Malaria Decision Analysis Support Tool (MDAST):

Evaluating Health, Social and Environmental Impacts and Policy Tradeoffs

Project Implementation Report

August 2013

Ministry of Health (Kenya) – Division of Malaria Control

National Institute of Medical Research (Tanzania)

Ministry of Health (Uganda) – Vector Control Division

University of Pretoria – School of Health Systems and Public Health

Duke University – Duke Global Health Institute

WHO Regional Office for Africa

World Health Organization REGIONAL OFFICE FOR Africa

gef GLOBAL ENVIRONMENT FACILITY INVESTING IN OUR PLANET

UNEP United Nations Environment Programme

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The project was accomplished through strong partnerships among WHO-AFRO and the five collaborating institutions (Duke University- Duke Global Health Institute, University of Pretoria – School of Health Systems and Public Health, Ministry of Health (Kenya) - Division of Malaria Control, National Institute of Medical Research – Tanzania), and the Ministry of Health (Uganda)- Vector Control Division.

The World Health Organization (WHO) served as the GEF Executing Agency. Dr. Birkinesh Ameneshewa (Regional Focal Person, Integrated Vector Management, WHO Regional Office for Africa (AFRO)) oversaw and coordinated execution of the project.

Each of the in-country leads served as the focal point for stakeholder engagement and tool evaluation in his or her country, including organizing and implementing workshops and training sessions. The project notes these essential contributions from Dr. Kiambo Njagi and Dr. Rebecca Kiptui (Ministry of Health (Kenya) – Division of Malaria Control), Dr. Leonard Mboera (National Institute of Medical Research – Tanzania); and Dr. Edridah Muheki and Dr. Narcis Kabatereine (Ministry of Health (Uganda), Vector Control Division).

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Dr. Randall Kramer served as the principal investigator at the Duke Global Health Institute at Duke University. The Duke University team also included Dr. Marie Lynn Miranda as co-investigator, Dr. Zachary Brown as the lead modeler, Dr. Dohyeong Kim as lead on value of information analysis activities and model development contributor, and Chris Paul and Adriane Lesser as project managers.

Executive Summary

The Malaria Decision Analysis Support Tool (MDAST) project sought to improve the protection of human health and the environment by promoting sustainable malaria control strategies that are consistent with the successful implementation of the Stockholm Convention on Persistent Organic Pollutants (POPs). The project was developed in a collaborative manner with various stakeholders involved in malaria control policy making and implementation, and responded to a need for capacity building for improved policy formulation. The aim of MDAST is to promote evidence-based, multi-sectoral malaria control policy-making in Kenya, Tanzania, and Uganda, with the project serving as pilot for other malaria-prone countries. The key project partners were UNEP/GEF, WHO-AFRO, Ministry of Health, Uganda, Ministry of Health, Kenya, National Institute of Medical Research, Tanzania, University of Pretoria, and Duke University.

The project focused on achieving four main outcomes:

(1) Development of a Malaria Decision Analysis Support Tool (MDAST) that jointly incorporates health, social and environmental priorities for malaria control in Kenya, Tanzania, and Uganda.

(2) Increased capacity for evidence-based malaria control policy making through the use of MDAST in Kenya, Tanzania, and Uganda.

(3) Creation of an agenda for policy-relevant malaria research through development of MDAST and identification of key knowledge gaps.

(4) Elucidation of requirements for replication of MDAST in other malaria-prone countries around the world.

These outcomes were pursued through 7 specified Project Activities which guided the project in its undertakings, including stakeholder and expert consultations, conceptual modeling, policy dialogue workshops, training and information sharing, partnership building, incentives analysis, and identification of knowledge gaps and research priorities. The project established an inter-disciplinary network of practitioners and policymakers, and contributed to research, monitoring, and analytical capacity to make more informed and evidence-based decisions about alternative approaches to malaria prevention and treatment.

This final report details what was accomplished under each project activity. Under Activity 1 ("Draft prototype MDAST"), the team developed working schematics of the decision support tool model and refined the conceptual decision analysis framework for MDAST. Under Activity 2 ("conduct country-specific development activities to create initial MDAST for Tanzania, Kenya, and Uganda"), project partners worked together closely to coordinate a range of country-specific stakeholder engagement activities that furthered the user-driven development of the initial MDAST, including a project inception meeting, a stakeholder survey, and stakeholder workshops. Under Activity 3, team members identified institutional barriers to implementing optimal policies as well as incentives for addressing these barriers. The purpose of Activity 4 was to engage in country-specific

training, testing, and refinement activities of MDAST. This occurred through a variety of mechanisms including incorporating feedback from the workshops and the Steering Committee meetings, conducting stakeholder webinar consultations, developing the MDAST User Manual, conducting in-country expert consultations, and in-country workshops and training sessions. Activity 5 employed MDAST in conducting value of information analyses (VOI). Project partners disseminated project results and lessons learned (Activity 6) through creating and maintaining the MDAST website as a resource, developing presentation tools on MDAST for stakeholders to use, and making presentations at conferences and developing publications related to MDAST.

Under Activity 7, guidelines were developed for replication of MDAST in other countries. Both project partners and surveyed in-country stakeholders are confident in the value of MDAST as a tool for improved evidence-based decision-making, and these guidelines were developed towards the end of achieving the successful dissemination and implementation of MDAST and its aims in other countries affected by malaria.

The project has built enhanced decision-making capacity and mutual understanding among the diverse networks of players involved in malaria policy formulation in three East African countries, serving as a pilot for other countries facing the burden of malaria. The extension of MDAST beyond this project to include additional countries would require the availability and commitment of certain human resources, including a core group of stakeholders headed by an in-country lead with the interest and authority to engage with MDAST, and of technical staff to support the dissemination, training, and implementation activities. Introduction and adoption of the tool in other countries would also require financial resources to move the process forward. Beyond the scope of this project, there are excellent opportunities to continue the iterative improvement of the tool and further its networks through future expansion activities.

Contents

I. INTRODUCTION

A. Project Background

Despite progress over the past decade in reducing the global burden of malaria, its prevention and control remains a complex challenge to health agencies in many countries. The Malaria Decision Analysis Support Tool (MDAST) project developed an approach for improving comprehensive malaria control policy formation with an integrated decision analysis framework to guide the evaluation of alternative malaria control strategies. The framework allows the systematic analysis of sustainable malaria control strategies that are consistent with the successful implementation of the Stockholm Convention on Persistent Organic Pollutants (POPs). The project was developed in a collaborative manner with various stakeholders involved in POPs implementation and malaria control policy making and implementation, and responds to a need for capacity building for improved policy formulation. The aim of MDAST is to promote evidence-based, multi-sectoral malaria control policy-making in Kenya, Tanzania, and Uganda, with the project serving as pilot for other malaria-prone countries. The MDAST framework simultaneously considers multiple outcomes and attributes of various combinations of malaria control options, including both ecological and human health risks and benefits.

To accomplish this goal, the project focused on achieving four main outcomes:

(1) Development of a Malaria Decision Analysis Support Tool (MDAST) that jointly incorporates health, social and environmental priorities for malaria control in Kenya, Tanzania, and Uganda.

(2) Increased capacity for evidence-based malaria control policy making through the use of MDAST in Kenya, Tanzania, and Uganda.

(3) Creation of an agenda for policy-relevant malaria research through development of MDAST and identification of key knowledge gaps.

(4) Elucidation of requirements for replication of MDAST in other malaria-prone countries around the world.

These outcomes were pursued through a range of activities including stakeholder and expert consultations, conceptual modeling, policy dialogue workshops, training and information sharing, partnership building, incentives analysis, and identification of knowledge gaps and research priorities. The project established an inter-disciplinary network of practitioners and policymakers, and enhanced research, monitoring, and analytical capacity to make more informed decisions about alternative approaches to malaria prevention and treatment.

The key project partners were UNEP/GEF, WHO-AFRO, Ministry of Health, Uganda, Ministry of Health, Kenya, National Institute of Medical Research, Tanzania, University or Pretoria, and Duke University.

B. Structure of the Final Report

The aim of this Final Report is to summarize the key project deliverables completed over the course of the entire three-year project period. The presentation of project deliverables within the Final Report is structured according to the seven specified project activities, summarized below:

- Activity 1: Draft prototype of MDAST
- Activity 2: Conduct country-specific development activities to create initial MDAST for Tanzania, Kenya, and Uganda
- Activity 3: Identify institutional barriers to implementing optimal policies, as well as incentives for addressing these barriers
- Activity 4: Engage in country-specific training, testing, and refinement activities
- Activity 5: Use country-specific MDAST in value of information (VOI) analyses to identify key knowledge gaps and create policy-relevant research agenda
- Activity 6: Disseminate project results and lessons learned
- Activity 7: Develop guidelines for replication in other countries

The Final Report then considers challenges and enabling factors for the continued implementation of the tool and its principles, and concludes with recommendations.

II. ACTIVITY 1: DRAFT PROTOTYPE OF MDAST

A. Development of Schematic Diagrams for MDAST

Effective control of malaria and the ultimate goal of elimination require a coordinated, adaptive decision making approach based on the best available evidence from the field. As a first step in developing the tool, the project team developed a schematic representation of the conceptual framework based upon extensive discussions with the investigators and the research team as well as a review of the literature. The literature review focused on malaria prevalence, malaria control methods, modeling of the disease, and literature on infectious disease management, particularly with regards to implementation science. Over 500 references useful to the development of the MDAST and for the identification of the parameters to be used in the tool were collected from refereed journals using PUBMED and other bibliographic services. Studies were also collected from WHO and other organizations via web searches. Substantial secondary information on malaria was also gathered from the ministries of health of participating countries, especially Uganda.

Figure 1: Decision analysis framework for comparing alternative malaria control policy combinations

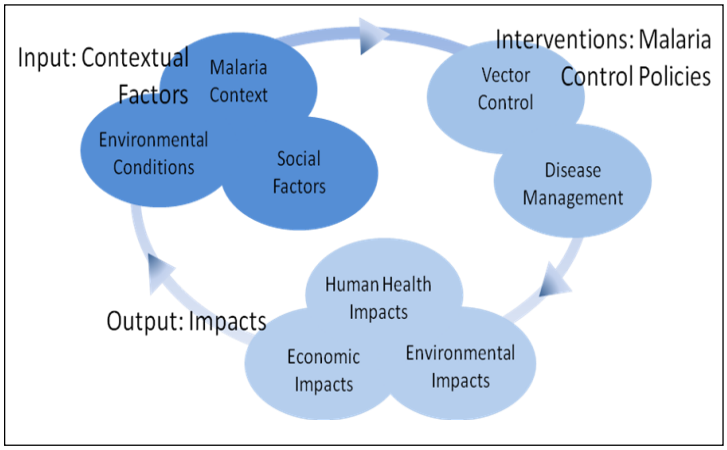


Figure 1 represents the conceptual framework for systematically comparing alternative malaria control policy combinations. First, input parameters describe local contextual factors, such as socio-economic factors, environmental conditions, malaria endemicity, insecticide and drug resistance and parasitological indices. Second, the outcomes of malaria control policies – including health, environmental, and economic impacts – are derived from the input parameters based on relationships identified through the literature, expert interviews (referred to as elicitations), and field-based experiments. Third, each policy combination can then be described in terms of its negative and positive impacts. Policy combinations can then be compared across user-selected metrics, including inputs (e.g., cost or personnel requirements) and outcomes (e.g., predicted malaria morbidity and mortality by age group or insecticide exposure). This schematic was used to initially guide the development of the prototype version of the tool.

Based upon the parameters determined from the literature and experts in the field, the model was designed to offer a variety of options for disease management and vector control to the decision maker, in addition to inputs for baseline data. The MDAST model calculates the outcomes of the health delivery strategy by combining parameters describing the malaria context with the health delivery decisions to generate estimates of the economic impacts, human health impacts, and environmental impacts.

B. Development of the prototype MDAST Model

1. Refinement of the conceptual framework

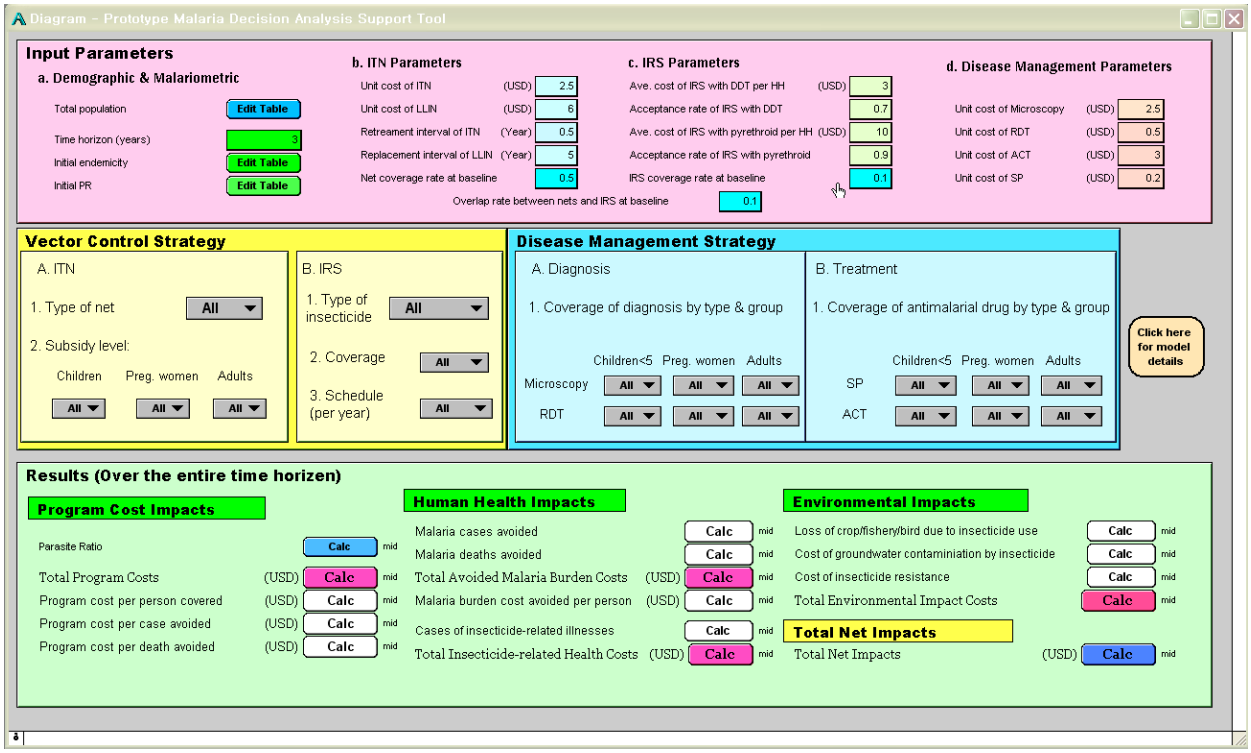
All MDAST project investigators (i.e., from in-country leads, University of Pretoria, and Duke University) actively collaborated to refine a conceptual decision analysis framework for a malaria decision analysis support tool (MDAST). MDAST was at this stage an iterative model undergoing refinement to further incorporate input from key stakeholders gathered through systematic processes (i.e., the MDAST Stakeholder Survey and stakeholder workshops).

The decision analysis framework was applied to facilitate analysis of alternatives for implementing technologies, as well as of different mechanisms for delivering the technology to the target population. The decision analysis framework can promote an integrated approach to malaria management by drawing attention to a wide range of malaria control options and allowing policymakers to explore the impacts of varying combinations of control strategies on both the disease management and vector control sides. The concepts and general framework of the malaria decision analysis tool are described in the paper Kramer et al., 2009.

2. Development of the draft prototype

Based on the conceptual decision analysis framework, the team developed a prototype MDAST as described below and developed a fully-implemented MDAST by employing the decision analysis software Analytica® (Lumina Decision Systems, Inc., Los Gatos, CA). **Figure 2** shows a screen shot of the initial prototype MDAST, which illustrates the initial top-level interface developed for decision makers to use the tool to analyze policy trade-offs (the user interface has been modified significantly since this prototype version).

Figure 2: Screenshot of initial prototype MDAST created with Analytica®



The foundation and main features of MDAST were established at this time as summarized below. Future development of these features continued throughout the project period as detailed throughout the rest of the report.

a) Input Parameters

Because the impacts of different decisions are dependent on local context, parameters describing this context may be entered by the user. Within the prototype, the initial level of malariometric indicators, such as the parasitemia rate (PR) and malaria endemicity status, could be entered directly into the model by the user. Also, in order to provide a platform for systematically comparing alternative malaria control policy combinations over time, the prototype MDAST model was developed to incorporate the dynamics of malaria transmission and control over different timeframes. Thus, the user can define the number of years for which the output parameters of each malaria control policy combination are estimated.

b) Health Delivery Decisions: Vector Control and Disease Management

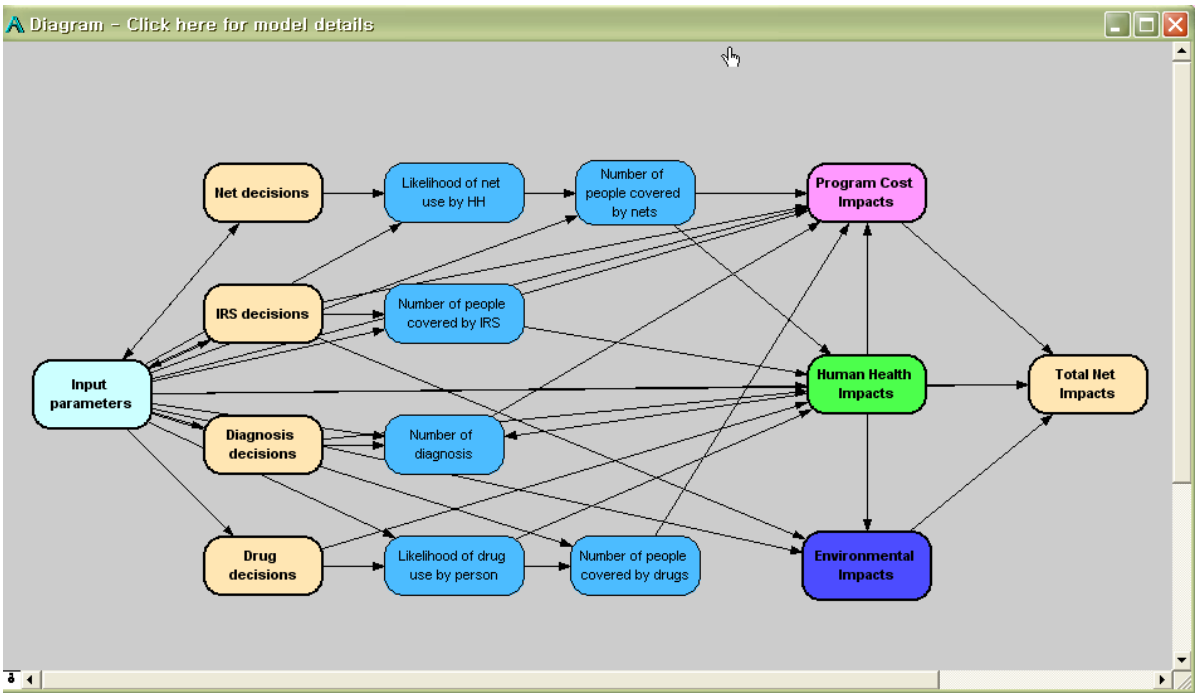
This initial version of the MDAST prototype required the user to input decisions regarding preventive measures, which include net type (ITN or LLIN) and subsidy level, IRS type (DDT or specific pyrethroid) and coverage level, retreatment schedule, diagnostic strategies (microscopy or RDT), as well as treatment strategy (SP or ACTs, as chloroquine resistance is widespread). All strategies on subsidy and coverage levels can be stratified by the three demographics mentioned above. All of the choices are made by the user with the gray buttons in the central section of the MDAST user interface. When clicking each button, a pull-down menu appears for each specific choice from which the user can select a particular option or "All". The prototype presented above

included several of the more commonly used interventions. The suite of interventions available in MDAST was revised based on stakeholder interviews and workshops during August 2010.

c) Modeling and Output

Once the input parameters and health delivery decisions are specified, MDAST calculates the outcomes of the user-defined health delivery strategy by combining parameters describing the malaria context with the health delivery decisions within a systematic modeling framework. The screenshot of the influence diagram for the underlying prototype model is shown in **Figure 3**. As shown in the figure, a module was created for each of the three impacts components, where various output parameters are estimated based on theoretical equations and various scientifically-proven assumptions. The initial versions of the program cost impacts module and the human health impact module were completed at this stage.

Figure 3. Screenshot of basic influence diagram of the prototype model



One of the most critical components of the modeling is to estimate the terminal level of parasitemia rate (PR) for each malaria control policy combination chosen by the user during the user-specified time interval. The estimated PR function is then used to generate: (1) economic impacts, (2) human health impacts, and (3) environmental impacts. To estimate the PR, we developed a relatively standard epidemiological model of vector-borne disease transmission, incorporating vector control and drug therapy impacts. The functions and measures that must be assumed in this model introduce some significant uncertainties into the overall MDAST structure.

In order to validate the estimation process and calibrate the terminal PR estimates, the team conducted a systematic literature review and meta-analysis for the effectiveness of vector control methods in reducing malaria risk or prevalence by systematic search of five journal databases to develop meta-regression models

using several covariates such as age, type, coverage, and so on. The findings of this meta-analysis provide rigorous estimates of effectiveness measures of nets and IRS, along with the combined effects of both strategies.

III. ACTIVITY 2: CONDUCT COUNTRY-SPECIFIC DEVELOPMENT ACTIVITIES TO CREATE INITIAL MDAST FOR TANZANIA, KENYA, AND UGANDA

Project partners worked together closely to coordinate a range of country-specific stakeholder engagement activities that furthered the user-driven development of the initial MDAST for Tanzania, Kenya, and Uganda. This included convening a project inception meeting, conducting and analyzing a stakeholder survey, and running stakeholder workshops in each of the three project countries. Beyond initial development of the tool, later sections of this report detail how project partners used feedback from additional stakeholder engagement activities throughout the process of tool refinement.

A. Inception Meeting of the Malaria Decision Analysis Support Tool Project

An inception meeting was held on March 9, 2010 at the Fairview Hotel in Nairobi to; (1) review the project proposal for a common understanding on the project framework; (2) develop a work plan for the 1st year of the project; and (3) agree on specific contributions expected from the involved stakeholders. There were 16 participants from 6 countries representing governmental and international organizations.

The meeting began with overviews of malaria control policy making presented by representatives from each of the three project countries - Kenya, Uganda, and Tanzania. In addition, participants completed a draft survey on malaria control policy. An overview of the project objectives and rationale, project timeline, and the roles of each partner and stakeholders was presented, and this was followed by a discussion among the participants.

The main points of discussion with regards to the development of MDAST touched upon various important themes, including the importance of reliable information, the implications of data issues, selecting proper and adequate parameters, and the value of bringing researchers and policymakers together. There was also considerable discussion on the current malaria control decision-making processes in each of the project countries. The details of these discussions constituted important feedback for the further development of the initial MDAST.

B. MDAST Stakeholder Survey

The stakeholder survey engaged a wide range of stakeholders in the project countries towards the end of gathering and analyzing country-specific stakeholder feedback for use in the informed and responsive development of the initial tool.

1. Stakeholder Respondents

The survey respondents were drawn from a non-random purposeful sample of stakeholders selected by the in-country MDAST leaders. The survey targeted individuals in ministries, non-governmental organizations (NGOs), universities and research institutes whose policy decisions and actions are likely to have impact on the status of

malaria or influence malaria control decision-making in the respective countries. The primary sectors represented in the survey were those dealing with health, agriculture and environment issues. The survey was administered to respondents in August 2010. There were a total of 97 respondents (Tanzania: 31, Uganda=33, Kenya= 33).

2. Summary of some key findings

Analysis included summary measures of the survey data, comparing results by country as well as aggregated across all three project countries. The results suggested interesting and important trends in stakeholder knowledge and perspectives to be given consideration in further development of the MDAST.

Significant results (aggregated across countries) included:

- A belief that donor preferences and agendas were exerting too much influence on malaria policies in the country.
- A misalignment of the respondents' desired level of importance to be given to a range of objectives in deciding among alternative malaria control policies compared with the level of importance they felt those objectives were currently accorded (i.e., respondents on average thought that most relevant objectives were not being given enough consideration in malaria decision-making).
- A greater understanding of the importance of various factors in consideration of specific malaria control strategies, including costs, effectiveness, human health impacts, environmental health impacts, compliance/acceptance, financial sustainability, and vector resistance.

Detailed analysis can be found in the MDAST Year 1 Project Progress Report (available for download at < http://sites.duke.edu/mdast/reports/ >).

C. August 2010 Stakeholder Workshops

1. Background & objectives of the August 2010 Workshops

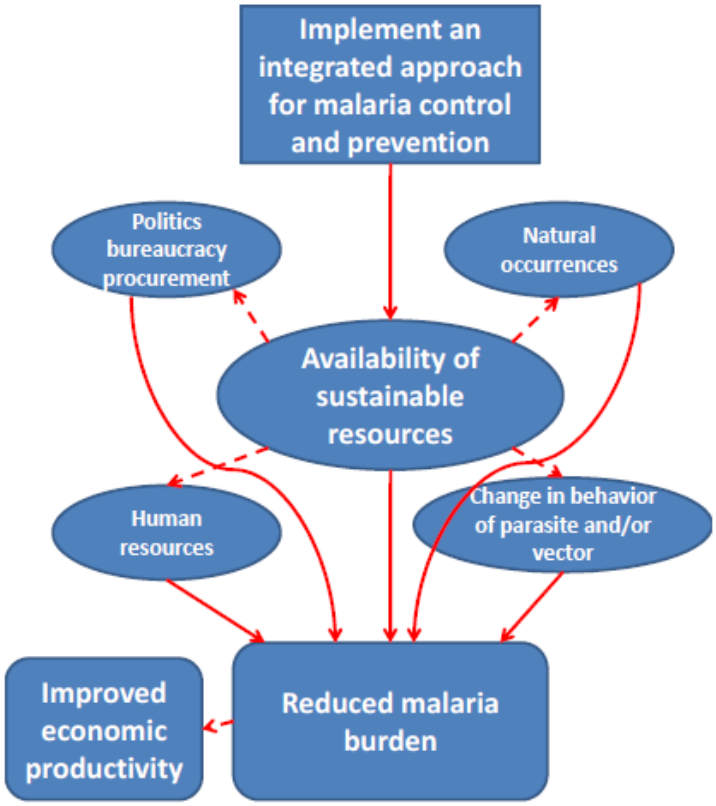
As the next stage in advancing the first-year work plan for MDAST, a stakeholder workshop was held in each of the three participant countries during August 2010. Stakeholder workshops were organized by collaborators based in each of the project countries as well as collaborators at Duke University, the University of Pretoria, and the WHO. Relevant ministries within government including health, environment and agriculture, as well as representatives of district level governments, where appropriate, were invited to participate in the stakeholder workshops. In addition, participation was sought from other relevant organizations. The objectives for holding the workshops were to: 1) familiarize key stakeholders with the MDAST project and its objectives; and 2) collect inputs on malaria control decision-making from key stakeholders.

2. Structure and content of the August 2010 Workshops

Following welcoming remarks and introductions, an overview on the purpose of the MDAST project as a whole was provided, followed by the specific objectives of the stakeholder workshops. This session was followed by a presentation on how influence diagrams work. Because influence diagrams are essential to the development of MDAST, workshop leaders took time to formally convey the structure and purpose of influence diagrams. All participants were asked to draw a simple influence diagram related to malaria control policy making in the host country. Workshop participants were then assigned to teams, and each team was asked to develop a more

complex influence diagram of how malaria control policy making happens at the program level in the respective country. These breakout sessions were characterized by lively discussions amongst the team members, demonstrating a clear interest in how influence diagrams might be used to better understand – and better design – malaria control policy making. The hand-drawn influence diagrams were converted into an electronic version using computer graphics for a cleaner look and easier interpretation. An example of one of the influence diagrams developed during this exercise is shown below (**Figure 4**).

Figure 4: An example of an influence diagram developed during the 2010 Stakeholder Workshop in Uganda



Each workshop featured a leader from the national malaria control policy program who provided an overview presentation on how malaria control policy decisions are made at the program level. These presentations were followed by presentations from each of the teams. These presentations engendered significant discussion regarding the strengths and weaknesses of each of the influence diagrams presented. The MDAST team viewed these influence diagrams and the discussion that ensued as invaluable inputs into the design and implementation of the MDAST. For example, a number of groups brought out the importance of advisory committees in shaping malaria control decision making. The influence diagrams of other groups distinguished between decisions that are made at the national level and those that are made at the district level. The workshops also offered the opportunity to present to the stakeholders the preliminary results of the stakeholder survey mentioned above. This presentation also engendered lively discussion and perspectives. These and other important points were taken into account as the MDAST was developed.

The discussion of survey results was followed by a discussion of inter-sectoral collaboration. It was emphasized that MDAST in its current conceptualization focused on the making of distinct program choices and not necessarily the entire policy process from agenda setting to implementation of interventions. After this clarification the views of the participants were sought about the importance of involving different sectors in decision-making. Furthermore, participants were invited to air their views regarding status of collaboration and the main challenges in their countries. Their opinion was also sought regarding how they thought MDAST could be enhanced and used to promote policy dialogue and address concerns, including the political context of policy processes.

August 2010 Stakeholder Workshops

Uganda: August 9, 2010

Tanzania: August 13, 2010

Kenya: August 17, 2010

In the concluding discussion session, next steps for the MDAST project were discussed and input was invited from the group on the direction of the project team's work. A prototype user interface for MDAST was previewed as well. During this part of the meetings, participants suggested ways that the tool could be improved and implemented.

In the closing session, a summary of the key points made during the workshop was presented. Some points were common across all three workshops, while others were unique to each country. Themes in common across all of the workshops included the complex and dynamic nature of malaria and its control, concern and advice regarding the research agenda for malaria control, and the need to address the relationship between research and policy. Each workshop also yielded unique insights on malaria control research and policy as well as the development and uptake of MDAST. The details of key points from the workshops can be found in the comprehensive Report on the 2010 Stakeholder Workshops in Project Countries produced by the project, contained within the MDAST Year 1 Progress Report (available for download at <http://sites.duke.edu/mdast/reports/>). The information gained from the August 2010 stakeholder workshops was essential to the process of refining the MDAST model so that it can better address the full range of health, social, and environmental risks and benefits associated with alternative malaria control strategies. Described later in this report is the second round of stakeholder workshops held in 2012, which presented another opportunity to further refine the tool according to an enhanced understanding of the situation on the ground as well as the needs of its anticipated users.

IV. ACTIVITY 3: IDENTIFY INSTITUTIONAL BARRIERS TO IMPLEMENTING OPTIMAL POLICIES, AS WELL AS INCENTIVES FOR ADDRESSING THE BARRIERS

A. Background

Using the MDAST framework to select optimal malaria interventions will not result in policy or regulatory reform unless existing barriers to implementing these policies are eliminated and appropriate incentives are put into place to activate the new policies and monitor their results. This activity used institutional analysis to identify the barriers to preferred policies that may exist at the national and district level and to ascertain necessary incentives to overcome those barriers. In addition, barriers and incentives related to conducting policy-relevant research and evaluating policy results were identified so that each round of policy reform can generate additional feedback for future policy deliberations.

Given the complexity of malaria and thus the complexity of control, significant barriers to implementation of optimal malaria policy making exist. Barriers exist in a wide variety of dimensions, including those which are social, financial, cultural, and institutional. The tool and its implementation serve to identify extant barriers in each policymaking setting and provide opportunities to reduce their impact.

MDAST offers users a suite of potential malaria control interventions and models the simultaneous effects of these potential actions in a population. By permitting policymakers to consider alternative interventions, use of the tool may provide the means to identify solutions that were previously considered infeasible.

Barriers may exist specifically to the use of a decision making tool such as MDAST. Policymaking may be divided between various departments and ministries, central and regional government, and government and non-governmental organizations. MDAST is designed to provide policy makers with both a broad set of possible policy making options and the information necessary to engage in intersectoral dialogue about improved policy making.

The efforts of the MDAST project to document barriers to the optimal malaria control policies suggested by the tool include a review of the literature, feedback from stakeholder activities, interactions with the WHO-coordinated steering committee, and surveys of stakeholders. Finally, the identification of barriers presents the opportunity to eliminate them. The role of MDAST in improving decision-making includes improved transparency and information made available to decision makers, and an improved platform for discussion between policymakers.

B. Literature review on barriers

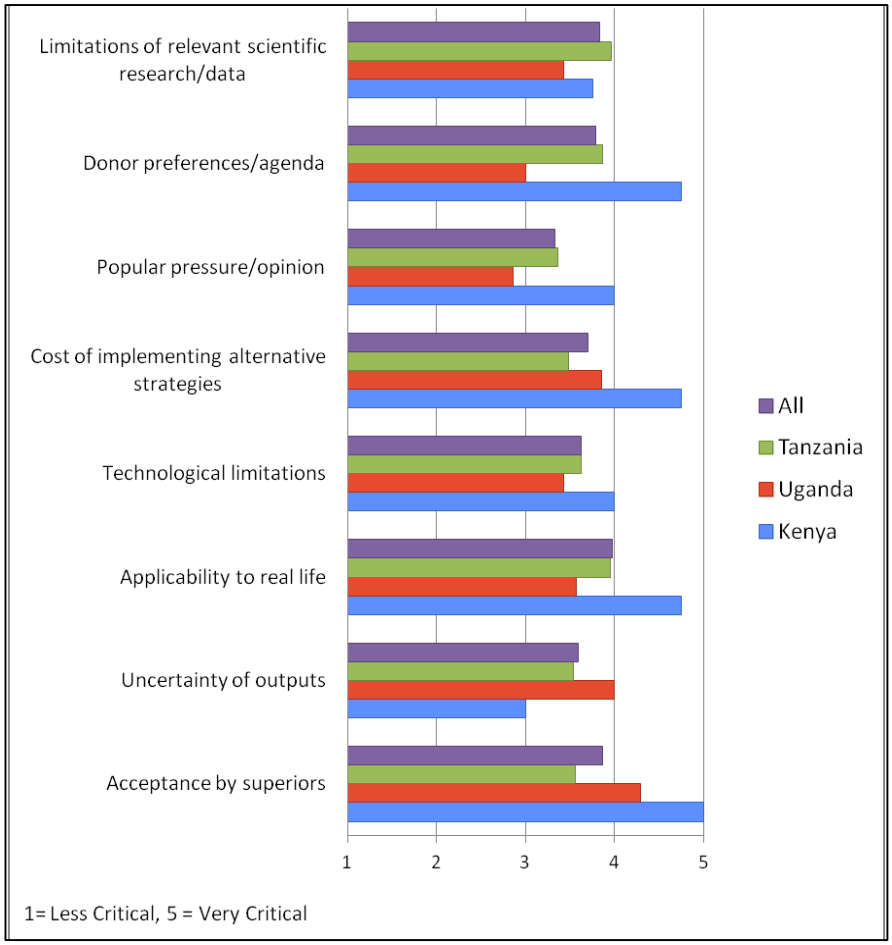
A review of the literature from the previous 15 years (1996-2011) on malaria policy barriers was conducted in July 2011. This structured review generates a useful perspective of the published literature on malaria policy barriers. The most important value in identifying barriers to optimal outcomes is the determination of opportunities to overcome these barriers. Thus, a literature on barriers to optimal malaria policy does not exist,

per se, but rather a literature describing current shortcomings and potential for improvements in malaria control policy. The results of the literature review are being incorporated into a manuscript for forthcoming publication.

C. MDAST Stakeholder Feedback on barriers

The responses from the August 2010 Stakeholder Survey detailed earlier have implications for perceptions of barriers to optimal malaria control policy. Respondents from all three countries (n=97) overwhelmingly reported (78% agreeing) that there are additional people or organizations that should be included in malaria policymaking that are not currently. The free response section to this question elucidated which groups respondents believe should additionally be included, in particular local communities and researchers. Twenty per cent of respondents wrote that local governments should be included, and 12% wrote that local communities should be included (respondents listed multiple groups). Nineteen per cent of respondents named additional national-level government agencies that should be included in malaria control policymaking. A number of questions from the survey indicate the differential between current practices and those practices considered optimal by the respondents. Respondents in all three countries indicated that donors should have much less influence over policy-making than they currently have and policymakers should consider research more frequently in policymaking. Respondents also indicated, though less strongly, that more attention should be given to the costs of alternative strategies.

Figure 5: Expert Consultation responses to the question "please indicate how critical each of the following barriers is to full implementation (or dissemination) of the tool for decision-making?":



At each of the August 2010 workshops, participants expressed the need for malaria research to generate high-quality information and data specific to the situation in the country and/or the distinct regions within the country. Strategic integration of research efforts was a common theme across all of the workshops. Participants specifically noted the importance of inter-sectoral collaboration in both research and malaria control implementation. Participants noted that even though good tools for malaria control may exist or are being developed, politics and issues in

the political process can obstruct effective implementation. Relevant country-specific feedback can be found in the report on the first stakeholder workshops contained within the MDAST Year 1 Progress Report (available for download at < http://sites.duke.edu/mdast/reports/ >).

In-country expert consultations were held in all three project countries in August 2011. The expert consultations are detailed in more depth later in the report. After a presentation on the MDAST model and participation in an interactive, hands-on demonstration, expert consultation participants were asked about their perceptions on how critical various barriers are to the implementation and/or dissemination of MDAST for decision making (**Figure 5**). Interestingly, the aggregate average across all countries for all potential barriers rated below 4 on the Likert scale, suggesting that on average participants did not perceive the issues as very critical barriers to the success of MDAST. The barrier that received the highest aggregate average (near 4 on the Likert scale) was "applicability to real life", followed by "acceptance by superiors" and "limitations of relevant scientific research / data".

D. Additional survey work on barriers

Student team members of MDAST conducted interviews and data collection activities in Uganda and Tanzania which provide useful input to the understanding of certain barriers in each country setting. In Uganda, 34 stakeholders were interviewed for their perceptions of malaria and vector control, particularly with regards to the use of integrated vector management (IVM) (Mutero, et al., 2012). In Tanzania, an expert elicitation was conducted with 19 experts on the benefits and risks of insecticide treated nets and indoor residual spraying (Pfau, 2011).

In the Uganda IVM interviews, key barriers to vector management included budget shortcomings, a dependence on external funding, and a lack of internal political capacity to support vector control. Respondents also reported a variety of potential environmental risks related to vector management in Uganda, and expressed a belief that IRS posed the greatest risk if mismanaged. According to participants, IVM presented particular challenges in coordination of sectors, management of resources, information sharing, and the maintenance of political support. A majority of respondents (67%) felt that communities were actively being engaged in IVM but that community response was mixed. Community engagement was important for acceptance, and respondents indicated opportunity for more local involvement in malaria interventions. An area of concern for IVM appeared to be the application of research and evaluation results to policy change, which respondents reported happened neither frequently nor rapidly enough. Participants identified research for evidence based decision making as the key to successful IVM. However, participants responded also that the greatest current barrier to improved malaria vector control in Uganda was program financing.

The expert elicitation in Tanzania was conducted to gain information on risks of malaria control efforts which currently are characterized by high level of uncertainty. In particular, the expert elicitation sought to describe the tradeoffs between risks of malaria and risks of malaria control (risk-risk tradeoffs). The interviews revealed greater concern for the risk of DDT in IRS as compared to ICON (a pyrethroid). However, respondents noted that while the insecticides of IRS are dangerous, properly conducted IRS itself presents low risk to human health. In comparing intervention policy, respondents noted the significant uncertainty of outcomes due to a multitude of

factors, including reductions in immunity and movement of people. A majority of respondents in a discussion about risk-risk tradeoffs considered the current risk (and burden) of malaria to be of much greater concern than the risks of malaria control, but some respondents noted the complex long term risks, such as the environmental risks if insecticides are not applied and managed appropriately in a safe manner.

E. Opportunities and incentives: The role of MDAST

The existence and identification of barriers to optimal malaria control activities can productively be viewed as a set of opportunities to improve interventions. In understanding the complex nature of malaria control, we must recognize that the incentives for policymakers may differ from the incentives of individuals affected by malaria control policies. For example, a head of household is going to be concerned about immediate, affordable treatment options, while policymakers may be more concerned with the possibility of the parasite developing resistance to treatment.

MDAST is designed to give policymakers the ability to consider interventions in concert. However, recognizing that traditionally multiple agencies and organizations implement the range of malaria prevention and control programs, better coordination amongst policymakers is key to improved policymaking. Careful attention has been placed on producing a model that is useable by policy makers in Kenya, Tanzania, and Uganda on available computer infrastructure.

In the implementation of MDAST, the facilitators, partners, and stakeholders should use the opportunity to prompt cross-sector discussion about barriers to improved malaria policy-making. An effective computer model such as MDAST is inadequate in and of itself to alter the outcomes of control efforts. While the computer-based tool is itself a carefully designed resource for policymakers, the potential benefits of the tool will only be realized if the stakeholders and partners use the tool as an opportunity for increased communication and collaboration in malaria policymaking. MDAST can facilitate informed decision making and evidence-based malaria policy development.

V. ACTIVITY 4: ENGAGE IN COUNTRY-SPECIFIC TRAINING, TESTING, AND REFINEMENT ACTIVITIES

Key Stakeholder Engagement Activities

2010 Stakeholder Workshops

Annual Steering Committee Meetings

Stakeholder surveys

Webinars

Expert Consultations

2012 Stakeholder Demonstration & Training Workshops

The purpose of Activity 4 was to engage in country-specific training, testing, and refinement activities of MDAST. This occurred through a variety of mechanisms. In further developing the tool, the team took into full consideration input from discussions and survey feedback gained during the first round of MDAST Stakeholder Workshops. In addition, we received valuable feedback on the tool from the Steering Committee. Throughout the months of April, May, and June 2011, the MDAST model development team conducted webinars on the tool with key in-country project partners. In addition, expert consultation sessions generated important feedback on the tool, highlighting areas where modifications would be valuable. A second round of workshops in April 2012 had great success in further engaging a range of stakeholders in the review and initial use of the tool, raising enthusiasm for MDAST as well as eliciting further valuable feedback on the model from its targeted users. A summary description of the refined tool is contained at the end of this section.

A. 2011 Expert Consultations

The expert consultation sessions were held in each of the three project countries in August 2011. A team of primary MDAST project researchers closely involved with the development of the model and previous stakeholder engagement activities arranged to meet with key expert stakeholders involved in the National Malaria Control Program (NMCP) and/or other important malaria control entities in their respective home countries. Each consultation session followed a semi-structured format. A recurring concern in all three countries was healthcare practices. Experts raised the issue of improper use of ACTs by clinicians administering the drugs to misdiagnosed patients or patients with negative RDT results because of a lack of trust in the tests, and suggested the representation of this issue in the model. The issue of both insecticide and drug resistance was frequently raised during the consultations. Other requests for additions were related to insecticidal net parameters, financial parameters, climate parameters, environmental management activities and an indicator of burden. The consensus was that the importance of the parameters must be weighed against the goal of a manageable and user-friendly tool; adding too many parameters and components could reduce the user-friendliness of the tool. Therefore, only a few of the identified parameters were considered in-depth, based on perceived importance (e.g., insecticide resistance). Inclusion of more parameters could be considered in the future based on field application and experience in the use of the tools. Regarding the user-friendliness of the tool, a key suggestion was to make a clearer representation of the probabilities and uncertainties in the model output.

Importance of Stakeholder Feedback

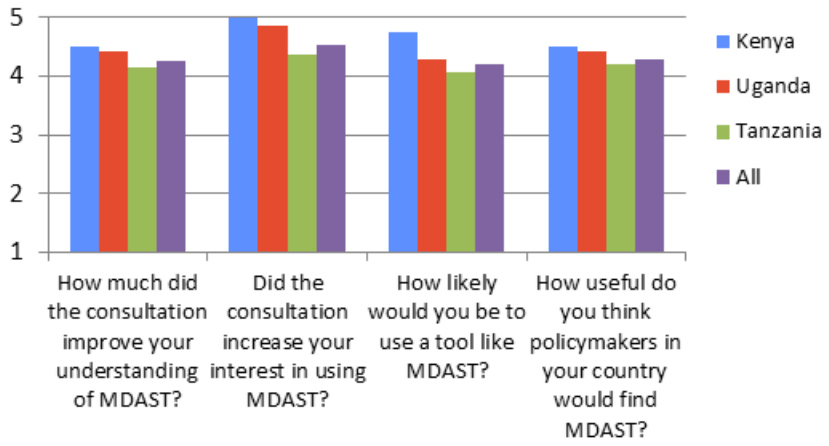
Refinements to the MDAST model reflect stakeholder feedback, priorities, & needs

Feedback strengthens the value and applicability of the tool to its targeted users

Eliciting & incorporating feedback builds a sense of ownership of the tool among stakeholders

At the end of the expert consultation session in each project country, time was allotted for individual written feedback. The detailed results for these surveys can be found in the MDAST Year 2 Progress Report (available for download at < http://sites.duke.edu/mdast/reports/ >). Questions included rankings on the level of priority for incorporation of additional specified features into the model, potential barriers to implementation and dissemination of MDAST, and likelihood of using MDAST. When queried on their interest in and perceived usefulness of MDAST and the consultation, all three countries responded positively about the usefulness of the consultation and the usefulness of the tool, with all averaged responses above 4 on a 5-point scale (for both the aggregate average and the average for each country) **(Figure 6)**. The average response in each country indicated agreement that the consultation improved their understanding of MDAST and increased their interest in using MDAST. The average response in each country indicated that they would be likely (or very likely) to use a tool like MDAST, and that they thought policymakers in their country would find MDAST useful. These are encouraging results that highlight the promise of MDAST and the success of the expert consultation sessions in engaging key policy-makers and potential users of the tool in the future.

Figure 6: Rating of the interest in and usefulness of MDAST: Feedback from the 2011 Expert Consultations



Q1 & Q2: 1= Not at all; 3= somewhat; 5=Very much
Q3: 1= Not likely at all; 3= somewhat; 5= Very likely
Q4: 1=Not useful at all; 3 = somewhat; 5 = Very useful

B. 2012 Stakeholder Demonstration and Training Workshops

This subsection summarizes the background, objectives, activities, and outcomes of the Malaria Decision Analysis Support Tool Demonstration and Training Workshops held in April 2012 in Kenya, Uganda, and Tanzania. The series had great success in further engaging a range of stakeholders in the review and initial use of the tool, raising enthusiasm for MDAST as well as eliciting further valuable feedback on the model from its targeted potential users. A detailed report on the 2012 Workshops was produced and covers the activities, feedback, and lessons learned in greater detail. This report is contained within the MDAST Year 3 Progress Report and is available for download at < http://sites.duke.edu/mdast/reports/ >.

1. Methodology

The aim of the 2012 MDAST Demonstration and Training Series was to demonstrate, train, and gain expert feedback on the current version of MDAST from key stakeholders in order to assess the model and strategies for its dissemination and implementation. The demonstration and training sessions were organized by collaborators based in each of the project countries (at the Vector Control Division in Uganda, the Division of Malaria Control in Kenya, and the National Institute of Medical Research in Tanzania) as well as collaborators at Duke University, the University of Pretoria, and the WHO. Relevant ministries within government including health, environment and agriculture, as well as representatives of district level governments, where appropriate, were invited to participate. In addition, participation was sought from other relevant organizations. The workshops held in all three countries were well-attended by a range of key stakeholders from various organizations.

The workshops were held as follows:

Country Workshop:	Workshop Venue:	Date:
Kenya	*icipe* Headquarters, Nairobi	April 23, 2012
Uganda	Imperial Resort Beach Hotel, Entebbe	April 25, 2012
Tanzania	Centre for Enhancement of Effective Malaria Interventions (CEEMI), Dar es Salaam	April 27, 2012

a) Objectives

The objectives for holding the workshop and training sessions were:

1. To demonstrate the use of MDAST to key stakeholders using different scenarios of malaria control interventions, disease epidemiology, and social factors;
2. To provide in-depth training on how to use MDAST to key persons in each participating country;
3. To elicit additional stakeholder feedback regarding the latest version of MDAST, and further inputs leading to refinements of the tool;
4. To engage stakeholders in discussion on strategies for implementation and dissemination of the tool.

2012 Stakeholder Workshops & Training Series

Kenya: April 23, 2012

Uganda: April 25, 2012

Tanzania: April 27, 2012

These objectives were agreed upon by all collaborating institutions in advance of the series and were presented to stakeholder participants a few days prior to the workshop in each country. The clear definition of these objectives guided the appropriate design and scope of the sessions towards achieving the desired outcomes outlined below.

b) Format & structure

While each workshop was dynamic in responding to stakeholders' interests, in general, each workshop followed a very similar format.

The welcome remarks provided an opportunity for an informative and insightful overview of the status of malaria control strategies in the country, including current successes and challenges that the national malaria control program was experiencing. The first session topic focused on recognizing the many ways in which input from past in-country stakeholder engagement activities had been incorporated to revise and improve the tool. The core of the main session was the demonstration of the tool. The outcome of the scenario demonstrations was to raise both interest in and understanding of the tool and its abilities among the participating stakeholders. Following the scenario demonstrations, the session turned to a user-driven exercise of the tool. In each country, a volunteer from among the participants was chosen to lead the exercise through soliciting and inputting expert feedback from the audience in order to run the model for a given scenario. Overall, the user-driven exercise was a valuable demonstration of the tool and the ability of a new user to learn and implement some of its basic functions in a short time.

The next session engaged stakeholders in discussion on strategies for implementation and dissemination of the tool towards the outcome of revising these strategies based on the expert input. A recurrent theme throughout all workshops was discussion on the appropriate level(s) (e.g., district, national) at which the tool should and could be applied. The general agreement was that the tool can be applicable mainly at the level where policy is formulated. The conversation was then directed to a consideration of the mechanisms that could be used in dissemination of the tool. Forums discussed included the project website (which was briefly introduced and presented upon), workshops, policy briefs, conferences, and peer-reviewed publications. Details on these conversations can be found in the report on the workshops (contained within the MDAST Year 3 Progress Report (available for download at < http://sites.duke.edu/mdast/reports/ >). The main session concluded

with the distribution and completion of an evaluation questionnaire and closing remarks (the results and preliminary analysis of the evaluation questionnaire are contained in full in the workshop report).

The primary aim of the separate training sessions was to provide in-depth training on how to use MDAST to key persons in each participating country. At the same time, the training session gave additional opportunities to further facilitate the other workshop objectives of demonstrating MDAST to key stakeholders and eliciting additional stakeholder feedback regarding the latest version of MDAST. In the hands-on training session, participants formed small groups which were guided through developing, implementing, and interpreting a number of scenarios using the model. Following the hands-on training, all trainees came back together to discuss their experiences and feedback. This was an immensely valuable discussion in each country, allowing for the MDAST team to get direct feedback on many aspects of the model including user-friendliness from those that were approaching the tool as users for the first time. The feedback gained in these discussions made clear priorities for revising the tool according to user preferences and requirements. The details and conclusions from these discussions can be found in the workshop report (contained within the MDAST Year 3 Progress Report and available for download at < http://sites.duke.edu/mdast/reports/ >). Finally, the training session concluded by collecting written feedback from participants on the training activities and the model itself (the results and analysis of the evaluation questionnaire are also contained in the workshop report).

2. Key Points

The stakeholders engaged in lively discussions throughout each of the workshops, contributing valuable feedback drawn from their knowledge and expertise. While each workshop provided unique insights, there were also comments and suggestions which were held in common across countries.

In general, stakeholder participants in all countries exhibited interest and enthusiasm for learning more about using MDAST to improve evidence-based policymaking. Participants indicated that they were particularly attracted to the ability to use the tool to both combine and compare alternative malaria control strategies side-by-side and across time horizons; they saw this value-added functionality as responsive to both the real-world situations in their countries as well as to guidelines from international institutions involved in malaria control. Stakeholders were pleased to find in both the demonstration and training sessions that they could understand and explain the general mechanisms influencing model projections given specific scenarios that had been set out; participants felt that in general the tool "worked" in that it modelled the trends they would expect to see given the inputs, while adding value by providing high levels of detail in its outputs (e.g., malaria burden indicators, cost projections, etc.). The workshops in all countries also provided an opportunity to clarify and discuss the ultimate aim and appropriate application of MDAST as a user-driven tool to inform policy decisions.

A common theme across all workshops revolved around data requirements of the model. Stakeholders in all countries were interested to discuss the sources of data used in the tool, the type and amount of data that the user would need to provide, and in a more general sense the issues of availability and quality of data accessed by both the modellers and the users. The clarification and discussion of these issues built a stronger understanding of the model's capacities and limitations among the stakeholders. These discussions provided an opportunity to underscore the transparency and robustness of the model with regards to its data sources and underlying structure. The discussions allowed for pointing out limitations of the model to reflect all contexts and reflect the emergence of new data, while in turn highlighting the strength of the model in allowing the user to

draw on his or her own experience and local knowledge to define the input values for many of the parameters. The flexibility of the model to reflect users' specific situations was seen as key. Nonetheless, others felt that the need to search out and enter data across many parameters could be a barrier to using the tool effectively. Some of these users were appreciative that default parameters and assumptions based on the literature could be used but generally felt that default parameters specific to the country context would be even more helpful. Finally, there was discussion about how to build user confidence in the quality of input data and the model calculations more generally, e.g., through model validation. Additional details on the outcomes of data-related discussions in each country are provided in the country-specific summaries that follow.

At all workshops, a mini-session was held in which participants were asked to share and discuss their thoughts on developing and refining the implementation and dissemination strategies for MDAST. Among all countries, and especially in Tanzania and Uganda, there was considerable discussion about the level at which the tool could or should be implemented, i.e., at a district or national level. It was generally agreed that while district-level data could be valuable in reflecting and addressing varied situations across the country, ultimately the tool would have to be introduced and used in a way that was consistent with the established organizational structures for policymaking and implementation in the country. Generally, this meant that dissemination strategies should recognize and reflect an understanding that policy directives come from the central level of government in these countries. Conversations in Tanzania and Uganda in particular addressed in more detail the specific policy environments in each country and how these should inform contextual implementation and dissemination strategies for the tool.

Finally, the workshops provided insights on specific malaria control strategies as they were incorporated into the model. In particular, all workshops discussed IRS methods at length. In all countries, stakeholders expressed a need for the model to expand the number of insecticide types for IRS made available as a choice to the user (in the version presented at the workshops, the user could choose among only 3 types of insecticides to be used in an IRS program defined in the model). A similar issue was raised regarding the number of larvicides included in the tool. The MDAST modellers have responded to this advice by expanding the IRS insecticide and larvicide selections available to the user. Other discussions regarding IRS, which are detailed in the country specific summaries, included the issues of insecticide resistance and its proposed management strategies including application of insecticides in rotation. Regarding ITNs, the use of different distribution mechanisms and how these can be compared and applied using the tool was raised and discussed.

Unique insights from each of the country workshops are detailed in the Report on the 2012 Stakeholder Demonstration & Training Workshops contained within the MDAST Year 3 Progress Report (available for download at < http://sites.duke.edu/mdast/reports/ >).

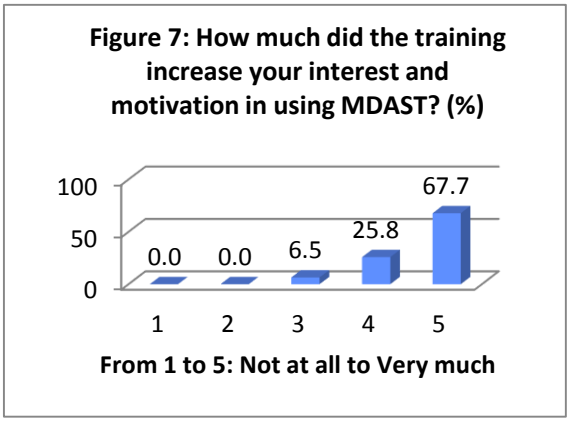
3. April 2012 Surveys

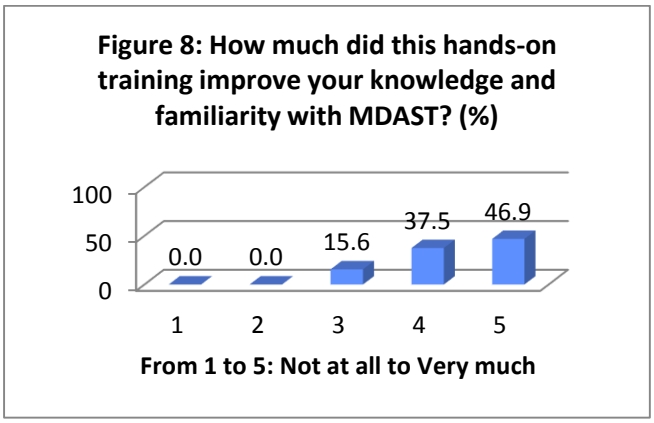
Workshop participants responded to feedback questionnaires at the conclusion of each main session and training session. A few findings of interest are mentioned below. A detailed summary of results is presented in the MDAST Year 3 Progress Report (available for download at < http://sites.duke.edu/mdast/reports/ >).

The survey administered to the workshop participants included sections for: 1) Evaluating their interest and opinion on the value of MDAST, 2) what features of MDAST they find most useful, 3) how critical various

barriers are to the implementation and dissemination of the tool for decision making, and 4) what aspects of the MDAST project website are most important. Participants were also asked to rate how critical eight barriers are to the implementation and dissemination of MDAST for decision making. Applicability to real life and limitation of relevant scientific research were rated most critical, with 80% of the total ratings being 4 or 5 for both barriers. Next, donor preferences, acceptance by superiors, and costs of implementing alternative strategies were also rated critical, with 75-77% of ratings being 4 or 5 for all three barriers.

A second feedback questionnaire was given to participants of the training session. The questionnaire surveyed participants' opinion on MDAST following the training session, as well as their satisfaction with the current version of the tool. Training session partipants reported an overwhelmingly positive increase in their interest and motivation to use MDAST, as seen in **Figure 7**. When questioned about how much the training session improved their knowledge and familiarity with MDAST, the response was also very positive (**Figure 8**). With regard to their comfort using MDAST to compare multiple policy alternatives, on a scale of 1-5, from not comfortable at all to very comfortable, 28.1% of responses were 3, 62.5% were 4, and 9.4% of responses were 5.





The results of the evaluation questionnaires from the main demonstration sessions and training sessions along with the feedback from discussions in these sessions have been fully considered by the MDAST team in assessing priorities for refinement of the model as well as implementation and dissemination strategies.

C. Description of the MDAST Tool

1. Purpose of the MDAST tool

The purpose of MDAST is to allow decision makers to explore the likely impacts of different malaria control strategies on health, environmental, and economic outcomes and to optimize health delivery across both disease management and vector control options. Because the impacts of different decisions are dependent on local context, parameters describing this context may be entered by the user. Such parameters include population size by age cohort, malariometric indicators, and the cost of various health delivery options, such as the costs of ITNs and RDT kits. Population data and malariometric indicators are stratified by three demographic cohorts (children under 5, pregnant women, and other adults). The age classification system is motivated by the common knowledge that the severe symptoms of the disease are more commonly associated with children and pregnant women.

2. Conceptual Framework

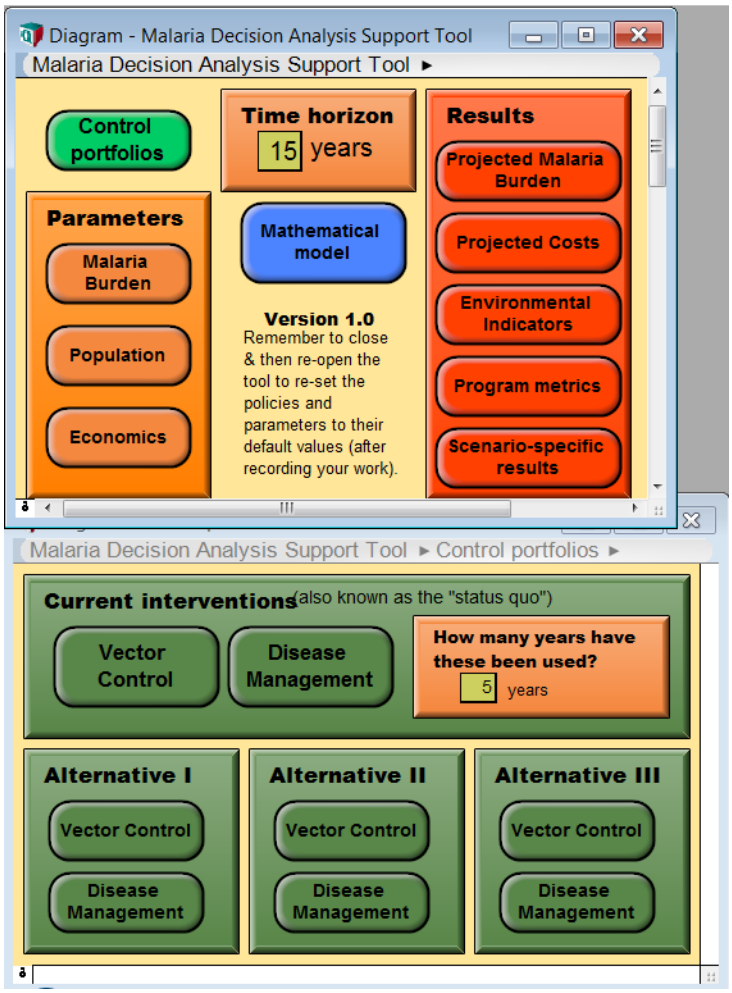
Malaria control decisions are informed by a number of different contextual factors, including the malaria context (e.g., prevalence of the disease), environmental conditions (e.g., rainfall), and social factors (e.g., acceptance of different malaria control methods). These decisions then affect both those same contextual factors (e.g., educational campaigns increase community acceptance) and, ultimately, a set of policy outputs. **Figure 9** shows the MDAST user interface as well as the module for comparing policy combination alternatives to the status quo. The MDAST allows decision-makers to examine the potential impacts of alternate malaria control policies (i.e., vector control and disease management strategies) on human health, environmental quality, and social costs relative to the status quo. In addition, the MDAST will allow policy makers to combine these outputs into an aggregate measure of policies' net benefits, based on user-defined decision weights.

Figure 10 shows the role of influence diagrams in MDAST. The tool works based on parameters from the published scientific literature, in combination with user-provided local knowledge on social and economic factors, ecological and environmental conditions (including insecticide resistance), malaria endemicity, drug resistance, and the current availability of different malaria prevention and control options in the community. MDAST uses all of these parameters to first conduct a historical malaria transmission simulation to better understand what likely happened with malaria transmission in the past (within a window of time specified by the user), and what could happen if current conditions were maintained (i.e. if policies were left as they currently are). MDAST then conducts 3 additional simulations based on hypothetical malaria control policies that the user is considering. Finally, MDAST gathers together the simulated impacts of the baseline projection with those of the 3 potential alternative policies. The user can then compare baseline and alternative policies using a number of different metrics (e.g., cost or personnel requirements) and outcomes (e.g., predicted malaria morbidity and mortality by age group). Panel (a) of Figure 10 depicts this relationship between the historical simulation, the baseline projection, and the 3 policy alternatives.

Each simulation – historical, baseline, and the 3 alternatives – uses a common set of "modules," which are sub-models depicting economic and biological aspects of malaria transmission and control. It should be pointed out that the structure of the underlying transmission model is heavily based on Griffin, Hollingsworth, et al. (2010), and we recommend users look at this paper to understand many of the details of MDAST. Panel (b) in Figure 10 shows the set of submodules used in these simulations. Panel (c) shows the inside of the submodule relating to vector ecology which includes a number of additional submodules relating to vector emergence, mortality, biting behavior, and insecticide resistance. Panel (d) shows the details of the submodule depicting vector emergence (*i.e.* the number of mosquito vectors emerging over time).

The decision analysis framework allows examination of alternatives for implementing technologies, as well as of different mechanisms for delivering the technology to the target population. The decision analysis framework can promote an integrated approach to malaria management by drawing attention to a wide range of malaria control options and allowing policymakers to explore the impacts of varying combinations of control strategies on both the disease management and vector control sides. Disease management options include diagnostics coverage and adherence to results in prescribing treatment as well as drug coverage. Vector control interventions include long-lasting insecticidal nets (LLINs), indoor residual spraying (IRS), and larviciding. The user can specify the details of each intervention to reflect the different mechanisms, costs, coverage rates, frequency, insecticide/larvicide type, etc. as applicable.

Figure 9: MDAST User Interface & Policy Alternatives



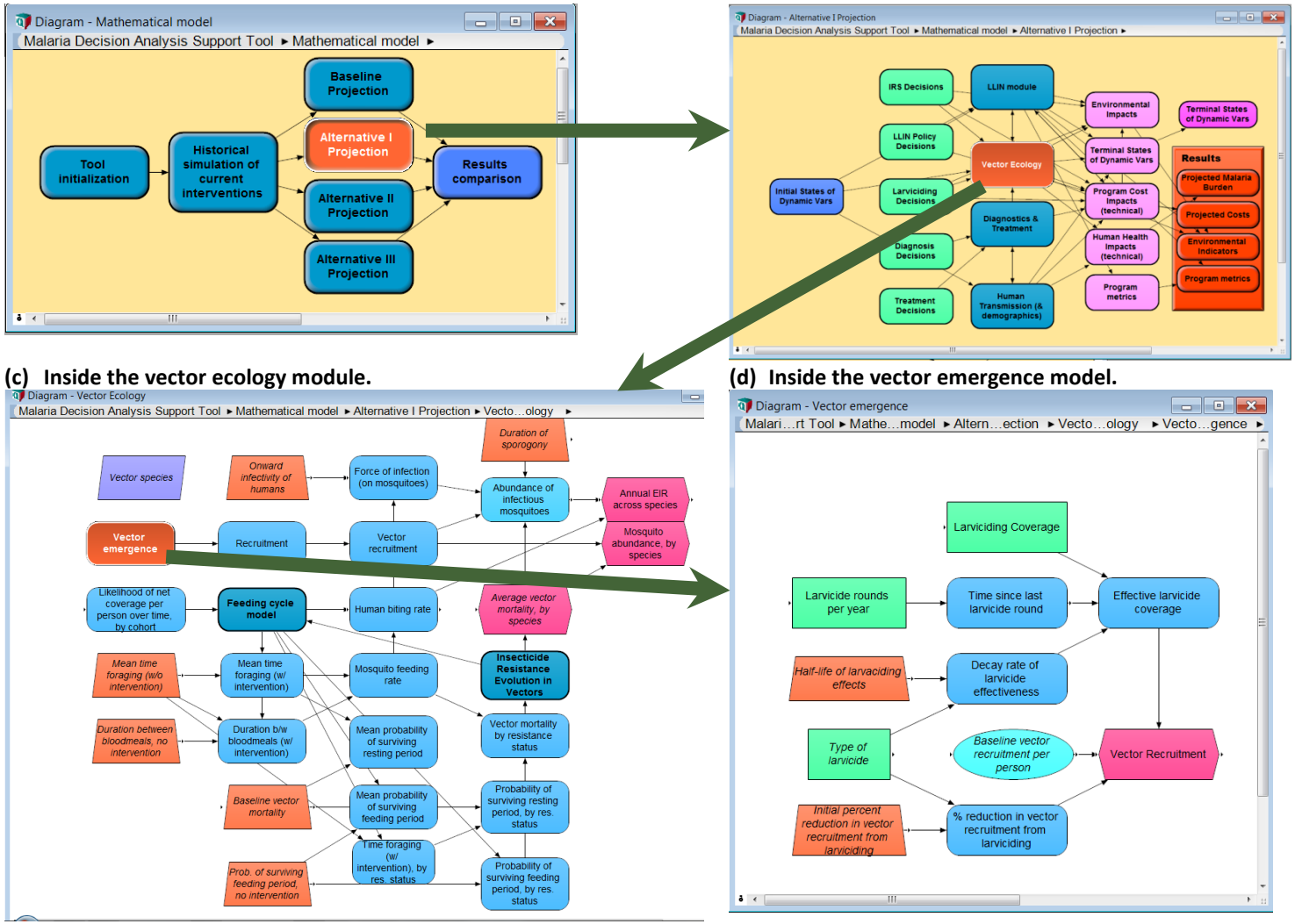
Based upon the parameters determined from the literature and experts in the field, the model offers a variety of options for disease management and vector control to the decision maker, in addition to inputs for baseline data. The MDAST model calculates the outcomes of the health delivery strategy by combining parameters describing the malaria context with the health delivery decisions to generate estimates of the economic impacts, human health impacts, and environmental impacts. The users can specify the length of time (in years) over which the predicted impacts of different malaria control policies will be analyzed. MDAST can produce a broad range of outputs including projected malaria burden (for example: monthly incidence, annual number of severe cases, malaria-attributable deaths, DALYs lost due to malaria); projected costs (including program cost and cost-effectiveness); and environmental indicators.

To explore the model in more detail, visit the MDAST website(**http://sites.duke.edu/mdast/**) to download the most up-to-date version of the model and the accompanying User Manual.

Figure 10: Mathematical Model Influence Diagrams in MDAST.

(a) Influence diagram of how historical conditions, baseline projection, and alternative projections relate to one another and influence the results and the comparison of alternatives.

(b) An influence diagram for one of the alternatives.



(c) Inside the vector ecology module.

(d) Inside the vector emergence model.

VI. ACTIVITY 5: USE MDAST IN VALUE OF INFORMATION (VOI) ANALYSES

In developing MDAST, information gaps were identified in a range of areas, including regarding insecticide resistance, environmental and health damages from insecticides, and the effectiveness of larvicide alternatives. The VOI in the MDAST context has been defined as the social value of being able to know the predicted outcomes of multiple malaria control options for policy decisions, with some uncertainty due to lack of knowledge and research findings. The final version of the MDAST has been used to predict the simulated outcomes of multiple malaria control options which provide the scenario-based quantitative data for the VOI analyses. These findings may offer guidance on comparing the benefits of acquiring additional information from MDAST with the direct and indirect costs of acquiring such information, and investing optimally in the acquisition of new information that would in turn support better choices among control options.

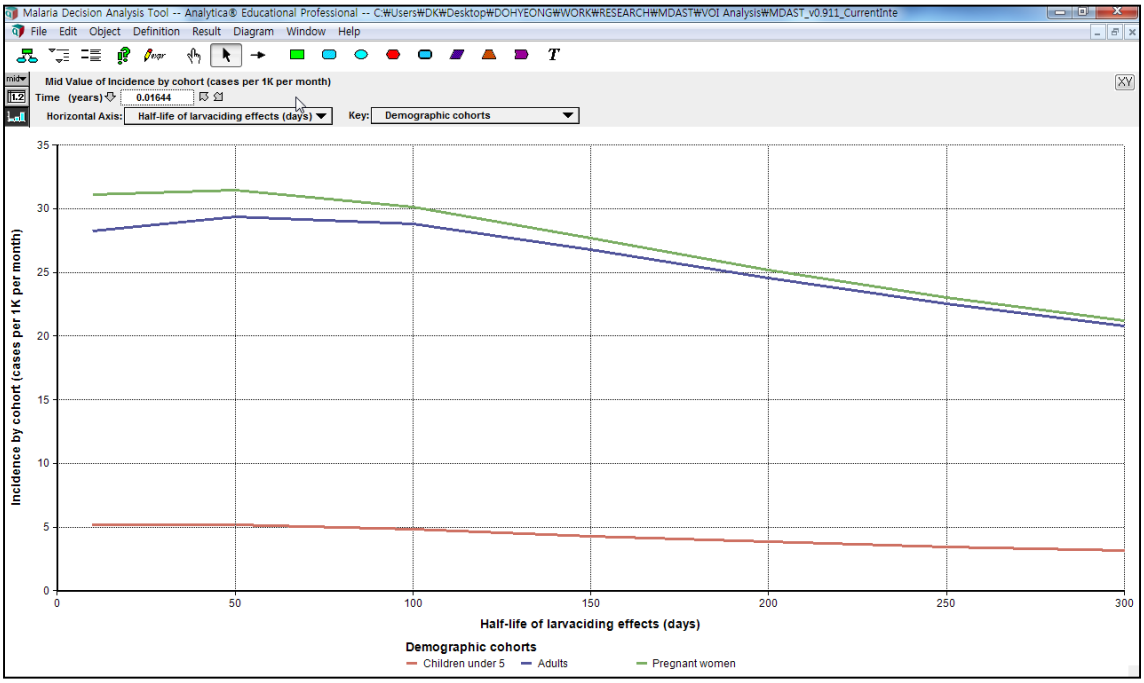
A. Selecting Parameters for VOI Analysis

The team has identified in the literature what aspects and parameters of malaria transmission are appropriate for VOI analysis and has evaluated a series of parameters in the recent version of MDAST which could be a potential source of uncertainty and substantially influential to the key outcome parameters of MDAST. Also, we reviewed the literature and communicated with a few experts and local stakeholders to identify the areas with a lack of knowledge and research findings which should feed into the MDAST framework. We chose two parameters in the area of insecticide resistance, two in the area of larviciding impact, along with a parameter of the baseline vector recruitment per person. Using these parameters, we performed the "Importance Analysis" and "Sensitivity Analysis" to evaluate how influential and sensitive each parameter is to a range of assumed values in predicting the key output measures. Prior to performing the multi-step VOI analyses, the probability distributions for the selected parameters were specified based on literature values and simulations.

The goal of the importance analysis is to identify key sources of uncertainty in a selected output result by comparing the relative importance of the "uncertain" (stochastic) input parameters to the level of uncertainty in the output. The results imply that there might be substantial reduction of uncertainty for malaria control policy decisions when specified variables are informed by a tool such as MDAST. This approach would enable users of the MDAST models to invest optimally in the acquisition of new information that will in turn support better choices among control options and improve collaborations between researchers and policymakers to improve the implementation of MDAST.

The sensitivity analysis determines which parameters are most influential in determining model results and examines how sensitive the key MDAST modeling output measures are to the assumed distribution of each of the selected "uncertain" input parameters. The findings from this sensitivity analysis can inform policy-relevant discussions on how much the additional information on a specific parameter provided can reduce the level of uncertainty in the outcome measures.

Figure 11. Results of sensitivity analysis for malaria incidence by half-life of larviciding effects



For instance, **Figure 11** shows how sensitive the projected malaria incidence is to the assumed half-life of larviciding effects, ranging from 10 to 300 days, for each age cohort. This finding could guide policy-relevant VOI discussions on how much the additional information on the variable can reduce the level of uncertainty in the outcome measures. A series of sensitivity analyses have been performed with other selected parameters to assess the size of changes in the outcome measures due to their variations, whose results are summarized in **Table 1** below.

These preliminary results imply that there would be substantial reduction of uncertainty for malaria control policy decisions when informed by the tool such as MDAST, compared to those without such information. In order to better compare such value of information with the possible costs of obtaining the additional information on these variables, we constructed a table which integrates the findings on the level of uncertainty and sensitivity for the selected input variables from not only the literature review and expert consultation but also the sensitivity and importance analyses using the MDAST.

Table 1. Comprehensive view of the levels of uncertainty on the selected parameters

Parameter	Assumed distribution in MDAST	Importance on outcomes by MDAST	Level of sensitivity on outcomes by MDAST
Evolutionary speed	Lognormal (1.6377, 1.3233)*	Less important	Less sensitive
Evolutionary fitness cost	Lognormal (0.0113, 3.5964)*	Important	Less sensitive
Initial effect of larviciding	Lognormal (0.9, 1)*	Less important	Sensitive
Half-life of larviciding effects	Lognormal (90, 10)*	Important	Sensitive
Baseline vector recruitment per person	Uniform (0, 4)	Very important	Sensitive

** Lognormal distributions are defined as the mean and the geometric standard deviation.*

B. Measuring Value of Information

Although the current results of the importance and sensitivity analyses could be further refined with additional parameters and different sets of distribution assumptions, these efforts reveal major areas of malaria research gaps which should be filled with additional information. Since obtaining additional information could bring about substantial costs, we attempted to measure the value of additional information on the selected parameters in reducing the uncertainty level on the outcomes of malaria control policy. The findings from the value of information analysis will provide MDAST users an approximation of an expected return-on-investment into these research areas, which can in turn improve collaboration between researchers and policymakers on a policy-relevant malaria research agenda. The in-depth comparison of value and cost of additional information on selected parameters would enable users of the MDAST models to invest optimally in the acquisition of new information that will support better choices among control options and thus improve the effectiveness and feasibility of the MDAST models in project countries.

The most typical way of estimating the "value of information" in the literature is to quantify the values in either monetary or non-monetary terms (Morgan and Henrion, 1990, Runge et al, 2011). Such efforts often require a payoff table for all possible decisions under all possible scenarios, which can be used to calculate the expected value of perfect information (EVPI). Once the payoff table is complete and the EVPI is calculated for each selected parameter and compared to each other, it is argued that the parameter with the largest EVPI would be the most critical to be supported by additional information from further research for improved malaria control policy.

As a simple example, if the director of a National Malaria Control Program would like to decide the IRS coverage (80% vs. 100%) whose impacts are potentially affected by the two uncertain parameters (evolutionary speed and fitness cost), it would be valuable to know which parameter is associated with a larger EVPI and thus deserves additional research support to reduce the level of uncertainty. Therefore, we defined program cost per avoided severe malaria case as a target "payoff" and determined four possible scenarios using high and low values for the two parameters along with a specific probability. Then, we ran the MDAST to calculate the payoff values for each combination of the two parameters and the results are summarized in Table 2 below.

Table 2. Payoff table (program cost per avoided severe case, USD) for the four scenarios with a discrete probability of evolutionary speed and evolutionary fitness cost (using alpha-cypermethrin once a year)

	80% IRS coverage	100% IRS coverage
prob (Low evolutionary speed (0.03) & low evolutionary fitness cost (0.01)) = 0.3	2,350	2,021
prob (High evolutionary speed (0.1) & low evolutionary fitness cost (0.01)) = 0.3	3,330	3,046
prob (Low evolutionary speed (0.03) & high evolutionary fitness cost (25)) = 0.2	362	391
prob (High evolutionary speed (0.1) & high evolutionary fitness cost (25)) = 0.2	368	799
EMV (expected monetary value)	**1,850**	**1,758**

If decision-makers were uncertain about the two parameters, they would choose the option whose expected value of the cost was smaller. Table 2 shows the second option (100% IRS coverage) would be the optimal choice without perfect information because the expected monetary value (EMV) of program cost per avoided severe case is smaller (1,758 USD vs. 1850 USD).

With perfect information about the parameter, however, users would be able to know which is the best (most effective) option for each case and choose it to reach the best payoff (lowest EMV). For instance, the payoff value for the 100% coverage (2,021 USD) is smaller and should be chosen for the first case (low & low); while the payoff value for the 80% coverage (368 USD) is smaller and should be used for the last case (high & high). Therefore, with perfect information, the expected monetary value (EMV) is calculated as the sum of the lowest payoff for each case multiplied by the corresponding probability (i.e. 2,021x0.3 + 3,046x0.3 + 362x0.2 + 368x0.2), which turns out to be only 1,666 USD.

Therefore, the expected value of perfect information (EVPI) on these two parameters, calculated as a difference between EMV with and without perfect information, would be 92 USD per avoided severe case (1,758 – 1,666). If 1,000 severe cases are averted in a program, the total EVPI would be around 92,000 USD. This example illustrates how MDAST can be used to prioritize policy-relevant malaria research agenda in the project countries.

VII. ACTIVITY 6: DISSEMINATE PROJECT RESULTS AND LESSONS LEARNED

MDAST project partners engaged in a variety of dissemination activities in addition to those already described in depth (e.g., various workshops, trainings, and expert consultations). These included the launch and on-going development of the MDAST website, the development of a slide set for in-country partners to present on MDAST to relevant stakeholders , presentations on MDAST at conferences, and the publication of a meta-analysis paper on a key malaria control intervention (IRS) employed in the model (Kim, et al., 2012). Additional manuscripts are being prepared for publication.

A. MDAST User Manual

The MDAST User Manual provides a detailed description and guide to the MDAST tool itself. The manual explains both the structure and a user's guide for the tool, including examples. The Installation section explains how to get the software for the tool and check for updates. For users in a hurry, a QuickStart Guide explains the basic components of MDAST, how to use them, and goes through 2 simple examples. The Parameter Inputs section goes into greater depth on data that is inputted into the tool and how to improve accuracy of the tool in the user's context. The Policy Decisions section discusses how MDAST results can be factored into malaria control decision and policy-making. The section on Results gives greater guidance on the interpretation of MDAST output, while the Examples section walks the user through a number of scenarios with the aim of demonstrating the capabilities and interpretation of the tool. Finally, the Future Features section outlines additional functionalities that developers and

stakeholders alike would like to see added to future versions of the tool as feasible. The manual concludes by discussing the implementation of the tool and using it in cross-sector dialogues.

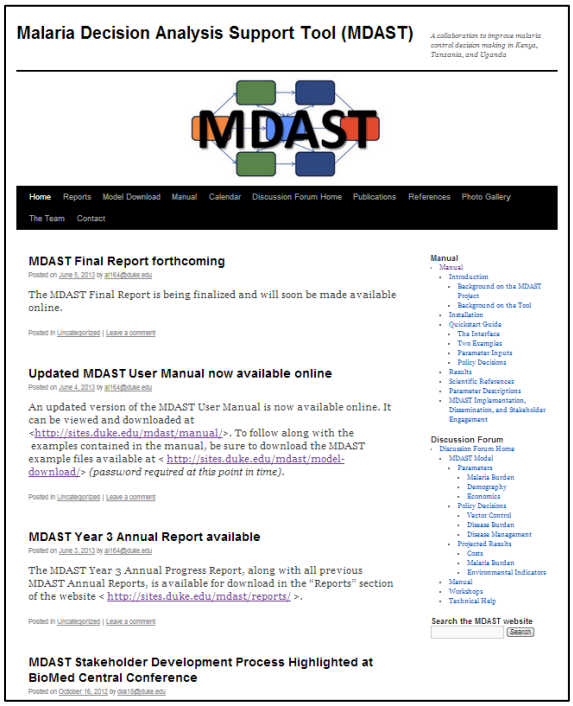
Please visit the MDAST website to download the latest version of the MDAST User Manual, available at < http://sites.duke.edu/mdast/manual/ >.

B. MDAST Website

The MDAST website can be found at < http://sites.duke.edu/mdast/ >.

The website is designed to serve as a platform for the dissemination and implementation of MDAST by providing the newest version of the tool for download, as well as training tools including a User Manual and a forum where users can engage in discussion about the tool. The website also provides additional background information about the MDAST project and tool, such as scientific references, relevant publications, and photo galleries of MDAST events.

Figure 12: MDAST Website Homepage



The MDAST website was demonstrated to stakeholders during the 2012 Workshops. Both oral and written feedback on the website was elicited from workshop participants. The feedback indicated areas for expanding and improving the website to enhance its role in dissemination and implementation of MDAST. The MDAST website continues to be updated to keep pace with MDAST developments and events.

C. Other forums for dissemination

As recommend by the Steering Committee Meeting, a slide set was drafted for in-country partners to use in presenting on MDAST. The presentation aims to support in-country dissemination efforts by providing in-country partners with a template which gives a general introduction and background on MDAST, particularly for those who are not familiar with it. The profile of MDAST has been raised through presentations at multiple conferences and through a series of past and forthcoming publications (including Kramer et al., 2009, Mutero et al., 2012, Kim et al., 2012).

VIII. ACTIVITY 7: DEVELOP GUIDELINES FOR REPLICATION IN OTHER COUNTRIES

The MDAST project initially involved three East African countries, which together serve as a pilot for the wider use of the policy tool in malaria-prone countries. These guidelines were developed to facilitate the successful dissemination and implementation of MDAST in other countries affected by malaria. The

guidelines consider what would be required for the replication of MDAST, including: 1) the identification of characteristics forming an environment conducive to the success of MDAST elsewhere, 2) a proposed process for the replication of MDAST, 3) areas of anticipated variation of MDAST across countries, and 4) potential challenges to replicating MDAST (and opportunities for addressing these challenges). The process of replication in each country would be well-documented by the MDAST team throughout its stages and the lessons learned applied to subsequent replication activities. The guidelines also summarize potential challenges that may be associated with the replication of MDAST, as well as recommendations for addressing these potential challenges.

A. Characteristics promoting success of MDAST

Stakeholder feedback and other insights from various development, dissemination, and implementation activities in Kenya, Tanzania, and Uganda have contributed to a greater understanding of characteristics contributing to the success of MDAST. However, it is important to realize that the success and value of MDAST is not precluded in the case that all of the enabling components highlighted below are not in place. In fact, the very process of engaging with MDAST may actually strengthen many of the beneficial characteristics and thereby increase the potential value of the tool in the policymaking context.

The most essential component for realizing the value of MDAST is the involvement and commitment of in-country stakeholders, especially implementers and policy-makers involved in malaria control. Input from stakeholder engagement activities is a key element behind the iterative process of tool development and refinement. It is important to note that the process of gaining and incorporating stakeholder feedback has also been instrumental in building understanding and a sense of ownership among the stakeholders. Stakeholder involvement in countries interested in engaging with MDAST should be manifest both through a general belief in the value of decision analysis for improved malaria decision making, as well as a willingness to commit time and energy to work collaboratively with the MDAST team to adapt, disseminate, and implement the tool.

MDAST will be most valuable to in-country decision makers as a tool for considering alternative malaria control strategies under certain governance and policymaking conditions. Intersectoral collaboration (for example, between ministries) that facilitates stakeholder dialogue and collaboration will improve the ability to consider the full range of possibilities and tradeoffs related to malaria control strategies. Participatory decision-making processes will ensure that consideration is given to alternative malaria control strategies. Furthermore, the decision-making processes for malaria control policies must be open to weighing the input and recommendations of those that would use the tool.

It is also important to realize the broader context in which malaria control policymaking is made. Ultimately the tool would have to be introduced and used in a way that was consistent with the established organizational structures for policymaking and implementation in the country. Policymaking environments vary and will be an important consideration in tailoring the tool for use in different countries. Nonetheless, regardless of the policymaking environment, avenues for participatory decision-making must be open for MDAST to have an appreciable impact.

The role of MDAST as a tool to support improved evidence-based decision-making will best be achieved when appropriate forums exist for regularly reviewing and updating malaria control policies.

The tailoring, dissemination, and implementation of MDAST in new candidate countries will require the availability and commitment of certain human resources. Firstly, as has been stated before, there should be a core group of stakeholders invested in MDAST and willing to work closely with project team members. This core group should reflect key stakeholder interests across a range of relevant ministries, organizations, and sectors. Within the core group, there should be a key figure with the willingness and authority to serve as the in-country lead responsible for coordinating the roll-out of MDAST in the country. In addition to the in-country lead and additional core stakeholders, there should be an effort early on to identify and engage a number of technical staff to support the dissemination, training, and implementation activities.

Development of the tool has sought to balance user-friendliness with allowing the user to highly tailor the tool to his or her specific context, including the alteration of a range of inputs for which context-specific data may be available. The ideal situation would be for the users of MDAST to have dependable access to quality, reliable, complete and timely country-specific data for inputting into the tool, but the tool maintains functionality and value even when the user may not always be able to access perfect and complete data. Finally, it is worth noting that the regular use of MDAST in support of an evidence-based policymaking approach should in turn help to improve the availability, access, and quality of applicable data through increased demand, including through the identification of research gaps.

B. Process for replicating MDAST in other countries

In general, the process for replicating MDAST in a new candidate country will be similar to that of the original process, while realizing that the aim of replication is primarily to familiarize and train stakeholders in its use, and not to reinvent the tool itself. However, the replication process should consider ways in which the tool and its use could be tailored to best meet the needs in different countries and contexts. In this sense, stakeholder involvement in the iterative improvement and customization of the tool remains an important component.

The first step for replication in a new candidate country is to assess the viability of and commitment to the MDAST approach within the institution(s) responsible for malaria control decision making in the country. In-country lead(s) should be identified and commit themselves to engaging with MDAST before replication activities can begin in full. The formal launch of MDAST in the country would be an inception workshop involving relevant stakeholders. An MDAST demonstration session during the workshop would include showing the range of tool functionalities as well as running through interactive scenarios as guided by stakeholders' particular interests and inputs. The demonstration session would be followed by a discussion to include proposed modifications to be made to the tool in order for it to fit within the country's context. The tailored tool would be introduced to stakeholders during a second workshop, which would focus on providing additional training and engaging stakeholders in discussions about how to disseminate and implement the tool.

C. Anticipated variation of MDAST across countries

The following are some anticipated areas or components that could require modifications to the tool and/or strategies for its dissemination and implementation according to the country context:

- The characteristics and/or structure of interventions may need to be adapted to reflect country and programmatic context.
- Some of the default parameter values may need to be altered depending on context (e.g., malaria transmission context, vectors, etc.)
- The policymaking environment may differ depending on governance and decision-making structures. This could have an impact on which and how stakeholders are targeted and trained, as well as the contexts in which MDAST is used.

The variations and modifications of the MDAST tool and process should be well-documented. Countries should contribute their insights and experiences on what works and what doesn't, and how MDAST has influenced policymaking in the country.

D. Potential challenges to replicating MDAST

The following are potential challenges that may be faced in seeking to replicate MDAST, and some proposed associated opportunities for addressing these challenges. This list is not intended to be exhaustive, but rather to present potential issues that have been identified for consideration by MDAST team members.

- Some countries may not be ideal candidates for implementing MDAST (e.g., based on characteristics described within these guidelines). However, it is important to note that MDAST can still be of great value even when conditions are not ideal. As pointed out earlier, the process of engaging with and using MDAST may actually help to strengthen many of these characteristics over time and thereby increase the potential value of the tool in the policymaking context.

- Policy-makers may not immediately perceive a need for a robust evidence-based decision making / decision support tool, or may be resistant to changing the existing decision-making system (which may currently be conducted on an ad-hoc basis or based on what was done before). The level of motivation for trying a new approach may be an issue. The main consideration is that if there is sufficient stakeholder involvement and commitment, then MDAST has the potential to support the deepening of an evidence-based decision-making agenda.

- It may be a challenge to generate buy-in and commitment among potential new country partners. Malaria control decision makers may wonder whether to use MDAST given that other malaria decision support tools exist. It is useful to draw distinctions between the various malaria support tools in existence as they serve a range of different purposes and applications. It is therefore

important to demonstrate the ways in which MDAST is uniquely positioned to support in-country decision makers in making improved, evidence-based malaria control policies, including:

- The strong partnerships it cultivates with and among key malaria control stakeholders including within the WHO and NMCP/MOH and across other sectors;
- The iterative, stakeholder-driven tool development process that reflects a cohesive understanding and response to the situation on the ground, as well as the ability to adapt the tool for use in different contexts;
- A user-friendly tool designed for and in collaboration with in-country malaria control decision-makers, whose use is supported by training activities and resources.

- There may be a need to build trust and confidence in MDAST among stakeholders in potential candidate countries. Firstly, MDAST should facilitate communication between stakeholders in countries interested in using MDAST and stakeholders in countries that have already participated in the dissemination and implementation of MDAST. Secondly, monitoring and evaluation reporting (including results of stakeholder surveys) and results of "field trials" of MDAST could also be used to build confidence in the value of MDAST.

- The replication of MDAST presents many opportunities for its further development. MDAST should harness expansion activities to benefit the tool and its networks? The following are steps that the MDAST project could take in this regard:
  - Encourage the exchange of experiences among stakeholders in different countries, (e.g., through forums on the project website, a newsletter, etc.);
  - Convene stakeholders to address cross-border issues;
  - Consider how to employ regional bodies in dissemination and implementation of MDAST (e.g., The East African Community);

- Funding for replication activities and to sustain support for continued implementation of MDAST will need to be secured. MDAST project partners and in-country collaborators alike should actively explore the range of funding opportunities. Raising awareness of the MDAST project generally through a basic orientation to its purpose and objectives might open up additional avenues for funding training and field trial testing.

- The involvement of donors and external funding in the formation of national malaria control research agendas is a subject that has received attention during MDAST workshops and evaluations. How can the project ensure that the role of donors / external funding with regards to MDAST continues to be positive and responsive to in-country needs and wants? There must be a careful consideration of the role of donors in terms of facilitating MDAST (e.g., funding for replication activities). The project should work to promote the role of donors in encouraging evidence-based

decision making, in close collaboration with the national frameworks for malaria control decision-making. There is also a need to engage donors as stakeholders in the project, as well.

The process of replication in each country should be well-documented by the MDAST team throughout its stages and the lessons learned applied to subsequent replication activities and the overall improvement of MDAST.

IX. CONCLUSION

In spite of the existence of effective interventions and significant local resources and international funding for malaria control, it is often difficult for malaria policy decision-makers to determine the best combination of interventions in consideration of the many parameters and tradeoffs involved. The situation presents a serious challenge for evidence-based policy development. The stakeholder-driven Malaria Decision Analysis Support Tool (MDAST) project has employed a comprehensive decision analysis framework to assess and compare the range of benefits associated with alternative malaria control strategies through the development of a user-friendly tool (MDAST) that jointly incorporates health, social and environmental priorities for malaria control in Kenya, Tanzania, and Uganda. The end result is a computer-based model developed in a consultative manner between stakeholders that facilitates well informed policy making.

The project has built enhanced decision-making capacity and mutual understanding among the diverse networks of players involved in malaria policy formulation in three East African countries, serving as a pilot for other countries facing the burden of malaria. The project has actively included stakeholders in all three project countries in the iterative process of tool development through surveys, workshops, expert consultations, and interactive training sessions. Stakeholder feedback has allowed for the development and refinement of MDAST according to an enhanced understanding of the situation on the ground as well as the needs of anticipated users in multiple settings. Moreover, MDAST development activities have provided a novel forum for these varied actors to interact with each other, share ideas, and build a sense of joint ownership of the tool. Continued engagement with various stakeholders will be key to the successful dissemination, implementation, and iterative refinement of MDAST and to develop extensions of similar tools to additional locations and situations. . The extension of MDAST to additional countries will require the availability and commitment of certain human resources, including a core group of stakeholders headed by an in-country lead with the interest and authority to engage with MDAST, and of technical staff to support the dissemination, training, and implementation activities.

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