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Review Article

Prevalence of Apical Periodontitis in Saudi Arabia: A Systematic Review and *Meta*-analysis

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ABSTRACT

Objective: This systematic review was aimed to assess the prevalence of apical periodontitis (AP) in Saudi Arabia, focusing on individual-level prevalence and the frequency of AP in endodontically versus untreated teeth.
Methods: This review followed the PRISMA guidelines and involved searches in several databases, including PubMed-MEDLINE, Cochrane-CENTRAL, and EMBASE, without date restrictions until August 19th, 2023. Eligibility criteria encompassed studies using CBCT, panoramic, and periapical radiographs to diagnose AP in the Saudi population. The *meta*-analysis employed a random-effects model due to high heterogeneity among studies.
Results: From 359 records, 13 studies were included, indicating a 40% prevalence of AP in individuals and a 6% prevalence across all teeth within the Saudi population. Root canal-treated teeth demonstrated a higher prevalence at 47%. The data revealed a substantial prevalence of AP compared to global averages, with first molars being the most affected. Studies showed moderate risk of bias and significant heterogeneity.
Conclusion: The high occurrence of AP in Saudi Arabia, particularly in root-treated teeth, emphasizes the need for enhanced endodontic care and more accurate diagnostics. Urgent improvements in dental health policies and further research are essential to understand AP's impact and improve oral health outcomes.

1. Introduction

Apical periodontitis (AP) develops due to a combination of various factors, with bacteria playing a significant role in its development (Siqueira and Rôças, 2007). It is characterized by an inflammatory response of the periapical tissues which occurs due to gradual and prolonged diffusion of irritants originating from an necrotic or inflamed pulp, or as a result of an unsuccessful endodontic treatment (Nair, 2004). Microbes and their toxins have the ability to access the pulp space through caries lesions, operative procedures, or trauma. Later, they could extend into the periapical tissues, where they interact with the host's defense mechanisms. (Möller et al., 2004, Kirkevang et al., 2007, Al-Omari et al., 2011). The main goal of endodontic treatment is to prevent AP and promote healing. This involves removing the infection, eliminating bacteria from the root canal system, and taking preventive measures against reinfection (ABBOTT, 2008, Good and McCammon, 2012). The therapeutic and biological objective of root canal treatment is to create an optimal environment that supports healing, restores health, and prevents the development or progression of AP (Young et al., 2007, Ørstavik, 2019). The difficulties of endodontic treatment is widely recognized, and epidemiological studies indicate a high incidence of teeth with suboptimal quality endodontic procedures (Kabak and Abbott, 2005, Kirkevang et al., 2007, Al-Omari et al., 2011). The diagnosis of AP is primarily based on radiographic examinations since it often lacks noticeable symptoms (Abbott, 2004). Consequently, the true prevalence and consequences of endodontic disease may be underestimated or not fully understood. Policy-makers must recognize the periapical health status of populations, as this understanding can result in improved resource allocation for preventing and treating endodontic diseases.

The global prevalence of AP among individuals with at least one affected tooth varies significantly, with documented cases ranging between 16 % and 86 % (Georgopoulou et al., 2005, Skudutyte-Rysstad and Eriksen, 2006, Al-Nazhan et al., 2017). The variation in reported prevalence rates of AP can be attributed to factors such as access to dental care, age, level of education, and the specific radiographic

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methods employed for diagnosis (Aleksejuniene et al., 2000, Kirkevang et al., 2007, Kruse et al., 2019). Previous research has utilized systematic review methodologies to synthesize existing data on apical periodontitis. However, certain studies have focused mainly on root canal-treated teeth (Hamedy et al., 2016, Segura-Egea et al., 2016), while others have examined specific population subgroups, including those with systemic conditions, old age individuals, and smokers (Walter et al., 2012, Hamedy et al., 2016, Khalighinejad et al., 2016, Segura-Egea et al., 2016, Berlin-Broner et al., 2017). A study by Pak et al. focused on a broader population but only included studies that analyzed teeth rather than individuals, thus lacking information on the individual-level prevalence of AP (Pak et al., 2012). Alternatively, a *meta*-analysis collected data across different communities, discovering AP in 52 % of individuals (Miri et al., 2018).

Despite the Saudi Arabian government's substantial investments in healthcare infrastructure and the provision of free dental treatment to its citizens, localized studies have revealed varying rates of AP prevalence. These studies, however, are not nationally representative, leaving a gap in our understanding of AP's true prevalence across the country. This discrepancy is further compounded by the absence of a national oral health survey and a unified system for medical records, which makes it challenging to gauge the overall impact of AP on the population's oral health. Given these circumstances, there's a pressing need to conduct comprehensive research to inform workforce allocation and investment in the oral healthcare sector more effectively.

To address this need, our study primarily aims to conduct a systematic review and *meta*-analysis using an extensive search strategy. This approach is designed to assess the prevalence of AP among the Saudi population, treating individuals as the primary unit of analysis. Furthermore, the study will assess the prevalence of AP across all teeth, including both root canal-treated and untreated teeth, with the tooth serving as the secondary unit of analysis. We aim to provide a clearer picture of AP's prevalence in Saudi Arabia, thereby facilitating more informed decisions in oral healthcare planning and resource allocation.

2. Material and methods

This study adhered to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist. (Moher et al., 2009), and the protocol was registered in the International Prospective Register of Systematic Reviews (CRD42023455937). We followed the updated PRISMA guidelines (Page et al., 2021) and the Cochrane Handbook of Systematic Reviews of Interventions guidelines (O'Connor et al., 2008).

2.1. Search strategy

The objective of this study is to answer the following research question: 'What is the prevalence of AP in the Saudi Arabian population?' The primary focus of the study was to analyze the main outcome using individuals as the basis for analysis. Additionally, secondary outcomes were examined using teeth as the basis for analysis, including the prevalence of AP in all teeth, and the prevalence of AP in teeth that received endodontic treatment. A comprehensive electronic search was conducted without any limitations on publication dates, encompassing studies published until August 19th 2023. The search was performed on databases including the US National Library of Medicine (PubMed-MEDLINE), Excerpta Medica (EMBASE), and Cochrane-CENTRAL. The Saudi Dental Journal was also searched manually. Free-text terms and keywords were utilized in the search strategies, which are provided in the Supplemental Material. In addition, grey literature was explored through resources such as Google Scholar and the OpenGrey repository. Furthermore, the reference lists of selected studies were manually screened for additional relevant full-text articles. The search strategy is presented in Supplementary File 1.

2.2. Eligibility criteria

The study incorporated various types of research designs, including prospective studies, cross-sectional, and baseline data from randomized controlled trials studies, which investigated the prevalence of AP in the Saudi Arabia population using cone-beam computed tomography (CBCT), panoramic radiographs, or periapical radiographs. When it comes to randomized controlled trials (RCTs) and cohort studies, only the prevalence data at the baseline was specifically collected and considered.

The following criteria were used to exclude studies: (1) studies lacking adequate data to assess the occurrence of AP on an individual or tooth level in the Saudi Arabia population, (2) studies that included participants with mixed dentition, (3) studies that did not clearly specify the method used to evaluate the status of the periapical tissues (such as PAI score, Strindberg criteria, etc.), and (4) conference abstracts, posters, letters, case reports/case series, and theses containing data already available in a journal article.

2.3. Study selection

The selection of included studies followed a two-phase process. In the initial screening phase (first phase), two reviewers (RA and RO) independently carefully examined the titles and abstracts of all identified studies from electronic databases to identify those that met the predetermined inclusion criteria. Moreover, articles lacking abstracts but appearing relevant based on their titles were also preselected and subjected to a thorough full-text analysis for eligibility. Subsequently, in the eligibility phase (second phase), both reviewers independently applied the same selection criteria to determine the final eligibility of the preselected studies. Additionally, to ensure consistency and accuracy, other reviewers (AB, AJ, and BA) also assessed the studies for conformity with the inclusion criteria.

In cases where there were differences of opinion regarding the eligibility of a particular study, the reviewers (RA and RO, or AB, AJ, and BA) engaged in extensive discussions until a consensus was reached. These discussions aimed to address any discrepancies and resolve any disagreements regarding the study's eligibility. If a consensus could not be reached through these discussions, the judgment of a third reviewer (FH) was sought and considered as the final and decisive factor in determining the study's eligibility. This process ensured a thorough and objective evaluation of the studies and the resolution of any conflicts in a fair and systematic manner.

2.4. Risk of bias (quality) assessment

Two reviewers independently assessed the methodological quality of the included studies (MH and FH) using a methodology entitled "Assessing risk of bias in population-based prevalence studies." Ten items make up the tool, which are divided into two domains: internal validity (items 5–10) and external validity (items 1–4). To reflect the likelihood of bias, each item is given a "yes" or "no" rating. Discussion between reviewers was used to settle disagreements. According to Hoy et al.'s (2012) methodology, the overall risk of bias for each study will be assessed based on agreement among all authors. Depending on how many items are rated "yes", studies will be classified as having a "High", "Moderate", or "Low" risk of bias.

2.5. Data analysis

Data from the reviewed manuscripts were systematically tabulated. Using Stata version 18 (StataCorp. 2023. Stata Statistical Software: Release 18. College Station, TX: StataCorp LLC.), we executed a *meta*-analysis to assess the prevalence of individuals with at least one tooth affected by AP, as well as the prevalence in all teeth and root-filled teeth. Subgroup analyses assessed the influence of imaging methods,

examination protocols, and tooth types on AP prevalence. Due to significant heterogeneity (I2 > 50 %), which is likely due to variations in study designs, populations, diagnostic criteria, and imaging techniques among the included studies, we adopted a random-effects model, which assumes that the true effect sizes vary between studies and is more appropriate when expecting heterogeneity across studies.

3. Results

3.1. Study selection and study characteristics

As shown in the PRISMA flow chart depicted in Fig. 1, we systematically selected studies for review. This selection process began with manual searches in Saudi dentistry journals and was supplemented with searches in three established databases: MEDLINE PubMed, Scopus/EMBASE, and the Cochrane Library. From an initial pool of 412 records, duplicates were filtered out, resulting in 359 unique records. After a thorough title and abstract screening, 22 papers advanced for full-text review. Out of these, nine were discarded for various reasons: four were not based in Saudi Arabia, one was a narrative review, another was a systematic review, one centered on animal studies, and one addressed AP per canal. The final stage consisted of 13 studies deemed appropriate for both qualitative synthesis and quantitative *meta*-analysis (Bahammam, 2012, Alfouzan et al., 2016, Al-Nazhan et al., 2017, Aldakhili and Alnasser, 2017, Khan et al., 2017, Sadaf et al., 2017, Balto et al., 2019, Mashyakhy et al., 2021, Al-Awasi et al., 2022, Alnowailaty and Alghamdi, 2022, Alghamdi and Almehmadi, 2023).

From 2016 to 2023, 13 studies were included, which are summarized in Table 1. All studies were published in English, and all were cross-sectional studies. A significant 26.6 % of these studies were conducted in Jeddah (Bahammam, 2012, Alnowailaty and Alghamdi, 2022, Alghamdi and Almehmadi, 2023). The rest spanned regions such as Dammam, Riyadh, Almadinah Al-munwarrah, Jazan, and Qassim. Most of the studies (93.3 %) were based in university dental clinics, though Al-Awasi's 2022 study was conducted in a specialized dental center. Methodologically, these studies adopted convenience sampling with participant counts ranging from 98 to 2161. The participants' mean age varied from 28.7 to 39.2 years, with a diverse gender representation—some studies having up to 100 % female participants.

While a few studies (Al-Awasi et al., 2022) and (Alrahabi and Younes, 2016), reported on patients with apical periodontitis, the majority highlighted the number of teeth affected by the condition. The imaging techniques primarily employed were CBCT and OPG. The focus of most studies was a comprehensive full mouth examination, though some cantered on specific teeth, especially posterior ones. Based on the tabulated data in Table 1, it emerges that the first molars are predominantly the teeth most affected by AP.

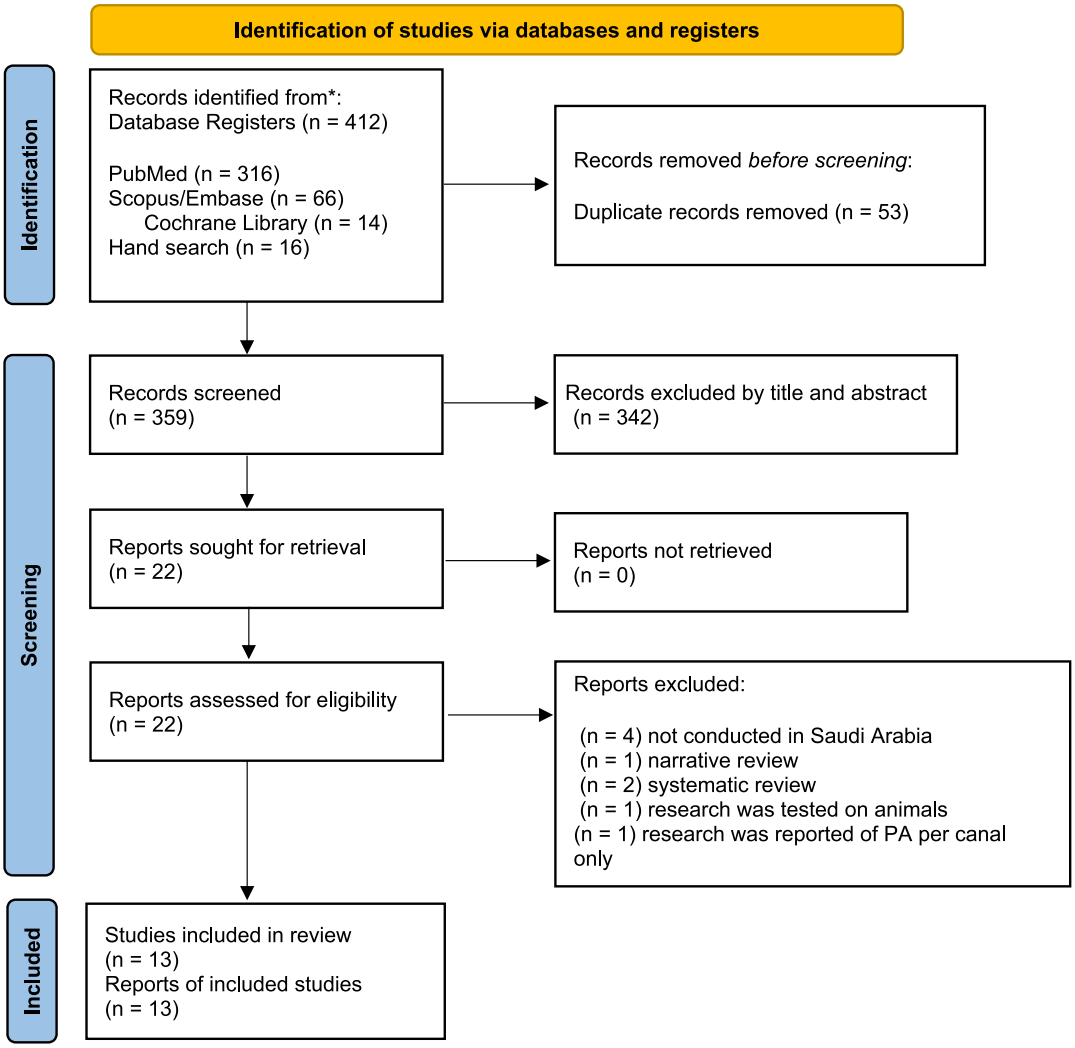

Fig. 1. PRISMA flow chart of the studies selection.

Table 1
Characteristics of the selected studies – Prevalence of apical periodontitis on person and tooth levels.

Study	City	Location of recruitment	Number of participants	Gender (% of females)	Age mean (SD)	Age range	Full mouth/ specific teeth?	Method of assessing AP	Image method	Only RCT teeth included	Patients with AP N (%)	Number of examined teeth	Teeth with AP N (%)	N of RCT Teeth (%)	N of RCT Teeth with PA (%)	Most Prevalent tooth
Mashyakhy, 2021 (A)	Jazan	University dental clinic	208	57 %	28.74 ± 9.56	NR	Full mouth	Radiographic criteria	CBCT	No	NR	5,504	264 (4.50 %)	246 (4.50 %)	163 (66.26 %)	First molars
Al-Awasi, 2022	Dammam	Specialized Dental Center	2161	59.2 %	41.56 ± 12.85	17–81	Full mouth	Periapical index (PAI)	OPG	Yes	756(35 %)	2161	756 (35 %)	2034 (93 %)	634 (31 %)	Molars with poor RCT
Alnowailaty, 2022 (A)	Jeddah	University Dental Hospital	300	50 %	40.1 ± 18.1	18–80	Posterior teeth	Radiographic criteria	CBCT	Yes	NR	385	61 (15.84)	385 (100 %)	61 (15.84 %)	Maxillary first molars
Mashyakhy, 2021 (B)	Jazan	University dental clinic	208	52 %	NR	NR	Posterior teeth	Radiographic criteria	CBCT	No	NR	3046	123 (4 %)	165 (5.40 %)	123 (74.50 %)	Maxillary first molars
Farah, 2017	Qassim	University dental clinic	NR	19 %	NR	NR	Full mouth	Periapical index (PAI)	PA	Yes	NR	327	72 (22 %)	327 (100 %)	72 (22 %)	Maxillary premolars
Alrahabi, 2017	Madinah	University dental clinic	630	49.8 %	NR	16->76	Full mouth	Radiographic criteria	OPG	No	337 (53.50 %)	15,686	667 (4.20 %)	997 (100 %)	658 (53.50 %)	Mandibular first molars
Bahammam, 2023	Jeddah	University dental clinic	98	0 %	69.66(27.8)	20–60	Full mouth	Radiographic criteria	OPG	No	7 (7.14 %)	2410	159 (6.60 %)	159 (6.60 %)	126 (79 %)	NR
Alghamdi, 2022 (A)	Jeddah	University dental hospital	300	50 %	39.2 ± 17.6	18–80	Posterior teeth	Radiographic criteria	CBCT	Yes	NR	433	79 (18.20 %)	433 (100 %)	79 (18.20 %)	Mandibular first molars
Sadaf, 2017	Qassim	University dental clinic	400	100 %	30 ± 2 years	18–70	Full mouth	Periapical index (PAI)	OPG	Yes	NR	1108	813 (73.40 %)	1108 (100 %)	813 (73.40 %)	NR
Balto, 2018	Riyadh	University dental clinic	46	0 %	30.2 ± 12.2 years for smokers, and 32.8 ± 14.1 years for non-smokers.	NR	Full mouth	Radiographic criteria	CBCT	No	NR	600	85 (14.20 %)	NR	NR	NR
Alfouzan, 2016	Riyadh	University dental hospital	193	58 %	Males 38.4 ± 11.3 / females 36.8 ± 10.4	NR	Full mouth	Periapical index (PAI)	OPG	Yes	NR	324	190 (58.60 %)	324 (100 %)	190 (58.60 %)	Maxillary right posterior teeth
Al-Nazhan, 2017	Multi-cities	University dental clinics and other dental centers	926	42 %	NR	16->55	Full mouth	Radiographic criteria	OPG	No	592 (63.90 %)	25,028	1,556 (6.20 %)	1,541 (6.16 %)	617 (40 %)	Mandibular incisors
Khan, 2017	Dammam	University dental hospital	146	49 %	NR	13->65	Full mouth	Periapical index (PAI)	OPG and PA	Yes	NR	325	72 (22.15 %)	325 (100 %)	72 (22.15 %)	First molars

NR: Not reported

3.2. Risk of bias

As all of the included studies utilized a convenience sampling technique, all of the studies were lacking in the external validity criteria. All of the included studies were at moderate risk of bias (Table 2).

3.3. Meta-analysis

3.3.1. Primary outcome (Prevalence of AP in the Saudi population – Patients as the unit of analysis)

The prevalence of individuals with AP within the Saudi population was 40 % based on four studies that reported the prevalence of AP using patients as the unit of analysis (95 % CI 16 %–64 %; I2 = 99.56 %) (Fig. 2).

3.3.2. Secondary outcomes

3.3.2.1. Prevalence AP in Saudi Arabia – Teeth as the unit of analysis. The overall prevalence of teeth affected by AP was 6 % (95 % CI 4 %–9%; I2 = 99.41 %) based on six studies that examined all teeth (Fig. 3).

3.3.2.2. Prevalence AP in Saudi Arabia – Root-filled teeth as the unit of analysis. The focus for this secondary outcome was on the prevalence of teeth that underwent endodontic treatment and presented with apical periodontitis. The findings indicated that 47 % (95 % CI 33 %-61 %), of the endodontically-treated teeth exhibited AP. In the subgroup analysis, we divided these studies based on the location of the root canal-treated teeth into two sub-categories: full mouth and posterior teeth. The full mouth category, which included nine studies, showed a prevalence of 51 % (95 % CI 36 %-66 %; I2 = 99.41 %). In contrast, the posterior teeth category, comprising three studies, reported a lower prevalence of 36 % (95 % CI 1 %-74 %; I2 = 99.55 %) (Fig. 4).

3.3.2.3. Subgroup analysis based on the imaging technique. The aggregated data shows variations in the frequency of AP. Five studies that used CBCT for AP assessment recorded an 11 % prevalence (95 % CI 5 %–17 %; I2 = 99.15 %). This is comparatively lower than the six studies which utilized OPG radiographs, where the AP frequency was 31 % (95 % CI 7 %–55 %; I2 = 99.99 %). Additionally, one study that integrated both OPG and PA radiographs identified an AP frequency of 22 % (95 % CI 18 %–27 %). Similarly, another study that exclusively used PA radiographs also reported an AP frequency of 22 % (95 % CI 18 %–27 %) (Supplementary File 2).

4. Discussion

The aim of this systematic review is to assess the prevalence of apical periodontitis (AP) in Saudi Arabia, with a primary focus on individuals. We found a significant average AP prevalence of 40 % (95 % CI: 16–64 %), revealing substantial variability and highlighting AP's considerable impact on Saudi Arabia's adult population. The secondary outcome analysis identified a general AP prevalence of 6 % across all teeth, escalating to 47 % in root canal-treated teeth. These findings underscore the critical need for immediate action and targeted intervention strategies by health policymakers, dental professionals, and academic institutions in Saudi Arabia to address the significant AP burden.

We have identified 13 studies that evaluated the prevalence of AP in Saudi Arabia using teeth as a unit of analysis. The prevalence of AP ranged from 4 % to 14 % in studies that assessed AP in all teeth, and from 16 % to 73 % in studies that assessed AP in root canal-treated teeth only. Pooling data from 13 studies encompassing 52,274 teeth; we executed an extensive *meta*-analysis, providing a consolidated view of AP disease prevalence in the Saudi Arabian population. The *meta*-analysis showed an overall prevalence rate of around 6 % among all teeth of the included studies. Significantly, this rate is comparable to the global prevalence of AP, which a recent systematic review estimated at 5 % (Tibúrcio-Machado et al., 2021). Furthermore, it mirrors the 6.3 % prevalence rate identified in an earlier systematic review, which analyzed AP prevalence in the general population based on cross-sectional studies published from 2012 to 2020 (Jakovljevic et al., 2020). On the other hand, our *meta*-analysis on root canal-treated teeth, synthesizing data from 12 studies and 8044 teeth, indicates an AP prevalence of roughly 47 %. This surpasses the global prevalence for root canal-treated teeth, set at 39 % (Tibúrcio-Machado et al., 2021) and the prevalence of 41.3 % found by an earlier systematic review (Jakovljevic et al., 2020).

In the reviews, eight studies highlighted that molars, both maxillary and mandibular, were most commonly associated with AP in Saudi Arabia (Alfouzan et al., 2016, Alrahabi and Younes, 2016, Khan et al., 2017, Mashyakhy and Alkahtany, 2021, Mashyakhy et al., 2021, Al-Awasi et al., 2022, Alnowailaty and Alghamdi, 2022, Alghamdi and Almehmadi, 2023). This could be attributed to the complex anatomy of these teeth, which act as a reservoir for the bacteria and their by-products. Such anatomical complexities, combined with accessibility issues, can affect the success of root canal treatments and periapical lesion resolution. The proficiency of the dentist during treatment could also influence the persistence of periapical lesion and play a role in these findings. Most studies in the review did not specify when radiographs were taken, a factor influencing the resolution of periapical lesions, especially in teeth treated endodontically. Over time, periapical lesions can diminish or vanish (Endodontology, 2006). However, the presence of periapical lesion in such teeth doesn't always signify treatment failure. It is challenging to determine whether these lesions are healing, developing, or worsening — a limitation intrinsic to cross-sectional studies which capture data at a single point, neglecting the temporal

Table 2
Risk of bias of the included studies.

	Articles	External validity				Internal validity						Overall RoB
		Selection and non-response bias domains				Measurement bias and bias related to the analysis domains						
		1	2	3	4	5	6	7	8	9	10	
1	Mashyakhy, 2021 (A)	X	X	X	✓	✓	✓	✓	✓	✓	✓	**Moderate RoB**
2	Al-Awasi, 2022	X	X	X	✓	✓	✓	✓	✓	✓	✓	**Moderate RoB**
3	Alnowailaty, 2022 (A)	X	X	X	✓	✓	✓	✓	X	✓	✓	**Moderate RoB**
4	Mashyakhy, 2021 (B)	X	X	X	✓	✓	✓	✓	X	✓	✓	**Moderate RoB**
5	Farah, 2017	X	X	X	✓	✓	✓	✓	✓	✓	✓	**Moderate RoB**
6	Alrahabi, 2017	X	X	X	✓	✓	✓	✓	✓	✓	✓	**Moderate RoB**
7	Bahammam, 2023	X	X	X	✓	✓	✓	✓	✓	✓	✓	**Moderate RoB**
8	Alghamdi, 2022 (A)	X	X	X	✓	✓	✓	✓	✓	✓	✓	**Moderate RoB**
9	Sadaf, 2017	X	X	X	X	X	✓	X	✓	✓	✓	**Moderate RoB**
10	Balto, 2018	X	X	X	✓	✓	✓	✓	✓	✓	✓	**Moderate RoB**
11	Alfouzan, 2016	X	X	X	✓	✓	X	X	✓	✓	✓	**Moderate RoB**
12	Al-Nazhan, 2017	X	X	X	✓	✓	✓	✓	✓	✓	✓	**Moderate RoB**
13	Khan, 2017	X	X	X	✓	✓	✓	✓	✓	✓	✓	**Moderate RoB**

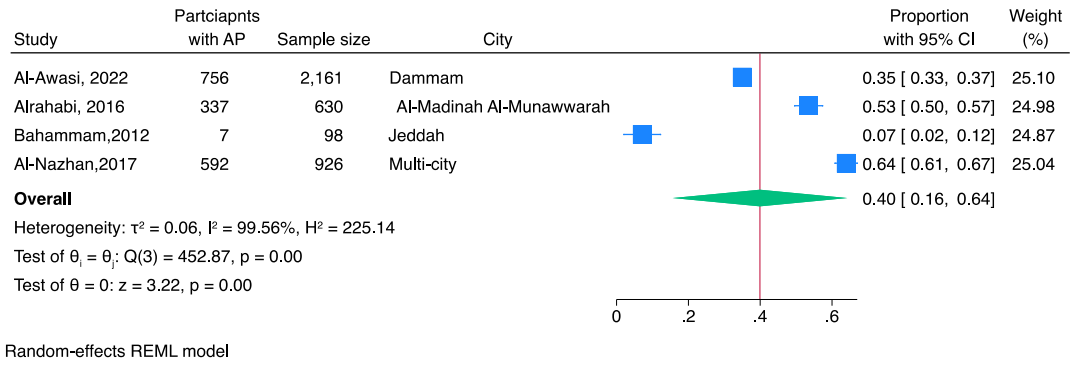

Fig. 2. Prevalence of AP in Saudi Arabia (individuals' level).

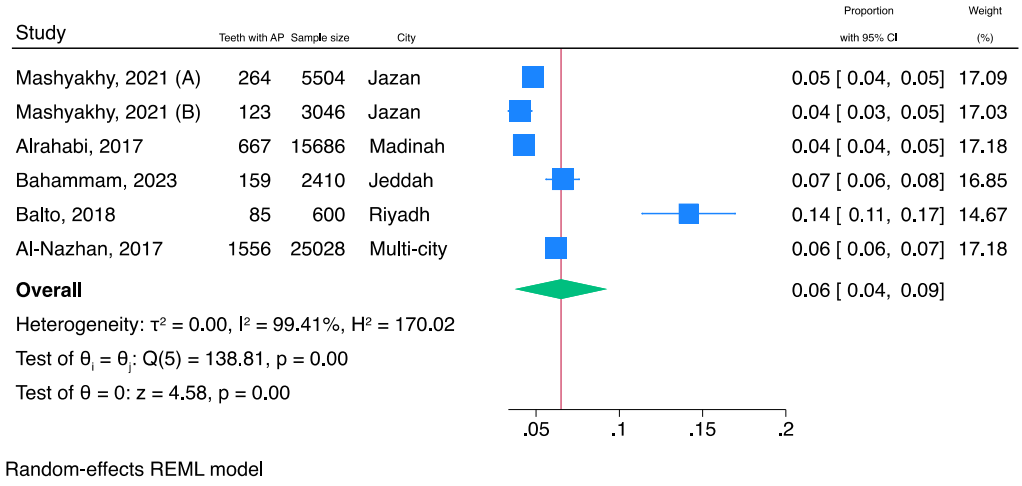

Fig. 3. Prevalence of AP in Saudi Arabia (tooth level).

effects on variables.

Five studies used CBCT as an assessment method, six used the OPG, and only two used periapical x-rays. Many studies showed that CBCT has more accurate diagnostic than the other imaging methods, which could increase the risk of overestimating the results (Mostafapoor and Hemmatian, 2022). However, in the current study, the pooled data of CBCT studies showed a lower prevalence of periapical lesions (11 %) than those that used OPG (31 %) as a diagnostic method, which might be explained by the reduced diagnostic ability of CBCT in the presence of root canal fillings (Queiroz et al., 2018, Patel et al., 2019). OPG images alone are the least effective evaluation method in assessing the periapical area of teeth, which could be inadequate for the screening of AP. The distortion and magnification in the produced image can significantly reduce the OPG dimensional accuracy, which increases the risk of underestimation of periapical lesions (Eriksen and Bjertness, 1991, Stramotas et al., 2002).

Several limitations in this review should be acknowledged. Firstly, the inherent nature of the cross-sectional design in all included studies restricts the ability to discern the trajectory of AP lesions—be it healing or deteriorating. Secondly, a majority of the studies did not delineate whether root canal treatments were performed by general dentists or endodontists. Such differentiation could offer deeper insights into treatment quality and its potential relation to AP lesion incidence. Thirdly, a limited number of studies provided data on AP prevalence amongst patients, with most focusing on teeth as the primary unit of analysis. Consequently, an overall prevalence of AP among adults in Saudi Arabia might not be truly representative of the current situation. Fourthly, in our systematic search for relevant studies on AP prevalence in Saudi Arabia, we located 13 studies spanning only six regions, which may not wholly represent the nation's true prevalence. Fifthly, a significant 92 % of the studies were based in university clinics or hospitals, with no identified studies from general dental practices. The potential influence of incorporating studies from general dental practices on AP prevalence remains undetermined. However, this review does bear several merits. Adhering to the latest guidelines for the planning, execution, and reporting of reviews (Higgins, 2008, Page et al., 2021) lends it methodological robustness. Our approach included multiple *meta*-analyses and subgroup analyses. As far as we know, this is the pioneer systematic review examining the prevalence of AP in Saudi Arabia. Such findings hold potential utility for policymakers and regional health authorities in strategizing public oral health enhancements for the Saudi population.

Future research on AP prevalence in Saudi Arabia should prioritize longitudinal studies to capture dynamic AP lesion patterns over time. It's essential to differentiate between root canal treatments performed by general dentists and endodontists to ascertain treatment quality variations. Additionally, shifting the focus from teeth to a more patient-centric analysis and expanding the study scope to include unrepresented regions and general dental practices will offer a holistic view of AP prevalence. Integrating advanced diagnostic tools and considering factors like patient nutrition, systemic health and hygiene practices would enhance study accuracy and offer a comprehensive understanding vital for policy formulations.

5. Conclusion

In conclusion, this comprehensive review has offered valuable insights into the occurrence of AP in Saudi Arabia, revealing an elevated

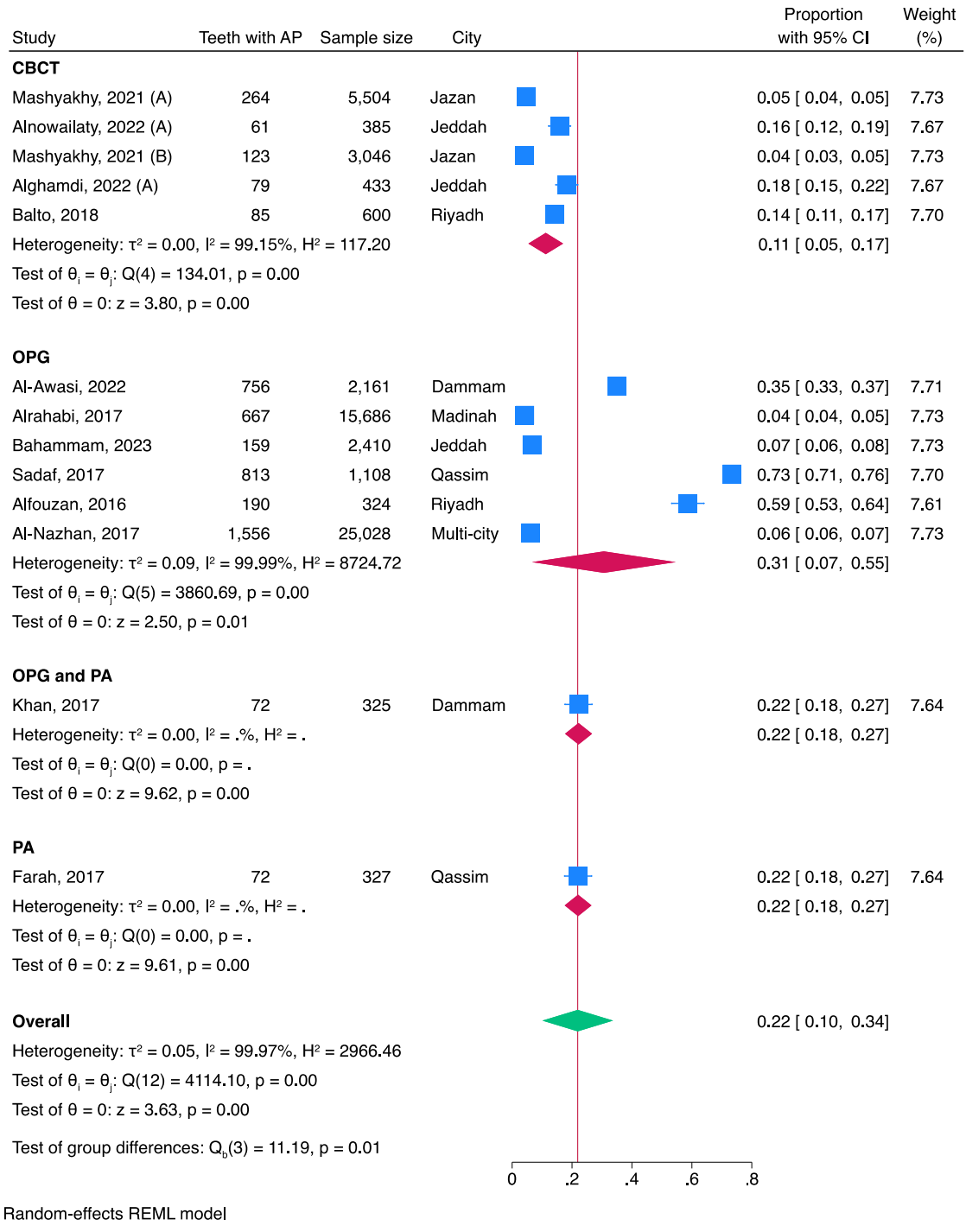

Fig. 4. Subgroup analysis of prevalence of AP in Saudi Arabia (tooth level) according to the method of image.

prevalence among all teeth and endodontically-treated teeth, respectively. Nevertheless, considering the restricted quantity of studies, along with diverse research methodologies and heterogeneity, there is a compelling need for additional research to achieve a more accurate understanding of AP prevalence in Saudi Arabia and enhance the oral health of the Saudi population.

Funding

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Ethical approval

Since this study is a systematic review, it did not entail gathering primary data from human subjects, thus obviating the need for ethical approval. The review protocol was registered with PROSPERO to ensure transparency and compliance with established review methodologies.

CRediT authorship contribution statement

Faisal F. Hakeem: Conceptualization, Formal analysis, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Muhannad M. Hakeem:** Conceptualization, Data curation,

Methodology, Writing – original draft. **Abdulmajeed Abdulaziz Baik:** Conceptualization, Data curation, Methodology, Writing – original draft. **Rasha Omar Aldadjan:** Conceptualization, Data curation, Methodology, Writing – original draft. **Razan Ali Alsahli:** Conceptualization, Data curation, Methodology, Writing – original draft. **Arina Jafar Almarwani:** Conceptualization, Data curation, Methodology, Writing – original draft. **Basim M. Abu Zaid:** Conceptualization, Data curation, Methodology, Writing – original draft.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sdentj.2024.06.009.

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