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Review

An Overview of Oral Cancer Screening Programs in Family Dentistry

Manar Ali Assiri[1*], Abdullah Abdulaziz Alhadlaq[2], Manal Abdulrahman Ajina[3]

[1] *General Dentist, Ministry of Health, Abha, Saudi Arabia*
[2] *Department of Family Dentistry, Ministry of Health, Tabuk, Saudi Arabia*
[3] *Department of Oral and Maxillofacial Surgery, Ministry of Health, Qurayyat, Saudi Arabia*

Correspondence should be addressed **Manar Ali Assiri**, General Dentist, Ministry of Health, Abha, Saudi Arabia, Email: manaraassiri@gmail.com

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Abstract

Oral cancer is one of the most common cancers worldwide. The incidence of oral cancer is increasing, especially in low- and middle-income countries. Despite the improvements in cancer treatment, the survival rate of oral cancer is still low. Early detection of oral cancer can significantly improve the 5-year survival rate in these patients. Screening for oral cancer is considered an effective method for detecting and managing oral cancers early. General dental practitioners and family dentists can play a vital role in oral cancer screening programs due to their critical role as frontline dental professionals. However, the integration of oral cancer screening into family dentistry is still inadequate. Thus, this review aims to discuss the role of general dental practitioners and family dentists in oral cancer screening programs. Oral cancer screening programs conducted in various countries have demonstrated effectiveness and cost-effectiveness; however, challenges, such as length bias and lead time bias, still limit the generalizability and the reliability of these findings. A lack of routine oral cancer screening was observed due to limited knowledge, skills, and confidence among general dental practitioners and family dentists. It is crucial to enhance their awareness and knowledge of oral cancer detection, along with improving dental education. Artificial intelligence can improve the accessibility of oral screening programs, especially in low-resource areas. Future studies should focus on developing strategies to improve the awareness and knowledge of family dentists and integrating them into oral cancer screening programs.

Keywords: *Oral Cancer, Oral Cancer Screening, Screening, Family Dentistry, Family Dentists, General Practitioners, Dentists*

Introduction

Oral cancer is the 6th most common cancer worldwide. It affects about 275,000 cases annually, and its incidence is increasing (1). Oral cancer accounts for 2% of all malignancies and 1.2% of all cancer-associated deaths in the United States (2). The incidence of oral cancer varies geographically, with two-thirds of cases occurring in low- and middle-income countries from Latin America, South and South-East Asia, and Eastern Europe (3). It can occur on various sites in the oral cavity, including the lips, tongue, palate, gingiva, oral floor, and buccal mucosa (4).

The 5-year survival rate of early oral cancers (82%) is better than those involving regional tissues/lymph nodes (50%) or those that have metastasized (28%) (5, 6). The rising incidence of oral cancer is further exacerbated by the disease's low survival rate. The most significant risk factors for oral cancers are gender, age, tobacco, alcohol, betel quid, and sunlight (3). More recently, evidence has emerged supporting the role for Candida and human papillomavirus in the disease (7).

Although the effectiveness of treatment modalities for cancer, including surgery, chemotherapy, and radiotherapy, has been improving, the oral cancer survival rate has not improved significantly, especially in advanced-stage cancers (8, 9). Thus, early detection and screening for oral cancer is critical. Early detection of cancer aims to reduce morbidity and mortality, and screening has long been considered an effective strategy (10). Oral cancer screening is a unique case due to its relative simplicity and the high prevalence of dental issues, which provide opportunities for incidental examination or screening of the oral mucosa (11). However, despite these potential benefits, there is limited evidence demonstrating that oral cancer screening effectively reduces mortality (12).

It is always hard to detect oral cancers, especially in the initial stage, as they are always asymptomatic and mimic benign lesions (13, 14). Even general dental practitioners (GDPs) and family dentists (FDs) may find it hard to differentiate between early-stage oral cancer and benign lesions (15). Family dentists can play a vital role in early detection and screening for oral cancers. In Japan, most oral cancer cases are identified by family dentists, who then refer these patients to core hospitals for treatment (4). However, the global integration of oral cancer screening into family dentistry is still inadequate.

This review aims to explore current evidence focusing on oral cancer screening programs in family dentistry, highlighting the effectiveness of these programs and the challenges impeding their implementation.

Methods

A comprehensive literature search was conducted in Medline (via PubMed), Scopus, and Web of Science databases up to June 10, 2025. Medical Subject Headings (MeSH) and relevant free-text keywords were used to identify synonyms. Boolean operators (AND, OR) were applied to combine search terms in alignment with guidance from the Cochrane Handbook for Systematic Reviews of Interventions. Key search terms included: "Oral Cancer" AND "Screening" AND "Family dentistry". Summaries and duplicates of the found studies were exported and removed by EndNote X8. Any study that discusses oral cancer screening in family dentistry and is published in a peer-reviewed journal was included. All languages are included. Full-text articles, case series, and abstracts with related topics are included. Case reports, comments, animal studies, and letters were excluded.

Discussion

Effectiveness of Oral Cancer Screening

Oral cancer screening consists of a direct physical examination of the head and neck, mainly palpation and visual inspection. Although these screening procedures are simple, the methodology is always unclear (16). Nevertheless, most screening programs involve a standard protocol, focusing on examining the oral cavity, lips, and visible oropharyngeal areas (17). This simple oral cancer screening is feasible in remote or low-resource areas, providing a unique opportunity for

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opportunistic screening and potentially reducing health disparities.

A remarkable cluster-randomized controlled trial was held over 15 years in Kerala, South India to evaluate the effects of oral cancer screening. The program comprised four rounds of screening completed in 1998, 2002, 2004, and 2009, and included 13 municipalities, divided into seven screened clusters and six control clusters (18, 19). The study included over 190,000 participants, making it the most influential study in oral cancer screening, to date. The standard oral examination was followed to detect malignant lesions, and the primary outcome of the study was mortality from oral cancer.

The overall difference in mortality was not statistically significant with 15.4 deaths per 100,000 person-years in the screened group versus 17.1/100,000 in controls; however, mortality was reduced by 24% among high-risk individuals (tobacco and/or alcohol users), with 30 vs. 39 deaths per 100,000 person-years (18). The trial saved 269 life years per 100,000 individuals overall, and 1,438 life years among high-risk groups. Although the study showed important results, its applicability is limited due to certain methodological issues (20). Nevertheless, it remains the only randomized controlled trial showing a mortality reduction from oral cancer screening. This is noteworthy considering that oral examinations are significantly less complex than screening modalities for other cancers, such as mammography or CT scans.

The most available evidence focusing on oral cancer screening is observational and population-based studies. A nationwide oral cancer screening program was initiated in Cuba in 1984. It included annual dental examinations and detected 16% of oral cancer cases between 1984 and 1990. The program also observed increased diagnosis of stage I lesions; however, it did not significantly affect overall incidence or mortality (21). A subsequent case-control study provided limited support for a stage shift resulting from the program (22).

Other extensive oral cancer screening programs were conducted in Taiwan focusing on high-risk individuals, such as smokers and betel quid chewers. Over 4.2 million adults were eligible between 2004 and 2009, with 599,103 participating in at least two screenings. These programs led to a lower incidence of oral cancer in the screened group (133.4 per 100,000) compared to non-screened individuals (190.9 per 100,000), showing potential benefits (23). However, this difference may be due to baseline group differences rather than true screening effectiveness, as the study was based on modeled data and showed no significant difference in hazard ratios after adjusting for confounding variables.

A recent systematic review including 17 studies evaluated the effectiveness of oral cancer screening programs (24). The review reported that most studies demonstrated effectiveness in reducing severe oral cancer cases and increasing diagnoses at early stages when applying these screening programs over a subsequent year. This can lead to an improvement in patient survival by reducing morbidity and mortality (23). An increase in survivability at 3, 5, and 10 years was observed in three of the studies included in the review, as the survival rate was increased by 7.9% for a period of 3 years and 4.9% for a period of 5 years in the comparison of screened and not screened patients (18).

Another study assessed the survival rate in two subsequent five-year periods (1989 to 1998 and 1999 to 2008) and found an 8.2% increase in the survival rate of patients screened when the second five-year period was compared to the first (24). Furthermore, Sankaranarayanan et al. evaluated the survival rate in a ten-year period and found a 24.9% increase in the survival rate of patients screened compared to the control group (18).

These findings suggest that longer duration of screening programs may result in better survival rates in screened patients, with a 10-year program period being the optimal timeframe. In addition, two other studies evaluated mortality outcomes and showed positive results. Notably, one study found that screening high-risk individuals three to four times over consecutive years resulted in an 81%

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reduction in mortality, underscoring the importance of repeated screenings in improving program effectiveness (18).

Cost-Effectiveness of Oral Cancer Screening

The cost-effectiveness of the oral cancer screening program was assessed in the Kerala study. It was reported that the cost of a screening examination per person was $6, while the incremental cost per life-year saved was US$835 for all individuals and US$156 for those at high risk (3). A study used the Markov modeling approach to evaluate the cost-effectiveness and outcomes of four different approaches: conventional oral examination, oral cytology, light-based detection, and toluidine blue staining. The study found that conventional oral examination at 10-year intervals was the most cost-effective approach for oral cancer screening in high-risk populations above 30 years of age in India and low-to-mid-income countries (25).

However, these estimates cannot be generalizable to high-income countries, as a modeling study conducted in the United Kingdom explored different screening scenarios within the British health system and found that invitation-based screening and opportunistic screening conducted in general dental or medical practices have consistently proven to be not cost-effective options (26). An analysis from the United States stated that a community-based screening program targeting high-risk males was likely to be cost-effective (27).

Challenges of Oral Cancer Screening

Farina and Cirillo discussed multiple challenges that face the accurate evaluation of oral cancer screening programs (16). The early detection and the increase in 5-year survival rates associated with oral cancer screening are not necessarily correlated with a true reduction in mortality (28), due to various factors such as lead time bias and length bias.

The lead time bias is the artificial increase in survival time by early detection without changing the actual time of death. This can inflate the benefit of screening based on survival metrics alone. This bias can be mitigated by using all-cause or cancer-specific mortality rates and adjusting for lead time statistically (29). However, these approaches have not yet been implemented in oral cancer screening studies.

Another challenge is the length bias, which is the preferential detection of slower-growing and less aggressive cancers that typically lead to better outcomes. This bias may overestimate the effectiveness of oral cancer screening, as these cases would likely have good prognoses regardless (30). Length bias can be mitigated by comparing cancer stage at detection and mortality rates between screened and unscreened groups (31).

Other challenges include selection bias, shown in the high probability of healthier and more health-conscious individuals participating in screening, skewing results (32), sticky-diagnosis and slippery-linkage bias, described as the influence of inaccuracies in diagnosis and health data linkage on cancer-specific mortality assessments (33), false positives/negatives results that may lead to overtreatment, unnecessary anxiety, increased costs, and missed diagnoses (34, 35), overdiagnosis, which is the detection of lesions or cancers that would never cause harm during a person's lifetime, and population heterogeneity and differences across populations that make it difficult to generalize screening outcomes (36).

Oral cancer screening programs also face implementation barriers such as the cost of screening, especially in low-resource settings. Thus, cost-effectiveness assessment is crucial to justify resource allocation. Furthermore, low follow-up rates on abnormal results can significantly reduce the effectiveness of screening efforts (37).

Role of General Dental Practitioners and Family Dentists

About half of oral cancer patients experience diagnostic delays, increasing the risk of advanced cancer stages and mortality. It has been reported that the longer duration between the first symptoms to diagnostic referrals is associated with advanced stages of cancer (38). General dental practitioners and family dentists are responsible for the early detection of oral cancers, especially due to the

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shortage of specialists and the critical role of dentists as frontline dental professionals. However, many GDPs often lack sufficient training in assessing and diagnosing oral mucosal diseases, which can lead to missed identification of early precursor lesions (39). Limited knowledge, skills, and confidence among GDPs are the main causes of the lack of routine oral screening (40). This can lead to inadequacy in addressing suspicious lesions and insufficient preventive education for patients, which is crucial for primary prevention.

GDPs and FDs see their patients routinely and always have the opportunity to discuss alcohol, smoking, diet, and betel quid use (11). Thus, it is crucial to enhance their awareness and knowledge of early oral cancers. Their ability to perform thorough examinations and appropriate referrals should also be improved, as this was associated with reduced diagnostic delays and lower mortality rates (41, 42). Therefore, reforming dental and oral health curricula and improving dental education are essential to reducing oral cancer mortality and inadequate knowledge, skills, and awareness among GDPs (42).

A recent study performed a change to simplify the detection of oral cancer in the classification of premalignant disorders that emphasizes only the most critical pathologies, ones that GDPs and FDs should be trained to detect effectively (43). This approach simplifies the complex and varied clinical presentations of precancerous diseases, enabling more immediate intervention. It may also be crucial in enhancing GDP training by directing their attention toward recognizing the clinical features of oral cancer.

Furthermore, a recent study explored the risk factors for delayed referral of patients with oral cancer from family dentists to core hospitals (4). The study found that misdiagnosis of lesions by FDs is the most significant risk factor for referral delays. It also investigated the tumor size as a risk factor for referral delays by FDs and found that tumor size (or T-classification) was not statistically significant (4). However, it stated that higher T-classification oral cancers cause remarkable clinical features such as lumps and ulcerations (13), enabling FDs with no experience in diagnosing oral cancers to recognize these lesions and refer them to the core hospital. On the other hand, smaller oral lesions are difficult to recognize by family dentists without oral surgery specialization, as these smaller lesions mainly mimic the characteristics of benign lesions (14, 44).

New Strategies in Oral Cancer Screening

Artificial Intelligence

Artificial intelligence (AI) is an emerging tool in the field of oral cancer screening, particularly in low- and high-income countries (45). AI can improve the accessibility of screening programs, especially in low-resource areas and enhance diagnostic accuracy as it can detect minute pixel-level changes (46). Morikawa et al. investigated the utilization of optical instruments and AI in detecting premalignant oral lesions which have shown potential for population-level screening (47). Shamim et al. used deep convolutional neural networks on tongue lesion images, which is a significant step toward inexpensive, practical screening, though limited in scope (48). Furthermore, Rosma et al. offered fuzzy neural network models to improve the prediction of oral cancer, using demographic and behavioral risk data (49).

Recently, molecular and prognostic AI tools were also introduced. AI was used to analyze gene expression arrays to predict cancer development in patients with oral potentially malignant disorders, using Fisher's discriminant analysis (50). However, most AI tools lack validation for reproducibility and generalizability in clinical practice. Ongoing improvements in algorithm development, computing power, and training datasets are expected to further enhance AI’s role in oral oncology.

Salivary proteomics

Salivary proteomics is a non-invasive screening method that has great value in the early detection and prognosis estimation of oral squamous cell carcinoma (51). Several salivary protein biomarkers have been identified and have shown significant diagnostic value. Chen et al. used selected/multiple

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reaction monitoring and recognized 25 significantly altered proteins in oral squamous cell carcinoma patients using SRM/MRM (52). They proposed a biomarker panel of Complement factor H, C-reactive protein, with fibronectin for early screening of oral cancer. Another study identified 25 proteins that are specific for oral squamous cell carcinoma, including 12 novel ones such as keratin type II, cofilin, galectin-7, and retinoic acid binding protein II (53).

However, salivary proteomic analysis faces some barriers in transferring it from the laboratory to clinical practice (54). Post-translational modifications increase the complexity of the proteome and are considered the most troublesome impediments. Post-translational modifications include proteolytic cleavages, disulfide bond formation, glycosylation, sulphation, and phosphorylation. Many of these modifications are highly reversible and dynamic, adding to the complexity of protein activity, stability, and localization (55). As a result, studying post-translationally modified proteins remains a significant challenge.

Conclusion

Despite the growing burden of oral cancer and the critical role family dentists can play in early detection, there remains a notable scarcity of studies focusing specifically on oral cancer screening within the context of family dentistry. While some programs have shown promise, limited evidence, knowledge gaps among practitioners, and methodological challenges hinder widespread implementation. Strengthening research efforts in this area is essential to optimize screening strategies and integrate them effectively into routine dental practice, ultimately improving patient outcomes through earlier diagnosis.

Disclosure

Conflict of interest

There is no conflict of interest.

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Ethical considerations

This study is a systematic review of previously published literature and does not involve any original data collection involving human or animal subjects. Therefore, ethical approval was not required.

Data availability

Data that support the findings of this study are embedded within the manuscript.

Author contribution

All authors contributed to conceptualizing, data drafting, collection, analysis and final writing of the manuscript.

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