Public Health 232 (2024) 114–120

Contents lists available at ScienceDirect

Public Health

journal homepage: www.elsevier.com/locate/puhe

Original Research

Implementation and evaluation of a SARI surveillance system in a tertiary hospital in Scotland in 2021/2022

J.M.M. Evans [a, *], J.J. Young [a], H. Mutch [a], A. Blunsum [b], J. Quinn [c], D.J. Lowe [c, d], A. Ho [b, e], K. Marsh [a], D. Mokogwu [a]

[a] Public Health Scotland, Glasgow, United Kingdom
[b] Department of Infectious Diseases, Queen Elizabeth University Hospital, Glasgow, United Kingdom
[c] Emergency Department, Queen Elizabeth University Hospital, Glasgow, United Kingdom
[d] School of Health and Wellbeing, University of Glasgow, Glasgow, United Kingdom
[e] Medical Research Council-University of Glasgow Centre for Virus Research, Glasgow, United Kingdom

ARTICLE INFO

Article history:
Received 15 January 2024
Received in revised form
9 April 2024
Accepted 10 April 2024

Keywords:
Hospital surveillance
Sentinel SARI
Symptoms
Evaluation
Scotland

ABSTRACT

Objective: To set up and evaluate a new surveillance system for severe acute respiratory infection (SARI) in Scotland.
Study design: Cross-sectional study and evaluation of surveillance system.
Methods: The SARI case definition comprised patients aged 16 years or over with an acute respiratory illness presentation requiring testing for influenza and SARS-CoV-2 and hospital admission. Data were collected from SARI cases by research nurses in one tertiary teaching hospital using a bespoke data collection tool from November 2021 to May 2022. Descriptive analyses of SARI cases were carried out. The following attributes of the surveillance system were evaluated according to Centers for Disease Control and Prevention (CDC) guidelines: stability, data quality, timeliness, positive predictive value, representativeness, simplicity, acceptability and flexibility.
Results: The final surveillance dataset comprised 1163 records, with cases peaking in ISO week 50 (week ending 19/12/2021). The system produced a stable stream of surveillance data, with the proportion of SARI records with sufficient information for effective surveillance increasing from 65.4% during the first month to 87.0% over time. Similarly, the proportion where data collection was completed promptly was low initially, but increased to 50%–65% during later periods.
Conclusion: SARI surveillance was successfully established in one hospital, but for a national system, additional sentinel hospital sites across Scotland, with flexibility to ensure consistently high data completeness and timeliness are needed. Data collection should be automated where possible, and demands on clinicians minimised. SARI surveillance should be embedded and resourced as part of a national respiratory surveillance strategy.

Introduction

The COVID-19 pandemic has highlighted the significance of respiratory surveillance systems at the population level, a recognition further supported by the World Health Organization (WHO).[1] Most European countries have well-established weekly near real-time surveillance systems for influenza-like illness (ILI) and/or acute respiratory infections (ARI) in primary care.[2,3] These systems have since been expanded to SARS-CoV-2.[4]

Ideally, primary care ARI systems are complemented by surveillance of severe acute respiratory infections (SARI) in secondary care.[5] SARI surveillance involves the identification of acute presentations of infectious respiratory symptoms, regardless of causative pathogen, that are so severe they require admission to hospital. This differs from pathogen-based surveillance as SARI cases are defined by WHO as the presentation of a clinical syndrome, regardless of causative pathogen; specifically: an acute respiratory infection with history of fever or measured fever of ≥38 C° and cough; with onset within the last 10 days.[6] The primary

* Corresponding author. Public Health Scotland, 2 Central Quay, Glasgow, G3 8BW, United Kingdom.
E-mail address: josie.evans@phs.scot (J.M.M. Evans).

https://doi.org/10.1016/j.puhe.2024.04.019

aims of SARI surveillance are to monitor trends in SARI and their impact on hospital admission and in-hospital mortality, to ensure early detection and response to unusual and unexpected events caused by common or emerging respiratory pathogens, and to assess the impact of public health interventions on respiratory infections. Secondary objectives are to identify risk factors for SARI and mortality, and to contribute to vaccine effectiveness monitoring.[7]

In response to the 2009 influenza pandemic, syndromic SARI surveillance based on active case finding was established in a number of settings, including in nine Eastern European countries,[8] and in sentinel hospital sites in China,[9] Belgium[10] and New Zealand.[11] Sentinel SARI surveillance in one sentinel hospital in Ireland was also established between July 2021 and April 2022.[12]

In 2021, Scotland established a passive system for severe acute respiratory infection (SARI) surveillance. This system uses routine healthcare data to serve as an indicator for the secondary care impact of emerging SARI outbreaks. It involves the use of national hospital admission datasets to identify patients admitted to hospitals, specifically those assigned ICD-10 diagnosis codes indicative of a syndromic SARI admission.[13] This is similar to an approach used within a private hospital network in Germany.[14] However, the specificity of the Scottish system (known as proxy-SARI) to capture true SARI admissions is relatively low, and validated data are not sufficiently timely for prompt public health response.

To overcome these limitations in the passive systems, a new SARI surveillance system was developed and piloted at a large regional University hospital (Queen Elizabeth University Hospital – QEUH) in the largest of 14 independent Health Boards in Scotland (NHS Greater Glasgow and Clyde – GGC) in November 2021. The aims of the system were to provide a more accurate and timely measure of SARI cases by person, place and time, as well as to characterise patient risks and outcomes. This artricle describes the implementation and evaluation of Scotland's new SARI surveillance system.

We describe the characteristics of patients included in the surveillance system, discuss the process and outputs, evaluate data quality and completeness, and consider the future for population-level active SARI surveillance in Scotland.

Methods

Study design and data source

The GGC SARI surveillance system was set up by Public Health Scotland (PHS) as one component of a wider research study, clinical characterisation of respiratory viral infections among patients with hospitalised severe acute respiratory illness using point-of-care multiplex asssays (CHARISMA).[15] CHARISMA is a prospective cohort study of adult patients who attended the Emergency department (ED), the Specialist assessment and treatment area (SATA) or the acute receiving units (ARU) within a tertiary teaching hospital (QEUH) in NHS Greater Glasgow and Clyde (NHSGGC). This hospital typically admits around 110,000 patients per year. Those with a SARI presentation were recruited and underwent a cobas® Liat® point-of-care multiplex real-time polymerase chain reaction (RT-PCR) test. This test detects influenza A/B and SARS-CoV-2 in 20 min from a single upper respiratory tract (URT) sample and this process was implemented specifically for the CHARISMA study.

A large dataset was collected on admissions of all SARI cases as part of the CHARISMA study. The SARI surveillance system was then operationalised by a specific surveillance dataset (an agreed subset of variables from the larger CHARISMA dataset) being securely provided to PHS weekly.

SARI case definition, inclusion, and exclusion criteria

The case definition used for the CHARISMA study was expanded from the WHO-SARI definition[6] and included any hospitalised patient aged over 16 years with clinical suspicion of severe acute respiratory illness who was therefore tested for influenza and SARS-CoV-2 within 24 h of emergency admission. Unlike the WHO criteria, there was no limit on time since symptom onset. All patients who fit the case definition were eligible for the CHARISMA study (although they were not necessarily all recruited during periods of high activity). Detailed inclusion and exclusion criteria are presented in Supplementary Table 1, alongside the WHO-SARI definition.

Sampling and data collection

SARI cases for the CHARISMA study were identified by the clinical team at triage or during the admission process, and augmented by any other eligible patients who had a point-of-care test but had not already been recruited. The aim was to identify all SARI cases, although this was not always achieved. Data were collected on admissions of SARI cases using a bespoke data collection tool, the Turas Clinical Assessment Tool (TCAT). The TCAT tool was designed to support clinical workflow when a SARI patient was identified, taking only a few minutes to complete.

Research nurses collected a large dataset for the CHARISMA study, but the SARI surveillance dataset contained only a subset* of the CHARISMA variables, specifically: demographic details of the patient*, SIMD deprivation category*, date of admission*, symptoms*, COVID-19 and influenza vaccination history*, presence of co-morbidities, drugs administered, laboratory results, radiology results and viral sequencing. Once the surveillance dataset was complete, the SARI record was marked as completed and submitted. However, complete data collection was not necessarily achieved during hospital admission, and there could be a time lag between a draft record being created, and the complete record being submitted.

Linkage and analysis

All records of SARI cases with complete surveillance data and a proportion of draft records (those with complete symptoms data) were used for weekly surveillance analyses and outputs. Any admissions to Intensive Care Unit/High Dependency Unit (ICU/HDU) within 7 days of hospital admission, or death within 30 days of hospital discharge, were identified by performing deterministic data linkage at PHS using the CHI number (a 10-digit number used to index health and mortality records in Scotland). Cases were also linked to vaccination records for COVID-19 to validate vaccination status. Periodic snapshots of the data within the TCAT tool were generated monthly to monitor data quality. A final SARI surveillance dataset was sent to PHS at the end of the surveillance period.

Evaluation

Eight attributes of a surveillance system were assessed at various timepoints and within the final SARI dataset. Attributes were described according to the US Centers for Disease Control and Prevention (CDC) guidelines for evaluation of surveillance systems.[16] Table 1 defines each of these attributes and how they were assessed.

Results

Total number of SARI cases

Overall, 1665 records of SARI admissions were identified during the study period. After removing 115 duplicates and 346 records

Table 1
Definitions of the attributes of a surveillance system and how they were assessed.

Attribute	Definition	How assessed
Stability	Reliability to operate without failure	Whether there were any breaks in SARI data submission over time
Data quality (completeness)	Completeness and validity of the data	Proportion of all SARI records that were useable for surveillance Comparison of numbers of SARI cases with those identified in the passive surveillance system[13] Variable-level: Proportion of cases with completed: Date of onset Ethnicity, and vaccination status for influenza, COVID-19 (variables with assigned null values)
Timeliness	Whether information is available in time for effective public health response	Proportion of all SARI records that were completed in the previous month Proportion of all SARI records used for surveillance outputs from the previous month (completed records or draft records with symptoms completed)
Positive predictive value (PPV)	Proportion of reported cases that have the health event of interest	PPV of records in Turas meeting SARI case definition PPV of SARI records used for surveillance meeting the WHO-SARI case definition (for the subset of cases that had a date of onset provided)
Representativeness	Whether cases accurately reflect distribution of cases over time, and by time/place	Assessment of demographic characteristics of SARI cases
Simplicity	How simple in structure and ease of operation	Qualitative work to evaluate the attitudes and perceptions of staff towards the process of taking part: 9 semi-structured interviews with emergency departments clinicians, with thematic analysis of the responses using the framework approach. This work has been reported elsewhere.[17]
Acceptability	Willingness of individuals and organisations to participate	
Flexibility	How adaptable to changing operational conditions	Assessment of timeliness and completeness over time

that did not meet the case definition, 1204 valid records remained (Supplementary Fig. 1). Of these, 1155 completed records and eight draft records with symptoms information (total 1163; 96.6%) were analysed. Those not analysed were draft records with no symptoms data available 1063 (91.4%) records were for patients resident in GGC Health Board, with the rest from other Health Boards in Scotland. Fig. 1 shows that the number of SARI admissions varied by week, with a peak in week 50 (week ending 19/12/2021).

Demographic characteristics of SARI cases

Overall, 647 (56%) of 1163 SARI cases were female. The mean and median age were 69 years and 72 years, respectively (range 16–99). The highest proportion of SARI cases (42% overall) were aged 75 years and older, followed by 25% in the 45–64 age group, 22% in the 65–74 age group and the remaining 11% in the 16–44 age group. Consistent with the underlying population demographics of the NHS Board, the majority (89%) of SARI cases were from white ethnic groups, with 60 (5%) in Asian, Asian Scottish or Asian British group ethnic groups and 4% unknown. Fewer than 10 healthcare workers and pregnant women were admitted to hospital for SARI during the study period. This demographic information is summarised in Table 2.

SARI cases by confirmed pathogen

There were 264 (23%) SARI patients who tested positive for SARS-CoV-2, 34 (2.9%) tested positive for influenza A (one co-infection with influenza B), and two influenza A and SARS-CoV-2 coinfections. Fig. 2 shows the weekly number of SARI cases stratified by confirmed pathogen. The proportion of SARI cases with confirmed SARS-CoV-2 increased between weeks 47 and 52, but was at a lower level thereafter.

SARI symptoms

The three most frequently reported symptoms among SARI patients were shortness of breath, reported by 80% (933/1163), cough reported by 67% (783/1163) and fever, reported by 37% (431/1163). This distribution was consistent throughout the surveillance period. The symptoms distribution among all SARI cases is presented in Supplementary Fig. 2.

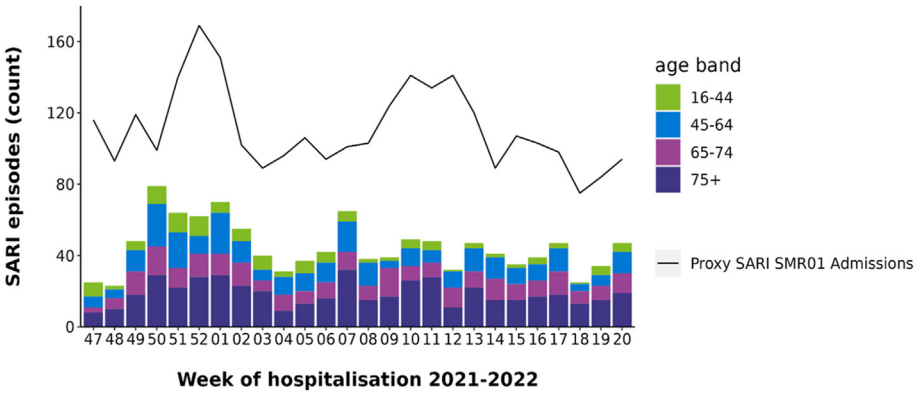

Fig. 1. The number of SARI hospital episodes recorded each week by age group with overall proxy-SARI trends.

Table 2
Demographic characteristics of SARI cases.

	Males N (% of total in age group)	Females N (% of total in age group)	Total N (% of overall total)
Age			
16–44 years	60 (46.2)	70 (53.8)	130 (11.2%)
45–64 years	126 (43.9)	161 (56.1)	287 (24.7%)
65–74 years	119 (46.3)	138 (53.7)	257 (22.1%)
75+ years	211 (43.1)	278 (56.9)	489 (42.0%)
Ethnic background			
White	451 (43.8)	579 (56.2)	1030 (88.6%)
Asian	33 (55.0)	27 (45.0)	60 (5.2%)
African	3 (100)	0	3 (0.3%)
Mixed or multiple ethnic groups	4 (44.4)	5 (55.6)	9 (0.8%)
Other/not known	25 (41.0)	36 (59.0)	61 (5.2%)
Total	516	647	1163

ICU/HDU admission and deaths of SARI cases

Of the 1163 SARI cases, 107 (9%) patients required admission to ICU/HDU, with 93 (87%) admitted to HDU. The median length of stay in ICU/HDU was 3 days. 35% (37/107) of the SARI patients admitted to ICU/HDU tested positive for SARS-CoV-2. 83 SARI patients died in hospital or within 30 days of hospital discharge.

Evaluation

Stability

The SARI surveillance system provided a stable stream of surveillance data, with potential SARI cases identified by clinicians and research nurses in real-time upon admission. There were no breaks in SARI data submission during the surveillance period.

Data quality (completeness)

During the surveillance period, the proportion of valid SARI records available for surveillance increased from 65.4% during the first month to 87.0% during the final period (Table 3). In the final analysis dataset, 96.6% of valid SARI records were available.

Although the aim was to identify all SARI cases, this was not always achieved. It was expected that the number of SARI cases actively identified for SARI surveillance would be lower than those identified using the passive proxy SARI surveillance system (known to over-estimate cases[13]) (Fig. 1.) However, it is notable that they do not closely follow the same trend. The peak between week 50 and week 01 is discernible, but not the peak in weeks 9–13.

There were 783 SARI cases (67.3%) where a date of symptom onset was provided. Completeness of ethnicity and vaccination data was very high (over 93% and over 96%, respectively).

Timeliness

As an indication of timeliness of data collection, the proportion of SARI records where data collection was complete was low during the first month, but increased to between 50% and 65% during later periods (Table 3).

Positive predictive value

After removing duplicates, there were 1204 records out of 1550 that met the SARI case definition. This gave a positive predictive value of 77.7%. It was also possible to determine whether a case fulfilled the WHO-SARI case definition for the 783 SARI cases with a date of symptom onset. Of these, 174 did so, giving a positive predictive value of 22%.

Representativeness

The SARI system was based in a large tertiary teaching hospital in one Health Board. While the majority of patients (91.4%) were resident in this one Health Board, there were a minority from elsewhere in Scotland. There were high proportions of older people with SARI which are in line with national trends.

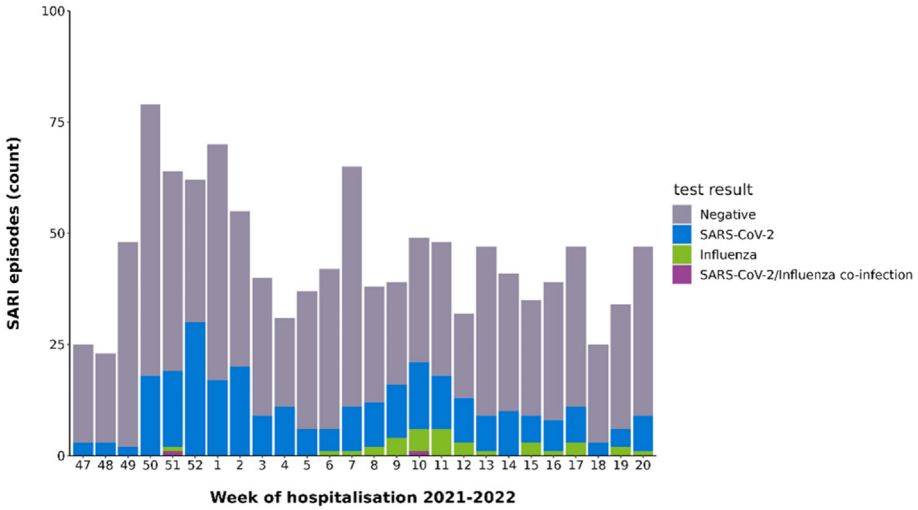

Fig. 2. The number of hospital episodes recorded each week with a pathogen confirmed.

Table 3
Selected indicators of data quality, completeness, and timeliness within periodic data snapshots.

Data collection period: (no. of valid records)	N (%) of valid records with complete data	N (%) of valid records in draft	N (%) of draft records with symptoms data	N (%) of valid records useable for surveillance[a]	% completeness of ethnicity variable	Completeness of COVID-19 vaccination variable	Completeness of 'influenza vaccination variable
1: 509 21 Nov–21 Jan	105 (20.6)	404 (79.4)	228 (56.4)	333 (65.4)	95.3	98.6	97.1
2: 647 22 Jan–18 Feb	328 (50.7)	319 (49.3)	217 (68.0)	545 (84.2)	95.5	99.4	98.0
3: 794 19 Feb–11 Mar	520 (65.5)	274 (34.5)	188 (68.7)	708 (89.1)	94.6	99.0	97.6
4: 1067 12 Mar–15 Apr	675 (63.2)	392 (36.8)	238 (60.7)	913 (85.6)	94.8	98.6	97.5
5: 1262 16 Apr–20 May	741 (58.7)	521 (41.2)	358 (68.7)	1099 (87.0)	93.7	98.3	96.2
[b]Final dataset: 1204	1155 (95.9)	49 (4.1)	8 (16.3)	1163 (96.6)	–	–	–

[a] Records useable for surveillance included all records with complete data, and draft records with complete symptoms data completed.
[b] Final dataset was subject to more stringent quality checks than records analysed during the surveillance period.

Simplicity, acceptability, and flexibility

Information on these attributes came from qualitative analysis that has been described in detail elsewhere,[17] and also informal feedback from clinicians. In terms of simplicity, there were some technological challenges such as ensuring all clinicians could access the TCAT data collection tool and that all staff were aware of, and able to use, the pre-defined SARI surveillance order set.

At this time clinicians were still required to complete written notes, so there was a duplication of effort which may have affected acceptability. This may also have been compromised by clinicians not recognising the value of the research, and by specific barriers to case ascertainment and data collection, particularly relating to workload.

Sufficient flexibility was not necessarily built into the system to cope with varying demands. SARI cases were recruited across multiple clinical areas including the Emergency Department, Medical Receiving Unit and SATA, all of which periodically experienced high volumes of attendance and long waits for admission. During these periods, high staff turnover posed further challenges in terms of raising and maintaining awareness of the need to recruit SARI patients.

Discussion

The pilot of this new SARI surveillance system established in the emergency department and acute receiving units of a large tertiary teaching hospital provided a stream of data for SARI surveillance in Scotland during the 2021/2022 respiratory season.

Although there were no breaks in SARI surveillance during the surveillance period, indicating a degree of stability in the system, there were challenges during periods of high activity in the wards, which may have affected timeliness of data collection and entry of required variables. This is exemplified by the low proportion of complete records available for surveillance (and high proportion of draft records) during the first data collection period. SARI cases recruited during this first 2 months coincided with the emergence of the Omicron BA.1/2 variant,[18] and timeliness improved after a surge in cases. In general though, symptoms data were not available in a timely enough fashion for effective surveillance, and many records had a 6–8 week time lag before moving from draft to completed state. Although the final dataset had high levels of completeness, this reflected a retrospective backfilling of data collection at the end of the surveillance period rather than actual availability during the reporting period.

It is not possible to assess the completeness of SARI case ascertainment over time without knowing the definitive number of SARI cases. There may have been incomplete ascertainment of cases early in the study (weeks 47 and 48), when clinicians were not yet fully informed and aware of the study, and also in weeks 9–13 during another peak in cases. This suggests that sufficient flexibility was not built in to cope with varying demand.

The strengths of our SARI surveillance system were the detailed data collected on each SARI case, and the ability to link to outcomes data, so that secondary objectives of SARI surveillance could be addressed. This was enabled by a multidisciplinary collaboration, having dedicated SARI research nurses located at the hospital site, guidance provided by the local health board, and governmental support and funding. Regular active recruitment of SARI patients was a key feature, in contrast to passive register-based surveillance where case definitions are more difficult to adhere to, although passive systems generally require fewer personnel and resources.[19] However, completeness and timeliness of data are essential for meeting the primary objectives of monitoring SARI trends and fulfilling an early warning function and this was not always achieved. Active surveillance systems need to be adequately resourced to enable this.

The resourcing of this SARI system was not entirely independent of routine clinical work and the wider CHARISMA research project, in that there was only a fixed number of dedicated research nurses on site, and they were called upon to assist with other clinical and research work at a time of huge external pressures and competing priorities. It was therefore not always possible for them to identify and collect complete data on all SARI patients. The CHARISMA study also required a much larger dataset of variables than needed for SARI surveillance. Restricting data collection only to variables essential for SARI surveillance would expedite data collection as would automation of data collection and linkage, where possible, such as vaccination status.

The potential of the system to respond to surges in demand for surveillance activity was limited, although it was difficult to assess the effect of this, in terms of numbers of SARI cases that were missed and the ability to accurately monitor trends. With an increase in the overall burden of disease in Scottish hospitals, and a 22% increase in admissions in 2021/2022 compared to 2020/2021,[20] there needs to be more flexibility built into any SARI surveillance system so that sufficiently timely and complete information can still be captured even as demands of busy hospital wards increase during peak activity. Even in China's centralised system, data collection was incomplete for 7% of SARI cases.[9] Given that the more detailed clinical data (e.g. symptoms data) can often give clues to the emergence of a new pathogen or variant, and can be key to the early warning function of a surveillance system, high

levels of completeness of these variables need to be achieved, with minimal demands on clinical staff.

It is notable that other SARI surveillance systems that have been successfully implemented have been very well resourced and supported, often with dedicated surveillance staff.[8,10–12] Although physicians were responsible for data collection in the sentinel hospitals in China, they were supported by infection control and CDC staff.[9] The Belgian system required only two sampled SARI cases from each unit per week,[10] although meeting the primary objectives of WHO surveillance would not be possible with this strategy. While there is no need to collect detailed surveillance data on every SARI case, and a sampling strategy reduces strain on limited resources, any strategy needs to be carefully designed to still enable monitoring of trends in actual numbers of SARI cases, which is one of the primary objectives of SARI surveillance.

The Scottish case definition was wider than the WHO-SARI case definition, which requires the presence of fever and cough within 10 days of onset,[6] even though these symptoms may be absent in up to one third of patients with influenza or COVID-19.[21,22] Although fever and cough were common symptoms in our sample, they were both present for only 22% of a subset of cases for whom date of onset was available. This proportion was even lower than the 53% reported in a SARI sentinel hospital in Ireland.[12] Notably, the dominant SARS-CoV-2 variant during the recruitment period was Omicron BA.1/2, and during this period COVID-19 cases were less likely to report fever and cough than during the Delta period.[23]

Shortness of breath was the most common symptom in our SARI cases, and this symptom could be considered for future SARI surveillance in Scotland (although clinical judgement would also be needed as many chronic conditions also present with shortness of breath). While it is important to align with international definitions to enable global comparisons of disease, case definitions must not be so specific that sensitivity is undermined and that important surveillance signals are missed.

Nearly one quarter of the patients had confirmed SARS-CoV-2 infection, but there was low circulation and detection of influenza at this time. Testing for other pathogens would increase the utility of the system.

Establishing a real-time SARI surveillance system to collect both timely and complete data in one hospital was challenging. To inform public health planning and messaging more effectively at national level and to ensure that SARI surveillance covers a representative population, SARI surveillance would need to be extended to other sentinel sites in Scotland. The surveillance system was operational for a relatively short time period during the 2021/2022 respiratory season, so lengthening the time frame for operation and evaluation would also be important. The challenges experienced around SARI case identification and data collection, especially during periods of high activity, highlight the need for flexibility in any national system. SARI surveillance also relies upon support from clinicians. Exploring how real-time SARI data could be used to support patient care, and ways to communicate this effectively to clinicians, might encourage clinician buy-in and facilitate smoother integration of SARI surveillance into hospital settings.

Conclusion

We successfully established SARI sentinel surveillance in one hospital in Scotland. In further scale-up to a national system encompassing multiple sentinel sites across Scotland, there will need to be flexibility built into the system to ensure high timeliness and completeness of the data, even during periods of high activity. Data collection should be automated where possible, and demands on clinicians minimised. Embedding and resourcing SARI surveillance as part of a national respiratory strategy would help to achieve this, and to ensure that primary and secondary objectives of SARI surveillance are met.

Author statements

Acknowledgements

The authors acknowledge many colleagues in Public Health Scotland who provided ongoing advice and support at all stages of the study, including but not limited to: Mirza Amir Beag, Dan McPhail, Fatima Sadiq, Angela Stockton, Nick Young. Acknowledgements are also due to NES who developed and managed the TURAS data collection tool.

Ethical approval

Ethical approval was obtained from the NHS Research Ethics Committee (reference 21/NS/0136). The study was carried out in accordance with the ethical principles outlined by Good Clinical Practice (GCP) and the Declaration of Helsinki in its most current version.

Funding

Public Health Scotland.

Competing interests

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhe.2024.04.019.

References

1. World Health Organization. *End-to-end integration of SARS-CoV-2 and influenza sentinel surveillance: revised interim guidance, 31 January 2022*. https://www.who.int/publications/i/item/WHO-2019-nCoV-Integrated_sentinel_surveillance-2022.1; 2022.
2. de Fougerolles TR, Damm O, Ansaldi F, Chironna M, Crepey P, de Lusignan S, et al. National influenza surveillance systems in five European countries: a qualitative comparative framework based on WHO guidance. *BMC Public Health* 2022;**22**:1151. https://doi.org/10.1186/s12889-022-13433-0.
3. Vega T, Lozano JE, Meerhoff T, Snacken R, Beauté J, Jorgensen P, et al. Influenza surveillance in Europe: comparing intensity levels calculated using the moving epidemic method. *Influenza Other Respir Viruses* 2015 Sep;**9**(5):234–46. https://doi.org/10.1111/irv.12330. PMID: 26031655; PMCID: PMC4548993.
4. Bagaria J, Jansen T, Marques DFP, Hooiveld M, McMenamin J, de Lusignan S, et al. Rapidly adapting primary care sentinel surveillance across seven countries in Europe for COVID-19 in the first half of 2020: strengths, challenges, and lessons learnt. *Euro Surveill* 2022;**27**:26.
5. European Centre for Disease Prevention and Control (ECDC). *COVID-19 surveillance guidance – transition from COVID-19 emergency surveillance to routine surveillance of respiratory pathogens*. https://www.ecdc.europa.eu/en/publications-data/covid-19-surveillance-guidance, 2021. [Accessed 12 April 2023].
6. World Health Organization. *WHO surveillance case definitions for ILI and SARI*. https://cdn.who.int/media/docs/default-source/influenza/who_ili_sari_case_definitions_2014.pdf?sfvrsn=d3890b31_7#:~:text=SARI%2520case%2520definition,days%253B%2520%25E2%2580%25A2%2520and%2520requires%2520hospitalization; 2014.
7. European Centre for Disease Control. Severe acute respiratory infections (SARI). *Report Protoc* 2023. https://www.ecdc.europa.eu/sites/default/files/documents/SARIsurv-Reporting-Protocol_381.pdf.
8. Meerhoff TJ, Simaku A, Ulqinaku D, Torosyan L, Gribkova N, Shimanovich V, et al. Surveillance for severe acute respiratory infections (SARI) in hospitals in the WHO European region – an exploratory analysis of risk factors for a severe outcome in influenza-positive SARI cases. *BMC Infect Dis* 2015;**1**.
9. Peng Z, Feng L, Carolyn GM, Wang K, Zhu G, Zhang Y, et al. Characterizing the epidemiology, virology, and clinical features of influenza in China's first severe acute respiratory infection sentinel surveillance system, February 2011 – October 2013. *BMC Infect Dis* 2015;**143**.

10. Subissi L, Bossuyt N, Reynders M, Gerard M, Dauby Nlacor P, et al. Spotlight influenza: extending influenza surveillance to detect non-influenza respiratory viruses of public health relevance: analysis of surveillance data, Belgium, 2015 to 2019. *Euro Surveill* 2021;**26**:38.
11. Huang QS, Baker M, McArthur C, Roberts S, Williamson D, Grant C, et al. Implementing hospital-based surveillance for severe acute respiratory infections caused by influenza and other respiratory pathogens in New Zealand. *West Pac Surveill Response J* 2014;**5**:23–30.
12. Brady M, Duffy R, Domegan L, Salmon A, Maharjan B, O'Broin C, et al. Establishing severe acute respiratory infection (SARI) surveillance in a sentinel hospital, Ireland, 2021 to 2022. *Euro Surveill* 2023;**28**:23.
13. Wells J, Young JJ, Harvey C, Mutch H, McPhail D, Young N, et al. Real-time surveillance of severe acute respiratory infections in Scottish hospitals: an electronic register-based approach, 2017-2022. *Publ Health* 2022;**213**:5–11.
14. Buda S, Tolksdorf K, Schuler E, Kuhlen R, Haas W. Establishing an ICD-10 code based SARI-surveillance in Germany – description of the system and first results from five recent influenza seasons. *BMC Public Health* 2017 Jun 30;**17**(1):612.
15. Emquire, 2023. https://emquire.care/project/charisma. [Accessed:12 April 2023].
16. CDC. *Updated guidelines for evaluating public health surveillance systems*. https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5013a1.htm; 2001.
17. Quinn J, Ho A, Lowe DJ. A qualitative study to evaluate the attitudes and perceptions of staff involved. In: *SARS-CoV-2 related research during the first wave of the SARS-CoV-2 epidemic*. EUSEM; 2023.
18. Chadeau-Hyam M, Tang D, Eeales O, Bodinier B, Wang H, Jonnerby J, et al. Omicron SARS-CoV-2 epidemic in England during February 2022: a series of cross-sectional surveys. *Lancet Reg Health Europe* 2022;**21**:100462.
19. Murray J, Cohen AL. Infectious disease surveillance. *Int Encycl Public Health* 2017:222–9.
20. Public Health Scotland. *Acute hospital activity and NHS beds information (annual)*. 2022. https://publichealthscotland.scot/media/15265/2022-09-27-annual-acuteactivity-summary.pdf. [Accessed 29 September 2023].
21. Monmany J, Rabella N, Margall N, Domingo P, Gich I, Vazquez G. Unmasking influenza virus infection in patients attended to in the emergency department. *Infection* 2004;**32**(2):89–97.
22. ISARIC Clinical Characterisation Group. COVID-19 symptoms at hospital admission vary with age and sex: results from the ISARIC prospective multinational observational study. *Infection* 2021;**49**(5):889–905.
23. Menni C, Valdes AM, Polidori L, Antonelli M, Penamakuri S, Nogal A, et al. Symptom prevalence, duration, and risk of hospital admission in individuals infected with SARS-CoV-2 during periods of omicron and delta variant dominance: a prospective observational study from the ZOE COVID Study. *Lancet* 2022;**399**:1618–24.