Public Health in Practice 1 (2020) 100014

Contents lists available at ScienceDirect

Public Health in Practice

journal homepage: www.journals.elsevier.com/public-health-in-practice

Original Research

Experience of establishing severe acute respiratory surveillance in the Netherlands: Evaluation and challenges

S.D. Marbus [a,*], W. van der Hoek [a], J.T. van Dissel [a,b], A.B. van Gageldonk-Lafeber [a]

[a] Centre for Infectious Disease Control, National Institute for Public Health and the Environment, Bilthoven, the Netherlands
[b] Department of Infectious Diseases and Internal Medicine, Leiden University Medical Center, Leiden, the Netherlands

ARTICLE INFO

Keywords:
Severe acute respiratory infections
Surveillance
Evaluation
Challenges

ABSTRACT

The 2009 influenza A (H1N1) pandemic prompted the World Health Organization (WHO) to recommend countries to establish a national severe acute respiratory infections (SARI) surveillance system for preparedness and emergency response. However, setting up or maintaining a robust SARI surveillance system has been challenging. Similar to other countries, surveillance data on hospitalisations for SARI in the Netherlands are still limited, in contrast to the robust surveillance data in primary care.

The objective of this narrative review is to provide an overview, evaluation, and challenges of already available surveillance systems or datasets in the Netherlands, which might be used for near real-time surveillance of severe respiratory infections.

Seven available surveillance systems or datasets in the Netherlands were reviewed. The evaluation criteria, including data quality, timeliness, representativeness, simplicity, flexibility, acceptability and stability were based on United States Centers for Disease Control and Prevention (CDC) and European Centre for Disease Prevention and Control (ECDC) guidelines for public health surveillance. We added sustainability as additional evaluation criterion.

The best evaluated surveillance system or dataset currently available for SARI surveillance is crude mortality monitoring, although it lacks specificity. In contrast to influenza-like illness (ILI) in primary care, there is currently no gold standard for SARI surveillance in the Netherlands.

Based on our experience with sentinel SARI surveillance, a fully or semi-automated, passive surveillance system seems most suited for a sustainable SARI surveillance system. An important future challenge remains integrating SARI surveillance into existing hospital programs in order to make surveillance data valuable for public health, as well as hospital quality of care management and individual patient care.

1. Introduction

Surveillance is a vital tool to monitor shifts in the occurrence and burden of infectious diseases in the population, which is necessary for prevention and control [1,2]. Most European countries have a well-established weekly near real-time surveillance system of influenza-like illness (ILI) and/or acute respiratory infections (ARI) in primary care, reported weekly in the bulletin Flu News Europe [3]. Arguably, influenza is the best organised infectious disease surveillance program that exists today. However, during the 2009 influenza A (H1N1) pandemic, it became apparent that countries had very limited historic and real-time data on hospitalised patients with severe respiratory infections, such as pneumonia as a complication of influenza. In response, the World Health Organization (WHO) recommended to establish national severe acute respiratory infection (SARI) surveillance systems to gain insight in the severity of epidemics and enable earlier detection of potential epidemics and pandemics [4–6]. According to the WHO, a severe acute respiratory infection is defined as an acute respiratory infection requiring hospitalisation with a history of fever (≥38 °C), cough, and onset within the last 10 days [7]. SARI surveillance data would be essential for guiding healthcare interventions, such as additional vaccination, and communication with healthcare professionals and the public [8].

Over the past decade, many countries have piloted some type of

* Corresponding author. Centre for Infectious Diseases Epidemiology and Surveillance, Centre for Infectious Disease Control (CIb), National Institute for Public Health and the Environment (RIVM), PO Box 1, 3720 BA, Bilthoven, the Netherlands.
E-mail address: Sierk.Marbus@rivm.nl (S.D. Marbus).

https://doi.org/10.1016/j.puhip.2020.100014
Received 6 December 2019; Received in revised form 2 May 2020; Accepted 12 May 2020
Available online 30 May 2020

severe respiratory infection surveillance, but only few countries have established a robust SARI surveillance system [9–11]. In Europe, these are mainly eastern European countries, while in western Europe, Germany [12] and Belgium maintain a syndromic sentinel SARI surveillance system, which is complemented with influenza testing in Belgium [13,14]. Since 2013, the United Kingdom (UK) publishes weekly national influenza reports, including incidence estimates of influenza-confirmed hospitalisations [15]. Other European countries merely report the absolute number of influenza positive patients admitted to general wards or intensive care units (ICUs), i.e. without any denominator data [16–18]. Insight in the spectrum of surveillance systems and datasets that could potentially be used for SARI surveillance is scarce. In addition, studies which focus on challenges and main lessons learned for establishing a robust SARI surveillance system are lacking.

In the Netherlands, several initiatives aim at setting up a severe infectious disease surveillance system [19,20]. Our objective is to provide an overview, evaluation, and challenges of the available surveillance systems or datasets in the Netherlands, which could potentially be used for near real-time surveillance of severe respiratory infections. Our lessons learned could be valuable to other countries aiming to establish a robust SARI surveillance system.

2. Available surveillance systems or datasets

2.1. Quality of care monitoring system in intensive care

To date, 90 adult ICUs report to National Intensive Care Evaluation (NICE), reaching 100% coverage in the Netherlands. The catchment population therefore represents the total Dutch population in 2018 (17.2 million inhabitants). The syndromic, aggregated data are only available retrospectively with a time lag of one to three months and without microbiological test results. All ICUs participating in the NICE registry have adopted the Acute Physiology and Chronic Health Evaluation IV (APACHE IV) model [21]. The APACHE IV scoring system contains codes for several respiratory syndromes that could potentially be used for SARI surveillance, such as pulmonary sepsis and pneumonia due to bacteria, viruses, fungi, parasites, and/or other causative agents [22,23].

2.2. National register of hospital discharge diagnoses

In the Netherlands, Dutch Hospital Data (DHD) maintains a national register consisting of discharge diagnoses of hospitalised patients in the Netherlands. Annually, 90 hospitals report to DHD, but their exact catchment populations are unknown. Reaching 90% coverage in 2014, this dataset is updated annually for participating hospitals with a one-year time lag [24,25]. International Classification of Diseases and Related Health Problems (ICD-9 & 10) registration are used for coding discharge diagnoses and are reported in DHD. Discharge diagnosis with ICD-10 codes, J00-J22, could be defined as a SARI case.

2.3. Mortality monitoring

Deaths are notified to municipalities and reported to Statistics Netherlands (CBS). During the 2009 influenza A (H1N1) pandemic, RIVM and CBS initiated a prospective, syndromic surveillance system, reporting aggregated all-cause mortality data weekly. Deaths from all causes are further stratified by age group and region. The presence of excess mortality (i.e. above a pre-defined threshold obtained from historical data) is verified weekly [26]. The catchment population comprises the total population in the Netherlands.

2.4. SARI sentinel surveillance

SARI sentinel surveillance is a prospective, case-based, surveillance system with lab-confirmed outcomes and currently only implemented in one Dutch hospital, Jeroen Bosch Hospital (JBH) (catchment population 323,000 persons). The SARI sentinel surveillance was part of a pilot study initiated in 2015 with the main objective to set up SARI surveillance in the Netherlands [19]. In this pilot study different strategies were tested to assess which hospital data were best suited for a sustainable real-time SARI surveillance system. In JBH, an active, case-based surveillance system was set up, with registration by medical staff of any patient fulfilling the SARI case definition. A SARI case is defined as a hospitalised patient with at least one systemic symptom or deterioration of general condition *and* at least one respiratory symptom *and* symptoms started within a week from admission.

2.5. Financial coding system

In Leiden University Medical Center (LUMC), SARI surveillance was embedded in an automated cluster detection system, which was operational since 2013 [27]. This passive, prospective, syndromic SARI surveillance system was based on financial claim codes corresponding to diagnoses related to the clinical syndrome SARI. These clinical syndromes include upper respiratory infections, lower respiratory infections and other respiratory infections The aggregated data were reported real-time by LUMC (catchment population 183,000 persons).

2.6. Ambulance dispatch calls data

Ambulance dispatch calls data could be used as syndromic data for an early warning system for respiratory infectious disease [28]. The Advanced Medical Priority Dispatch System (AMPDS) or Netherlands Triage Standard (NTS) are used to determine the medical urgency. Specific emergency signs, such as breathing difficulties, are protocolled in AMPDS and provided with specific triage codes. NTS further subdivides medical emergencies according to presenting symptom with a triage code. Retrospective ambulance dispatch calls data are analysed for potential use for a real-time, syndromic surveillance system of acute respiratory infections [51]. A SARI case is detected if the patient adheres to specific triage codes related to respiratory syndrome calls. The data are provided in aggregated format. Data of 4 dispatch centers using AMPDS are available to the RIVM, covering 4.2 million inhabitants in 2016 distributed over 5 provinces.

2.7. Virological laboratory surveillance

Currently, about 20 laboratories, with an unknown catchment population, report weekly the number of laboratory-confirmed, positive test results of various pathogens to the virological laboratory surveillance. No distinction can be made between specimens from primary- and hospital care and information on the diagnostic methods is absent. Aggregated data are reported without patient medical history and/or clinical data [29] and therefore a SARI case definition cannot be established. Positive test results are available for influenza virus, RSV, para-influenza (type 1–4), human metapneumovirus, coronavirus, rhinovirus, adenovirus, bocavirus, *Mycoplasma pneumoniae*, *Chlamydia pneumoniae*, *Chlamydia psittaci* and *Coxiella burnetii*.

Examples of each surveillance system or dataset are given in supplemental file, figure S1-7.

3. Evaluation surveillance system or dataset

Available infectious disease surveillance systems or datasets in the Netherlands were reviewed for evaluation as a potential SARI surveillance system. The 4 authors assessed the 7 surveillance systems or datasets by using 8 evaluation criteria.

3.1. Evaluation criteria

The selected evaluation criteria, based on United States Centers for Disease Control and Prevention (CDC) and European Centre for Disease

Prevention and Control (ECDC) guidelines for public health surveillance [30,31] are:

- data quality: the completeness and validity of the data recorded in the surveillance system, including the addition of microbiological diagnostics;
- timeliness: the speed between steps in a surveillance system, from event occurrence, recognition, report, to control and prevention activities;
- representativeness: the ability to accurately describe the occurrence of an event over time, place and person;
- simplicity: the system's structure and ease of operation;
- flexibility: the ability to adapt to changing information needs or technological operating conditions;
- acceptability: the willingness of persons and organisations to participate in the system;
- stability: the system's reliability (ability to collect, manage and provide data without failure) and availability (ability to be operational when needed);

We added one additional evaluation criterion:

- sustainability; the ongoing maintenance and support of a routine epidemiologic and/or microbiologic surveillance system;

3.2. Evaluation method

To asses each evaluation criterion, the 4 authors (2 infectious disease consultants, 1 medical doctor/epidemiologist, 1 senior epidemiologist) independently assigned the qualification 'good', 'moderate', or 'poor'. A semi-quantitative score for the surveillance system or dataset was obtained by attributing three points for each evaluation criterion rated "good", two points for each evaluation criterion rated "moderate" and one point to each evaluation criterion rated "poor". If the opinions of the 4 experts diverged, the assessment was re-evaluated in order to reach consensus. The total evaluation score was calculated as the sum of 8 evaluation criteria scores. Descriptive statistics were used for reporting the score per surveillance system or dataset, such as total number and the percentage of the maximum score.

3.3. Evaluation results

Crude mortality monitoring scored the best if comparing the 7 surveillance systems or datasets based on the evaluation criteria (Table 1). The SARI sentinel surveillance had the lowest score. In all surveillance systems or datasets data quality and sustainability was moderate to good. The largest contrast in evaluation scores (poor versus good scores) between surveillance systems or datasets were seen for timeliness.

3.4. Discussion

The best evaluated surveillance system or dataset currently available for SARI surveillance is crude mortality monitoring, although it is still not sufficient. This system is well-established in the EU region with weekly country reports on the EuroMOMO and on the RIVM website [26,32]. However, crude mortality surveillance reports only all-cause mortality and therefore lacks specificity for SARI. Within the EuroMOMO network, models are now being developed to attribute mortality to influenza [33]. Crude mortality monitoring is also providing crucial data in the COVID-19 pandemic, in addition to the reported deaths from laboratory-confirmed SARS-CoV-2 infection. If disease-specific mortality, such as respiratory mortality, could be reported, a more sensitive endpoint for SARI surveillance would be reached. However, it is not expected that cause-of-death statistics will become available near real-time in the foreseeable future.

In ICUs a large amount of patient data is collected for quality assurance. In the Netherlands, these data are available in the NICE database and selected variables could provide a robust, syndromic SARI surveillance system, if timeliness could be improved together with maintaining current coverage. An exploratory query indicated that reporting frequency could be improved to every six weeks. However, to be better optimised for a SARI surveillance system for preparedness and emergency control, timeliness has to be improved to at least a weekly reporting frequency. During the current COVID-19 pandemic NICE was quickly modified for COVID-19 monitoring with several updates per day.

The financial coding system comprised a passive, syndromic SARI surveillance system, which is evaluated as good for timeliness, simplicity and acceptability. Passive surveillance systems, such as fully automated cluster detection systems, are the preferred design for SARI surveillance, because they minimize administrative burden and increase sustainability.

National register of hospital discharge diagnoses with specific ICD-10 codes related to respiratory infections are available with a one-year time lag, which precludes its use for SARI surveillance . Efforts are underway to improve timeliness, which could make these data potentially valuable for SARI surveillance. In Germany, weekly SARI surveillance was established based on ICD-10 discharge codes from a large number of hospitals [12]. A relative drawback of DHD is the unknown denominator estimate of participating hospitals, which could be compensated by using the proportion of respiratory-related and total number of hospital admissions instead.

Ambulance dispatch calls data are available real-time, but contain a high background incidence of non-infectious causes of respiratory disease, and have high variability if attributed to ILI [34,51]. If representativeness could be improved, it could potentially complement other available respiratory infectious disease surveillance systems.

Ideally, severe respiratory infectious disease surveillance would consist of sentinel syndromic SARI surveillance with virological testing of

Table 1
Evaluation of available surveillance systems and datasets that could potentially be used for SARI surveillance in the Netherlands.

System or dataset	Data quality	Timeliness	Representativeness	Simplicity	Flexibility	Acceptability	Stability	*Sustainability*	*Score (% of maximum score)*[a]
Quality of care management system	Good	Poor	Moderate	Moderate	Good	Good	Good	Good	20 (83)
National register discharge diagnoses	Moderate	Poor	Moderate	Good	Moderate	Good	Moderate	Good	18 (75)
Mortality monitoring	Good	Good	Moderate	Good	Good	Good	Good	Good	23 (96)
SARI sentinel surveillance	Moderate	Good	Poor	Poor	Poor	Moderate	Poor	Moderate	13 (54)
Financial coding system	Moderate	Good	Poor	Good	Poor	Good	Moderate	Good	16 (67)
Ambulance dispatch calls data	Moderate	Good	Poor	Good	Good	Moderate	Poor	Poor	16 (67)
Virological laboratory surveillance	Good	Good	Poor	Moderate	Moderate	Good	Good	Good	20 (83)

[a] Score: per evaluation criterion the following scores were attributed: 3 points if rated "good", 2 points if rated "moderate", 1 point if rated "poor". The total evaluation score was expressed as the sum of all individual evaluation criteria and percentage of the total maximum score.

a subset of cases, comparable with ILI surveillance in primary care. Such sentinel SARI surveillance is still in a pilot phase in the Netherlands, contributing to poor current scores on simplicity, flexibility and stability. By extending to five or more, evenly geographically-distributed hospitals, a sentinel SARI surveillance system with relatively good coverage in the Netherlands could be achieved. Currently, Dutch sentinel SARI surveillance of patients, aged 65 years and older with influenza test results, also has international scientific value by sharing data with the European influenza monitoring vaccine effectiveness study (I-MOVE+) [35]. By pooling data from ten European countries, the seasonal influenza vaccine effectiveness against laboratory-confirmed SARI among elderly is calculated [36].

The virological laboratory surveillance, as it is available in the Netherlands and several other European countries, lacks linked-patient data, catchment population estimate, and distinction between primary- and secondary care, which makes it less suitable for use as SARI surveillance on its own. However, it could be of potential value in complementing another surveillance system or dataset, such as syndromic SARI sentinel surveillance. In comparison, Denmark has a national microbiology database available, with national legislation that allows for linkage with other patient data [37].

3.5. Limitations of the evaluation

Established public health surveillance systems may be more extensively evaluated based on other surveillance system attributes, such as level of usefulness, sensitivity, and positive predictive value [8]. We chose a limited amount of evaluation criteria which are applicable and available for the current surveillance systems and datasets that could potentially be used for SARI surveillance in the Netherlands. In addition, costs for developing a SARI surveillance system are not included in this evaluation. With limited public health funding in many countries, this might be a critical first obstacle in setting up SARI surveillance [8,47]. We have also not considered possible legal constraints for national public health agencies in obtaining data for surveillance. For example, because of the implementation of General Data Protection Regulation (GDPR) in the EU in 2018, DHD stopped providing case-based hospital discharge data to the RIVM and other organisations.

3.6. SARI surveillance in Europe

Based on literature, online reports, and personal communication, we made an overview of 15 available SARI surveillance systems in Europe (Supplemental material, Table S8). If recent data on a SARI surveillance system were unavailable, countries were not included in this overview. Available SARI surveillance systems in Europe show great diversity, ranging from syndromic SARI to laboratory-confirmed severe influenza surveillance in ICU. When comparing SARI surveillance between European countries various methodological challenges are encountered. Firstly, multiple different SARI case or severe influenza case definitions exist, with possibly different sensitivities and specificities. Secondly, the representativeness of the surveillance data between countries is different, because catchment population sizes vary substantially. Only two countries lacked catchment population estimates and reported absolute numbers. Thirdly, the number of pathogens under surveillance is diverse between countries, but influenza virus is reported the most. Fourthly, variation in threshold for hospitalisation may exist due to differences in healthcare systems between countries.

4. Current and future challenges

4.1. Microbiological diagnostics

Besides virological laboratory and SARI sentinel surveillance, all evaluated surveillance systems or datasets have in common that they lack diagnostic specificity. Adding microbiology diagnostics to syndromic surveillance improves both timeliness and completeness of a SARI surveillance system [8]. For identification of epidemics, causative pathogen detection is essential for implementing timely healthcare interventions [38]. Firstly, adding microbiological diagnostics to syndromic SARI surveillance is challenging, because SARI could be caused by multiple, different pathogens [9,39]. Influenza and *Streptococcus pneumoniae* were chosen for inclusion in our SARI sentinel surveillance system, because they are common causative pathogens of SARI with a high burden of disease [40,41]. Introduction of point-of-care tests and multiplex PCR in microbiology laboratories in the last decade, offers a great opportunity to expand the number of pathogens under surveillance in the future [42,43]. Secondly, another challenge when adding microbiological diagnostics is to decide which sampling strategy to implement. An option is to upscale baseline microbiological diagnostics, based on differential diagnosis, if an elevation of SARI incidence occurs above a predefined threshold. To facilitate a more systemic testing policy in SARI patients and minimize the amount of testing bias in the Netherlands, hospital or national guidelines would have to be improved. Currently, microbiological diagnostics often occur at the discretion of the treating physician and hospital or national guidelines regarding microbiological diagnostics are scarce. The Infectious Diseases Society of America/American Thoracic Society (IDSA/ATS) clinical guidelines state that testing for at least influenza should be considered in adult patients admitted with suspected respiratory infection during local epidemics [44]. However, there are no recommendations for respiratory virus testing, besides influenza virus, in SARI patients admitted to regular ward or ICU [44].

4.2. Sustainability of surveillance systems

Based on our experience and evaluation, improving sustainability is crucial for establishing a robust SARI surveillance system. In terms of sustainability, several challenges play an essential role. Firstly, the administrative burden associated with surveillance should be addressed. In a demanding hospital setting with increasing registration burden for hospital staff [45], our experience from SARI sentinel surveillance indicated that additional workload associated with surveillance should be decreased as much as possible. Thus, to improve timeliness, simplicity, and acceptability of a SARI surveillance system, we believe that implementation of a passive, fully or semi-automated, SARI surveillance system is required. This is underlined by high scores evaluations scores for mortality monitoring and virological laboratory surveillance, which are largely automated surveillance systems as well. Secondly, a different appreciation of the value of epidemiological surveillance data by data providers, such as clinicians, laboratories or hospitals, should be taken into account. We experienced that stakeholders withdrew their participation in SARI surveillance after a year, because of different appreciation of the value of epidemiological surveillance data. Therefore, we believe it is essential that a SARI surveillance system serves both a public health and a patient care goal [46]. This could be achieved by integrating SARI surveillance in existing hospital programs in order to make surveillance data valuable for public health as well as patient care [48]. SARI surveillance data could for example be utilised for monitoring antibiotic or antiviral use and resistance and lead to targeted antibiotic stewardship programs (ASP) interventions in patient care [49]. Embedding SARI surveillance in a quality of care program for SARI patients is a strategy that was pursued in our SARI sentinel surveillance [8,50]. Being part of routine quality care helped improve efficiency of our SARI sentinel surveillance system and increased the commitment of the participating hospital.

4.3. Future directions SARI surveillance in the Netherlands

Our aim is establishing a fully or semi-automated passive SARI surveillance system in the Netherlands based on financial codes. The advantages are the limited administrative burden and the data availability based on financial coding is (near) real-time. Based on our experience

with SARI sentinel surveillance, it is currently not possible to easily combine syndromic SARI data with microbiological diagnostics due to information communication technology (ICT) difficulties. Therefore, we aim to establish a separate laboratory surveillance system for influenza, RSV, *S. pneumoniae* and SARS-CoV-2, parallel to passive syndromic surveillance. In the long term, our goal is establishing an integrated, automated, passive SARI surveillance system with laboratory outcomes in sentinel hospitals evenly geographically distributed across the Netherlands.

5. Conclusion

Multiple surveillance systems or datasets are available in the Netherlands with potential use for SARI surveillance. In contrast to ILI in primary care, there is currently no gold standard for SARI surveillance in the Netherlands. Based on our experience from sentinel SARI surveillance, a potential sustainable SARI surveillance system for the long-term is a fully or semi-automated, passive surveillance system. In addition to increased timeliness, and simplicity of the surveillance system, the acceptability is improved by reducing unnecessary administrative burden of hospital staff. An important future challenge remains integrating SARI surveillance into existing hospital programs in order to make surveillance data valuable for both public health and patient care.

Financial support

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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.

Acknowledgements

Liselotte van Asten, Elisa Benincà and Susana Monge for sharing data for this manuscript. Sibylle Bernard-Stoecklin, Nicki Boddington, Nathalie Bossuyt, Silke Buda, Annasara Carnahan, Joan O Donnell, Ampara Larrauri, Jan Kynčl, Goranka Petrovic, Odette Popovici, Bozidarka Rakocevic, Daiva Razmuviene, Ana Rodrigues, Ragnhild Tønnessen and Ingrida Zurlyte for sharing information about their national SARI surveillance system.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhip.2020.100014.

References

[1] S.M. Teutsch, S.B. Thacker, Planning a public health surveillance system, Epidemiol. Bull. 16 (1995) 1–6.
[2] S. Declich, A.O. Carter, Public health surveillance: historical origins, methods and evaluation, Bull. World Health Organ. 72 (1994) 285–304.
[3] ECDC-WHO, Flu News Europe [June 13, 2018]; Available from, https://flunewseurope.org/, 2018.
[4] WHO, Global epidemiological surveillance standards for influenza [March 13, 2018]; Available from, https://www.who.int/influenza/resources/documents/influenza_surveillance_manual/en/, 2013.
[5] ECDC, Surveillance and Studies in a Pandemic: Fourth Meeting of the SSiaP Working Group, 2009 [March 13, 2018]; Available from, https://ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/0908_MER_Surveillance_and_Studies_in_a_Pandemic_Meeting_Report.pdf.
[6] C.C. van den Wijngaard, W. van Pelt, N.J. Nagelkerke, M. Kretzschmar, M.P. Koopmans, Evaluation of syndromic surveillance in The Netherlands: its added value and recommendations for implementation, Euro Surveill. 16 (2011) bulletin Europeen sur les maladies transmissibles = European communicable disease bulletin.
[7] WHO, WHO surveillance case definitions for ILI and SARI [March 13, 2018]; Available from, http://www.who.int/influenza/surveillance_monitoring/ili_sari_surveillance_case_definition/en/, 2014.
[8] L.M.T.S. Lee, S.B. Thacker, M.E. St Louis, Principles & Practice of Public Health Surveillance, Oxford University Press, New York, 2010.
[9] Q.S. Huang, M. Baker, C. McArthur, S. Roberts, D. Williamson, C. Grant, et al., Implementing hospital-based surveillance for severe acute respiratory infections caused by influenza and other respiratory pathogens in New Zealand. Western Pacific surveillance and response, J. : WPSAR 5 (2014) 23–30.
[10] T.J. Meerhoff, A. Simaku, D. Ulqinaku, L. Torosyan, N. Gribkova, V. Shimanovich, 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. 15 (2015) 1.
[11] Z. Peng, L. Feng, G.M. Carolyn, K. Wang, G. Zhu, Y. Zhang, 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. 15 (2015) 143.
[12] S. Buda, K. Tolksdorf, E. Schuler, R. Kuhlen, W. Haas, Establishing an ICD-10 code based SARI-surveillance in Germany - description of the system and first results from five recent influenza seasons, BMC Publ. Health 17 (2017) 612.
[13] Thomas I HA, van Gucht S, Weyckmans J, Bauwens D, el Kadaani K, Abady M, Fdillate I. Virological Surveillance of Influenza in Belgium: Season 2013-2014: Scientific Institute of Public Health2014.
[14] ISP-WIV, Sentinel Network of Hospitals, 2018 [June 13, 2018]; Available from, https://epidemio.wiv-isp.be/ID/Surveillance/Pages/SH.aspx.
[15] GovUK, Weekly National Flu Reports, 2018 [3-8-2018]; Available from, https://www.gov.uk/government/collections/weekly-national-flu-reports#2014-to-2015-season.
[16] C. Pelat, I. Bonmarin, M. Ruello, A. Fouillet, C. Caserio Schonemann, D. Levy-Bruhl, et al., Improving regional influenza surveillance through a combination of automated outbreak detection methods: the 2015/16 season in France, Euro Surveill. 22 (2017) bulletin Europeen sur les maladies transmissibles = European communicable disease bulletin.
[17] NHS, Weekly ICU/HDU Flu Collection (UK Severe Influenza Surveillance System), 2017 [June 13, 2018]; Available from, https://digital.nhs.uk/about-nhs-digital/corporate-information-and-documents/directions-and-data-provision-notices/secretary-of-state-directions/weekly-icu-hdu-flu-collection-uk-severe-influenza-surveillance-system-direction-2017.
[18] C. Pelat, I. Bonmarin, M. Ruello, A. Fouillet, C. Caserio Schonemann, D. Levy-Bruhl, et al., Improving regional influenza surveillance through a combination of automated outbreak detection methods: the 2015/16 season in France, Euro Surveill. 22 (2017) bulletin Europeen sur les maladies transmissibles = European communicable disease bulletin.
[19] S.D. Marbus, J.A. Oost, W. van der Hoek, A. Meijer, F.N. Polderman, C.P.C. de Jager, et al., Ernstige acute luchtweginfecties: de ontbrekende bouwsteen in de surveillancepiramide, Nederlands Tijdschrift Voor Med. Microbiol. 1 (2016) 52–56.
[20] A.C. Teirlink, L. van Asten, P.S. Brandsema, et al., Annual Report Surveillance of Influenza and Other Respiratory Infections in the Netherlands: Winter 2016/2017, 2017. Bilthoven.
[21] MSDManual, Critical Care Scoring Systems, 2017 [2-11-2018]; Available from, https://www.msdmanuals.com/professional/critical-care-medicine/approach-to-the-critically-ill-patient/critical-care-scoring-systems.
[22] L. van Asten, A. Luna Pinzon, D.W. de Lange, E. de Jonge, F. Dijkstra, S. Marbus, et al., Estimating severity of influenza epidemics from severe acute respiratory infections (SARI) in intensive care units, Crit. Care 22 (2018) 351.
[23] A. Koetsier, L. van Asten, F. Dijkstra, W. van der Hoek, B.E. Snijders, C.C. van den Wijngaard, et al., Do intensive care data on respiratory infections reflect influenza epidemics? PloS One 8 (2013), e83854.
[24] Dutch hospital data [April 18, 2019]; Available from, https://www.dhd.nl/Pagina s/home.aspx, 2019.
[25] E. Beninca, M. van Boven, T. Hagenaars, W. van der Hoek, Space-time analysis of pneumonia hospitalisations in The Netherlands, PloS One 12 (2017), e0180797.
[26] RIVM. Mortality Monitoring Netherlands, 2019 [April 18, 2019]; Available from, https://www.rivm.nl/monitoring-sterftecijfers-nederland.
[27] G.H. Groeneveld, A. Dalhuijsen, C. Kara-Zaitri, B. Hamilton, M.W. de Waal, J.T. van Dissel, et al., ICARES: a real-time automated detection tool for clusters of infectious diseases in The Netherlands, BMC Infect. Dis. 17 (2017) 201.
[28] L. Yilmaz, W.K.V. Chan, I. Moon, T.M.K. Roeder, C. Macal, M. Rossetti, A Simulation Model for Emergency Medical Services Call Centers, Winter Simulation Conference, 2015.
[29] RIVM, Virological Surveillance Data, 2018 [March 13, 2018]; Available from, http://www.rivm.nl/Onderwerpen/V/Virologische_weekstaten.
[30] CDC, Updated Guidelines for Evaluating Public Health Surveillance Systems, 2001 [March 13, 2018]; Available from, https://www.cdc.gov/mmwr/preview/mmwrhtml/rr5013a1.htm.
[31] ECDC, Data Quality Monitoring and Surveillance System Evaluation - A Handbook of Methods and Application, ECDC, Stockholm, 2014.
[32] EuroMOMO, Mortality Monitoring in Europe, 2018 [8-8-2018]; Available from, http://www.euromomo.eu/.
[33] J. Nielsen, T.G. Krause, K. Molbak, Influenza-associated Mortality Determined from All-Cause Mortality, Denmark 2010/11-2016/17: the FluMOMO Model. Influenza and Other Respiratory Viruses, 2018.
[34] Reukers DFM, van Asten L, Brandsema PS, et al. reportAnnual Report Surveillance of Influenza and Other Respiratory Infections in the Netherlands: Winter 2017/20182018.

[35] Epiconcept, I-MOVE+, 2018 [3-8-2018]; Available from, http://www.i-moveplus.eu/.
[36] M. Rondy, E. Kissling, H.D. Emborg, A. Gherasim, R. Pebody, R. Trebbien, et al., Interim 2017/18 influenza seasonal vaccine effectiveness: combined results from five European studies, Euro Surveill. 23 (2018) bulletin Europeen sur les maladies transmissibles = European communicable disease bulletin.
[37] M. Voldstedlund, M. Haarh, K. Molbak, R. MiBa Board of, The Danish microbiology database (MiBa) 2010 to 2013, Euro Surveill. 19 (2014) bulletin Europeen sur les maladies transmissibles = European communicable disease bulletin.
[38] R. Canton, Role of the microbiology laboratory in infectious disease surveillance, alert and response, Clin. microbiol. Infect. 11 (Suppl 1) (2005) 3–8, the official publication of the European Society of Clinical Microbiology and Infectious Diseases.
[39] T. Vega, J.E. Lozano, T. Meerhoff, R. Snacken, J. Beaute, P. Jorgensen, et al., Influenza surveillance in Europe: comparing intensity levels calculated using the moving epidemic method, Influenza Resp. Viruses 9 (2015) 234–246.
[40] M.W. Pletz, H. von Baum, M. van der Linden, G. Rohde, H. Schutte, N. Suttorp, et al., The burden of pneumococcal pneumonia - experience of the German competence network CAPNETZ, Pneumologie 66 (2012) 470–475.
[41] C.E. Luyt, T.W. Rice, Co-infection in severe influenza: a new epidemiology? Intensive Care Med. 43 (2017) 107–109.
[42] N.J. Gadsby, C.D. Russell, M.P. McHugh, H. Mark, A. Conway Morris, I.F. Laurenson, et al., Comprehensive molecular testing for respiratory pathogens in community-acquired pneumonia, Clin. Infect. Dis. 62 (2016) 817–823, an official publication of the Infectious Diseases Society of America.
[43] B. Visseaux, C. Burdet, G. Voiriot, F.X. Lescure, T. Chougar, O. Brugiere, et al., Prevalence of respiratory viruses among adults, by season, age, respiratory tract region and type of medical unit in Paris, France, from 2011 to 2016, PloS One 12 (2017), e0180888.
[44] F. van Someren Greve, D.S. Ong, O.L. Cremer, M.J. Bonten, L.D. Bos, M.D. de Jong, et al., Clinical practice of respiratory virus diagnostics in critically ill patients with a suspected pneumonia: a prospective observational study, J. Clin. Virol. 83 (2016) 37–42.
[45] A.J. Heuer, J.S. Parrott, D. Percival, R.M. Kacmarek, Examining the phenomenon of the administrative burden in health care, allied health, and respiratory care, J. Allied Health 45 (2016) 152–156.
[46] G.E. Smith, A.J. Elliot, I. Lake, O. Edeghere, R. Morbey, M. Catchpole, et al., Syndromic surveillance: two decades experience of sustainable systems - its people not just data!, Epidemiol. Infect. 147 (2019), e101.
[47] N. Mirza, T. Reynolds, M. Coletta, K. Suda, I. Soyiri, A. Markle, et al., Steps to a sustainable public health surveillance enterprise commentary from the international society for disease surveillance, Online J. Publ. Health Inform 5 (2013) 210.
[48] A. Moen, Challenges and Opportunities: Builiding Sustainable Surveillance Systems: WHO2018, 19-03-2018.
[49] C. Remschmidt, S. Schneider, E. Meyer, B. Schroeren-Boersch, P. Gastmeier, F. Schwab, Surveillance of antibiotic use and resistance in intensive care units (SARI), Dtsch Arztebl Int. 114 (2017) 858–865.
[50] J. Fabry, I. Morales, M.H. Metzger, I. Russell, P. Gastmeier, Quality of information: a European challenge, J. Hosp. Infect. 65 (Suppl 2) (2007) 155–158.
[51] S. Monge, J. Duijster, G.J. Kommer, J. van de Kassteele, G.A. Donker, T. Krafft, et al., Use of Ambulance Dispatch Calls for Surveillance of Severe Acute Respiratory Infections, Emerg Infect Dis 26 (2020) 148–150.