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# Cost analysis of an integrated vaccine-preventable disease surveillance system in Costa Rica☆

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## Abstract

**Introduction—**Following World Health Organization recommendations set forth in the Global Framework for Immunization Monitoring and Surveillance, Costa Rica in 2009 became the first country to implement integrated vaccine-preventable disease (iVPD) surveillance, with support from the U.S. Centers for Disease Control and Prevention (CDC) and the Pan American Health Organization (PAHO). As surveillance for diseases prevented by new vaccines is integrated into existing surveillance systems, these systems could cost more than routine surveillance for VPDs targeted by the Expanded Program on Immunization.

**Objectives—**We estimate the costs associated with establishing and subsequently operating the iVPD surveillance system at a pilot site in Costa Rica.

**Methods—**We retrospectively collected data on costs incurred by the institutions supporting iVPD surveillance during the preparatory (January 2007 through August 2009) and

☆*Disclaimer*: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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[1]See Appendix A for the list of iVPD Working Team.

**Conflict of interest**

None of the authors report a conflict of interest.

implementation (September 2009 through August 2010) phases of the iVPD surveillance project in Costa Rica. These data were used to estimate costs for personnel, meetings, infrastructure, office equipment and supplies, transportation, and laboratory facilities. Costs incurred by each of the collaborating institutions were also estimated.

**Results—**During the preparatory phase, the estimated total cost was 128,000 U.S. dollars (US$), including 64% for personnel costs. The preparatory phase was supported by CDC and PAHO. The estimated cost for 1 year of implementation was US$ 420,000, including 58% for personnel costs, 28% for laboratory costs, and 14% for meeting, infrastructure, office, and transportation costs combined. The national reference laboratory and the PAHO Costa Rica office incurred 64% of total costs, and other local institutions supporting iVPD surveillance incurred the remaining 36%.

**Conclusions—**Countries planning to implement iVPD surveillance will require adequate investments in human resources, laboratories, data management, reporting, and investigation. Our findings will be valuable for decision makers and donors planning and implementing similar strategies in other countries.

### Keywords

Cost studies; Vaccine preventable disease surveillance; Integrated surveillance; Program costs

## 1. Introduction

Given the increasing availability and introduction of new vaccines in the developing world, accurate assessments of disease burden and vaccination impact will be necessary. Systems that integrate surveillance for diseases prevented by new vaccines such as rotavirus, influenza, *Haemophilus influenzae* type b (Hib), and *Streptococcus pneumoniae* (pneumococcus) with existing surveillance systems for polio, measles, rubella, diphtheria, and tetanus are needed to maintain support and long-term sustainability of vaccination programs.

In 2007, the World Health Organization published the Global Framework for Immunization Monitoring and Surveillance (GFIMS), which outlines recommendations for ministries of health to enhance national surveillance of vaccine-preventable diseases (VPDs) [1]. Rather than implementing new disease-specific and vertical VPD surveillance systems, the GFIMS recommends that VPD surveillance be placed in a “unified framework” that builds upon the strengths of existing surveillance systems. The goals of an integrated VPD (iVPD) surveillance system are to identify and capitalize on the efficiencies of combining surveillance systems and disease surveillance objectives and to reduce costs by eliminating duplication of efforts while providing quality surveillance.

## 2. Implementation of iVPD surveillance in Costa Rica

In 2009, Costa Rica was the first country to implement iVPD surveillance following the GFIMS. The Costa Rica Ministry of Health (MoH) coordinated the initiative, with technical assistance from the U.S. Centers for Disease Control and Prevention (CDC), Pan American Health Organization (PAHO) headquarters, and the PAHO Costa Rica office. The planning and preparation for iVPD surveillance implementation (the preparatory phase of the project)

took place from January 2007 to August 2009; activities during this project phase included a series of meetings to prepare the standardized surveillance protocol as well as training materials and sessions for personnel. In September 2009, the iVPD surveillance system began operating in a single pilot sentinel hospital, the *Hospital San Vicente de Paúl* (HSVP), so that experience could be gained before expanding to other sites. At this site, iVPD surveillance was incorporated into existing VPD surveillance.

Before implementation of iVPD surveillance, VPD surveillance in Costa Rica included syndromic surveillance for acute flaccid paralysis (AFP), febrile rash, and influenza-like illnesses along with surveillance for tetanus, diphtheria, and pertussis in all health care facilities in the country. Nationwide passive surveillance for AFP and febrile rash was conducted in all health care facilities with the objective of tracking progress toward meeting disease eradication and elimination goals. Sentinel surveillance for influenza-like illnesses was based in outpatient clinics and emergency rooms to monitor circulating strains and detect outbreaks.

During the implementation of iVPD, sentinel syndromic surveillance for bacterial meningitis (Hib, pneumococcus, meningococcus), severe diarrhea (rotavirus), and severe acute respiratory illnesses (SARI) (pertussis, influenza, Hib, pneumococcus) was incorporated into the existing VPD surveillance networks. Hyde and colleagues provide more detailed information on the development and implementation of the iVPD surveillance system [2].

HSVP, a 250-bed public hospital managed by *Caja Costarricense de Seguro Social* (Social Security Fund of Costa Rica [CCSS]), is the only hospital in the province of Heredia (estimated population: 450,000), a metropolitan area of the country. The hospital laboratory performs bacterial isolation and identification and rotavirus rapid diagnostic testing. The national reference laboratory, Instituto Costarricense de Investigación y Enseñanza en Nutrición y Salud (Costa Rican Institute for Research and Training on Nutrition and Health [INCIENSA]), located in the country's capital, performs diagnostic testing for viral diseases and serotyping of selected bacterial agents. INCIENSA receives specimens and isolates from HSVP daily.

The Costa Rica MoH is responsible for the general coordination of iVPD surveillance; CCSS, which is responsible for health care for the population covered by the social security health system (approximately 90% of the population), provides oversight of iVPD surveillance. INCIENSA is under the jurisdiction of the MoH. CDC and PAHO provided technical and financial support for establishing iVPD surveillance.

## 3. Processing of specimens

When HSVP identifies a suspected VPD case, the health care provider completes a standardized case report form, enters clinical and epidemiological information about the patient into a standardized electronic spreadsheet, and obtains the appropriate specimens according to the presenting clinical syndrome (Table 1). All patients <5 years of age who present with a severe acute respiratory illness undergo an on-site chest radiograph.

Depending on the type of testing and etiologic agents considered in the differential diagnosis (Table 1), the HSVP laboratory or INCIENSA tests the specimens. A single specimen from a person with a suspected VPD may be tested for one or more etiologic agents according to the surveillance protocol. Some of the differential diagnoses considered are not VPDs, including dengue, respiratory syncitial virus, adenovirus, and parainfluenza virus.

To better understand the resources required for iVPD surveillance, we analyzed the costs of establishing and implementing iVPD surveillance at a pilot site in Costa Rica. We believe these cost data will help to evaluate the pilot program itself, stimulate the development of new and efficient ways to carry out program activities, and plan future program needs, budget allocation, and fundraising. Finally, program cost data will aid in analyses of the cost-effectiveness of iVPD surveillance in Costa Rica and will provide valuable cost information for other countries and regions planning such surveillance.

## 4. Methods

We included retrospectively collected cost data from each of the participating institutions that supported iVPD surveillance in Costa Rica, recorded all cost data in local currency units (Costa Rican colones), and converted the figures to U.S. dollars (US$) using the mean 2009 annual exchange rate of 573 Costa Rican colones per U.S. dollar [3]. We adjusted all costs to 2010 U.S. dollar equivalents.

We collected data on all resources used in the process of establishing and implementing iVPD surveillance activities, including capital costs (one-time purchases) and recurrent (ongoing) costs, for the preparatory phase (January 2007 through August 2009) and the first year of the implementation phase (September 2009 through August 2010). Preparatory phase costs are one-time costs incurred during the project, while those associated with the implementation phase are annual costs required each year for ongoing iVPD surveillance. For the implementation phase, we present costs per 100,000 population.

Costs incurred at the country level included national-level (MoH, CCSS, and INCIENSA) costs and sentinel hospital (HSVP) costs. Costs incurred by international institutions supporting surveillance (PAHO headquarters, the PAHO Costa Rica office, and CDC) were also included. The investigators collected primary cost data at the country level during October 2010 through January 2011, when each institution compiled resource utilization and costing data, followed by a 1-week additional data collection period during February 2011, when the rest of the data were collected and verified.

For each institution, we categorized resources as personnel, infrastructure, office equipment and supplies, transportation, laboratory facilities, or meetings. We did not consider information system support and maintenance costs, as no specific system was established for iVPD surveillance. We reviewed documents related to iVPD surveillance activities and conducted interviews with key staff to ascertain CDC and PAHO cost data. In the final costing results, we report CDC and PAHO donations to laboratory institutions involved in iVPD surveillance in Costa Rica as costs from the laboratory institution performing the activity.

We determined *personnel costs* by collecting data on the number of staff persons, including their annual remuneration, and by interviewing staff at each institution to estimate the time dedicated to iVPD surveillance. We apportioned total personnel costs attributable to iVPD surveillance according to the ratio of staff time allocated to iVPD relative to all other activities. Remuneration packages include base salary and any benefit packages, such as those for dangerous/risky activities, exclusive work at the institution, certain career paths, and length of service; a 1-month salary bonus at the end of every year; a retirement contribution (9.17% of the employee's salary); and support for children at school.

With respect to *meeting costs*, we considered all meetings, including routine and one-time training sessions, during both the preparatory and implementation phases and recorded the number of participants, by institution, at each of the meetings. For international travel, we included costs of airfare and per diems; for local travel, we calculated approximate costs by multiplying average per diem estimates by the number of meeting days.

We classified infrastructure, office, transportation, and laboratory costs as either capital or operational costs. Capital costs are typically one-time expenditures on buildings, vehicles, laboratory, and office equipment that will be used over a period of time. We applied an annual 5% depreciation rate to buildings, vehicles, and office and laboratory equipment over 50-year, 10-year, and 5-year useful-life time horizons, respectively. We assumed the scrap value of the capital items at the end of their useful life to be zero. Operational costs included costs for supplies, utilities, security, maintenance, and repairs. We multiplied total capital and operational costs by estimated fractions of costs attributable to iVPD surveillance.

*Capital infrastructure costs* are building or office/laboratory space costs. *Operational infrastructure costs* include costs for utilities (communication, electricity, water, and cleaning), security, maintenance, and repairs.

We estimated current market values for building and spaces and computed the estimated attributable iVPD surveillance fraction for capital costs by dividing the number of full-time-equivalent (FTE) surveillance staff by the total staff in the building or as a percentage of the building area occupied by surveillance FTE staff.

We also estimated annual operational costs and computed the estimated attributable fraction for operational costs by dividing the number of FTE surveillance staff by the total staff in the building (or total staff in the country, if building-specific costs were not available). We then multiplied total capital and operational costs by estimated cost fractions attributable to iVPD surveillance to estimate annual operational costs.

We calculated the costs of *office equipment and supplies* used for iVPD surveillance. We derived separate estimates of bacteriology and virology laboratory costs for INCIENSA and of epidemiology and laboratory costs for HSVP.

We derived *transportation costs* from the capital costs of vehicles (the percentage of days per year the vehicle was used for iVPD surveillance activities) and operational costs, which we calculated by estimating an average fuel consumption of 4.5 l of gasoline per round trip (assuming an average distance of 45 km and a fuel economy figure of 10 km/l of gasoline) at

an average cost of 588 Costa Rican colones/l of gasoline. We also included estimated costs of insurance, taxes, and maintenance. We estimated costs for transportation by taxi using information on the number of trips and the average taxi fare for each destination. We computed operational (fuel) costs as the product of fuel consumption, average distance, and number of trips. We included the costs for transporting clinical specimens from HSVP to INCIENSA in hospital transportation costs, assuming one daily round trip, and included the costs for shipment of specimens from Costa Rica to the regional reference laboratory in the calculation of PAHO transportation.

*Laboratory costs* included costs related to laboratory equipment, laboratory and medical supplies, and chest X-rays. For high-value laboratory equipment (valued at more than US $5000), the exact year of purchase was used if this information was available. We assumed that all other equipment items were purchased in 2008. We multiplied total laboratory equipment costs by the estimated fraction of cost attributable to iVPD surveillance, which was estimated as the number of FTE laboratory staff dedicated to iVPD surveillance divided by the total laboratory staff. We used current market prices to estimate the cost of donated equipment and supplies. Laboratory costs included the cost of testing for all etiologic diagnostic agents considered in relation to the syndromes under surveillance (Table 1).

To determine the cost of *medical supplies*, we initially estimated the number of respiratory, blood, and stool samples collected and then used this estimate to itemize the number of medical supplies required for collection of these specimens. Next, we multiplied this figure by the individual cost of the supply item. We assumed that all patients with a suspected severe acute respiratory illness underwent a chest radiograph, at an estimated cost of US$26 (30% of the private-sector cost).

We then stratified all estimated costs by activity or cost components, the institution bearing the cost, whether the cost was capital or operational, and whether it was associated with the preparation phase or the implementation phase. For INCIENSA, we further stratified the costs by bacteriology and virology; for HSVP, we stratified costs according to epidemiology, laboratory, and medical supplies (for sample collection).

We used Microsoft Excel to compile and analyze the data. For the preparatory phase, we estimated the costs for personnel and meetings. For the implementation phase, we estimated costs for all of the major categories described above, disaggregated by capital and operational costs.

## 5. Results

The total cost for the preparatory phase of Costa Rica's iVPD surveillance system was US $128,101, US$82,000 (64%) for personnel and US$46,101 (36%) for meeting airfares and per diems.

The total cost for a single year of iVPD surveillance implementation was US$422,149: US $245,736 (58%) for personnel costs, US$ 117,674 (28%) for laboratory costs, and US$ 58,379 (14%) for the remaining cost categories (meetings, infrastructure, office, transportation). Institutional costs included US$153,689 (36%) for INCIENSA, US$117,675

(28%) for the PAHO Costa Rica office, US$70,100 (17%) for CCSS, and US$69,781 (17%) for HSVP (Table 2). Considering the population covered by the iVPD surveillance system, the estimated cost was US$91,846 per 100,000 population.

Costs by major categories and by cost-bearing institution, disaggregated by capital and operational costs, are presented in Table 2. Personnel costs represented the greatest proportion (58%) of iVPD surveillance implementation costs, which were borne entirely by national Costa Rican institutions. PAHO Costa Rica office personnel costs accounted for 41% of total personnel costs.

Laboratory-related costs represented 28% of total costs. INCIENSA was responsible for 81% (US$94,815) of total laboratory costs, among which 94% were costs associated with laboratory supplies. Supplies donated by PAHO headquarters and CDC (influenza, rotavirus, measles, and rubella diagnostic kits and polymerase chain reaction testing for influenza) accounted for 23% (US$16,650) of INCIENSA virology laboratory supply costs. CDC also contributed US$2700 to HSVP for a refrigerator and consumables (e.g., sheep blood agar), accounting for 10% of laboratory costs.

Among the 762 clinical specimens collected and tested, 14 cases of influenza A, 51 cases of pertussis, 13 cases of rotavirus diarrhea, and 2 cases of bacteremic pneumonia (1 due to *S. pneumoniae* and 1 due to *H. influenzae* type e) were detected and diagnosed by the iVPD surveillance system (Table 3), in addition to other non-VPD differential etiologies considered in the diagnostic procedures. Costs per confirmed and suspected cases were estimated at US$2069 and US$762, respectively.

The remaining costs included costs associated with transportation (5%), infrastructure (4%), meetings (3%), and office equipment and supplies (2%). CDC was responsible for 45% of total meeting costs and did not directly support other activities during the implementation phase.

In the case of all cost categories for which operational and capital costs were estimated (i.e., infrastructure, office, and transportation costs), operational costs were more significant than capital costs.

Considering all institutions funding the implementation of iVPD surveillance in Costa Rica, the largest cost share was attributed to INCIENSA (36.5%), followed by the PAHO Costa Rica office (28%); CCSS and HSVP were each responsible for 16.5% of the total. PAHO headquarters, CDC, the Costa Rica MoH, and other Costa Rica agencies combined were responsible for a very small portion of iVPD surveillance funding.

## 6. Discussion

Surveillance system costs are difficult to quantify because they are generally shared with other programs and encompass a broad range of activities. The benefits of surveillance systems are also not easy to quantify, as the impact on the health of a population is indirect [4].

It is unlikely that a universal, fully integrated surveillance system appropriate for all diseases is possible, because of the inherent differences in surveillance objectives and methods for different diseases. Nonetheless, planners can efficiently integrate many elements of a surveillance system; Costa Rica's iVPD surveillance system succeeded in integrating multiple VPDs into an existing surveillance platform. Integrated surveillance systems require adequate infrastructure, and Costa Rica has a number of characteristics that facilitated implementation of iVPD surveillance, including the availability of national sustainable funding for immunization and VPD surveillance, the existence of laboratory capacity, and a functional VPD surveillance platform.

To our knowledge, very few studies have included cost analyses of surveillance systems [5-7], and ours is the first study reporting the costing of an iVPD surveillance system. Although available surveillance system costing studies are not directly comparable to ours, personnel and laboratory costs also represent the major cost components in these studies [5-7].

## 7. Conclusion

Our evaluation demonstrated that the costs incurred during the preparatory phase of the project, costs that are usually not captured or reported, were considerable. As expected, personnel costs accounted for the largest share of costs during the implementation phase. It is important to account for the high labor benefit packages offered by employers in Latin American countries, which result in higher personnel costs than in countries with lower benefit packages. Laboratory costs accounted for the second largest share, and these costs are particularly important in syndromic surveillance systems in which laboratory diagnostic testing for various etiologic agents in a variety of clinical specimens is performed, as is the case with surveillance for many of the diseases prevented by newer vaccines and their differential diagnoses. Thus, such surveillance systems require more laboratory resources and a larger budget share than non-integrated systems for the laboratory component of surveillance. Among the various institutions supporting iVPD surveillance, costs borne by INCIENSA were highest, including personnel, equipment, supplies, and other cost components. This finding is similar to results reported by other authors [7].

One limitation of this study is that we did not estimate baseline costs of existing VPD surveillance before implementation of iVPD surveillance. Also, iVPD surveillance was implemented not at the national level but as a pilot in a sentinel hospital. Finally, we did not consider the cost-effectiveness of the system. As modeled and discussed in an earlier study [8], we believe that integrated surveillance systems can improve the cost-effectiveness of public health surveillance.

Our findings provide information and guidance to other countries and regions considering implementation of integrated VPD surveillance, as well as donors, immunization partners, policymakers, and decision-makers. A commitment of national and international resources to public health surveillance systems will be required as other countries and regions plan to implement integrated VPD surveillance. These systems will require investments to strengthen national capacities in terms of human resources, laboratories, data management,

reporting, and epidemic response. It is expected that such investments will yield higher surveillance quality. Results from this evaluation could provide data inputs for a cost-effectiveness analysis of iVPD surveillance in Costa Rica; we suggest using these data to implement such studies as a means of providing evidence to support decision-making on investing in integrated VPD surveillance systems.

## Appendix A. iVPD Working Team

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## Table 1

Syndromes and age groups targeted for surveillance, samples collected for each syndrome, and processing of specimens: integrated vaccine-preventable disease surveillance system, Costa Rica, September 2009–August 2010.

| Syndrome | Age group targeted for surveillance | Specimen type(s) | Laboratory diagnostic procedures | Etiologic agents evaluated | Processing lab location |
|---|---|---|---|---|---|
| Meningitis | <5 years | Cerebrospinal fluid, blood | Gram stain, latex agglutination test, culture, typing, antimicrobial susceptibility testing | *S. pneumoniae*, *N. meningitidis*, *H. influenzae*, other *Streptococcus* | Sentinel hospital laboratory, INCIENSA |
| Acute flaccid paralysis | <15 years | Stool | PCR<br>Viral isolation | Poliovirus<br>Poliovirus | INCIENSA<br>INCIENSA, international/regional reference laboratory |
| Severe acute diarrhea | <5 years | Stool | Latex agglutination test<br>ELISA | Rotavirus<br>Rotavirus | Sentinel hospital<br>INCIENSA |
| Rash and fever illness | All ages | Blood | ELISA<br>Genotyping | Measles/rubella/dengue<br>Measles/rubella | INCIENSA<br>INCIENSA |
| Severe acute respiratory illness | ≥5 years | Nasopharingeal/oropharingeal aspirate | Chest radiograph, blood culture | *S. pneumoniae*, *H. influenzae* | Sentinel hospital laboratory<br>INCIENSA |
| | <5 years | Nasopharingeal/oropharingeal aspirate, blood, chest X-ray | Immunofluorescence, PCR, viral isolation | *B. pertussis*, influenza virus, respiratory syncitial virus, adenovirus, parainfluenza virus types 1–3 | |

*Note*. PCR: polymerase chain reaction; ELISA: enzyme-linked immunosorbent assay.

**Table 2**

Total costs (2010 U.S. dollars) during the implementation phase (September 2009-August 2010), by institution: integrated vaccine-preventable disease surveillance system, Costa Rica.

| Institution | Personnel | Meetings | | Infrastructure | | Office | | Transportation | | Laboratory | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flights | Per diems | Capital | Operational | Capital (equipment) | Operational (supplies) | Capital | Operational | Capital (equipment) | Operational (supplies) | Grand total (U.S. dollars and % of total) |
| CDC | | 2682 | 1144 | | | | | | | | | 3826(1) |
| PAHO headquarters | | 612 | 1610 | | | | | | | | | 2222(0.5) |
| Costa Rica Ministry of Health | 2929 | | 134 | 0 | 51 | 66 | 55 | 170 | 74 | | | 3480(1) |
| Costa Rica Social | 60,000 | | 134 | 0 | 8883 | 587 | 134 | 269 | 92 | | | 70,100(16.5) |
| Security Fund | | | | | | | | | | | | |
| PAHO Costa Rica office | 100,961 | | 84 | 0 | 945 | 5168 | 5955 | 828 | 3734 | | | 117,675(28) |
| INCIENSA | | | 486 | 418 | 5673 | | | 65 | 346 | | | |
| Virology | 24,771 | | | | | 266 | 88 | | | 2805 | 73,122 | |
| Bacteriology | 26,621 | | | | | 102 | 39 | | | 2888 | 16,001 | |
| INCIENSA | 51,392 | 0 | 486 | 418 | 5673 | 367 | 127 | 65 | 346 | 5692 | 89,122 | 153,689(36.5) |
| subtotal | | | | | | | | | | | | |
| HSVP | | | | | | | | | | | | |
| Total | | | 268 | 0 | 1475 | | | 5895 | 8053 | | | |
| Epidemiology | 27,932 | | | | | 3 | 731 | | | | | |
| Laboratory | 2521 | | | | | 3 | 39 | | | | | |
| Virology | | | | | | | | | | 53 | 16,545 | |
| Bacteriology | | | | | | | | | | 179 | 5606 | |
| Biochemistry | | | | | | | | | | 120 | 197 | |
| Hospital: medical supplies | | | | | | | | | | | 161 | |
| HSVP subtotal | 30,454 | 0 | 268 | 0 | 1475 | 6 | 770 | 5895 | 8053 | 351 | 22,508 | 69,781(16.5) |
| Other Costa Rica agencies | | | 1377 | | | | | | | | | 1377(0.5) |

| Institution | Personnel | Meetings | | Infrastructure | | Office | | Transportation | | Laboratory | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Flights | Per diems | Capital | Operational | Capital (equipment) | Operational (supplies) | Capital | Operational | Capital (equipment) | Operational (supplies) | Grand total (U.S. dollars and % of total) |
| Total by subcategory | 245,736 | 3294 | 5237 | 418 | 17,029 | 6194 | 7041 | 7226 | 12,300 | 6044 | 111,631 | 422,149 |
| Subtotal by category (U.S. dollars and % of total) | 245,736 (58) | | 8531 (2) | | 17,446 (4) | | 13,236 (3) | | 19,526(5) | 117,674(28) | | 422,149(100) |

## Table 3

Numbers ofsamples processed and positive laboratory results, by etiology: integrated vaccine-preventable disease surveillance system, Costa Rica.

| Clinical syndrome | Specimen | Suspected etiology | No. samples tested | Confirmed etiology | No. (%) positive |
|---|---|---|---|---|---|
| Severe acute respiratory illness | Respiratory | Influenza | 240 | Influenza type A | 14 (5.8) |
| | | | | Adenovirus | 27 (11.3) |
| | | | | Parainfluenza type 3 | 4 (1.7) |
| | | | | Respiratory syncitial virus | 91 (37.9) |
| | Respiratory | Pertussis | 231 | *B. pertussis* | 51 (22.1) |
| | Blood | Bacteremic pneumonia | 186 | *H. influenzae* type e | 1 (0.5) |
| | | | | *S. pneumoniae* type 14 | 1 (0.5) |
| Bacterial meningitis | Cerebrospinal fluid | Bacterial meningitis | 7 | *S. agalactiae* [a] | 1 (14.3) |
| Rash and fever illness | Serum | Dengue | 42 | Dengue | 1 (2.4) |
| Severe acute diarrhea | Stool | Rotavirus | 47 | Rotavirus | 13 (27.7) |
| Acute flaccid paralysis | Stool | Poliovirus | 9 | None | 0 (0.0) |

[a] Group B *Streptococcus*.