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ORIGINAL ARTICLE

"Diagnostic ability in oral pathology among different population clusters"

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Abstract

Objectives: To assess the diagnostic ability in detecting oral lesions among dentists, dental hygienists, dentistry students, oral hygiene students, and non-healthcare subjects.

Materials and Methods: Participants were invited to classify 30 images of oral lesions in "benign" or "suspected malignant" only based on the visual appearance of the lesion. Diagnostic accuracy was assessed by calculating sensitivity and specificity with 95% confidence intervals and stratified by population group and image features (color, shape, and size of the lesions).

Results: A total of 16,590 examinations by 553 subjects were analyzed. Overall sensitivity and specificity were 57% (95% confidence interval 56%–58%) and 64% (95% confidence interval 63%–65%). Diagnostic accuracy varied among population groups, with experienced dentists showing the lowest sensitivity (52%) and the highest specificity (71%). Red lesions, flat lesions, and large lesions had the lowest sensitivity (42%, 36%, 57%) but the highest specificity (70%, 75%, 76%).

Conclusions: We found worrying low ability to detect suspected malignant oral lesions by both healthcare workers and non-healthcare subjects. Lesion-specific characteristics may lead to differences in recognition. Specific courses and more adequate teaching methods should be proposed to increase identification of oral lesions.

KEYWORDS
diagnostic ability, OPMDs, oral cancer, prevention

1 | INTRODUCTION

Worldwide, oral cancer represents a malignancy with an annual incidence of about 300,000 cases (Ferlay et al., 2015). Despite advances in treatments, the survival rate remains low with the 5-year survival rates as low as 40% (Abati et al., 2020). The most common form of oral cancer is oral squamous cell carcinoma (OSCC), which accounts for over 90% of malignant lesions in the oral cavity (Carreras-Torras & Gay-Escoda, 2015). The onset of oral cancer is due to mutations of proto-oncogenes and tumor suppressor genes of oral mucosa cells (Carolina et al., 2017), and the main risk factors for these mutations are tobacco and alcohol (Pfeifer et al., 2002; Reidy et al., 2011).

In several cases, oral cancers are preceded by oral potentially malignant disorders (OPMDs), a group of oral mucosal lesions

including: leukoplakia, oral submucous fibrosis, and actinic cheilitis (Warnakulasuriya et al., 2020). Oral potentially malignant disorders have an increased risk of cancerous transformation, so early recognition and treatment of OPMDs and oral cancer remains the most effective approach to control morbidity and mortality (Yang et al., 2018).

The standard method for oral cancer detection is the conventional oral examination and palpation (Shin et al., 2010). There are also others diagnostic tests such as toluidine blue, acetowhitening, and autofluorescence imaging (AFI), which unfortunately have low accuracy; hence, the biopsy with histopathological examination remains the gold standard for diagnosis of lesions that does not heal in a reasonable amount of time (Bacci et al., 2014; Mark, 2017). The major problem is when and where the biopsy should be taken, and this depends on the clinical ability of the physician to differentiate malignant lesions and OPMDs from benign lesions (Vijayakumar et al., 2019).

Nowadays, oral cancer represent a global health disease, but there are no standardized screening programs for oral cancer (Brocklehurst et al., 2013). For this reason, dentists and dental hygienists play an important role in primary and secondary prevention as they should promote oral healthy lifestyles and detect oral cancer or OPMDs at early stages. Several reports suggest that those asymptomatic oral cancers are more likely to be detected in a dental setting during routine dental care (Seoane et al., 2006). In fact, the oral cavity provides easy access for clinical inspection, and oral cancer development is preceded by visible mucosal changes (Shin et al., 2010).

Therefore, we believe that dentists, dental hygienists, dentistry students, and dental hygiene students represent the present and the future healthcare workforce with the responsibility for oral cancer diagnosis.

Several studies highlighted the need to improve the knowledge on preventing and detecting oral cancer and also dentists would be interested to have further oral cancer educational and training sessions (Ahmed & Naidoo, 2019; Kebabcıoğlu & Pekiner, 2018). In fact, previous studies showed reduced diagnostic ability of dentists and dentistry students when assessing oral lesions by image recognition (Hassona et al., 2017; Seoane et al., 2006). Of note, the literature does not offer any information on the knowledge of oral diseases by non-healthcare subjects, while data on knowledge by healthcare subjects have been reported (Yao et al., 2019; Zhou et al., 2022). This aspect is interesting because recent studies are focusing on patient's knowledge on specific pathologies (i.e., breast cancer) in order to be able to make self-diagnoses as early as possible.

To our knowledge, there are no studies investigating the diagnostic ability in oral pathology among dentists, dental hygienists, dentistry students, dental hygiene students, and non-healthcare subjects. The aim of this study was to assess the diagnostic accuracy of these categories in order to evaluate how training and clinical experience may influence the ability to recognize oral lesions. Non-healthcare subjects were included to evaluate the need for providing more information about oral pathology in the population.

2 | METHODS

2.1 | Study design

This is a prospective study on the diagnostic accuracy in oral pathology among dentists, dental hygienists, dentistry students, dental hygiene students, and non-healthcare personnel. The implementation of this study benefited from the indications outlined in the Standards for Reporting Diagnostic Accuracy (STARD) (Bossuyt et al., 2015) and in the QUADAS-2 tool (Reitsma et al., 2011). Of note, some indications were not applicable since this study assessed the diagnostic accuracy of subjects and not of a medical diagnostic test. The study was approved by the ethics committee of the Azienda Ospedaliera di Padova (protocol number 258n/AO/22).

2.2 | Participants

Eligible subjects included dentists with a degree for at least 5 years (DDSXP), dentists with a degree for less than 5 years (DDS), dental hygienists with a degree for at least 5 years (DHXP), dental hygienists with a degree for less than 5 years (DH), dentistry students (DS), dental hygiene students (DHS), and non-healthcare subjects (NHS). Eligible subjects were personally contacted and asked to participate in the study. The participation was voluntary and anonymous.

2.3 | Procedures

Two researchers (LS and CB) developed the survey, which was supervised by a third researcher (ES) and implemented by another researcher (RZ) using Google Form application. The survey displayed 15 images of benign oral lesions and 15 images of suspected malignant oral lesions (Table 1). The images were archive photographs taken at the oral pathology unit of the University of Padua (Italy), which were chosen to obtain a heterogeneous collection of oral lesions. All lesions had been previously confirmed through biopsy. For analytical purpose, all images were subsequently classified according to three parameters: color (white, red, and dark), shape (endophytic, exophytic, and flat), and size (large or small).

The original survey is available as a separate file in Appendix S1. The survey was administered in Italian and was shared to students and graduates from the University of Padua and other Italian Universities between January and June 2021.

Participants were invited to access to the online survey and to classify 30 images of oral lesions in “benign” or “suspected malignant” only based on the visual appearance of the lesion. Participants were masked to the reference assessment of each picture and to the number of benign and suspected malignant images under examination. Clinical or anamnestic information was not provided for each image. In the introductory section of the survey, a definition of benign lesion and suspected malignant lesion was given to allow non-healthcare subjects to carry out the survey. The landing page

TABLE 1 List of the 30 oral lesions in the questionnaire.

Reference	Sub-type	List
Benign lesions ($n=15$)	Benign lesions ($n=15$)	Aphthous stomatitis ($n=2$) Pseudomembranous Candidiasis ($n=1$) Angular cheilitis ($n=1$) Traumatic fibromas ($n=2$) Traumatic ulcers ($n=2$) Mucoceles ($n=2$) Geographic tongue ($n=1$) Amalgam tattoos ($n=2$) Vascular lesions ($n=2$)
Suspected malign lesions ($n=15$)	Oral potentially malignant disorders ($n=10$)	Erythroplakia ($n=1$) Leukoplakias ($n=4$) Erosive lichens ($n=2$) Erythroleukoplakia ($n=1$) Pemphigus vulgaris ($n=1$) Actinic cheilitis ($n=1$)
	Malign lesions ($n=5$)	Oral squamous cell carcinomas ($n=5$)

of the questionnaire reported the following definitions: "by benign lesions we mean all pathological or physiological conditions that do not endanger the patient's life" and "by suspected malignant lesions we mean precancerous lesions that can evolve into malignant lesions and frankly malignant lesions." Participants also indicated their age and profession.

2.4 | Sample size

A minimum number of 384 examinations of suspicious malignant and benign images was required to construct a 95% confidence interval with a precision of 5%, assuming a sensitivity (specificity) of 50%. Given the lack of information a priori, we set the expected sensitivity (specificity) at 50% to obtain the largest sample size estimate. In this study, the web survey remained active for 6 months (from January to June 2021) ensuring to achieve the minimum of 384 examinations of suspicious malignant and benign images in each rater strata.

2.5 | Statistical analysis

Examination results were summarized as the numbers of true positive (suspected malignant lesions identified as such), true negative (benign lesions identified as such), false positive (benign lesions identified as suspected malignant), and false negative (suspected malignant lesions identified as benign). Diagnostic accuracy was assessed by calculating sensitivity and specificity with 95% confidence intervals (CIs). In this study, sensitivity meant the ability to identify a suspected malignant lesion and specificity the ability to identify a benign lesion. Positive and negative predictive values were not calculated because their values depend on the prevalence of the disease in a population, whereas this study included a fixed proportion of benign and malignant images (1:1 ratio) under examination. Sensitivity and specificity were calculated in the overall sample and within strata (professional group, color of the lesion, growth type, and size of the lesion). Comparisons of sensitivity and specificity between strata were performed using proportion tests, and the effect sizes was reported as difference in proportion with 95% CI. The analysis did not include any approaches for handling indeterminate or missing data because none occurred. All tests were two-sided, and a p-value less than 0.05 was considered statistically significant. Statistical analysis was performed using R 4.1 (R Foundation for Statistical Computing, Vienna, Austria) (R Core Team, 2023).

3 | RESULTS

Five hundred and fifty-three subjects participated in the online survey and examined 30 images (15 displaying benign lesions and 15 displaying suspected malignant oral lesions for a total of 16,590 examinations). The participants included 175 dentists (65 DDS and 110 DDSXP), 165 dental hygienists (54 DH and 111 DHXP), 66 students of dentistry, 59 dental hygiene students, and 88 non-healthcare subjects.

Summary of image assessment by participants compared with image classification by the oral pathologist (benign or suspected malignant oral lesion) is displayed in Table 2. There were no indeterminate or missing data.

Estimates of diagnostic accuracy are summarized in Table 3. Overall sensitivity and specificity were 57% (95% CI 56%–58%) and 64% (95% CI 63%–65%), respectively. Both sensitivity and specificity were different among population groups, with DDSXP recording the lowest sensitivity and the highest specificity (Table 3). When considering image features, sensitivity was lower in red vs. white lesions (difference −28%, 95% CI −30% to −26%), while specificity was higher in red lesions (difference 12%, 95% CI 10%–15%) and dark lesions (difference 6%, 95% CI 3%–9%) compared with white lesions. Examination of the images with exophytic lesions had good sensitivity and moderate specificity (90% and 70%), while examination of images with endophytic lesions had good sensitivity but low specificity (87% and 27%) and examination of images with flat lesions had low sensitivity but moderate specificity (36% and 75%). Large-sized lesions yielded lower sensitivity (difference −3%, 95% CI −7% to −1%) but higher specificity (difference 18%, 95% CI 16%–20%) than small-sized lesions. A summary of the main findings is displayed in Figure 1.

Group	Strata	True positive	True negative	False negative	False positive
All participants	—	4739	5302	3556	2993
Professional group	DDSXP	865	1174	785	476
	DDS	554	656	421	319
	DHXP	947	1090	718	575
	DH	491	532	319	278
	DS	595	617	395	373
	DHS	515	504	370	381
	NHS	772	729	548	591
Color	White	1642	1915	2229	1403
	Red	3097	2333	1327	985
	Dark	—	1054	—	605
Growth type	Endophytic	483	450	70	1209
	Exophytic	2487	1935	278	830
	Flat	1769	2917	3208	954
Size	Large	4070	2103	3119	662
	Small	669	3199	437	2331

TABLE 2 Cross-tabulation of image assessment by participants vs. the image classification by the oral pathologist (benign or suspected malignant oral lesion).

TABLE 3 Estimates of diagnostic accuracy (sensitivity and specificity) with 95% confidence interval and comparisons between strata.

Group	Strata	Sensitivity (95% confidence interval)	Difference (95% confidence Interval)	*p*-Value	Specificity (95% confidence interval)	Difference (95% confidence interval)	*p*-Value
Overall		57% (56% to 58%)	—	—	64% (63% to 65%)	—	—
Professional group	DDSXP	52% (50% to 55%)	Reference		71% (69% to 73%)	Reference	
	DDS	57% (54% to 60%)	5% (1% to 8%)	0.032	67% (64% to 70%)	−4% (−8% to −1%)	0.041
	DHXP	57% (54% to 59%)	5% (1% to 8%)	0.011	65% (63% to 68%)	−6% (−9% to −2%)	<0.001
	DH	60% (57% to 64%)	8% (4% to 12%)	<0.001	66% (62% to 69%)	−5% (−10% to −1%)	0.007
	DS	60% (57% to 63%)	8% (4% to 12%)	<0.001	62% (59% to 65%)	−9% (−13% to −5%)	<0.001
	DHS	58% (55% to 61%)	6% (2% to 10%)	0.006	57% (54% to 60%)	−14% (−18% to −10%)	0.0001
	NHS	58% (56% to 58%)	6% (2% to 10%)	0.001	55% (52% to 58%)	−16% (−19% to −12%)	<0.001
Color	White	70% (69% to 71%)	Reference		58% (56% to 69%)	Reference	
	Red	42% (40% to 44%)	−28% (−30% to −26%)	<0.001	70% (69% to 72%)	12% (10% to 15%)	<0.001
	Dark	—	—	—	64% (61% to 66%)	6% (3% to 9%)	<0.001
Growth type	Endophytic	87% (84% to 90%)	Reference		27% (25% to 29%)	Reference	
	Exophytic	90% (89% to 91%)	3% (0% to 6%)	0.080	70% (68% to 72%)	43% (40% to 46%)	<0.001
	Flat	36% (34% to 37%)	−51% (−55 to −49%)	<0.001	75% (74% to 76%	48% (46% to 51%)	<0.001
Size	Large	57% (55% to 57%)	−3% (−7% to −1%)	0.168	76% (74% to 78%)	18% (16% to 20%)	<0.001
	Small	60% (57% to 63%)	Reference		58% (57% to 59%	Reference	

Note: There were no dark malign lesions among the pictures under examination; hence, the corresponding cells are empty. Within each group, one stratum is considered as "reference" to calculate differences between strata in terms of sensitivity and specificity.

4 | DISCUSSION

The present study evaluated the diagnostic abilities in recognizing oral lesions by some professional categories and non-healthcare subjects. Early recognition of neoformations, especially if malignant, plays a significant role in the potential success of the therapy. In a recent study (Sarumathi et al., 2013) conducted on 70 primary care physicians, 80% of the doctors misdiagnosed an early squamous carcinoma.

Our data suggested different diagnostic ability among participants. The ability to identify a suspected malignant lesion ranged in 52%–60% and was the lowest in experienced dentists. On the

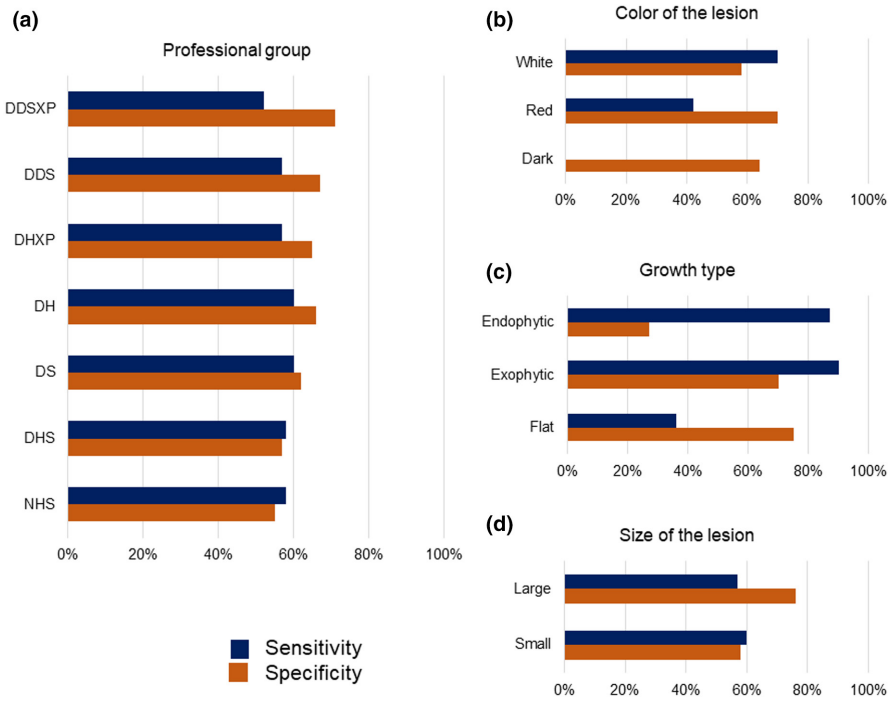

FIGURE 1 Summary of the main findings.

contrary, the ability to identify a benign lesion ranged in 55%–71% and was highest in experienced dentists, followed by other healthcare categories (less-experienced dentists and dental hygienists) and other participants (students and non-healthcare subjects). Benign lesions of the oral cavity are the most frequently observed lesions in clinical practice, and this could explain why experienced participants were more likely to identify such lesions. Another possible explanation may be that less-experienced subjects may be prone to overestimate any physical alteration in the oral cavity. Our findings are in agreement with Seoane et al. (2006) who reported higher diagnostic ability regarding benign lesions compared with suspected malignant lesions. One recent study (Hassona et al., 2017) evaluated the diagnostic ability of dental students, reporting a 49.3% sensitivity achieved by the fifth-year students. Our findings are slightly more optimistic, but in line with the previous mentioned study. An older study evaluated the influence of professional experience on diagnostic skills (López-Jornet et al., 2008). The authors compared dentists with less than 5 years of experience and with more than 5 years of experience, as in our study. The results revealed a sensitivity with a range of 82.8%–85.8% and 73.7%–80.0% for more experienced and less experienced dentists, respectively, and a specificity of 89.5% and 87% for the same categories. These data are slightly more optimistic than those of the present study even if the sample used in our paper is much larger.

Interestingly, we found that diagnostic ability was associated with specific characteristics of the lesions such as size, grow type, and color. Red lesions were more likely to be judged as benign and white lesions as malignant. These findings are in accordance with a previous study by Seoane et al. The authors found lower sensitivity for malignant red lesion detection by dental students, and the hypothesis of the lower index of suspicion was due to the low prevalence of these malignant lesions (Seoane et al., 1999). Flat lesions were more likely to be judged as benign and endophytic lesions as malignant, while exophytic lesions were often identified correctly as benign or malignant. These results are consistent with clinical experience, where flat lesions may represent the only visible portion of an infiltrative potentially malignant lesion. In addition, small lesions showed lower specificity with respect to larger lesions. This concept should be explored during training because small lesions could be misdiagnosed by clinicians.

The results of the present study demonstrated percentages of diagnostic skills just over 50%, in line with previous studies. Therefore, there is still much work to be carried out in the training of health personnel to increase skills in oral pathology. In the future, trained health operators may allow extremely early diagnosis of OPMDs and may reduce the incidence of frankly cancerous lesions. Another important information work should be carried out on non-healthcare people. As already done for other dental disciplines such as oral hygiene in adolescence (Sbricoli et al., 2022) and imitating other carcinoma self-diagnostic procedures (e.g., breast cancer), it would be desirable to achieve a good level of oral pathology knowledge by patients, who could come to the attention of the oral pathologist in the early stages of disease.

Of note, the online survey was shared to students and graduates from the University of Padua and other Italian universities between January and June 2021 without any restrictions/controls on the number of participants per group; hence, the number of participants per group was not homogeneous.

This study has some limitations that should be considered by the reader. First, the generalizability of the findings should be limited to similar subjects. Second, the images chosen were heterogeneous, so it was not possible to investigate individual lesions separately. More selective studies could allow more specific investigations for individual neoformations. Third, the total time for

filling the survey—as well as the time to assess each type of lesion—would have provided additional interesting information, but such data were not recorded. Of note, the reproducibility of the survey could not be assessed because the participants anonymously accessed the online survey, and the order of the images was random. However, the validity of the survey relied on the involvement of dental experts (the researchers developing and implementing the survey) and the clear definitions of "benign," "malignant," and "suspected malignant" provided to the participants.

5 | CONCLUSION

In conclusion, this study showed a worrying low ability to detect suspected malignant oral lesions by both healthcare workers and non-healthcare people. Clinical experience did not seem to provide an advantage in this ability. Lesion-specific characteristics led to significant differences in diagnosis. Specific courses and more adequate teaching methods should be proposed to increase recognition of oral lesions.

AUTHOR CONTRIBUTIONS

Luca Sbricoli: Conceptualization; writing – review and editing. **Riccardo Zago:** Investigation; writing – original draft. **Francesco Cavallin:** Data curation; writing – review and editing. **Edoardo Stellini:** Supervision; writing – review and editing. **Christian Bacci:** Conceptualization; methodology.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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