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Original Article

Evaluation of an influenza-like illness sentinel surveillance system in South Korea, 2017-2023

Bryan Inho Kim [a,1], Seonghui Cho [b,1], Chiara Achangwa [b,1], Yumi Kim [a], Benjamin J. Cowling [c], Sukhyun Ryu [b,*]

[a] Division of Infectious Disease Control, Korea Disease Control and Prevention Agency, Cheongju-si, Republic of Korea
[b] Department of Preventive Medicine, College of Medicine, The Catholic University of Korea, Seoul, Republic of Korea
[c] World Health Organization Collaborating Centre for Infectious Disease Epidemiology and Control, School of Public Health, Li Ka Shing Faculty of Medicine, The University of Hong Kong, Hong Kong, China

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ABSTRACT

Background: Guided by the data from the surveillance system, public health efforts have contributed to reducing the burden of influenza in many countries. During the COVID-19 pandemic, many surveillance resources were directed at tracking the severe acute respiratory syndrome-Coronavirus 2. However, most countries have not reported surveillance evaluations during the COVID-19 pandemic.
Methods: Using the U.S. CDC surveillance evaluation method, we evaluated the influenza-like illness (ILI) sentinel surveillance performance in South Korea between January 2017 and September 2023. For the timeliness, we measured the mean time lag between the reports from the sentinel sites to the Korea Disease Control and Prevention Agency (KDCA) and surveillance result dissemination from KDCA. For the completeness, we measured the submission rate of complete reports per overall number of reports from each sentinel site to the KDCA. For the sensitivity, we calculated the correlation coefficient between the monthly number of ILI reports and the patients with ILI from the Korea national reimbursement data by either Pearson's or Spearman's test. For the representativeness, we compared the age-specific distribution of ILI between the surveillance data and the national reimbursement data using a chi-squared test.
Results: We found that the surveillance performance of timeliness (less than 2 weeks) and completeness (97 %–98 %) was stable during the study period. However, we found a reduced surveillance sensitivity (correlation coefficient: 0.73 in 2020, and 0.84 in 2021) compared to that of 2017–2019 (0.96–0.99), and it recovered in 2022–2023 (0.93–0.97). We found no statistical difference across the proportion of age groups between the surveillance and reimbursement data during the study period (all *P-values* > 0.05).
Conclusions: Ongoing surveillance performance monitoring is necessary to maintain efficient policy decision-making for the control of the influenza epidemic. Additional research is needed to assess the overall influenza surveillance system including laboratory and hospital-based surveillance in the country.

1. Background

Seasonal influenza virus has caused substantial morbidity and mortality globally [1]. Monitoring the influenza activity is important as it provide useful information for prevention and control measures against influenza to the public health authorities. The influenza activity data are primarily collected through using influenza like illness (ILI) sentinel surveillance system in which designated healthcare sites routinely report the daily number of individuals seeking treatment for ILI to public health authorities [2,3]. ILI is typically used for influenza surveillance purpose and it is defined as a patient with measured fever (≥ 38 °C) and cough or sore throat (Appendix Table 1) [4].

South Korea has had an ILI sentinel surveillance system since 2001 to monitor the trends of influenza activity at the community level throughout South Korea and it is provided by the Korea Disease Control and Prevention Agency (KDCA) [4]. The ILI sentinel surveillance system is composed of a network of about 200 outpatient

* Correspondence to: Department of Preventive Medicine, College of Medicine, The Catholic University of Korea, R6117, Banpo-daero 222, Seocho-gu, Seoul, Republic of Korea.
E-mail address: gentryu@catholic.ac.kr (S. Ryu).
[1] These authors contributed equally to this work.

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clinics that use a web-based reporting system to report weekly numbers on the ILI patients and the overall number of outpatients visited in the same week (Appendix Figure 1). The sentinel sites are assigned based on the population at the province level and the weekly surveillance result reports are released on the KDCA website [5].

There have been concerns of the ILI surveillance data in regards the timeliness, reporting completeness, representativeness, and sensitivity [3], which are major components of sentinel surveillance systems that meet the objectives of infectious disease surveillance [6–9]. During the coronavirus 2019 (COVID-19) pandemic, very substantial surveillance resources were mobilized towards tracking severe acute respiratory syndrome-Coronavirus 2 (SARS-CoV-2) [10], a situation that may have changed the performance of routine longstanding ILI surveillance.

This study aimed to evaluate the ILI sentinel surveillance performance for the timeliness, report completeness, sensitivity of incidence trend, and representativeness in South Korea, and to determine whether there have been any systematic changes in these metrics during the COVID-19 pandemic.

2. Material and methods

We evaluated the ILI sentinel surveillance system using a structured framework based on the updated evaluation of public health surveillance system guidelines from the U.S. Centers for Disease Control and Prevention [9]. We assessed four surveillance system performances including timeliness, completeness, sensitivity, and representativeness, which have been identified in prior research on ILI surveillance data and have the potential impact on the data's use [3]. We collected the weekly number of ILI reports from the outpatient department in the sentinel sites between 1 January 2017 and 31 September 2023.

2.1. Timeliness

To assess the timeliness performance of the surveillance system, we measured the mean time lag for each year between the case reports from the physician at the sentinel sites to the KDCA, acquired from case-report records, and surveillance results released from the KDCA to the public, collected from the weekly sentinel surveillance reports [11] (Appendix Table 2 and Appendix Figure 2–3).

2.2. Completeness

For the performance of completeness, we measured the submission rate of complete reports per the overall number of reports from each sentinel site to the KDCA every year (Appendix Table 2).

2.3. Sensitivity

For the comparison with the nationwide data in the performance evaluation of the sensitivity, we collected the monthly number of patients with ILI who visited outpatient departments from the Korean Health Insurance Review and Assessment Service (KHIRA) (Appendix Table 1) [12]. We collected the monthly number of patients with ILI using the International Classification of Diseases, Clinical Modification, 10th Revision (ICD-10-CM: J10.1 and J11.1). As national health insurance is mandatory for all Korean populations, we assumed that the data represents the incidence trends of ILI at the community level [13,14]. To assess the sensitivity performance, we calculated the correlation coefficient between the monthly number of ILI notifications from the sentinel surveillance system and the number of patients with ILI from the KHIRA. We first performed a Shapiro-Wilk test to ascertain if the variables were normally distributed. We then performed either Pearson's or Spearman's test, where appropriate (Appendix Table 2).

2.4. Representativeness

For the representativeness performance of surveillance, we also used KHIRA data to examine the age-specific distribution of ILI and the geographic distribution of the sentinel sites. To assess the age-specific distribution, we compared the age-specific proportion of ILI from the sentinel data to that of the patients with ILI from the KHIRA. We used a chi-squared test to identify the statistical differences in the proportions among different age groups for each year. We also compared the geographical distribution of the sentinel sites with the Korean population distribution data [15] using a chi-square test (Appendix Table 2).

3. Results

This sentinel surveillance system in South Korea has been carried out through a network between 192 and 196 during 2017–2023 (Table 1). The weekly number of notifications from the sentinels increased from November to February or March peaking in January, 2017–2018 and 2019–2020. However, this seasonal pattern was not identified in 2020–2021 and 2021–2022 (Fig. 1).

Table 1
The number of sentinel sites, timeliness, report completeness, incidence trend sensitivity, and representativeness for the evaluation of the influenza-like-illness surveillance system in South Korea, 2017–2023.

Year	2017	2018	2019	2020	2021	2022	2023
Number of sentinel sites	192	194	199	198	197	197	196
Timeliness							
Meantime elapse from case notification to case report dissemination with standard deviation (unit: week)	1.8 ± 1.4	1.7 ± 1.6	1.2 ± 0.4	1.0 ± 0.1	1.0 ± 0.01	1.0 ± 0.1	1.0 ± 0.01
Completeness							
Submission rate of report†	97.0 %	97.8 %	98.4 %	98.4 %	98.2 %	98.4 %	98.4 %
Sensitivity							
Correlation coefficient with *P*-value‡	0.96 ($P < 0.01$)	1.00 ($P < 0.01$)	0.99 ($P < 0.01$)	0.73 ($P < 0.01$)	0.84 ($P < 0.01$)	0.97 ($P < 0.01$)	0.93 ($P < 0.01$)
Age-specific representativeness							
Chi-squared test (*P*-value)	0.38 ($P = 0.83$)	1.81 ($P = 0.40$)	1.64 ($P = 0.44$)	3.19 ($P = 0.20$)	5.42 ($P = 0.07$)	2.19 ($P = 0.33$)	1.87 ($P = 0.39$)
Geographic representativeness							
Chi-squared test (*P*-value)	4.88 ($P = 0.99$)	4.74 ($P = 0.99$)	5.23 ($P = 0.99$)	5.84 ($P = 0.99$)	8.26 ($P = 0.94$)	8.11 ($P = 0.95$)	7.81 ($P = 0.95$)

†Rate of report is defined as the observed number of reports in a year per the expected number of reports that year (i.e., 52 or 53 weeks).
‡Correlation coefficient: the coefficient between the number of monthly ILI case notifications from the KDCA and the monthly number of patients with ILI from the KHIRA was calculated by Pearson's or Spearman's test, where appropriate.

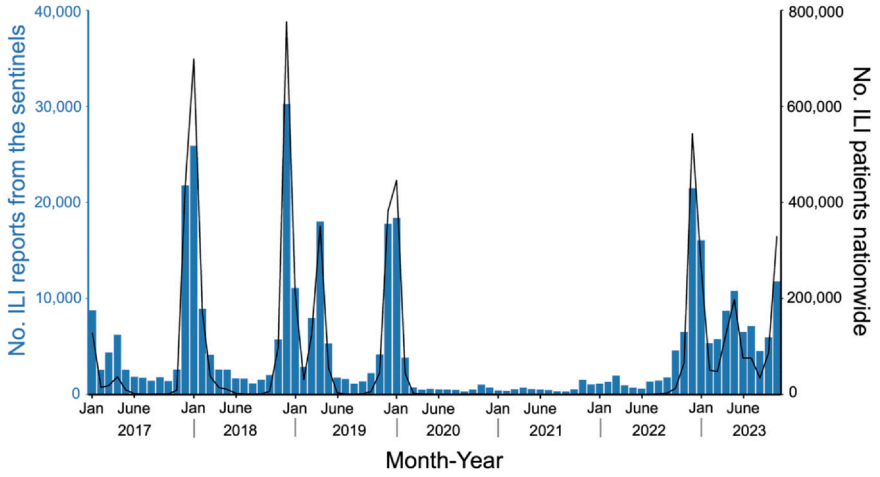

Fig. 1. Monthly number of notifications of influenza-like-illness (ILI) from the sentinel surveillance system and the monthly number of patients diagnosed with ILI from a nationwide reimbursement system in South Korea between 2017–2023. The blue vertical bar indicates the number of ILI notifications from the Korea Disease Control and Prevention Agency. The black solid line indicates the ILI cases diagnosed clinically at the outpatient department using the International Classification of Diseases, Clinical Modification 10th revision (ICD-10-CM, J10.1 and J11.1).

3.1. Timeliness

We found a 1.8-week (standard deviation [SD] of 1.4) mean time lag between the ILI report and surveillance results released in 2017. In 2020, the mean time lag decreased to 1 week (SD of 0.01), and in 2021–2022, it remained the same (Table 1) [16].

3.2. Completeness

For the submission rate of complete reports, we found it was 97 % in 2017. It increased to 98 % in 2019 and remained the same in 2020–2023 (Table 1).

3.3. Sensitivity

We found that the correlation coefficient between the case notifications from the ILI surveillance system from KDCA and the number of ILI patients from KHIRA was 0.96–0.99 in 2017–2019, 0.73 in 2020, 0.84 in 2021, and 0.93–0.97 in 2022–2023 (Table 1 and Appendix Table 3).

3.4. Representativeness

We found no statistical difference across the proportion of age groups of ILI case report from the ILI surveillance during the study period compared to that of the reimbursement data from KHIRA (all *P*-values > 0.05 in 2017–2023) (Table 1 and Table 2). Furthermore, we found no statistical difference in the geographical distribution of sentinel sites by the population distribution under the designated number of sentinels (all *P*-values > 0.94 in 2017–2023) (Appendix Table 4).

4. Discussions

Our results suggest that the surveillance performance of timeliness and completeness was stable during the study period, but the sensitivity was reduced during 2020–2021 and recovered in 2022.

4.1. Timeliness

Epidemics can be significantly reduced or delayed by rapidly detecting their onset and placing public health measures in action [1,17,18]. This in turn helps to minimize social and economic consequences [19]. Therefore, the evaluation of the timeliness of the surveillance system is important. The International Health Regulation recommends routine evaluation of the timeliness of disease surveillance (i.e., detect; assess and report; and respond) at the national level to assess the capacity for conducting surveillance activities in the country [20,21,16]. In the study, we focused on assessing the time lag between the case report and the surveillance result dissemination (i.e., assess and report). There was less than a two-week lag in the assessment during the study period because the ILI notification was conducted consistently through a web-based notification system from the sentinel site to KDCA. This time lag may be comparable with other countries as the ILI surveillance is voluntarily basis (i.e., no penalty for delayed notification).

4.2. Completeness

Many countries now have standardized web-based notification systems, which enhance the completeness and timeliness of the surveillance system. The web-based notification system, which tracks reporting at the sentinel sites and alerts the sentinels to fill in any missing fields on the notification form, is one of the primary operating components of the Korean ILI surveillance system. In this study, there were no missing data fields found in the reporting system during the surveillance system evaluation. Therefore, the data completeness was good during the study period. Previous studies reported the disruption of healthcare services provided by healthcare workers during the COVID-19 pandemic [22,23]. However, in the present study, we could not identify the impact of the COVID-19 pandemic on the report submission rate as the submission completeness was 97 %–98 % during the study period.

4.3. Sensitivity

In many countries, sentinel syndromic surveillance is the primary monitoring tool employed in seasonal influenza activity. However, ILI is not specific to influenza, and other respiratory infections that have similar symptom patterns may skew the temporal signal [2]. Therefore, in this study, we evaluated the syndromic surveillance of ILI with national health reimbursement data for ILI (i.e., ICD-10-CM for either influenza identified or unidentified) in terms of sensitivity of incidence and age-specific representativeness. This national health reimbursement data have been widely used as an another source of reference information to measure the incidence of diseases

Table 2
The age representativeness for the evaluation of the influenza-like illness surveillance system in South Korea, 2017–2023. Newly diagnosed patients with ILI and case notification of ILI data were collected from the Korea National Health Insurance and Review Agency (KHIRA) and the Korea Disease Control and Prevention Agency (KDCA), respectively. The units of age classification are 0–19, 20–64, and ≥ 65-year-old.

Year	2017	2018	2019	2020	2021	2022	2023
Reimbursed data from the KHIRA[†]							
0 – 19-year-olds	164,875	513,691	405,172	108,982	1,220	198,605	293,853
20 – 64-year-olds	87,699	398,421	199,055	116,044	2,243	94,671	154,978
> 64-year-olds	13,191	61,854	19,872	15,106	924	5,314	13,796
Overall no.	265,765	973,966	624,099	240,132	4,387	298,590	462,627
Proportion of 0 – 19-year-olds	62.0 %	52.7 %	64.9 %	45.4 %	27.8 %	66.5 %	63.5 %
Proportion of 20 – 64-year-olds	33.0 %	40.9 %	31.9 %	48.3 %	51.1 %	31.7 %	33.5 %
Proportion of ≥ 65-year-olds	5.0 %	6.4 %	3.2 %	6.3 %	21.1 %	1.8 %	3.0 %
Sentinel surveillance data from KDCA[‡]							
0 – 18-year-olds	19,368	55,238	54,895	16,080	3,539	27,306	47,665
19 – 64-year-olds	8,502	28,792	18,294	10,488	3,377	14,510	19,312
> 64-year-olds	1,436	4,845	2,794	2,295	1,179	2,769	4,338
Overall no. of ILI data	29,306	88,876	75,982	28,863	8,096	44,585	71,315
Proportion of 0 – 18-year-olds	66.1 %	62.2 %	72.2 %	55.7 %	43.7 %	61.2 %	66.8 %
Proportion of 19 – 64-year-olds	29.0 %	32.4 %	24.1 %	36.3 %	41.7 %	32.5 %	27.1 %
Proportion of ≥ 65-year-olds	4.9 %	5.5 %	3.7 %	8.0 %	14.6 %	6.2 %	6.1 %
Chi-squared test (*P*-value)	0.38	1.81	1.64	3.19	5.42	2.19	1.87
	(*P* = 0.83)	(*P* = 0.40)	(*P* = 0.44)	(*P* = 0.20)	(*P* = 0.07)	(*P* = 0.33)	(*P* = 0.39)

Note: [†]KHIRA: Korea National Health Insurance and Review Agency
[‡]KDCA: Korea Disease Control and Prevention Agency

[24], and the reimbursement data has been used to evaluate the sensitivity and representativeness of the surveillance system under the assumption that the data reflects well on the disease incidence at the community level [8,25,26]. In the study, we identified the temporarily reduced sensitivity in 2020–2021 and recovered to above 0.90 in 2022–2023. This was likely affected by the activity of other respiratory viruses as there was no seasonal influenza epidemic during this period [11,27]. Therefore, the temporarily reduced sensitivity performance of the surveillance is likely not caused by issues within the surveillance system, but rather by external factors (for example, the implementation of strict social distancing measures during the pandemic).

4.4. Representativeness

A relatively small number of outpatient departments across the country of Korea serve as the sentinel sites of the ILI surveillance system. To evaluate the representativeness, it was necessary to compare the demographic characteristics (i.e., age) of the notified number of ILI cases that were collected during the surveillance period to the total number of ILI cases [9]. Furthermore, the evaluation of the sentinel's geographical distribution with the regional population is required due to a shortage of public health resources. In the study, we identified the geographic distribution of the sentinels were well located in account for the number of populations at the region across the study period. In addition, by contrasting the age distribution of patients from the national reimbursement data, we were able to determine that the ILI surveillance system well-captured the age distribution of notified cases during the study period. We identified the changing pattern of age distribution during the early pandemic (i.e., temporarily reduced proportion of 0–18-year-olds in 2020–2021 compared to that of other years; Table 2). This is likely due to the strict public health and social measures including wearing face masks and mandatory ILI screening for school-aged children and kindergarteners against SARS-CoV-2 during the early pandemic [28].

Our study has some limitations. First, this study was primarily focused on evaluating the ILI syndromic sentinel surveillance and we did not include the laboratory surveillance of influenza in the study as it has been separately operated in the different report system [29]. Further research is required for the evaluation of Korea's overall influenza surveillance system, since the ILI data in conjunction with laboratory surveillance offers valuable insights into influenza virus activity in the country [29,30]. Furthermore, additional evaluation of hospital-based influenza surveillance system (i.e., surveillance of acute respiratory infection and sever acute respiratory infection) will provide more broad insights of overall influenza system evaluation in Korea [27,31]. Second, in our assessment of timeliness, we only considered a time lag between case notification and results dissemination. Additional studies of the time lag between the symptom onset of the case patient and consultation, and time lag between the consultation and notification to KDCA are recommended to identify the specific timeliness (Appendix Figure 2). Third, we used an alternative method using nationwide reimbursement data to evaluate sensitivity performance [8,13,32]. Previous studies demonstrated that reimbursement data could be used as a proxy of the nationwide trend of influenza infection as the patient codes of influenza with respiratory manifestations were highly correlated with the ILI trend [13,14]. Fourth, because of the nature of syndromic-based surveillance of ILI, surveillance data is not free from reporting bias. Fifth, we did not examine the other attributes of surveillance performance including simplicity, flexibility and acceptability for the case notification. Comprehensive survey for the persons in the sentinel sites is recommended to identify these attributes [9].

In conclusion, our findings suggest that the sensitivity performance of an ILI surveillance system was temporarily reduced during the early COVID-19 pandemic and recovered in 2022–2023. Continuous evaluation of the ILI surveillance system is needed to support timely and appropriate decision-making for public health authorities.

Ethical approval

Ethical approval was waived by the Institutional Review Board of the Catholic University of Korea College of Medicine (IRB No. MC24ZASI0052).

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Data Availability

The data that support the findings of this study are available from the corresponding author, SR, upon reasonable request.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.jiph.2024.102515.

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