Expansion of syndromic vaccine preventable disease surveillance to include bacterial meningitis and Japanese encephalitis: Evaluation of adapting polio and measles laboratory networks in Bangladesh, China and India, 2007–2008

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Abstract

Background—Surveillance for acute flaccid paralysis with laboratory confirmation has been a key strategy in the global polio eradication initiative, and the laboratory platform established for polio testing has been expanded in many countries to include surveillance for cases of febrile rash

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illness to identify measles and rubella cases. Vaccine-preventable disease surveillance is essential to detect outbreaks, define disease burden, guide vaccination strategies and assess immunization impact. Vaccines now exist to prevent Japanese encephalitis (JE) and some etiologies of bacterial meningitis.

Methods—We evaluated the feasibility of expanding polio–measles surveillance and laboratory networks to detect bacterial meningitis and JE, using surveillance for *acute meningitis-encephalitis syndrome* in Bangladesh and China and *acute encephalitis syndrome* in India. We developed nine syndromic surveillance performance indicators based on international surveillance guidelines and calculated scores using supervisory visit reports, annual reports, and case-based surveillance data.

Results—Scores, variable by country and targeted disease, were highest for the presence of national guidelines, sustainability, training, availability of JE laboratory resources, and effectiveness of using polio–measles networks for JE surveillance. Scores for effectiveness of building on polio–measles networks for bacterial meningitis surveillance and specimen referral were the lowest, because of differences in specimens and techniques.

Conclusions—Polio–measles surveillance and laboratory networks provided useful infrastructure for establishing syndromic surveillance and building capacity for JE diagnosis, but were less applicable for bacterial meningitis. Laboratory-supported surveillance for vaccine-preventable bacterial diseases will require substantial technical and financial support to enhance local diagnostic capacity.

Keywords

1. Background

Strong systems for vaccine-preventable disease (VPD) surveillance are essential for making evidence-based decisions concerning the introduction of new vaccines. To provide a strategic approach for enhancing VPD surveillance and immunization program monitoring, the World Health Organization (WHO) and other global partners developed a Global Framework for Immunization Monitoring and Surveillance (GFIMS) [1]. One principle of the framework was to link epidemiologic and laboratory surveillance systems for all VPDs and leverage the investment for poliomyelitis surveillance.

Since 1985, identification of poliomyelitis cases has relied on active surveillance for acute flaccid paralysis (AFP) and laboratory testing of stool specimens for polioviruses [2–4]. Beginning in the early 1990s, many countries expanded viral VPD surveillance to facilitate measles case detection by adding a rash-fever syndrome case definition. Measles diagnostic testing capacity has been developed within poliovirus reference laboratories, and a network of sub-national laboratories. This polio–measles surveillance infrastructure has provided a platform for establishing laboratory-supported surveillance for other VPDs of viral etiology, including rubella and yellow fever. A survey in countries in the WHO African Region found that adding other VPDs to the AFP surveillance program did not compromise polio surveillance [5].

The availability of vaccines against diseases caused by *Haemophilus influenzae* type b (Hib), *Neisseria meningitidis* (Nm), and *Streptococcus pneumoniae* (Sp) has created the need to include bacterial disease surveillance in the VPD surveillance framework. Diagnosis of bacterial diseases, however, is more complex than that of viral diseases because of the need for specimen collection before starting antibiotic treatment, an invasive specimen collection procedure, quality laboratory capability at the specimen collection site, and immediate specimen transportation from the collection site to diagnostic laboratories. Surveillance for invasive bacterial disease (IBD) has been conducted in many countries primarily through sentinel hospital networks [6–10], but these systems have not been linked to VPD surveillance.

In 2005, the United States Centers for Disease Control and Prevention (USCDC) and WHO proposed using polio–measles surveillance networks to establish case-based acute encephalitis syndrome (AES) surveillance in India and acute meningitis-encephalitis syndrome (AMES) surveillance in Bangladesh and China. These countries were selected because of strong networks for surveillance and laboratory confirmation of polio and measles; these syndromes were selected because they may be manifestations of several VPDs, including those caused by Japanese encephalitis (JE) virus, Sp, Hib or Nm. Available vaccines that protect against these diseases include multiple formulations of JE vaccine, multivalent pneumococcal conjugate vaccines (PCV), monovalent and combination Hib vaccines, and polysaccharide and conjugate meningococcal vaccines [11–14]. None of the countries had introduced PCV, JE, Hib or meningococcal vaccines into their routine immunization programs, although China provided routine and/or campaign vaccination in some provinces.

Data on JE and bacterial meningitis incidence in Bangladesh, China and India are limited. In Bangladesh, JE virus appears to be endemic throughout the country [15,16]. In China, approximately 33,900 cases of JE occur annually [17]. JE is endemic throughout much of India with large seasonal outbreaks documented in several states in northern India [18,19]. Although meningitis caused by Sp, Hib and Nm has been greatly reduced in countries where vaccines against these pathogens are routinely used [20], cases continue to occur in Bangladesh, China, and India. In Bangladesh, meningitis caused by Sp and Hib has been monitored through sentinel surveillance networks [10,21,22]. Outbreaks of meningococcal meningitis and septicemia were reported in China from 2003 to 2005 [23]. In Vellore District in the Indian state of Tamil Nadu, the estimated annual Hib meningitis incidence was 7.1 cases per 100,000 children <5 years of age, comparable to rates reported from Europe before Hib vaccine introduction [24].

AMES surveillance was launched by Ministries of Health (MOH) in China in May 2006 and in Bangladesh in October 2007 using the infrastructure of the polio–measles surveillance and laboratory networks. Because of India's priority to identify best practices to improve AES surveillance, meningitis surveillance was not included in India; AES surveillance started in May 2007. Project areas included three sentinel hospitals (one in each of three districts) in Bangladesh, 24 (six in each of four prefectures) in China and four (one in each of four JE-endemic states) in India (Fig. 1). Criteria for selection of project areas included the absence of wild poliovirus circulation and meeting the global indicators for rates of non-

polio AFP and adequate stool collection[6] [25]. Details and data of the AMES–AES surveillance systems are described elsewhere [16,26–31]. The purpose of this paper is to evaluate the feasibility of expanding polio–measles surveillance and laboratory networks to detect bacterial meningitis and JE, using surveillance for *acute meningitis-encephalitis syndrome* in Bangladesh and China and *acute encephalitis syndrome* in India.

2. Methods

Countries established active surveillance for clinically recognizable characteristics and symptoms at sentinel hospitals. An AMES case was defined as the acute onset of fever in a person of any age at any time of year, accompanied by a change in mental status, or new onset seizures (excluding simple febrile seizures), or meningeal signs or neck stiffness [32]. The AES case definition did not include meningeal signs or neck stiffness. Cerebrospinal fluid (CSF) and blood specimens were collected from all identified AMES and AES case–patients and tested for JE IgM by enzyme-linked immunosorbent assay (ELISA). CSF specimens from AMES case–patients were also tested for bacterial meningitis by bacterial culture and latex agglutination (for Hib, Nm serogroups and Sp) where available, and CSF and sera by real-time polymerase chain reaction (PCR). If specimen quantity permitted, the primary sentinel site laboratory referred aliquots to secondary and tertiary laboratories for quality control and advanced testing.

To evaluate AMES and AES surveillance, we developed post hoc nine qualitative indicators to assess implementation of surveillance and six quantitative indicators to evaluate performance (Box 1). Five of the nine qualitative indicators (national guidelines, monitoring, feedback, representativeness and sustainability) assessed the overall implementation of syndromic surveillance, irrespective of the target syndrome. Implementation of surveillance to detect JE or bacterial meningitis was evaluated through the four remaining qualitative indicators—training, availability of laboratory resources, data standardization and effectiveness of building on polio–measles networks (how readily polio–measles standard operating procedures [SOPs], staff, specimen shipping, engagement with hospital clinicians were adaptable to AMES/AES). Six quantitative indicators (data completeness, data validity, timeliness, specimen collection, specimen referral to secondary and tertiary laboratories) evaluated performance based on core surveillance attributes and activities.

We developed indicator scores by adapting quantitative criteria and targets from published polio–measles surveillance guidelines and recommendations and two authors (KFC, HSS) awarded points as described below [32–34]. Each indicator included 1–7 components. Components whose achievement could be measured as "yes" or "no", were awarded points as follows: 1 point for "yes" and 0 points for "no" (for example, "were guidelines based on international standards?"). Components that could be measured for each year of surveillance, or had multiple criteria were worth up to 2 points (for example, "conducted biannual visits to sentinel sites"). For representativeness, if all health facilities in the project

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[6]At least one case of non-polio AFP should be detected annually per 100,000 population aged less than 15 years, and all AFP cases should have a full clinical and virological investigation with at least 80% of AFP cases having adequate stool specimens collected. Adequate stool specimens are two stool specimens of sufficient quantity for laboratory analysis, collected at least 24 h apart, within 14 days after the onset of paralysis, and arriving in the laboratory by reverse cold chain and with proper documentation.

area (province, district, or state) reported cases, 2 points were awarded; if an indirect measure of representativeness was used, such as catchment survey, 1 point was awarded.

To compute the percentages used to calculate scores, we used the number of cases that met the indicator target as the numerator, and the number of AMES cases detected in China (May 2006–September 2008), or in Bangladesh (October 2007–December 2008); or the number of AES cases detected in India (May 2007–December 2008) as the denominator. Timeliness of reporting was scored according to country guidelines for preliminary case reporting. It was not possible to evaluate sensitivity, as we did not have data on active case searches.

We used reports from supervisory visits and annual reports to calculate the indicator scores. In China, we reviewed semi-annual and annual case-based surveillance data, and in Bangladesh and India, we examined computerized epidemiological and laboratory data. We also analyzed a convenience sample of observations collected during field visits in India (autumn 2008) and Bangladesh (winter 2009) to evaluate specimen collection and transport practices and to assess laboratory data flow. Statistical Package for the Social Sciences (SPSS, IBM Corporation) was used for data analysis.

3. Results

3.1. Implementation of syndromic surveillance

In all three countries, national AMES–AES surveillance guidelines were developed based on WHO standards, and copies were present at sentinel sites in China and India; in Bangladesh, guidelines were developed at the national level, but were not distributed (Table 1). National program officers in all countries conducted and documented monitoring and supervisory visits to sentinel sites at least semiannually; international partners participated annually, although standard monitoring protocols were not used. Feedback to sentinel sites was delayed in all countries, primarily because of policies requiring the national level to wait for confirmation from tertiary laboratories before reporting results. In India, feedback was also delayed because epidemiologic and laboratory data were not readily linkable in the national database. China applied a population-based approach consisting of active surveillance at all hospitals in the prefecture and laboratory confirmation only at sentinel sites. Bangladesh undertook catchment surveys in project districts to provide a basis for adjusting surveillance data, and India conducted only sentinel surveillance. All three countries developed credible plans to sustain AMES and AES surveillance in at least some sentinel sites, using national and donor resources and funding.

3.2. Implementation of surveillance for JE and bacterial meningitis

Comprehensive training agendas for disease-specific surveillance were developed in all countries (Table 2). These included (1) surveillance workshops for staff at sentinel, intermediate and national levels; (2) laboratory workshops on WHO- and USCDC-recommended techniques for JE IgM ELISA, bacterial culture, and, in China, on real-time PCR for diagnosis of bacterial meningitis; and (3) training at USCDC for senior surveillance and laboratory specialists in epidemiology and molecular techniques.

JE testing equipment and initial stocks of ELISA kits were received in all project laboratories, but frequent shortages in Bangladesh and India limited JE testing. Provision of equipment and supplies for bacterial culture and PCR in China was delayed for several months. In Bangladesh, micro-centrifuges were not available for CSF processing in some hospital laboratories, necessitating the use of conventional centrifuges, which consumed larger specimen volumes, leaving less for other tests.

Data standardization was stronger for clinical case reporting than for laboratory reporting, mainly because of differences in availability of data management software and staff skilled in their use. For example, polio–measles surveillance staff in each project district used a software application (Epi Info™ [CDC, Atlanta, USA] in India and Bangladesh; EPIDATA [EpiData Association, Odense Denmark] in China) to create a clinical AMES and AES case database, while laboratory staff at sentinel sites had limited tools and experience in data management and reporting. Hospital laboratory staff in Bangladesh and China manually recorded diagnostic results and reported to the district level, where surveillance staff entered results into the AMES database. In India, hospital laboratory staff recorded JE ELISA results into a spreadsheet (MicroSoft Excel®), but lacked capability to maintain the integrity of the unique identifiers or manage large data sets. The spreadsheets were sent to the regional reference laboratory, where the results were compiled and dispatched to the national level. Loss of unique identifiers delayed linkage of JE laboratory data and AES surveillance data resulting in delayed reporting of JE test results to clinicians (per field visits).

Overall, we found polio–measles surveillance networks to be effective for developing JE and bacterial meningitis surveillance. All countries adapted polio–measles case investigation and line list formats and software for creating an AMES–AES case database; polio–measles staff provided technical oversight to AMES–AES sentinel sites. However, there were some missed opportunities to link with polio–measles surveillance. For example, none of the countries adapted polio–measles monitoring procedures and supervisory checklists for oversight of AMES–AES surveillance. While the WHO South-East Asia Regional Office (SEARO) expanded regional polio–measles surveillance bulletins to include AES surveillance data, the WHO Western Pacific Regional Office did not. Additionally, the strong links between surveillance officers and pediatricians forged by polio–measles infrastructure were not expanded to include clinicians on adult wards, who are important for AMES–AES surveillance. In addition, a 2006–2007 polio resurgence in India in non-AES areas limited the availability of national polio–measles staff to conduct surveillance [35].

Because both measles and JE testing rely on similar indirect methods, polio–measles protocols for handling and testing specimens, and reporting results were easily adapted and used for JE IgM ELISA, and laboratory staff responsible for measles diagnostic testing readily incorporated JE testing into their work. In addition, WHO regional polio–measles laboratory experts provided technical support, oversight and external quality assessment for JE testing. In contrast, few areas of overlap existed between testing for polio and measles and for bacterial meningitis. Major differences in laboratory methods, equipment and reagents prevented use of the same staff and quality-control procedures for both JE and bacterial meningitis testing.

3.3. Surveillance performance

The major strengths in surveillance performance were data completeness, concordance in JE results by ELISA retesting at secondary and tertiary laboratories, timeliness of investigation and sentinel site reporting, collection of clinical specimens and referral of specimens to a secondary laboratory (Table 3). Only China met the target for complete reporting of discharge status and concordance of JE results by proficiency testing in both 2007 and 2008, only Bangladesh met the case reporting timeliness target during both years, and only India met the 2008 target for CSF collection. No country performed well in referral of CSF specimens to secondary and tertiary laboratories. In nine of 11 instances of annual variation in meeting performance targets, the target was met in 2007 but not in 2008. Field observations in Bangladesh and India suggested that clinicians sometimes did not report case–patients from whom CSF had not been obtained, even though the patient's illness met the case definition. It was also anecdotally reported that pediatric AMES–AES cases were more likely than adult cases to be reported.

Barriers to CSF collection and testing were found, particularly in Bangladesh and India, where many patients (or their families) did not consent to lumbar puncture, particularly if they had been referred from another facility where venipuncture had been performed. In addition, patients often bore the cost of specimen collection and testing in hospital laboratories; this resulted in some clinicians ordering specimen collection and testing based on the family's perceived ability to pay. Family members were sometimes required to transport clinical specimens from the patient's bedside to the laboratory, with no control or monitoring of temperature or interval from collection to receipt by the laboratory. Because JE and bacterial meningitis tests were performed on the same specimens, but in different parts of the hospital laboratory, coordination was required for aliquoting and distribution.

4. Discussion

In this evaluation of AMES–AES surveillance systems in Bangladesh, China, and India, we found that polio–measles laboratory networks were useful for the development of JE diagnostic capacity, but not for confirming bacterial meningitis, primarily because of differences in laboratory staff and viral and bacterial testing methodologies.

Polio–measles surveillance networks provided a useful infrastructure for AMES–AES surveillance and permitted case detection, specimen collection and testing, and compilation of case-based epidemiological and laboratory data. Key features included adaptable data collection protocols, experienced surveillance field staff and national surveillance officers, and WHO regional surveillance and laboratory advisors available for guidance and oversight. In addition, the polio–measles laboratory network offered an appropriate platform for building a JE laboratory network. Similar materials and technical protocols for measles and JE testing facilitated equipping AMES–AES laboratories and training staff, and (at some laboratories) permitted use of the same physical facility and personnel for measles and JE testing. All the systems were functioning within 14–28 months, which was likely accelerated by the strong partnerships among polio–measles surveillance medical officers, pediatric clinicians and network laboratory staff.

Despite these advantages, we found that the polio–measles protocols for documenting and reporting active case searches and conducting supervision were not used for AMES–AES surveillance, and bulletins for dissemination of surveillance data were only used in SEARO. Application of these tools might have improved data completeness, timeliness, monitoring and feedback for AMES–AES surveillance.

We identified several important limitations of the polio–measles surveillance systems in conducting AMES–AES surveillance. Because of the focus on children aged <15 years in case-based polio–measles surveillance, existing partnerships between surveillance medical officers and clinicians at sentinel sites involved only pediatric clinicians, and adult ward staff required a more comprehensive orientation to AMES–AES surveillance protocols. In addition, whereas the collection, handling and indirect testing of blood for AMES and AES cases were easily integrated into polio–measles systems, the collection, handling and transport of CSF for bacterial culture posed a multitude of logistic challenges, including prior treatment with antibiotics and delayed specimen transport that may have affected culture results. Polio–measles laboratory testing is used for program monitoring, not for clinical management, permitting testing to be centralized at regional or national facilities. The identification of bacterial causes of AMES, on the other hand, is needed rapidly for case management and requires on-site laboratory services. Since bacteriology requires different skills, equipment and reagents, it was not possible to use polio–measles staff or resources for bacterial meningitis diagnostic testing. Moreover, bacteriology laboratories at all levels suffered from long-standing deficiencies in equipment, quality assurance and quality control, data management skills and training. Thus, the approach for AMES surveillance did not appear to offer greater efficiencies than the current sentinel networks that have supported IBD surveillance in many countries and regions [36,37,10,21,38], although in China this project has provided the first population-based IBD surveillance data, which has continued to be sustained by the national government. A permanent bacteriology technical advisor at SEARO might have improved CSF and data management at the sentinel sites through the development of SOPs for CSF and data handling, training, on-site visits, and laboratory indicators adapted to bacteriology.

Our evaluation had several limitations. Slight differences among national surveillance protocols posed challenges in developing indicator criteria relevant to all three countries, and because the indicators were developed after the project ended, data to calculate them were not systematically collected during the evaluation period. Because country data sources differed, we had difficulty obtaining data for some indicators. Finally, it was not always possible to separate performance at start-up from that later in the project.

This multi-country, cross-regional effort to adapt the polio–measles surveillance infrastructure for laboratory-supported surveillance of JE and bacterial meningitis adds to a growing body of evidence that supports expanding VPD surveillance networks to include additional syndromes and supports the GFIMS principle of linking systems [2] and recently updated WHO guidelines recommending integration of JE surveillance with that for AFP or meningitis [32,39]. Elements facilitating integration include similarities in target age, surveillance protocols, specimen requirements, and reporting and data management systems; commonalities among laboratory protocols enable rapid capacity development. Successful

integration of JE surveillance into an established, functional bacterial meningitis surveillance system in Cambodia supports these observations [40]. However, to apply the GFIMS to the development of surveillance for bacterial VPDs, enhancement of laboratory capacity for bacteriology and appropriate data management are needed to ensure that challenges do not bias disease burden estimates downward and delay the introduction of lifesaving vaccines [41].

Acknowledgments

Abbreviations

AES	acute encephalitis syndrome
AFP	acute flaccid paralysis
AMES	acute meningitis-encephalitis syndrome
BNG	Bangladesh
CHN	China
CSF	cerebrospinal fluid
ELISA	enzyme-linked immunosorbent assay
GFIMS	Global Framework for Immunization Monitoring and Surveillance
Hib	*Haemophilus influenzae* type b
IBD	invasive bacterial disease
IND	India
JE	Japanese encephalitis
MOH	Ministry of Health
Nm	*Neisseria meningitides*
PCR	polymerase chain reaction
PM	polio–measles
PCV	pneumococcal conjugate vaccine
SEARO	South-East Asia Regional Office
Sp	*Streptococcus pneumonia*

SPSS	Statistical Package for the Social Sciences
UNICEF	United Nations Children's Fund
USCDC	United States Centers for Disease Control and Prevention
VPD	vaccine-preventable disease
WHO	World Health Organization

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Box 1

Indicators used for the evaluation of acute meningitis-encephalitis syndrome (AMES) an acute encephalitis syndrome (AES) surveillance

Implementation indicators

Syndromic surveillance

1. National guidelines

2. Monitoring and supervision

3. Feedback

4. Representativeness

5. Sustainability

Japanese encephalitis or bacterial meningitis surveillance

1. Training

2. Availability of laboratory resources

3. Data standardization

4. Effectiveness of building on polio–measles networks

Performance indicators

1. Data completeness

2. Data validity

3. Timeliness

4. Specimen collection

5. Specimen referral to secondary laboratory
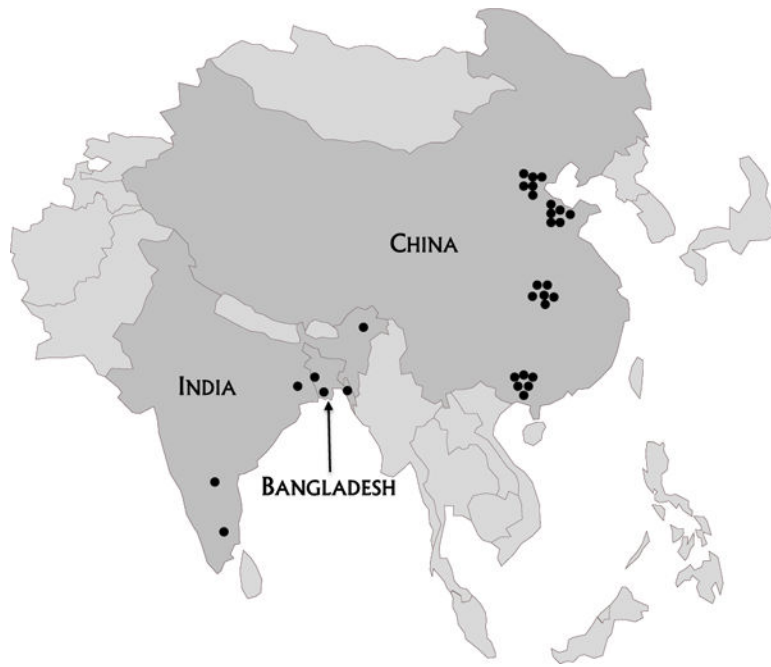
6. Specimen referral to tertiary laboratory

Fig. 1.
Location of AMES surveillance sites in Bangladesh and China, and AES surveillance sites in India.

Table 1

Evaluation of implementation of syndromic surveillance for AMES–AES[a] Bangladesh (BNG), China (CHN) and India (IND), using four qualitative indicators.

Indicator	Component	Scores for syndromic surveillance			
		Max score[c]	BNG	CHN	IND
1. National guidelines	Guidelines based on international standards	1	1	1	1
	Guidelines used at all administrative levels	1	0	1	1
	Total	2	1	2	2
2. Monitoring and supervision	Conducted biannual visits to sentinel sites	2	2	2	2
	Used standard protocol for monitoring and supervisory visits	2	0	0	0
	Documented site visits	2	2	2	2
	Total	6	4	4	4
3. Feedback	Monthly feedback to sentinel sites	2	0	0	0
	Total	2	0	0	0
4. Representativeness	Population-based data[d]	2	1	2	0
5. Sustainability	MOH[b] plan to sustain surveillance	1	1	1	1
	MOH budget to sustain surveillance	1	1	1	1
	Total	2	2	2	2
	Total	14	8	10	8

[a]AMES–AES, acute meningitis-encephalitis syndrome/acute encephalitis syndrome.

[b]MOH = Ministry of Health.

[c]Maximum score—if the component could be answered in a "yes/no" fashion, the maximum score was 1 point (e.g., components for national guidelines and sustainability); if the component could be measured for each year of surveillance, a maximum score of 2 points were possible (e.g., components for monitoring and supervision and feedback).

[d]If all health facilities in the project area (province, district or state) reported cases, 2 points were awarded; if an indirect measure of representativeness was used, such as catchment survey, 1 point was awarded.

Table 2

Evaluation of implementation of AMES–AES[b] surveillance targeting Japanese encephalitis and bacterial meningitis in Bangladesh (BNG), China (CHN) and India (IND), using four qualitative indicators.

Indicator	Component	JE surveillance				Bacterial meningitis surveillance[a]		
		Max score[b]	BNG	CHN	IND	Max score	BNG	CHN
1. Training	Content based on technical protocol	1	1	1	1	1	1	1
	Target audience relevant[c]	1	1	1	1	1	1	1
	Timing appropriate[d]	1	1	1	1	1	1	1
	Total	3	3	3	3	3	3	3
2. Availability of laboratory resources	Appropriate equipment in place[e]	2	2	2	2	2	1	1
	Appropriate reagents in place[e]	2	1	2	1	2	1	1
	Total	4	3	4	3	4	2	2
3. Data standardization	Electronic data management[f]	2	1	1	2	2	1	1
	Surveillance, laboratory data linkable[g]	2	2	2	1	2	2	2
	Total	4	3	3	3	4	3	3
4. Effectiveness of building on polio–measles (PM) networks	Surveillance protocols, tools adapted[h]	2	1	1	1	2	1	1
	PM district staff oversaw sentinel sites	2	2	2	2	2	2	2
	PM national staff oversaw surveillance	2	2	2	1	2	2	2
	PM regional bulletins adapted	1	1	0	1	1	0	0
	Laboratory protocols, tools adapted[i]	2	2	2	2	2	0	0
	PM laboratory staff utilized	2	2	2	1	2	0	0
	PM regional staff oversaw laboratory	2	2	2	2	2	0	0
	Total	13	12	11	10	13	5	5
	Total	24	21	21	19	24	13	13

AMES–AES, acute meningitis–encephalitis syndrome/acute encephalitis syndrome.

[a] India did not conduct surveillance for bacterial meningitis.

[b] Components that could be answered in a "yes/no" fashion, were each worth 1 point (e.g., all components for training and one component of effectiveness of building on polio–measles networks); components that could be measured for each year of surveillance, were each worth 2 points (e.g., components for availability of laboratory resources, data standardization and other components for effectiveness of building on polio–measles networks).

[c]Surveillance, laboratory and clinical staff at all levels.

[d]Introductory training prior to launch and refresher training as needed.

[e]For encephalitis surveillance, equipment and reagents to perform JE IgM ELISA at all laboratories; for meningitis surveillance, equipment and reagents to perform Gram stain and bacterial culture at sentinel site laboratories, and to perform real-time PCR at secondary laboratories in all three countries and tertiary laboratories in China.

[f]Electronic data base used for local database for surveillance (1 point) and laboratory (1 point) data.

[g]National level surveillance data easily linked with laboratory data.

[h]Protocols and tools for case investigation, line listing, reporting, monitoring, data management and feedback.

[i]Protocols and tools for specimen transport, laboratory reporting, monitoring and data management.

Table 3

Evaluation of AMES–AES[a] surveillance performance in Bangladesh (BNG), China (CHN), and India (IND).

Indicator	Component[a]	Max score[b]	BNG[c]	CHN[d]	IND[b]
1. Data completeness	90% cases with age	2	2	2	2
	>90% cases with gender	2	0	2	2
	90% cases with discharge status	2	0	2	0
	90% cases with immunization history	2	1	2	2
	90% cases with laboratory results for either JE[e] or BM[f]	2	1	1	1
	Total	10	4	9	7
2. Data validity	90% concordance by retesting serum[g]	1	1	1	1
	90% concordance by PT, serum[h]	1	0	1	0
	Total	2	1	2	1
3. Timeliness	80% cases were reported on time[i]	2	2	0	0
	80% cases were investigated on time[j]	2	2	2	2
	80% sentinel sites reported on time[k]	2	2	2	2
	Total	6	6	4	4
4. Specimen collection	80% cases with any specimen collected[l]	2	2	2	2
	80% cases with blood collected	2	1	2	0
	80% cases with CSF collected	2	0	0	1
	Total	6	3	4	3
5. Specimen referral to secondary lab[m]	80% cases with any specimen referred	2	2	2	1
	80% cases with serum referred	2	1	0	0
	80% cases with CSF referred	2	0	0	0
	Total	6	3	2	1
6. Specimen referral to tertiary lab[n]	80% cases with any specimen referred	2	1	0	1
	80% cases with serum referred	2	1	0	0
	80% cases with CSF referred	2	0	0	0
	Total	6	2	0	1
	Total	36	19	21	17

AMES–AES, acute meningitis-encephalitis syndrome/acute encephalitis syndrome; JE, Japanese encephalitis; BM, bacterial meningitis; NA, not applicable; CSF, cerebrospinal fluid; PT, proficiency testing; ND, no or insufficient data for scoring.

[a]For calculating percentages, the following denominators were used: 867 for Bangladesh, 2815 for China, and 1637 for India.

[b]For all indicators with the exception of data validity, each component was worth 2 points; 1 point was awarded for having achieved the target for each year of surveillance. Each component for data validity was worth 1 point because only aggregate data were available.

[c]Bangladesh and India results from analysis of national data set; 2007 data include cases with hospital admission from launch through December 2007; 2008 data include cases with hospital admission from January through December 2008.

[d]2007 China data from Annual Report December 2007, which includes cases with hospital admission from launch through October 2007; 2008 data from Annual Report December 2008, which includes cases with hospital admission from launch through September 2008.

[e]Laboratory results for JE IgM ELISA.

[f]Laboratory results for Gram stain, latex agglutination, bacterial culture or real-time PCR for Nm, Hib, and Sp.

[g]Based on the retesting of positive specimens (China) or of positive and negative specimens (India and Bangladesh) by tertiary laboratories.

[h]Based on results of testing serum samples provided in a proficiency testing panel.

[i]Each country was evaluated against the country protocol. The protocol in China specified case reporting 24 h after admission, while those in India and Bangladesh specified notification 48 h after admission.

[j]Protocols in all three countries specified case investigation 48 h after notification of case.

[k]Protocols in all three countries specify weekly reporting from sentinel sites.

[l]Serum or CSF.

[m]Secondary laboratories in China were prefecture Chinese CDC laboratories; in India, the National Institute of Mental Health and Neurological Sciences, Bangalore; and in Bangladesh, the Institute of Public Health, Dhaka.

[n]The National Chinese CDC Laboratories in Beijing served as the Tertiary Laboratory in China, and the Laboratories of USCDC served as Tertiary Laboratories for India and Bangladesh.