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IMPACT OF THE FACE MASK WEARING ON THE DRY EYE SYMPTOMS IN DENTISTRY

GRADUATE THESIS

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Dedication

To my mentor, Assoc. Prof. Ivanka Petric Vicković, MD, PhD, thank You for selfless help, patience and knowledge that guided me throughout this process.

To my parents, brother and grandparents, without you, this whole journey would not be possible. I owe you everything.

To my friends, which I consider family, thank you for sharing unforgettable moments and everyday support.

To my Guardian from above, thank You for all that has been and is yet to come.

IMPACT OF THE FACE MASK WEARING ON THE DRY EYE SYMPTOMS IN DENTISTRY

Summary

The purpose of this study is to analyze the presence of self-reported mask-related dry eye disease (MADE) during the COVID-19 pandemic in healthcare practitioners.

A cross-sectional study included 405 dental healthcare professionals who voluntarily and anonymously completed a survey. The online questionnaire consisted of 17 questions and included demographic characteristics and clinical characteristics: presence and deterioration of dry eye disease (DED) symptoms while wearing the face mask, personal protective face equipment, use of contact lenses, history of eye surgery, current use of medications, number of hours wearing face mask, and evaluation of subjective DED symptoms using modified Ocular Surface Disease Index (OSDI).

An overall prevalence of MADE in our study group was 29.1% (95% CI: 24.7 - 33.6).

Participants with MADE had a statistically higher OSDI score (31.25 (IQR = 22.92 – 43.75)) compared to the previous DED and non-DED participants (16.67 (IQR = 4.17 - 25), 4.17 (IQR = 0 – 10.42)) respectively.

A statistically higher OSDI score 12.5 (IQR = 4.17 – 29.17) was reported by the participants who used masks more than 6 hours at the workplace compared to the participants who used masks less than 6 hours a day at the workplace, 8.33 (IQR = 0 – 22.92); Mann-Whitney U Test $p = 0.040$).

The prevalence of self- reported MADE among dental healthcare practitioners appears to be significant. The use of a face mask for prolonged duration increases OSDI scores.

Keywords: dentists; face masks; dry eye; MADE; ocular discomfort; COVID-19; protective face equipment

Utjecaj nošenja maske za lice na simptome suhoće oka kod stomatologa

Sažetak

Cilj rada bio je analizirati samoprijavljeni sindrom suhog oka povezanog s nošenjem maske (engl. mask-related dry eye - MADE) kod stomatologa tijekom epidemije bolesti COVID-19. Ova presječna studija uključila je 405 dentalnih zdravstvenih djelatnika koji su dobrovoljno i anonimno ispunili anketu. Online upitnik se sastojao od 17 pitanja koja su obuhvaćala demografske i kliničke podatke: prisutnost i pogoršanje simptoma bolesti suhog oka (engl. dry eye disease - DED) tijekom nošenja maske za lice, osobne zaštitne opreme za lice, korištenje kontaktnih leća, povijest operacija oka, trenutnu upotrebu lijekova, broj sati nošenja maske za lice i procjenu subjektivnih simptoma DED-a s pomoću modificiranog indeksa za bolesti očne površine (OSDI).

Ukupna prevalencija MADE u našoj studijskoj skupini iznosila je 29,1% (95% CI: 24,7 - 33,6). Sudionici s MADE-om imali su statistički viši OSDI rezultat (31,25 (IQR = 22,92 – 43,75)) u usporedbi s prethodnim DED i ne-DED sudionicima (16,67 (IQR = 4,17 - 25), 4,17 (IQR = 0 – 10,42)) respektivno. Statistički viši OSDI rezultat 12,5 (IQR = 4,17 – 29,17) zabilježen je kod sudionika koji su koristili maske više od 6 sati na radnom mjestu u usporedbi sa sudionicima koji su koristili maske manje od 6 sati dnevno na radnom mjestu, 8,33 (IQR = 0 – 22,92); Mann-Whitney U test p = 0,040). Prevalencija samoprijavljenog MADE-a među dentalnim zdravstvenim djelatnicima čini se značajnom. Dugotrajna uporaba maske za lice povećava OSDI rezultate.

Ključne riječi: stomatolozi; maske za lice; suho oko; MADE; nelagoda u očima; bolest COVID-19; zaštitna oprema za lice

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List of abbreviations

ATM- Active Management Technology

CDC-Centers for Disease Control and Prevention

CI-Confidence Interval

EDE-Evaporative Dry Eye

MADE-Mask-Related Dry Eye

MGD-Meibomian Gland Dysfunction

NFkB-Nuclear Factor kB

WHO-World Health Organization

DED-Dry Eye Disease

IQR-Interquartile Range, Median Score

MAPK-Mitogen-Activated Protein Kinase

OD- Odds Ratio

OSDI-Ocular Surface Disease Index

SANDE-Symptom Assessment in Dry Eye

SPSS-Statistical Program for Social Sciences

TDEE-Tear-Deficient Dry Eye

TBUT-Tear Break Up Time

1. INTRODUCTION

Chronic condition known as dry eye disease (DED) is a major issue on a global scale. One of the most frequent reasons patients visit ophthalmologists is DED, which affects over 340 million people worldwide. The first formal definition od DED was published in 1995 by the National Eye Institute, International Dry Eye Workshop. The definition of DED has envolved and been supplemented over the years, so today we use the definition established in 2017, which states that DED is: “a multifactorial disease of the ocular surface characterized by a loss of homeostasis of the tear film, and accompanied by ocular symptoms, in which tear film instability and hyperosmolarity, ocular surface inflammation and damage, and neurosensory abnormalities have etiological roles” (1).

Contemporary understanding of the tear film differs significantly from historical knowledge dating back to the middle of the last century. During that time, it was commonly believed that the tear film consisted of three distinct and separate layers: outer lipid, middle aqueous and inner mucin. According to today's research, the mucous-aqueous layer is considered a single layer that actually forms a gel, so the term mucous-aqueous gel is mostly used (2), and the entire tear film complex is considered a dynamic unit of a double structure consisting of a mucous-aqueous layer and a superficial thin lipid layer.

Outer lipid layer is secreted by meibomian glands. Secretion is facilitated through blinking—each blink compresses the eyelid tissue, triggering the release of secretions from the Meibomian glands (2, 3) Function of the lipid layer is to lower surface tension of the tear film, delay evaporation of the aqueous layer of the tear film and lubrication of eyelids (3).

Middle aqueous layer is secreted by the lacrimal glands. It’s made of proteins, electrolytes and water (3). Electrolytes are responsible for tear osmolarity (2), while proteins such as IgA, lactoferrin and lysozyme have antibacterial roles. Function of this layer is to provide oxygen for avascular corneal epithelium.

Inner mucin layer is secreted by the conjunctival goblet cells which are the crypts of Henle and the glands of Manz (2, 3). The mucous layer possesses viscoelastic properties, allowing it to spread smoothly over the surface of the eye to cover any irregularities or damage as well as lubrication (2, 3).

In 1996, the NEI/Industry Workshop on Dry Eye categorized dry eye into two types:

1. Tear-deficient dry eye (TDDE), stemming from a lack of tears.
2. Evaporative dry eye (EDE), characterized by excessive tear evaporation (2).

McCulley et al propose more precise terminology: hyposecretory dry eye and hyperevaporative dry eye (2).
Hyposecretory dry eye typically results from insufficient secretion of the aqueous component of the tear film, often referred to as dry eye in general (3).
Hyperevaporative dry eye, a relatively novel clinical term, arises from inadequate function of the tear lipid layer. In this condition, tear secretion may be normal or even excessive, but increased evaporation due to an inadequate lipid layer leads to tear dysfunction. It might be caused due to oil deficiency or due to improper restoration of the eye surface (2, 3).
The significance of hyperevaporative dry eye lies in its association with tear film dysfunction in younger individuals, which is rapidly increasing today due to long-term work at the computer, staying in air-conditioned rooms, etc (2).

Hyperosmolarity of the tear film is the primary pathophysiological basis underlying hyperevaporative and hyposecretory dry eye. It arises from evaporation, implying that dry eye always includes an evaporative component regardless of its etiology (2). Tear hyperosmolarity is a key mechanism in dry eye disease because it triggers a cascade of compensatory events that leads to inflammation of the ocular surface and this mechanism is known as the *vicious circle of DED* (4, 5).

Osmotic imbalances in the tear film lead to hyperosmolarity of the tears and associated cell dehydration. This leads to cell damage and apoptosis of conjunctival and corneal cells.

Epithelial cell stress activates mitogen-activated protein kinase (MAPK) and nuclear factor κB (NFκB), initiating the activation of inflammatory cytokines, proapoptotic factors, and proteases. Those mediators contribute to the damage of the epithelial glycocalyx and loss of goblet and epithelial cells. T-lymphocytes are also triggered thus producing various inflammatory mediators. This cascade of events leads to damage of the tear film (4).

Furthermore, environmental factors and personal habits also have an effect on tear hyperosmolarity. These include air humidity and temperature, wind speed, as well as individual factors like blinking frequency and eye aperture width (2).

The diagnosis of dry eye syndrome presents a complex challenge due to its multifactorial nature and the variability of symptoms among individuals. Clinicians rely on a combination of subjective assessments, objective measurements, and clinical judgment to accurately diagnose this condition (3, 6).

Subjective evaluation involves obtaining a detailed medical history and assessing symptoms reported by the patient, such as ocular discomfort, dryness, irritation, and fluctuating vision. Questionnaires, such as the Ocular Surface Disease Index (OSDI), (Figure 1.) or the Symptom Assessment in Dry Eye (SANDE) questionnaire, can aid in quantifying symptom severity and impact on quality of life (6).

Ocular Surface Disease Index© (OSDI©)[2]

Ask your patients the following 12 questions, and circle the number in the box that best represents each answer. Then, fill in boxes A, B, C, D, and E according to the instructions beside each.

Have you experienced any of the following *during the last week*?	All of the time	Most of the time	Half of the time	Some of the time	None of the time
1. Eyes that are sensitive to light? . .	4	3	2	1	0
2. Eyes that feel gritty?	4	3	2	1	0
3. Painful or sore eyes?	4	3	2	1	0
4. Blurred vision?	4	3	2	1	0
5. Poor vision?	4	3	2	1	0

Subtotal score for answers 1 to 5 (A)

Have problems with your eyes limited you in performing any of the following *during the last week*?	All of the time	Most of the time	Half of the time	Some of the time	None of the time	N/A
6. Reading?	4	3	2	1	0	N/A
7. Driving at night?	4	3	2	1	0	N/A
8. Working with a computer or bank machine (ATM)?	4	3	2	1	0	N/A
9. Watching TV?	4	3	2	1	0	N/A

Subtotal score for answers 6 to 9 (B)

Have your eyes felt uncomfortable in any of the following situations *during the last week*?	All of the time	Most of the time	Half of the time	Some of the time	None of the time	N/A
10. Windy conditions?	4	3	2	1	0	N/A
11. Places or areas with low humidity (very dry)?	4	3	2	1	0	N/A
12. Areas that are air conditioned? . . .	4	3	2	1	0	N/A

Subtotal score for answers 10 to 12 (C)

Add subtotals A, B, and C to obtain D
(D = sum of scores for all questions answered) (D)

Total number of questions answered
(do not include questions answered N/A) (E)

Please turn over the questionnaire to calculate the patient's final OSDI© score.

Figure 1. The OSDI Questionnaire consists of items that ask patients about how their dry eye affects daily activities (7).

Objective assessments typically include a comprehensive eye examination to evaluate tear film stability, tear production, ocular surface integrity, and eyelid function. Specialized tests may be employed to measure tear volume and quality, including tear breakup time (TBUT), Schirmer's test, tear osmolarity, tear film lipid layer analysis, and ocular surface staining with vital dyes such as fluorescein and lissamine green (3, 6).

The tear breakup time (TBUT) test is a key diagnostic tool used to assess tear film stability and detect abnormalities associated with dry eye disease. The time it takes from blinking to the onset of tear film break-up is measured as the tear film break-up time (TBUT), (Figure 2.).

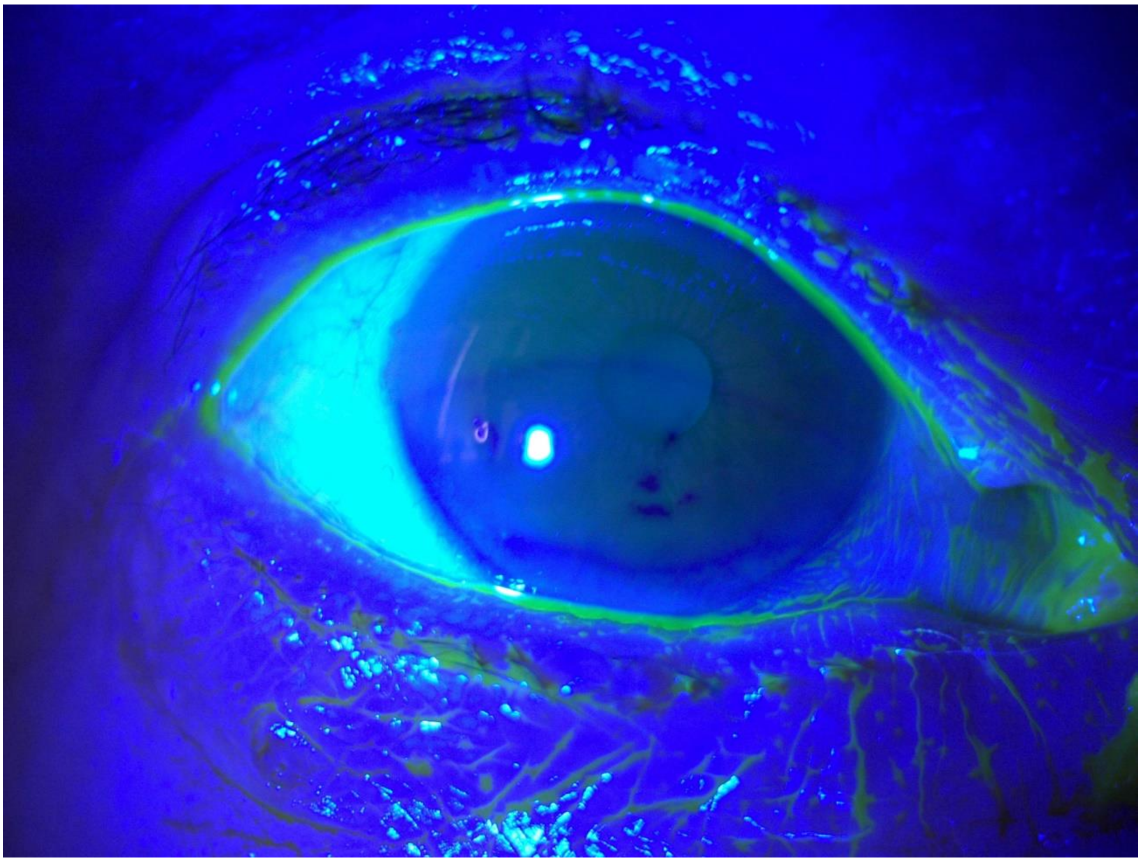

Figure 2. Tear break-up time showing breaks in the fluorescein. Taken with permission of the author: Asocc. Prof. Ivanka Petric Vicković, MD, PhD.

A shorter TBUT, less than 10 seconds, indicates reduced tear film stability and may suggest underlying dry eye disease or other ocular surface disorders (3, 6).

The expression of Meibomian glands is a crucial aspect of evaluating the function and health of the ocular surface.

Meibomian glands, located within the eyelids, play a vital role in producing the lipid component of the tear film, which helps prevent tear evaporation and maintains ocular surface lubrication

(3, 6). This test is used to diagnose hyperevaporative dry eye. During Meibomian gland expression, gentle pressure is applied to the eyelids to express the glandular secretions onto the ocular surface. This process allows clinicians to assess the quantity and quality of the meibum, the oily substance produced by the glands.

The Schirmer test is a diagnostic tool used to measure the quantity of tear production, known as aqueous tear production, in individuals suspected of having dry eye disease or other ocular surface disorders. This test provides valuable information about tear film dynamics and ocular surface health. The Schirmer test is particularly useful in differentiating between aqueous-deficient dry eye and evaporative dry eye, as well as assessing the severity of tear deficiency (6).

It's important to recognize that dry eye is a heterogeneous condition with various underlying etiologies, including aqueous deficiency, evaporative dysfunction, or a combination of both. Therefore, a comprehensive diagnostic approach tailored to each patient's specific clinical presentation is essential for accurate diagnosis and personalized management strategies (2).

DED is a rapidly expanding health issue globally, with a prevalence ranging from 20 to 50% worldwide (8). Many risk factors for DED have been identified such as older age, female gender (8), the use of systemic medications, previous ophthalmological surgical procedures, contact lens wearing, and environmental factors (1). Although DED is considered a disease of older people, DED is increasingly present in the younger population. (9, 10).

The increase in the prevalence of DED is also a result of changes in lifestyle and new circumstances. As a consequence of the COVID infection, wearing a face mask has become mandatory to reduce the spread of the infection. COVID-19 could be spread via the aerosol route, hence the widespread use of face masks as well as physical distancing and hand hygiene was recommended during the COVID-19 pandemic (11).

Although physical distancing has not always been practicable during the COVID-19 pandemic, it is advised that people wear face masks in both public and enclosed areas to prevent the spread of the virus (12, 13).

In the majority of countries, face mask usage has been compulsory and has integrated into our daily habits. Therefore, it is advised that healthcare workers wear face masks as a crucial infection control measure in medical settings. Following the guidelines, dentists in Croatia should persist in wearing face masks in their practices (14).

During the COVID pandemic, wearing a face mask was mandatory, and as a consequence of prolonged mask-wearing, a new entity called MADE has been described (15-17).

DED is characterized by a number of symptoms of discomfort like foreign body sensation, burning, gritty feeling, itching, tearing and dryness. (2).

For an accurate assessment of DED, it is beneficial to record the subjective symptoms of DED using questionnaires completed by the patients themselves in addition to clinical results.

The symptoms of dry eye are very important in diagnosing DED, because what we actually treat are the symptoms of the disease. Therefore, treatment is sometimes necessary even if we only have positive symptoms of the disease. This prompted us to examine the frequency of dry eye symptoms among dentists who use face masks in the workplace, as mask-wearing extended during the COVID pandemic (18).

The purpose of this study is to analyze the presence of self-reported MADE during the COVID-19 pandemic in healthcare practitioners.

2. MATERIAL AND METHODS

This cross-sectional study was conducted in collaboration with the School of Dental Medicine at the University of Zagreb and the Sestre Milosrdnice University Hospital Centre. The participants included registered dentists working in Croatian national healthcare facilities, encompassing both private and public clinics, as well as general and specialist dentists.

All participants received an online questionnaire designed in survey software (Google Forms®). The questionnaire was completely anonymous, and participation in the research was voluntary. After reading the informative consent form, confirming understanding of the purpose, and consenting to participate in the survey, participants were given access to the questionnaire. Data gathering occurred between February 2022 and August 2022. Out of 1000 dental healthcare professionals who received the questionnaire, 405 provided responses, resulting in a response rate of 40.5%. The Ethics Committee of the Faculty of Dentistry at the University of Zagreb granted approval for the research, aligning with the principles outlined in the Declaration of Helsinki.

The questionnaire consisted of 17 questions divided into three parts. The first section included demographic characteristics of the participants: age, gender, and place of work (21 counties were grouped into five regions: the City of Zagreb, Istria, Lika, Gorski kotar and Kvarner, Dalmatia, Northern Croatia, and Slavonia) . We also analyzed the length of wearing a face mask, in the way that we analyzed the lenght of wearing a face mask during working hours, and the total length of wearing a mask throught the day. The time of wearing the face mask is divided into 4 categories: using a mask less than 3 hours, from 3 to 6 hours, from 6 to 9 hours, and more than 9 hours. We also analyzed the presence of previous DED symptoms, the use of DED therapy, and the presence of DED symptoms when using a face mask, and if there were previous DED symptoms, the worsening of those symptoms while wearing a face mask. YES/NO answers were used for the last four questions..

The second section of the questionnaire investigated the presence of DED risk factors such as previous eye surgery, use of contact lenses, current use of medications, and wearing additional protective face equipment (visor, refractive glasses with or without magnification, protective glasses, etc.).

The third part investigated the presence of subjective DED symptoms using modified Ocular Surface Disease Index (OSDI). The standard OSDI questionnaire was modefied in such a way that „while wearing a face mask“ was added to the questions used to evaluate dry eye symptoms.

For example, the question „Have problems with your eyes limited you in performing any of the following during the last week?“ was modified to „Have problems with your eyes limited you in performing any of the following during the last week while wearing a face mask?“ (19).

The Ocular Surface Disease questionnaire assesses DED symptoms and the effects it has on vision-related function in the past week of the patient's life. The questionnaire is divided into three subscales: ocular symptoms, vision-related function and environmental triggers. To identify DED symptoms, the question “Have you experienced any of the following during the last week while wearing a face mask?” (items 1–5: eyes that are sensitive to light, eyes that feel gritty, painful or sore eyes, blurred vision, and poor vision) was asked. Question “Have problems with your eyes limited you in performing any of the following during the last week while wearing a face mask?” (items 6 –9: reading, driving at night, working with a computer or bank machine, and watching TV) was used to identify vision-related functions. To identify DED environmental triggers, the question “Have problems with your eyes limited you in performing any of the following during the last week while wearing a face mask?” (items 10 – 12: windy conditions, places or areas with low humidity, and areas that are air-conditioned). was used. Patients rate their responses on a 0 to 4 scale with 0 corresponding to “none of the time” and 4 corresponding to “all of the time.” The total OSDI score was calculated according to the formula OSDI= (sum scores)x25/(number of questions answered). The scale is ranged from 0 to 100 with scores 0 to 12 representing normal, 13 to 22 representing mild dry eye disease, 23 to 32 representing moderate dry eye disease, and greater than 33 representing severe dry eye disease. This study also adopted the criteria followed by other researchers; hence, symptomatic DED is defined as any OSDI score exceeding 22 (8).

MADE was characterized as a new onset or worsening pre-existing DED symptoms while wearing a face mask. Both individuals experiencing new DED symptoms under a face mask and those whose pre-existing symptoms exacerbated while wearing one, were included in the MADE.

For statistical analysis, SPSS software package (Statistical Package for Social Sciences version 18.0, Chicago, IL) was used. The OSDI results did not exhibit a normal distribution as per the Kolmogorov-Smirnov test, necessitating the use of non-parametric tests: the Mann-Whitney test for comparing two groups and the Kruskal-Wallis test for comparing more than two groups. The Chi square test was used for comparing categorical variables.

3. RESULTS

The study included a total of 405 dental health professionals who voluntarily completed the survey. Dentists from all parts of Croatia were included, and Croatia was divided into 5 regions: the City of Zagreb, Istria, Lika, Gorski Kotar and Kvarner, Dalmatia, Northern Croatia, and Slavonia. The largest number of participants came from the City of Zagreb (36%). Most of the members who completed the survey were from the Northern Croatia region, according to the distribution by the individual Regional Headquarters of the Croatian Dental Chamber (20), (Figure 3.).

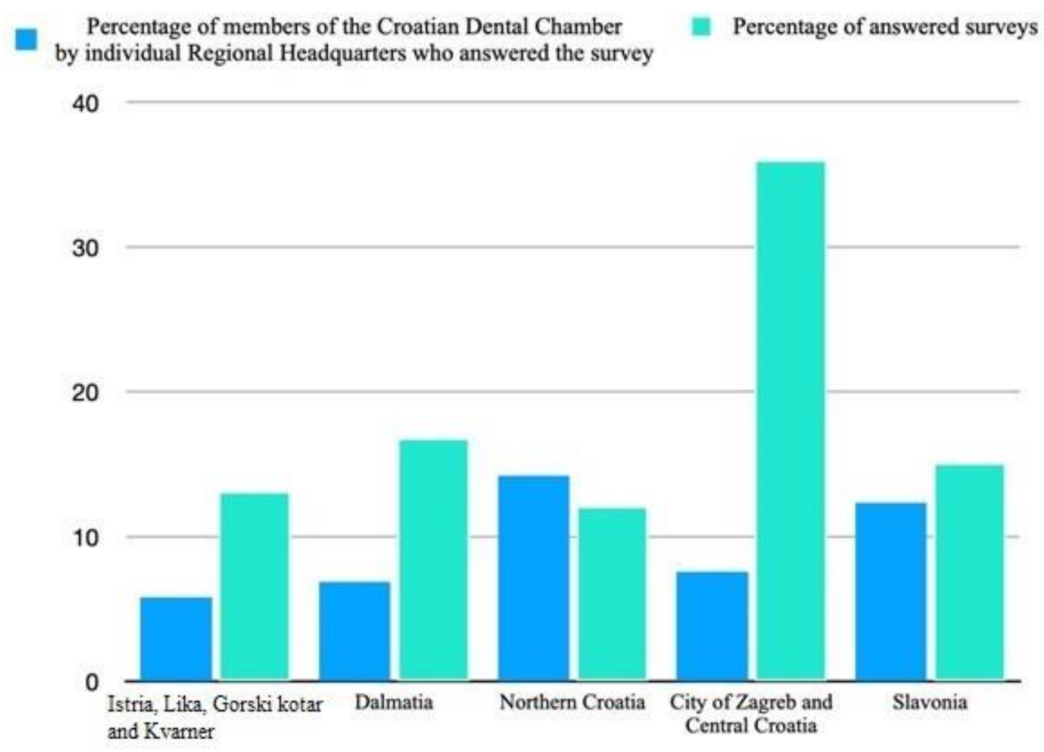

Figure 3. Geographical distribution of the participants in the study and answered surveys by the number of members of the Croatian Dental Chamber by individual Regional Headquarters (Y-axis = percentage of participants)

Participants were divided into three age groups: 56.6% were under 40 years old, 33.1% were between 41 and 60 years old, and 8.4% were over 61 years old. Regarding gender, 75.6% of respondents were women, while the representation of men was 24.4% (Table 1.).

Table 1. Study sampled demographic characteristics

		Non-DED No (%)	MADE No (%) Prevalence (%) (95% CI)	Previous DED No (%)	Total No Prevalence (%) (95% CI)	P value
Overall		238 (58.8%)	118 (29.1%)	49 (12.1%)	405 100%	
Age (years)	≤40	151 (63.45%)	56 (47.46%)	22 (44.90%)	229 56.5% (51.6-61.5)	p=.00219
	41-60	76 (31.93%)	45.(38.14%)	21(42.86%)	142 35.1% (30.4-39.7)	
	>61	11 (4.62%)	17 (14.41%)	6 (12.24%)	34 8.4% (5.7-11.1)	
Sex	Female	172 (72.27%)	93 (78.81%)	41(83.67%)	306 75.6% (71.4-79.8)	p=.13781
	Male	66 (27.73%)	25 (21.19%)	8 (16.33%)	99 24.4% (20.2-28.6)	

Risk factors for the development of DED and their distribution are shown in Table 2. Glasses were the most commonly used for correcting refractive errors (42.2%), while 13.6% of participants wore contact lenses. The most frequently used systemic therapy was hormone therapy (11.1%), followed by antihistamines (7.2%), and antihypertensives (6.9%). The most common reported personal protective face equipment was visor (68.1%).

Table 2. Distribution of possible risk factors for MADE

Factor		nonDED	MADE	Previous DED	P value	Factor		nonDED	MADE	Previous DED	P value
		No (%)	No (%)	No (%)				No (%)	No (%)	No (%)	
history of eye surgery	Yes	220 (92.44%)	112 (94.92%)	43 (87.76%)	p=.27139	Working hours facemask wearing	> 6h	124 (52.1%)	81 (68.6%)	28 (57.1%)	p=.012
	No	18 (7.56%)	6 (5.08%)	6 (12.24%)			< 6h	114 (47.9%)	37 (31.4%)	21 (42.9%)	
use of contact lenses	No	212 (89.08%)	101 (85.59%)	37 (75.51%)	p=.03939	All day facemask wearing	> 6h	177 (74.4%)	99 (83.9%)	36 (73.5%)	p=.108
	Yes	26 (10.92%)	17 (14.41%)	12 (24.49%)			< 6h	61 (25.6%)	19 (16.1%)	13 (26.5%)	
Hormone replacement therapy	No	214 (89.9%)	106 (89.9%)	40 (81.6%)	p=.226	Visor	No	73 (30.7%)	39 (33.1%)	17 (34.7%)	p=.813
	Yes	24 (10.1%)	12 (10.2%)	9 (18.4%)			Yes	165 (69.3%)	79 (66.9%)	32 (65.3%)	
Antihistamine therapy	No	222 (93.3%)	105 (89%)	49 (100%)	p=.039	Refractive glasses	No	140 (58.8%)	68 (57.6%)	26 (53.1%)	p=.758
	Yes	16 (6.7%)	13 (11%)	0 (0.0%)			Yes	98 (41.2%)	50 (42.4%)	23 (46.9%)	
Antihypertensive therapy	No	226 (95%)	104 (88.1%)	47 (95.9%)	p=.041	Protective glasses	No	217 (92.2%)	103 (87.3%)	44 (89.8%)	p=.519
	Yes	12 (5%)	14 (11.9%)	2 (4.1%)			Yes	21 (8.8%)	15 (12.7%)	5 (10.2%)	

42.5% of participants reported wearing a face mask for less than 6 hours during working hours, while 57.6% of participants wore a face mask for more than 6 hours. During the surveyed period (during the COVID pandemic), longer face mask usage was recorded among dentists throughout the entire day (face masks were worn both at work and outside of work), with 77.1% of dentists wearing a face mask for more than 6 hours throughout the entire day.

Regarding self-reported dry eye symptoms, 23.2% (94/405) of participants reported having dry eye symptoms before they started prolonged mask use. Therefore, 47.9% (n=45) of these participants indicated that their pre-existing DED symptoms worsened while wearing a face mask, whereas the remaining 52.1% (n=49) stated that there was no change in their DED symptoms due to mask-wearing. The reported prevalence of previous DED was 12.1%. (95% CI: 9.1 - 15.8), these were paticipants whose dry eye symptoms did not increase while wearing a face mask.

An overall prevalence of MADE in our study group was 29.1% (95% CI: 24.7 - 33.6), and this prevalence included participants who reported newly developed DED symptoms while wearing face mask (18%), as well as those who reported worsening of existing DED symptoms while wearing face masks (11.1%).

The prevalence of DED was higher among female, 78.8% (CI: 73.3 - 94.0) compared to male, 21.2% (CI: 13.8 - 28.6). In terms of the age of the participants, the highest prevalence was in the age group younger than 40 years, 47.5% (CI: 38.7 - 56.4), in the age group of 41 to 60 years it was 38.1% (CI: 29.9 - 47.1), while the lowest was in those older than 61 years, 14.4% (CI: 8.1 - 20.7).

The distribution of participants according to OSDI score is presented in Table 3. 52.3% reported a normal OSDI score, 15.1% mild presence of DED symptoms, 14.1% moderate dry eye symptoms, and 18.5% severe dry eye symptoms.

Table 3. Distribution of participants according to OSDI score

OSDI score	N	%
0 to 12 representing normal	212	52,34%
12 to 22 representing mild dry eye disease	61	15,06%
22 to 32 representing moderate dry eye disease	57	14,07%
Greater than 32 representing severe dry eye disease	75	18,52%

The prevalence of symptomatic DED (OSDI score greater than 22) was 32.6%, while the median (IQR) OSDI score in the study group was 10.42 (2.08 - 27.08).

In females, a statistically higher OSDI score was found (11.46 (IQR = 2.08 – 29.17)) compared to males (6.25 (IQR = 0 – 20.83); Mann-Whitney U Test, p = 0.030) (Figure 4.).

The OSDI score according to age is shown below (Figure 5.).

Participants older than 62 years had a statistically significantly higher OSDI score, 30.21 (IQR = 8.33 – 41.67) compared to younger age groups, 10.42 (IQR = 2.08 – 22.92), 10.42 (IQR = 0 – 29.17), Kruskal-Wallis test, p =.0015.

Participants with reported MADE had a statistically higher prevalence of DED (76.3%) compared to participants with previous DED (36.7%) and non-DED participants (10.1%). Similarly, participants with MADE had a statistically higher OSDI score (31.25 (IQR = 22.92 – 43.75)) compared to the previous DED and non-DED participants (16.67 (IQR = 4.17 - 25), 4.17 (IQR = 0 – 10.42)) respectively (Figure 6.).

Figure 4. OSDI score according to gender

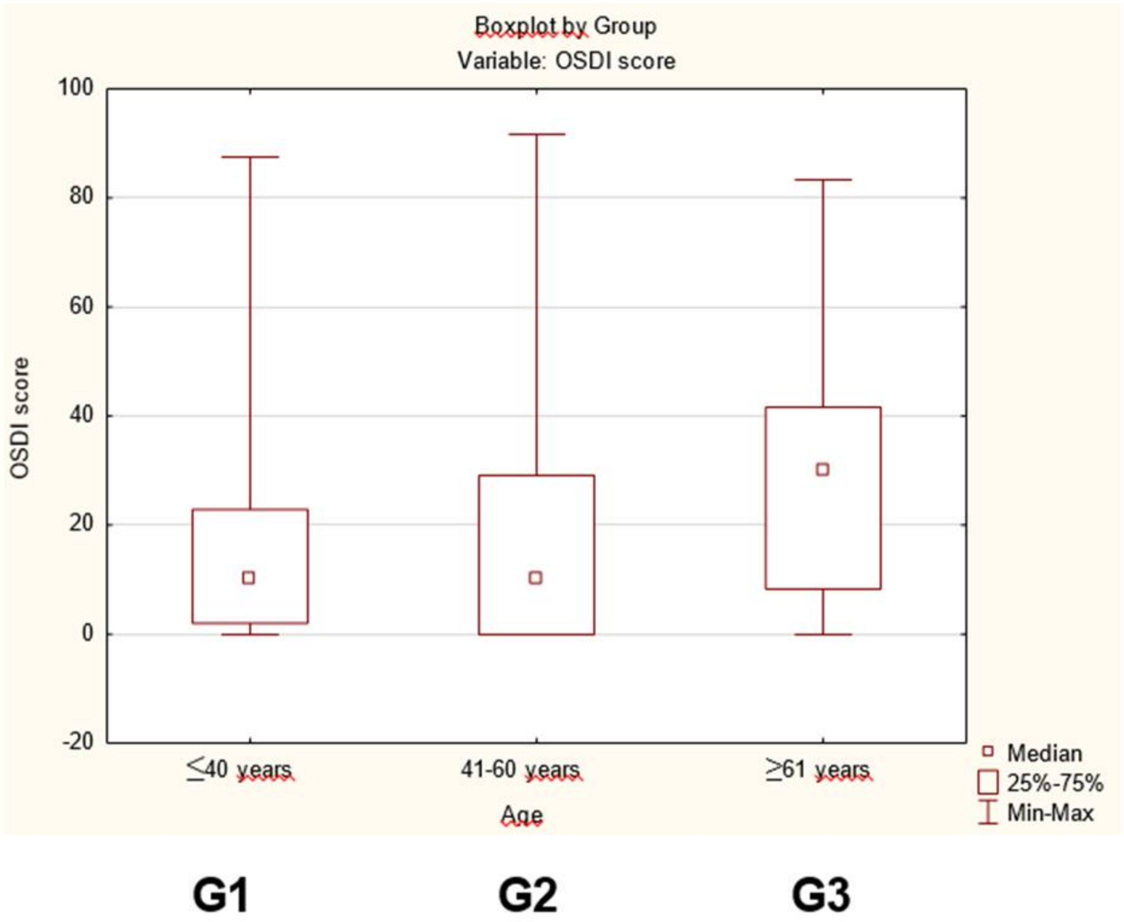

Figure 5. OSDI score according to age

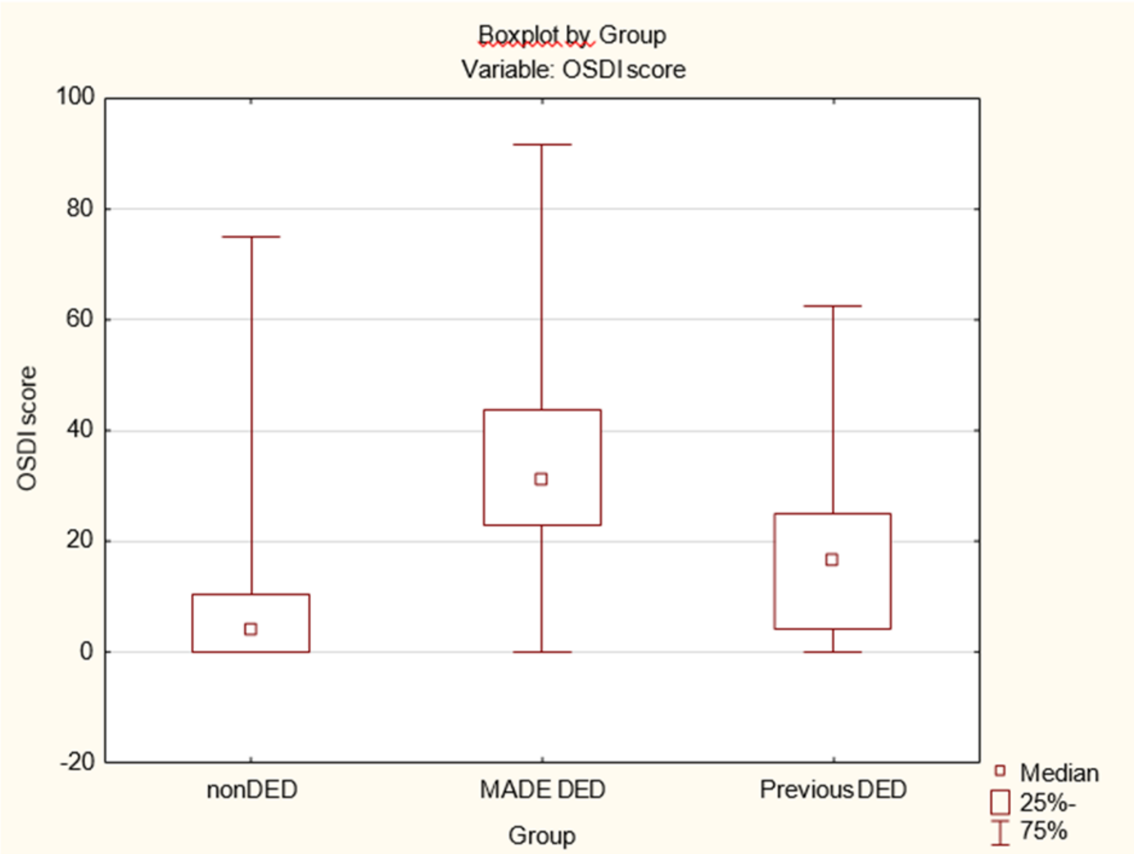

Figure 6. OSDI score according to DED

OSDI score according to daily mask-wearing at the workplace is shown in Figure 7.

A statistically higher OSDI score 12.5 (IQR = 4.17 – 29.17) was reported by the participants who used masks more than 6 hours at the workplace compared to the participants who used masks less than 6 hours a day at the workplace, 8.33 (IQR = 0 – 22.92); Mann-Whitney U Test p = 0.040). Similarly, a higher OSDI score of 12.5 (IQR = 2.6 – 29.2) was found in participants who used masks for more than 6 hours per day during the whole day compared to participants who used masks less than 6 hours per day, 6.25 (IQR = 0 – 22.92); Mann-Whitney U Test p = 0.066).

In all investigated groups, more than 50% of participants wore a face mask for more than 6 hours per day during working hours, 68.6% in the MADE group, 57.1% in the previous DED group and 52.1%in non-DED group.

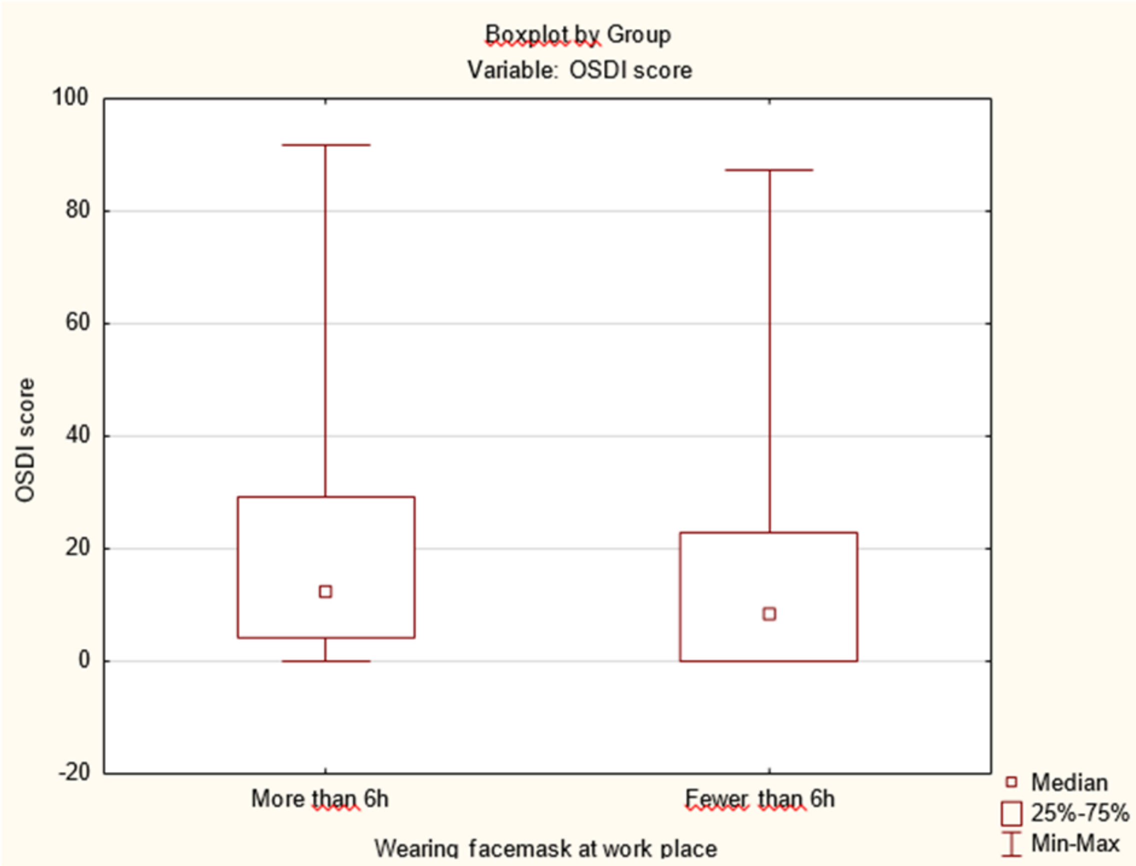

Figure 7. OSDI score according to daily mask-wearing at the workplace

4. DISCUSSION

Dental professionals, as part of the health-care workforce, face a significant risk of contracting infectious diseases. These diseases can be transmitted through direct or indirect contact with instruments or bodily fluids like blood and saliva. Due to their proximity to the oral cavity, dentists are particularly susceptible to airborne infections (21).

Therefore, unlike other health-care professionals, dentists have consistently worn mouth masks during all dental procedures for many years. The use of masks in dentistry as a protective measure dates back to the 19th century, with masks being used as protection against bacterial and viral infections during procedures.

The regular use of medical or mouth masks is crucial in minimizing the occupational inhalation of aerosols, saliva, microorganisms, blood, tooth fragments, and restorative materials from the patient's mouth and airway.

Dentistry is a profession where equipment that is used, produces a large amount of aerosol and splatter. Additionally, these particles predominantly accumulate within 2 meters of the patient, where dental operators can readily inhale them (22).

According to the CDC (Centers for Disease Control and Prevention) (23), masks are the main protective equipment used by dentists to prevent disease transmission while operating mechanical instruments. Prior to the COVID-19 pandemic, wearing masks was a standard infection control practice among dentists.

In 2020, we faced a new and unknown infection caused by the novel coronavirus (SARS-CoV-2), which had its genome sequence identified in January. The World Health Organization (WHO) declared COVID-19 a global pandemic in March 2020 (24, 25). The COVID-19 pandemic, caused by the SARS-CoV-2 virus, primarily spreads through close contact with the droplets from infected individuals when necessary protective measures are not in place. According to the WHO, the early and effective prevention and control strategies included the use of face masks, hand hygiene, and social distancing as part of a comprehensive approach (26). Face masks, as protective equipment, have become part of our daily routine, and when worn correctly, they may be effective at helping prevent the transmission of respiratory pathogens.

Ever since the use of face masks all day long became an essential part of our daily lives due to the pandemic, a marked increase in DED symptoms has been reported.

The two most commonly used types of masks are the surgical mask and the N95. While both surgical masks and N95 respirators provide some level of protection against respiratory infections, N95 masks offer superior filtration efficiency and are specifically designed for situations where airborne transmission is a significant risk. Similary, both types of masks can lead to dysfunction of the tear film and disturbances in tear film parameters (27, 28). The mechanism behind prolonged wearing of a facemask leads to worsening of DED, has not yet been fully clarified. Several studies have indicated that improper fit of a mask can cause air circulation around the eyes, potentially affecting the ocular surface. With face masks significantly reducing outward air flow, wearing a loosely fitted mask allows exhaled air to move upwards, leading to increased tear evaporation and exacerbating symptoms of ocular surface disease (16). An improperly fitted face mask, featuring an opening at its upper edge, can lead to unstable tear films, higher corneal and bulbar conjunctival temperatures, and heightened blood circulation in the bulbar conjunctiva (29). The studies report a higher risk for DED symptoms when using surgical mask and N95 masks. It has been found that both masks increase risk of developing DED symptoms (28, 30). Azzam et al reported higher symptoms of dry eyes with N95 mask than with surgical mask (27). The unexpected result stems from the greater air-sealing of N95 masks compared to surgical masks. This discrepancy may be attributed to the fitting of the nose wire, potentially causing lower lid displacement and consequently affecting the eye-blinking process. Properly fitted face masks may reduce the risk of MADE, and taping the upper edge of the mask could help prevent MADE. After White first described DED as a consequence of wearing face mask and named it MADE, many authors reported on this condition during the COVID pandemic. Krolo and colleques confirmed the presence of MADE in their study (19), Moshirfar et al. reported increased ocular irritation and dryness among regular mask users during the COVID-19 pandemic (15), and Boccardo (31) reported the prevalence of MADE of 18.3% in the general population. Itokawa et al. (29) found that 21.7% of young participants (with a mean age of 27.1 ± 5.1 years) had MADE.

Healthcare workers are often a population that faces prolonged use of face masks and their side effects on the ocular surface (32, 33). Among healthcare professionals in an ophthalmology department, prolonged surgical mask wearing was associated with a higher prevalence (57.6%) of DED symptom deterioration, as reported in study (32). Dag et al. repored that 70% of healthcare workers in a tertiary hospital, in the COVID-19 outpatient and intensive care units, self-reported having MADE (33). Among healthcare workers, a higher prevalence of MADE was recorded during the COVID-19 pandemic, as they were often exposed to prolonged mask wearing due to the nature of their work compared to the general population (32-35).

In this study, a prevalence of self-reported MADE of 29.1% was found among dentists, and it was higher in women (78.8%) compared to men (21.2%) (18). A higher prevalence of DED has also been noted in other studies (8, 30). In our study, 68.6% of dentists who reported MADE wore masks at work for more than 6 hours per day, and the duration of face mask wearing was statistically longer compared to previous DED and non-DED participants. The total duration of wearing face masks during the day among dentists was longer compared to the non-healthcare population, 77.1% of dentists reported that they wore a mask for more than 6 hours during the day.

Dentists are a profession that has been wearing face masks as a preventive measure against infection even before the COVID-19 pandemic. During the COVID-19 pandemic, prolonged wearing of face masks was recorded for enhanced infection control and protection of both patients and the dental team. In our study, it was found that only 3.2% of dentists wore a face mask for less than 3 hours at work, and 4% of dentists wore a mask for less than 3 hours throughout the day. Prolonged mask wearing among dentists was associated with higher OSDI scores. Therefore, participants who wore a face mask for more than 6 hours during working hours exhibited statistically higher OSDI scores in comparison to participants who wore a face mask for less than 6 hours during working hours.

Motwani et al. (30), found that healthcare professionals under the age of 40, who had previously experienced DED, could experience exacerbated or increased symptoms by wearing a face mask for more than three to six hours per day. Alsulami et al. (34) found a significant association between moderate to severe DED and wearing a mask for more than six hours per day among female nursing staff. Additionally, Shalaby et al. (28) identified a notable positive correlation between OSDI and corneal staining, as well as the duration of mask-wearing per day, along with a significant negative correlation with the Schirmer test.

Wearing a face mask for more than six hours per day was significantly associated with moderate to severe DED among female nursing personnel (34). Boccardo reported that retailers in the general population were a potential risk factor for MADE, reporting more cases compared to other professionals (31). Retailers, as professionals, are exposed to significantly more social interactions during their working day, so considering these social contacts, they likely had longer periods of face mask wearing compared to other professions with fewer social interactions. We found that females had a statistically higher OSDI score compared to males. Regarding the age of the participants, the oldest age group had the statistically highest OSDI score, which correlates with other studies (8,36).

We acknowledge the limitations of our study, particularly the lack of analysis regarding the type of face mask used. In Croatia, healthcare workers not working in COVID-19 high-risk areas were not required to wear a specific type of mask. As a result, most participants during the COVID-19 pandemic used both types of face masks, and sometimes they combined them (using respiratory masks together with surgical masks). Additionally, in this study, we only have analyzed self-reported dry eye symptoms. This results might be biased due to the subjectie nature of the OSDI.

The OSDI questionnaire is a standardized instrument used to evaluate symptoms and has been validated to distinguish between normal, mild to moderate, and severe dry eye disease, but it is not without limitations (37).

There is no „gold standard“ sign or symptom for the diagnosis of DED. For the diagnosis of DED, it is necessary to analyze clinical tests in addition to evaluating symptoms. What is characteristic of DED is the poor correlation between symptoms and signs of the disease, so clinicians often rely on the subjective symptoms reported by patients.

5. CONCLUSION

In conclusion, there seems to be a sizable frequency of self-reported MADE among dentists. A longer duration of time spent using a face mask is consistently linked to greater OSDI scores. In their daily practice, dentists are advised to wear face masks as part of their personal protective equipment, regardless of the presence of the COVID-19 disease. Our research may contribute to greater understanding of the possible risk that improperly fitted face masks pose to ocular surface health.

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7. AUTHOR'S BIOGRAPHY

Antonija Mendeš was born on July 3rd, 1999, in Split, Croatia. She began her education at Stjepana Ivičevića Primary School in Makarska and continued her studies at Fra Andrije Kačića Miošića Gymnasium, also located in Makarska. In 2018, Antonija enrolled in the School of Dental Medicine, University of Zagreb.

From 2022, Antonija actively participated as a member of the student's organizations Oral Cancer Week and Zubić. In 2023, she was included in writing scientific paper titled *„Prolonged Face Mask Wearing Worsens Self-Reported Dry Eye Symptoms during the COVID-19 Pandemic in Dental Healthcare Practitioners"* which was published in the journal Acta Stomatologica Croatica.