



Performance of the Severe Acute Respiratory Infection (SARI) Surveillance System: A Case Study of Chey Chumneas Hospital, Kandal Province, Cambodia, 2022

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Abstract

Cambodia's Severe Acute Respiratory Infection (SARI) surveillance system was established in 2012. The system monitors SARI cases, detects outbreaks, and identifies influenza trends. However, the system has not undergone evaluation since its inception. This evaluation aimed to assess surveillance attributes at Chey Chumneas Hospital, Kandal Province. A mixed-methods approach was utilized, following US-CDC guidelines. Medical records in 2022 were reviewed to assess sensitivity and positive predictive value (PPV). Case reporting forms were reviewed to determine completeness. The timeliness of weekly reports in the system and the release of laboratory results were evaluated. Semi-structured interviews with key stakeholders were used to assess qualitative attributes. Between 2018 and 2022, 576 SARI cases were reported. The sensitivity in detecting true SARI cases among admitted patients was 33%, and the PPV was 73%. In 2022, 54% (28/52 weeks) of weekly reports were submitted on time, and 59% (52/88) of SARI cases had laboratory results released within 24 hours. Of 88 case reporting forms, 91% of socio-demographic and date of onset variables were complete, and three SARI symptom variables had a completion of 95%. The system was positive in terms of usefulness, simplicity, acceptability, and flexibility, but stability was relatively weak due to dependence on external funding. The system was useful in estimating morbidity and mortality and monitoring influenza trends. Although its performance was good, gaps in sensitivity, timeliness, and stability remained. Targeted training, supervision for the hospital SARI focal point, and sustained financial support are needed to improve the surveillance system's performance.

Keywords: Cambodia, evaluation, SARI surveillance, attribute

Introduction

Public health surveillance involves the continuous collection, analysis, and interpretation of data to guide public health actions.¹ It is crucial for monitoring infectious diseases and informing prevention and control efforts.^{2,3} Global influenza surveillance has been conducted through the World Health Organization (WHO) Global Influenza Surveillance and Response System (GISRS) since 1952.⁴ Most countries have a well-established weekly

near-real-time surveillance system for influenza-like illness (ILI) and acute respiratory infections (ARIs) in primary care, which are reported weekly.² In the past century, four pandemics emerged from new influenza strains: the 1918 Spanish flu, 1957 Asian flu, 1968 Hong Kong flu, and 2009 swine flu.⁵ The WHO recommended establishing national severe acute respiratory infection (SARI) surveillance systems to assess epidemic severity and enable early detection of potential epidemics and pandemics.^{2,6}

In 2009, the Department of Communicable Disease Control, Ministry of Health (CDC-MOH), Cambodia established sentinel SARI surveillance at nine hospitals: three sites in the national hospital in Phnom Penh and one site in each of the following provinces—Siem Reap, Takeo, Svay Rieng, Kampong Cham, Kampot, and Kandal. Once patients are identified as having SARI based on case definitions, nasopharyngeal samples are collected and transported to the National Institute of Public Health (NIPH) laboratory in Phnom Penh for influenza virus testing. The system's primary goal is to monitor influenza in humans and detect outbreaks of novel influenza strains.⁷

The SARI surveillance system in Chey Chumneas Hospital (CCH) has not undergone formal evaluation since its inception. We conducted a surveillance system evaluation of the SARI sentinel surveillance site at CCH in Kandal Province. The CCH is located 11 kilometers from Phnom Penh. The provincial population in 2023 was 1,820,505.⁸ The CCH sentinel site had low data quality as a result of the surveillance data quality audit. Regular evaluation of the SARI surveillance system is essential to ensure its effectiveness in detecting abnormal increases in respiratory infections. The findings of this evaluation should help guide improvements in surveillance in other similar hospitals in Cambodia. Therefore, our evaluation aims to assess SARI surveillance attributes and recommended improvements to enhance its functioning.

Methods

Study Design and Setting

We conducted a descriptive cross-sectional study to assess both qualitative and quantitative attributes of the SARI surveillance system at the CCH sentinel site between June and July 2023, following the updated U.S. Centers for Disease Control and Prevention guidelines for evaluating public health surveillance systems.⁹

CCH is a provincial-level referral hospital with eight inpatient wards and 120 inpatient beds. The pediatrics, internal medicine, and intensive care unit (ICU) wards, with 40 beds, participate in SARI surveillance.

We analyzed weekly trends of reported SARI cases over a five-year period (2018–2022) as part of the stability assessment of the surveillance system.

Quantitative attributes assessed included timeliness, sensitivity, positive predictive value (PPV), and completeness. Timeliness was assessed for both

laboratory processing and weekly reporting of SARI cases. Sensitivity was defined as the proportion of SARI cases in the hospital records that are reported by the surveillance system, while PPV was defined as the proportion of reported cases that are SARI cases. Completeness was defined as the proportion of variables in the SARI case reporting form that were fully recorded. To evaluate these attributes, 10 individual weeks out of 52 in 2022 were selected by simple random sampling, and full medical record reviews were conducted and compared with the corresponding reports in the system.

For qualitative attributes, we assessed simplicity, acceptability, flexibility, usefulness, and stability. Semi-structured interviews were conducted with national-level focal points, including SARI surveillance chiefs and officials selected through convenience sampling, and local-level focal points directly involved in implementing the system at the CCH.

Case Definition

A SARI case was defined as an individual who meets all of the following criteria: (1) a measured temperature of $\geq 38^{\circ}\text{C}$ (fever) or a history of fever with onset within the past ten days; (2) cough or sore throat; (3) shortness of breath or difficulty breathing; and (4) hospitalization required.¹⁰ A reported SARI case was defined as any case reported in the SARI surveillance system, regardless of whether it met the SARI case definition.

Data Source

Weekly aggregated data between 2018 and 2022 were collected from the CCH's SARI surveillance system database. For 2022, additional data were obtained on SARI cases, including demographic characteristics, admitted hospital, and patient disposition. Laboratory data in 2022—including time of sample collection and result availability—were obtained from the NIPH to assess timeliness. In 10 randomly selected weeks of 2022, all admitted patients' records were reviewed to identify SARI cases. Data on symptoms, onset date, and admission date were extracted. A single interviewer administered a semi-structured questionnaire to relevant stakeholders from national and provincial surveillance focal points.

Data Analysis

SARI case trends

We analyzed weekly trends of reported SARI cases from 2018 to 2022. Descriptive statistics were performed for the total SARI cases in 2022 and for the

cases identified during the 10 randomly selected weeks.

Timeliness

We assessed the timeliness of the SARI surveillance in 2022 using two measures. First, timeliness of laboratory processing was defined as the proportion of nasopharyngeal samples with results released within 24 hours of collection. Second, timeliness of the weekly SARI report was defined as the proportion of weeks in which all SARI cases were entered into the surveillance system by Monday of the following week, calculated across all 52 weeks.

Completeness

Completeness was assessed by completing all variables in the 2022 SARI case report forms. It was calculated by dividing the number of completed variables by the total number of required variables for each form.

Sensitivity and positive predictive value

Among the admitted patients selected for medical record review during the 10 sampled weeks, we compared the number of patients who met the SARI case definition upon review of clinical information in the medical record “gold standard” with reported SARI cases. Sensitivity was calculated by dividing the number of SARI cases reported in the surveillance system that met the SARI case definition by the total number of SARI cases identified in the medical record review. PPV was defined as the percentage of SARI cases reported in the surveillance system. PPV was calculated by dividing the number of reported SARI cases that met the SARI case definition by the total number of reported SARI cases, both overall and stratified by ward.

All data analysis was performed by Microsoft Excel version 16.96.1 (25042021).

Simplicity, acceptability, flexibility, usefulness, and stability

We adapted a previous study's semi-structured questionnaire. Stakeholders were asked to evaluate specific indicators of the qualitative attributes via a 5-point Likert scale (1=strongly disagree, 2=disagree, 3=neutral, 4=agree, 5=strongly agree) for simplicity, acceptability, and flexibility.¹¹ For usefulness and stability, a binary format was used (1=yes, 0=no). Higher scores reflected better performance in the given attribute. The total scores for each attribute were calculated by summing the indicator scores and dividing by the maximum possible score to yield a percentage. The qualitative attributes were then ranked as follows: excellent (>80%), good (60%–80%), average (40%–60%), poor (20%–40%), and very poor (≤20%). We analyzed key insights and quotations from interviews (paper-based questionnaires) with SARI focal points at the national and provincial levels to further assess the qualitative attributes of the surveillance system.

Results

Description of the SARI Surveillance System Flowchart

The SARI surveillance system involves identifying cases in clinical departments, reporting data, sending specimens to the sentinel site, and forwarding samples to the NIPH laboratory for testing. Test results and aggregated reports are submitted to the CDC-MOH, which then shares its findings with international partners (Figure 1).

Trend of SARI Cases over a 5-year Period

Between 2018 and 2022, 576 reported SARI cases were recorded in the SARI surveillance system, including two deaths. No reported SARI cases were documented during 103 weeks, including 65 consecutive weeks between week 10 of 2021 and week 27 of 2022 (Figure 2).

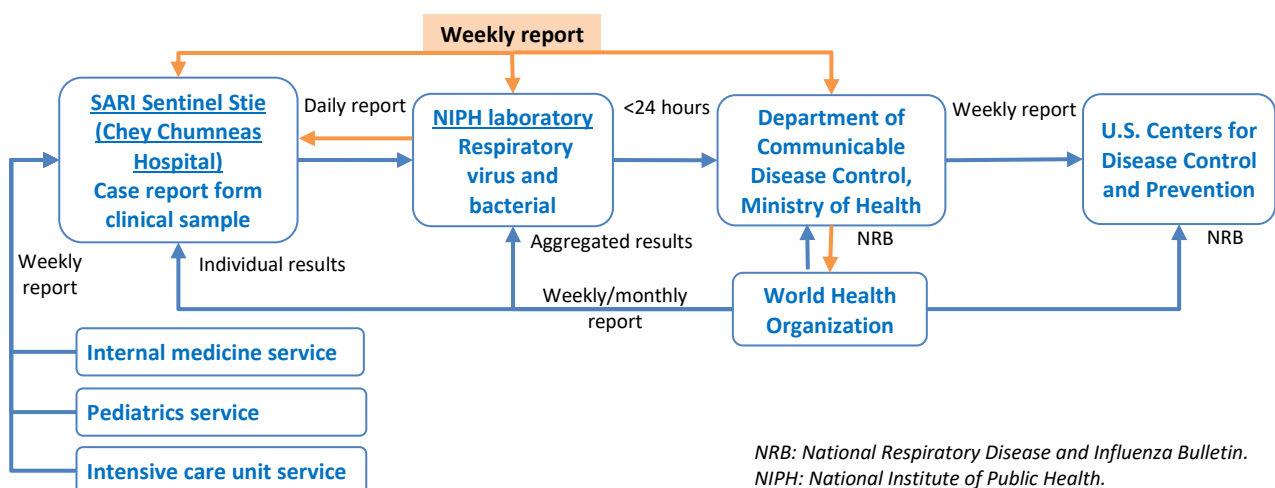


Figure 1. Flowchart for the severe acute respiratory illness (SARI) surveillance system in Chey Chumneas Hospital, Kandal Province, Cambodia, 2022

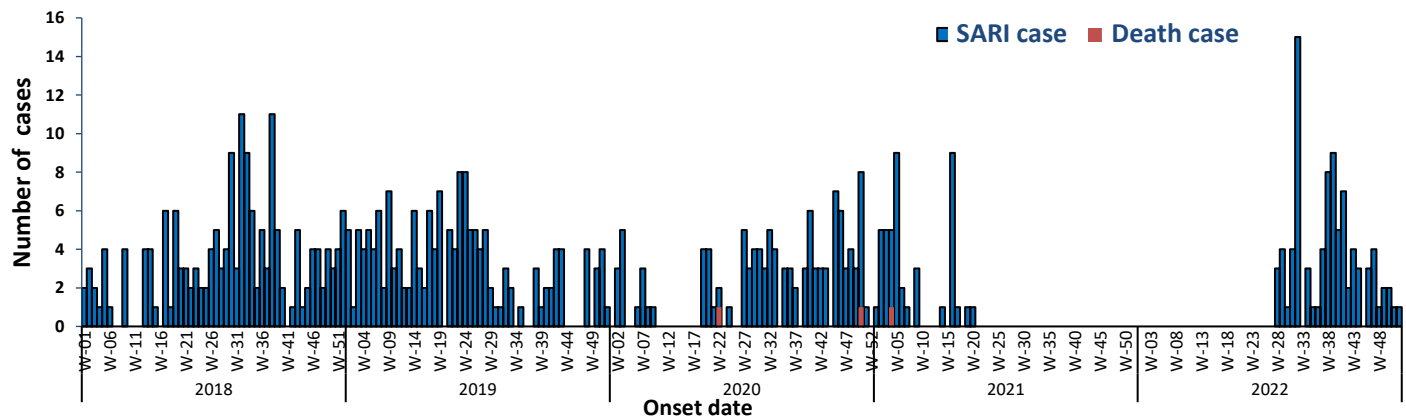


Figure 2. Distribution of SARI cases by week at Chey Chumneas Hospital, Kandal Province, Cambodia, 2018–2022 (n=576)

In 2022, 88 reported SARI cases were recorded in the SARI surveillance system at CCH. Among the cases tested for influenza, 9 (45%) were positive for A (H3N2), 4 (20%) were positive for influenza B/Victoria, and 7 (35%) were positive for COVID-19. Of the 88 reported SARI cases in 2022, 19 (22%) were selected from 10 weeks (weeks 3, 7, 16, 25, 27, 28, 31, 40, 44, and 47) for

full medical record review. Among these, 57.9% were male, compared with 59.1% male among all reported SARI cases. The age group with the largest proportion was children aged 0–4 years (26.1%), compared to 36.8% of the reviewed group. Most were treated in the ICU ward (40.9%), followed by the pediatric ward (32.9%), and the internal medicine ward (26.1%) (Table 1).

Table 1. Patient characteristics under monitored the severe acute respiratory illness (SARI) surveillance system at Chey Chumneas Hospital, Kandal Province, Cambodia, 2022

Characteristics	Total reported cases in 2022 (N=88)		Cases in 10 randomly selected weeks in 2022 (n=19)	
	n	%	n	%
Gender				
Male	52	59.1	11	57.9
Female	36	40.9	8	42.1
Age group (years)				
0–4	23	26.1	7	36.8
5–14	6	6.8	2	10.5
15–24	7	7.9	0	0.0
25–49	17	19.3	3	15.8
50–64	19	21.6	5	26.3
65+	16	18.2	2	10.5
Wards				
ICU	36	40.9	6	31.6
Pediatrics	29	32.9	9	47.4
Internal medicine	23	26.1	4	21.0
Sample types				
NP/OP swab	88	100.0	19	100.0
Sputum	0	0.0	0	0.0
Province				
Kandal	59	67.1	12	63.2
Others*	29	32.9	7	36.8
Final outcome				
Discharged	85	96.6	19	100.0
Transferred	3	3.4	0	0.0
Lab result (Influenza)[†]				
H3N2	9/20	45.0	2/3	66.7
Influenza B/Victoria	4/20	20.0	1/3	33.3
COVID-19	7/20	35.0	0/3	0.0

*Phnom Penh, Kampong Cham, Takeo, and Kampong Speu Provinces. [†]We used only virus-positive cases as the denominator. NP: nasopharyngeal. OP: oropharyngeal. ICU: intensive care unit.

Quantitative Attributes

Timeliness

In 2022, 54% (28/52 weeks) of surveillance reports were submitted on time, meeting the reporting requirements every Monday following the week under review. Among the 88 reported SARI cases, 59% (52/88) had laboratory results processed within 24 hours.

Completeness

Of the 88 reported SARI cases in 2022, 91% of the variables were complete, and three SARI symptom variables had a completeness of 95%.

Sensitivity and positive predictive value

In the 10 weeks selected for full medical record review, 289 patients were admitted to three medical wards where SARI surveillance was implemented. Among these, 42 met the SARI case definition; 14 SARI cases were reported into the SARI surveillance system, resulting in a sensitivity of 33% (14/42). Nineteen SARI cases were reported in the system, resulting in a PPV of 73% (14/19). In pediatric ward, the PPV was 100% (8/8) and the sensitivity was 47% (8/17). The internal medical ward had a PPV of 50% (2/2) and a sensitivity of 11% (2/17), while the ICU had a PPV of 57% (4/7) and a sensitivity of 50% (4/8) (Table 2).

Table 2. Performance of the severe acute respiratory illness (SARI) surveillance system at Chey Chumneas Hospital, comparing the number of reported cases with the number identified by manual medical record review of all admitted patients during the evaluation period

Ward	Reported SARI cases that met the case definition (true SARI)	Reported SARI cases that did not meet the case definition*	SARI cases not reported	Sensitivity [§]	PPV [†]
Pediatrics	8	0	9	47% (8/17)	100% (8/8)
Internal medicine	2	2	15	11% (2/17)	50% (2/4)
Intensive care unit	4	3	4	50% (4/8)	57% (4/7)
All wards combined	14	5	28	33% (14/42)	73% (14/19)

*Those reported into the surveillance system as a SARI case but did not meet the case definition upon manual medical record review. [†]Positive predictive value calculated as SARI cases/total reported SARI cases. [§]Sensitivity is calculated as SARI cases that reported in the system/SARI cases.

Qualitative Attributes

We conducted semi-structured interviews with three persons at the national sites and eight persons at the hospital sites (three nurses, four medical doctors, two laboratory technicians, one data entry personnel or information technology staff, and a public health specialist) to evaluate the system.

Usefulness and stability

Three national-level focal points reported the system's usefulness and stability. The usefulness was rated as excellent, and the stability as good. All questions were ranked as excellent or good, except for stability without sponsor funding, which was rated poor (Table 3). Moreover, the unclear temporal pattern of reporting SARI cases might reflect a lack of system stability.

A national-level focal point stated: *"The SARI surveillance system played a critical role in detecting all avian influenza cases in Cambodia in 2022. Without this system in place, the outbreak could have spread much more widely."*

Simplicity and acceptability

Eight local-level focal points highlighted the system's simplicity and acceptability; simplicity was excellent, and acceptability was good. With a score of 80%, the SARI system is well accepted by the focal points involved in its operation. The focal points' willingness to participate in the system, as well as their satisfaction with it, both received a score of 80% (Table 3).

Flexibility

All eleven national and local focal points were asked about the system's flexibility. The system demonstrated good flexibility, with a score of 69%. It adapts well to changes in the SARI case definition (76%) and integrates with other surveillance systems (71%). The system also accommodates new and additional information reasonably well (65%) and adapts to new health events with moderate efficiency (62%) (Table 3).

A national-level focal point stated the following: *"It is possible to add new variables or information as needed. For example, during the COVID-19 pandemic, we incorporated sample collection to monitor COVID-19."*

Table 3. Qualitative attribute performance of the severe acute respiratory infection (SARI) surveillance system at Chey Chumneas Hospital, Kandal Province, Cambodia, 2022

Indicators	Score	Percent	Rank
Usefulness (n=3)*			
Estimates morbidity and mortality related to SARI	3	100	Excellent
Stimulates research for prevention and control of SARI	3	100	Excellent
Supports resource planning for SARI prevention, control, and interventions	2	67	Good
Informs updates to national SARI policy and strategy	3	100	Excellent
Detects trends and outbreaks of SARI	3	100	Excellent
Enables timely detection and diagnosis of SARI	2	67	Good
Total score	16/18	89	Excellent
Stability (n=3)*			
Adapts to resource changes	3	100	Excellent
Stable without sponsor funding	1	33	Poor
Supported by external or governmental funds	2	67	Good
Total score	6/9	67	Good
Simplicity (n=8)[†]			
SARI case definition available or staff remembers it	32	80	Good
SARI case definition is easy to use	35	88	Excellent
System is user-friendly and easy to fill out	34	85	Excellent
Staff received special training to update and use the system	29	72	Good
Total score	130/160	81	Excellent
Acceptability (n=8)[§]			
Focal point willing to participate in the SARI system	32	80	Good
Focal point satisfied with participating in the system	32	80	Good
Total score	64/80	80	Good
Flexibility (n=11)			
Easily adapts to changes in SARI case definition	42	76	Good
Integration with other surveillance systems	39	71	Good
Accommodates new, additional information.	36	65	Good
Adapts to new health events with minimal resources, time	34	62	Good
Total score	151/220	69	Good

**Usefulness and Stability: Interview with yes/no questions with 3 SARI focal points at the national level. [†]Simplicity and acceptability: Interview with a 5-point Likert scale with 8 SARI focal points at the provincial level, and the total score is the denominator. [§]Flexibility: Interview with a 5-point Likert scale with 3 SARI focal points at the national level and 8 SARI focal points at the provincial level; the total score is the denominator.*

Discussion

For a five-year period, there were several weeks with no reported SARI cases. The system exhibited low sensitivity and low PPV in medical wards and the intensive care unit; however, it had lower accuracy in correctly identifying SARI cases. The stability of the system was rated as good overall; however, it was found to be vulnerable due to a lack of external funding. Despite the challenges in terms of sensitivity, PPV, and stability, the SARI surveillance system, which is useful, simple, flexible, acceptable, timely, and complete, performs well.

We found low sensitivity, meaning that a large proportion of true SARI cases were missed. This poor result was largely due to the evaluation being conducted during the COVID-19 pandemic, when most staff were occupied with outbreak response efforts, lacked supervision, and were monitoring at a relatively high level. This finding was consistent with an evaluation in Ireland during the same period.¹² In addition, the lack of formal training for newly appointed SARI focal points likely contributed to this under-detection. Unsurprisingly, our sensitivity was lower than that of a previous SARI evaluation at Kirivong Hospital, Takeo Province, Cambodia, 2016.¹³

The PPV of the surveillance system varied across wards, with the pediatric ward performing excellently, whereas the medicine ward and the ICU had lower accuracy, probably because one of SARI's focal points in these two areas was a new staff member who had never received formal training. Another reason for the low accuracy may be due to inconsistent application of the case definition at sentinel sites or incomplete documentation of signs and symptoms in medical records. This variability highlights the need for targeted improvements in case identification, particularly in more complex clinical settings, such as ICUs, where the nature of patient conditions may make SARI diagnosis more challenging.

The timeliness of reporting and rapid laboratory results is critical for effective case management, early outbreak detection, and timely public health response. In CCH, the timeliness of laboratory processing is good because the hospital is near the national laboratory, facilitating faster sample transfers. We also discussed how delays in reporting could weaken the system's ability to detect emerging threats such as avian influenza, highlighting the need for continuous efforts to improve timeliness in surveillance operations.

The SARI surveillance system is invaluable for estimating morbidity and mortality related to SARI, promoting research aimed at its prevention and control. Most importantly, it plays a critical role in detecting avian influenza. In fact, the system was instrumental in identifying all avian influenza cases in Cambodia in 2022. Without this system, the outbreak could have spread far more extensively. Similarly, previous studies in Zambia and Yemen demonstrated the usefulness of their surveillance systems.^{14,15}

The stability of the system was rated as good overall; however, it was found to be vulnerable due to a lack of external funding. This reflects the system's reliance on external resources, which may pose a risk to its long-term sustainability. Establishing a more robust and locally supported financial framework is crucial to ensuring that the system can continue to operate effectively, even during periods of funding shortages.

The system's simplicity was one of its strongest attributes. The SARI case definition is clear and easy to use, making it straightforward for healthcare workers to identify and report cases. Additionally, the system's user-friendly design facilitates efficient data entry and reporting, reducing the potential for errors and minimizing the time required for staff to learn and implement the system. This ease of use promotes consistent case identification and data collection, ensuring that the system operates effectively without placing an undue burden on healthcare workers.

The system demonstrated considerable flexibility, particularly during the COVID-19 pandemic. The ability to integrate COVID-19 testing alongside routine SARI surveillance without major system modifications reflects its capacity to adapt to new health threats. Furthermore, the system's ability to accommodate changes in the SARI case definition and the inclusion of additional information, such as new testing protocols, highlights its versatility in responding to evolving public health needs. This flexibility ensures that the system can remain relevant and useful even as new challenges arise.

The acceptability of the SARI surveillance system was also a key strength, with high levels of engagement and satisfaction reported among healthcare workers. Staff are willing to participate in the system, indicating a strong sense of ownership and commitment to its success. This high level of acceptability is critical for ensuring the system's sustainability, as it relies on the active participation of healthcare providers to function effectively. The system's design, which is both easy to use and adaptable, likely contributes to positive perceptions among those responsible for its implementation.

Limitations

This evaluation had several limitations. First, it was conducted at a single sentinel site and focused only on data from 2022, which had relatively few SARI cases, limiting the generalizability of the findings to other regions or SARI sites. Additionally, a small number of interviewees were for qualitative attributes, which may limit the depth and diversity of perspectives captured. Expanding the evaluation to include multiple years, more sites, and a larger sample size would provide a more comprehensive and representative assessment of the effectiveness of the SARI surveillance system.

Recommendations

To strengthen the severe acute respiratory infection (SARI) surveillance system, it is recommended that both provincial and national SARI focal points conduct regular supervision and provide refresher trainings to improve case detection, ensuring that all true SARI cases admitted to hospitals are accurately reported. Newly assigned focal points should also be provided with comprehensive training and continuous guidance to build their capacity and ensure consistency in implementation. In addition, detailed budget planning should be developed to secure the sustainability of the system over the long term. To further improve data quality, continuous monitoring of reporting practices should be implemented, coupled with timely and constructive feedback to reporting sites.

Conclusion

While the SARI surveillance system has strengths in terms of data completeness, timeliness, usefulness, flexibility, simplicity, and acceptability, the system did poorly in terms of sensitivity, PPV, and stability. Targeted training for health care workers involved in SARI reporting and regular supervision, particularly in medical wards and ICUs, is essential. Our evaluation contributes not only to improving the surveillance system at the CCH hospital but also provides evidence representative of the gaps that other health facilities should consider or lessons applicable to the SARI surveillance in the country. Future evaluations should continue to monitor these attributes, with particular attention given to improving case detection and system resilience.

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Author Contributions

Khemrin Pong: Conceptualization, formal analysis, methodology, project administration, writing—original draft, writing—reviewing & editing. **Sophanith Ung:** Supervision, resources. **Sengdoeurn Yi:** Supervision. **Piseth Keam:** Supervision, validation. **Sokly Mom:** Writing—review & editing. **Hayputhik Long:** Conceptualization, methodology, writing—reviewing & editing.

Ethical Approval

Approval from the National Ethical Review Board was not required. This evaluation utilized data from routine surveillance systems and various types of surveillance quality improvement.

Informed Consent

Verbal consent was obtained from key SARI stakeholders prior to the interviews. Written (paper-based) consent was not required, as this type of evaluation did not involve the collection of detailed personal information and posed no risk to participants.

Data Availability

The datasets supporting this study are available from the corresponding author upon reasonable request (via khemrinpong@gmail.com).

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this report.

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Declaration of Generative AI and AI-assisted Technologies in the Writing Process

No artificial intelligence (AI) tools were used to generate the content or findings of this evaluation. However, while the preparation of this manuscript, the author used AI-ChatGPT solely for grammar correction, language refinement, and formatting support. All content was reviewed, edited, and finalized by the author, who takes full responsible for the final text.

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