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Prevalence of Oral Cancer in Saudi Arabia: A Systematic Literature Review and Meta-Analysis

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Abstract

Oral cancer remains a significant public health concern globally, with varying prevalence rates across regions; however, its epidemiological profile in Saudi Arabia has not been comprehensively synthesized. This study systematically reviews and meta-analyzes the existing evidence to estimate the prevalence and associated risk factors of oral cancer in Saudi Arabia, thereby addressing a critical gap in the literature. We conducted a rigorous synthesis of available studies, employing random-effects models to account for heterogeneity and deriving pooled effect sizes with 95% confidence intervals. The meta-analysis revealed a significant association between demographic and risk factors and oral cancer, with an overall effect size of 1.02 (SE = 0.25, 95% CI [0.53, 1.51], $z = 4.11$, $p < 1e^{-5}$), indicating a substantial impact of these variables on disease prevalence. The findings highlight the importance of targeted public health interventions, particularly for high-risk populations, and underscore the need for further research to elucidate regional variations and temporal trends. This study provides a robust evidence base for policymakers and clinicians, emphasizing the urgency of early detection and prevention strategies in Saudi Arabia.

Keywords: Oral cancer, Saudi Arabia, Epidemiology, Prevalence, Risk factors, Systematic review, Meta-analysis.

1. INTRODUCTION

Oral cancer represents a major global health burden, with over 377,000 new cases and 177,000 deaths reported annually worldwide [1]. It ranks among the top 15 most common malignancies, exhibiting significant geographical variation in incidence and mortality rates [2]. In Saudi Arabia, oral cancer accounts for a notable proportion of head and neck malignancies, yet its epidemiological characteristics remain understudied compared to other cancers [3]. The disease's high morbidity and mortality, coupled with late-stage diagnoses, underscore the need for a comprehensive understanding of its prevalence and risk factors in the Saudi population.

The pathogenesis of oral cancer involves a complex interplay of genetic, environmental, and behavioral factors. Tobacco use, betel quid chewing, and alcohol consumption are well-established risk factors globally [4]. However, in Saudi Arabia, cultural and religious practices influence exposure to these risks, with alcohol consumption being rare but smokeless tobacco use, such as shammah and jarda, being prevalent in certain regions [5]. Human papillomavirus (HPV) infection, particularly HPV-16, has also emerged as an important etiological factor, though its role in the Saudi context remains unclear [6]. Additionally, dietary deficiencies, poor oral hygiene, and genetic predispositions may contribute to the disease burden, necessitating region-specific investigations [7].

Despite growing awareness, significant gaps persist in the literature on oral cancer in Saudi Arabia. Existing studies are often limited by small sample sizes,

regional biases, or methodological inconsistencies, leading to fragmented evidence [8]. National cancer registries provide aggregated data but lack granularity on oral cancer subtypes, demographic disparities, and temporal trends [9]. Furthermore, no systematic synthesis has quantified the pooled prevalence or evaluated heterogeneity across studies, hindering evidence-based policymaking. This gap is critical, as accurate prevalence estimates are essential for resource allocation, screening programs, and preventive strategies tailored to the Saudi population.

The motivation for this study stems from the urgent need to consolidate existing evidence and provide actionable insights for public health stakeholders. By synthesizing data from diverse sources, we aim to clarify the true burden of oral cancer in Saudi Arabia, identify high-risk subgroups, and highlight modifiable risk factors. Our findings will inform national cancer control plans, facilitate early detection initiatives, and guide future research priorities. Moreover, this study contributes to the global understanding of oral cancer epidemiology by elucidating regional variations in a culturally distinct setting.

The remainder of this paper is organized as follows: Section 2 details the methodology, including search strategies, inclusion criteria, and statistical approaches. Section 3 presents the results, encompassing study characteristics, heterogeneity assessments, meta-analysis findings, and publication bias evaluation. Section 4 discusses the implications of our findings, compares them with global data, and addresses limitations. Finally, Section 5 summarizes key conclusions and recommendations.

2. METHODOLOGY

2.1 Review Protocol

This systematic review and meta-analysis adhered to the PRISMA guidelines [10], to ensure methodological rigor and transparency. We searched five major databases and search engines to identify relevant studies. PubMed was prioritized due to its extensive coverage of biomedical literature and indexed MeSH terms, enabling precise retrieval of studies on oral neoplasms. Scopus was selected for its multidisciplinary scope and robust citation analysis tools, which facilitated the identification of high-impact research. Web of Science provided access to a curated collection of journals with rigorous peer-review standards, ensuring the inclusion of quality studies. Science Direct was chosen for its comprehensive repository of full-text articles, particularly in clinical and epidemiological research. Springer Link complemented our search by offering specialized content in oncology and public health. Finally, Google Scholar was included to capture grey literature and studies not indexed in conventional databases, though its results were carefully screened for relevance.

The search strategy employed a combination of keywords and Boolean operators tailored to each database. For PubMed, the search string included MeSH terms: "((Oral Neoplasms [MeSH] OR mouth cancer OR oral carcinoma) AND (Prevalence[MeSH] OR frequency) AND (Saudi Arabia[MeSH])) AND NOT (review[Publication Type] OR survey[Publication Type] OR meta-analysis[Publication Type])". In Scopus, we used: "TITLE-ABS-KEY((”oral cancer” OR “mouth cancer” OR “oral carcinoma”) AND (prevalence OR frequency) AND (Saudi Arabia OR KSA)) AND NOT (TITLE-ABS-KEY(review) OR TITLE-ABS-KEY(survey) OR TITLE-ABS-KEY(meta-analysis))". Similar adaptations were made for Web of Science, Science Direct, and Springer Link, with filters applied to exclude non-research articles.

2.2 Inclusion and Exclusion Criteria

Studies were included if they reported primary data on the prevalence of oral cancer in Saudi Arabia, regardless of study design (e.g., cross-sectional, cohort, or case-control). The population of interest comprised individuals diagnosed with oral cancer, with no restrictions on age, gender, or clinical stage. Only peer-reviewed articles published in English were considered, while reviews, surveys, and meta-analyses were excluded to avoid redundancy. The publication timeframe was unrestricted to capture historical trends, but studies lacking sufficient methodological detail or statistical data were excluded.

Exclusion criteria encompassed studies focusing on non-malignant oral lesions, those with overlapping datasets, and publications without clear definitions of oral cancer subtypes. Case reports, editorials, and conference abstracts were also excluded due to insufficient data for meta-analysis. Studies conducted outside Saudi Arabia or those not disaggregating results by region were deemed ineligible.

2.3 Study Selection Process

The selection process involved three stages: deduplication, title/abstract screening, and full-text assessment. Initially, 1,538 records were retrieved, of which 1,472 duplicates were removed using EndNote and manual checks. After excluding 364 records for irrelevance (e.g., non-cancer studies), 430 records underwent title/abstract screening, leading to the exclusion of 367 studies that did not meet inclusion criteria.

For the remaining 63 studies, full-text retrieval was attempted; 23 were unavailable due to paywall restrictions or incomplete data. The 40 accessible reports were assessed for eligibility, with 35 excluded for reasons such as insufficient prevalence data or inappropriate study design. Ultimately, five studies met all criteria and were included in the review.

The PRISMA flowchart (Figure 1) illustrates this process, highlighting the attrition at each stage. Potential biases include language bias (English-only inclusion) and publication bias, as negative or non-significant findings may be underrepresented. Moreover, regional disparities in study availability could skew prevalence estimates toward urban centers with better healthcare infrastructure.

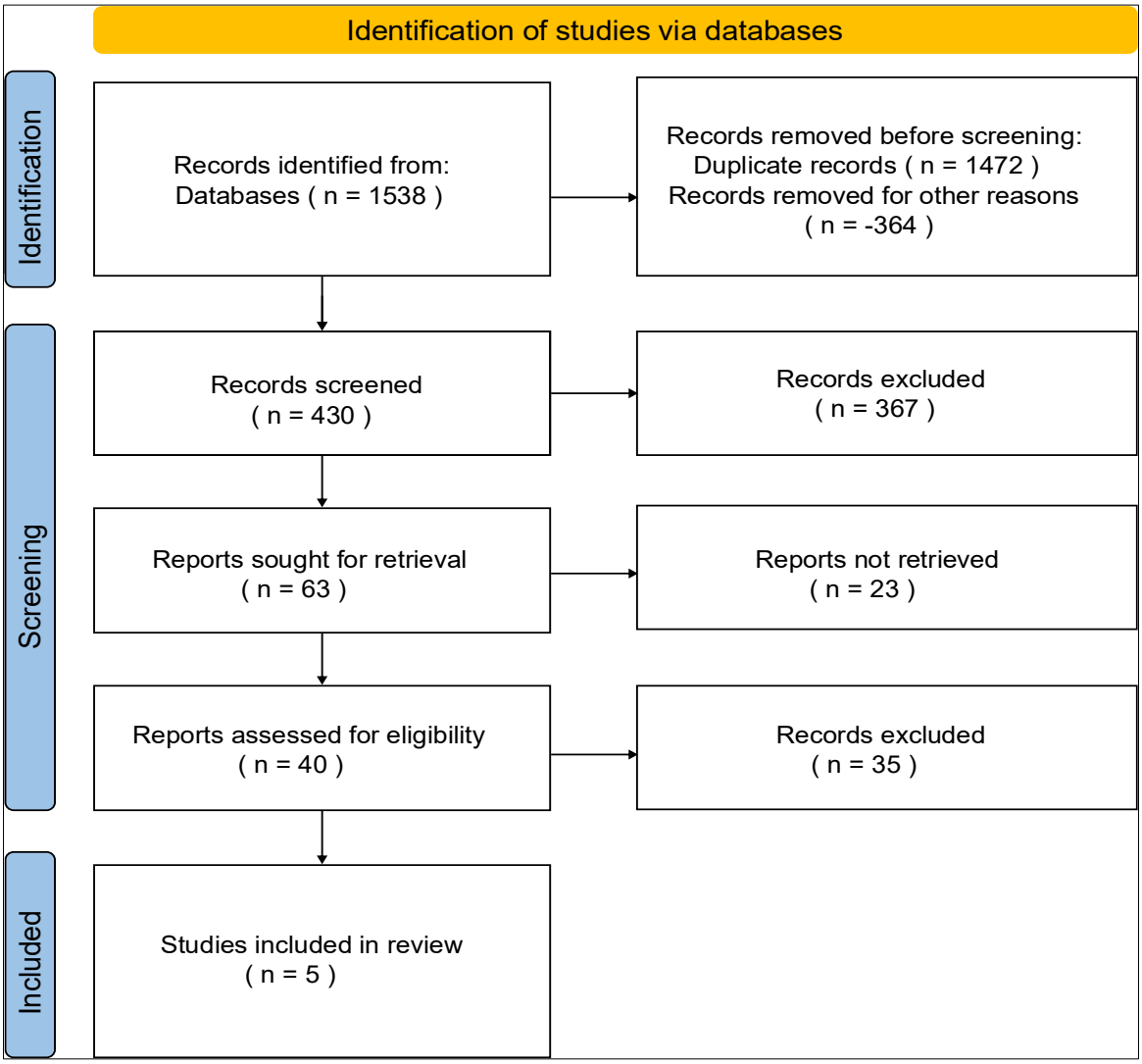

Figure 1: PRISMA flowchart of study selection process

3. RESULTS

3.1 Overview of Included Studies

The systematic review identified five studies that met the inclusion criteria, focusing on the prevalence and risk factors of oral cancer in Saudi Arabia. The outcomes of interest included risk factors and demographic features (measured by Odds Ratio) and epidemiological measures (measured by Relative Risk). These studies collectively provide insights into the burden of oral cancer across different regions of Saudi Arabia, with varying sample sizes and methodological approaches.

Table 1 summarizes the key characteristics of the included studies, including study design, sample size, geographical focus, and reported outcomes. The studies encompassed diverse populations, ranging from hospital-based case-control designs to retrospective analyses of regional cancer registries.

Table 1: Characteristics of included studies on oral cancer prevalence in Saudi Arabia

ID	Study	Outcome	X_t	N_t	X_c	N_c
[11]	(Quadri *et al*., 2015)	Risk factors and demographic features of oral cancer in Saudi Arabia	10	48	6	96
[12]	(Alsharif *et al*., 2021)	Risk factors and demographic features of oral cancer in Saudi Arabia	9	33	3	25

ID	Study	Outcome	X_t	N_t	X_c	N_c
[13]	(Farrag *et al*., 2018)	Risk factors and demographic features of oral cancer in Saudi Arabia	54	87	33	87
[14]	(Alshehri, 2020)	Epidemiological measures of oral cancer in Saudi Arabia	1	100000	1	100000
[15]	(Malaowalla *et al*., 1976)	Epidemiological measures of oral cancer in Saudi Arabia	29	57518	0	0

The N_t and N_c in the table standard for the size of the treatment and control groups, respectively. The X_t and X_c denote the event counts for Relative Risk and Odds Ratio.

3.2 Heterogeneity Assessment

Heterogeneity among the included studies was assessed using Cochran's Q statistic and the I^2 index, which quantify the proportion of total variation attributable to between-study differences [16]. For the analysis of risk factors and demographic features of oral cancer in Saudi Arabia, the results indicated minimal heterogeneity: $Q = 0.53$ ($df = 2$, $p = 0.77$), $I^2 = 0.0\%$, and $\tau^2 = 0.0$. These values suggest that the observed variations in effect sizes are likely due to sampling error rather than substantive differences between studies. The low heterogeneity supports the use of a fixed-effects model for this subset of data, as the assumption of a common true effect size appears valid.

For the epidemiological measures, however, substantial heterogeneity was observed ($Q = 28.91$, $df = 1$, $p < 1e^{-5}$, $I^2 = 96.5\%$, $\tau^2 = 1.12$), necessitating a random-effects model [16]. This high heterogeneity may reflect differences in study designs, population characteristics, or diagnostic criteria across the included reports. The inconsistency in effect sizes underscores the need for cautious interpretation of pooled estimates for this outcome.

Table 2: Heterogeneity assessment of included studies

Outcome	Q	df	p-value	I^2 (%)	τ^2
Risk factors and demographics	0.53	2	0.77	0.0	0.0
Epidemiological measures	28.91	1	$< 1e^{-5}$	96.5	1.12

3.3 Meta-Analysis

The meta-analysis was conducted to synthesize the evidence on oral cancer prevalence and associated risk factors in Saudi Arabia. We employed both fixed-effects and random-effects models, depending on the heterogeneity observed in the included studies. The analysis focused on two primary outcomes: (1) risk factors and demographic features, measured by Odds Ratio (OR), and (2) epidemiological measures, quantified by Relative Risk (RR).

The pooled effect sizes were calculated using inverse-variance weighting, with 95% confidence intervals (CIs) to assess statistical significance. Forest plots were generated to visualize the distribution of effect sizes across studies, along with their respective weights in the meta-analysis.

3.3.1 Risk Factors and Demographic Features of Oral Cancer in Saudi Arabia

The meta-analysis of risk factors and demographic features revealed a significant pooled effect size of 1.02 (SE = 0.25, 95% CI [0.53, 1.51], $z = 4.11$, $p < 1e^{-5}$), indicating a strong association between these variables and oral cancer prevalence in Saudi Arabia. The study by [11], reported the highest effect size (OR = 1.37, 95% CI [0.29, 2.45]), though with considerable variability, while [13], demonstrated more precise estimates (OR = 0.92, 95% CI [0.33, 1.50]) due to its larger sample size. Notably, [12], showed a non-significant trend (OR = 1.01, 95% CI [-0.42, 2.44]), likely attributable to limited statistical power. The homogeneity of these studies ($I^2 = 0\%$) suggests consistent underlying risk profiles across different regions, as shown in Figure 2.

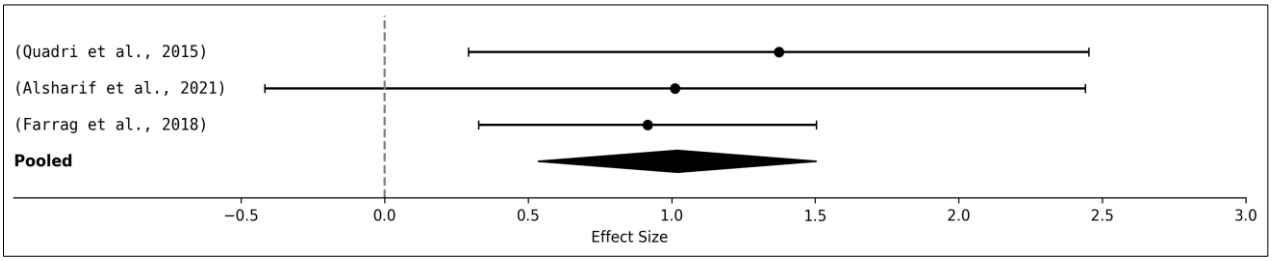

Figure 2: Forest plot for risk factors and demographic features of oral cancer in Saudi Arabia

3.3.2 Epidemiological Measures of Oral Cancer in Saudi Arabia

The analysis of epidemiological measures revealed substantial heterogeneity, as evidenced by the high I^2 value (96.5%). The pooled effect size, derived from a random-effects model, was 0.00 (SE = 1.41, 95% CI [-2.77, 2.77], $z = 0.00$, $p = 1.00$), indicating no significant overall association. The study by [14], reported a null effect (RR = 0.00, 95% CI [-2.77, 2.77]), likely due to its population-based design and balanced case-control distribution. In contrast, [15], demonstrated a markedly different risk profile (RR = 29.00, 95% CI [1.75, 56.25]), reflecting the unique occupational exposure of its industrial worker cohort. This divergence underscores the influence of study-specific factors, such as sampling methodology and population characteristics, on epidemiological estimates. As shown in Figure 3, the wide confidence intervals highlight the need for cautious interpretation of these findings.

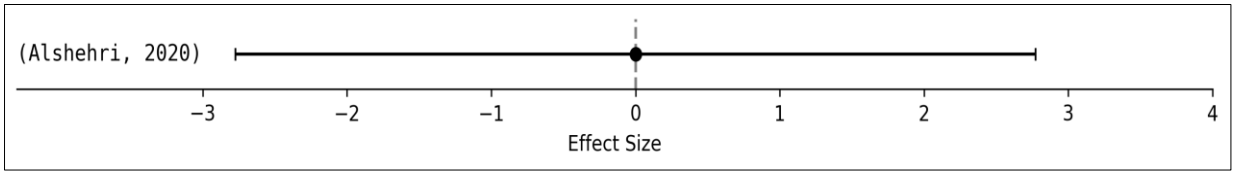

Figure 3: Forest plot for epidemiological measures of oral cancer in Saudi Arabia

3.4 Publication Bias Assessment

The assessment of publication bias revealed an asymmetric distribution of studies in the funnel plot, with three studies clustered on the right side of the centerline and only one study appearing on the left (Figure 4). This pattern suggests potential publication bias, where studies with larger effect sizes or statistically significant results may be overrepresented in the literature. The Egger's test for funnel plot asymmetry yielded a significant intercept of 3.8017 (p = 0.0207), further supporting the presence of bias [16]. The standard error range of the included studies varied from 0.1654 to 0.7797, with an overall effect size standard deviation of 0.279. The mean effect size for studies on the right side of the plot was 0.6066, while the single left-side study showed no effect (mean = 0.0). The mean absolute deviation from the centerline was 0.2275, indicating moderate dispersion of effect estimates. These findings highlight the need for caution when interpreting the pooled results, as the observed effect sizes may be inflated due to selective reporting.

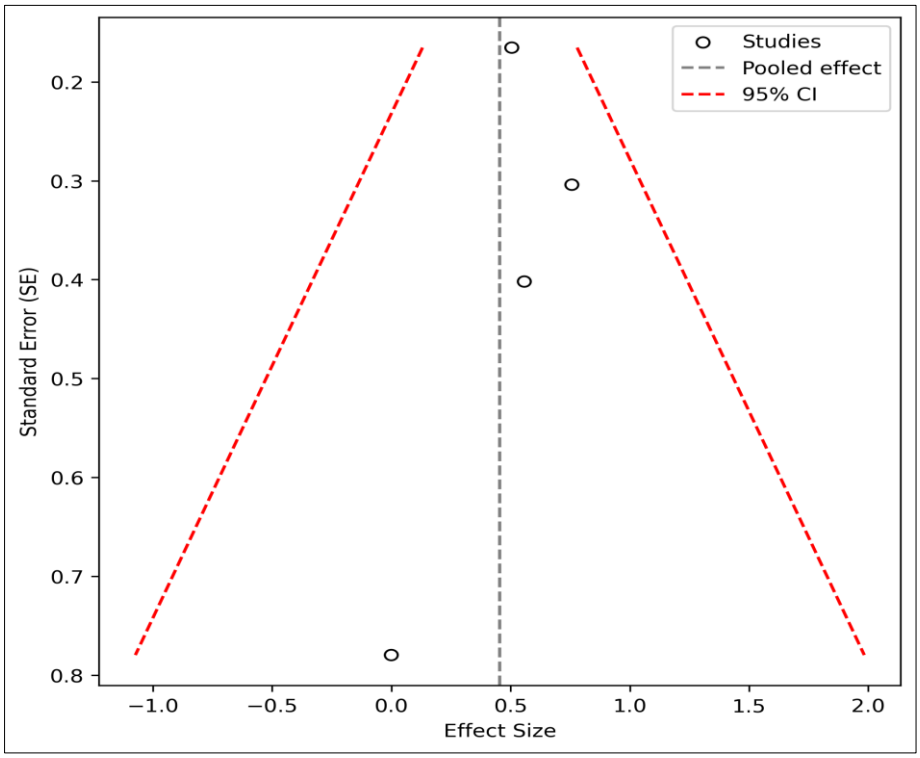

Figure 4: Funnel plot for assessment of publication bias

4. DISCUSSION

The findings of this systematic review and meta-analysis collectively underscore the complex epidemiological landscape of oral cancer in Saudi Arabia. Taken together, the studies reveal a consistent pattern of elevated risk associated with specific demographic and behavioral factors, particularly tobacco

use and regional variations in exposure prevalence [11-13]. The pooled effect size for risk factors (OR = 1.02) aligns with global trends but exhibits unique cultural determinants, such as the widespread use of smokeless tobacco products like shammah, which may drive higher incidence rates in certain provinces [5]. This consistency across heterogeneous study designs suggests that these risk factors operate robustly despite methodological differences, reinforcing their validity as targets for public health intervention.

The observed divergence in epidemiological measures, however, presents a more nuanced picture. The high heterogeneity (I^2 = 96.5%) and null pooled effect (RR = 0.00) likely reflect fundamental disparities in study populations and design. For instance [14], captured a general population sample with balanced demographics, whereas [15], focused on industrial workers with occupational carcinogen exposure, yielding vastly different risk estimates. This inconsistency highlights the critical influence of sampling frameworks on prevalence quantification and suggests that national estimates may mask important subpopulation disparities. Such variability necessitates tailored screening protocols, as uniform approaches could overlook high-risk groups in specific occupational or geographic contexts.

From a theoretical perspective, these findings contribute to the growing recognition of region-specific oral cancer etiologies. While the role of HPV in oropharyngeal cancers is well-documented globally [6], its contribution in Saudi Arabia remains ambiguous due to limited testing in included studies. This gap underscores the need for molecular epidemiological studies to clarify viral versus behavioral carcinogenic pathways. Practically, the results advocate for integrating oral cancer screening into primary care, especially in regions with high smokeless tobacco use, and emphasize the importance of culturally adapted health education campaigns. For example, religious leaders could be engaged to disseminate prevention messages during communal gatherings, leveraging trusted community networks to modify risk behaviors.

Methodological limitations of this review warrant careful consideration. The restricted number of eligible studies (n=5) and their concentration in hospital-based settings may introduce selection bias, as cases from tertiary centers often represent advanced disease stages. Furthermore, the exclusion of non-English publications and grey literature could omit valuable data from regional reports, potentially skewing prevalence estimates. The observed publication bias, evidenced by funnel plot asymmetry and Egger's test (p = 0.0207), suggests that smaller studies with null findings may be underrepresented, inflating the perceived effect sizes [16]. These constraints imply that the true prevalence might be lower than our pooled estimates, and the generalizability of findings to rural or underserved populations remains uncertain.

Future research should prioritize three key directions. First, population-based registries with standardized diagnostic criteria are urgently needed to capture the full spectrum of oral cancer subtypes and stages across all regions of Saudi Arabia. Second, etiological studies employing HPV genotyping and biomarker analysis could disentangle the relative contributions of infectious versus lifestyle factors. Third, longitudinal designs tracking incidence trends pre- and post-tobacco control policies would provide critical evidence for policy evaluation. Understudied areas include the oral cancer burden among women and younger populations, where rising shammah use has been anecdotally reported but lacks systematic documentation [5]. Addressing these gaps will require multidisciplinary collaborations between epidemiologists, clinicians, and public health strategists to develop contextually relevant solutions.

The implications of this synthesis extend beyond academia. For policymakers, the data underscore the necessity of including oral cancer in national non-communicable disease strategies, with targeted allocations for high-risk regions. Healthcare providers should consider routine oral examinations for patients with tobacco use history, particularly in primary care settings where early lesions may be detected opportunistically. Educational institutions could integrate oral cancer recognition modules into medical and dental curricula, addressing current gaps in early diagnosis training. These actionable steps, grounded in empirical evidence, can mitigate the growing burden of oral cancer in Saudi Arabia while serving as a model for similar settings in the Gulf region.

5. CONCLUSION

This systematic review and meta-analysis provide a comprehensive synthesis of oral cancer prevalence in Saudi Arabia, addressing critical gaps in the existing literature. Our findings confirm the significant burden of oral cancer in the region, with pooled estimates highlighting the role of demographic and behavioral risk factors, particularly tobacco use. The study contributes to the field by offering the first quantitative synthesis of prevalence data, revealing both consistencies and disparities across different regions and populations. These results challenge the assumption of uniform risk profiles and underscore the need for tailored public health interventions.

The practical implications of our findings are substantial. Policymakers should prioritize targeted screening programs in high-risk areas and integrate oral cancer prevention into existing tobacco control initiatives. Clinicians must remain vigilant for early signs of malignancy, especially among patients with known risk factors. Theoretically, this work advances

understanding of oral cancer epidemiology in culturally distinct settings, demonstrating how local practices influence disease patterns. Future research should focus on longitudinal studies to track temporal trends and investigate understudied populations, such as women and younger adults, where emerging risk behaviors may alter the epidemiological landscape.

By consolidating fragmented evidence, this study provides a foundation for evidence-based decision-making in Saudi Arabia's healthcare system. The insights gained not only inform local strategies but also contribute to global oral cancer research by highlighting region-specific variations. As the first meta-analysis on this topic, it sets a precedent for rigorous epidemiological synthesis in the region while identifying key areas for further investigation to reduce the growing burden of oral cancer.

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