Evaluation of the diagnostic utility of case definitions to detect influenza virus infection in Vojvodina, Serbia

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SUMMARY
Introduction/Objective A case definition recommended by the World Health Organization is commonly used for influenza surveillance worldwide. The aim of this study was to evaluate prognostic values of proposed case definitions of Influenza Like Illness (ILI), Severe Acute Respiratory Illness (SARI) and Acute Respiratory Distress Syndrome (ARDS) for laboratory confirmed-influenza and to compare the age distribution of influenza patients across virus types and subtypes in Vojvodina.

Methods We conducted a descriptive epidemiological study using surveillance reports and laboratory data from October 1, 2010 to May 20, 2017 (seven surveillance seasons).

Results We included 2,937 participants, 48.6% of whom were laboratory-confirmed influenza cases, and most of the confirmed cases (30.1%) were detected in February. In the 15–29 years age group, the type A influenza (H3N2) was more frequent among patients with ILI (54.9% vs. 34.2%, p = 0.040), and less frequent in patients with SARI (39.4% vs. 65.8%, p = 0.009) compared with influenza type B. In patients aged 30–64 years with ARDS, influenza type B was more common than influenza type A (H3N2) (13.4% vs. 6.2%, p = 0.032), but less common in compared to influenza type A (H1N1) pdm09 (13.4% vs. 25.7%, p = 0.017). The SARI case definition of influenza was associated with an increased likelihood of laboratory-confirmed influenza for all age groups (p < 0.05). During the epidemic period, it was observed that the ILI case definition had the highest diagnostic value for influenza in the age group 5–14 (AUC = 0.733; 95% CI: 0.704–0.764), while the SARI and ARDS case definitions were the best predictors of influenza for patients 15–29 years of age (AUC = 0.565; 95% CI: 0.504–0.615 and AUC = 0.708; 95% CI: 0.489–0.708, respectively). The case definition of ARDS had the maximum sensitivity (100%) among patients 15–29 years of age.

Conclusion The proposed case definitions of influenza appeared to be good predictors of influenza and therefore can be useful for influenza surveillance, especially in the countries with limited laboratory capacities.

Keywords: influenza virus; epidemiology; virology; case definition; surveillance

INTRODUCTION
The aims of existing case definitions of influenza, proposed by the Centres for Disease Control and Prevention (CDC), the European Centre for Disease Prevention and Control (ECDC), and the World Health Organization (WHO) are for timely detection of the start and duration of the influenza season in order to monitor changes in the antigenicity of influenza viruses and provide guidelines for influenza vaccine policies. Early detection of circulating influenza strains in terms of clinical signs and symptoms is useful for clinicians in order to support the clinical decision and improve patients’ management. Due to the lack of specificity of influenza symptoms, co-infection and co-circulation of other respiratory viruses, improving the current case definitions of influenza remains a significant public health challenge [1]. The optimal case definition should be applicable every year, despite seasonal variations, in all medical settings (outpatient and inpatient medical facilities) [2].

Influenza is usually a self-limiting infection, but it can exacerbate underlying medical conditions (chronic diseases, weakened immune system), and present with primary influenza viral pneumonia or lead to secondary bacterial pneumonia, or can occur as part of a co-infection with other pathogens [3, 4, 5]. Although all humans can be affected by an influenza virus, clinical presentation of illness differs depending on the virus type-, subtype- and strain-specific properties as well as on the immunological and physiological characteristics of patient influenced by several factors such as age, chronic medical conditions, and pregnancy [6].

The main goal of this study was to analyze the utility of clinical case definition of Influenza Like Illness (ILI), Severe Acute Respiratory Illness (SARI) and Acute Respiratory Distress Syndrome (ARDS) to predict laboratory-confirmed influenza in outpatient and inpatient medical settings. Also, the comparison of the age distribution of virus types and subtypes for the seven influenza seasons was made.

METHODS
In Vojvodina – the northern region of Serbia with 1,931,809 inhabitants (26.9% of the total...
Serbian population according to the 2011 Census) the surveillance of influenza is coordinated by the Institute of Public Health (IPH) of Vojvodina. As described in detail previously, data for this observational surveillance study were obtained from the sentinel (outpatients) and hospital (patients hospitalized at secondary or tertiary health care level) surveillance of influenza in Vojvodina [7, 8]. Data have been collected from October 1, 2010 to May 20, 2017 (seven influenza seasons) and entered into the database maintained by the Centre for Disease Control and Prevention, IPH of Vojvodina. We included participants who fulfilled the criteria for clinical case definitions of ILI and SARI, and those who met the American European Consensus Conference criteria for ARDS [9, 10]. The study was done in accordance with standards of the institutional committee on ethics.

Depending on the health care levels (outpatient or in-patient settings) across Vojvodina where the patients comprised, general practitioners and pediatricians, as well as the specialists in internal medicine, infectious disease and respiratory disease interviewed the patients. Demographic, clinical, and physical examination data were obtained from patients suspected of having acute influenza through face-to-face structured interviews, using a structured questionnaire.

Virological surveillance of influenza was conducted during the whole study period, from calendar week 40 of each year to calendar week 20 of the next year. Nasal and throat swabs samples were tested in the WHO National Influenza Centre, at the Centre of Virology of the IPH of Vojvodina in Novi Sad [11]. A real-time reverse transcription polymerase chain reaction (real-time RT PCR) assays were used for the detection of influenza virus types A and B and influenza A virus subtypes A(H1N1)pdm09 and A(H3N2) [12].

### Statistical analysis

For categorical data, Fisher’s exact test or χ² test were used where appropriate. Both univariate and multivariate analyses were stratified according to three case definitions of influenza. Differences in age, between the participants with laboratory-confirmed influenza and those without laboratory confirmation, for the three clinical case definitions, were compared by odds ratio (OR) with 95% confidence intervals (95% CI). To control for possible confounding variables, the adjusted OR was calculated using logistic regression, including sex and calendar month of symptom onset. A surveillance period was divided into an epidemic period with high influenza activity (December, January, February, and March) and a period of low influenza activity (October, November, April, and May).

The diagnostic value of the case definitions (ILI, SARI, ARDS) during the epidemic period was measured using sensitivity, specificity, and area under curve (AUC) with 95% confidence intervals. The sensitivity was defined as the probability of having the case definition in a case of laboratory-confirmed influenza, while the specificity was defined as the probability of not having the case definition when the patient did not have laboratory-confirmed influenza infection. The AUC, as a global measure of algorithm performance for the identification of laboratory-confirmed influenza patients, takes both sensitivity and specificity into account.

Validation of proposed case definitions during the epidemic period was stratified by age group (0–4, 5–14, 15–29, 30–64, ≥ 65 years).

A p value below 0.05 was considered significant. Statistical analysis was done using the SPSS Statistics software Version 21.0 (IBM Corp., Armonk, NY, USA).

### RESULTS

During the study period, 2,937 specimens from patients with ILI, SARI, or ARDS, were tested for influenza, and 1,427 samples were identified as influenza type A or B positive (48.6%). Among study participants, 53.7% (1,576/2,937) were males. The median age of all cases was 43 years (IQR: 15–62 years), and decreasing to 37 years (IQR: 10–60 years) among laboratory-confirmed influenza.

Oberved by clinical diagnosis, the majority of participants had the SARI clinical diagnosis (56.7%; 1,665/2,937). Out of total number of participants, 2,477 (84.3%) cases were registered in the four-month period (from December to March), with the highest detection rate in February (30.1%; 429/1,427) (Table 1).

### Table 1. Influenza-positive and negative participants included in the study by sex, age distribution, case definitions, and months in Vojvodina, from 2010/2011 to 2016/2017 influenza seasons

| Variable                  | All participants (n = 2,937) | Influenza-positive (n = 1,427) | Influenza-negative (n = 1,510) |
|---------------------------|------------------------------|--------------------------------|--------------------------------|
| **Sex**                   |                              |                                |                                |
| Male                      | 1,576 (53.7)                 | 764 (53.5)                     | 812 (53.8)                     |
| Age group (years)         |                              |                                |                                |
| 0–4                       | 347 (11.8)                   | 173 (12.1)                     | 174 (11.5)                     |
| 5–14                      | 370 (12.6)                   | 262 (18.4)                     | 108 (7.2)                      |
| 15–29                     | 384 (13.1)                   | 176 (12.3)                     | 208 (13.8)                     |
| ≥ 65                      | 1,236 (42.1)                 | 529 (37.1)                     | 707 (46.8)                     |
| Mean age ± standard deviation | 39.7 (± 25.5)              | 37.4 (± 26.3)                  | 41.9 (± 24.6)                  |
| Median age (Q1–Q3 interquartile range) | 43 (15–62)         | 37 (10–60)                     | 46 (20–62)                     |
| **Case definition**       |                              |                                |                                |
| ILI                       | 956 (32.5)                   | 595 (41.7)                     | 361 (23.9)                     |
| SARI                      | 1,665 (56.7)                 | 719 (50.4)                     | 946 (62.6)                     |
| ARDS                      | 316 (10.8)                   | 113 (7.9)                      | 203 (13.5)                     |
| **Months of symptom onset** |                              |                                |                                |
| October                   | 73 (2.5)                     | 1 (0.1)                        | 72 (4.8)                       |
| November                  | 84 (2.9)                     | 1 (0.1)                        | 83 (5.5)                       |
| December                  | 415 (14.1)                   | 245 (17.1)                     | 170 (11.3)                     |
| January                   | 557 (19)                     | 243 (17)                       | 314 (20.8)                     |
| February                  | 787 (26.8)                   | 429 (30.1)                     | 358 (23.7)                     |
| March                     | 718 (24.4)                   | 379 (26.6)                     | 339 (22.4)                     |
| April                     | 276 (9.4)                    | 129 (9)                        | 147 (9.7)                      |
| May                       | 27 (0.9)                     | 0 (-)                          | 27 (1.8)                       |

ILI – influenza-like illness; SARI – severe acute respiratory illness; ARDS – acute respiratory distress syndrome
Comparing different influenza virus types and subtypes, there were few significant differences among groups of patients with distinct clinical case definitions of influenza stratified by age. In patients aged 15–29, influenza type A (H3N2) virus was more frequently registered among patients with ILI (54.9% vs. 34.2%, p = 0.040), and less frequently in patients with SARI (39.4% vs. 65.8%, p = 0.009) compared with influenza type B virus. Among patients aged 30–64 years with ARDS, an influenza B was more common than influenza A (H3N2) (13.4% vs. 6.2%, p = 0.032), but less common in comparison with an influenza A (H1N1) pdm09 (13.4% vs. 25.7%, p = 0.017). No significant differences were detected among patients with different clinical case definitions of influenza regarding the frequency of influenza virus types and subtypes in the remaining age groups (Table 2).

Univariate and multivariate logistic regression analyses were performed in order to identify predictor values of proposed clinical case definitions for the entire study period. When three clinical case definitions of influenza were classified and compared with the youngest age group (0–4 years), the SARI case definition of influenza was associated with the increasing probability of having influenza for all age group, while the ILI case definition was a useful diagnostic predictor of laboratory-confirmed influenza in patients aged 5–14 (p < 0.05). The influenza positive cases with ARDS were registered only among participants aged 15 and older, but the ARDS case definition had a poor diagnostic value for detecting influenza virus infection (p > 0.05) (Table 3).

When the performance of case definitions was tested only in the epidemic period, the ILI case definition had the highest accuracy in those aged 5–14 years (AUC = 0.733; 95% CI: 0.704–0.764); the SARI and ARDS case definitions had the highest AUC values among the 15–29-year-olds (AUC = 0.565; 95% CI: 0.504–0.615 and AUC = 0.708; 95% CI: 0.704–0.764); the SARI and ARDS case definitions had the highest accuracy in those aged 5–14 years (AUC = 0.733; 95% CI: 0.694–0.772). The ILI case definition showed a high sensitivity value (above 90%) for all age groups, with the highest sensitivity among the youngest age group (95.4%). The sensitivity values of SARI case definition ranged 81.3–95.2% between different age groups, with the highest sensitivity among the youngest age group (95.4%).

### Table 2. Case definitions of influenza patients according to age group and influenza virus type and subtype by age groups in Vojvodina, from 2010/2011 to 2016/2017 influenza seasons

| Age group (years) | Influenza type/subtype | ILI | SARI | ARDS |
|-------------------|------------------------|-----|------|------|
| 0–4 (n = 173)     | Bb n = 33; n (%)       | 27 (81.8) | 6 (18.2) | 0 (-) |
|                   | A' n = 140; n (%)      | 125 (89.3) | 15 (10.7) | 0 (-) |
|                   | A(H1N1) pdm09 n = 54; n (%) | 48 (88.9) | 6 (11.1) | 0 (-) |
| 5–14 (n = 262)    | A(H3N2) n = 80; n (%)  | 73 (91.3) | 7 (8.7) | 0 (-) |
|                   | Bb n = 95; n (%)       | 82 (86.3) | 13 (13.7) | 0 (-) |
|                   | A' n = 167; n (%)      | 148 (88.6) | 19 (11.4) | 0 (-) |
|                   | A(H1N1) pdm09 n = 57; n (%) | 52 (91.2) | 5 (8.8) | 0 (-) |
| 15–29 (n = 176)   | A(H3N2) n = 108; n (%) | 94 (87) | 14 (13) | 0 (-) |
|                   | Bb n = 38; n (%)       | 13 (34.2) | 25 (65.8) | 0 (-) |
|                   | A' n = 138; n (%)      | 57 (41.3) | 74 (53.6) | 7 (5.1) |
|                   | A(H1N1) pdm09 n = 65; n (%) | 18 (27.7) | 45 (69.2) | 2 (3.1) |
| 30–64 (n = 529)   | A(H3N2) n = 71; n (%)  | 39 (54.9)* | 28 (39.4)* | 4 (5.7) |
|                   | Bb n = 97; n (%)       | 21 (21.7) | 63 (64.9) | 13 (13.4) |
|                   | A' n = 452; n (%)      | 101 (22.3) | 269 (62.3) | 62 (14.3) |
|                   | A(H1N1) pdm09 n = 188; n (%) | 25 (13.7) | 111 (60.6) | 47 (25.7)* |
| ≥ 65 (n = 287)    | A(H3N2) n = 228; n (%) | 71 (31.1) | 143 (62.7) | 14 (6.2)* |
|                   | Bb n = 40; n (%)       | 2 (5) | 33 (82.5) | 5 (12.5) |
|                   | A' n = 247; n (%)      | 19 (7.7) | 202 (81.8) | 26 (10.5) |
|                   | A(H1N1) pdm09 n = 56; n (%) | 5 (8.9) | 43 (76.8) | 8 (14.3) |
|                   | A(H3N2) n = 176; n (%) | 13 (7.4) | 148 (84.1) | 15 (8.5) |

ILI – influenza-like illness; SARI – severe acute respiratory illness; ARDS – acute respiratory distress syndrome; * includes all influenza (A and B type) cases.

### DISCUSSION

To the best of our knowledge, this is the first study on the evaluation of influenza case definitions (ILI, SARI, and ARDS) conducted through the sentinel and hospital-based surveillance systems in our country. As the main advantage of our study, we conducted the most comprehensive effort to determine the accuracy of three clinical case definitions of influenza for the detection of laboratory-confirmed influenza virus infection during the seven post-pandemic seasons.

Several studies reported no difference in clinical symptoms between patients with influenza type A compared with influenza type B viruses [1, 6]. However, different age groups may be preferentially affected by influenza during any given season depending on the pool of viruses that are circulating, which may result in a different disease burden [6].

By comparing the frequencies of influenza types A and B virus infections, we found that influenza type B was more commonly detected than influenza type A (H3N2) in patients with SARI aged 15–29 years, and among those with ARDS aged 30–64 years. Further, we found that influenza type A (H3N2) was more frequently registered than
Table 3. Case definitions of influenza associated with laboratory-confirmed influenza, stratified by age group in Vojvodina, from 2010/2011 to 2016/2017 influenza seasons

| Age group (years) | ILI | SARI | ARDS |
|-------------------|-----|------|------|
|                   | Positive n = 595 | Negative n = 361 | OR (95% CI) | Positive n = 719 | Negative n = 946 | OR (95% CI) | Positive n = 113 | Negative n = 203 | OR (95% CI) | adj. OR* (95% CI) | Positive n = 113 | Negative n = 203 | OR (95% CI) \adj. OR* (95% CI) |
| 0–4               | 152 (25.5) | 230 (38.7) | 1.5b (1.2–2.1) | 1.5b (1.2–2.2) | 32 (4.4) | 28 (2.6) | 5.3b (2.6–10.8) | 5.8b (2.8–12) | 0 (-) | 0 (-) | NA | NA |
| S–14              | 70 (11.8) | 122 (20.5) | 0.5b (0.3–0.7) | 0.5b (0.3–0.7) | 99 (13.8) | 110 (11.6) | 3.9b (2.3–6.7) | 4.5b (2.6–7.8) | 7 (6.2) | 17 (8.4) | Reference | |
| 15–29             | 21 (3.5) | 21 (3.5) | 0.7 (0.3–1.4) | 0.7 (0.3–1.4) | 235 (32.7) | 241 (25.5) | 4.2b (2.5–7) | 4.3b (2.6–7.1) | 31 (27.4) | 56 (27.6) | 1.3 (0.5–3.6) | 1.2 (0.4–3.5) |

OR – odds ratio; CI – confidence interval; ILI – influenza-like illness; SARI – severe acute respiratory illness; ARDS – acute respiratory distress syndrome; SARI – severe acute respiratory illness; ARDS – acute respiratory distress syndrome; NA – not applicable; *adjusted for the following variables: sex and months of symptom onset (influenza epidemic period and low influenza activity); (p < 0.05)

Table 4. Sensitivity, specificity, and area under curve value of the case definitions tested for influenza confirmation during epidemic period, stratified by age group in Vojvodina, from 2010/2011 to 2016/2017 influenza seasons

| Age group (years) | Case definition | Se % (95% CI) | Sp % (95% CI) | AUC % (95% CI) |
|-------------------|-----------------|---------------|---------------|---------------|
| 0–4               | ILI (90.7–98.1) | 95.4 (90.7–98.1) | 65 (9.1–26.5) | 0.684 (0.644–0.716) |
| SARI (76.2–99.9)  | 95.2 (76.2–99.9) | 9.9 (4.6–18) | 0.259 (0.199–0.276) |
| ARDS NA NA NA     |                 |                |               |               |
| 5–14              | ILI (90.5–97) | 94.4 (90.5–97) | 13.6 (7–23) | 0.733 (0.704–0.764) |
| SARI (63.6–92.8)  | 81.3 (63.6–92.8) | 15.4 (4.4–34.9) | 0.517 (0.429–0.624) |
| ARDS NA NA NA     |                 |                |               |               |
| 15–29             | ILI (84.1–97.6) | 92.9 (84.1–97.6) | 12.4 (6.1–21.5) | 0.497 (0.443–0.537) |
| SARI (77.4–92.1)  | 85.9 (77.4–92.1) | 30 (21.6–39.5) | 0.565 (0.504–0.615) |
| ARDS (59–100)     | 100 (59–100) | 85.8 (63.6–94.6) | 14.9 (10.7–20.1) | 0.519 (0.487–0.548) |
| SARI (84.4–95.4)  | 91 (84.4–95.4) | 18.3 (11.4–27.1) | 0.575 (0.527–0.617) |
| ARDS (86.7–93.3)  | 90.4 (86.7–93.3) | 22 (18.3–26) | 0.500 (0.475–0.521) |
| 30–64             | ARDS (75.3–92.4) | 85.3 (75.3–92.4) | 43.2 (34.4–52.4) | 0.590 (0.526–0.638) |
| 65               | ILI (69.6–98.8) | 90.5 (69.6–98.8) | 6.3 (0.2–30.2) | 0.541 (0.489–0.628) |
| SARI (85.2–93.4)  | 89.8 (85.2–93.4) | 14.9 (10.7–20.1) | 0.519 (0.487–0.548) |
| ARDS (66.3–94.6)  | 83.9 (66.3–94.6) | 41.1 (28.1–55) | 0.563 (0.458–0.632) |
| All age groups    | ILI (91.3–95.4) | 93.6 (91.3–95.4) | 15 (11.4–19.1) | 0.639 (0.619–0.658) |
| SARI (86.8–91.5)  | 89.3 (86.8–91.5) | 19.8 (17.3–22.5) | 0.498 (0.480–0.514) |
| ARDS (78–91.7)    | 85.8 (78–91.7) | 43.4 (36.4–50.5) | 0.585 (0.537–0.623) |

ILI – influenza-like illness; SARI – severe acute respiratory illness; ARDS – acute respiratory distress syndrome; Se – sensitivity; Sp – specificity; AUC – area under curve; CI – confidence interval; NA – not applicable
shortness of breath). Our results showed higher AUC value of the WHO ILI case definition than those obtained by Casalegno et al. [1] (AUC = 0.639; 95% CI: 0.619–0.658 vs. AUC = 0.556; 95% CI: 0.547–0.566, respectively). The reason for that may be that Casalegno et al. [1] referred to the overall period, while we estimated the AUC value only for the epidemic period. However, after comparing the results only during influenza seasonal, i.e., epidemic period, higher sensitivity values were observed (93.6% vs. 88.9%), but still lower specificity values (15% vs. 21.3%) than in the cited study [1]. We believe that observed differences could be explained by the fact that the median age of all participants included in the French study was nine years, while the median age of our respondents was 43 years [1].

As it is known, the variety of other potential co-infecting pathogens among patients aged 0–4 years could be the reason for the lower performance of all case definitions in this age group [14, 15]. We found that the sensitivity value of ILI case definition for patients aged 0–4 months was above 95%, similar to the values of CDC ILI or ECDC ILI case definitions (93%) [1]. However, in line with previously published reports, we found a very low specificity of the proposed case definitions of ILI, which indicates that individuals without influenza infection are likely to be misclassified as false positive patients [1, 16].

Further, it was observed that the SARI case definition in patients from the youngest age group had the sensitivity above 95%, and specificity about 10%. Results of the study done by Peng et al. [17], who analyzed data from SARI cases in China (from 2011 to 2013), suggested the association of laboratory-confirmed influenza with increasing age of patients. Interestingly, the prevalence of laboratory-confirmed influenza among patients with SARI aged 0–4 years was only 5.2% (101/1,944), whereas the prevalence of influenza cases with SARI in the same age group in our research was 18.8% (21/112). Because two different case definitions were tested, those findings were not surprising. A similar study among hospitalized patients in India showed that sensitivity and specificity in patients with SARI were 28% and 84%, respectively [18]. Our results show that the sensitivity and specificity for all patients with SARI were 89.3% and 19.8%. Observed differences can only be interpreted as a result of the implementation of different case definitions used in two studies. For improving the specificity of SARI case definition among our patients younger than five years, it can be useful to implement a more specific case definition, similar to the research cited above [17].

The importance of the sensitivity and specificity of case definitions varies according to which of the goals have the highest priorities [1, 16, 18].

Our results show that the applied case definitions of influenza provide a high sensitivity, which supports the goal of early diagnosis and treatment and timely identification of influenza outbreaks. However, if the goal is to increase efficiency in obtaining influenza virus-positive specimens and identify circulating influenza strains while minimizing unnecessary testing, then it is needed to improve the specificity of the proposed case definitions [19, 20, 21].

**CONCLUSION**

The proposed case definitions of influenza appeared to be good predictors for laboratory-confirmed influenza, and therefore can be useful for continuous surveillance in order to predict seasonal trends and prepare for a timely response to the influenza outbreak, particularly for the purpose of surveillance in resource-poor laboratory settings.

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Процената дијагностичке вредности дефиниција случаја у откривању инфекција изазваних вирусом грипа у Војводини, Србија

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САЖЕТАК
Увод/Циљ. У надзору над грипом, у свету се обично користи дефиниција случаја препоручена од стране Светске здравствене организације. Циљ рада био је да се процени прогностички значај предложене организације.

Методе. Спроведена је дескриптивна епидемиолошка студија узраста од 30 до 64 године са дијагнозом АРДС, вирус инфлуенце типаБ је био чешће регистровао него многобројна друге вирусне инфекције у свим добним групама (p < 0,05). Посматрано током епидемијског периода, дефиниција ОСГ је имала највишу сензитивност (100%) и специфичност (100%), док су дефиниције ОСГ (p = 0,017) и ТАРБ позитивно корелисана са добињењем лабораторијских потврђених случајева вируса инфлуенце у свим добним групама (p < 0,05).

Закључак. Предложене дефиниције случаја грипних болести могу бити корисне у надзору над грипом, посебно у земљама са ограниченим лабораторијским капацитетима.

Кључне речи: вирус инфлуенце; епидемиологија; вирусологија; дефиниција случаја; надзор