated in the cyberenvironment (discussed next) can be used to help understand the complex behavior and help optimize future interventions.

High volume complex multi-variable analysis

Cyberenvironment for Integrated Malaria Management (CE for IMM)

The science involved with mosquitoes, malaria parasites and the human host is complex. While it is possible to build and operate a quite simple models of behavior of each of the elements, and to create some management information about performance, such a model would ignore many of the issues that concern scientists such as the potential for uncontrolled pandemics and the unchecked emergence of resistance and other mutations.

A cyberenvironment does better than a wallmap, in essence because it can handle the same amount of data for an unlimited time series. for an unlimited number of geographic locations, and an unlimited number of different combinations of biological conditions and control interventions.

In the initial stages the cyberenvironment will not add substantial incremental value over simpler models, especially where there are effective local management information data flows. However, the cyberenvironment will have an ability to provide ongoing scientific analysis and management information very cost effectively on a long term basis. This is important because it must be anticipated that malaria will rebound to endemic levels quite quickly unless there are rapid control interventions. The best way to prevent a rebound is for there to be timely surveillance, timely analysis and timely reaction. This is exactly what a cyberenvironment for IMM will do.

The proposed cyberenvironment (CE) for IMM should not be thought of as the product of one-time development projects, but as a living infrastructure that will evolve with technology and with the scientific and engineering discoveries and understanding over time. Towards this end, the NCSA will develop a CE for IMM on the principles of sustainability and adaptability using current and emerging techniques, such as web and grid services, translating/integrating middleware (e.g., MyProxy), global unique identifiers and metadata, workflow, meta-workflow and provenance, and semantic descriptions of resources and data. These types of technologies lower the architectural coupling of cyberinfrastructure and CE components while maintaining end-to-end capabilities.

The CE for IMM will provide a computational framework for operational control, research and management information. All malaria-related parameters, including entomological, parasitological, socio-economic and case management data need to be tracked by household and mosquito source identifier numbers.

With these data, the cyberenvironment will be able to:

1. Simulate agent-based models of transmission and grid-based models of landscapes,
2. Tailor intervention strategies to local characteristics,
3. Integrate implementation and statistical analyses,
4. Share data and analyses for decision making,
5. Analyze progress for economic implications,
6. Serve as a data store for other future research.

Variants of the CE for IMM can be deployed for the control of other vector borne diseases such as Dengue Fever in Costa Rica, HIV in South Africa and multiple diseases in Brazil.

It is anticipated that understanding the specific interactions between the various aspects of mosquitoes, malaria and humans and the various possible interventions in specific locations will make it possible for models to optimize both the value of the interventions and the cost. The synergy of integrated comprehensive actions should make very substantial improvements in cost effectiveness possible. The proposed CE for IMM will serve not only the selected pilot locations but will also be capable for deployment into any geographic area.

Management Information and Performance Metrics

A LOT OF WORK TO BE DONE HERE

MOST OF THE INFO DETAIL WAS MOVED TO THE ANNEX ... NEED SUMMARY MATERIAL FOR THIS SECTIONS

About Costs and Value

Projected costs

THIS SECTION IS MORE DETAILED THAN THE SECTION AT THE BEGINNING OF THE REPORT

THIS IS GENERIC COST, NOT SPECIFIC TO A SINGLE LOCATION

MAKES USE OF A TABLE OF STANDARD COSTS

If the program is initially deployed in Kenya and Tanzania at the locations identified above, the cost is expected to be $ 1.5 million over a period of five years, made up as follows:

	Setting up CE ... connecting each new area	Setting up in area ... arranging data collection and logistics	Ongoing costs in area for 5 years	TOTAL
Initial mobilization	$800			$800
Kenya	$40	$90	$120	$250
Zanzibar	$40	$110	$150	$300
Contingency	$90	$30	$30	$150
TOTAL	$970	$230	$300	$1,500

There are three primary components of cost:

(1) one is to set up the cyberenvironment and build the initial data structure and model based on the IMM development work that has already been done. While ongoing processing costs will be very low, the work needed to ensure that the processing is rigorous and useful is significant. Absolute rigor in the development of the metadata and the analysis framework is essential. This

includes setting up a cost and value component of the cyberenvironment. There are also costs associated with making data flows from different geographic locations and jurisdictions compatible.

(2) the second is to set up the surveillance, data collection, data logistics and oversight structure for each of the selected operating areas. The initial operating protocols for field operations and data collection have to reflect the data flows needed by the IMM cyberenvironment, and have to include all the needed cost information. The initial set up includes helping with the orientation and training of local staff and professionals; and,

(3) to maintain these activities on a perpetual basis. The cost can be minimized with accurate data collection, local staff doing all the local data collection and analysis and use of the IMM cyberenvironment with a minimum of changes.

Expanding the IMMC cyberenvironment program to all areas where PMI is operating will cost less than 5% of total project costs, and will provide a good understanding of the costs incurred for the various interventions, and the results being achieved. The expectation is that the management information derived from this work will show in a clear and conclusive manner how cost effective different approaches to malaria reduction are being.

Projected value

The IMMC team includes experts with some of the best knowledge and experience of malaria and mosquito management, as well as knowledge of Africa and other malaria endemic regions. By bringing the competence of UAB with the expertise of NCSA, the group is able to facilitate the use of surveillance and scientific data in an efficient way to optimize the use of science in managing malaria. The value of state of the art scientific analysis using state of the art computing in collaboration with a large base of data from malaria affected areas is, in itself, substantial.

But in addition, IMMC and NCSA are cooperating with Tr-Ac-Net and the Millennium Institute to incorporate financial costs and economic impacts into the model, and to provide "management information" or the key metrics for operational decision making and the allocation of scarce resources. The value of good management information is substantial with the potential to make it possible to achieve more cost effective performance. Some preliminary indications are that better decision making about operations and the allocation of resources could improve outcomes by a factor of 10, or even 100. In a regime of limited resources this is a very important improvement in outcome.

Cyberenvironment is key element for management information

The cyberenvironment for integrated malaria management is a key element for IMM management information. It facilitates rapid analysis of complex data, and makes it possible to have simple, clear, timely, material information to inform decision making.

Management information is important and ubiquitous

Management information is everywhere. It is an integral part of everyone's life, but not usually recognized. In the area of sports, the measurement of performance is central to everything. In a team sport, the winner of the game is the one that scores the most, and league standings are based on the number of wins, losses and draws. There is a lot of clarity about how scores are kept.

In sports, in addition to the metric of winning and losing there are also the data about many other parameters of performance. Terms like “runs batted in”, “throws completed”, “yards run” are all part of a deeper set of metrics that help determine how to go about improving the team so that there are more wins and less losses.

In the area of integrated mosquito and malaria control, the primary goal is to reduce the impact of malaria on the society ... and to do this with the minimum use of available resources. Simply put, this is getting the most VALUE for the least COST. This is the win / lose dimension of the performance metric.

A secondary level of performance measurement are the operational metrics. These are measures of operational activity and their related costs. The operational activity may or may not have an immediate direct top level value, but, nevertheless do contribute to the team win ... trying winning a football game without a high performance set of line backers.

One key characteristic of management information is that it includes data that are “material” and excludes detail that has little immediate relevance. Another is that management information is timely and shows clearly what is being accomplished.

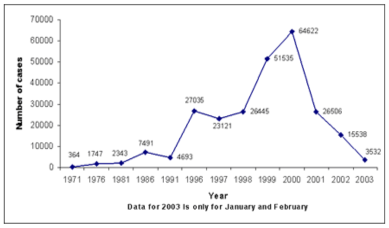
Management is a pragmatic construct used almost universally in high performance corporate organizations and is simply as little data as possible at the right time that ensures that decision makers make the best possible decision.

Most management information systems combine accounting information with other key metrics that reflect important operating elements. Accounting reports on their own are only a part of management information, and operational data also is only a part of management information.

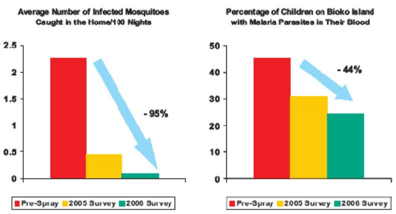
Making the information clear

The data presented in the following examples are clear. In the first case (Example 1) the measure was low, then increased rapidly, and then decreased again. The measure is the number of malaria cases, which rapidly increased when the use of DDT was stopped, and then decreased when DDT was reintroduced. This is experience from Kwa-Zulu Natal.

Example 1



Example 2



Example 2 shows progress in another measure. The left three year series shows malaria infected mosquitoes down 95% and the right series shows children with malaria parasites in their blood down 44%. This is experience from the Marathon Oil program on Bioko Island, Equatorial Guinea.

At their face value, these graphics are clear, but the data presented are not enough to be effective for management information and decision making. These presentations show how results are moving, but they do not show anything about the cost of the interventions associated with these results.

Performance metrics ... relating cost to results

There are two steps in relating costs to results:

1. Getting cost information about a specific identifiable intervention, and relating the cost to the intervention to a quantity of the activity
   1. This may be acres treated, or hours of activity, or the population affected by the treatment, and
   2. for example, the percent reduction in mosquito population from before to after the intervention.
2. Understanding the impact of the specific intervention on the end goal of:
   1. Reducing the socio-economic impact of malaria in the community, and
   2. The various measures for prevalence of malaria in the community:
      1. Prevalence in the human host population
      2. Prevalence in the mosquito population

The first step is specific to every different type of intervention, and to each location and each time the intervention is used.

This means that there are many elements of data, and potentially too many data feedbacks to be useful. One technique available to simplify the cost performance data by having a standard cost model for each type of intervention.

The use of standard costs

A preliminary standard cost model shows that for example:

1. For insecticide treated bednets (ITN)
    1. The ex-factory unit cost is $2.50
    2. The shipping and central warehousing costs are $2.00
    3. The distribution costs are $2.00
    4. The overhead and admin costs are $1.00
    5. For a TOTAL of $7.50
2. For interior residual spraying (IRS)
    1. The cost per room is made up of the following:
        1. Pesticide cost is $3.00 (varies depending on the pesticide and only $2.00 when DDT is used)
        2. Labor is $1.50
        3. Equipment is $0.50
        4. For a TOTAL of $5.00
3. For surveillance, data collection and field analysis:
    1. The cost per month per 100 grid units is made up of the following:
        1. Labor $200
        2. Transport $50
        3. Supplies $20
        4. For a total of $270
4. For source control (larvaciding):
    1. The cost per intervention

The management process embraced by IMMC (and Tr-Ac-Net) is one where "in time" in formation is used pro-actively to improve the activities so that the ultimate goals are achieved at least cost.

The management challenge that has always to be addressed is whether or not scarce resources are being used in the best possible way to achieve the desired results, and to the extent that they are not, how to change the activities so that better results are being achieved.

The IMMC approach that has quick data and quick analysis used for quick decision and optimized day to day operations, in combination with in depth analysis of the surveillance data, the activities or interventions undertaken, and the immediate and cumulative changes that are happening provides optimum operational information and optimum management oversight information.

The management information is made far clearer when the amount of detail is a minimum and the presentation has a focus on the material issues, the items that really matter. For example, in the case of cost, it is not very useful to know all the small differences in cost day by day, but it is useful to know that the costs each day are always exceeding the costs that would be the norm for this activity ... and this should get an explanation. In the IMMC approach to cost, every activity has a standard cost which serves as a benchmark for operating efficiency.

THIS SECTION NEEDS A LOT OF WORK ... A LOT

Performance Considerations
Strategic Issues

Strategy for sustainability

The IMMC strategy for sustainability has two components:

1. A commitment to low costs:
    1. training so that local people can do the essential work at local salary and wage rates in perpetuity,
    2. scale so that computer analysis of data is extremely low cost per data transaction.
2. A commitment to getting results that have substantial tangible economic value:
    1. reduction in morbidity so that economic activity is not constrained by recurrent bouts of malaria,
    2. reduction in the prevalence of malaria in both human host and the mosquito so that the need for perpetual high cost interventions is reduced, and
    3. ongoing analysis so that there can be minimum cost interventions that sustain progress.

A strategy of cooperation and collaboration

The malaria control sub-sector includes many organizations. Every organization can gain benefit from a low cost high performance scientific data analysis and management information system that is developed and deployed specifically to address the issues of the malaria control sector.

Accordingly the IMMC plans cooperation with the various actors to provide an information service that is useful for the participants. The exact form of cooperation will depend on the circumstances of an individual country and community, though the underlying data flows, data analysis and management information will not change much, and the ability to do cross location comparisons will not usually be compromised.

Some of the many organizations involved include:

1. Funding organizations like:
    1. The President's Malaria Initiative in the United States,
    2. The malaria component of the Global Fund for AIDS, Tuberculosis and Malaria,
    3. The international corporate community operating in Africa,
    4. The philanthropic community such as the Bill and Melinda Gates Foundation.
2. Governmental organizations engaged in malaria control activities like:
    1. Ministries of Health, and their malaria control activities,
    2. Hospitals and clinics providing malaria case management.
3. International non-governmental organizations engaged in malaria control activities like:
    1. RTI - Research Triangle Institute,

   2. PSI – Population Services International,
   3. Merlin,
   4. MSF – Doctors Without Borders.
4. Academic and Research Institutions like:
   1. North American and European Universities,
   2. African Universities,
   3. African research organizations like ICIPE, KEMRI, etc.
5. Community organizations like:
   1. Mosquito and vector control districts in the USA,
   2. Community based organizations,
   3. Faith based organizations ... churches,
   4. Local governance organizations.

A strategy to supplement local capacity

The IMMC strategy envisions having an effective local capacity for any mosquito and malaria control intervention that will optimize results. This comes after a first step that seeks to make the best use of resources that are already deployed in the area. An optimized program needs to be structured so that whatever is needed for a comprehensive program of mosquito and malaria control interventions is available in time, and at an economic cost from a reasonable local location.

Philosophy of support for local organizations

The broad philosophy is that as much as possible must be done in Africa by local Africans, with the goal of doing it right and doing it at least cost. The IMMC is organized so that there is professional and technical support available quickly and at reasonable cost.

All the practical expertise needed is available, but it is dispersed through the mosquito and vector control industry, and generally not available under the conditions and contractual terms of engagement usually offered by organizations, including donors and NGOs, in the international relief and development sector. The IMMC has a team that serves as the focal point for coordination of any needed support.

Community Focus: The Role of Mosquito and Vector Control Districts

Mosquito and Vector Control Districts (MVCD) or Mosquito Abatement Districts (MAD) are central to the success of vector control in the USA. They are controlled by local communities, usually paid for by local tax revenues, and are charged with mosquito and vector control as a part of public health.

Mosquito and vector control districts in the USA have a history that goes back almost 100 years. One of the first mosquito control districts was created in California in Marin County in 1915 to combat salt marsh mosquitoes. More and more mosquito abatement districts were formed through the 20's and 30's. In California and much of the USA the climate and topography supports the development of human disease vectors and nuisance pests. Because of continuing surveillance and active intervention when needed the mosquito and vector control programs have kept local malaria cases in the USA to near zero. While malaria is under control, the risk of other vector borne diseases such as West Nile Virus makes constant vigilance important for public health where early detection and early action is a requisite to stop any impending epidemic.

Mosquito and vector control districts in the United States (as well as places like Darwin, Australia) use all the possible interventions that science shows will help to control potential vectors and be safe for human populations and the environment. Where urgent action is required the use of ultra-low-volume (ULV) spraying of pesticides like Dibrom may be used. Where surveillance shows that the vector can be controlled by larviciding, then larviciding may be used. In all control interventions great care is taken that there is no hazard to human health or to the environment. While the biological agents and chemicals used are toxic to the target vectors they are not toxic to humans and not damaging to the environment and the eco-system as a whole.

Community based MVCDs may have a role in Africa to make mosquito and vector control sustainable. Life is local, and getting malaria under control is local. The vector operates locally, and can only be controlled locally. The community has a deep knowledge of the facts about the community: the people, the geography, the entomology, the epidemiology, and the environment. The community can do surveillance on a continuing basis to provide the data needed to determine what interventions are needed to improve the health of the community and maintain an improved health status.

When a MVCDs need additional support in the USA, there are easily accessible consultants, service organizations and others who can undertake the interventions and have all the equipment and experience needed. The same sort of support is needed for MVCDs in Africa, whether these are provided by government, by the private sector or by some innovative public/private partnership entity.

The IMMC has a contact network throughout the MVCD community in the United States and around the world. This community can be of long term value in maintaining success in the control of dangerous vectors like the mosquito.

Community focus: field surveillance and data collection

Data concerning everything that has an impact on the success of mosquito and malaria control needs to be measured and the data collected and included in a process that ensures that local decisions are made correctly, as well as being used to monitor for more strategic issues in both science and operations.

Local people have to be empowered to do the surveillance and collect the data. This is not quickly done, but with awareness and training local people can be trained and will do good work at reasonable cost. Ongoing oversight and training is required as in any activity.

The data being collected will provide a range of data about the people, the geography, the entomology, the epidemiology, and the environment ... in much the same way in Africa as is routine in mosquito control districts in the USA.

At the present time there are many ways of collecting data, from written papers to very sophisticated electronic devices incorporating global position information and continuously connected to a computer database. Exactly how the data are collected is less important than that the needed data are being collected.

Community level analysis, feedback and action

As much as possible the community should take responsibility for the performance of the program, and must therefore be empowered to do analysis and make local decisions to control the mosquito and malaria situation. This makes it possible to appropriate decisions to be made on a timely basis in the field where intervention is needed.

Training and operational support

The three most important things that IMMC will do are: training, training and training.

There is a massive amount of knowledge, but there is a challenge in getting people who need the knowledge to have it and to be in a position to use it.

After training there is the need to have operational support so that a decision can be turned into practical action.

The IMMC focus on data and management information helps to get decisions made that optimize the use of scarce resources, but this only will result in progress towards the ultimate goal if the ability to translate decisions into action also exists. Accordingly IMMC includes the capacity to facilitate the interventions and undertake operational activities. Both ADAPCO and West Coast Aerial Applicators have extensive practical experience that can be utilized where local capacity does not exist.

A strategy to assist wherever malaria is a burden

There are many possible sites where the value of the IMM metrics can be demonstrated. These include:

1. Kenya, where UAB has an active project located in XXX. It has an area of XXX acres and a population of XXX. The primary intervention is vector control using environment improvement and larviciding. There is an existing system of surveillance to support these specific interventions.
2. Tanzania, where PMI has an active project in Zanzibar. PMI has already distributed long lasting insecticide treated bednets in Zanzibar and is embarking on interior residual spraying (IRS). Others, specifically the Global Fund for Aids, Tuberculosis and Malaria, have funded anti-malarial medication and bednets in the same area. While there are reports of success in reducing the prevalence of malaria, the data to support has not been collected and analyzed.
3. There are many other countries in Africa where existing PMI funded projects have operations and some surveillance and data collection activities. Any of these projects could be used to demonstrate the value of the IMMC cyberenvironment, operations analysis and management information process to optimize malaria control program cost effectiveness.

4. The IMMC initiative is not limited to countries that are specifically funded by any organization. The initial focus is Africa, but the methodology has universal applicability.

The development of this program anticipates that its deployment can be anywhere that malaria or other vector borne diseases are a problem. Accordingly the design anticipates the need for replication and scalability.

Strategy for environmental protection

Knowledge of pesticides and biological agents

A knowledge of pesticides and biological agents is absolutely vital to success in the control of mosquitoes and malaria. While the spray technologies have evolved to make it possible to spray very efficiently, the target is not going to be killed if the resistance issue is not addressed fully. The decisions made about chemical use will be largely determined by cost, but cost with no results is expensive, and depending on the situation, the chemical used should be the one that gets the best results.

The IMMC uses the expertise of ADAPCO, one of the largest advisors to the vector control industry to ensure that IMM interventions are making best use of pesticides and biological agents.

Strategy to minimize the risk of resistance

Prevent human reinfection ad infinitum

No matter what drug is being used, if there is continuing reinfection, the likelihood of a fairly rapid buildup of resistance is high. '

The best way to eliminate the problem of resistance to medications is for the level of reinfection to be reduced to a very low level.

The build up of resistance is also accelerated when incorrect prescriptions are being made and when there are incomplete treatments. Both are widespread and cause by the poverty of many patients and the poor ethics of some business people and traders.

Resistance of mosquitoes to pesticides

There is a natural resistance in most pest species to some or other form of pesticide. Poor pesticide use practices can accelerate natural selection so that resistance builds up very rapidly, but a well managed vector control regime addresses this as an integral part of its operating protocol. If the anticipated results (kill rate) is not achieved, the reason is immediately identified and action taken to achieve a high kill rate using an alternative type of pesticide.

ANNEX 1-1

Organizations Forming IMMC

The University of Alabama - Birmingham

The Division of Infectious Diseases, William C. Gorgas Center for Geographic Medicine at the University Alabama-Birmingham School of Medicine (UAB) is the lead organization for the Integrated Malaria Management Consortium (IMMC). This institution has a long history of work with the problem of infectious diseases internationally, and the Center is named after Colonel Gorgas who is famous for his success in controlling malaria during the construction of the Panama Canal a century ago.

The UAB is a natural focal point for IMMC because of its strength in both the medical dimension of the malaria crisis and the entomological dimension. Located in the South of the United States, the University is close to areas where mosquito control is still an important component of public health activities and where Mosquito and Vector Control Districts are very active.

UAB has links with other universities in the United States where related research is be undertaken.

UAB also has strong connections with universities and research institutions in Africa that are involved with health sciences and the control of disease.

National Center for Supercomputing Applications

IMMC is cooperating with the Biomedical Computing group at the National Center for Supercomputing Applications (NCSA), Institute for Advanced Computing Applications and Technologies, University of Illinois at Champagne-Urbana to develop and operate a cyberenvironment for integrated malaria management (CE for IMM).

The NCSA is developing cyberenvironments to use data analysis to help gain a better understanding of the world's most complex problems. NCSA has access to some of the most powerful computing systems in the world, and has the capability to process any of the complex problems of mosquitoes and malaria within the time needed for optimum results.

Transparency and Accountability Network (Tr-Ac-Net)

The Transparency and Accountability Network (Tr-Ac-Net) is a focal point for performance metrics and management information. The key staff in the USA, India and Africa have been involved in corporate management and now are engaged in management issues related to the international relief and development sector, especially the use of technology and a focus on community centric sustainable development.

Tr-Ac-Net brings a network of professional Africans together to help with the ongoing monitoring and management of surveillance, data collection and data logistics. Tr-Ac-Net cooperates with African telecenters and other local African organizations in support of community development, of which malaria control is an important part.

Tr-Ac-Net started as a management consulting firm in 1978, and under the name Burgess Management Associates (BMA) carried out assignments for the World Bank, UNDP and other UN agencies, IFAD, KISR and others. The assignments included government financial management, development planning, and aid coordination as well as planning in crisis conditions brought on by natural disasters and war. BMA had expertise in management information and using information and communications technology (ICT) to create easily accessible decision support information. In 2000, the name was changed to ATCnet and in 2003 to Tr-Ac-Net Inc. with a focus on transparency and accountability and management information and services for the relief and development sector and support for diverse initiatives for development at the community level.

ADAPCO and West Coast Aerial Applicators

ADAPCO is the largest vector control consultants and contractors in the United States and is cooperating with IMMC to ensure that IMMC has access to the very latest and best technologies and equipment available commercially for mosquito control. ADAPCO operates almost exclusively in the United States and adheres to the highest standards of environmental responsibility. ADAPCO was established in 1985 as a marketer of products to the vector control and mosquito control sector, and now distributes a full line of vector control and mosquito control products and associated application equipment and technology. It is headquartered in Florida and has field representatives to provide customer support. Associated firms provide all contract services for all aspects of vector control include aerial operations, pesticide control systems and management and geographic information systems.

West Coast Aerial Applicators (WCAA) is a company registered in Liberia that has the capacity to carry out vector control operations in Africa, either using vehicle mounted equipment or aircraft mounted equipment. WCAA pilots have more than 30 years of flying experience, mostly in developing countries. They have the commitment to train Africans to do all of the work needed for sustainable vector control. The predecessor company has more than 20 years aircraft operations experience in Africa, as well as similar experience in the United States. The company has a commitment to training local staff in all areas of management and technical operations.

African institutions

IMMC cooperates with the academic community and researchers at many African institutions including (but not limited to) the following:

1. **Some Universities:**
    1. University of Nairobi in Kenya
    2. Kenyatta University in Kenya

    3. Makerere University in Uganda
    4. University of Malawi
    5. Others ...
2. **Some Research Organizations**
    1. International Centre of Insect Physiology and Ecology (ICIPE) in Kenya
    2. Eastern and Southern Africa Centre for Internal Parasite Control (ESACIPAC) in Kenya
    3. African Society of Bioinformatics and Computational Biology (ASBCB)
    4. International Livestock Research Institute (ILRI) in Kenya
    5. Kenya Medical Research Institute (KEMRI) in Kenya
    6. National Institute for Medical Research (NIMR) in Tanzania
    7. Africa Malaria Network (AMANET) in Tanzania
    8. Others ...
3. **Some Networks of Telecenters including:**
    1. Ugabytes ... a network for telecenters based in Uganda
    2. KENET ... a network of telecenters based in Kenya
    3. Others ...
4. **Some Community Organizations and Local NGOs like:**
    1. CORE Uganda in Uganda
    2. Fantsuam Foundation in Nigeria
    3. Others ...

Mosquito Abatement Districts (MADs)

IMMC has the benefit of the expertise and advice from the US Mosquito Abatement Districts that are helping to keep mosquitoes and other insect pests under control. Though their mission is less urgent in the US and usually more associated with nuisance control than the urgent health mission needed in Africa, their operational expertise is valuable to IMMC.

IMMC has also benefited from guidance from the Malaria Control Unit in Darwin, Australia where there is continuing vigilance to keep mosquitoes and malaria under control and prevent rebuilding of a malarial environment.

ANNEX 1-2

About NCSA

Some Current Cyberenvironment Projects

Environmental Cyberinfrastructure Demonstrator (ECID) Project

NCSA's ECID project is developing a cyberenvironment to demonstrate an end-to-end cyberinfrastructure capable of supporting environmental observatories, such as the WATer and Environmental Research System (WATERS) Network. ECID is based on a set of coordinating technologies that provide unique capabilities for integrating local and remote work and for capturing and exploiting data and interaction provenance.

The CyberCollaboratory portal, provides collaboration tools to discover, share, analyze, and discuss data and information. The CyberIntegrator is an exploratory workflow integration engine combining heterogeneous (local and remote) tools and workflows into "meta-workflows" to support complex scientific analyses and simulations. Both of these tools record rich provenance into the RDF-based Tupelo 2 Toolkit where it can be graphically browsed or used through CI-KNOW, a social network analysis suite, to provide context-specific recommendations within the CyberCollaboratory and CyberIntegrator. These capabilities, and the ability to dynamically connect new tools into group spaces, workflows, and provenance trails, will be critical to the next generation of community-scale, persistent cyberinfrastructure efforts.

http://cleaner.ncsa.uiuc.edu/cybercollab/web/CIDemo/Home#

Linked Environments for Atmospheric Discovery (LEAD) Project

A multi-disciplinary effort involving nine institutions and more than 100 scientists, students, and technical staff, LEAD comprises an array of services, applications, interfaces, and local and remote computing, networking, and storage resources for studying and forecasting mesoscale weather. LEAD is addressing fundamental research challenges in creating an integrated, scalable framework for identifying, accessing, preparing, assimilating, predicting, managing, analyzing, mining, and visualizing a broad array of meteorological data and model output independent of format and physical location and in a dynamically adaptive manner in contrast to today's fixed time schedules and configurations used in taking observations and running models.

NCSA's role in LEAD focuses on several areas including development of an ensemble broker for executing sets of simulations on distributed resources, such as the Teragrid, in the context of the overall LEAD framework, development of on-demand scheduling capabilities in a production environment, and meteorological modeling expertise.

LEAD capabilities are being released to both the research and educational communities and are designed to lower the barrier for using complex end-to-end weather technologies on the grid, increase the sophistication of mesoscale research problems that can be addressed, and facilitate rapid understanding, experiment design, and execution

https://portal.leadproject.org

Mid-American Earthquake Center Visualization (MAEviz) Cyberenvironment

A collaborative project between the Mid-American Earthquake Center and NCSA, MAEviz combines spatial information, data, and visual information into a CE for performing seismic loss assessment and analysis. It is a single interface that integrates a variety of data sources and types, so that earthquake engineers and policy makers can understand the physical, social, and economic ramifications of the next trembler. The system's software components enable engineers to develop risk-reduction strategies or mitigation plans that reflect possible threats and outcomes. This CE includes: visualization and data analysis, workflow services, collaborative tools, application codes, interfaces, and provenance/semantic services.

MAEviz's modular architecture not only makes it more flexible than other loss assessment software, but also more dynamic. As researchers such as those in the MAE Center produce algorithms and data that can provide more accurate estimates, the new modules can be swapped easily so decisions can always be based on the best science available. Because MAEviz is a network-aware environment, new software and data can be downloaded, and new results can be uploaded and shared between collaborating responders as desired, through a secure web portal. If disaster strikes, plans can be retrieved from the network and damage assessments can be recomputed with the latest information about the event.

https://maeviz.cee.uiuc.edu:8080/portal

Infectious Disease Cyberenvironment (INDICATOR)

INDICATOR will build on NCSA's CE knowledge base and bring together multi-stream surveillance data that includes both public health and veterinary information. The output from the surveillance data will serve as input for modeling, allowing INDICATOR to dynamically integrate input and output. Real-time data processing will enable the models to determine optimum responses and give public health decision makers the capability to develop and adapt intervention plans rapidly. Advanced visualization tools will present modeling results in an easily understandable manner. The benefits of collaboration and adaptability will be inherent in INDICATOR, as the programming will be written as open-source code.

The system will track and combine data submitted electronically by local, state, or federal agencies' public health, food, animal, air and water monitoring systems. By integrating and fusing this large amount of available surveillance information, the project team can begin to develop a baseline or background against which they can recognize anomalies and changes of significance indicating potential biological events.

Spatial data mining is a key component of the overall modeling and integration tasks for this CE. New objective functions for active data mining that mimic targeted detection and targeted vaccination goals in epidemiological modeling close the monitor-simulation-mine loop. Integrating data sources, mining of pertinent information, providing this information to the modeling and/or simulations are key provisions of this project.

ANNEX 1-3

Some Key IMMC Personnel

Biosketches

Michael Saag, MD,

Director, Division of Infectious Diseases, William C. Gorgas Center for Geographic Medicine University Alabama-Birmingham School of Medicine

Michael S. Saag, MD, is Professor of Medicine and Director of the Division of Infectious Diseases at The University of Alabama at Birmingham (UAB). In addition to leading the CFAR, Dr. Saag also serves as Director of the Gorgas Center of Geographic Medicine. In 2002, he was named Senior Scientist, Center for Outcomes and Effectiveness Research and Education at the UAB. Dr. Saag is Co-Editor of the textbook AIDS Therapy (soon to be released in its 2nd Edition), the Editor-in-Chief of Cases on the Web (COW) CME Program, International AIDS Society-USA, and a member of the editorial boards of several professional journals. Dr. Saag has authored over 140 articles, and has contributed numerous chapters to medical texts. In 1992, Dr. Saag was the recipient of the Outstanding Medical Research Achievement Award from the AIDS Task Force of Alabama and for the past several years has been recognized for his achievements by American Health magazine and America's Top Doctors. Dr. Saag's research activities focus on both clinical and basic aspects of the human immunodeficiency virus. He serves on several state and national advisory panels, including the NIH/NIAID Adult AIDS Clinical Trials Group Executive Committee. Dr. Saag received his medical degree in 1981 from the School of Medicine at the University of Louisville in Louisville, Kentucky, and did his internship and residency at the University of Alabama Hospital in Birmingham, Alabama.

Robert Novak, PhD ("Doctor Bob"),

Professor of Medicine, Division of Infectious Diseases, William C. Gorgas Center for Geographic Medicine University Alabama-Birmingham School of Medicine.

Dr Robert Novak formerly of the University of Illinois Urbana Champaign and the Director of the Medical/Vector Ecology Program in Illinois, directed a group of researchers to study a range of ecological, behavioral, toxicological, and epidemiological topics. Dr. Novak is the Past-President of the American Mosquito Control Association and has received the Medal of Honor, the Presidential Citation and the Memorial Lecturer from that scientific society. He is currently the President of the Society of Vector Ecology and was elected a Fellow of the American Association for the Advancement of Science. He has been a member of numerous scientific panels and committees including, the WHO Vector Biology and Control Expert Panel, The WHO Pesticide Evaluation committee, USEPA Scientific Advisory Panel and a consultant for the US Fish and

Wildlife and the Chinese Academy of Science-Wuhan. He has published over 120 scientific papers and 8 books and/or chapters. His research interests include both national and international studies primarily on malaria and arthropod-borne viruses. His current research efforts funded by NIH/NIAID focus on the management of malaria in rice agro-ecosystems in Kenya employing environmental management strategies and models. Dr Novak received his BS in biology from Colorado State University, his MS in Biology from the University of Utah and PhD in Entomology from the University of Illinois Urbana-Champaign. He was a NIH Postdoctoral Fellow at the University of Notre Dame.

Ian Brooks, PhD

Group Leader, Biomedical Computing, National Center for Supercomputing Applications, Institute for Advanced Computing Applications and Technologies, University of Illinois at Champagne-Urbana

Ian Brooks leads the computational medicine group at NCSA. He has been developing software systems for biomedical data management and analysis for almost twenty years, initially to support his work as a bench researcher in HIV/AIDS and more recently for larger biomedical communities. He is currently working to apply the common computational infrastructure NCSA is building for the earthquake, astronomy, environmental, and atmospheric science communities, to the biomedical field. These projects include developing cyberenvironments for infectious disease surveillance modeling and response, endemic disease control, translational biomedical research, and patient safety.

Dave Malone

ADAPCO Professional Staff

David Malone has academic entomological credentials as well as practical experience in vector control. He served as medical entomologist at the Royal Army Medical College in London and was Deputy Director of the Mosquito Research and Control Unit in Grand Cayman. He is on the professional staff of ADAPCO, the largest vector management organization in the United States. He has expertise on the impact of insecticides on pests and on the environment. He is an advisor to vector control organizations throughout the United States and some overseas locations.

Peter Burgess

Founder and CEO of Tr-Ac-Net Inc. (The Transparency and Accountability Network) Former consultant to the UN, World Bank and Corporations, and CFO of Continental Seafoods Inc.

Peter Burgess is the Founder and CEO of the Transparency and Accountability Network (Tr-Ac-Net) that provides a cost accounting and management information perspective on resource use, value creation and operational effectiveness. He has more than 20 years of professional and corporate management experience in North America, Europe and in developing countries. He has experience in the international relief and development sector consulting for organizations such as the World Bank, the United Nations and international corporations. He has done assignments in some 60 countries around the world from North America and Europe, to Latin America, Africa, South Asia and the former Soviet Union. He has written extensively about the role of accounting in financial control and for effective decision making. He is a critic of corruption and outspoken on the need for more ethics in government and throughout society. Peter Burgess was a pioneer in the use of computers for management information in the 1960s and 1970s and has subsequently used computer systems to help with government financial management (Kazakhstan and Barbados) and development planning (Namibia, inter alia). Peter Burgess is a Cambridge trained engineer and economist and a Coopers and Lybrand trained accountant.

Paul Driessen, JD

Author, consultant and senior policy advisor , Congress Of Racial Equality

Paul Dreissen is trained in geology, field ecology and environmental law, and serves as senior policy adviser for the Congress of Racial Equality, CORE Uganda and other nonprofit public policy institutes. His articles on malaria control, DDT and related topics have appeared in newspapers and news and opinion websites in the United States, Canada, Europe, Latin America, Kenya, South Africa, Uganda, Bangladesh and other countries. He has spoken on these issues on college campuses and radio talk shows, at disease control and religious conferences, and in documentary films. His book,

Eco-Imperialism Green Power - Black Death, includes a chapter on malaria and the ways misguided environmental policies have helped perpetuate this disease in developing countries. It is in its second US printing and has also been published in Argentina (Spanish), India (English), Germany (German) and Italy (Italian).

Bernard Okech, PhD,

Visiting Research Scientist, Membrane Transport Biology Group, University of Florida (native of Kenya).

Dr Okech holds a PhD in Medical Entomology, MSc in Medical Parasitology and BSc in Biology and has authored over 14 scientific publications on malaria. Dr Okech has several years scientific research experience on malaria transmission and control in Kenya. In addition, he has been involved in many activities including soil transmitted helminth (STH) control in Central Kenya, anti-malarial drug administration for malaria control in western Kenya, training of trainers of health workers and mosquito catchers, advocacy activities to increase awareness on malaria control. Dr. Okech has established and maintained solid contacts with high level Ministry of Health officials especially in the divisions that deal with vector and malaria control. At the Eastern and Southern Africa Center for International Parasite Control, Dr Okech laid the foundation for the STH control project in Central Kenya that covered a population of 40,000-plus children. Through his efforts to identify poor sanitation facilities in schools and villages, the STH control implemented a mass drug administration the resulted in a 90% reduction of STH. With ESACIPAC, AMREF and MoH, Dr Okech was involved in bed net distribution and anti-malarial advocacy that resulted in the more than 60% reduction in malaria cases at health centers in Mwea division. At the Kenya Medical Research

Institute, in collaboration with the Ministry of Health, Dr Okech screened and treated 10,000-plus people for malaria parasites both the at local health centers, schools and in villages resulting in significant reduction in gametocytaemia and malaria transmission. Was active organizer of Africa Malaria Day (Now World Malaria day) festivities in western Kenya. These projects enabled him to understand community wide disease control initiatives. He has traveled and worked in many countries including USA, Japan, Ghana, Ethiopia, Mali. Sadly, Dr Okech lost his last born brother to cerebral malaria earlier in the year. He was only 17 years old. Dr. Okech's fight against malaria is a very committed one, but after this tragic event, it has become personal.

Bill Nesler

Founder and President of West Coast Aerial Applicators Inc., a Liberia Corporation.

Bill Nesler has more than thirty years of experience applying pesticides and agricultural chemicals by air in all parts of the USA, and has flown extensively in Africa. He has been active in the malaria and vector control sector for most of this time. He has been active in training staff to understand all the issues related to safe pesticide use. He has been active in training staff to care for and maintain aircraft and all the equipment needed for safe operations. He has been associated with the US mosquito abatement districts and the ADAPCO organization for many years.

ANNEX 1-4

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An alphabetical listing

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NOTE: This is an incomplete listing not fully updated as of the above date

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ANNEX 1-5

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As of August 2007

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Paul Driessen is trained in geology, field ecology and environmental law and serves as senior policy adviser for the Congress of Racial Equality, CORE Uganda and other nonprofit public policy institutes
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ANNEX 2-1

Cost and Management Accounting Concepts of Cost Accounting

Cost Accounting

Cost or analytical accounting is the activity that informs about costs and how they behave in connection with each of the interventions. Cost accounting is a very simple concept, but becomes complex in most real world situations because there are a very large number of variables and "actual" cost changes all the time.

One important piece of information that should come from cost or analytical accounting is information about the behavior of cost. Decision makes should have the information so that they can change costs to their advantage. This can only be done if information about cost behavior is available.

One important technique for making cost accounting easier to understand and much clearer is the use of "standard" costs. A standard cost is the cost that might be expected under normal conditions, and calculated using a lot of assumptions about a normal state of affairs. Standard costs are widely used in industry in order to plan for production and to plan for improved performance. The disciplines of industrial engineering and operations research, as well as cost accounting, help to build standards in industry.

When actual costs are different from the standard costs, the difference is known as a variance and an explanation of variances helps the understanding of cost behavior. There are several ways to make standard costs reasonably accurate, but one is to compare the total of the standard cost of each activity for the period with the total cost in the accounts for the period. When the difference is small, the standard costs and the average of the actual costs may be reasonably comparable, but where there are big differences some work needs to be done to analyze what is causing the differences.

The IMMC analytical framework will make extensive use of the standard cost technique to simplify analysis and to make comparison across different areas easier to understand.

A clear understanding of costs can be very helpful in making decisions about what interventions should be a priority.

1. Bednets are relatively easy in that their cost does not vary much based on volume, though depending on the overhead of the distribution channels the delivered cast may be quite variable. The unit cost of a bednet is in the range of $5.00 to $10.00 with a useful life of 3 years, suggesting an annual cost of between $2 and $3.50
2. IRS costs vary depending on the chemicals used, the frequency of treatment, the staff costs and the productivity of the team. The per room cost is in the range of

$2.00 to $12.00 per year. DDT has the advantage of having longer lasting effectiveness than most other chemicals.

3. Medical treatment cost depends on the drug therapy being used. Chloroquine is low cost, probably under $2.00 for drugs per case, but often ineffective. ACT is effective but drug cost is probably $100.00 per case. The annual cost is high when there is rapid reinfection and a patient has 3 or more bouts of malaria in a single year. The cost of medical staff per case is quite low because staff are taking care of far too many patients, and the low cost of diagnosis results in a far too high level of mis-diagnosis and mistreatment of patients.
4. Source control has a relatively high cost during the phase where permanent data are being compiled, but much lower after this start up phase. Source control is cost effective when knowledge makes it possible to target the vector when it is concentrated in a small area and immobile. The two big costs and people and the chemical or biological agents. Aerial delivery of larvicides is cost effective in the right setting with a direct cost that depends very much on the agents being used and the area to be treated, but perhaps around $50 an acre.
5. Adult malaria control using ULV spraying with a chemical like Dibrom has a cost that varies with the area and the method of delivery. Use of aerial spraying is very cost effective, with a direct cost of around $2.50 an acre, and an ability to spray some 5,000 acres an hour. Note that this is very much faster and lower cost than larviciding, but the areas to be treated are significantly different.

Within the management framework these costs do not have to be minimized, they have got to be optimized so that the best possible results are achieved. The right combination of these interventions can produce very valuable results, when the same amount of money spent on any single intervention is likely to do little more than create some temporary progress, and then not very much.

ANNEX 2-2

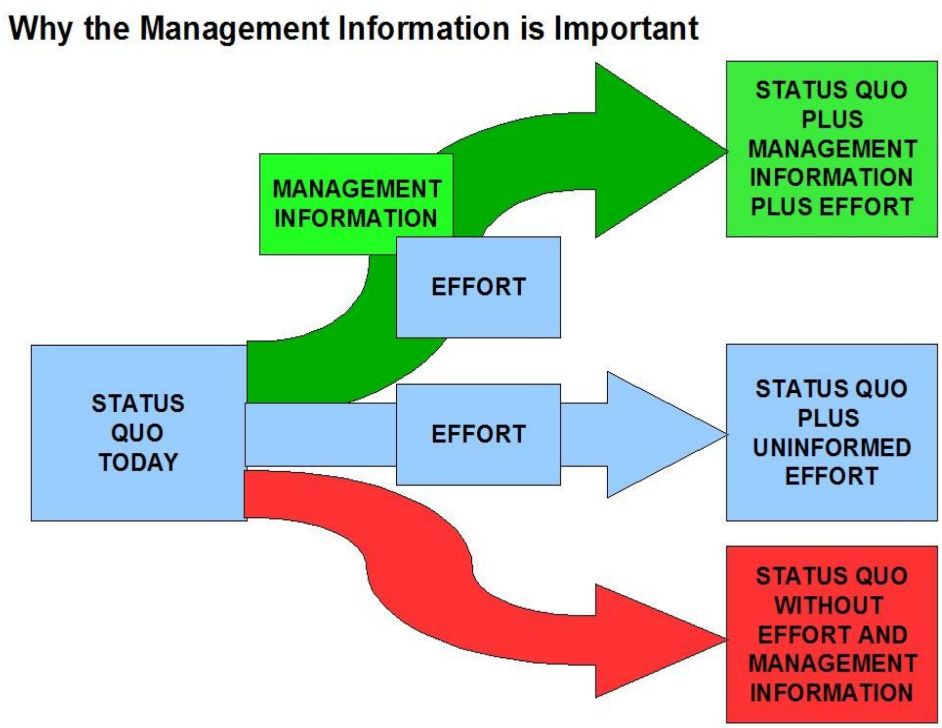
Cost and Management Accounting Impact of Management Information

What Organizational Experience Shows

Organizational experience shows that management information plays a major role in performance. Over the last fifty years the capacity of the corporate community to understand their operations and their opportunities has resulted in productivity improvements far better than was predicted before the advent of the information era.

The goal is simple ... better performance. The following graphic depicts progress over time with and without management information.

Figure 1



The deployment of management information usually follows three phases:

1. First phase: What value is it going to have? We know what we are doing and this information will cost and not have much value?
2. Second phase: The information is wrong. It has no value. I told you so. Why are you wasting time and money?

3. Third phase: You mean, we are doing that badly. Our costs are that much out of line. Our performance is really so poor. We can do much better than this if we change this and this and this.

In most cases the aggravation of the first two phases is well worth it, because the results derived from phase three can be quite spectacular.

ANNEX 2-3

Cost and Management Accounting
Cost and Value

Cost, price and value

Cost is how much of resources are used to make the product or deliver the service.

Price is the amount that is paid in exchange for the product or service

The difference between price and cost is profit.

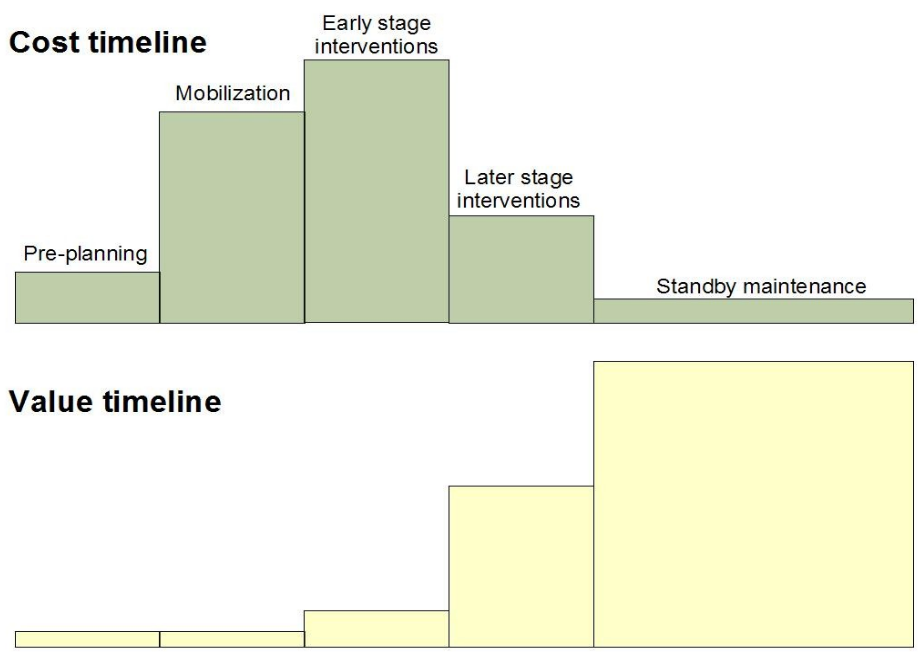
The value can be thought of as the maximum that would be paid for the product or service by a person thinking along rational economic lines.

Value adding, or value creation is the difference between value and cost.

How cost and value change over time

In integrated malaria management the costs and the value have something of the following profile over time.

Figure 6



These profiles reflect costs and values over a period of (say) 10 years. The very different profiles for costs and values over time adds to the difficulty of interpreting performance information.

Some simplifying assumptions can be made, and this is what needs to be done in the immediate future, but as fast as possible the proposed cyberenvironment for IMM should be activated to validate the assumptions and provide better decision rules. The CE for IMM will populate a datastore that contains prior experience incorporated in a model that makes it possible to relate current costs and current habitat data, mosquito data and malaria data to predict possible outcomes and to manage interventions in the best possible way for maximum performance.

Using rules development using the CE for IMM data analysis model, rapid decisions can be made to optimize interventions and as time goes on there will be increasing confidence that decisions will have the intended outcomes.

ANNEX 2-4

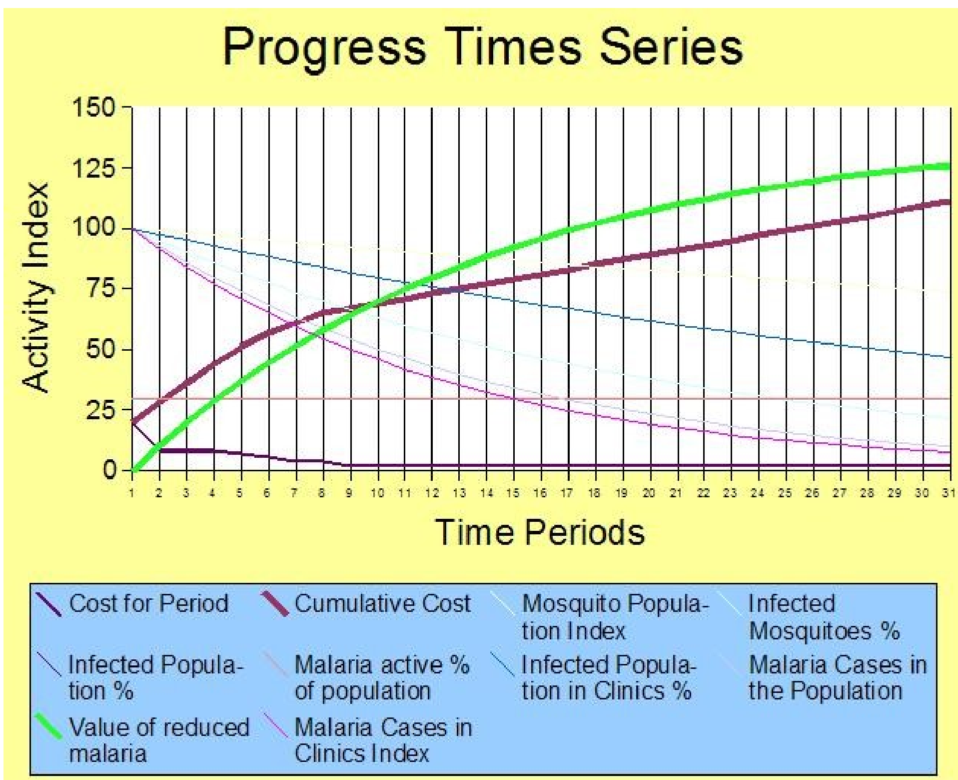
Cost and Management Accounting Measuring Progress

Measuring progress towards the ultimate goal

In order to progress towards the ultimate goal of eradicating malaria, there are three things that need to be done:

1. Reduce incidences of malaria and the prevalence of the malaria parasite in the population through detection and drug treatment,
2. Reduce re-infection of the population with personal protection including insecticide treated bednets, screens and interior residual spraying,
3. Reduce mosquito populations near homes with integrated vector management that includes breeding area control and killing adult mosquitoes.

Achieving optimized results is not simple. The following graphic shows the changes in various various metrics over time, and how costs and value change accumulate.



THIS GRAPHIC NEEDS TO BE REVISED TO SHOW INITIAL STATE AS A NEGATIVE, AND PROGRESS TOWARD ELIMINATION OF THE NEGATIVE. OTHER MODIFICATIONS ALSO

The IMM cynberenvironment will address this complexity and help to improve performance, but basic measures can help to keep a program going in the right direction and optimize use of resources.

This graphic is grossly simplified, but even in the simple form it shows some of the challenges that have to be addressed. The bold lines for cumulative cost and value suggest that value will be growing over time, and will exceed the costs incurred, but not immediately.

The indices of various intermediate results are interesting:

1. Over time it is to be expected that the population of mosquitoes will be reduced if there is effective source reduction and the killing of adult mosquitoes,
2. Over time it is to be expected that the proportion of the human population infected with the malaria parasite will go down if there is effective anti-malaria treatment, and there are less mosquitoes and and there are less opportunities for the mosquito to interact with the human host and take a blood meal,
3. Over time it is to be expected that the proportion of mosquito population infected with the malaria parasite will go down as the various interventions make it progressively more likely that a blood meal will not result in the mosquito being infected.
4. The data from the clinics may or may not be a good indicator of the status of the population as a whole. Malaria cases in the population may be a higher proportion than in the clinic, or it may be the other way round.

A successful program will get reduction in many of these key metrics, and there will be real value in the reduction in malaria in the society. Interventions that merely serve to get the intermediate results, are costly and do not serve the public interest in the long run. Worse, the process or perpetual treatment and subsequent reinfection sets the stage for resistance and a worsening of the crisis over time.

Interventions, and their cost, for achieving the ultimate goal

The ultimate goal can be achieved using a set of mosquito and malaria control interventions. These interventions, or activities, have little value in themselves, but toegther can result in achievement of the ultimate goal which has enormous value. The interventions have costs. The interventions may, or may not be making a useful contribution to the ultimate goal and the ultimate value.

Cost is a very simple concept, and also one that has many variants and complexities. Cost in management information must be a clear and consistent measure, supported as needed by other detail of cost to explain material issues.

Performance is not based simply on cost, but on the relationship between cost and the results being achieved. Because there are significant time lags between the time costs are incurred and time results are achieved, use of time series tables and charts is often desirable.

There are many interventions needed in order to achieve the goals most cost effectively including:

1. Medical case management,
2. Personal protection using insecticide treated bednets (ITN),
3. Personal protection using interior residual spraying (IRS),
4. Personal protection using screens and other repellency techniques,
5. Vector control using environmental cleanup,
6. Vector control using larviciding, and
7. Vector control using adulticidng.

In addition there needs to be the scientific data and management information dimension that includes:

1. Surveillance,
2. Data collection,
3. Data logistics,
4. Data analysis (cyberenvironment for IMM),
5. Management information, and
6. Feedback to operational and strategic decision makers.

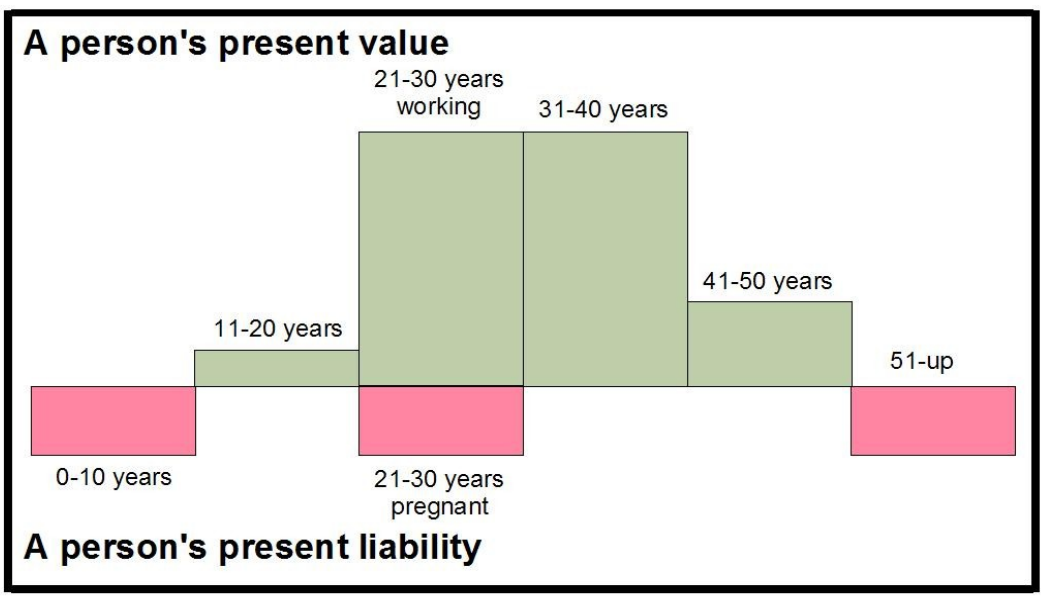
ANNEX 2-5

Cost and Management Accounting About Value

What Value Is

In any program that "saves lives" the value is huge ... indeed big enough to justify the sloppiest of interventions. But this "emotional" or "moral" value cannot be correlated directly at all with socio-economic value and tangible value related to wealth creation. A strategy that limits interventions to young children and pregnant mothers has "moral value" but tangible socio-economic value to the family and the community is going to be realized when older children and all adults also included and do not suffer from malaria induced morbidity. In simple terms, socio-economic value is created when people can work and produce something of economic value.

Figure 7



This is not to understate the value of "motherhood" and the importance of children, both have unlimited value in the continuum of human survival ... but the present socio-economic value is a function of adult people's ability to work and be economically productive.

In the long run ... and in the long run we may be dead, but the results of good and bad policy will live on for a long time ... socio economic progress is a function of how productive a community can be. Malaria elimination is one step in making it possible for a community to be productive.

In the IMMC approach to performance measurement, value is an important part of the metric. But because there are many views of value, IMMC uses the concept of a standard value so that there can be simple comparison between various locations and approaches. Where a standard value is inappropriately set, it is easy to make a change and rework the analysis

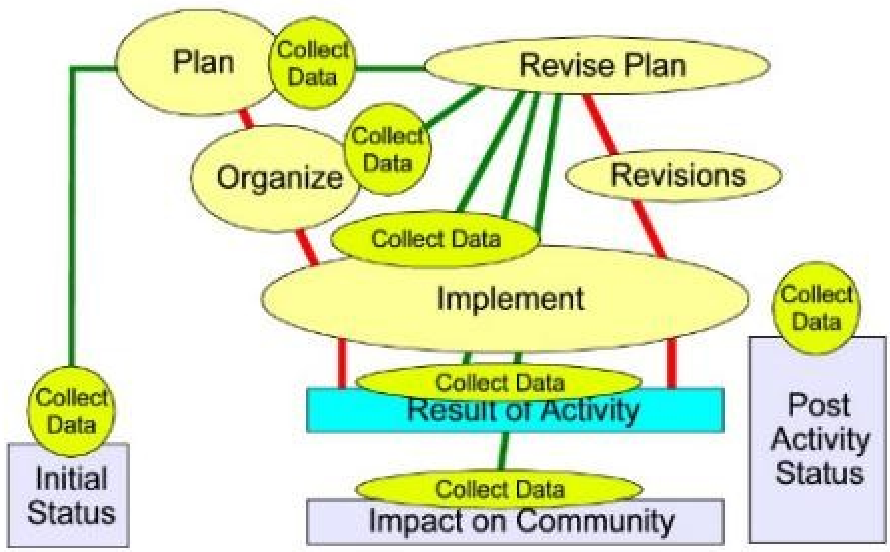
ANNEX 2-6

Cost and Management Accounting Control Theory and Feedback

Collect data, plan, organize and implement

The basics of control theory and management feedback are very similar. The following sketch shows how high performance operations integrates data collection, analysis, planning, action, more data collection, more planning, more action in a perpetual process.

Figure 2.



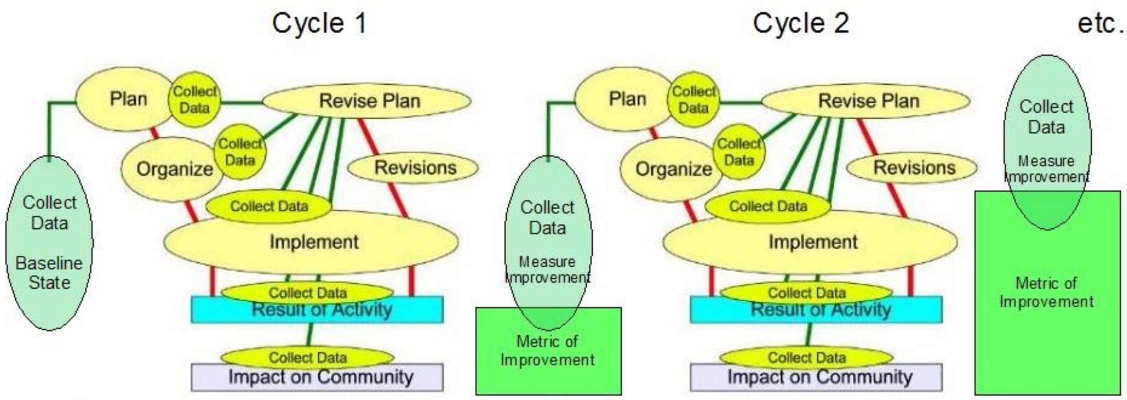
The ultimate measure of success is whether the change between the initial status and the post activity status has a value that (substantially) exceeds the costs.

Not much is known about the relationship between the different interactions carried out in a coordinated manner. There was success in controlling malaria during the Panama Canal construction using an integrated approach, but the scientific details of the interactions are still not well understood.

What is apparent is that there is no simple relationship between funds disbursed, interventions used, results of these activities and the ultimate impact on the community. At the present there is no understanding of how a comprehensive portfolio of control interventions can best be optimized.

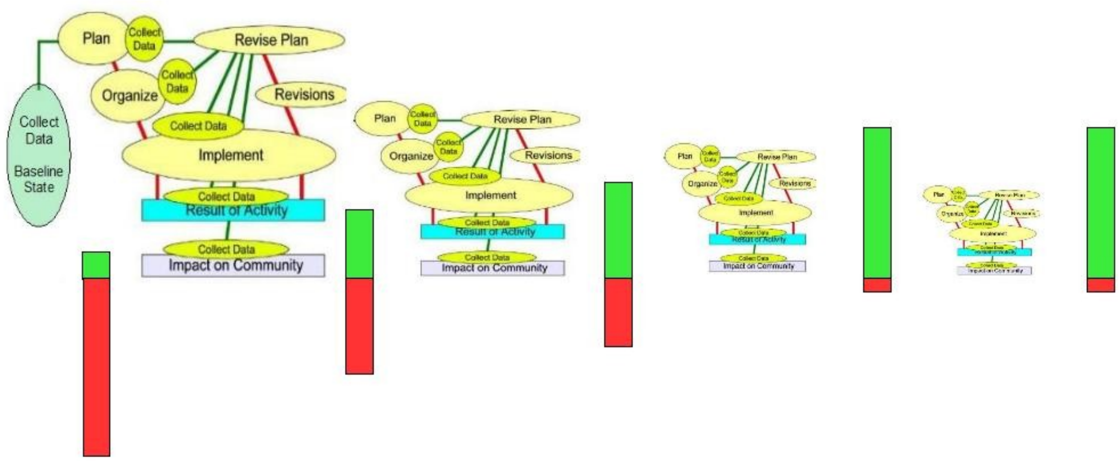
There are some things that seem to apply, and data needs to be compiled so that there is better understanding.

One reality is that the planning, implementation, review cycle is ongoing, not just a single cycle.



In this schematic the activities that are implemented produce their own results or outcomes, and in turn these have an impact on the community. The metric of improvement is mainly that of impact on the community and the constituents of the community. Does the impact on the community justify the expenditure on the activities, and are the activities costing the right amount given the situation and experience elsewhere.

Over multiple cycles the aim is for the scale of the interventions to diminish and for the impact on community to get better and better, and the bad things to get smaller.



This is the essence of success and sustainability. In the long run the value of a good status in the community should be sufficient to pay for the cost of the essential ongoing activities that are needed to maintain the improved status.

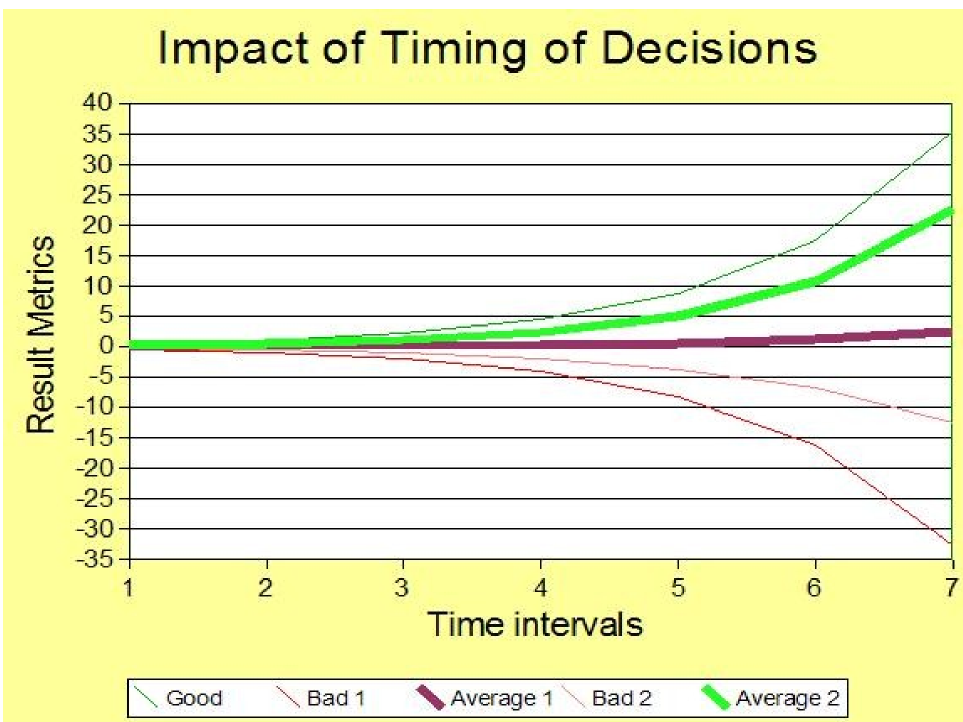
ANNEX 2-7

Cost and Management Accounting Impact of Timing on Performance

Improved performance derived from rapid feedback

A result is made up of a normal distribution of good and bad decisions. If there is no management system and no feedback and decision making to minimize the unfavorable impact of the bad decisions, then the average of good and bad is likely to be rather mediocre. The narrow light green and the narrow red maroon represent good and bad decisions respectively, and the average is the thick maroon line.

Clearly the thick maroon line is very poor compared to the potential reflected by the thin green line.



If the feedback system corrects the bad decisions quickly, then instead of the thin maroon line for bad decisions (Bad 1), the bad decision impact can be somewhat controlled and improve to the Bad 2 situation. The average result is then the thick green line, very much better than the mediocre result of the thick maroon line.

Handling the different time cycles for optimum feedback

In planning for the data flows and the feedback there is a role for local analysis and action as well as the use of a central cyberenvironment and datastore. Much of the daily analysis and feedback can and should be handled locally, and the same data used in the central location for comparative analysis and as detail that completes the dataset.

Local data and oversight data are the same ... but they go through different processes and on different time schedules. Local action must be done based on local data and analysis that is "in time" so that optimum results can be achieved. The same data can be processed and used in various models to help with scientific research on the one hand and with oversight of the interventions as well. Oversight data do not hold up quick decisions, they merely confirm that quick decisions were good decisions, and if not, why not. The oversight analysis is part of a learning organization and process so that activities can be improved.

ANNEX 2-8

Cost and Management Accounting

Data Analysis Cyberenvironment for Integrated Malaria Management

NCSA will develop a cyberenvironment (CE) for the organization and storage of IMM data.

To understand a CE, consider the state of the internet in the early 1990s. At that time a significant amount of information was available, but finding it through FTP and gopher sites was unnecessarily time consuming. When NCSA developed Mosaic, these resources became easier to access.

There are many resources available online today for the scientific community, including databases, sensors streaming real-time data, supercomputers, visualization resources, ultra high-speed networks, and communities of researchers, but again they are difficult to use effectively.

Bringing these resources together in a usable environment is the current challenge, one that NCSA is tackling with a number of CEs.

CEs incorporate collaboratory and grid technologies, web services, and other cyberinfrastructure into an overall framework that balances the need for efficient coordination with the ability to innovate. They are designed to support the full scientific lifecycle, both at the level of individual experiments, as they move from data to workflows to publication, and at the level of larger scale collaboration, where new discoveries lead to additional data, models, tools, and conceptual frameworks that augment and evolve community-scale systems.

ANNEX 2-9

Cost and Management Accounting Dialog

Ref: TAN doc 0221

Understanding Management Information

From an Africa colleague, Guido Sohne

Let me see if I can understand this by simplifying it ...

1) Management information can be explained, in the most simple terms possible, by resorting to arithmetic to illustrate the issues. When you have a mathematical equation, such as 9+9=18, or 5*6=30, you have the components of the final result. You are able to determine how and why the result is 18 or 30. If you simply listed, 18 or 30, you would have no clue whether 30 is 3*10, 15*2, or 5*6. Top down analysis of a situation, will end up blocked by the information that has been lost or aggregated. In this context, management information is simply the ability to drill down through data to find out what caused the data to be what it is. We need to have detailed information in order to make sensible decisions, which is at the heart of it being called "management information".

2) In order to understand what is happening, what is working and what is failing, one needs to capture data in a sensible way. Accounting tricks exist to change the way financial information looks by shifting certain data there, and other data here until it looks "good enough." Management information provides the tools necessary to reverse these shifts in order to ascertain the true picture. What makes life difficult, is that there is no one true picture. Everything is relative to the point of view one decides to look from. If you take a flat sheet of paper, it looks big when viewed from the top down, but when you turn it to show the thin edge of the paper, it suddenly looks very small. In this case, management information is being able to rotate the paper, in all directions, to see how small it looks from this point and how big it looks from that point. What we need to prevent, is people being able to fix the paper, and fix your position, so that you are unable to look at it from all the angles that you want. This is the goal of management information - to be able to look at the situation from as many possible angles as possible, in order to be able to make a sensible decision.

3) Due to the need to have results, or to make bad results look better, there is intentional hiding of information. People collapse data into components that cannot be further broken down or dissected. They also partition data into compartments that are hard to access from other compartments. If you cannot put the pieces of the jigsaw puzzle together, you cannot know what the picture is ... Much information is concealed this way. When you are in New York, you have a hard time figuring out how to get information out of a government office in a rural area of some African country; in fact, even when you are in the capital city of that country, you still have huge problems getting that information!

4) No condition is permanent, and the information that one needs to have available needs to take into account changes over time. Without knowing what happened before, or what happened after some initiative or disaster, it is next to impossible to make any informed judgment.

So in summary, management information leads to the ability to make decisions based on the availability of information instead of on politics, inexperience, or personal subjective beliefs. It is akin to science and engineering where decisions are based on facts, rather than in the arts, where they are based on opinion ...

ANNEX 4-1

Surveillance

Types of Surveillance

Why surveillance and data collection?

The main objective of surveillance is to have data for planning and for the immediate and continuing evaluation of integrated malaria management programs. For this purpose, the surveillance strategy aims at having a high sensibility for detecting changes caused by medical control, personal control and vector control interventions.

The IMM surveillance system comprises two sub-systems:

1. epidemiological metrics to know the status of malaria in the human population,
2. entomological metrics that provide cost-effective measures of transmission intensity.

The IMM system also incorporates the following:

1. Geospatial information
2. Cost, results and value information

Selection of monitoring sites

Selection of monitoring sites will be addressed using geospatial information and through interview of local health workers and preliminary field surveys. Use of satellite imagery makes it possible to focus immediately on areas that are most likely to be hot spots for high malaria intensity and plan for interventions that will have the maximum impact at least cost.

Epidemiological surveillance

The data that are available from clinics and hospitals should be used to the maximum possible extent. It must be recognized, however, that this may not be representative of the population as a whole.

Steps must be taken to carry out some survey work to be able to relate the clinical survey results with the populations as a whole. This work should also help ascertain more accurately than the clinic information critical information about the accurate location of the hot spots that have higher intensity of malarial infection.

Besides collecting reports of cases from local clinics and hospitals, a cross-sectional prevalence survey in school children of age less than 10 can yield useful information. The advantages of monitoring prevalence in school children are:

1. they are readily accessible and representing exposure in a large area,
2. they are unlikely immune to new infection, and thus more sensitive to change in transmission intensity.

The approach is for one school in each of three clusters to be selected for parasite survey. Every 6 month, up to 200 children in each of the selected school will be chosen for finger prick blood collection. Thick blood smear will be prepared and microscopically examined for falciparum parasite.

Medical surveillance

Medical surveillance is used to measure the incidence of malaria in the human population. There are several populations that need to be surveyed:

1. Those that come to clinics and can be tested in that setting
2. Those that live in the community
3. Those that that migrate into the community from other places, either for short visits or for a longer period.

There is some evidence that the incidence of malaria is overstated in current data because of incorrect diagnosis and the assumption that a fever is automatically malarial. Accordingly, the IMM surveillance must include some effort to ensure that the surveillance is done accurately.

These data presented as a time series in summary form will show the profile of progress. Typically the time series can be presented for month periods.

Medical case management

The management information related to medical case management has the following elements:

1. Number of incidences of malaria in the community,
2. Number of incidences of malaria treated and analysis of treatments used,
3. Costs of the treatments,
4. Information concerning impact of treatment on the individual patients,
5. Geographic location of residences and workplaces of patients treated.

Entomological surveillance

Entomological surveillance.

Entomological surveillance is used to measure the incidence of malaria parasite in the mosquito population. In the course of surveillance the following data can be obtained:

1. The abundance of mosquitoes,
2. The species of mosquitoes,
3. The proportion of the mosquito population that carries the malaria parasite.

Vector control surveillance of the area.

The management information needed about vector control and surveillance of the area is permanent data, with critical detail being an essential key information for operational decisions.

From a management overview perspective information is needed about:

1. Population and its spatial distribution
2. Different structures and their spatial distribution

3. Different habitats and potential breeding grounds and their spatial distribution

From an operational viewpoint data are needed much more frequently about the actual status of the various habitats and breeding grounds and the status of the mosquito population.

The management information concerning vector control and surveillance of the area will be:

1. Key metric about how much of the habitat and breeding grounds were surveyed in the period
2. Key information from mosquito traps located in the area and the summary results of the data for the period
3. Cost of the surveillance.

Operational information for vector control

The operational information needed about vector control, both larvaciding and adulticiding, includes:

1. Geographic or spatial information: the physical description of the place, where it is and what it is,
2. Biological information about the place: what is the habitat, what organisms are present,
3. Time information: when is the data being collected,
4. Surveillance techniques: how is the data being collected (mosquito traps, dipping, etc.)
5. Administrative information: who is collecting the information, control information to set up data provenance,
6. Cost information: how much time spent collecting these data,
7. What intervention activity was done last.
8. Field recommendations about what intervention activity should be done next and assessment of the performance of the last intervention,

Mosquito surveillance

Mosquito surveillance is used to identify the main vector mosquitoes, their spatial distribution and the seasonal dynamics. These data are used to plan an optimum mosquito intervention program that will help reduce the malaria transmission rate at lowest cost.

Understanding of biological characteristics of targeted mosquito species is the key of designing effective vector control. Detection of transmission will be centered on testing of mosquito samples for malaria parasites.

Individual houses in each cluster will be selected for adult mosquito sampling. The houses will be evenly distributed in the study area. Various procedures will be used:

1. Monthly adult mosquito collection will be carried out in the selected houses by using pyrethrum spray collection. The count gives a measure of mosquito population density.
2. Adult mosquito samples will be sorted to species.
3. From each of the study areas, adult mosquito samples will be tested for Plasmodium faciparum using immunoassay techniques.

From these data several elements of key information can be obtained:

1. An index of mosquito population can be established
2. Entomological inoculation rates (the number of infectious bites per month) can be estimated.
3. Time series information can be compiled and progress performance assessed.

Vector control intervention - adulticiding

The operational information needed about adulticiding interventions includes:

1. The place where the adulticiding is being done,
2. What method is being used,
3. Who is doing the work and how much time it takes,
4. What equipment is being used for how much time,
5. What fuel is being used and how much,
6. What chemical or biological agent is being used and how much
7. What is the cost of the intervention.

The data are best when they are collected at the most detailed level, and information is simple. It is best to aggregate simple information later using electronic means.

The reference data, such as 1 (where the adulticiding is being done), should be sufficient for the data to be related to other information about the place.

Habitat survey

All habitats in the selected grids will be identified and mapped based on high-resolution remote sensing images and ground inspection. These habitats will be categorized into types. Preliminary larval sampling of representative habitats in the main categories will be conducted to document presence/absence of anopheline mosquitoes. Habitats where larvae are present and are close to human residences will be selected for intensive survey.

Intensive survey provides data about the habitat and how it changes over time. Monthly visits to the selected habitats will be conducted. Presence of water will be recorded alone with other habitat variables such as surface area, depth of water and presence of vegetation. Larval density will be measured by using standard World Health Organization dipping. Up to 30 dips will be collected from each habitat. Collected larvae will be brought back to the laboratory for morphological identification.

Data collection about standing water sites

The question of where are the mosquitoes starts with the identification of standing water sites that are also the potential breeding places for the mosquito.

The area is divided into 4 or more sections (i.e. A, B, C, D) based on geography and the number of potential aquatic habitats. These sections can be modified as more information is gained.

In each section all standing water sites will be mapped and each individual site given a number (i.e. A-001, A-002 etc.) followed by the date inspected (i.e. A-001-02/15/01, A-002-02/15/01 etc). Each site will be inspected for the presence of mosquito larvae.

Inspection of each site will be repeated based on the larval developmental stage, rainfall and later post insecticide treatment. During the first year each site must be inspected when water is present in order to establish mosquito species succession and multiple generations of individual species. The location of larvae and pupae in each site will be recorded and illustrated on the field map.

These data provide the basis for a larval habitat database that shows temporal and spatial distributions and habitat productivity.

Vector control intervention - larviciding

The operational information needed about larvaciding interventions includes:

1. The place where the larviciding is being done,
2. What method is being used,
3. Who is doing the work and how much time it takes,
4. What equipment is being used for how much time,
5. What fuel is being used and how much,
6. What chemical of biological agent is being used and how much
7. What is the cost of the intervention.

The data are best when they are collected at the most detailed level, and information is simple. It is best to aggregate simple information later using electronic means.

The reference data, such as 1 (where the larvaciding is being done), should be sufficient for the data to be related to other information about the place.

Data collection about the population

Data about the population is a key part of the dataset needed to have a cost effective program. Some of the critical demographic information is geographical, some is medical, some is economic and some relates to malaria control interventions. Some of the information is:

1. Geographical
   1. Where are people located?
   2. Where are people with active malaria located?

    3. Where are people with inactive malaria parasites located?
2. Medical
    1. Where are malaria infections?
    2. What medication is being used?
    3. What clinic or hospital or other source of treatment?
    4. Is the medication effective?
    5. Is this repeat? How many repeats in the year? When?
    6. What is the prevalence of malaria in the individual and in the family members?
3. About Anti-Malaria Interventions
    1. What interventions have taken place? For each:
        1. What?
        2. When?
        3. Where?

These data are difficult to collect quickly, but they can be compiled by systematic analysis of the area, and building the data incrementally, and especially the detail.

At the outset it is possible to make use of satellite images to get an overview understanding of where populations are located, and as time goes by more and more information can be compiled so that there is eventually very good information and the community, and while this is being done, there is also material progress in reducing the prevalence of malaria in the population.

Data collection about houses and households

Data about the houses is also an important component of the integrated malaria management dataset. A cost effective program requires using resources where the results are going to be optimum, and house characteristics have a material impact.

1. Basic information
    1. Where are the houses located?
    2. What number of people live in the houses?
    3. What type of houses? What construction type?
    4. What sort of immediate surroundings for the house?
2. Medical
    1. Which houses have people with malaria infections?
    2. What is the history of malaria in the house?
    3. What medications are being used?
    4. What clinic or hospital or other source of treatment?
    5. Is the medication effective?
    6. Is this repeat? How many repeats in the year? When?
3. About Anti-Malaria Interventions
    1. What interventions have taken place that affect this house?
    2. Changes in the physical construction?
    3. Interior Residual Spraying (IRS)
        1. What chemical?

    2. When treated?
    3. Any noticeable changes?
4. Use of Bednets
    1. What type?
    2. How many?
    3. How many sleep using the bednets
    4. How many do not have use of bednets
5. Area cleanup
    1. Why was this done?
    2. What was done?
    3. When was it done?
6. Other interventions
    1. Any area wide programs like ULV spraying?
    2. Any area wide source control – larviciding
    3. Any public awareness and education campaigns

These data are difficult to collect quickly, but they can be compiled by systematic analysis of the area, and building the data incrementally, and especially the detail. At the outset it is possible to make use of satellite images to get an overview understanding of where structures are located, and as time goes by more and more information can be compiled so that there is eventually very good information about the structures and the way in which structures impact the prevalence of malaria in the community.

Personal protection using insecticide treated bednets

The management information needed relative to the use of insecticide treated bednets has the following elements:

1. The number and type of bednets distributed, the mode of distribution and the place of distribution,
2. Costs of bednets up to the point of distribution,
3. Geographic distribution of bednets and patterns of useage.

Personal protection using interior residual spraying

The management information needed relative to interior residual spraying (IRS) has the following elements:

1. The number of rooms (structures, or other) that have been treated, the type of chemicals used, the type of construction,
2. Costs of interior residual spraying,
3. Geographic distribution of IRS treatment.

Personal protection using screens and repellency techniques

The management information needed relative to other forms of insect repellent techniques has the following elements:

1. What techniques are being used and where,

2. Cost of these techniques,
3. Geographic location of these.

Data collection about the environment

Environmental and meteorological surveillance.

Environmental and meteorological surveillance is used to ensure that there the environment is not being adversely affected by any of the IMM interventions and to help predict the behavior of the mosquito and malaria as a result of weather conditions.

Environmental degradation needs to be taken into consideration in planning interventions. In the course of surveillance the following data can be obtained:

1. Changes in the environment
2. Basic meteorological information: temperature, rainfall, humidity, barmoetric pressure.

Field data collection

Manual data collection sheet

The field data collection sheet must include the reference data need to relate to the permanent information and have space for the variable data and the administration data.

1. Permanent information
   1. Name of MAA
   2. Site Code Number
   3. Area of site (measurement),
   4. Type of site (marsh, riparian, ephemeral pools, animal drinking, ditch etc),
   5. Water quality (clear, turbid, foul etc),
   6. Water depth,
   7. Vegetation,
   8. Shade,
   9. Reference to photographs of the site
   10. Reference to sketch of the site,
2. Variable information: Administration
   1. Inspectors Name
   2. Date
3. Variable information: Activities undertaken
   1. Mosquito sample collected: Where and sample reference,
   2. Aquatic sample collected: Where and sample reference,
   3. Water sample collected: Where and sample reference,
   4. Plankton sample collected: Where and sample reference,
   5. Photograph taken: Where and photograph reference.

4. Variable information: Changes to permanent information (These may be permanent changes or changes related to season, or weather conditions)
    1. Area of site (measurement),
    2. Type of site (marsh, riparian, ephemeral pools, animal drinking, ditch etc),
    3. Water quality (clear, turbid, foul etc),
    4. Water depth,
    5. Vegetation,
    6. Shade,
    7. Reference to photographs of the site
    8. Reference to sketch of the site.

Electronic systems for data collection

There are many emerging technologies that support electronic capture of data. In general they require a certain level of infrastructure that is not always available in malaria endemic areas where data need to be collected.

The question of best use of available resources is also an issue. Electronic equipment is low cost relative to labor cost in places like Europe and North America, but in Africa, the use of local labor and a manual system is likely to be more cost effective and to have higher social value.

The rapidly expanding capacity of the mobile phone to be used to handle data will probably change the economics of data collection in the near future. The technological capacity is already in existence, but the deployment of the essential basic infrastructure is still not certain.

ANNEX 4-2

Surveillance
Sampling

How sampling is done

The following sector describes in detail how sampling is done.

Mosquito larvae and pupae sampling

Mosquito larvae and pupae will be sampled and returned to the laboratory from each site. Samples of larvae taken will show the Number as illustrated above and the specific location of the collection will be added (1,2,3,4 etc) to discriminate the individual samples within a site. All larval samples will be passed through a sieve and placed with water into labelled zip plastic bags and returned to the laboratory for rearing and identification. A sub-sample of larvae and pupae will be killed with hot water and placed into 75% alcohol tubes as voucher specimens. A sub-sample of larvae if available will be reared to adults (male and females) and will be pinned using standard procedures for voucher adult specimens. This material will be used for species identification. Pupae collected will be placed in cups in the laboratory and allowed to emerge. Pupal skins and associated adults will be mounted as stated above. The number of pupae per habitat per time will be used to establish habitat productivity and thus assist in prioritising management procedures.

Aquatic samples: invertebrates, non-mosquitoes and predators

At selected sites (to be determined) detailed sampling of aquatic invertebrates will be done using standard dip-net techniques or aquatic light traps.

All samples collected will use the same code identification system as listed above but will carry a recognition number or letter that will show that it is a sample of non-mosquito invertebrates. Samples will be either preserved for future identification in 75 % alcohol or reared to a stage where identification is possible.

A sub-sample may also be set aside for predator/prey studies to establish the impact on the larval mosquito population.

Aquatic samples: plankton and bacteria

Also at selected sites a plankton and bacteria (biofilm layer; method of collecting and identification will be described in other documents) samples will be taken in order to establish the biodiversity and nutritional resource levels of these habitats.

This information will be used to compare habitats pre-and post-treatment.

Effectiveness measurement includes:

1. Data collection about the population of adult mosquitoes
2. Analysis of the samples
3. Recording the data

4. When source management is attained within the mosquito abatement area borders, there should be continued surveillance for adults to identify any invasion of adult mosquitoes from outside the area.

Data collection about mosquito population

There are several techniques for monitoring the adult mosquito population. These can give reliable information about fluctuations in the adult mosquito population and the species composition over time and space. The techniques also can show how the population of parasite infected mosquitoes is changing over time.

The techniques employed will include:

1. light traps,
2. house fumigation,
3. mechanical aspiration, and
4. vehicle mounted traps.

Landing biting counts will be used only under specific conditions which will be determined based on need.

The adult population of mosquitoes will also be indirectly measured by

1. Oviposition traps,
2. Black jar/can traps charged with water for Aedes species (i.e. Ae aegypti) and Oviposition bucket traps charged with an attractive infusion (i.e. grass, animal feed etc) for attracting gravid female Culex species.
3. Gravid/Adult traps (CDC gravid trap) will be used to collected eggs and post-gravid females.

Light traps

Placement of the light traps should range from outside around dwellings to areas with little or no human concentrations. To begin at least 4 light trap stations should be established in each of the subzones. Light traps must be operated for a period of 24 hours 2 times per week. Light traps should be placed in areas that are protected from vandalism, from the sun and other elements such as wind.

Oviposition traps

A transect should be established for the placement of the black can/jar (Aedes) oviposition traps ranging from around human dwellings to more feral locations. A total of 10 of these traps should be placed in each subzone. These traps should be painted black and filled half with water. The oviposition paper (seed germination paper) should be appropriately labelled and place into the oviposition trap so that half of the paper is submerged into the water. The papers can be removed once per week. The papers are transferred back to the lab where the eggs are counted. The paper with eggs can than be placed in larval rearing pans for subsequent rearing and identification. A sub-sample of larvae (4th instar) and adult males and females should be preserved in 75% alcohol or mounted and set aside for voucher samples. The data on number of eggs and species should be entered by site location and date. Eggs and egg rafts will be brought back to the lab allowed to hatch and reared to either 4^{th} stage larvae or adults in order to provide for positive identification.

Black bucket or Culex traps

The Black bucket or Culex traps are 5-gallon plastic pails painted black and filled 75% full with water. Animal feed or a grass/straw infusion is used to foul the water and provide the attractant for ovipositing females. These black pails are set in a sheltered position away from the sun and wind, preferably under vegetation or in a protected area around dwellings. A total of 10 of these traps should be placed per subzone. These black pails must be checked for egg rafts daily or covered when not in use to prevent them from becoming a source of mosquitoes. The egg raft is removed from the pail by using a small paintbrush and placing them into a petri dish filled with moist cotton or other absorbent material. The egg rafts are counted and than place into petri dishes (1 egg raft per dish) and are reared to the 4th instar. The larvae are than killed and placed into 75% alcohol for identification. The number of rafts per day or hour will collect the data by species. Location and date should be correctly labeled on each sample.

Gravid traps

The Gravid traps should be placed in areas protected from vandalism, the sun and wind. Preferable these traps should be placed under vegetation or in a protected area around dwellings. The gravid traps are filled half with water to which grass has been added to provide an attractant. The vacuum tube of the trap should be no more the 10 cm from the water surface. Since these traps operate on re-chargeable batteries they should be run 2 times per week. Collections include gravid adult females from the net, which is fitted over the suction tube, plus anopheles eggs and egg rafts found on the surface of the water. It is important to remove all eggs so that the trap does not become a source of mosquitoes. Samples should be taken back to the lab for species identification and counting. Females can be used for pathogen analysis since only gravid females are captured and had at least taken one blood meal. Adult females collected in these traps will be identified to species, counted and used to establish if pathogens (especially Plasmodia sp) are present. Specimens of non-anopheline species can be preserved for future pathogen analysis (nematodes, viruses etc).

Aquatic non-mosquito sampling

A detailed sampling protocol will be independently established for the use of standard aquatic dip net sampling, aquatic light traps and plankton.

ANNEX 4-2

Protocol for Sampling
Using satellite imagery

Example

A grid-based infrastructure for ecological sampling Anopheles gambaie s.l. aquatic larval habitats in Stone Town, Zanzibar, Tanzania

For remote identification of mosquito aquatic habitats the first step is often to construct a discrete tessellation of the region [Jacob et al. 2006]. In applications where complex geometries need to be represented such as urban aquatic habitats orthogonal grids can be constructed in Geographic Information Systems (GIS) and overlaid on satellite images [McKinney and Tsai 1996]. Overlaying a GIS grid on remotely sensed high resolution data can help organize and characterize Anopheline larval habitats [Keating et al. 2003 Jacob et al 2003, Keating et al 2004; Jacob et al 2006]. A grid is constructed by applying a mathematical algorithm in order to fit a continuous and bounded surface consisting of equidistant estimates of a quantity from a field sampled attribute [wwwESRI.com]. A sampling scheme consists of columns and rows of uniform cells coded according to data values. Each sampling cell within a matrix contains an attribute value as well as location coordinates. The spatial location of each cell is implicitly contained within the ordering of the matrix. As such aquatic habitats containing the same spatial attribute value are easily recognized.

We will use multiple QuickBird 0.61 m spatial resolution images for the Stone Town, Zanzibar, Tanzania study site. QuickBird multispectral products provide 4 discrete non-overlapping spectral bands covering a range from 0.45 μm to 0.72 μm. Image analyst and GIS software will be used for spatial and remote sensing data processing. ERDAS *Imagine* is specialized software for image processing, mapping and visualization used in the image classification process, mosaicking, and re-projection. Upon acquisition of standard imagery QuickBird image, data scenes will be re-projected to a common projection UTM zone 37 South WGS 84. The reprojected images will be co-registered using ground control points (GCP). QuickBird images will be co-registered by applying a first order polynomial algorithm with a nearest neighbor resampling method. Standard Imagery products (QuickBird) are already radiometrically corrected, sensor corrected, geometrically corrected, and mapped to a cartographic projection (www.digitalglobe .com).

A 100 mx100m grid will be overlaid on the QuickBird visible and near-infra-red (NIR) data in Arc Info® . Information from visible and NIR channels can distinguish between high and low mosquito producing rice fields [Wood et al.1991a].A unique identifier will be placed in each grid cell (i.e. polygon). The grid will extend out to a 1 km distance from the external boundary of the study site.

A geodatabase will be designed and created to store ecological and geographic data for the study site inside a spatial relational database. A grid-based algorithm incorporating QuickBird visible and NIR data in GIS will be associated with the sampling scheme and the spatial and non-spatial characteristics will be incorporated into the geospatial database. Multiple data layers will be created using different coded values for various field attributes to the same sampling cell which will allow for multiple interactions between compatible ecological data bases enabling retrieval and transformation of seasonal larval habitat data efficiently regardless of spatial dimensionality and location of an aquatic habitat.

Additional base maps for a study site including roads, irrigation canals, and rivers will be generated in ArcInfo. We will incorporate human population data constructed using population totals from the last available censuses for administrative units (communities or districts). These data will then be converted into a geodatabase of population totals. The process will incorporate information on where people tend to live: in or close to towns and cities, close to transportation infra structure, around protected areas, near water bodies, and not at very high elevations. Using GIS based information on the location and size of towns and cities, roads, railroads, navigable rivers, and uninhabitable areas, population density will be weighted, a high value implying a high density and a low or zero value implying low or no population. The digital map will extract population distributions according to each QuickBird grid cell.

All remote data will be validated through extensive ground truthing. Each *An. gambaie* s.l. larval habitat with its associated land cover attributes from the study site will be entered into a Vector Control Management System® (Clarke Mosquito Control Products, Inc. 159 N. Garden Avenue. Roselle, IL 60172) database. VCMS can support the mobile field data acquisition in the study site through a Microsoft PocketPC™. All two-way, remote synchronizing of data, geocoding, and spatial display will be processed using the embedded GIS Interface Kit™ that will be built using ESRI's MapObjects™ 2 technology. The VCMS database will plot and update all DGPS ground coordinates of aquatic larval habitats seasonal information and support exporting data to a spatial format. All field and remote data of *An. gambaie* s.l. larval habitats in the study site will be exported in a GIS as a shape file format. Differentially corrected GPS data acquired from a CSI Max receiver can ensure that each aquatic habitat sampled is co-registered with a 0.61 m pixel [Jacob et al. 2006]. This information will be displayed onto a user-defined field base map.

Determining spatial heterogeneity in larval habitat distribution using QuickBird visible and NIR data and a digitized grid cell database can have important operational significance because vector control operations can be designed to target zones where high larval densities occur. Treatments or habitat perturbations should be based on surveillance of larvae in the most productive areas of the agro-ecosystem and adjacent village [Gu and Novak 2005].

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ANNEX 4-2

Using satellite imagery to jump-start baseline data

Spatial information

An important source of performance improvement

Mosquito and malaria control has a strong spatial characteristics that have a very large impact of control results. Accordingly spatial information and mapping are a very important part of cost effective high performance integrated malaria management.

Some of the characteristics that need to be taken into consideration include the following:

6. Where are people that are host to the malaria parasite located: where do these people live, where do they work, where do they congregate together, where do they travel to,
7. Where are the sources of mosquitoes,
8. Where do the mosquitoes travel and other details of their behavior including when they travel and how they behave relative to homes, people and animals,
9. Where are infected mosquitoes located,
10. What mosquito and malaria control interventions have been done: when and where.

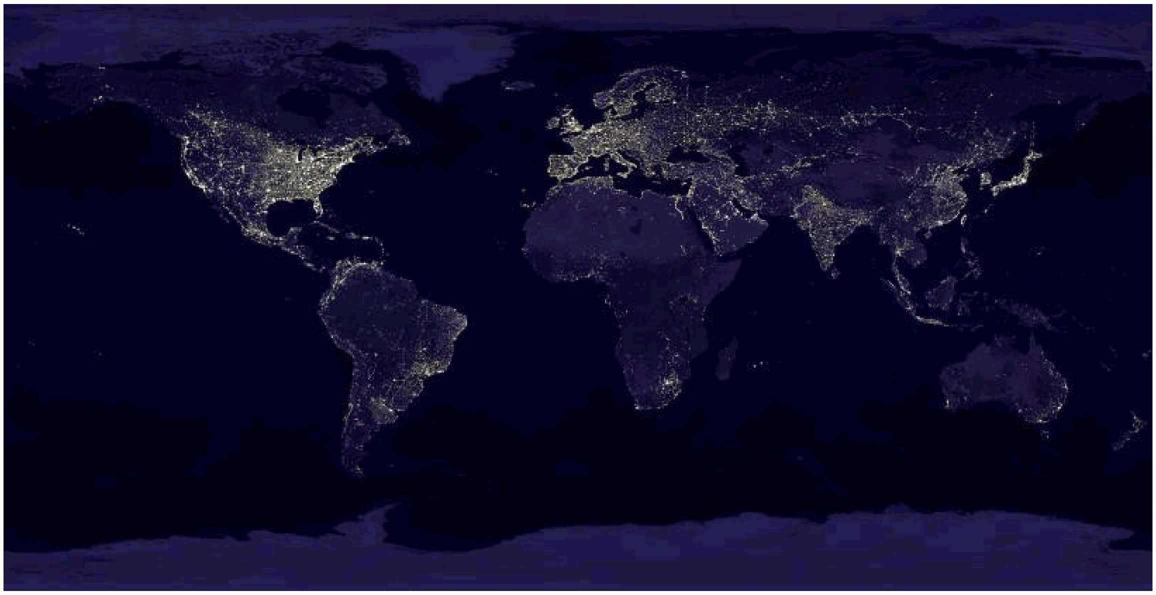
In addition to mapping that shows the simple spatial dimension of the data, there also needs to be an ability to understand the changes that occur over time about a specific place and a specific characteristic of the data.

The ultimate measure of performance is how much has been spent in order to achieve an improvement, and to a great extent money spent well today will only result in sustainable value sometime in the future. However it is also possible to relate the money spent well today with various intermediate results, that in turn will produce the sustainable long term value.

Getting baseline information from satellite imagery

The use of satellite images is relatively new, and the techniques can be very powerful. It is important, however, to use them in ways that are cost effective and valuable. The image below is an old classic that shows the spatial distribution of socio-economic progress and the large areas where population and/or electricity is absent. It also highlights the great difficulty there will be with electricity and communications infrastructure.

This is a reconstructed image of the world from NASA earth observations at night:

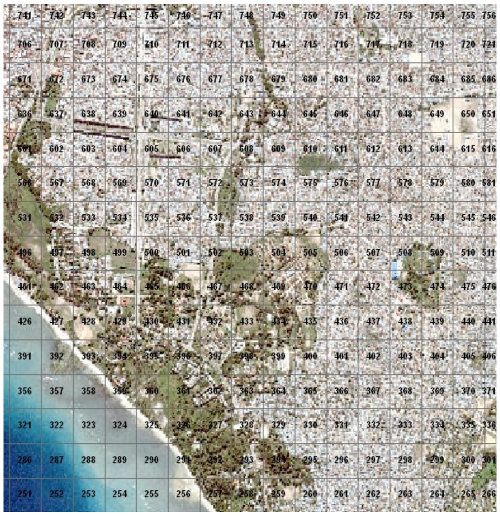


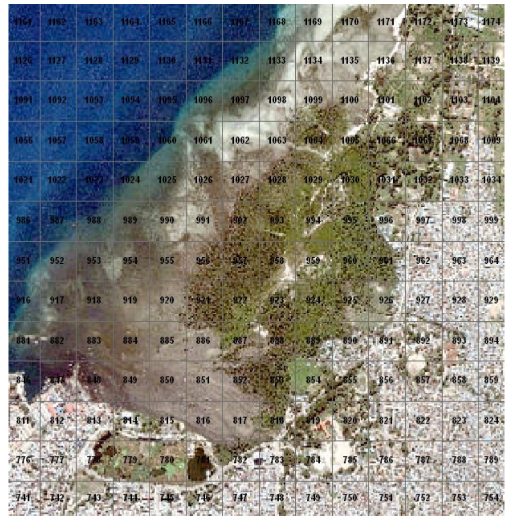
Africa is almost totally dark except for Johannesburg and Cape Town in South Africa.

Satellite imagery can be used for desk review and analysis in ways that are very time saving and cost effective. The following images were accessible using Google Maps and show respectively the whole of the Monrovia are in Liberia, and a small section of the built up area of Monrovia where individual houses can be identified.

On the all Monrovia image, the area within the yellow line is 50,000 acres, and the dark brown area is about 15,000 acres of tidal marsh right in the middle of the city where mosquitoes breed prolifically.

The following images are of Stone Town and its outskirts in Zanzibar. They are images supplied by QuickBird incorporating data from the visible and near-infra-red (NIR) spectra. A grid-based matrix has been overlaid.





These remote sensing and aerial/satellite images are the basis for a rapid build of data about the area, and a framework for rigorous spatial analysis. These images can also be used to develop an initial hypothesis about the profiles of mosquito and malaria prevalence in the area.

The first phase of surveillance is to validate some of the hypothesis derived from the remote sensing. This ground truthing is used both in the immediate process of establishing a baseline and data about the starting state, but also to initiate a process of determining what the optimum interventions strategy would be.

The techniques for doing this surveillance are established, and involve building statistically valid samples relative to each square of the grid.

The following is another example of the use of aerial imagery for planning. The area of potential high mosquito population is identified and a possible area to be treated laid out. With modern GPS equipment it is possible for the aircraft navigation system to be programmed so that spray is accurately delivered to the target area taking into account airspeed and wind over the ground.

Ground truthing

The early work of surveillance combines use of satellite imagery with ground verification of the conclusions derived from study of the images. This process of validating conclusions drawn from study of images should be taken very seriously because it has the potential to save both money and lives on a very large scale.

There has been work done that suggests that the effectiveness of anti-malaria and anti-mosquito interventions could be improved substantially by making planning assumptions based on what can be deduced from study of satellite images. Hardly any use of this is going on at the present time on the large scale interventions that have been funded by the international community.