Identifying Climate Impacts on the Incidence of Meningitis Epidemics

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INTRODUCTION
The Meningitis Environmental Risk Information Technologies (MERIT) initiative is a multi-disciplinary community of partners who conduct research to advance the use of climate-related information in strengthening public health strategies for the control of epidemic meningitis in Africa. By linking climate factors with meningitis incidence, MERIT streamlines efforts to develop new knowledge; it also strengthens processes to enable operational services and field activities focused on reducing the socio-economic and health burdens of meningitis in low-resource countries in Africa. MERIT was created in 2007 and is chaired by the World Health Organization (WHO).

MERIT activities are guided by the needs of the public health community (also referred to as "end-users" or "audience") in response to the threat posed by meningitis epidemics. To date, these activities have involved collaborative efforts of end-users and service providers to develop enhanced decision-support tools and improve meningitis surveillance, prevention, and control strategies. This work is expected to have an immediate impact on the public health outcomes in Africa by increasing the effectiveness of meningitis prevention and response control strategies.

The MERIT project creates opportunities to integrate calculable information into meningitis prevention and control activities through the development of:

• Risk maps of the current situation and future scenarios, based on projected changes in climatic and environmental factors
• Early warning systems
• Improved impact assessment methodologies for prevention effort

SOCIOECONOMIC BACKGROUND
Recurrent epidemics of meningococcal meningitis place an enormous toll on countries of Africa’s Meningitis Belt, which stretches from Senegal and the Gambia to Ethiopia in the East. Predominantly caused by Neisseria meningitidis A (Nm A), meningitis epidemics are responsible for high fatality rates throughout the region. In addition to the yearly outbreaks that occur during the dry season, large epidemic waves hit the Meningitis Belt every 10 to 14 years. These waves can be responsible for up to 80,000 cases across the Meningitis Belt, burdening 20% of non-fatal cases with chronic, debilitating conditions such as deafness and/or neurological and orthopedic disorders. These disabilities reduce the affected individuals’ quality of life and their ability to work, and increase the use of health resources. As a result, meningitis epidemics significantly disrupt health systems, reduce family incomes, and impair development.

TARGET AUDIENCE
The institutions engaged in the MERIT initiative represent three areas: i) public health policy and decision makers, ii) researchers, and iii) providers of information and climate services. These partners support training and research with the intention of:

• Improving the application of climate and environmental information to meet the needs of public health policy-makers in Africa
• Enhancing regional and national surveillance capabilities
• Strengthening decision-making and public health policy development through institutional capacity building efforts.

Among its expected outcomes, MERIT seeks to increase the number of public health policy-makers capable of effectively using climate, environmental, and other data in decision-making.

CLIMATE AND CONTEXTUAL INFORMATION
Meningitis control relies on the early identification of epidemics, followed by a reactive immunization of large populations. The effectiveness of the reactive strategy can determine whether an outbreak is controlled or risks spread to neighboring districts and/or countries. To be effective and prevent as many cases as possible, vaccination needs to be implemented quickly, which is challenging considering the inevitable delay in the flow of information and the time required to deliver the vaccine and to organize and run an epidemic control campaign.
To advance these efforts, MERIT supports projects that use climate and environmental information to increase lead-time, even before a district is identified as being at risk of passing into an epidemic. These projects use meningitis data from epidemiological surveillance, a routine system implemented by ministries of health in the countries at risk for meningococcal meningitis. The system allows the health ministries to track the location and intensity of the disease in a country at the district level and take appropriate control measures. On an as-needed and as-agreed-upon basis, the weekly incidence of meningitis is made available at no cost to teams involved in the MERIT Initiative. MERIT partners also make use of climate data including, but not limited to, relative humidity, position of the wind convergence, and dust conditions. Climate information has the potential to allow decisions regarding meningitis control to be made earlier and based on more accurate predictions, such as triggering mass vaccination campaigns to respond to an outbreak, or forecasting the end of an epidemic that would allow more effective vaccine allocation.

In this context, MERIT partners are engaged in research to define (i) the temporal (e.g., climatology, seasonal, sub-seasonal) and spatial (e.g., district-, regional- or country-level) scales that are relevant to the diseases dynamic and trends; (ii) the importance of direct observations, satellite-based information, or model simulations; and (iii) the appropriate time-lag, if any, at which the climate information is useful. Depending on the project conducted, MERIT uses meningitis-related climate information provided by national meteorological services, research centers, universities, and space agencies, etc. MERIT encourages both users (public health decision-makers) and providers of climate information to work together to tailor the data so that it can be used to improve public health activities. In order to make data and information more relevant to the needs and resources of the country where the project is implemented, this includes adjusting i) the type of climate information, for instance relative humidity; ii) the spatial and temporal scales of that information; and iii) the source of the information.

**IMPLEMENTATION**

The MERIT Steering Committee provides a structure to streamline the activities of partners and to provide guidance on research needs and priority areas. The Steering Committee is represented by practitioners and researchers from both public health and climate communities, including the Center for Vaccine Development (CVD Mali), the Group on Earth Observations (GEO), the Health and Climate Foundation (HCF), Ethiopia’s Health, Development & Anti Malaria Association, the International Research Institute for Climate and Society (IRI), the National Center of Research Institute/Institute of Research for Development Research Unit (IRD), WHO, and WMO.

Using a consultative approach, steering committee members are responsible for providing technical guidance, suggesting and reviewing project proposals, identifying funding opportunities, and organizing annual meetings where outputs are shared and new partnerships are launched.

**PROCESSES AND MECHANISMS**

**STAKEHOLDER AND ISSUE IDENTIFICATION**

Prior to the creation of MERIT, the first Meningitis Environmental Risk Consultative Meeting was held in Geneva in September of 2007. The meeting was hosted by the Group on Earth Observations (GEO) and organized jointly by representatives from WHO, WMO, IRI, and HCF. At this first meeting, over 25 institutions came together and identified as stakeholders at the interface between epidemic meningitis control, research, and environmental and climate information. These institutions recognized that by coming together, they could collectively contribute new information, knowledge and guidance to address the problem of meningitis epidemics in Africa. Agreement was reached to form the MERIT project, and a clear set of objectives and goals was identified for a 10-year period. The MERIT Steering Committee was formed in 2008 to guide the research questions and activities of the Initiative, which is chaired by WHO.

Since 2007, the MERIT community has evolved to reflect changes in the public health strategy. New stakeholders have been identified, while other partners have become less engaged. During its initial phase, the MERIT consortium has focused on core countries of the Meningitis Belt (including Niger, Burkina Faso, Ethiopia, Ghana, and Nigeria). Table 1 highlights the core stakeholder groups (both African and international) and their respective roles. All groups contribute to the translation of new knowledge into decision-making.

<table>
<thead>
<tr>
<th>Table 1: Roles of different groups that participate in MERIT</th>
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<tr>
<td><strong>Core Stakeholder Groups</strong></td>
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<tr>
<td><strong>Public health policy and decision-making community</strong></td>
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<td><strong>Environmental community</strong></td>
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<td><strong>Research community</strong></td>
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<tr>
<td><strong>Other partnerships and donors</strong></td>
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STAKEHOLDER INVOLVEMENT
Under the auspices of MERIT, the environmental community delivers climate and environmental data to the modeling and research community, which integrates health and climate data using predictive tools to produce forecasts (see Figure 2). This information is then delivered to the WHO country offices and to the Ministries of Health. In

FUNDING MECHANISMS
As a research consortium without core funds, MERIT achievements are in reality the achievements of its members, whose funding comes primarily through research grants. While some members have developed and implemented specific MERIT-related research projects, others have contributed research efforts produced as part of separate initiatives to support the overall MERIT Initiative. During the past five years, nearly 30 partner organizations have been engaged in MERIT activities with an estimated combined investment of over several million US dollars.

Following a formal strategic review of the MERIT initiative in December 2011, a number of clear recommendations were presented to the MERIT Steering Committee in relation to the ongoing viability and success of the project. The main challenge identified was the lack of funding, which has limited the coordination of tasks, specific research, and the translation of research into operations. As a result, the MERIT Steering Committee is actively seeking funding opportunities to support priority activities over the short, medium, and long term and to ensure the ongoing viability of the project.

MANAGEMENT AND DECISION MAKING
One of the strengths of the MERIT community is the willingness and commitment of its partners to collaborate, share research outputs, and facilitate the dissemination of information between its providers and users. Annual technical meetings and national workshops provide an opportunity to exchange information and research results, facilitating this interaction.

EVALUATION
In 2011, the MERIT Steering Committee held a strategic review of the initiative to assess and ensure its ongoing relevance alongside the evolving needs of the public health sector. The purpose of the meeting was to identify a means for accelerating the production and use of

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Figure 2: MERIT organizational infrastructure and flow of information

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1 The International Coordinating Group (ICG) on Vaccine Provision for Epidemic Meningitis Control is composed of representatives from Médecins sans Frontières (MSF), International Federation of the Red Cross and Red Crescent Societies (IFRC), UNICEF and WHO.
Looking Toward the Future

Goals
Moving forward, MERIT’s goals include improving the public health response to epidemic meningitis and preventing epidemics from occurring in the first place. Each of these goals is outlined in greater detail below.

Improving the Public Health Response to Meningitis Epidemics
Identifying the complex set of factors that trigger either an increase or decrease in the risk of meningitis outbreaks will allow the public health community to better allocate scarce resources and focus effort in areas that are most critical. Routine surveillance data are currently the only data available in the field; as a result, these data are the only quantitative criteria incorporated into the assessment of the meningitis situation and the decision to launch control measures.

Other data, including climate information, could provide forecasting and anticipation opportunities for both risk assessment and control measures. Expanding the decision-making process to include this kind of data could help reduce the delay before launching reactive immunization. Climate information and seasonal forecasts can also support regional-level predictions on the magnitude of the epidemic season to inform vaccination production. Further studies will improve forecasts for the end of the epidemic season by establishing linkages between the increase in humidity and the decrease in the incidence of meningitis.

Improving the Prevention of Meningitis Epidemics
Recent evidence suggests that the fringes of the Meningitis Belt may be evolving and the dynamics of the disease changing in certain areas. Climate and the environment are expected to play a significant role in these epidemiological changes, and efforts should be dedicated to understanding this situation. Climate information could be used to i) help guide the introduction of the preventive meningitis vaccine in these fringe areas; ii) determine how the Meningitis Belt might look in the next 5 to 10 years; and iii) help decision-makers determine whether the preventive vaccine should be introduced in areas that were not previously considered at risk.

While the preventive vaccine has been shown to decrease the incidence of the disease in the countries protected to date, the emergence or re-emergence of other serogroups remains a potential threat to public health. Climate and environmental information might be used to inform this phenomenon and assess whether these serogroups respond to particular climate patterns.

It is also expected that climate information will help in assessing the impact of the preventive vaccine. Analyzing the incidence of meningitis and eliminating climate factors such as humidity and dust, for example, could help to correlate a decrease in the number of cases with the vaccine campaign.

These priority areas and goals are summarized in the table on the following page.
To improve the impact of the reactive mass vaccination campaigns

<table>
<thead>
<tr>
<th>Research need</th>
<th>Spatial scale</th>
<th>Time scale</th>
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<tbody>
<tr>
<td>To prepare for the following epidemic season</td>
<td>Region, country</td>
<td>Forecast the magnitude of an epidemic (yearly cumulative rate) one year ahead of time</td>
</tr>
<tr>
<td>To refine the response strategy for outbreaks due to serogroups other than A (NmW135, NmX)</td>
<td>District</td>
<td>Forecast the weekly attack rate several weeks ahead of time</td>
</tr>
<tr>
<td>To assess the risk of NmA outbreak in an area previously vaccinated with the conjugate A vaccine</td>
<td>District</td>
<td>Forecast the weekly attack rate several weeks ahead of time</td>
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<tr>
<td>To guide the introduction of the conjugate A vaccine</td>
<td>Region, country, district</td>
<td>Seasonal risk and historical trends</td>
</tr>
<tr>
<td>To estimate the impact of the conjugate A vaccine</td>
<td>Region, country, district</td>
<td>Predict the number and magnitude of epidemics one/ several year(s) ahead of time</td>
</tr>
<tr>
<td>To gather information on the possible vaccine needs in the medium and long term</td>
<td>Region, country</td>
<td>Predict changes in the meningitis belt 5-10 years ahead of time</td>
</tr>
</tbody>
</table>

**PROJECT EXPANSION**

MERIT is expected to scale up its activities, building on the following key elements of the initiative: (i) the high level of commitment from professionals of different communities; (ii) a commitment to projects that lie at the cross-roads of different disciplines; (iii) research excellence; and (iv) the potential for the initiative to be useful and relevant to users.

Potential areas for expansion include reinforcing and developing in-country MERIT activities, bringing new actors to the initiative, and, further down the road, integrating MERIT activities into a multi-disease approach so that lessons learned can be transferred to other climate-sensitive diseases.

For the time being, it is important to maintain the clarity of the initiative and its focus on meningitis; adding new disciplines into meningitis-oriented projects would be a significant step forward in terms of the overall efficiency and comprehensiveness. Social scientists, communicators, and Africa-based partners from different fields (epidemiology, immunology, microbiology, and climate sciences) would enrich the systemic approach of MERIT and facilitate the dissemination results. In the future, the multi-disease potential of the MERIT model could be relevant from a country perspective as a means to integrate several public health efforts and save resources.

**LESSONS LEARNED**

While the early efforts of the MERIT initiative and its partnership network have been successful, several factors have presented challenges for the MERIT community and research projects. The development and introduction of a new vaccine has moved more quickly than MERIT research, which has meant that projects have needed to be adapted and modified to stay relevant to the public health needs. Furthermore, data quality and availability issues have in some cases delayed research progress. Core funding to sustain the activities and coordination of the initiative has meant that progress has relied solely on voluntary contributions and willingness of members.

Still, five areas in which climate information can inform meningitis health policy were identified. These include (i) biological mechanisms; (ii) spatial and seasonal risk, i.e. where and when epidemics occur in an average year; (iii) subseasonal and inter-annual changes in risk; (iv) long-term trends in risk; and (v) assessment of the impact of interventions.
THE WAY FORWARD
The collaborative partnership model of MERIT provides an innovative framework to support public health preparedness and control strategies for climate-sensitive diseases. Public health decision-makers have been willing to explore unfamiliar territory and take advantage of opportunities to improve well-established control strategies by leveraging new knowledge and expertise from other disciplinary communities including climate and environmental research. Equally important have been the investments made by the multi-disciplinary research and practice community to adapt research projects in line with the evolving public health strategy across the Meningitis Belt. The lessons learned from the MERIT project offer valuable input and new ideas for improving global public health strategies for other climate and environmentally sensitive epidemic prone diseases

PRINCIPLES OF THE GFCS
The MERIT Initiative addresses Principles 2, 3, 4, 6, 7, and 8.

Principle 1: All countries will benefit, but priority shall go to building the capacity of climate-vulnerable developing countries.

Principle 2: The primary goal of the Framework will be to ensure greater availability of, access to, and use of climate services for all countries.

Principle 3: Framework activities will address three geographic domains; global, regional and national

Principle 4: Operational climate services will be the core element of the Framework.

Principle 5: Climate information is primarily an international public good provided by governments, which will have a central role in its management through the Framework.

Principle 6: The Framework will promote the free and open exchange of climate-relevant observational data while respecting national and international data policies.

Principle 7: The role of the Framework will be to facilitate and strengthen, not to duplicate.

Principle 8: The Framework will be built through user – provider partnerships that include all stakeholders.