

Assessment of dentists' knowledge of oral manifestations of *Corynebacterium diphtheriae* infection: a questionnaire-based survey

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Abstract

Introduction: Diphtheria is a severe airborne bacterial anthroponosis characterized by high mortality rates and high prevalence in many geographical regions. It presents with a distinctive appearance in the oral cavity, marked by extensive pseudomembranes, and dentists may frequently be the first healthcare providers to diagnose it.

Aim: The objective of our study was to assess dental practitioners' awareness of the distinct oral manifestations of diphtheria and the necessary anti-epidemic measures to implement before and during dental treatment of a patient with a suspected infection.

Materials and methods: An anonymous survey of 367 dental practitioners was conducted from March to August 2025 using a questionnaire designed specifically for the study and containing 12 closed questions.

Results: A significant proportion of respondents (51.5%, n=189) assessed themselves as "partially familiar." Just 36.0% (n=132) of them thought they could spread the infection to other patients by using *Corynebacterium diphtheriae*-contaminated tools, surfaces, and equipment. The remainder have shown a lack of awareness of the potential modes of transmission within the dental practice. A considerable percentage of the surveyed dentists indicated their awareness of the necessary actions to take in the event of a suspected diphtheria patient (51.0%, n=187), while 49.0% (n=180) reported feeling partially prepared.

Conclusion: The general theoretical ignorance among dental professionals of the epidemiological factors, transmission mechanisms, and typical oral manifestations of diphtheria is likely to result in a failure to implement all necessary precautions to prevent its spread in their clinical practice.

Keywords

anti-epidemic measures, oral manifestation of infectious diseases, prevention of HAI

Introduction

Corynebacterium diphtheriae was first described by Klebs in 1883, and that same year Löffler isolated and cultured it. It is a gram-positive, rod-shaped bacterium. Pathogenic

strains generate diphtheria toxin, a highly cytotoxic protein accountable for the systemic signs of the disease. The primary pathogenic factor is diphtheria exotoxin, which obstructs protein synthesis in host cells.^[1,2]

Diphtheria is a dangerous airborne bacterial anthroponosis with high lethality, which continues to be endemic

in many regions of the world, including Sub-Saharan Africa, South Asia, Southeast Asia, India, Indonesia, the Middle East, some countries of South America, Haiti, Nigeria, and the Dominican Republic, as well as parts of Eastern Europe.^[3,4] The highest number of cases of diphtheria in Europe in the last 70 years was registered in 2022, with over 320 cases, mainly among migrant communities.^[3] Continued local spread among vulnerable groups is also reported – homeless people living in migrant centers, people with regular drug use and unvaccinated adults.^[6-8] Diphtheria is rare in developed countries due to mass immunization. The population remains well protected thanks to the high immunization coverage, but targeted measures are needed for vulnerable groups in order to better protect public health.^[9,10]

In Bulgaria, the last case of diphtheria was registered in 1994.^[11] Bulgaria has sustainable national vaccination programs and a good level of population protection.^[12] The dynamic situation in the world – outbreaks of wars, migrant and refugee waves, etc. – leads to a lower coverage of vaccines for these risk groups. This, as well as facilitated international transport, makes it possible to import this infection into other countries. Bulgaria is certainly no exception.^[13]

Diphtheria is characterized by a distinctive presentation in the oral cavity, manifesting as dense pseudomembranes, among other symptoms and it is highly possible that dentists may be the first healthcare professionals to recognize it. This unequivocally requires dentists to know the characteristic oral appearance of diphtheria and the relevant anti-epidemic measures that must be taken.^[14]

Despite the widespread introduction of diphtheria toxoid in combination vaccines (DTP/DTaP), the disease has not been eliminated and remains endemic in several regions of Asia, Africa, and South America.^[13] In many African countries, diphtheria remains endemic, with outbreaks occurring periodically, particularly in countries such as Nigeria, Madagascar, and Sudan.^[15] Diphtheria is a rare disease in Europe, with a decline in cases largely attributable to the high vaccination rates (>95%) that have been achieved across the continent. The most significant outbreak in recent decades occurred in Russia and other former Soviet republics between 1990 and 1998.^[16] Diphtheria has been virtually eliminated in the United States and Canada, with fewer than one case reported annually.^[5] In contrast, some Latin American countries, such as Brazil and Haiti, still experience local outbreaks among unvaccinated populations.^[17]

Aim

To assess the knowledge of dental practitioners about the characteristic oral manifestation of diphtheria and the anti-epidemic measures that they should take before and after dental treatment of a patient with suspected infection.

Materials and methods

A survey was conducted among 367 dental practitioners, the aim of which was to ascertain the level of knowledge among dentists in general for the country as a whole. The study did not seek to identify regional differences.

The data were collected via an online survey disseminated through professional channels for dental practitioners. The survey approach was selected for the following reasons: it is targeted directly at specialists and is conducted at their request; online surveys facilitate rapid, efficient, and economical data collection; and the geographical scope of the study is considerably broadened, enabling the collection of data from users across various regions within a relatively brief timeframe. This approach also guaranteed respondent anonymity, potentially fostering more candid and transparent responses.

The questionnaire was designed based on current epidemiological data and established clinical guidelines. To ensure relevance, only actively practicing dentists were included as respondents, while individuals not qualified as dentists were excluded. The instrument was developed by our research team specifically for this study, and its purpose was clearly stated at the beginning of the survey to inform participants. Sample size calculation was prepared in the form of an online survey and was sent to dentists, using lists of professional organizations. Dental specialists were randomly selected. The questionnaires were sent to the maximum number of respondents in order to achieve at least 5% coverage of the relevant specialists.

Statistical analysis

The processing and analysis of the empirical data was conducted using descriptive statistical methods and non-parametric statistical tests, which were appropriate for the analysis of categorical and unevenly distributed data. Qualitative indicators were presented as absolute frequencies and relative shares (percentages), with the objective of facilitating a more visual representation of the sample's structure and enabling comparative analysis.

To evaluate the relationships between categorical variables, the Pearson's chi-square test (χ^2) was utilized for multivariate contingency tables, while the Fisher's exact test was employed for two-dimensional four-fold tables. The strength of the association between variables was assessed using the Cramer's V coefficient, which provides information about the degree of connectivity for significant χ^2 results.

The level of statistical significance was set at $p < 0.05$, which means that the probability that the results are due to chance is below 5% and allows the rejection of the null hypothesis with a sufficient degree of certainty.

The data processing and analysis were performed with specialized statistical software SPSS version 23, as well as with the help of MS Excel 2016, used for primary processing and visualization of the results.

Results

A total of 367 dentists were included, with men accounting for 39.2% (n=144) and women accounting for 60.8% (n=223). The remaining demographic characteristics are presented in **Table 1**.

Table 2 displays the distribution of dentists' responses to questions regarding their understanding of the distinctive oral signs of diphtheria and their awareness of the anti-epidemic measures to implement while treating a patient suspected of this infection.

Diphtheria is an infection that is transmitted mainly by respiratory droplets (droplet transmission), with direct contact also a possible route (e.g., within a household or via contaminated items). It is interesting that all dentists (100%, n=367) indicated that diphtheria has a characteristic oral manifestation; however, when asked to specify which symptoms they associate with this oral manifestation, the responses varied widely, with different symptoms reported as the most characteristic of the infection (**Table 2**). Only 19.1% (n=70) provided the accurate and optimal response that included all the specified answers.

In response to a suspected diphtheria infection, 36.5% (n=134) recommended rigorous disinfection of every object in the external dental environment, while 12.5% (n=46) advocated for both rigorous disinfection of all items and ventilation of the entire office. The provided answers were undoubtedly accurate; however, the most optimal response encompassed all the specified measures, including rigorous disinfection of all items in the external dental environment, thorough ventilation of the entire office, notification of the patient's primary physician, and alerting the RHI regarding a potential case of diphtheria. Fifty-one percent (n=187) would take this action.

We evaluated the self-criticism of respondents regard-

ing their understanding of this illness; the majority (80.4%; n=295) expressed a need for further training on the subject. These responses are noteworthy and indicate that dentists recognize the deficiencies in their knowledge.

Regarding the complete vaccination status against diphtheria and tetanus, 49.3% (n=181) of the surveyed individuals reported that they had always received all the doses provided for in the immunization calendar of Bulgaria. However, it is worrying that almost the same share indicated that they had not received all the necessary doses, which potentially puts their own health at risk. As the main reason for incomplete vaccination status against diphtheria and tetanus, 29.2% (n=107) of the respondents indicated the belief that there is no real risk of infection, because the disease can no longer be found in Bulgaria. However, this opinion is problematic since the infection can be imported from outside or acquired during travel to diphtheria-endemic regions of the world. In this context, only 11.4% (n=42) of the participants identified travel to such regions as a motive for vaccination, which nevertheless indicates some assessment of the epidemiological risk. Additionally, 12.0% (n=44) reported that they had not been contacted by their GP for vaccination, while 47.4% (n=174) could not give a specific reason for the lack of vaccination. The latter is an indicator of a superficial and insufficiently responsible attitude towards this public health problem.

We examined several correlations and obtained the following significant results. An examination of the correlation between sex and awareness of the clinical signs and epidemiology of diphtheria revealed a statistically significant disparity: 14.6% (n=21) of men lacked knowledge on this topic, in contrast to 5.4% (n=12) of women ($p=0.009$). A weak correlation exists (Cramer's $V=0.160$); yet it may be asserted that sex influences the level of awareness. A

Table 1. Demographic characteristics of the studied individuals

Demographic characteristics	n	%	χ^2	df	P	
Age	Under 30	151	41.1	65.817	3	0.000
	30–40	85	23.2			
	41–50	89	24.3			
	Over 50	42	11.4			
	Total	367	100.0			
Years of professional experience	Under 5	144	39.2	139.213	3	0.000
	5–10	42	11.4			
	11–20	152	41.4			
	Over 20	29	7.9			
	Total	367	100.0			
Workplace	Individual practice	187	51.0	0.134	1	0.715
	Group practice	180	49.0			
	Total	367	100.0			

*Chi-square test was used to assess distribution differences

Table 2. Distribution of dentists' answers to questions assessing their knowledge of the characteristic oral manifestations of diphtheria and their knowledge of the anti-epidemic measures

Questions		n	%
Do you know the clinic and epidemiology of diphtheria?	Yes	145	39.5
	No	33	9.0
	Partially	189	51.5
What is the mechanism of transmission of diphtheria?	Airborne	239	65.1
	Blood	128	34.9
Do you think that you can transmit the infection to your other patients through instruments/surfaces/equipment contaminated with diphtheria bacteria?	Yes	132	36.0
	Rather yes	143	39.0
	I have no opinion	92	25.1
Do you think that diphtheria has a characteristic oral manifestation?	Yes	367	100.0
	Thick pseudomembranes on the tonsils and pharynx	146	39.8
	Pain when swallowing	113	30.8
	Thick pseudomembranes on the tonsils and pharynx; bad breath from the mouth; ulcerations on the mucous membrane	7	1.9
	Thick pseudomembranes on the tonsils and pharynx; bad breath from the mouth; bleeding gums	15	4.1
	Thick pseudomembranes on tonsils and pharynx and bleeding gums	16	4.4
	All together	70	19.1
Have you encountered a case of a patient with suspected diphtheria in your practice?	No	367	100.0
Do you know what measures you should take in case of doubt?	Yes	187	51.0
	Partially	180	49.0
If your answer is "yes", please indicate the measures	Strict disinfection of all objects from the external dental environment	134	36.5
	Strict disinfection of all objects from the external dental environment and ventilation of the entire office	46	12.5
	Strict disinfection of all objects from the external dental environment and ventilation of the entire office, notifying the patient's GP and notifying the RHI of a probable case of diphtheria	187	51.0
Do you think that diphtheria still poses a risk to society?	Yes	32	8.7
	Only for the unvaccinated	178	48.5
	No	157	42.8
Do you think that additional training is necessary?	Yes	295	80.4
	No	18	4.9
	Cannot assess	54	14.7

statistically significant correlation was found between sex and knowledge of diphtheria transmission in dental offices through contaminated objects, equipment, and instruments. 24.3% (n=35) of males and 43.5% (n=97) of women provided affirmative responses, indicating that women exhibit greater decisiveness in their answers ($p=0.000$). The association is weak, however, present (Cramer's $V=0.231$).

The study by age groups revealed that the most unfavorable responses for knowledge of the clinic and epidemiology of diphtheria were provided by those aged 30–40 years, with a rate of 25.9% (n=22) ($p=0.000$).

A correlation exists between the years of professional experience and understanding of diphtheria's clinical and epidemiological aspects. The highest proportion of erro-

neous responses was observed among those with 11–20 years of experience, totaling 15.8% (n=24) ($p=0.008$). The workplace proved to be a crucial determinant of awareness levels. Professionals in individual dental practices showed markedly superior knowledge, with 64.7% (n=121) providing a correct response regarding the principal clinical and epidemiological features of diphtheria ($p=0.000$). A strong association was established (Cramer’s $V=0.550$), indicating that the type of practice has a decisive impact.

The correlation between the type of practice and the respondents’ self-evaluation of their understanding of diphtheria transmission methods is noteworthy. Among individuals employed in private practices, 44.9% (n=121) confirmed a definite “yes”, indicating that they believed they had full awareness, while 36.4% (n=68) responded with a “rather yes”. In group practices, the corresponding figures were 26.7% (n=48) and 41.7% (n=75), respectively. In solo dental practices, 81.3% of employees reacted positively, whereas in group practices, the percentage was 68.3% ($p=0.000$).

To assess the complex influence of the independent variables on the self-assessment of dentists, binary logistic regression was applied. The regression model showed statistical significance (Omnibus test: $\chi^2=112.708$, $df=4$, $p<0.001$), with good fit (Hosmer-Lemeshow test, $p>0.05$), explaining 35.8% of the variance of the dependent variable (Nagelkerke R^2). **Table 3** presents the factors that in previous analyses correlated with self-assessment and were included in the logistic model.

The correlation between the type of practice and the respondents’ self-evaluation of their understanding of diphtheria transmission methods is noteworthy. Among individuals employed in private practices, 44.9% (n=121) affirmed a definitive “yes,” indicating they believe they possess complete awareness, whereas 36.4% (n=68) responded with a “rather yes”. In group practices, the corresponding figures are 26.7% (n=48) and 41.7% (n=75), respectively. In solo dental practices, 81.3% of employees reacted positively, whereas in group practices, the percentage was 68.3% ($p=0.000$).

Discussion

Diphtheria is an acute infection that has emerged as a sig-

nificant issue in numerous regions globally in recent years. It presents distinctive symptoms in the oral cavity, making it imperative for dentists to be knowledgeable about it and its modes of transmission. They must first identify the infection through its oral expression and differentiate it from other infections with similar symptoms before referring the patient with suspected diphtheria to the appropriate specialists. Diphtheria is an infection mostly transmitted through airborne droplets; however, home contact transmission is also feasible due to the pathogen’s significant resilience in the external environment.^[14,18] The proportion of respondents providing this answer was insufficient at 65.1% (n=239), while the remaining 34.9% (n=128) were unaware of the transmission method.

Epidemiological reasons for the spread of diphtheria in dental offices include contamination of instruments, surfaces, and equipment with diphtheria bacteria.^[7,8] Merely 36.0% (n=132) of our respondents evaluated this risk. The results indicate a lack of understanding regarding the transmission routes of diphtheria at the dental workplace. The oral manifestations of diphtheria are notably varied. Solano et al. reported a case of a 15-year-old child in Venezuela who presented with an atypical clinical profile, including macroglossia, dyspnea, dysphagia, odynophagia, recurrent fever episodes, gradual weight loss, and enlargement of the left buccal region. Pseudomembranous plaques were noted on the tongue and oral cavity.^[19]

A notable characteristic of diphtheria in adults is the elevated prevalence of toxic variants and the increased incidence of severe combination forms and uncommon localizations. The oral cavity is one of the uncommon sites for this infection. A study undertaken in 1995 evaluated twelve subjects afflicted with the condition, which was localized to the upper and lower lips, hard and soft palate, cheeks, and tongue. The scientific analysis concluded that the incidence of formerly uncommon diphtheria localizations had increased, thereby complicating the diagnosis and treatment of the disease.^[20]

A membrane usually forms on one or both tonsils and spreads to the tonsillar pillars, uvula, soft palate, oropharynx, and nasopharynx. The pseudomembrane appears white at first, but gradually turns dirty grey over time. Upon conclusion of the infection, patches of green or black necrosis may be present.^[21-24] Additional clinical signs may encompass pharyngodynia, wheezing, lymphadenopathy,

Table 3. Factors influencing the self-assessment of dentists

	B	S.E.	Wald	df	Sig.	Exp(B)	95% CI for EXP(B)	
							Lower	Upper
Sex	0.188	0.266	0.497	1	0.481	1.206	0.716	2.032
Workplace	2.607	0.283	84.893	1	0.000	13.560	7.788	23.611
Age	0.382	0.236	2.613	1	0.106	1.466	0.922	2.329
Professional experience	-0.165	0.234	0.501	1	0.479	0.848	0.536	1.340
CONSTANT	-2.445	0.415	34.737	1	0.000	0.087		

dyspnea, rhinorrhea, pyrexia, and chills.^[7,14]

While all respondents recognized that diphtheria presents with a distinctive oral manifestation, only 19.1% (n=70) accurately identified all the enumerated features associated with oral symptoms, and the remainder provided correct yet incomplete responses. Understanding the appropriate steps for a patient suspected of diphtheria infection remains inadequate, with just 51.0% (n=187) identifying all the correct protocols. This indicates that the other half was unaware and hence could not implement all measures comprehensively.

The most commonly affected age group is children under five years of age who have not been immunized. This requires increased attention when administering the vaccine according to the immunization schedules of all countries, especially against the backdrop of emerging military conflicts, among migrants, refugees and others, where their implementation is difficult. According to data for 2024 published by UNICEF and WHO, the immunization coverage of the diphtheria vaccine in Bulgaria with the first dose of the six-component vaccine, which also includes diphtheria toxoid, is 95.6%, the second dose – 94.9%, and the third dose – 94.2%.^[25] The coverage with the third dose remains below the recommended value of 95% to achieve collective immunity.

Globally, in 2024, approximately 89% of infants received at least one dose of DTP vaccine, and 85% completed the full three-dose series (DTP3).^[26,27] The COVID-19 pandemic and the challenges faced by health systems in response have led to a disruption in the implementation of immunizations, including against diphtheria. Undoubtedly, misinformation among the population and anti-vaccination movements play an important role in this direction. According to data from various studies, in various economically developed countries, the coverage of at least one dose of DTP has decreased, which is worrying and should increase our attention.^[28-31]

Despite the modest sample size, our study revealed a consistent trend in the implementation of the immunization calendar. The data indicated that 49.3% (n=181) of the participants had received all doses of the vaccination according to the Bulgarian immunization calendar. However, it is concerning that a similar proportion of individuals had not received all doses. It is crucial to note that our inquiry focuses on the administration of doses as outlined in our schedule for individuals aged 25 to 75 years, given that our respondents are all practicing physicians, thus being above 25 years of age.

They should have been vaccinated with the previous doses in childhood according to the immunization calendar, which should be applied as follows: primary immunization – at 2, 3, and 4 months; booster doses – at 16 months, 6 years, 12 years, and 17 years; then – periodic revaccinations against diphtheria and tetanus every 10 years (from 25 to 75 years).^[32] Regarding their subsequent neglect of vaccination after 25 years, most often 47.4% (n=174) could not indicate a specific reason why they were

not vaccinated. This trend is alarming, since the infection can be imported or acquired while traveling to endemic areas of the world.^[33]

The likely explanations for the observed deficiency in dentists' knowledge are: most dentists have likely not seen diphtheria cases, as no instances have been recorded in Bulgaria since 1994. The absence of practical experience diminishes the likelihood of achieving an appropriate clinical diagnosis.

The focus of dental practice frequently centers on esthetic, restorative, and therapeutic procedures for patients' teeth, rather than on the oral manifestations of infectious disorders. Infectious diseases are inadequately prioritized in the education of dentistry students.

Limitations of the study

- Data were collected through an online survey, and participation was voluntary, but limited to dentists active on professional platforms; thus, it does not fully reflect the general population of dentists, but rather the younger ones among them.
- The study is based on self-reporting and there is a risk that respondents may have given socially acceptable answers
- The reliability of the answers cannot be independently verified, as the survey is anonymous and there is no mechanism for verifying the reality of the declared knowledge or experience.

Conclusion

The absence of theoretical knowledge regarding epidemiological factors, transmission mechanisms and typical oral manifestations among dental practitioners is likely to result in the neglect of all necessary measures to prevent the spread of diphtheria in their clinical practice, i.e., the potential risk is not known by everyone and is not fully assessed. The study provides a foundation for future research and, most importantly, postgraduate training for practicing dental practitioners, helping to identify knowledge gaps among them regarding infectious diseases with potential oral manifestations.

The results highlight the necessity to direct the attention of students during their training, as well as of dental practitioners as part of their postgraduate training, to maintaining up-to-date knowledge about rare but potentially serious infectious diseases such as diphtheria.

Ethical approval

The Local Ethics Committee of the Medical University of Plovdiv granted an approval for the study by protocol No. 24 of September 19, 2025.

Ethical statements

- The authors declared that no clinical trials were used in the present study.
- The authors declared that no experiments on humans or human tissues were performed for the present study.
- The authors declared that all respondents were asked if they wanted to participate in the survey by placing a tick at the beginning of the administered questionnaire.
- The authors declared that no experiments on animals were performed for the present study.
- The authors declared that no commercially available immortalized human and animal cell lines were used in the present study.

Conflict of interest

The authors have declared that no competing interests exist.

Use of AI

No use of AI was reported.

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Author contributions

VS: concept and design of the study, data collection, wrote the target version of the manuscript; RS: performed statistical analysis of the data and their interpretation; VK: concept, design and organization of the study. All authors approved the final text and were responsible for the decision to submit for publication.

Data availability

All data used are referenced or included in the article.

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