



Epidemic meningitis surveillance in the African meningitis belt

Deciding on the most appropriate approach

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Acronyms

AFRO	African Regional Office of WHO
CSF	cerebrospinal fluid
HCC	health-care centre
<i>Hib</i>	<i>Haemophilus influenzae</i> b
HQ	Headquarters (WHO)
IDSR	integrated disease surveillance and response
IST-West	Inter-country Support Team for West Africa
LP	lumbar puncture
MoH	ministry of health
NGO	nongovernmental organization
<i>Nm</i>	<i>Neisseria meningitidis</i>
PBM	paediatric bacterial meningitis
PCR	polymerase chain reaction
RL	reference laboratory
SOP	standard operating procedure
<i>Sp</i>	<i>Streptococcus pneumoniae</i>
WHO	World Health Organization

Preliminary note

Two terms used throughout the document need to be clarified to avoid confusion: “enhanced epidemic surveillance” and “case-based surveillance”.

Enhanced epidemic surveillance refers to a specific meningitis surveillance strategy that was developed in the early 2000s for the African meningitis belt, which spans from Senegal and the Gambia to Ethiopia. It has some unique characteristics within the broader approach of integrated disease surveillance and response (IDSR), and is the baseline surveillance strategy for meningitis in the belt. A population-based approach, enhanced epidemic surveillance uses aggregated data counts to compute weekly incidences at the district level, with epidemic investigation and containment measures launched accordingly. In this type of surveillance, laboratory confirmation is required only for the first cases when an epidemic is suspected, mainly to identify the pathogen responsible for the outbreak.

Case-based surveillance collects information at the individual level on each suspected case, and documents these cases thoroughly from both an epidemiological and a microbiological perspective. A characteristic of this type of surveillance is that it allows epidemiological and microbiological information to be linked. The term “case” implies a focus on information “at the case level”, rather than an antonym to “population-based” surveillance. Case-based surveillance can be conducted in a context of population-based surveillance; that is, involving a defined population with a denominator from which cases come and rates can be calculated. Depending on its modalities of implementation, case-based surveillance can provide population-based information (e.g. meningitis rates per district) and individual data (e.g. vaccination status for the *Neisseria meningitidis* A conjugate vaccine).

Introduction

Rationale

Surveillance primarily enables relevant information to be continuously disseminated and applied to disease prevention and control, to avert deaths and disabilities through appropriate public health interventions. Until recently, surveillance for meningitis was synonymous with assessing the case burden and incidence trends of the disease (in terms of time, place and people), and with launching and evaluating measures for investigation and control (1-3).

In 2010, the *Neisseria meningitidis* (Nm) A conjugate vaccine was introduced on a large scale in the African meningitis belt. It is expected that this vaccination programme will substantially modify the epidemiology of the disease in the region.¹ In addition to conferring long-term protection, the safe and highly immunogenic Nm A conjugate vaccine decreases carriage rates in immunized populations, and provides herd immunity (4, 5); hence, the occurrence of both epidemic and non-epidemic Nm A meningitis should drop significantly. However, it is also likely that new serogroups of meningitis or new pathogens will emerge as prevailing causes of meningitis, and that the patterns and dynamics of meningitis outbreaks will change (6).

These probable epidemiological shifts will have consequences for surveillance and response strategies, and for case management. The introduction of a new vaccine also requires quantification of its effectiveness and epidemiological impact. Taken together, these elements impose new challenges for surveillance systems, and create a need for such systems to adapt in order to remain relevant, accurate and efficient.

Within the World Health Organization (WHO), the Inter-country Support Team for West Africa (IST-West) of the African Regional Office of WHO (AFRO) and the WHO Headquarters (HQ) are working closely with the ministries of health (MoHs) and their partners to monitor those changes, and to assess the impact of the mass vaccination campaigns on meningitis transmission and trends. WHO and the MoHs also partner to upgrade surveillance systems, to ensure that accurate and relevant epidemiological and microbiological information is generated.

Baseline surveillance approach and associated information gaps

Enhanced epidemic surveillance has been implemented since 2002, and is the baseline surveillance strategy that prevails in the African meningitis belt. It has been associated with significant public health improvements over the past decade, notably through rapid detection and laboratory confirmation of meningitis epidemics, selection of the most adequate polysaccharide vaccine for outbreak response, and a consequent decrease in the delay for reactive immunization. As such, it contributed to the optimization of containment interventions against meningitis and the evaluation of such interventions, without imposing too heavy a burden on countries' disease surveillance systems (3, 7, 8). Enhanced epidemic surveillance also contributed to:

- assessment of the case burden and incidence trends of meningitis;

¹World Health Organization and United Nations Children's Fund, 2008. *Eliminating serogroup A meningococcal meningitis epidemics as a public health problem in Africa, an investment case for the GAVI Alliance*. Geneva, Switzerland. Unpublished work.

- obtaining information about:
 - antibiotic resistance profile;
 - circulation of strains;
 - distribution of meningococcal serogroups and of other pathogens.

Enhanced epidemic surveillance relies on aggregated data and requires limited laboratory confirmation. Thus, it cannot fully respond to the new epidemiological needs and questions raised by the introduction of the *Nm A* conjugate vaccine, such as the effectiveness of the new vaccine, and its impact on the circulation of different serogroups and epidemic patterns (4, 5, 9). To address these issues, a strategy providing thorough epidemiological and microbiological information on suspected cases of meningitis at the individual level was designed; that is, case-based surveillance, which is further detailed in the document (10). This strategy is highly informative, but also highly resource intensive; therefore, it may not be possible to implement case-based surveillance in all areas where the conjugate vaccine is introduced (6).

In most countries, in undertaking surveillance, it is necessary to make trade-offs between the amount of information that can be expected and the amount of resources that are needed. There are different approaches to this issue, ranging from a “moderate resource/moderate information” strategy (enhanced epidemic surveillance) to a “high resource/high information” approach (national case-based surveillance). These strategies can be used alone or in combination.

Finally, by its nature, for various reasons, public health surveillance tends to underestimate the true incidence of disease and to have difficulty capturing information from individuals with limited access to health care. Although research studies that focus on a specific population might be able to mitigate this limitation and complement surveillance data, such studies are outside the scope of this document.

Objectives of the document

The objectives of this document are to assist national public health policy-makers in:

- choosing the most appropriate meningitis surveillance approach for their country;
- setting up milestones for implementing the chosen strategy.

The document outlines the scope of potential meningitis surveillance strategies that make it possible to obtain the data required for epidemic alert, monitoring of epidemiological and microbiological trends, evaluation of meningitis control strategies and assessment of the impact of *Nm A* conjugate vaccine. It also provides information that can be used to decide on a surveillance method that is most appropriate to the needs and capacity of a country. Finally, the document provides some elements that should be considered in the estimation of the resources required for the implementation of the strategies described, as a support for planning. This document is expected to serve as a basis and a reference for countries to determine their own costs estimates, which will be highly dependent on the baseline surveillance situation of each country.

This strategic document is not a substitute for the standard operating procedures (SOPs) for meningitis surveillance that have already been developed and that (7, 10, 11):

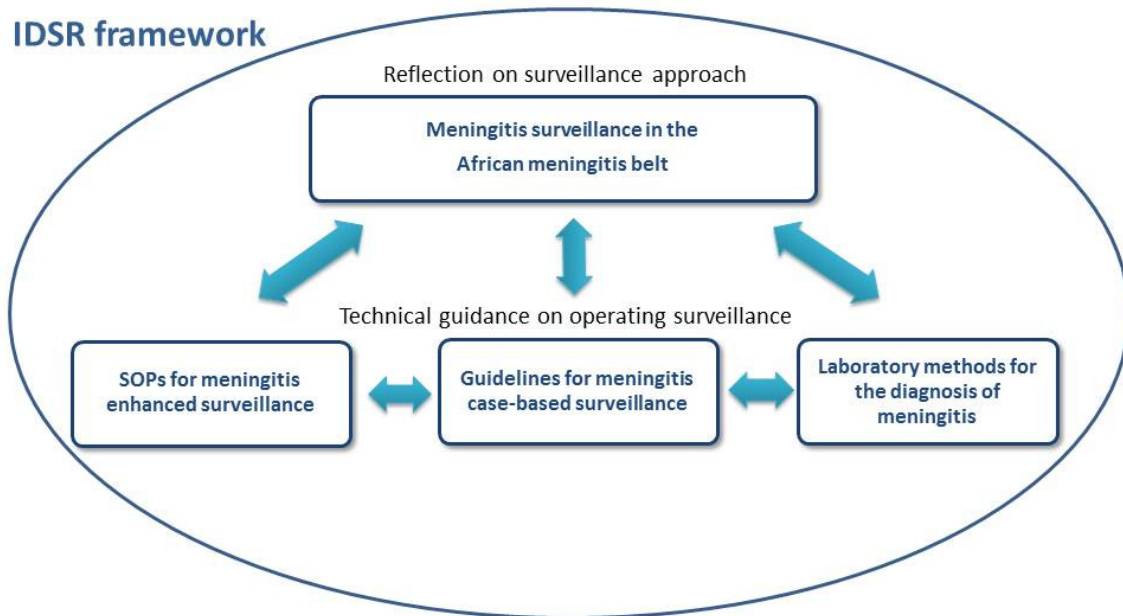
- provide guidance on the tools and processes needed for running the surveillance;

- detail the principles of epidemic detection, and of the actions to be taken in different epidemic phases;
- describe data management and specimen collection, storage, transportation and processing;
- specify the criteria for vaccine choice in response to an epidemic;
- specify the procedures for case management, communication, monitoring and evaluation (and associated indicators), and feedback.

In contrast to the SOPs, this document – *Meningitis surveillance in the African meningitis belt* – focuses on the strategic reflection that comes before operating the surveillance; that is, selecting a strategy and preparing for its implementation.

The strategies presented in this document refer to meningitis; however, they should be integrated as much as possible with existing surveillance systems within the integrated disease surveillance and response (IDSR) framework (Figure 1). This coordinated approach will optimize resources and increase efficiency (12).

Figure 1. Relationship between the documents related to meningitis surveillance available as of January 2013



IDSR, integrated disease surveillance and response; SOPs, standard operating procedures

Target audience

The target audience for this document includes:

- national stakeholders at the MoH working on epidemiological and microbiological surveillance, disease control and immunization, with strong knowledge of the situation at the regional and district levels (e.g. national supervisors of laboratories, and of epidemiological and immunization surveillance);
- experts from the same fields working for technical and financial partners, such as WHO.

All those responsible for, or able to contribute to, making a decision on the appropriate surveillance strategy and on setting up an operational plan to implement it should be involved. Once an agreement has been reached and a plan has been set, other groups should be involved. For example, professionals working at a more peripheral level in the public sector and in relevant structures of the private sector should actively participate in the implementation and operating of the surveillance strategy.

Structure of the document

This document has three parts. Part One introduces the possible surveillance strategies and the characteristics that are important for making a decision on what strategy is most appropriate for each country. Part Two displays the key features of these strategies in the form of factsheets, including strengths and limitations. Part Three illustrates the decision-making process and its practical details.

For information purposes, Appendices A and B recall the indicators and tools associated with meningitis surveillance in general. Details about these tools and indicators – for example, target or computation – can be found in the surveillance SOPs and guidelines; hence, they are not specified in this strategic document (7, 10, 11). Appendix C uses summary tables and charts to compare the indicators and resources associated with the proposed meningitis surveillance approaches.

Part One: Overview of surveillance objectives and strategies

1.1 Background

Countries introducing the *Nm* A conjugate vaccine differ markedly in terms of infrastructure, number of skilled health staff, quality of surveillance and availability of adequate resources. For example, in some countries, collection of cerebrospinal fluid (CSF) specimens in rural health centres is a routine activity practised by rural nurses, whereas in other countries, collection of such specimens is less common. Similarly, in some countries only medical doctors are allowed to practise lumbar punctures (LPs), and the procedure is therefore rarely available in rural areas; in such instance, the surveillance strategy may rely only partially on laboratory confirmation.

Countries must tailor their surveillance of meningitis to their own circumstances, while maintaining the objective of generating systematic and high-quality data in a way that is practical, uniform and rapid (2). MoHs need practical guidance and support to identify the most appropriate surveillance approach. The countries that were protected with the *Nm* A conjugate vaccine until 2011 already had highly efficient surveillance systems before the introduction of the vaccine (6, 9, 13). They also benefited from substantial technical and financial support. Furthermore, some lessons have been learned in terms of the long-term sustainability of these approaches, when external support is reduced. In contrast, the countries that are now introducing the *Nm* A conjugate vaccine are generally those that are likely to have important surveillance challenges and therefore to need major technical support and guidance. These countries will also probably require large investments in infrastructure, training and logistics.

1.2 Surveillance objectives

This section details the objectives of meningitis surveillance in the African meningitis belt as the *Nm* A conjugate vaccine is gradually introduced in this region. The objectives of the surveillance, organized by category, are:

- Epidemiology:
 - Detect and confirm outbreaks, and launch appropriate response strategies.
 - Assess the case burden and incidence trends (in terms of time, place and people) of meningococcal meningitis and other acute bacterial meningitis.
- Microbiology:
 - Monitor the circulation, distribution and evolution of *Nm* serogroups and other pathogens.
 - Monitor the antibiotic resistance profile of *Nm*.
 - Monitor the circulation, distribution and evolution of *Nm* strains (by sequence-typing).
- Policy:
 - Evaluate control strategies.
- Conjugate vaccine:

- Evaluate the impact of the conjugate meningitis A vaccine on the number of cases and outbreaks, on epidemic patterns and on circulating serogroups.
- Estimate the effectiveness of the meningitis A conjugate vaccine.

In preparing for the introduction of the conjugate vaccine, a country should list the objectives it aims to meet with its surveillance programme. However, given the diversity in epidemiology, population and resource patterns across the countries of the meningitis belt, it is unlikely that all of the objectives given here will be relevant to, or can be met in, all countries.

The objectives relevant to each of the strategies described in this document are summarized in Table C1 of Appendix C.

1.3 Principles of proposed surveillance strategies

This section lists the strategies that are proposed for the meningitis belt, based on previous surveillance experiences with meningococcal meningitis and other preventable outbreak-prone diseases. The strategies, which can be used alone or in combination, depending on the surveillance objectives set by the country, are:

- enhanced epidemic surveillance;
- case-based surveillance;
 - comprehensive case-based outbreak documentation;
 - sentinel case-based surveillance;
 - paediatric case-based surveillance;
 - hospital case-based surveillance;
 - district case-based surveillance;
 - nationwide case-based surveillance.

The rest of this section details the core principles of these strategies. All of the strategies include some tasks that need to be conducted in partnership with the private sector (e.g. private laboratories or clinics), and some that are beyond country level. For example, all of the strategies recommend that:

- relevant surveillance data be reported to WHO, and included in a weekly meningitis feedback bulletin circulated by e-mail to key partners, and posted on the WHO web site (14);
- a subset of the *Nm* strains isolated in the country be sent on a regular basis to the international reference laboratory for meningococcal meningitis, for genomic characterization.

Regardless of the strategy chosen and the partners involved, regular feedback should be provided to all relevant stakeholders.

1.3.1 Enhanced epidemic surveillance

Enhanced epidemic surveillance has been implemented comprehensively at the national level in the countries of the meningitis belt since 2002. It uses aggregated data counts and operational

thresholds of weekly incidence of meningitis, systematically computed throughout the year at district level; ideally, such surveillance is part of an integrated approach to disease surveillance (1, 7, 12). Although case line-listings are compiled at the early stages of an epidemic, detailed information on the epidemiology or microbiology of all meningitis suspected cases is not necessary under this strategy, which focuses on data at a population level.

As of 2013, enhanced epidemic surveillance is considered baseline or routine surveillance in most of the areas that are highly endemic for meningococcal meningitis. This approach was introduced using the SOPs developed by WHO, tailored by the countries to match their needs and specificities (7). Enhanced epidemic surveillance was a major step forward in maximizing outbreak control. Further, the continued dissemination of updated epidemiological information through the IST-West's *Weekly Meningitis Bulletin* has been instrumental in the close monitoring of meningitis activity at the regional level (14). This dissemination of information also allows a better understanding of the epidemiological and microbiological dynamics of the disease, and constitutes a key advocacy tool for stakeholders and decision-makers (3, 14).

A disadvantage of enhanced epidemic surveillance, if used as a single strategy, is that it has limited capacity to respond to the new epidemiological needs and questions raised by the introduction of the *Nm A* conjugate vaccine, mainly because it lacks precise information at the individual level. Therefore, although enhanced epidemic surveillance may be the main strategy in some areas, it needs to be supplemented by other surveillance approaches, to address these new matters.

1.3.2 Case-based surveillance

Case-based surveillance, implemented after the introduction of the *Nm A* conjugate vaccine, is the best way to characterize the potential changes in epidemiological patterns induced by the wide use of this vaccine, and is the only one that allows assessment of vaccine effectiveness (10). Depending on its modalities of implementation, case-based surveillance can have population-based characteristics.

Unlike the surveillance approaches that rely on aggregated data or laboratory counts, case-based surveillance uses information collected at the individual level. It requires all suspected cases of meningitis to be investigated individually, and documented as comprehensively as possible both epidemiologically (e.g. gender, age, location and vaccination status with regard to the *Nm A* conjugate vaccine) and microbiologically (e.g. CSF macroscopic aspect, and results of culture or polymerase chain reaction [PCR] testing). The epidemiological and microbiological information are linked by a unique identification number, which is a key feature of this approach. Ideally, all cases should be laboratory confirmed, but it is understood that CSF samples might not be properly taken, processed or analysed in all facilities; therefore, some cases may not be laboratory confirmed. However, these cases should not be discarded nor confirmed; instead, they should be notified as suspected or probable cases.

Case-based surveillance is highly resource intensive and therefore it may not be possible to implement this approach nationwide in all countries of the meningitis belt. When such surveillance is needed, sentinel rather than national case-based strategies could be implemented. The sentinel approach could be location based (i.e. district) or facility based (i.e. hospital); alternatively, it could target a specific part of the population, such as the group most at risk (e.g. paediatric). For instance,

after the introduction of the *Nm A* conjugate vaccine, some countries opted for a sentinel district-based approach to case-based surveillance, targeting about one third of their districts. The number of districts involved in case-based surveillance was dictated by the quality of the existing surveillance system for meningitis and associated facilities, the total amount and nature of the resources available, and the location of the districts. Case-based surveillance can also build on the investigative measures conducted when an epidemic has been detected, and use this opportunity to document the suspected cases as thoroughly as possible (see next section, which discusses case-based outbreak documentation).

Comprehensive case-based outbreak documentation

Comprehensive case-based outbreak documentation comprises the active and systematic collection of detailed epidemiological and bacteriological information at the individual level on each case in a meningitis epidemic. It uses the principles of case-based surveillance (e.g. unique identifying number, information on immunization status, extensive laboratory documentation) and its purposes, applied to investigative measures. In that sense, comprehensive case-based outbreak documentation represents a paradigm shift in terms of outbreak investigation.

This strategy has both similarities and differences with the outbreak investigations conducted in most of the areas of the meningitis belt as part of enhanced epidemic surveillance:

- *Similarities* – both enhanced epidemic surveillance and comprehensive case-based outbreak documentation:
 - rely on a baseline surveillance system rather than being a substitute for such a system;
 - are triggered by the detection of a potential epidemic phenomena through routine surveillance and operational incidence thresholds;
 - identify the circulating pathogen responsible for the epidemic.
- *Differences* – compared to enhanced epidemic surveillance, comprehensive case-based outbreak documentation:
 - characterizes the epidemic situation at the individual level, including information related to the *Nm A* conjugate vaccine;
 - requires all suspected cases to be investigated and recorded in line-listings (i.e. beyond the early stages of the epidemic);
 - requires more extensive CSF sampling and microbiological documentation (i.e. beyond the initial suspected cases).

Sentinel case-based surveillance

Sentinel surveillance uses data systematically collected in multiple high-quality sites across the country. Ideally, these sites are purposely selected to bring valuable information and answer specific epidemiological questions (see Box 1). Sentinel surveillance is particularly relevant when high-quality information cannot be collected widely in all facilities, or when resources are too sparse to implement nationwide effective surveillance.

By nature, a sentinel approach will not answer directly all the epidemiological questions associated with the introduction of the *Nm* A conjugate vaccine; however, it is possible to combine different strategies to reach a satisfying level of information and meet the surveillance goals set for meningococcal meningitis. In particular, epidemics cannot be recognized through sentinel surveillance – except in certain situations – and neither the burden of the disease nor the incidence trends of the disease at country level can be reflected. Consequently, whenever a case-based sentinel strategy is implemented, enhanced epidemic surveillance should still be applied as a basis for this approach, to ensure these information gaps are filled.

Proposed sentinel surveillance strategies for meningitis are:

- paediatric case-based surveillance;
- hospital case-based surveillance;
- district case-based surveillance.

Each of these is discussed below.

Paediatric case-based surveillance relies on the same principles as the paediatric bacterial meningitis (PBM) surveillance strategies and networks implanted in the WHO African Region for *Haemophilus influenzae b* (*Hib*), *Streptococcus pneumoniae* (*Sp*) and *Nm*, which assess the impact of newly introduced vaccines (15). In the event of limited resources or infrastructures, paediatric case-based surveillance focuses on the group most at risk; this gives the best chance that the surveillance will retrieve useful information about the disease. Although this case-based strategy has certain specific information requirements, this should not prevent it from being integrated with existing networks and projects conducting PBM sentinel surveillance, or from working in synergy with these efforts (e.g. through the use of common tools, methods and finances, as well as human resources).

Hospital case-based surveillance uses the principles of case-based surveillance applied to a set of selected facilities where meningitis suspected cases – ideally both adults and children – are treated. Private hospitals may also be designated as sentinel surveillance sites if they meet the general principles described in Box 1 and detailed in the factsheet for this strategy (at Section 2.4).

District case-based surveillance builds on the principles of a population-based surveillance approach, with information at the individual level recorded for all the meningitis suspected cases of the district. This strategy captures cases comprehensively from all the public and private health structures of the district – that is, from the entire population – but only in certain districts of the country.

Nationwide case-based surveillance

Nationwide case-based surveillance is a strategy that provides epidemiological and microbiological information at the individual level on all the suspected cases of meningitis identified in the health structures of the country nationwide. It is the widest and most comprehensive – but also the most demanding and challenging – approach to case-based surveillance. This national approach makes it possible to compute rates, and assess case burden and trends (both epidemiological and microbiological), but also to assess the impact of the vaccine on the entire population, rather than simply on a set of relevant sites.

Box 1 General criteria for selecting sentinel sites

The quality of the surveillance system is highly dependent on the selection of the sentinel sites. It is critical to ensure that these sites supply high-quality data. It is also better to obtain small amounts of high-quality information than large amounts of poor-quality information. This is partially achieved by selecting “just enough and not too many” sentinel sites. In other words, it is important to implant only sentinel sites that can function well and be monitored effectively. This notion, however, is dynamic, and the amount of sites established and networked may be gradually scaled up and adjusted in subsequent years as the surveillance capacities of the country develop and strengthen (see Section 3.2 and Table 2).

Sentinel sites must be selected strategically in terms of feasibility, sustainability and relevance, to ensure that they represent the experience of particular groups (2, 16, 17). The sites could be located in specific areas (e.g. areas at risk or with a dense population; sites of pilgrimages, displacements or seasonal migrations; or areas where climatic conditions are favourable to the transmission of meningitis) or in specific facilities (e.g. reference hospitals or laboratories, or district hospitals). Sentinel sites might also be selected in relation to their ability to capture specific populations (e.g. age group most at risk) or to be representative of some others (e.g. general population), although the latter is neither a necessary nor a binding criterion (18-22). The criteria for selecting sentinel sites are outlined below.

Resources, feasibility and sustainability:

- total amount and nature of resources available in the country and at the site;
- site’s capacity to implement and sustain the surveillance strategy;
- existing network for data and specimen transmission;
- capacity to:
 - notify cases in a timely manner;
 - perform appropriate microbiological tests;
 - process, store and ship the specimens to reference laboratories;
- existence of relevant personnel and infrastructures (including for communication) that can be adapted to perform case-based surveillance with moderate cost in time and funds;
- commitment of site’s directing and managing bodies to engage in case-based surveillance and to coordinate with relevant partners.

Catchment area:

- site’s catchment area and ability to provide denominator data;
- location (e.g. specific climatic, demographic or socioeconomic features);
- nature of the site (e.g. district health facilities, regional hospitals or laboratories);
- proportion of cases notified and likelihood of capturing cases with sufficient volume.

Good quality case-management services

1.4 Prerequisites for adequate surveillance

The general prerequisites that should be met for effective surveillance, common to all the surveillance strategies, include:

- political support and commitment from MoH and relevant partners;
- clear notion of what needs to be achieved through surveillance, and of who will use the data and how;
- review and assessment of existing surveillance resources and structures in order to:
 - characterize the baseline surveillance situation;
 - determine whether reinforcement is required to meet surveillance objectives tailored to the country's needs and capacity (and if so, what such reinforcement would involve);
- defined areas targeted for implementation;
- trained proficient personnel;
- access to adequate resources (e.g. funding, laboratory equipment, materials, software and shipping capacities);
- assistance from technical and financial partner agencies such as WHO and reference laboratories.

In addition to these fundamentals, some strategies might have specific requirements; these are detailed in the factsheets under "Specific prerequisites".

1.5 Resources

The implementation or strengthening of a surveillance system for meningitis requires a range of resources that encompass everything from capacity (human resources, laboratory capacity, and the conservation and shipment of specimens), to training and consumables (laboratory consumables and lumbar puncture kits), to the ability to support a complex preparation or implementation. These resources should be maximized to ensure the efficiency of the surveillance system. Overall, nationwide case-based surveillance is the most resource-demanding strategy.

1.6 Estimated costs

The estimation of costs is particularly important during two steps of the process of tailoring surveillance after the introduction of the *Nm A* conjugate vaccine; that is, in:

- setting realistic expectations regarding which strategies might be implemented;
- estimating the amount of resources to be raised for implementing a new strategy after the existing surveillance system has been evaluated.

Financial figures related to the implementation of enhanced epidemic surveillance are not given here because this is the baseline strategy already used in most of the countries where the *Nm A* conjugate vaccine has been introduced. In particular, no accurate financial figures are available to estimate the cost of enhanced surveillance and the incremental costs associated with the implementation of surveillance strategies that complement enhanced epidemic surveillance.

As a tentative way to mitigate this lack of information, Table 1 provides a list of the activities associated with the implementation of a national case-based surveillance strategy. These activities might serve as a basis to develop appropriate cost estimation at the central level, as well as by region, district and cluster of health facilities, as appropriate.

The scope of the activities displayed is limited to the implementation of the surveillance per se; it does not include costs associated with outbreak response, or preventive immunization using the *Nm* A conjugate vaccine. Further, these activities relate to the additional costs needed to develop a nationwide case-based strategy, based on an assumption that the baseline is an efficient enhanced epidemic surveillance system implemented across an entire country (as described in the SOPs for enhanced epidemic surveillance in Africa). The activities listed correspond to the start-up costs associated with the implementation of the case-based strategy, not with its functioning.

Table 1. Summary of activities to be considered in costs estimation for the implementation of case-based surveillance

<p>At national level</p> <ul style="list-style-type: none"> • National workshop to decide on the strategy most appropriate for the country • Evaluation of existing surveillance system and subsequent needs • National workshop to tailor the SOPs to the country, and develop an introduction plan for case-based surveillance • Adaptation, reproduction and distribution of the surveillance tools to the health facilities • Strengthening of national laboratories in supplies and equipment (estimated cost per laboratory) • Implementation of a mechanism for the transportation of CSF samples • Quality analysis and control of the epidemiological and microbiological data • Monitoring and feedback to relevant structures • Supervision of surveillance activities • Midterm evaluation of the implementation of case-based surveillance • Final evaluation of the implementation of case-based surveillance after complete introduction of the <i>Nm A</i> conjugate vaccine
<p>At regional and district levels</p> <ul style="list-style-type: none"> • Strengthening of regional laboratories in supplies, equipment and personnel • Strengthening of district laboratories in supplies, equipment and personnel • Series training of laboratory, surveillance and data-management personnel • Micro-planning for the implementation of the new surveillance strategy • Computers and printers and phone or Internet communications • Monitoring and feedback to relevant structures • Supervision of surveillance activities • Midterm evaluation of the implementation of case-based surveillance • Final evaluation of the implementation of case-based surveillance

Part Two: Key features of surveillance strategies – factsheets

This section outlines the key features of each strategy in the form of a factsheet. The indicators proposed here for each strategy should be adapted to a country's existing policies. The factsheets do not give the numerator, denominator and target for each indicator, because these are given in the SOPs for meningitis surveillance. Also, date and location are not given here or in Appendix A, because these should always be referenced for all indicators. The surveillance tools associated with each strategy are summarized in Appendix B, with more information available in the SOPs.

2.1 Enhanced epidemic surveillance

2.1.1 Objectives

- Detect and confirm outbreaks; launch appropriate response strategies.
- Assess the case burden and incidence trends (in time, place and people) of meningococcal meningitis and other acute bacterial meningitis.
- Monitor the circulation, distribution and evolution of *Nm* serogroups and other pathogens.
- Monitor the circulation, distribution and evolution of *Nm* strains (sequence-type).
- Monitor the antibiotic resistance profile of *Nm*.
- Evaluate control strategies.

2.1.2 Methods

- Systematic weekly collection, compilation and analysis of the number of meningitis suspected cases and fatalities at the district level.
- Collection, transportation and analysis of laboratory specimens from a proportion of suspected cases (i.e. initial suspected cases at the early stage of an outbreak).

2.1.3 Specific prerequisites

- There is no specific prerequisite for enhanced epidemic surveillance, because this baseline strategy was already functioning in the countries where the *Nm* A conjugate vaccine has been introduced.

2.1.4 Relevant indicators

Epidemiological indicators

- Suspected cases and fatalities: number, gender and age distribution.
- Confirmed cases (all pathogens identified): number, gender and age distribution, both in total and per pathogen.
- Confirmed epidemics: number, pathogens' distribution and dynamic.
- *Nm* A: area of origin, whether vaccinated or not with regard to the *Nm* A conjugate vaccine.
- Antimicrobial resistance profile: *Nm* resistance status to relevant antibiotics.

Performance and monitoring indicators

- Notification and timing:
 - proportion of reporting districts;
 - time needed to notify the cases and fatalities following the initial medical consultation;
 - time to launch an investigation following the crossing of the epidemic threshold.
- Laboratory confirmation and contamination:
 - proportion of cases with laboratory confirmation.

2.1.5 Epidemiological tools

- SOPs
- CSF analysis registry
- Weekly epidemiological summary sheet
- Framework for outbreak investigation
- Country database
- Subregional database
- Weekly epidemiological feedback bulletins

2.1.6 Strengths and limitations

Strengths

- Already implemented in hyperendemic countries.
- Does not require significant epidemiological investigation at the individual (case) level.
- Does not require significant laboratory facilities.
- Is representative of the situation in the entire country.

Limitations

- Requires important coordination and follow-up at all levels of surveillance system.
- Does not provide sufficient information to closely monitor the potential epidemiological and microbiological changes induced by the introduction of the conjugate vaccine.
- Does not provide sufficient information to assess the effectiveness of the conjugate vaccine.
- Focuses on meningococcal meningitis rather than on other pathogens responsible for meningitis such as *Sp* or *Hib*.

2.2 Comprehensive case-based outbreak documentation

2.2.1 Objectives

- Monitor the circulation, distribution and evolution of *Nm* serogroups and other pathogens.
- Monitor the circulation, distribution and evolution of *Nm* strains (sequence-type).
- Monitor the antibiotic resistance profile of *Nm*.
- Evaluate control strategies.
- Evaluate the impact of the conjugate meningitis A vaccine on the number of cases and outbreaks, on epidemic patterns, and on circulating serogroups.
- Estimate the effectiveness of the meningitis A conjugate vaccine.

2.2.2 Methods

- Intervention of mobile field investigation teams (e.g. clinicians, microbiologists, epidemiologists and logisticians) in areas with increased meningitis incidence, and in districts crossing the alert or epidemic threshold (as detected by the baseline surveillance system).
- Systematic collection of epidemiological information and CSF specimens from as many suspected cases as possible (if not all) during the entire duration of the outbreak.
- Mobile teams are equipped to perform Gram coloration and rapid diagnostic tests on the spot, where possible, and to collect and store specimens for further testing in references laboratories.

Additionally, enhanced epidemic surveillance continues in the entire country to compute the weekly incidence of meningitis, to determine the alert or epidemic status of districts and to launch appropriate investigation and containment measures.

2.2.3 Specific prerequisites

- Existence of a baseline functioning routine surveillance system (usually, enhanced epidemic surveillance).
- Ability for the system to be deployed quickly once the epidemic of meningitis has been identified, with associated policy and financial requirements.
- Implementation of specific mechanisms to rapidly release sufficient funds to cover the costs in personnel and equipment associated with the investigation, to constitute an investigation team, and to ensure its rapid and safe transportation to the epicentre of the outbreak.

2.2.4 Relevant indicators

Epidemiological indicators

- Suspected cases and fatalities: number, age and gender distribution.
- Confirmed cases (all pathogens identified): number, age and gender distribution, both in total and per pathogen.
- Confirmed epidemics: pathogens' distribution and dynamic.
- *Nm A*: number, age and gender distribution among vaccinated and unvaccinated cases with regard to the *Nm A* conjugate vaccine, area of origin of vaccinated and unvaccinated cases.
- All specimens tested: number of specimens tested and methods used, pathogen(s) identified in total and per method.
- Antimicrobial resistance profile: *Nm* resistance status to relevant antibiotics.

Performance and monitoring indicators

- Notification and timing:
 - time to notify the cases and fatalities following the initial medical consultation;
 - time to identify the pathogen;
 - time to launch an investigation following the crossing of the alert or epidemic threshold when relevant.
- Laboratory confirmation and contamination:
 - proportion of cases with CSF sampling and with laboratory confirmation;
 - number of specimens tested using one, two and three techniques;
 - proportion of samples contaminated, proportion of samples confirmed negative and proportion of contamination;
 - discordance of positivity, pathogen discordance and serogroup discordance.

2.2.5 Epidemiological tools

- SOPs
- Individual sample notification form
- Cases description sheet (line-list)
- CSF analysis registry
- Framework for outbreak investigation
- Country database
- Subregional database
- Weekly epidemiological feedback bulletins

2.2.6 Strengths and limitations

Strengths

- Requires small additional efforts for implementation.
- Requires important resources but over limited time and space.
- Can mitigate for gaps in the investigative and response capacities; in particular, in remote areas or in areas where a full surveillance and intervention system could not be implemented or sustained (or both).

Limitations

- Relies on enhanced epidemic surveillance for outbreak detection, and therefore for triggering the implementation of this strategy; its efficiency and timeliness therefore depend on the quality of this strategy.
- Provides epidemiological and microbiological information on epidemic cases only.
- Provides information that can be used to assess the impact of the *Nm A* conjugate vaccine based on epidemic cases only, which are unlikely to be related to *Nm A* in vaccinated areas.
- Must be implemented in addition to a routine surveillance strategy for outbreak detection, with associated potential limitations.

2.3 Paediatric case-based surveillance

2.3.1 Objectives

- Monitor the circulation, distribution and evolution of *Nm* serogroups and other pathogens.
- Monitor the circulation, distribution and evolution of *Nm* strains (sequence-type).
- Monitor the antibiotic resistance profile of *Nm*.
- Evaluate the impact of the conjugate meningitis A vaccine on the number of cases and outbreaks, on epidemic patterns, and on circulating serogroups.
- Estimate the effectiveness of the meningitis A conjugate vaccine.

2.3.2 Methods

In selected paediatric structures:

- Systematic collection, compilation and analysis of case-based information from all children with suspected meningitis hospitalized in these facilities.
- Collection, storage (as needed), transportation and analysis of laboratory specimens taken from all these cases (e.g. rapid diagnostic tests, culture and PCR).
- A unique identification number links the epidemiological and microbiological data relevant to each case. This information, collected as the cases are detected, is reported to the central surveillance body on a weekly basis for appropriate action.

Additionally, enhanced epidemic surveillance continues in the entire country; that is, in the districts engaged in case-based surveillance as well as in the others, in order to compute the weekly incidence of meningitis, to determine the alert or epidemic status of districts and to launch appropriate containment measures.

Criteria for selecting paediatric wards are:

- Total amount and nature of resources available.
- Catchment area:
 - Location (e.g. specific climatic, demographic or socioeconomic features).
 - Proportion of cases reported compared to the rest of this group at risk across the country and, hence, likelihood of capturing cases with sufficient volume.
 - If possible, known denominator data.
- Feasibility and sustainability:
 - Existence of laboratory facilities within the site to ensure rapid management of the samples.
 - Capacity to notify cases in a timely manner, to perform appropriate microbiological tests, and to process, store and ship the specimens to reference laboratories.
 - Existence of relevant personnel and infrastructures that can be adapted to perform case-based surveillance with moderate cost in time and funds.
 - Commitment of the hospital board and heads of paediatric wards to engage in case-based surveillance and to coordinate with relevant surveillance partners.
 - Existing surveillance projects or networks, in particular for PBM surveillance and evaluation of the impact of new vaccines.
 - Good quality case-management services.

The sites selected may belong to district, regional or national hospitals, as well as to more peripheral health-care centres meeting the selection criteria for sentinel sites.

2.3.3 Specific prerequisites

- Well-functioning baseline surveillance system – most likely enhanced epidemic surveillance.
- In facilities where implemented: higher level of resources needed compared to those not targeted for this case-based strategy and only engaged in routine surveillance.

2.3.4 Relevant indicators

Epidemiological indicators

- Suspected cases and fatalities: number, age and gender distribution.
- Confirmed cases (all pathogens identified): number, age and gender distribution in total and per pathogen.
- *Nm A*: number, age and gender distribution among vaccinated and unvaccinated cases with regard to the *Nm A* conjugate vaccine, area of origin of vaccinated and unvaccinated cases.
- All specimens tested: number of specimens tested and methods used, pathogen(s) identified in total and per method.
- Antimicrobial resistance profile: *Nm* resistance status to relevant antibiotics.

Performance and monitoring indicators

- Notification and timing:
 - time to notify the cases and fatalities following the initial medical consultation;
 - time to identify the pathogen.
- Laboratory confirmation and contamination:
 - proportion of cases with CSF sampling;
 - proportion of cases with laboratory confirmation;
 - number of specimens tested using one, two and three techniques;
 - proportion of samples confirmed negative, proportion of contamination;
 - discordance of positivity, pathogen discordance, serogroup discordance.

2.3.5 Epidemiological tools

- SOPs
- Individual sample notification form
- Cases description sheet (line-list)
- CSF analysis registry
- Weekly epidemiological summary sheet
- Weekly microbiological summary sheet
- Country database
- Subregional database
- Weekly epidemiological feedback bulletins

2.3.6 Strengths and limitations

Strengths

- Requires moderate additional efforts for implementation.
- Builds on resources existing in key facilities.
- Can be easily integrated to and work in synergy with PBM, and with the paediatric diseases surveillance networks and strategies (*Sp*, *Hib*, rotavirus).

- Provides some information on the potential epidemiological and microbiological changes induced by the introduction of the conjugate vaccine among the group most affected by meningococcal meningitis.
- Provides some information to assess the impact of the conjugate vaccine among the age group most at risk.

Limitations

- Focuses on children, where pathogens such as *Sp* and *Hib* are also frequent, and therefore requires careful attention when epidemiological results are interpreted without laboratory confirmation.
- Does not provide comprehensive information on the situation of meningitis in the country.
- The information available may not be representative of the epidemiology of meningitis across the entire country.
- Must be implemented in addition to a routine surveillance strategy for outbreak detection, with associated potential limitations.
- The catchment area and population, and hence the denominator for incidence figures, are not necessarily known.

2.4 Hospital case-based surveillance

2.4.1 Objectives

- Monitor the circulation, distribution and evolution of *Nm* serogroups and other pathogens.
- Monitor the circulation, distribution and evolution of *Nm* strains (sequence-type).
- Monitor the antibiotic resistance profile of *Nm*.
- Evaluate the impact of the conjugate meningitis A vaccine on the number of cases and outbreaks, on epidemic patterns and on circulating serogroups.
- Estimate the effectiveness of the meningitis A conjugate vaccine.

2.4.2 Methods

In selected district, regional or national hospitals:

- Systematic collection, compilation and analysis of case-based information from all the meningitis suspected cases hospitalized in participating facilities.
- Collection, storage (as needed), transportation and analysis of laboratory specimens taken from all these cases (e.g. rapid diagnostic tests, culture, PCR).
- A unique identification number links the epidemiological and microbiological data relevant to each case. This information, collected as the cases are detected, is reported to the central surveillance body on a weekly basis for appropriate action.

Additionally, enhanced epidemic surveillance continues in the entire country; that is, in the districts engaged in case-based surveillance as well as in the others, in order to compute the weekly incidence of meningitis, to determine the alert or epidemic status of districts and to launch appropriate containment measures.

Criteria for selecting hospitals are:

- Total amount and nature of resources available.
- Catchment area:
 - Location (e.g. specific climatic, demographic or socioeconomic features).
 - Nature of the hospital (e.g. community, general, district, regional, national or private hospital).
 - Proportion of cases notified compared to the entire population and, hence, likelihood of capturing cases with sufficient volume.
 - If possible, known denominator data.
- Feasibility and sustainability:
 - Existence of laboratory facilities within the hospital to ensure rapid management of the samples.
 - Capacity to notify cases in a timely manner, to perform appropriate microbiological tests, and to process, store, and ship the specimens to reference laboratories.
 - Existence of relevant personnel and infrastructures (including for communication) that can be adapted to perform case-based surveillance with moderate cost in time and funds.
 - Commitment of the hospital board to engage in case-based surveillance and to coordinate with relevant surveillance partners.
- Good quality case-management services.

2.4.3 Specific prerequisites

- Existence of a well-functioning baseline routine surveillance system – most likely, enhanced epidemic surveillance.
- In facilities where implemented: higher levels of resources needed compared to facilities not targeted for this case-based strategy and only engaged in routine surveillance.

2.4.4 Relevant indicators

Epidemiological indicators

- Suspected cases and fatalities: number, age and gender distribution.
- Confirmed cases (all pathogens identified): number, age and gender distribution in total and per pathogen.
- *Nm A*: number, age and gender distribution among vaccinated and unvaccinated cases with regard to the *Nm A* conjugate vaccine, area of origin of vaccinated and unvaccinated cases.
- All specimens tested: number of specimens tested and methods used, pathogen(s) identified in total and per method.
- Antimicrobial resistance profile: *Nm* resistance status to relevant antibiotics.

Performance and monitoring indicators

- Notification and timing:
 - time to notify the cases and fatalities following the initial medical consultation;
 - time to identify the pathogen.
- Laboratory confirmation and contamination:
 - proportion of cases with CSF sampling;
 - proportion of cases with laboratory confirmation;
 - number of specimens tested using one, two and three techniques;
 - proportion of samples confirmed negative, proportion of contamination;
 - discordance of positivity, pathogen discordance, serogroup discordance.

2.4.5 Epidemiological tools

- SOPs
- Individual sample notification form
- Cases description sheet (line-list)
- CSF analysis registry
- Weekly epidemiological summary sheet
- Weekly microbiological summary sheet
- Country database
- Subregional database
- Weekly epidemiological feedback bulletins

2.4.6 Strengths and limitations

Strengths

- Requires moderate additional efforts for implementation.
- Builds on resources existing in key facilities.
- Provides some information on the potential epidemiological and microbiological changes induced by the introduction of the conjugate vaccine.
- Provides some information to assess the impact of the conjugate vaccine among hospitalized cases.

Limitations

- Does not provide comprehensive information on the situation of meningitis in the country.
- The information available may not be representative of the epidemiology of meningitis across the entire country.
- Must be implemented in addition to a routine surveillance strategy for outbreak detection, with associated potential limitations.
- The catchment area and population, and hence the denominator data for incidence figures, are not necessarily known.
- Is biased towards more severe cases.

2.5 District case-based surveillance

2.5.1 Objectives

- Detect and confirm outbreaks, launch appropriate response strategies.
- Monitor the circulation, distribution and evolution of *Nm* serogroups and other pathogens.
- Monitor the circulation, distribution and evolution of *Nm* strains (sequence-type).
- Monitor the antibiotic resistance profile of *Nm*.
- Evaluate control strategies.
- Evaluate the impact of the conjugate meningitis A vaccine on the number of cases and outbreaks, on epidemic patterns, and on circulating serogroups.
- Estimate the effectiveness of the meningitis A conjugate vaccine.

2.5.2 Methods

In selected districts:

- Systematic collection, compilation and analysis of case-based information from all meningitis suspected cases consulting or attending rural and urban health facilities.
- Collection, storage (as needed), transportation and analysis of laboratory specimens taken from all these cases (e.g. rapid diagnostic tests, culture and PCR).
- A unique identification number links the epidemiological and microbiological data relevant to each case. This information, collected as the cases are detected, is reported to the central surveillance body on a weekly basis for appropriate action.

Additionally, enhanced epidemic surveillance continues in the entire country; that is, in the districts engaged in case-based surveillance as well as in the others, in order to compute the weekly incidence of meningitis, to determine the alert or epidemic status of districts and to launch appropriate containment measures.

Criteria for selecting districts are:

- Total amount and nature of resources available.
- Catchment area:
 - Burden of meningitis compared to the rest of the country and, hence, likelihood of capturing cases with sufficient volume.
 - Location (e.g. specific climatic, demographic or socioeconomic features).
- Feasibility and sustainability:
 - Capacity to notify cases, to process and to ship laboratory specimens and epidemiological data in a timely manner, using adequate communication infrastructures and transmission networks.
 - Existence of relevant personnel and infrastructures that can be tailored and trained to perform case-based surveillance with moderate cost in time and funds.
 - Commitment of the district authorities to engage in case-based surveillance and to partner with relevant surveillance bodies to collect, analyse and transmit data, and to take appropriate action.

2.5.3 Specific prerequisites

- Existence of a well-functioning routine surveillance system – most likely, enhanced epidemic surveillance.
- In districts where implemented: higher level of time commitment, trained personnel and other resources compared to districts where only enhanced epidemic surveillance is in operation.
- Overall, requires fewer resources than nationwide case-based approach.

2.5.4 Relevant indicators

Epidemiological indicators

- Suspected cases and fatalities: number, gender and age distribution.
- Confirmed cases (all pathogens identified): number, age and gender distribution in total and per pathogen.
- Confirmed epidemics: number, pathogens' distribution and dynamic.
- *Nm A*: number, age and gender distribution among vaccinated and unvaccinated cases with regard to the *Nm A* conjugate vaccine, area of origin of vaccinated and unvaccinated cases.
- All specimens tested: number of specimens tested and methods used, pathogen(s) identified in total and per method.
- Antimicrobial resistance profile: *Nm* resistance status to relevant antibiotics.

Performance and monitoring indicators

- Notification and timing:
 - proportion of reporting districts;
 - time to notify the cases and fatalities following the initial medical consultation;
 - time to identify the pathogen;
 - time to launch an investigation following the crossing of the epidemic threshold.
- Laboratory confirmation and contamination:
 - proportion of cases with CSF sampling;
 - proportion of cases with laboratory confirmation;
 - number of specimens tested using one, two and three techniques;
 - proportion of samples confirmed negative, proportion of contamination;
 - discordance of positivity, pathogen discordance, serogroup discordance.

2.5.5 Epidemiological tools

- | | |
|--|---|
| • SOPs | • Weekly epidemiological summary sheet |
| • Individual sample notification form | • Framework for outbreak investigation |
| • Cases description sheet (line-list) | • Country database |
| • CSF analysis registry | • Subregional database |
| • Weekly microbiological summary sheet | • Weekly epidemiological feedback bulletins |

2.5.6 Strengths and limitations

Strengths

- Requires important resources but over specific space.
- Provides some information on the potential epidemiological and microbiological changes induced by the introduction of the conjugate vaccine.

- Provides some information to assess the impact of the conjugate vaccine on epidemic and non-epidemic cases.
- Allows outbreak detection using threshold principles in the districts where implemented.
- Denominator data is known.

Limitations

- Does not provide comprehensive information on the situation of meningitis in the country.
- The information available may not be representative of the epidemiology of meningitis across the entire country.
- Must be implemented in addition to a routine surveillance strategy for outbreak detection, with associated potential limitation.

2.6 Nationwide case-based surveillance

2.6.1 Objectives

- Detect and confirm outbreaks, in order to launch appropriate response strategies.
- Assess the case burden and incidence trends (in time, place and people) of meningococcal meningitis and other acute bacterial meningitis.
- Monitor the antibiotic resistance profile of *Nm*.
- Monitor the circulation of *Nm* strains (sequence-type).
- Monitor the distribution of *Nm* serogroups and other pathogens.
- Evaluate control strategies.
- Evaluate the impact of the conjugate meningitis A vaccine on the number of cases and outbreaks, on epidemic patterns and on circulating serogroups.
- Estimate the effectiveness of the meningitis A conjugate vaccine.

2.6.2 Methods

- Systematic country-wide collection, compilation and analysis of case-based information from all the meningitis suspected cases consulting or attending rural and urban health facilities.
- Collection, storage (as needed), transportation and analysis of laboratory specimens taken from all these cases (e.g. rapid diagnostic tests and PCR).
- A unique identification number links the highly detailed epidemiological and microbiological data relevant to each case. This information, collected as the cases are detected, is reported to the central surveillance body on a weekly basis for appropriate action.
- The threshold principles continue to be used to determine the alert or epidemic status at the district level.

2.6.3 Specific prerequisites

- Demands a high level of resources – whether financial, material or in terms of proficient staff and time commitment from the MoH and its partners.

2.6.4 Relevant indicators

Epidemiological indicators

- Suspected cases and fatalities: number, gender and age distribution.
- Confirmed cases (all pathogens/micro-organisms identified): number, age and gender distribution in total and per pathogen.
- Confirmed epidemics: number, pathogens' distribution and dynamic.
- *Nm* A: number, age and gender distribution among vaccinated and unvaccinated cases with regard to the *Nm* A conjugate vaccine, and area of origin of vaccinated and unvaccinated cases.
- All specimens tested: number of specimens tested and methods used, pathogen(s) identified in total and per method.
- Antimicrobial resistance profile: *Nm* resistance status to relevant antibiotics.

Performance and monitoring indicators

- Notification and timing:
 - proportion of reporting districts;
 - time to notify the cases and fatalities following the initial medical consultation;

- time to identify the pathogen;
- time to launch an investigation following the crossing of the epidemic threshold.
- Laboratory confirmation and contamination:
 - proportion of cases with CSF sampling;
 - proportion of cases with laboratory confirmation;
 - number of specimens tested using one, two and three techniques;
 - proportion of samples confirmed negative;
 - discordance of positivity, pathogen discordance, serogroup discordance.

2.6.5 Epidemiological tools

- SOPs
- Individual sample notification form
- Cases description sheet (line-list)
- CSF analysis registry
- Weekly epidemiological summary sheet
- Weekly microbiological summary sheet
- Framework for outbreak investigation
- Country database
- Subregional database
- Weekly epidemiological feedback bulletins

2.6.6 Strengths and limitations

Strengths

- Provides comprehensive information on the potential epidemiological and microbiological changes induced by the introduction of the conjugate vaccine on epidemic and non-epidemic cases.
- Provides comprehensive information to assess the impact of the conjugate vaccine.
- Allows outbreak detection using threshold principles.
- Is representative of the situation in the entire country.
- Allows measurement of vaccine effectiveness.

Limitations

- Requires a high level of resources for implementation and sustainability.
- Requires a high level of coordination and follow-up at all levels of the surveillance system.
- Requires considerable preparation and planning (time constraint).
- Is associated with a large number of CSF samples that require important transportation procedures and laboratory capacities to be managed and analysed properly and in a timely manner.
- Is associated with heavy data flow and complex data management.

Part Three: Deciding on the strategy and preparing its implementation

3.1 Deciding on the most appropriate strategy

The decision-making process proposed should lead to agreement on the:

- surveillance objectives tailored to the country's capacities and needs;
- most appropriate strategy for reaching these objectives in a feasible, integrated and sustainable manner;
- practical details of the strategy selected (e.g. selection of sentinel sites, flux of information and transmission of specimens);
- partners involved and respective roles and contributions within a clear framework; in particular, regarding the strengthening of laboratory capacities;
- strategy to mobilize appropriate resources;
- strategy to develop an operational plan for the implementation of the strategy, including roles and responsibilities at different levels;
- timeline.

The decision should be guided by the country's current surveillance capacities and by the need to transition its surveillance system towards a case-based approach. It should be based on realistic long-term assumptions and lead to feasible goals and expectations that can be met practically and can be sustained over the long-term. In this respect, a realistic analysis of the costs associated with the implementation of a new surveillance strategy will help in selecting an approach that is feasible and sustainable (see Section 1.6).

The principles of the case-based surveillance approach and the strategy selected need to be approved by the national authorities. A structured, transparent and evidence-based selection process that relies on strong knowledge of surveillance or of the local situation (or both) will facilitate endorsement by the national authorities. In line with the target audience of this document, key people who should participate in the strategic decision-making process include:

- high-level technical and political professionals working at the national level, with strong knowledge of the situation on the ground at regional and district levels;
- relevant partners from national and international technical and financial organizations, with experience of similar surveillance processes in the country of interest or in other countries of the meningitis belt.

The decision-making process may vary slightly from one country to another. To facilitate stakeholder engagement from the outset, it is helpful to initiate the process with a formal introductory meeting of relevant partners to discuss the surveillance issues raised by the introduction of the *Nm A* conjugate vaccine and subsequent possible surveillance strategies. This introductory meeting could be followed by a national workshop with the people who will be involved in reaching an agreement on the items listed at the start of this section. Depending on the size of the country and its specific patterns, it is recommended that this second workshop involve:

- the national directors of the surveillance and disease prevention and control units;
- the head of the national reference laboratory or laboratories;
- the national directors of immunization and of surveillance applied to immunization (and, when relevant, their counterparts at the state or regional level).

Workshop numbers should be limited to 30 people.

Ideally, the workshop should span 2–3 days, and combine plenary presentations followed by discussions and working group sessions. The main topics that could be covered include:

- epidemiology of meningitis in the country and the existing surveillance systems, including strengths and limitations;
- targets and phases for the introduction of the *Nm A* conjugate in the country;
- possible surveillance objectives and strategies in the meningitis belt;
- experience from relevant partners from other countries in selecting a tailored surveillance approach from the pool of strategies proposed.

Some considerations, such as the following, are best addressed in working group sessions:

- determination of the surveillance objectives that can be realistically achieved by the country, and selection of a surveillance strategy accordingly;
- selection of sentinel sites, when appropriate;
- flow of information;
- practical details for transport of specimens (e.g. by public transport);
- review of existing surveillance tools from a perspective of integration and harmonization;
- an operational plan for preparing for the implementation of the strategy selected.

This document can be used as a basis for preparing the workshop, with a particular focus on the tables and charts that compare the different strategies, shown in Appendix C.

3.2 Principles of implementation for the strategy selected

Enhanced epidemic surveillance is already widely used in the meningitis belt; therefore, its implementation is not detailed here. However, that information is available in the SOPs for enhanced meningitis surveillance in Africa (7). For the other possible surveillance strategies, the implementation process comprises four phases:

- preparation and development;
- pilot launch;
- monitoring and evaluation;
- scaling-up of the system.

These phases are common to all the strategies and are described in Table 2, with the relevant time frame. Even if the timeline proposed cannot be met, it is still important to implement the

surveillance strategy selected; therefore, a modified timeline, tailored to the specific situation, should be agreed upon.

Additional practical information can also be found in the guidelines for meningitis case-based surveillance in the WHO African Region, and in a guide developed by WHO for the monitoring and evaluation of surveillance systems (10, 23).

3.3 Roles and responsibilities at different levels

Meningitis surveillance is an ongoing integrated system. To function optimally, it requires a dynamic interaction with regular feedback at four different levels:

- peripheral (e.g. district health facilities);
- intermediate (e.g. regional hospital or laboratory);
- central (e.g. national reference laboratory, MoH's department of disease surveillance);
- international (e.g. WHO collaborating centres).

Each of these levels is responsible in different ways for activities involving management of cases and outbreaks, laboratory processing and confirmation, and data collection and analysis. These activities, which apply to all surveillance strategies, are summarized in Table 3. Patient care and laboratory facilities from the private sector should also be engaged in surveillance activities.

Table 2 Summary phases for the implementation of meningitis surveillance Strategies

Phase	Activities	Duration
Preparation and development	Implementation of a multisectoral and multidisciplinary planning and development committee, with clear terms of reference	12 months before vaccine introduction
	Inventory and evaluation of existing surveillance systems, and identification of opportunities for building upon existing structures (through evaluation of capacities, gaps, needs and partnerships)	
	Awareness raising and advocacy among national authorities for the implementation of a surveillance system adapted to the introduction of the <i>Nm</i> A conjugate vaccine	
	Selection of surveillance strategy relevant to the country and of criteria for site selection, when needed (see Section 3.1)	
	Definition of roles and responsibilities at different levels within a clear framework, including partnerships	
	Development of tailored national guide for SOPs, including surveillance and performance indicators, data collection and management tools, and a monitoring and evaluation plan	
	Micro-planning for the implementation of the appropriate surveillance strategy, including monitoring and evaluation	
Pilot launch	Resource mobilization based on the micro-plan	6 months
	Capacity building in laboratory confirmation, data management, reporting and notification, and on case management (preparation or renovation of relevant structures and training of relevant staff)	
	Identification of pilot areas and structures	
Monitoring and evaluation	Definition of mechanisms for monitoring the pilot with periodic reviews	Ongoing since launch of the strategy; continued beyond pilot launch
	Provision of resources for implementing and running surveillance	
	Monitoring of strategy's level of implementation	
	Evaluation of surveillance strategy and review of data-management tools	
Scaling-up of the system	Data quality analysis and control for both epidemiological and microbiological data	At least 1 year, depending on resources
	Identification of gaps and reinforcement needed, particularly in laboratory confirmation, data management and case management	
	Provision of recommendations at regular intervals, as defined in SOPs	
Scaling-up of the system	Expansion of the new surveillance strategy to areas selected but not yet covered; the scale of this expansion and the different scenarios possible will depend on resources and policies	At least 1 year, depending on resources
	Capacity building based on filling gaps and implementation of reinforcements identified by monitoring and evaluation	

Nm, *Neisseria meningitidis*; SOP, standard operating procedure

Table 3 Surveillance activities per structure at different levels

Structures		Activities		
Level	Facilities	Identification of cases	Specimen processing and laboratory confirmation	Data collection and analysis ^a
Peripheral	HCC	<ul style="list-style-type: none"> • Detect suspected cases • Take CSF sample 	<ul style="list-style-type: none"> • Process specimen and send to the district laboratory 	<ul style="list-style-type: none"> • Fill out sample-case notification forms and line-listings with epidemiological information and macroscopic CSF aspect, and send to relevant structure at the intermediate level • Keep local records (copies of notification forms, etc.)
	District hospital and laboratory	<ul style="list-style-type: none"> • Detect suspected cases • Take CSF sample 	<ul style="list-style-type: none"> • Perform first line analysis^b of samples taken at the HCC of the district hospital • Send samples to intermediate or central RL for second and third line analysis^c 	<ul style="list-style-type: none"> • When applicable, fill out or complete notification forms with epidemiological and microbiological information, and send to relevant structure at the intermediate level
	Data-management team or structure ^d			<ul style="list-style-type: none"> • Centralize forms, enter data into the appropriate database and perform relevant analysis • Provide feedback to peripheral health facilities • Send database to intermediate data-management structure
Intermediate	Regional hospital and laboratory	<ul style="list-style-type: none"> • Detect suspected cases • Take CSF sample 	<ul style="list-style-type: none"> • Perform first line analysis of samples taken at the regional hospital • Perform second line analysis of all samples taken at the regional and district levels • Send all samples to central RL for third line analysis 	<ul style="list-style-type: none"> • When applicable, fill out or complete notification forms with epidemiological and microbiological information, and send to relevant data-management structure at the intermediate level
	Data-management team or structure ^e			<ul style="list-style-type: none"> • Centralize regional forms and database, and perform relevant data analysis • Provide feedback to intermediate health facilities • Send reconciled database to central data-management structure • Keep regional records (copy of the forms and database)

Structures		Activities		
Level	Facilities	Identification of cases	Specimen processing and laboratory confirmation	Data collection and analysis ^a
Central	Reference hospital and laboratory	<ul style="list-style-type: none"> • Detect suspected cases • Take CSF sample 	<ul style="list-style-type: none"> • Perform first and second line analysis of national hospital samples • Perform third line analysis of all samples taken at all levels • Send 10% of all samples to international RL for genomic analysis 	<ul style="list-style-type: none"> • When applicable, fill out notification forms with epidemiological and microbiological information, and send to data-management body at central level
	National data-management coordination body			<ul style="list-style-type: none"> • Centralize national database, including epidemiological and laboratory information, and perform in-depth data analysis • Provide feedback and inform local health facilities, regional and international data-management structure and coordination body, and technical and financial partners • Keep national records
Collaborating centres ^e	WHO	<ul style="list-style-type: none"> • Provide guidelines and SOPs 	<ul style="list-style-type: none"> • Provide guidelines and SOPs 	<ul style="list-style-type: none"> • Analyse data to capture the global epidemiological and microbiological situation • Keep international records • Inform and provide feedback to national and international stakeholders • Coordinate appropriate strategies, including mobilization of resources • Provide technical support, including for evaluation of the surveillance system and of the pilot of the new strategy
	International RL		<ul style="list-style-type: none"> • Perform genomic analysis on all samples sent by national RL^f 	<ul style="list-style-type: none"> • Send summary and feedback to data-management body at national and international levels

CSF, cerebrospinal fluid; HCC, health-care centre; RL, reference laboratory; SOP, standard operating procedure; WHO, World Health Organization

^a On a weekly basis, except for notification forms filled at the time the patient is seen or the sample processed

^b For example, direct Gram examination or rapid diagnostic test

^c For example, culture of polymerase chain reaction

^d May be integrated to the hospital

^e Usually one centre globally for each of the key activities: coordination, epidemiology and laboratory

^f For example, typing and sequencing

Appendices

Appendix A Surveillance indicators

The epidemiology of meningitis may change in the era of the *Nm A* conjugate vaccine. To assess changes in epidemiology, and whether surveillance is properly implemented to detect such changes, two main categories of surveillance indicators are used:

- *epidemiological indicators*, which are the outputs of the surveillance per se (e.g. age distribution, location of cases and pathogens identified);
- *performance and monitoring indicators*, which assess the functioning and usefulness of the surveillance system (e.g. degree of implementation, efficiency, sensitivity and timeliness).

These indicators are usually collected routinely, without overburdening a country and its surveillance systems. Hence, the indicators must be both informative and easy to collect, compute and interpret in a standardized manner. Additional evaluation surveys may be conducted to address specific questions, using a broader range of indicators (e.g. cost-effectiveness and resources estimation).

This appendix lists the surveillance indicators that are relevant to meningitis as the *Nm A* conjugate vaccine is gradually introduced in the meningitis belt. The list is not exhaustive or binding, and it should be adapted to local surveillance policies and expectations. Not all indicators apply to all the surveillance approaches described in this document; rather, they depend on the strategy implemented (see Part Two). **Date** and **location** are not specified in the descriptions below, because they should always be referenced for all indicators.

Epidemiological indicators

The epidemiological indicators include:

- *suspected cases and fatalities*: number, gender and age distribution;
- *confirmed cases (all pathogens/micro-organisms identified)*: number, gender and age distribution per pathogen (e.g. *Nm A*, *Nm W135*, *Nm X*, *Nm Y*, *Nm C*, *Sp* and *Hib*), used to compute case burden, incidence changes and trends;
- *confirmed epidemics*: number, pathogens' distribution and dynamic;
- *Nm A*: number, gender and age distribution among vaccinated and unvaccinated cases with regard to the *Nm A* conjugate vaccine, area of origin of vaccinated and unvaccinated cases (transmission from district vaccinated with the *Nm A* conjugate vaccine, district not vaccinated with the *Nm A* conjugate vaccine or from another country);
- *all specimens tested*: number of specimens tested and methods used, pathogen(s) identified in total and per method (*Nm* and others, such as *Hib* or *Sp*);
- *antimicrobial resistance profile*: pathogens' resistance status (sensible, intermediate or resistant) for relevant antibiotics (e.g. chloramphenicol, ceftriaxone, cefotaxime and amoxicillin).

Performance and monitoring indicators

The performance and monitoring indicators include:

- *notification and timing*:
 - proportion of reporting districts;

- time needed to notify the cases and fatalities following the initial medical consultation, to identify the pathogen, to launch an investigation following the crossing of the epidemic threshold when relevant;
- *laboratory confirmation and contamination:*
 - proportion of cases with CSF sampling and proportion of cases with laboratory confirmation;
 - number of specimens tested using one technique (e.g. rapid diagnostic test or culture or PCR), two techniques (e.g. rapid diagnostic test and culture or PCR) and three techniques (e.g. rapid diagnostic test and culture and PCR);
 - proportion of samples confirmed negative;
 - proportion of samples contaminated;
 - discordance of positivity – proportion of samples positive with one technique and negative with at least one other;
 - pathogen discordance – number of *Nm* samples (i.e. with positive culture) identified as *Sp* or *Hib* by another technique;
 - serogroup discordance – number of *Nm* A specimens (i.e. with positive culture) identified as *Nm* of another serogroup with another technique.

All of these indicators require careful interpretation and require the local context to be taken into account. For example, a high proportion of positive CSF samples could indicate that not enough samples are being collected, whereas a low proportion could indicate that resources are not being used most efficiently. To detect local patterns or specific issues, it is also important to compare surveillance outcomes based on different locations, different networks or, for laboratory results, different techniques. For instance, the comparison of outcomes per technique (direct examination, rapid diagnostic test, culture or PCR) makes it possible to compute the sensibility, specificity and predictive values of the techniques compared to each other and to PCR, the technique of reference.

Appendix B Epidemiological tools

This appendix details all the tools available for meningitis surveillance, regardless of the strategy selected by a given country. Each tool is given with its associated input mask (Excel, Epi-info or on paper) or guiding framework. The tools required for each surveillance approach are described in the factsheets in Part Two of this document.

Standard operating procedures

SOPs provide detailed written instructions for the implementation and operation of meningitis surveillance in countries lying within the African meningitis belt. As such, they ensure that surveillance activities are carried out uniformly, and in the most efficient way possible.

Unique identification number

A unique identification number is attributed to each patient at the health-care facility where the patient seeks care and the CSF sample is taken. It comprises a sequence of the country, region, district and health-facility codes, of the date and of the sequential case number at the facility. Once attributed, this identification number appears on all the supports that contain information related to that case. The number makes it possible to reconcile the information available on each single suspected case through the parallel paths of epidemiological and microbiological surveillance.

Individual sample notification form

This form gathers some epidemiological and detailed microbiological information related to each of the suspected cases and the accompanying specimen, identified using a unique identification number that makes it possible to link this information to that available in the cases description sheet (described below). This notification form is displayed in Appendix 2 (page 43) of the guidelines for meningitis case-based surveillance in the WHO African Region (10).

Cases description sheet (line-list)

The line-listing gathers detailed epidemiological information on all suspected cases (including vaccination status with regard to the *Nm A* conjugate vaccine); that is, the initial clinical evolution of the case. Line-lists are found in all health-care facilities involved in meningitis surveillance. For each case, the line-list uses the same unique identification number as the sample notification form. This description sheet is available in Appendix 3 (page 46) of the guidelines for meningitis case-based surveillance in the WHO African Region (10).

Cerebrospinal fluid analysis registry

This registry exists in each of the laboratories involved in meningitis surveillance, from peripheral to central level. For each entry, the registry must carry the unique identification number attributed to the patient during that person's initial consultation at the health-care facility. The registry also includes basic information on the date and location of the specimen sampling.

Weekly epidemiological summary sheet

This document notifies of cases and fatalities at the district level, on a weekly basis.

Weekly microbiological summary sheet

This sheet summarizes the outcomes of the analysis of the CSF taken from the suspected cases of meningitis. It also provides some basic characteristics of these cases and their geographical origin.

Framework for outbreak investigation

This framework guides the development of an outbreak investigation report. It describes how to summarize the epidemiological and microbiological findings of the investigation performed at the case level. The framework is illustrated in Appendix 6 (page 50) of the guidelines for meningitis case-based surveillance in the WHO African Region (10).

Country database

This database gathers all the information listed on the different notification forms (epidemiological, microbiological and so on), using the input masks and guiding frameworks provided with them.

Subregional database

This database summarizes the key facts about the epidemiological situation of meningitis and associated indicators. It serves as the main source of information for the weekly epidemiological feedback bulletins developed by AFRO/IST-West.

Weekly epidemiological feedback bulletins

Each week, this electronic bulletin summarizes the total number of cases, national incidences, numbers of districts in alert or epidemic, incidence trends over the years, and pathogens identified for each of the countries of the African meningitis belt sending aggregated data to the IST-West. This information tool is sent by e-mail to relevant partners, and is posted on the WHO web site on a weekly basis (14).

Appendix C Summary and comparison of surveillance strategies

This section of the document puts into perspective the varied strategies proposed for meningitis surveillance after the introduction of the *Nm A* conjugate vaccine. It provides a generic comparison template that does not account for any country-specific context. Importantly, some of the scales and attributes used to compare the strategies were defined qualitatively and do not involve quantitative assessment. Hence, these results are presented as an appendix.

The chart and summary tables below capture the characteristics of all the possible strategies for meningitis surveillance. They also provide information on key features of the strategies (Figures C1 and C2), their respective objectives (Table C1) and the resources needed to implement and run these strategies (Table C2). Therefore, these visual supports are useful in confirming that the selected surveillance strategy best suits the needs and capacities of the country in terms of the balance between the objectives set and the amount of resources needed. The chart and summary tables can be used in preparing and running the decision-making workshop, to characterize these surveillance features in light of each country's specific capacities and needs.

Figures C1 and C2 below display some key characteristics of the surveillance strategies and visual them over a scale of 1–4, where 4 represents the optimal situation for the category of interest. Five features are represented on these graphs:

1. *Informativeness* – describes the amount of information generated by the system and what we learn from it. This feature does not account for the quality or precision of the data. The scale is as follows: 1 – weak (least optimal), 2 – moderate, 3 – high, 4 – very high (optimal).
2. *Sustainability* – estimates the likelihood that the system can be maintained in the long term. The scale is as follows: 1 – not at all (least optimal), 2 – somewhat, 3 – moderately, 4 – very (optimal).
3. *Resource-intensiveness* – includes the human, financial and logistical resources needed to set up and run the system. The scale is as follows: 1 – very high (least optimal), 2 – high, 3 – moderate, 4 – small (optimal). These resources should be understood as incremental for non-baseline approaches.
4. *Flexibility* – describes the ease with which the system and facility can be adapted to integrate into other systems. The scale is as follows: 1 – not flexible (least optimal), 2 – a little flexible, 3 – flexible, 4 – very flexible (optimal).
5. *Simplicity* – refers to the overall functioning of the system. The scale is as follows: 1 – very complex (least optimal), 2 – relatively complex, 3 – simple, 4 – very simple (optimal).

Figure C1 combines the characteristics of the four main categories of possible surveillance strategies, as assessed qualitatively (enhanced epidemic surveillance, comprehensive case-based outbreak documentation, nationwide case-based surveillance, and sentinel case-based surveillance). For the sake of clarity, Figure C2 displays the characteristics of each of these categories.

Figure C1 Informativeness, sustainability, resource-intensiveness, flexibility and simplicity of the four categories of meningitis surveillance strategies

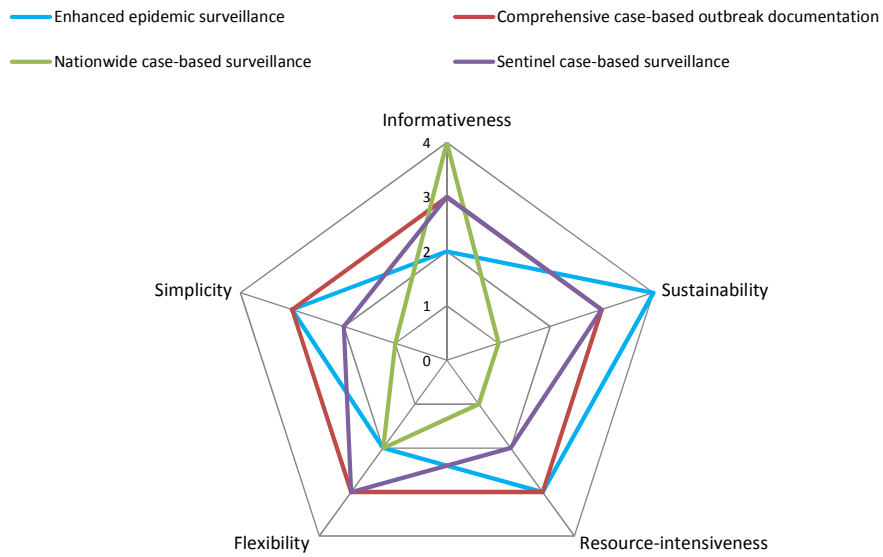
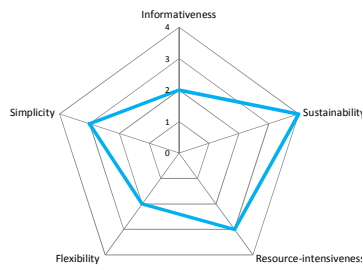
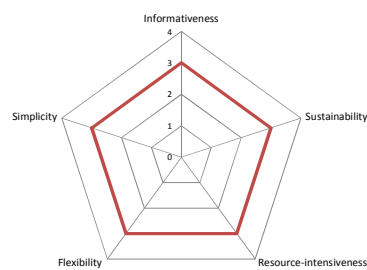


Figure C2 Informativeness, sustainability, resource-intensiveness, flexibility and simplicity of each of the four categories of meningitis surveillance strategies

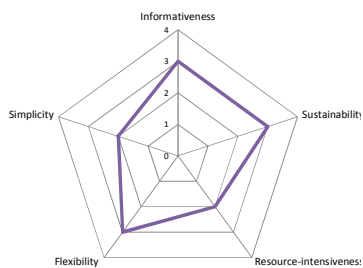
2a. Enhanced epidemic surveillance



2b. Comprehensive case-based outbreak documentation



2c. Sentinel case-based surveillance



2d. Nationwide case-based surveillance

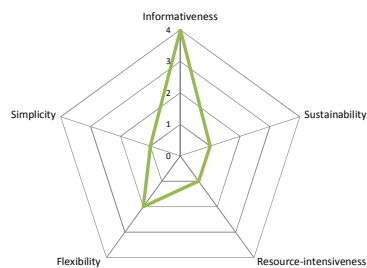


Table C1 Meningitis surveillance strategies and associated objectives

Surveillance objectives	Surveillance strategies					
	Enhanced epidemic surveillance	Comprehensive case-based outbreak documentation	Paediatric case-based surveillance	Hospital case-based surveillance	District case-based surveillance	Nationwide case-based surveillance
Detect and confirm outbreaks, launch appropriate response strategies	X				X ^a	X
Assess the case burden and incidence trends in time, place and people of meningococcal meningitis and other acute bacterial meningitis	X					X
Monitor the circulation, distribution and evolution of <i>Nm</i> serogroups and other pathogens	X	X	X	X	X	X
Monitor the circulation, distribution and evolution of <i>Nm</i> strains (sequence-type)	X	X	X	X	X	X
Monitor the antibiotic resistance profile of <i>Nm</i>	X	X	X	X	X	X
Evaluate the control strategies	X	X			X	X
Evaluate the impact of the conjugate meningitis A vaccine on the number of cases and outbreaks, on epidemic patterns and on circulating serogroups		X	X	X	X	X
Estimate the effectiveness of the meningitis A conjugate vaccine		X	X	X	X	X

Nm, *Neisseria meningitidis*

^a Using incidence thresholds in the districts involved in sentinel case-based surveillance

Table C2 Qualitative breakdown of incremental resources needed per surveillance strategy using enhanced epidemic surveillance as baseline

Surveillance strategies ^a	Types of incremental resources ^b							
	Human resources	Laboratory capacity	Specimens conservation and shipment	Training	Laboratory consumables	Lumbar puncture kits	Complex preparation	Complex implementation
Comprehensive case-based outbreak documentation	Light	Light	Light	Light	Moderate	Light	Light	Light
Paediatric case-based surveillance	Light	Light	Light	Light	Light	Light	Light	Light
Hospital case-based surveillance	Light	Light	Light	Light	Light	Light	Light	Light
District case-based surveillance	Moderate	Light	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Nationwide case-based surveillance	Heavy	Moderate	Heavy	Heavy	Heavy	Heavy	Heavy	Heavy

^a Baseline is enhanced surveillance (used as reference)

^b These resources reflect the need to operate baseline surveillance and serve as a reference for assessing the incremental resources required to run the other strategies

Note: For sentinel strategies, the total amount of resources needed will depend on the number of sites or district selected. The below breakdown is provided as an estimate of incremental resources needed per site or district.

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