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The surge in infectious complications of dental and periodontal infections in the Czech Republic between 2010 and 2022

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Abstract

Dental and periodontal infections can lead to serious systemic complications through bacterial dissemination. While global awareness of these risks is increasing, data on the incidence and outcomes of such complications remain limited. This study aims to quantify the incidence of serious extraoral infectious complications associated with dental infectious foci, using dental procedures as markers of active oral infection, in the Czech Republic between 2010 and 2022. A retrospective analysis was conducted using data from the National Register of Reimbursed Health Services. Patients who underwent invasive dental procedures indicating active dental/periodontal infection and were hospitalized for severe infectious conditions within 7 days were identified. This temporal criterion captured both cases where dental procedures preceded systemic spread and cases where dental foci were identified during workup for serious infections. Descriptive statistics and linear regression analysed incidence rates and temporal trends. Among 15 098 093 dental procedures over 13 years, annual hospitalizations for associated infectious complications ranged from 855 to 1252 cases. Overall incidence was 12.82 per 100 000 population annually. Oral region complications (cellulitis, abscesses, osteomyelitis) were most common (9.48 per 100 000), followed by systemic complications (sepsis and endocarditis) (2.89 per 100 000). Significant increasing trends were observed for jaw periostitis ($P = .006$), endocarditis ($P < .001$), and central nervous system abscesses ($P = .027$), while acute sinusitis declined ($P < .001$). This population-based analysis reveals a substantial incidence of serious infectious complications associated with dental infectious foci, with concerning increasing trends in potentially life-threatening conditions. These findings emphasize the importance of preventive dental care and early intervention strategies.

Introduction

The oral microbiome consists of over 700 different species of bacteria, some of which are organized in complex biofilms [1]. These bacteria can enter the systemic circulation or adjacent tissues in the event of mucosal or gingival disruption. One pathway involves entry from the periodontium in conditions such as gingivitis and chronic periodontitis, which are precipitated by the accumulation of plaque biofilms. An alternative route to the circulation involves infections in the root canal or periapical areas entering the alveolar blood vessels. This can occur due to the progression of untreated dental diseases or during dental procedures [2]. Iatrogenic gingival or mucosal trauma mainly occurs during dental procedures such as tooth extractions, periodontal and apical surgery, removal of caries affecting cervical or subgingival portions of the tooth, periodontal probing, and endodontic treatment [3, 4]. Individuals with poor oral hygiene are at higher risk of developing bacteraemia during dental treatment procedures [5].

Virtually any organ may be affected by localized bacterial spread from the oral cavity; amongst those most vulnerable are the central nervous system, bones, joints, and the endocardium. Direct spread of infection from the oral cavity to surrounding tissues may lead to sinusitis, oral abscesses, osteomyelitis of the jaw, orbital cellulitis, or when progressing through interfascial spaces to more distant regions, deep neck infections and cellulitis, or even mediastinitis and pyothorax. Because of anatomical proximity to the oral cavity, infection can spread to the brain or the upper part of the spinal cord and may cause bacterial meningitis, abscesses, ventriculitis, or spinal infections [6, 7].

Comprehensive population-level data quantifying the burden of serious extraoral infectious complications remain limited. Most existing studies focus on specific complications such as endocarditis or are limited to single-centre experiences. Recent Spanish data from a referral centre demonstrated that oral streptococci accounted for 19.4% ($n = 94$) of 485 infective endocarditis cases over a 3-decade period, underscoring the clinical relevance of odontogenic sources in serious cardiac complications [8].

This study aims to quantify the incidence of serious extraoral infectious complications associated with dental infectious foci, using

dental procedures as markers of active oral infection, in the Czech Republic between 2010 and 2022, providing the first comprehensive population-based epidemiological data on this important clinical phenomenon.

Methodology

Data source

This study utilized open access datasets from the National Register of Reimbursed Health Services (NRHZS) database from 2010 to 2022. The Czech Republic has a comprehensive general health insurance system, in which all citizens and residents (10.67 million in 2022) have mandatory health insurance that fully covers acute care and many chronic conditions. The NRHZS collects data reported for billing by all approximately 30 000 healthcare providers to the seven health insurance companies. Information about patients outside the public health insurance system (foreigners not residing in the Czech Republic and directly paid care at private dental clinics, representing approximately 10% of dental care) is not included. It is thus the broadest and most comprehensive data source within the Czech National Health Information System. Upon request, only data anonymized with respect to the identity of both the patient and the provider may be provided for processing according to legally defined rules. Each external data transfer is subject to assessment of the request from the given external entity by the advisory board of the Institute of Health Information and Statistics (ÚZIS) management and is duly protocolled and recorded, as obtained in this study [9].

Study design and cohort

For this study, data from all age groups were included, encompassing both adults and children, with no specific exclusion criteria applied. We identified patients who had an infectious dental focus treated by a dentist and who were hospitalized for a serious infection in close temporal relationship, which could potentially be associated with the dental infection. Two datasets were utilized. First, claims for dental procedures representing acute treatment of dental/periodontal infections, as coded by Decree No. 134/1998 Coll., a decree of the Ministry of Health of the Czech Republic establishing the list of medical procedures with point values for reimbursement, as detailed in Supplementary Appendix S1 [10]. The second dataset comprised hospitalizations due to one of the severe infectious conditions listed in Table 1. Two temporal scenarios were considered for dental procedures relative to hospitalization. The first scenario involved procedures performed during the hospital stay, where patients were admitted for severe infection and dental or periodontal conditions were identified as potential sources during the clinical workup. The second scenario included procedures occurring up to 7 days prior to hospital admission. This arbitrary 7-day window captured two clinical situations: cases where dental procedures potentially caused infection dissemination, and cases where procedures aimed to treat intraoral foci in which extraoral spread might have already commenced. Data on these hospital admissions, with diagnoses coded and claimed for reimbursement according to the International Classification of Diseases, 10th revision (ICD-10), were available without any demographic data related to individual patients. A single patient could have multiple conditions (coded diagnoses) simultaneously.

Table 1. Main and adjacent hospitalization diagnoses were used for analysis, as coded according to the ICD-10

Cellulitis and abscess of the mouth, Osteomyelitis or periostitis of the jaw	K12.2, M86.1, M86.9, K10.2
Cellulitis of larynx, Mediastinitis, Pyothorax, Fasciitis	J38.7, J98.5, J86, M72.9
Acute sinusitis	J01[a]
Orbital cellulitis, Orbital abscess, Purulent endophthalmitis	H05.0, H44.0
Bacterial meningitis, Brain abscess, Extradural or epidural abscess, Ventriculitis	G00[a], G04.2, G06[a], G04.9
Intracranial septic thrombosis	G08
Sepsis, Endocarditis, Infectious pericarditis	A40[a], A41[a], I33[a], I30.1

a: Replaces any number.

Statistical analysis

The data were analysed using descriptive statistics, including frequencies, proportions, and incidence rates per 100 000 population for all hospitalization diagnoses. Annual incidence rates were calculated using Czech Statistical Office population data as denominators. Temporal trends from 2010 to 2022 were analysed using simple linear regression models for each outcome variable (individual infectious complications) and for dental procedure frequencies. For each unique diagnosis, a simple linear trend was estimated by regressing annual case counts on calendar year (2010–22) using ordinary least squares (OLS). The coefficient of determination (R^2), adjusted R^2 (adjustment using $n = 13$ observations and $k = 1$ predictor) and regression coefficients were calculated to assess trend strength and direction. Statistical significance was set at $P < .05$. Additionally, descriptive analysis was performed to identify the most common types of infectious complications and their relative frequencies. All statistical analyses were performed using JASP version 0.18.3 (JASP Team, 2024).

Results

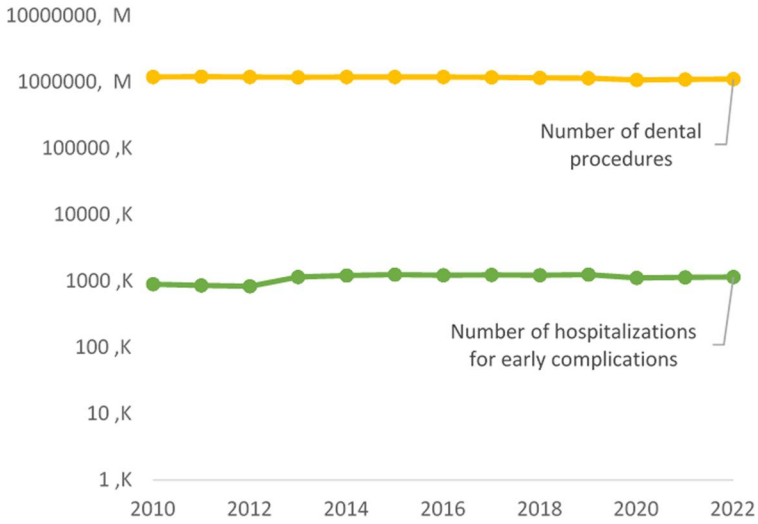
A total of 15 098 093 dental procedures were claimed for reimbursement over the 13 years, ranging from 1 069 591 (2020) to 1 202 203 (2011). The number of dental procedures showed a statistically significant decreasing trend over the study period ($R^2 = 0.68$, coefficient $= -7.46e^{-5}$, $P < .001$), whilst the number of hospital admissions for complications possibly related to odontogenic infections according to the defined criteria did not demonstrate a statistically significant trend ($R^2 = 0.37$, coefficient $= 0.0154$, $P = .028$) (Fig. 1).

Complications in the oral region (sum of cellulitis and abscess of the mouth, osteomyelitis or periostitis of the jaw, and acute inflammation of the paranasal sinuses) were the most common, with an incidence rate of 9.48 per 100 000 population, followed by systemic complications with or without cardiovascular involvement (sum of streptococcal sepsis, other sepsis, endocarditis, pericarditis, and septic thrombosis) with an incidence rate of 2.89 per 100 000 population. Complications in the orbit, respiratory tract, and mediastinum, or complications in the central nervous system, were considerably less frequent, as shown in Table 2. The exact numbers of individual diagnoses are given in Supplementary Appendix S2.

A statistically significant increasing trend was observed in cases of jaw periostitis ($P = .006$), endocarditis ($P < .001$), and abscesses of the central nervous system ($P = .027$). A decrease was observed only in the number of cases of acute inflammation of the paranasal sinuses ($P < .001$) (Fig. 2).

Discussion

This population-based study provides the first comprehensive analysis of serious extraoral infectious complications following dental procedures in the Czech Republic from 2010 to 2022. Our findings demonstrate several key results: (i) the overall incidence of serious infectious complications was 12.82 per 100 000 population annually, with oral region complications being most common (9.48 per 100 000); (ii) significant increasing trends were observed for potentially life-threatening complications including endocarditis ($P < .001$) and central nervous system abscesses ($P = .027$); (iii) jaw periostitis also showed an increasing trend ($P = .006$), whilst



Year	Number of dental procedures	Number of hospitalizations for early complications
2010	1,19M	897
2011	1,2M	855
2012	1,19M	829
2013	1,18M	1145
2014	1,19M	1215
2015	1,19M	1252
2016	1,19M	1230
2017	1,18M	1235
2018	1,16M	1218
2019	1,15M	1251
2020	1,07M	1119
2021	1,09M	1138
2022	1,11M	1146

Figure 1. Annual numbers of patients in whom at least one invasive dental procedure representing acute treatment of severe dental/periodontal infection was claimed and numbers of hospitalizations due to the selected severe infectious conditions.

Table 2. Average number of serious infectious complications requiring hospital admission that occurred in temporal relation to the treatment of dental infectious foci, average per year in the period 2010–23, the number per 100 000 population is given

	Average number of complications per year per 100 000 population
Complications around the jaw	9.48
Systemic conditions with or without cardiovascular involvement	2.89
Infection in the central nervous system	0.26
Infection in the eye	0.09
Infection in the respiratory tract and mediastinum	0.09
Total	12.82

acute sinusitis decreased significantly ($P < .001$); and (iv) despite a decreasing trend in dental procedures, the overall burden of serious infectious complications did not decrease correspondingly.

This study has quantified the association, not causality, between dental procedures and infectious complications. We believe that an invasive dental procedure would suggest that the patient has an active dental or periodontal infection, which is a possible focus of a more serious infectious complication. Any invasive dental procedure may be an indirect indicator that there was an infectious focus in the oral cavity. Alternatively, a dental procedure in the context of poor dental health may have been a source of bacterial spread via transient bacteraemia.

The ageing population could contribute to the rise in severe complications from dental infections. Periodontitis is thought to be one of the most common chronic inflammatory diseases in adults, with an age-related rising prevalence matching the increasing age of patients presenting with infectious endocarditis [10]. In the Czech Republic, the population aged 65 and over represented 15.5% of the total population in 2010. This percentage increased to 18.3% in 2015 and further to 20.2% in 2020 [11]. Older individuals often have a higher risk of complications due to age-related physiological changes and comorbidities. The healthy cardiac endothelium, more likely to be found in the younger population, carries a lower risk of developing infectious endocarditis caused by transient bacteraemia [12]. Older people may also prioritize other health concerns over regular dental check-ups. This can lead to delayed diagnosis and treatment of dental caries and periodontal disease, increasing the risk of severe complications. It has been pointed out that neglected oral hygiene and subsequent periodontal disease increase the likelihood of bacteraemia in connection with normal daily activities such as chewing and toothbrushing [13]. Some may also face barriers to accessing regular dental care, including travel distance to dental appointments, lack of transportation, or the physical strain of travel.

Secondly, immunodeficiency can significantly influence the oral health status of individuals. The increasing number of patients on long-term immunosuppressive therapy has increased the risk of progression of focal dental infection [14]. Moreover, some of these therapies can cause side effects such as dry mouth, which can further contribute to the development of dental caries. Antineoplastic therapy interferes with the turnover of epithelial cells; this is followed by mucosal injury and later by infection as a result of invasion by gram-negative bacteria and fungal species. Up to 37.2% of all patients receiving cancer chemotherapy develop acute oral complications, and up to 31.1% of all patients receiving cancer radiotherapy experience acute oral manifestations, which may result in significant morbidity, treatment delays, and dose reductions, affecting the prognosis of the primary disease [15]. Other conditions such as diabetes or regular alcohol consumption also contribute to poor oral health, negatively influence the immune system, and are regularly seen in patients admitted with serious infectious complications [16]. Other reported factors that play a role in the development of severe odontogenic infections include obesity, drug abuse, tobacco abuse, and malnutrition [17, 18].

Based on our knowledge of the local healthcare system and perspectives from multiple specialities dealing with dental complications, we assert that a substantial proportion of the cases were captured using this methodology. We focused on infections that are severe enough to require hospitalization. These are financially costly diagnoses, so we assumed that every medical facility would make maximum efforts to properly code these conditions to obtain reimbursement for the provided healthcare. However, there are likely missing cases where the patient was not surgically treated by a dental surgeon or dentist within the defined interval, or was treated only with a minor procedure that was not on our list of major intraoral procedures. But expanding the definition to include routine dental caries treatment or periodontitis treatment (dental hygiene) would lead to a significant increase in the number of cases

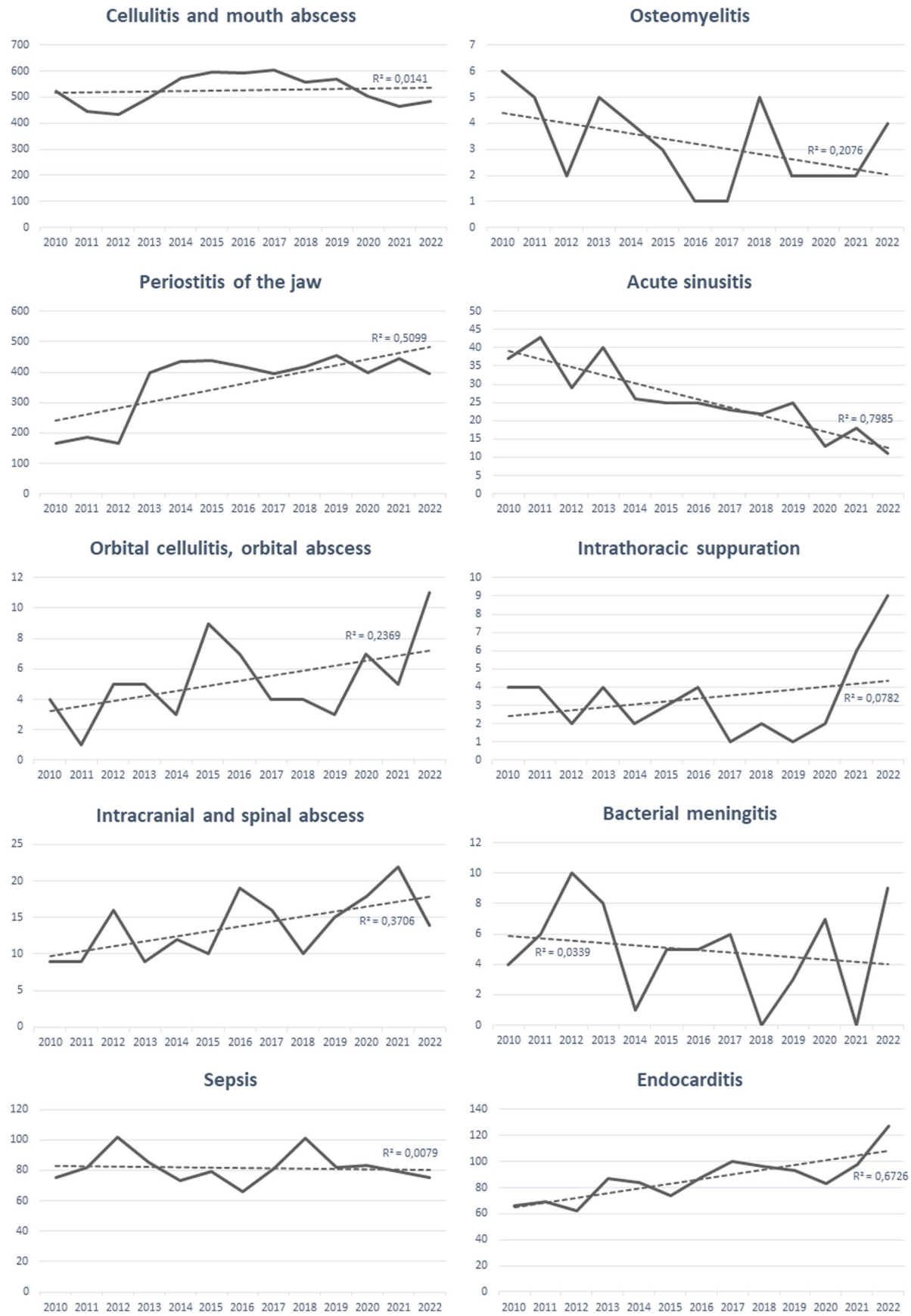


Figure 2. Graphs depicting the numbers of hospitalizations for individual diagnoses in the years 2010–22 and linear regression trend lines. R^2 is the coefficient of determination of the linear regression model.

with a random temporal relationship, such as sepsis and a visit to the dentist. This could dilute the significance of the findings.

There may also be a longer than 7-day time interval from a culprit dental procedure to hospital admission. The shorter time interval, however, was attempted to discern procedures performed to treat an infectious focus rather than situations where the dental procedure causes complications in distant organs and systems.

There was no change in the methodology of reporting healthcare for reimbursement from health insurance during the observed period. The decrease in the incidence of acute sinusitis might be attributed to the motivation to report only the most severe diagnoses for reimbursement purposes. Given the limitation on the number of reportable diagnoses, acute sinusitis in a patient with another severe infection does not increase the reimbursement from health insurance. This incentivizes healthcare providers to prioritize and code the most severe conditions that have a direct impact on the reimbursement rates. Consequently, less severe diagnoses such as acute sinusitis may be underreported, leading to an apparent decline in incidence rates.

Conclusion

The increasing trend of severe complications temporally associated with invasive dental interventions is likely to be multifactorial, probably encompassing both medical and sociological aspects. Without demographic data or known concomitant diagnoses for the patients, it is not possible to prove a causal relationship. Given these considerations, further research is necessary to fully understand the factors contributing to the growing trend in severe complications associated with poor dental health. This understanding may aid in the development of effective prevention and treatment strategies. Such approaches should include medical interventions, improvements in dental care access, and public health initiatives that promote good oral hygiene and healthy dietary habits.

Key points

- This study aimed to quantify the incidence of serious extraoral infectious complications associated with dental infectious foci in the Czech Republic, using dental procedures as markers of active oral infection. It addressed the lack of comprehensive population-based data on how dental infectious foci contribute to systemic infections requiring hospitalization. Understanding these epidemiological patterns is crucial for improving oral healthcare and preventing associated complications. The findings provide essential data to guide evidence-based public health interventions.
- The study revealed concerning increasing trends in severe complications such as jaw periostitis, endocarditis, and central nervous system abscesses associated with dental infectious foci over the 13-year period. It demonstrated a substantial overall incidence of 12.82 per 100 000 population annually, highlighting the significant burden of systemic infections linked to oral health problems. The findings underscore the need for enhanced preventive strategies and improved access to dental care. These epidemiological insights provide a foundation for targeted public health interventions.
- The findings emphasize the critical need to integrate oral health surveillance into public health policies to prevent severe systemic complications. The quantified incidence rates demonstrate the importance of promoting dental hygiene, improving access to care, and addressing risk factors in vulnerable populations. Early identification and treatment of dental infectious foci can significantly reduce the burden of serious extraoral complications requiring hospitalization. Public health initiatives must prioritize evidence-based education and prevention strategies informed by these epidemiological data.

Author contributions

Conceptualization: Matus Mihalcin and Ales Chrdle; methodology, acquisition, analysis and interpretation of data: Matus Mihalcin, Ales Chrdle, Vojtech Perina, Lenka Fasanekova, Barbora Macková, and Tomas Majek; writing–original draft preparation: Matus Mihalcin and Ales Chrdle; writing–review and editing; Vojtech Perina, Lenka Fasanekova, Barbora Macková, and Tomas Majek. All authors have read and agreed to the published version of the manuscript.

Supplementary data

Supplementary data are available at *EURPUB* online.

Ethical statement

No ethical approval was required for this register-based study based on routine surveillance data.

Conflict of interest: None declared.

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Data availability

The datasets generated during the current study are available from the corresponding author upon reasonable request.

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