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EVALUATION OF THE COMPLETENESS AND TIMELINESS OF THE INFANT PERTUSSIS SURVEILLANCE SYSTEM IN THE CZECH REPUBLIC IN 2015, 2017 AND 2019

VREDNOTENJE POPOLNOSTI IN PRAVOČASNOSTI SISTEMA ZA SPREMLJANJE OSLOVSKEGA KAŠLJA PRI DOJENČKIH NA ČEŠKEM V LETIH 2015, 2017 IN 2019

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ABSTRACT

Introduction: The completeness and timeliness of the pertussis questionnaire-based enhanced surveillance system (ESS) among infants and reported pertussis data within the electronic nationwide notification system (NNS) in the years 2015, 2017 and 2019 were evaluated in a pilot study.

Methods: The completeness of the variables for demographic characteristics, date of symptom onset, hospitalisation and vaccination status were assessed in both systems. Timeliness of reporting in the NNS was analysed as the interval between symptom onset and a) the date of first specimen collection (diagnostic delay), and b) the date of the Regional Public Health Authority receiving notification (notification delay).

Results: A total of 121 confirmed pertussis cases were reported to the NNS in the study years, while in the ESS a total of 104 confirmed cases were reported in infants. In both systems most cases were in the age group of one completed month of life (20% versus 23%) and males (55% versus 55%). The majority of cases were hospitalised (81% versus 85%) and unvaccinated (77% versus 78%). Within the NNS, the first dose of vaccine was reported in 13 cases, the second dose in 11, and third dose in three cases. Within the NNS, 100% completeness of following variables was found: symptom onset, week and region of reporting, age, gender and place of isolation. Median diagnostic delay was nine days. Median notification delay was 18 days.

Conclusions: Data completeness was high in the NNS, except for lack of vaccination data in those eligible by age. Efforts to improve the completeness of laboratory-related variables and timeliness are essential. Based on the study results, the project of improving the ESS for infants will continue with regular evaluation.

Keywords:
Whooping cough
Pertussis
Surveillance
Infants
Completeness
Timeliness

IZVLEČEK

Uvod: *V pilotni študiji sta bili ovrednoteni popolnost in pravočasnost izboljšanega sistema za spremljanje (ESS) oslovskega kašlja pri dojenčkih, ki temelji na vprašalnikih, ter podatkov o oslovskem kašlju, vnesenih v elektronski sistem obveščanja na državni ravni (NNS), v letih 2015, 2017 in 2019.*

Metode: *Pri obeh sistemih je bila ocenjena popolnost spremenljivk za demografske značilnosti, datum pojava simptomov ter hospitalizacijo in stanje cepljenja. Pravočasnost poročanja v sistem NNS je bila analizirana kot interval med pojavom simptomov in a) datumom prvega odvzema vzorcev (diagnostična zamuda); b) datumom, ko je regionalni organ za javno zdravje prejel informacije (zamuda pri obveščanju).*

Rezultati: *V obravnavanih letih je bilo v sistem NNS vnesenih 121 potrjenih primerov oslovskega kašlja, v sistemu ESS pa 104 potrjenih primerov pri dojenčkih. V obeh sistemih: večina primerov je bila v starostni skupini dopolnjenega 1 meseca (20 % v primerjavi s 23 %) in moškega spola (55 % v primerjavi 55 %). Večina primerov je bila hospitaliziranih (81 % v primerjavi s 85 %) in necepljenih (77 % v primerjavi z 78 %). V sistemu NNS je bila prva doza cepiva vnesena pri 13 primerih, druga doza pri 11 primerih in tretja doza pri 3 primerih. V sistemu NSN je bila ugotovljena 100-odstotna popolnost naslednjih spremenljivk: pojav simptomov, teden in regija poročanja, starost, spol in mesto izolacije. Povprečna diagnostična zamuda je bila 9 dni. Povprečna zamuda pri obveščanju je bila 18 dni.*

Zaključki: *Popolnost podatkov v sistemu NNS je bila na visoki ravni, razen pomanjkanja podatkov o cepljenju za primerne starosti. Treba si je prizadevati za izboljšanje popolnosti spremenljivk, povezanih z laboratoriji, in pravočasnosti. Na podlagi rezultatov študije se bo projekt izboljšanega sistema ESS pri dojenčkih nadaljeval z rednimi vrednotenji.*

Ključne besede:
oslovski kašelj
pertusis
spremljanje
dojenčki
popolnost
pravočasnost

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1 INTRODUCTION

Pertussis continues to be an important public health issue despite high levels of vaccination coverage with acellular pertussis vaccine. Young unimmunised infants represent the most vulnerable group with the highest rates of complications and death (1).

Since 1993 there has been a steadily increasing incidence of pertussis among infants (children under one year of age) in the Czech Republic (CZ) (2). Annual pertussis reports also demonstrate increasing incidence in the whole population, including infants (3). Between the 1st January 2015 and 31st December 2019, a total 3,978 pertussis cases were reported to the nationwide notification system (NNS) in CZ, including 199 infants (3). The proportion of infants among all reported pertussis cases from 2015 to 2019 in the NNS ranged from 3% in 2017, 4% in 2016, 5% in 2015 and in 2019, to 7% in 2018 (3).The upward trend in pertussis in CZ in the general population is also reflected in the increased number of cases in infants, including hospital admissions and pertussis-related complications (4). The annual incidence of pertussis in infants in CZ in the years 2015 to 2019 reported in NNS was 26.3, 23.5, 19.4, 42.9 and 64.6 per 100,000 inhabitants, respectively. A similar situation has also been reported in other countries, and in 2018 infants aged under one year of age were the age group with the highest reported incidence rates of pertussis (44.4 cases per 100,000 inhabitants) in the majority of Member States of the European Union/European Economic Area (EU/EEA) (5).

Pertussis is a mandatorily reported disease in CZ. The current pertussis surveillance system is comprehensive, nationwide, case-based and harmonised with the EU requirements (6). The public health system in CZ is based on 14 Regional Public Health Authorities (RPHAs) with 81 local branches and the National Institute of Public Health (NIPH). General practitioners (GPs) and physicians from hospitals report pertussis cases to the RPHAs, which collect information about such cases regardless of age and upload the related data to the NNS, with a new version of the NNS replacing the previous system on 1st January 2018. The NIPH validates the case-based data and exports it to the European Surveillance System (TESSy) on monthly basis, and provides annual analysis to the World Health Organization and to the Ministry of Health of CZ.

Due to the increased number of pertussis cases among infants, a questionnaire-based enhanced surveillance system (ESS) for laboratory confirmed pertussis cases among infants was introduced in CZ from 1st January 2015 including specific variables. Laboratories belong to health-care facilities and are obliged to report positive findings of pathogens to physicians and RPHAs. The ESS keeps track of active cases with the completion of a follow-up questionnaire of all infants with laboratory confirmed *B. pertussis* infection. Additional information is gathered on risk and protective factors for the acquisition of pertussis. RPHA personnel who have interviewed parents (usually the mother or other legal representative of the infant) by phone complete the ESS questionnaire (see additional file). The completed questionnaires are then sent to a contact person in the NIPH (in MS Excel, Word or PDF format) by email or in a hard copy (by post). Most of the ESS variables have been evaluated in another project (7).

Vaccination against pertussis has been part of the mandatory childhood vaccination programme in CZ since December 1958. Nowadays, a total of five doses of acellular pertussis vaccine are administered at the ages of three, five and 11 to 13 months, with booster doses given at the age of five to six years and at the age of 10 to11 years (8). Since 2015, the National Immunization Committee has recommended pertussis immunisation in pregnancy (4).

Administrative control of vaccination coverage in CZ by 31st December 2019 for hexavaccine (diphtheria-tetanus-acellular pertussis-inactivated poliovirus and *Haemophilus influenzae type b* vaccine and hepatitis B) in children born in 2017 and vaccinated following the 2+1 and 3+1 schedule showed that vaccination coverage was 96%. In the regions the value of total vaccination coverage ranged from 93% to 99%, while in the districts it ranged from 85% to 100%. In the 2018 birth cohort, 94% of infants were vaccinated with three doses of hexavaccine, and vaccination coverage in regions was found to be in the range of 83% to 100% (9).

The purpose of this project was to describe and assess the completeness and timeliness of laboratory confirmed pertussis using the ESS and NNS data, and to make recommendations for improvement based on the results. As there is a lack of infant-specific pertussis epidemiologic data in CZ, a pilot study was designed to address this gap in the knowledge.

2 METHODS

2.1 Case definition

A case was defined as any person meeting the clinical and laboratory criteria of a confirmed pertussis case using the EU definition (2008). Data reported to the NNS under the code ”A37.0” of the 10th revision of the International Classification of Diseases by reporting week was analysed. The study population included confirmed pertussis cases among infants reported in CZ between 1st January and 31st December in 2015, 2017 and 2019, in both systems, the NNS and/or ESS.

Data for the analysis was extracted from the ESS and NNS. Records were matched via a unique personal identifier (UPIN). The analysis was restricted to infant cases with completed questionnaires, as obtained from the ESS.

2.2. Data collection and cleaning

Data collection and transmission were done based on individual, case-based data. The information available from the NNS was the demographic characteristics (UPIN, date of birth, age, gender), date of symptom onset, vaccination status in infants (if vaccinated, number of doses), date of hospital admission, place of isolation, type of laboratory test, date of first specimen collection and date of first reporting of the case in the NNS, reporting week, and reporting region.

The information retrieved from the ESS was the date of birth, gender, date of symptoms onset, reporting region, vaccination status, date of hospital admission and date of hospital discharge, and place of isolation.

2.3 Data analysis

We conducted a validation study of both systems (ESS and NNS). Records from the NNS were compared individually with the questionnaire data (including a detailed investigation in the family). The NNS did not contain data that was included within the ESS. The ESS data was available in a separate file outside of the NNS.

2.3.1 Completeness

Completeness was evaluated by determining the proportion of reported data with completed and valid values on each chosen variable, number of vaccine doses and type of laboratory test. Variables with missing data were excluded from the analysis.

We used information from the NNS as the correct value in the case of any discrepancies.

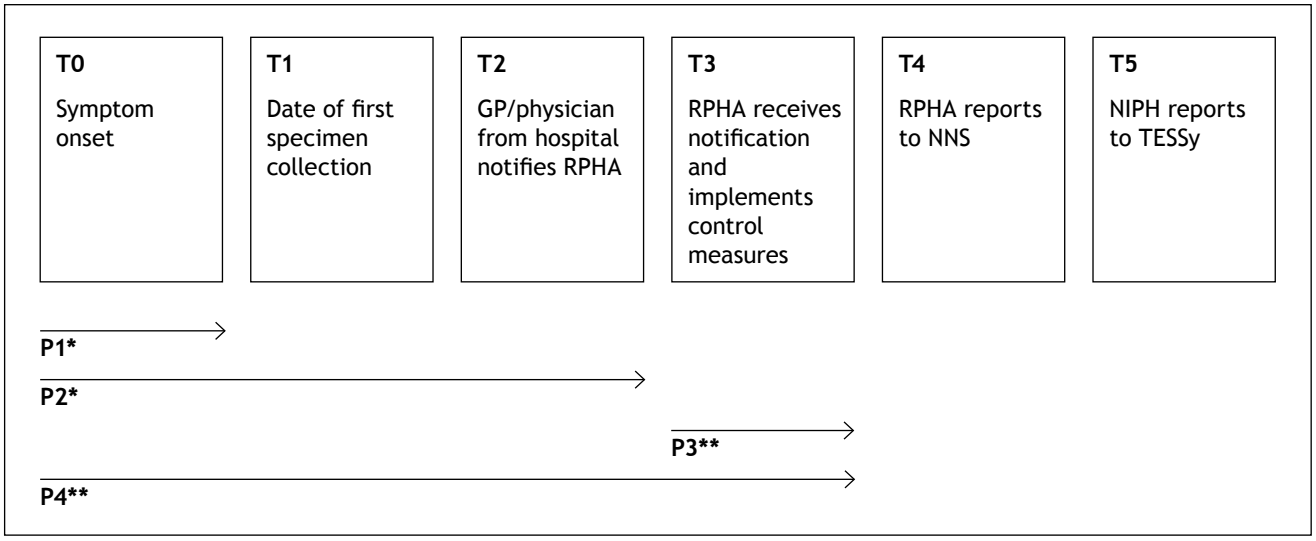
2.3.2 Timeliness

Timeliness was assessed by considering the delay between the onset of symptoms and case notification date in the NSS. Notification delay to the national level was calculated using the reported dates available in the NNS. We calculated time elapsed between the onset of symptoms and first reporting in the NNS and the period between symptom onset and the date of first specimen collection; we marked different intervals as P1-P4, explained in Figure 1.

P1 could serve as an estimate for the first visit to a healthcare facility. This is a very important indicator for a correct diagnostic algorithm. It is a signal as to whether pertussis was also considered as part of the differential diagnosis, given that pertussis is not automatically tested for in laboratories as part of the panel of respiratory infections in CZ.

All records of confirmed pertussis in infants from the NNS and ESS were analysed separately using absolute numbers and proportions. Descriptive analysis of data was performed in MS Excel. Stata 16 software (StataCorp LLC, College Station, Texas, U.S.A.) was used for Figure 2 and timeliness analysis.

We analysed anonymised data and report only aggregated data, and therefore no ethical concerns arise.



Notes: GP=General practitioner, NNS=National notification system, RPHA=Regional Public Health Authority, NIPH=National Institute of Public Health, TESSy=The European Surveillance System, *=time in days (**P1** is the interval between the date of symptom onset and date of first specimen collection. **P2** is the interval between the date of symptom onset and date of the RPHA receiving notification.), **=time in weeks (**P3** is the interval between the week of the RPHA receiving notification and week of reporting to the NNS. **P4** is the interval between the week of symptom onset and week of reporting to the NNS.)

Figure 1. Time-points (T) and intervals (P) in the notification process of pertussis surveillance system in the Czech Republic (10).

3 RESULTS

3.1. Descriptive analysis

3.1.1 Evaluation of data completeness in the NNS

Within the study years 2015, 2017 and 2019, a total of 121 confirmed pertussis cases were reported in the NNS in CZ: 27, 22 and 72, respectively.

We found 100% completeness of most variables reported in the NNS (Table 1).

Cases were reported from all 14 regions in CZ; the largest number of cases were reported from Prague and Moravian-Silesian region (Figure 2).

The majority of cases (73%) were reported among young infants in the age group 0–3 completed months of life (Figure 3). There were more male (n=67; 55%) infants reported to the NNS, making the male/female ratio 1.2/1.

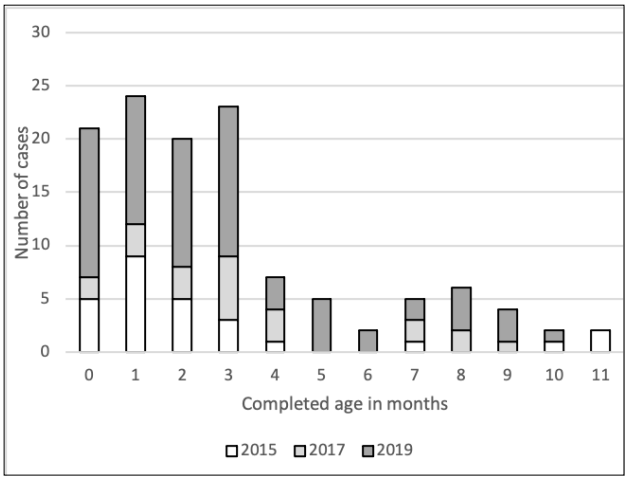


Figure 3. Number of confirmed pertussis cases among infants by age, national notification system, Czech Republic, for the years 2015, 2017, 2019 (n=121).

Table 1. Comparison of completeness of selected variables in confirmed pertussis cases among infants within two reporting systems, Czech Republic, for the years 2015, 2017, 2019.

National notification system		Enhanced surveillance system	
Variable	**N (%)**	**Variable**	**N (%)**
unique personal identifier, age, gender, date of onset, reporting week, reporting region, place of isolation, date of first specimen collection (n=121; for all variables)	121 (100%)	date of birth, gender, date of onset, reporting region, place of isolation (n=104; for all variables)	104 (100%)
vaccination status (n=121)	120 (99%)	vaccination status (n=104)	104 (100%)

Notes: N=number of records with completed and valid data, n=number of completed records

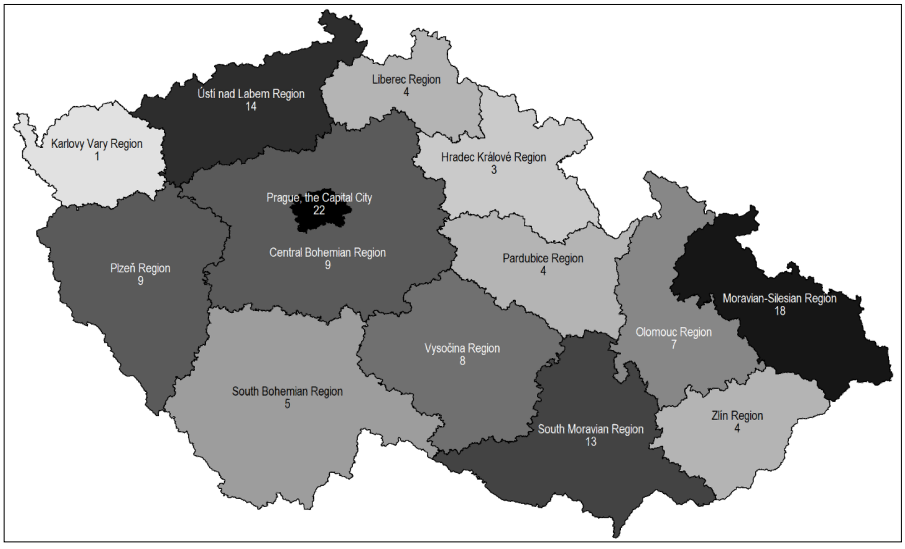


Figure 2. Number of confirmed pertussis cases among infants by administrative region, Czech Republic, for the years 2015, 2017, 2019 (n=121).

In total 98 (81%, n=121) infants were hospitalised. For all 121 cases the data on the place of isolation was available: 79 (65%) cases were hospitalised in a healthcare facility (usually a paediatric ward), 22 (18%) cases were isolated at home, 19 cases (16%) were isolated in an infectious diseases ward, and one (1%) case was not isolated.

Vaccination status of pertussis was reported in almost all (n=120) cases: in 27 cases (23%) vaccination status was reported as "vaccinated", while 93 (77%) cases were reported as not (yet) vaccinated in the NNS. One infant (two months old) had no data for the vaccination status (in the year 2019) in the NNS. We assessed the age groups, vaccination status and number of vaccination doses for all the pertussis cases among infants in the NNS (Figure 4). A total of 27 infants were vaccinated: three doses were given to three infants (aged 9 and 11 months), two doses to 11 infants and one dose to 13 infants (of different ages).

For laboratory diagnosis, the PCR method was used in 77 cases (64%, n=120) and ELISA (serology) in 29 cases (24%, n=120). The rest of cases were confirmed by other methods, namely agglutination, western blot and culture. The type of specimen was mainly reported in the NNS as nasopharyngeal swab, with a total of 65 cases (54%, n=121), and blood sample in 31 cases (26%, n=121). The use of a laryngeal swab is no longer recommended due to the possibility of inducing laryngeal spasm, although in our study seven cases (6%) were tested by this mode. In 10 cases (8%) the type of specimen tested was not specified. The option of a stool sample (one case) was an example of incorrect data entry.

3.1.2 Evaluation of data completeness in the ESS

We received 106 questionnaires from the ESS for the study years. Two questionnaires returned in 2015 had to be excluded because both cases were reported in the NNS in the year 2014 (based on date of birth and symptom onset). In the ESS, 27 (100%) cases were reported in 2015, 13 (59%, n=22) in 2017, and 64 (89%, n=72) in 2019.

In three (3%) cases a wrong date of birth was given, while the date of symptom onset was different in 12 (12%) cases. This means there were discrepancies between both systems, and the date of symptom onset was sometimes different for the same case reported in the NNS and ESS. Of the 104 cases reported in the ESS, the highest number was reported for the age group 0–3 months (n=75), with a peak in the age of one month (n=24). The number of males among all cases reported in the ESS was 57 (55%).

The NNS served as a verified source for the vaccination status. Vaccination status was available for all cases reported in the ESS. A total of 81 (78%) cases were not vaccinated, and 72 of these were hospitalised. A total of 23 (22%) were vaccinated, and 13 (12%) of these received only one dose, seven (7%) two doses and three (3%) of them three doses.

In total, 88 (85%) of 104 cases were hospitalised and 16 (15%) cases were isolated at home. Of the 88 hospitalised cases, three were hospitalised twice for pertussis.

In nine (9%) cases we found discrepancies between the date of hospital admission in the ESS and NNS. In six cases the length of hospitalisation was updated based on the correct date of hospital admission or discharge, or both.

In 85 cases we were able to measure the duration of hospitalisation. For three cases the date of discharge was missing. We counted the total duration of hospitalisation as a single number for these re-hospitalised cases. The median duration of hospitalisation was eight days (range: 3–83; lower and upper quartiles [Q1, Q3]: 6, 12). Of those which had completed information on the laboratory method in the ESS, 31 (38%) cases were confirmed by culture, 88 (87%) by PCR and 29 (34%) by specific IgA.

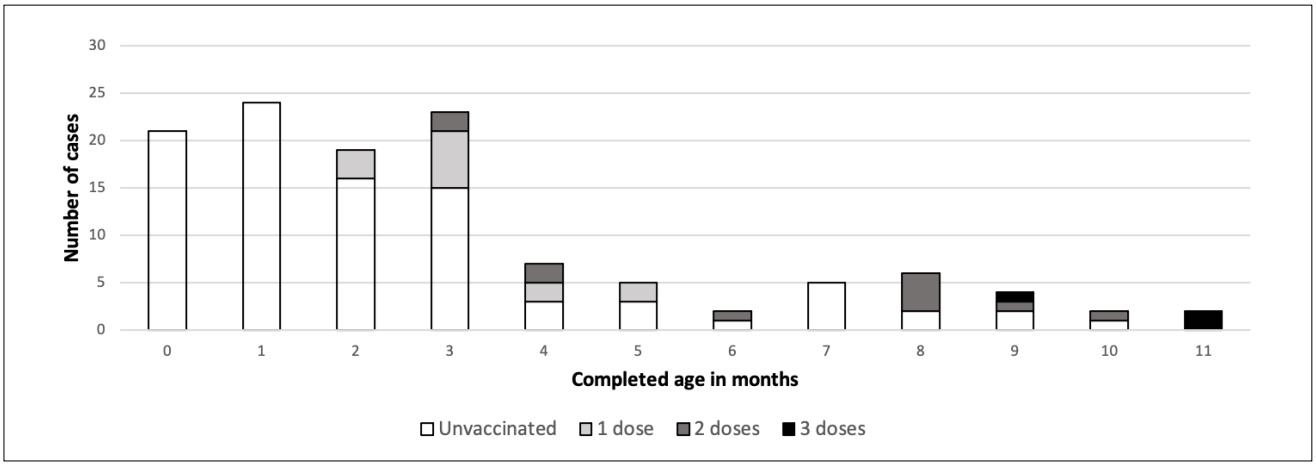


Figure 4. Confirmed pertussis cases among infants by age and vaccination status, national notification system, Czech Republic, in the years 2015, 2017, 2019 (n=120).

3.2 Timeliness analysis

The median interval between date of symptom onset and date of first specimen collection (P1; n=121) was nine days (range: 0-105 days; [Q1, Q3]: 6, 16). Eight cases (all in 2019) reported by RPHAs from different regions had a date of second specimen collection earlier than date of first specimen collection.

The median interval between date of symptom onset and date of the RPHA receiving notification (P2; n=121) was 18 days (range: 4-105; [Q1, Q3]: 10, 33).

The median interval between the week of the RPHA receiving notification and week of reporting to the NNS, calculable only for data in year 2019 (P3; n=72), was one week (range: 0–13; [Q1, Q3]: 0, 2).

The median interval between week of symptom onset and week of reporting to the NNS (P4; n=121) was five weeks (range: 1-18; [Q1, Q3]: 3, 7). Twelve cases (five in 2015, one in 2017 and six in 2019) had a week of symptom onset in December) and were reported to the NNS in the following year (usually in January).

4 DISCUSSION

The purpose of this study was to evaluate the completeness and timeliness of the infant pertussis surveillance system in CZ. The data from the ESS (which started from 1st January 2015) were analysed for the first time. The odd study years were chosen due to an upward trend of confirmed pertussis cases among infants in recent years. We demonstrated that the level of data completeness in the regular pertussis surveillance system (NNS) was high for the evaluated variables, except for the variables for the laboratory method used for pertussis diagnosis and type of specimen collected to confirm diagnosis. There is thus room for improvement or unification for these two related variables. The data in the ESS was less complete, with some discrepancies.

In the Czech legislation there is no specific time limit for reporting of pertussis cases. It is stated that the healthcare provider who diagnoses pertussis should report any case or death for this disease to the public health authority (11). The report of a life-threatening or rapidly spreading infectious disease or the suspicion of such an infectious disease or outbreak shall be submitted immediately by the healthcare provider to the competent public health authority according to the location of the infectious disease personally, by telephone, fax or email (12). In the case of the suspicion or detection of an individual case of an infectious disease, the decree No. 473/2008 Coll. regulates the extent of infections for which a surveillance system is in place. It stipulates a) the scope of data collected, the method and deadlines for their reporting, b) laboratory diagnostics, epidemiological investigation and determination of control measures, and c) basic characteristics, clinical definitions and classification of infectious diseases (11).

It is preferable that notification to RPHAs should be submitted within the incubation period of the disease in order to prevent transmission leading to secondary cases (10). We assume that it is not possible to report a case during the incubation period. Our study is based on the EU case definitions. For pertussis, the average incubation period is nine to 10 days (range six to 20 days) (13). Our study showed that the median interval between date of symptom onset and RPHA notification (n=121) was 18 days (range: 4–105; [Q1, Q3]: 10, 33). A total of 70 cases (58%) had an interval between the date of symptom onset and RPHA notification of three weeks or less. Our goal is now to draw attention to the need to reduce the reporting time from GPs to RPHAs and from RPHAs to the NNS, as this would provide more realistic online data about the current epidemiological situation. In an Italian study of hospital-based ESS among pertussis in infants, the median time from symptom onset to contact with the hospital was eight days (14), which is slightly less than in our study (nine days). This Italian study demonstrated that paediatric populations, too young to be protected by vaccination, had a greater risk of contracting pertussis.

It is thus necessary to promote additional immunisation strategies besides one booster dose in adolescents, including vaccination during pregnancy (1, 15, 16). In our study we noticed that infants with pertussis were under-vaccinated compared to the vaccination schedule. Most vaccinated infants (16 of 27, 59%) received the first dose of pertussis vaccine in age range of four to 11 months (Figure 4), later than advised based on the current vaccine schedule.

After the decline in morbidity in 2015 within the cyclical trend of pertussis, there was an increase in morbidity in 2016–2019. Despite the high level of vaccination coverage of the Czech population against pertussis, two to five year cycles of increase and decrease in reported morbidity are regularly repeated, similar to in other countries. These epidemic cycles indicate the persistent presence of *Bordetella pertussis* in the population (3).

In our study the majority of cases were hospitalised, unvaccinated and reported among infants aged <3 months, which is consistent with previous findings (1, 17).

Although there are some studies for the evaluation of the surveillance system, we found only a few that contained Czech data, including multinational studies (18-21). Therefore, we describe our evaluation to contribute to the literature and share our experience of local surveillance evaluation in CZ and other countries with a similar geographic location or pertussis incidence. We point out the importance of local surveillance evaluation in these countries and sharing the results of such evaluations. Based

on international research, the greatest burden appeared for the most part in infants in Bulgaria, Hungary, Latvia, Romania, and Serbia, but not in the other participating countries where the burden may have shifted to older children and adolescents (22).

Despite the number of cases reported, it is likely that the burden of pertussis in Europe is still considerably underestimated. Improved pertussis surveillance, associated with increased awareness and improved access to appropriate laboratory diagnosis, could thus contribute to a more accurate picture of the epidemiology of pertussis and support policy decisions to optimise the impact of vaccination (5).

4.1 Limitations

Although the NIPH prepared the original ESS questionnaire and RPHAs were informed about how to use it, several different versions have been created over time by RPHAs, and thus not all variables were fully available for the evaluation. In CZ the EU pertussis project PERTINENT was run from December 2015 to December 2018 with the aim to set up a European hospital network to address key questions on the burden of pertussis in infants, as well as vaccination effectiveness and the impact of different pertussis vaccination strategies in the EU/EEA (21). During the process of data digitisation, questionnaires from the PERTINENT project were completed and mistakenly sent to the NIPH, perhaps due to reporting fatigue among the RPHAs and physicians due to the high administrative burden.

The questionnaires for the ESS were not completed for all cases reported to the NNS, with the highest discrepancy in 2017, when only 59% of cases had completed questionnaires. We do not have a clear explanation for this. Nine reports in total were not been sent in 2017 from five different regions in CZ. Since recall and selection bias tend to appear in observational studies, we attempt to minimise interviewer bias by using a standardised questionnaire.

Another limitation of the study reported here is that a vaccination register was only launched recently in CZ, on 1st January 2022, so we had to rely on reported data from the NNS. It will take some time to obtain representative and relevant data from the national vaccination register.

Based on a similar annual incidence of pertussis in infants, we assume that data from unprocessed years (2016 and 2018) does not differ substantially from that for the processed years in terms of completeness and timeliness of reporting.

5 CONCLUSIONS AND RECOMMENDATIONS

Our primary aim was to get information about the validity of laboratory confirmed pertussis data in the ESS and NNS, to describe and assess its completeness and timeliness, and to make recommendations for improvement. Furthermore, we compared time delays between the onset of symptoms and first reporting in the NNS (notification delay), and the period between symptom onset and date of first specimen collection (diagnostic delay). Delays in reporting to RPHAs and reporting to the NNS occur at all levels of the system (e.g. symptom onset in October 2019, reporting to RPHAs in November 2019 and reporting to the NNS in February 2020). It would be desirable to minimise these delays, and thus we suggest reporting as many cases as possible as soon as possible, and preferably in the year of symptom onset. The NNS database for the previous year closes on February 28, but this deadline applies only to cases entered into the database by December 31. This two-month period is used for adjustments and additions to cases already entered in the NNS before the end of the year.

It is necessary to maintain a high level of data quality and to inform data providers (RPHAs) and other stakeholders about the results and recommendations coming out of this project.

Further, efforts should be made to improve the collection of data on variables with missing values by raising awareness of their importance. Additional (online) training may be useful in this regard, or regular information about the level of correct reporting of data can be shared with and amongst RPHAs. We also recommend that RPHAs carefully check input data when inserting data to the NNS in order to avoid possible errors and inconsistencies.

More effort to engage RPHAs and raise awareness about the infant pertussis ESS among employees of RPHAs (both new and old) is necessary, as well as more time and staff being assigned to such work.

Our goal was to integrate the selected variables from the ESS into the NNS (data entry form), to have all relevant information in one form.

In the meantime, the following variables were added to the NNS (data entry form) based on the ESS: maternal vaccination, date of last maternal vaccination, vaccine (for maternal vaccination) and batch (for maternal vaccination).

The project results were discussed with the epidemiologists at RPHAs, and it was agreed that pertussis cases in infants would be reported only to the NNS, and therefore the ESS questionnaire was terminated in 2020. This improved ESS in infants will continue with regular evaluation.

Technical changes of the mechanisms within the NNS should ensure a higher level of data completeness (e.g. more mandatory fields or more logical syntax to check data). The NNS should also automatically check various time variables, so it is impossible to report incorrect time information.

Based on the obtained data, it is necessary to improve the awareness of both the professional and lay public in CZ in order to maintain a high level of vaccination of children against pertussis and a high quality of pertussis surveillance, both in the paediatric and broader population.

ACKNOWLEDGEMENTS

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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ETHICAL APPROVAL

Ethical approval was not required as in the Czech Republic public health agencies are able to access and use personal identifiable information for communicable disease investigations in the public interest. Completion of the questionnaire was considered as implied consent.

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Supplementary file. ESS questionnaire in English.

Questionnaire - enhanced pertussis surveillance

Pertussis in children up to one year of age

Please fill in using capital letters or mark the correct answer

Send the completed questionnaire via email: katerina.fabianova@szu.cz. Information tel.:267082445 - Dr. Fabianova

Completed by:

	Patient		
1	Name (first two letters)		
2	Surname (first two letters)		
3	Date of birth (dd/mm/yyyy)		
4	Gender		
5	Report to the NNS (EPIDAT/ISIN)		
6	Date of 1st symptoms (dd/mm/yyyy)		

7	Preterm birth	Yes	No	Unknown
8	Please write a gestational week			
9	Cardiovascular disease	Yes	No	Unknown
10	Central nervous system disease	Yes	No	Unknown
11	Pulmonary disease	Yes	No	Unknown
12	Other disease, please specify:			

13	**Hospitalisation**	Yes	No	
14	Date of hospital admission (dd/mm/yyyy)			
15	Date of discharge (dd/mm/yyyy)			
16	Length of hospitalisation (days)			
17	Stay in Intensive care unit (ICU)	Yes	No	Unknown
18	Length of stay in ICU (days)			
19	Was the patient on artificial lung ventilation?	Yes	No	Unknown
20	Has positive pressure ventilation been used in the patient?	Yes	No	Unknown
21	How long on the artificial lung ventilation? (days)			
22	Has a transfusion been performed?	Yes	No	Unknown
23	Has plasmapheresis been performed?	Yes	No	Unknown

	Did the patient have the following symptoms of pertussis?			
24	Paroxysms of coughing	Yes	No	Unknown
25	Whooping	Yes	No	Unknown
26	Post-tussive vomiting	Yes	No	Unknown
27	Apnoe	Yes	No	Unknown
28	Choking	Yes	No	Unknown
29	Cyanosis	Yes	No	Unknown
30	If the patient had a cough, how long did the cough last (days)?			
31	If the patient still coughs, since when? (days, weeks)			

	Did the patient have the following complications?			
32	Conjunctival bleeding	Yes	No	Unknown
33	Pneumonia	Yes	No	Unknown
34	Seizure (convulsions)	Yes	No	Unknown
35	Encephalopathy	Yes	No	Unknown
36	Other, please specify:			

37	**Antibiotic (ATB) treatment**	Yes	No	Unknown
38	How many days after the first symptoms ATB treatment started?			
39	Name of ATB			
40	Length of ATB treatment - days			
41	Name of 2nd ATB			
42	Length of ATB treatment - days			

43	**Death due to pertussis**	Yes	No
44	Date of death (dd/mm/yyyy		
45	Cause of death		

46	**Diagnosis**					
47	Culture	Yes	No	Not tested	Unknown	
48	PCR	Yes	No	Not tested	Unknown	
49	Specific IgA	Yes	No	Not tested	Unknown	
50	Serology other - specify which					
51	Blood count, if any	the highest no. of leukoc.				
52		the highest no. of lymphoc.				

	Did the patient have close contact with a person with confirmed pertussis?			
53		Yes	No	Unknown

	Pertussis vaccination in family members				
	Parents	Age	Vaccinated		Date of last vaccination (dd/mm/yyyy)
54	Mather		No	Yes	
55	Father		No	Yes	

	Siblings	Age	Vaccinated		No. of doses	Unknown
56	1.		No	Yes		
57	2.		No	Yes		
58	3.		No	Yes		
59	4.		No	Yes		

	Other people in the household (Relationship = grandmother, aunt, grandfather, nanny)				
	Relationship	Age	Vaccinated		Date of last vaccination (dd/mm/yyyy)
60			No	Yes	
61			No	Yes	
62			No	Yes	
63			No	Yes	

Note: Most of variables from the ESS questionnaire were evaluated in other project. For detailed information please see the article Liptáková M, Špačková M, Balasegaram S, Malý M, Kynčl J, Fabiánová K. What risk factors affect hospitalisation for confirmed pertussis cases among infants in the Czech Republic? Epidemiol Mikrobiol Imunol. 2022;71(3):139-147.