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A large, stylized sunburst or fan-like graphic in a lighter shade of teal, positioned on the left side of the cover. It has a dark teal center and radiating segments that create a sense of movement and light.

# Integration of Oral Health into Primary Care: The Policy and Practice

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Balgis Gaffar





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# **INTEGRATION OF ORAL HEALTH INTO PRIMARY CARE: THE POLICY AND PRACTICE**

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*Praise be to Allah first and foremost  
who gave me strength and determination.*

*To my family.*

*To Nouf and Abdulrahman,  
the joy of my life.*

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Faculty of Medicine

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## ABSTRACT

This study evaluated global oral health policy integration, interdisciplinary practices, and the effectiveness of an educational intervention among healthcare providers in Saudi Arabia.

In phase I, data was collected from 60 countries to assess oral health policies. In phase II, 1,398 healthcare professionals from Saudi Arabia were surveyed to examine interdisciplinary practices, and 525 nurses were assessed for attitudes and practices in phase III. In phase IV, an educational intervention targeting nurses and physicians was evaluated for its impact on oral health knowledge and beliefs.

The study found that 55.2% of the countries had formal oral health policies for children, with 54% incorporating oral health into general health policies. Of the countries, 49.4% had programs targeting disadvantaged populations and 48.3% included dental care in universal health coverage. Interprofessional collaboration was encouraged in 53.3% of countries, with significant regional variation.

In Saudi Arabia, the mean oral health knowledge score among the healthcare professionals was  $7.1 \pm 2.1$  (out of 13), with physicians scoring the highest and nurses the lowest scores. Attitudes towards oral health care were generally positive. Among the nurses, 70.3% responded to patients' oral health concerns and 47.1% conducted screenings, while 19.7% provided oral health education. The key barriers included lack of training (61.7%) and heavy workloads (53.8%).

The educational intervention significantly improved the knowledge scores (mean post-intervention:  $20.3 \pm 3.6$  for the video participants,  $18.4 \pm 4.2$  for the brochure participants,  $p < 0.001$ ), while belief scores remained unchanged.

Global and national gaps persist in oral health policy integration and interdisciplinary practices. The educational intervention effectively improved oral health knowledge but had limited impact on beliefs. Enhanced training, policy support, and interprofessional collaboration are essential to advancing oral health integration.

**KEYWORDS:** Interprofessional engagement, Oral health policy, Interdisciplinary practices, Dental care, Oral Health, Integrated care.

## TURUN YLIOPISTO

Lääketieteellinen tiedekunta

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## TIIVISTELMÄ

Tässä tutkimuksessa arvioitiin maailmanlaajuisesti suun terveystieteiden integraatiota, monitieteisiä käytäntöjä ja terveydenhuollon ammattilaisten koulutustoimien tehokkuutta Saudi Arabiassa.

Vaiheessa I kerättiin tietoja 60 maasta suun terveystieteiden arvioimiseksi. Vaiheessa II kyselyyn osallistui 1398 terveydenhuollon ammattilaista Saudi-Arabiassa monitieteellisten käytäntöjen selvittämiseksi ja vaiheessa III 525 sairaanhoitajan asenteita ja käytäntöjä. Vaiheessa IV arvioitiin sairaanhoitajille ja lääkäreille suunnatun koulutusinterventioita vaikuttavuutta suun terveyteen liittyvään tietoon ja uskomuksiin.

Maailmanlaajuisesti 55,2 %:lla maista oli virallinen lasten suun terveystieteiden ja 54 %:lla maista suun terveydenhuolto sisällytettiin yleiseen terveystieteen. Maista 49,4 %:lla oli ohjelmia, jotka oli suunnattu heikommassa asemassa oleville väestöryhmille ja 48,3 % sisällytti hammashoidon yleiseen terveydenhuoltoon. Moniammatillista yhteistyötä kannustettiin 53,3 %:ssa maista ja alueelliset erot vaihtelivat merkittävästi.

Saudi-Arabiassa terveydenhuollon ammattilaisten keskimääräinen suun terveyden tietopistemäärä oli  $7,1 \pm 2,1$  (13:sta); lääkärit saivat korkeimmat ja sairaanhoitajat alhaisimmat pisteet. Asenteet suun terveyttä kohtaan olivat yleensä positiivisia. Sairaanhoitajista 70,3 % vastasi potilaiden suun terveyden kysymyksiin, 47,1 % teki seulontatutkimuksia ja 19,7 % antoi suun terveystieteen koulutusta. Keskeisiä esteitä olivat koulutuksen puute (61,7 %) ja raskaat työmäärät (53,8 %).

Koulutusinterventio paransi merkittävästi suun terveyden tietopisteitä (keskiarvo interventioon osallistuneilla:  $20,3 \pm 3,6$  videoryhmässä ja  $18,4 \pm 4,2$  esiteryhmässä;  $p < 0,001$ ). Uskomuspisteet pysyivät ennallaan.

Suunterveystieteiden integroinnissa ja monitieteisissä käytännöissä on edelleen maailmanlaajuisia ja kansallisia puutteita. Koulutusinterventio paransi merkittävästi tietämystä suunterveydestä, mutta sillä oli rajallinen vaikutus uskomuksiin. Tehostettu koulutus, poliittinen tuki ja ammattien välinen yhteistyö ovat välttämättömiä suun terveyden integroinnin edistämiseksi.

AVAINSANAT: Ammatillinen sitoutuminen, Suun terveystieteiden politiikka, Tieteiden väliset käytännöt, Hammashoito, Suun terveys, Integroitu hoito.

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# Abbreviations

ACA	Affordable Care Act
CHWs	Community Health Workers
ECC	Early Childhood Caries
EHRs	Electronic Health Records
ENT	Ear Nose and Throat
FDI	World Dental Federation
GP	General Practitioner
GRF	Global Research on Fatalities
HPV	Human Papillomavirus
HRSA	Health Resources and Services Administration
IAPD	International Association of Pediatric Dentistry
IARC	International Agency for Research on Cancer
IC	Integrated Care
IDP	Interdisciplinary Practices
IP	Interprofessional Practices
IPC	Interprofessional Collaboration
IPE	Interprofessional Education
KAP	Knowledge, Attitude, and Practice
LMICs	Low- and Middle-Income Countries
MOH	Ministry of Health
NCDs	Non-communicable Diseases
NHI	National Health Insurance
NHS	National Health Service
OC	Oral Cancer
OOP	Out Of the Pocket
OTC	Over The Counter
OHK	Oral Health Knowledge
OHE	Oral Health Education
PCMH	Patient-Centered Medical Homes
PCPs	Primary Care Physicians
PDS	Public Dental Service

SA	Saudi Arabia
SDGs	Sustainable Development Goals
SUS	Sistema Único de Saúde
UHC	Universal Health Coverage
UK	United Kingdom
UN	United Nations
USA	United States of America
WHO	World Health Organization

# List of Original Publications

This dissertation is based on the following original publications, which are referred to in the text by their Roman numerals:

- I **Gaffar, B.**, Schroth, R. J., Foláyan, M. O., Ramos-Gomez, F., & Virtanen, J. I. (2024). A global survey of national oral health policies and its coverage for young children. *Frontiers in Oral Health*, 5, 1362647.
- II **Gaffar, B.**, Farooqi, F. A., Nazir, M. A., Bakhurji, E., Al-Khalifa, K. S., Alhareky, M., & Virtanen, J. I. (2022). Oral health-related interdisciplinary practices among healthcare professionals in Saudi Arabia: Does integrated care exist?. *BMC Oral Health*, 22(1), 75.
- III **Gaffar, B.**, Bakhurji, E., AlKhateeb, R., AlHashim, H., AlGaoud, H., AlDaamah, Z., ... & Virtanen, J. I. (2023). Exploring factors influencing nurses' attitudes towards their role in dental care. *PLoS One*, 18(7), e0288927.
- IV **Gaffar, B.**, Alkhaldi, A., Alshehri, T., Altayyar, R., Farooqi, F. A., Bakhurji, E., Virtanen, J. I. (2025). Impact of educational video intervention to improve oral health knowledge and beliefs among physicians and nurses. *BMC Oral Health* 2025; 25.

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# 1 Introduction

It is now known that there is a reciprocal relationship between oral and overall health. Many general problems and medical conditions have oral manifestations (Peres, et al., 2019); in the same context oral and dental diseases might aggravate the consequences and comorbidities of health problems (Kapila, 2021 and Ciantelli et al., 2024). The World Health Organization (WHO) defined health as a condition of complete physical, mental, social, and spiritual well-being rather than just the absence of disease or infirmity, acknowledging the first holistic understanding of health (Card, 2017). Additionally, oral health is multifaceted, encompassing social, emotional, psychological, and physical aspects that are essential to general health and wellbeing (Peres et al., 2019). Worldwide, oral diseases are common and cause a substantial burden on both adults and children. The cost of dental care, a lack of screening and monitoring, along with country and patient-related factors are key players that contribute to prevalence of oral diseases (Aida et al., 2022).

Integrated care (IC) is defined as ‘bringing together inputs, delivery, management and organization of services related to diagnosis, treatment, care, rehabilitation and health promotion’ (Valentijn et al., 2013). It has been promoted by the WHO as a means of improving health outcomes and access to care and reducing the cost of healthcare (Gröne & Garcia-Barbero, 2001). The Surgeon General Report also called for measures to reduce disparities and to bridge the gap between medical and dental care (Quiñonez et al., 2022). The integrated primary care concept promotes the collaboration of healthcare professionals from different specialties to improve the delivery and quality of health services and thus reducing disparities between geographical and socioeconomic groups (Gröne & Garcia-Barbero, 2001 and Valentijn et al., 2013 and Atchison et al., 2018). As oral and systemic diseases share many common risk factors (Budreviciute et al., 2020); the WHO and the American Academy of Family Physicians have promoted mechanisms to incorporate essential oral health services into primary healthcare services (Petersen et al., 2020 and Phillips & Hummel, 2016).

In the literature integrated health practices include many aspects and levels such as undergraduate education, collaborative clinical practice, and public and private partnerships (Christian et al., 2023 and Bogossian et al., 2023). However, such

integration may be limited by structural, organizational and individuals' factors. (Choi et al., 2020 and Christian et al., 2023). Such integration is crucial especially in countries with limited resources, disadvantaged populations, and young children (George et al., 2019). Integrated care targeting children can start even before birth; it is reported that mothers who received oral health education and screening as part of their prenatal (George et al., 2019) or postnatal care showed significant improvements in their oral health behaviors as well as better oral health conditions (George et al., 2019).

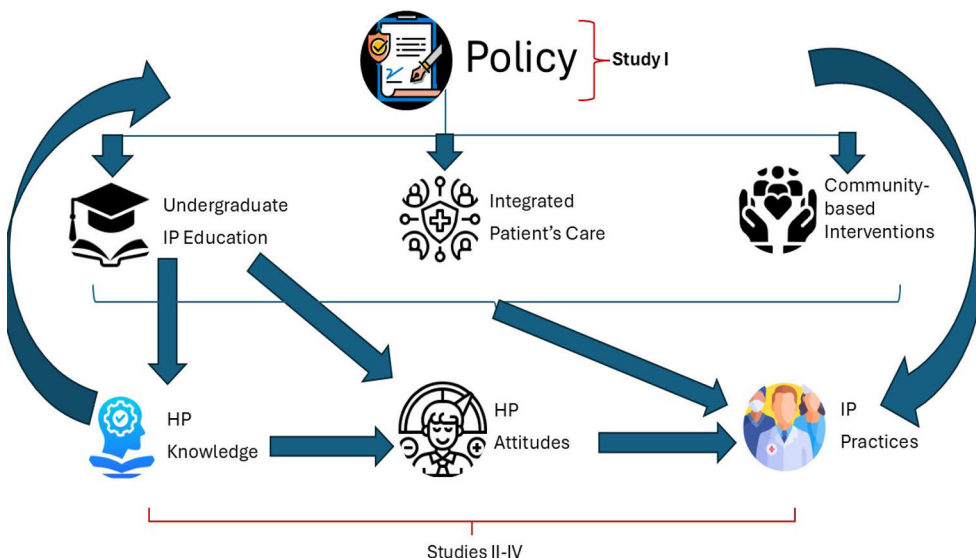
General and oral health care requires the combined efforts of the medical and dental professions. Healthcare professionals, namely nurses, and physicians can be trained to provide oral health screening and education and can play a significant role in the prevention and early detection of oral health conditions as part of their medical practice (Thema & Singh, 2013 and Kumar, 2021). To facilitate such integration and many interventions were evaluated, for example Park and colleagues explored the integration of dental care during formal education (Park et al., 2017). According to an article in the journal of medical ethics, the medical-dental divorce that still exists today -and prevents the integration of oral health with general health- is caused by the belief that the oral cavity is distinct from the rest of the body (Rasmussen et al., 2022). The authors suggested modifications in curricula to reunify dentistry and medicine, including dual degree training, interprofessional undergraduate education, and integrated residency training (Rasmussen et al., 2022). Others also proposed combining self-paced distance learning, integrated practice-based learning, and hospital rotations with dental students (Dolce et al., 2017). In the same context interventions after formal education were also evaluated, such as the use of oral health educational materials (Mohebbi et al., 2018), continuous education sessions and professional development (Huang et al., 2021) as well as the use of audiovisual aids and smart phone applications (Bonabi et al., 2019).

Despite numerous global oral health interventions and studies that evaluated IC and IP, more comprehensive research and evaluation are necessary. Evidence gaps persist, with many initiatives lacking robust evaluation and high-quality, long-term data (Wu et al., 2020 and Yimenu et al., 2020 and Wei et al., 2022 ). Cultural and socioeconomic contexts require tailored solutions, highlighting the inadequacy of one-size-fits-all approaches. Furthermore, weak policy integration hinders sustainable change (Abou El Fadl et al., 2016 and Wei et al., 2022). Lastly, monitoring implementation and impact is essential for understanding effectiveness and areas for improvement, promoting health system learning and informed policy decisions (Wei et al., 2022).

This research looked at current global oral health policies and current interprofessional practices (IP) in Saudi Arabia. There is a need to investigate factors that hinder integrated care across different contexts and settings from policies (on macrolevel) to knowledge, beliefs, and practices (on microlevel). The conceptual

framework in Figure 1, shows how these factors affect each other. Understanding oral health policies and interdisciplinary practices in a country like Saudi Arabia is crucial for contextualizing intervention effectiveness. Furthermore, mapping policy integration and healthcare delivery can reveal gaps and barriers, therefore, informing policymakers on best practices, support educational reforms, and provide data for effective collaboration within the context of Saudi Arabia. Globally, integration of oral health into general healthcare is still fragmented (Abou El Fadl et al., 2016 and Wei et al., 2022). By evaluating Saudi Arabia's experience, it allows the comparison with other systems (e.g., Brazil, UK, Sweden, U.S.), and can contribute to global dialogue on oral health integration. Such information can be of use for ministries of health, academic institutions as well as international health organizations.

This thesis is grounded in the hypothesis that, despite increasing recognition of the oral-systemic health relationship and national health policy, the integration of dental care into healthcare systems in Saudi Arabia remains limited and inconsistently applied. The thesis expects to prove the effectiveness of educational interventions in facilitating integrated practices through the improvements in knowledge and beliefs.



**Figure 1.** Study conceptual framework. This conceptual framework illustrates the interconnected components and the study phases. At the core, policy (Study I) influences three main domains: undergraduate IP education, integrated patient care, and community-based interventions, which are interlinked to reflect their mutual reinforcement. Undergraduate IP education contributes directly to health professionals' (HP) knowledge, which shapes their attitudes and influences IP practices. These pathways are the focus of Studies II–IV, which examine the relationships between knowledge, attitudes, and practices (KAP). The directional arrows represent the flow of influence among KAP components, highlighting how policy affects and is affected by healthcare professionals' KAP.

## 2 Review of Literature

### 2.1 Burden of oral diseases

The physical, psychological, social and economic impacts of oral diseases on individuals and countries are of global concern (Peres et al., 2019). While preventable, dental caries, periodontal disease and tooth loss are prevalent among all age groups (Peres et al., 2019) and can contribute to serious health complications (Altamura et al., 2024). The view of oral health independently from overall health has led to fragmented care (Kondru, 2016), as well as the lack of public awareness, and preventive measures aggravating further the burden of oral diseases especially among vulnerable populations such as the elderly, people with disabilities and those living in marginalized areas (Park et al., 2017 and James et al., 2018). Socio-economic status is a key determinant of oral diseases. Individuals from lower socio-economic backgrounds often experience higher rates of dental caries, periodontal disease, and oral cancer due lack of preventive dental care, inadequate oral hygiene practices, and increased exposure to risk factors like tobacco and alcohol (Rodriguez et al., 2023). In rural and underserved communities, the financial burden of dental care can prevent access to routine dental visits and early diagnosis, leading to an increase in untreated oral diseases along with their related complications (Listl et al., 2015).

#### 2.1.1 Prevalence of oral diseases

According to the report from the Global Burden of Disease (GBD) published in 2018 (GRF 2018), dental caries, periodontal diseases, and tooth loss, affect more than 44.5% of the worldwide population (Vos et al., 2020). The World Health Organization (WHO) has consistently identified oral health as one of the ten essential components of human well-being, due to its significant impact on the quality of life and global public health (Petersen, 2009; Jain et al., 2024). Untreated oral problems may result in pain, sepsis, decreased school attendance, diminished work productivity, and an overall deterioration in the quality of life (Jin at al., 2016 and Kazemina et al.,2020). The severity of oral diseases differs significantly by region,

ethnicity, age, and gender, highlighting pronounced inequalities in oral health among various populations (Petersen, 2009; Jain et al., 2024).

#### 2.1.1.1 Dental caries

Dental caries is one of the most prevalent oral diseases globally, with its prevalence influenced by factors such as demographics, geographical location, and access to dental care (Borg-Bartolo et al., 2022; Nath et al., 2023). This multifactorial disease starts as demineralization of hard tissues, primarily due to acids produced by cariogenic bacteria (Kazeminia et al., 2020). If untreated, the disease can proceed to cavitation, pulpal involvement and may lead to tooth loss (Kazeminia et al., 2020). The interaction between bacteria, dietary choices, and tooth-related factors is critical for the initiation and progression of caries (Kazeminia et al., 2020). The WHO estimates that around 2.3 billion people worldwide are affected by dental caries, particularly children and adolescents (WHO, 2022a). A global caries prevalence of 46.2% was reported for primary teeth and 53.8% in permanent dentition (Kazeminia et al., 2020) with lower incidences in Europe and higher rates in African nations (Frencken et al., 2017). In Saudi Arabia, recent studies reveal average prevalences of 75.4% in primary teeth and 67.7% in permanent teeth (Khan et al., 2024). In Finland, the caries mean DMFT has been declining from 2 in 1988 to 0.9 in 2018 (Linden, 2023) and the percentage of 12-years old children who are caries free increased from 30% in 1991 to 62% in 2018 (Linden, 2023). The WHO latest report showed the prevalence of untreated caries among adults was 29.7% (WHO, 2022b). In high-income countries, the incidence of dental caries has decreased over the past few decades, primarily due to improved oral hygiene practices, fluoride use, and better access to dental care (Frencken et al., 2017).

Early childhood caries (ECC) is defined as the presence of one or more decayed, missed, or filled tooth surfaces in primary dentition of children under the age of six (Avila, et al., 2015). ECC is a significant health concern, and its prevalence can vary due to geographic, socioeconomic, and cultural factors (Anil & Anand, 2017 and Avila et al., 2015). It was reported that 48% of preschool children worldwide suffer from ECC (Uribe et al., 2021). A recent review including data from 49 countries found that the global prevalence of ECC ranges from 19.3% in Greece to 72% in the Middle East (Maklennan et al., 2024). Higher rates of ECC were observed among low-income populations, children with health conditions, those with disabilities, and other vulnerable groups who have limited access to proper nutrition, oral hygiene, and preventive measures (Anil & Anand, 2017 and Kotha et al., 2022). In the Middle East, the overall prevalence of ECC in children under the age of six ranged from 26.5% to 99% (Kotha, 2022). In Saudi Arabia, the mean number of decayed, missing, and filled teeth varies from 0.95 to 16.9 (Kotha, 2022). Older studies from Finland

reported a prevalence from 1 to 32% (Milnes, 1996); recently the prevalence of ECC has notably decreased with values as low as 0.3% in children aged 0 to 2 years old (Folayan et al., 2023).

#### 2.1.1.2 Periodontal diseases

The inflammation of gingiva as a result of plaque accumulation and bacterial insult may proceed to periodontitis, a major cause of tooth loss worldwide. Periodontitis is defined as loss of clinical attachment and pocket depth of more than 3 mm in two teeth or more (Tonetti et al., 2018) and is particularly common among elderly individuals. Periodontitis is often associated with various systemic conditions such as diabetes and cardiovascular diseases (Jin et al., 2016). Estimates suggest that nearly 10% of the global population suffers from severe periodontal diseases (Nazir et al., 2020; Chen et al., 2021) which seems to be increasing as per a recent study, reporting a prevalence of severe periodontitis as 12.50%, and the prevalence of edentulism to be 4.11% (Nascimento et al., 2024). Although periodontitis can be more prevalent among elderly, the prevalence of gingivitis is higher, affecting individuals throughout their life span (Nascimento et al., 2024). The prevalence of periodontal disease varies across different geographical regions. In high-income nations, the incidence of severe periodontitis ranged between 15% and 30%; however, in low- and middle-income countries, these rates are even higher due to poor oral hygiene, and limited access to dental care and preventive strategies (Nazir et al., 2020). South Asia, for instance, has recorded the highest prevalence of severe periodontitis—a trend anticipated to persist until 2050- particularly in Bangladesh, Pakistan and India, countries that are well known for higher tobacco use (Nascimento et al., 2024). A recent systematic review has estimated that the prevalence of periodontal diseases in Saudi Arabia as 51% (Hakeem et al., 2024). In Finland, a study reported that the 15% of teenage smokers had periodontitis (Heikkinen 2011) and the overall prevalence of periodontal disease have been increasing among adults aged 30-44 years old (Linden, 2023). The latest WHO report showed that the prevalence of severe periodontitis in adults above the age of 15 years old was 23.8% (WHO, 2022b).

#### 2.1.1.3 Oral cancer

Oral cancer (OC) presents a significant public health challenge due to its high mortality and morbidity rates. According to the latest estimates, lip and oral cavity cancer ranks as the 16th among the thirty-six tracked cancer types in 2022 globally, with over 389,000 new cases (IARC, 2023). The incidence of oral cancer varies by region, with higher rates observed in countries known for higher tobacco and alcohol

consumption such as India and parts of South Asia (Conway et al., 2018). The higher prevalence in low and middle-income countries has also been linked to delayed diagnosis, as well as the interplay between various behavioral, environmental, and genetic factors (Alsanosy, 2014). In Saudi Arabia, the prevalence of oral cancer ranges from 21.6 to 68.6% with higher prevalence in the Southern regions of the country due to increased use of smokeless tobacco and predisposed genetic factors (Basha et al., 2019). In Nordic countries, the rates of OC were on the rise with proposed risk factors such as low consumption of vegetables and fruits, stress, poor oral hygiene, and genetics (Peltonen et al., 2024). The increased incidence of OC was also linked to certain occupations with increased higher rates observed in both genders among waiters (Peltonen et al., 2024). Incidence of oral cancer in Finland across all ages and each gender was three per one hundred thousand of the population (WHO, 2022b).

### 2.1.2 Risk factors of dental diseases

Dental caries is a multifactorial disease characterized by the demineralization of tooth enamel due to acid production by bacterial biofilm. The most significant risk factor is the frequent consumption of dietary sugars, which serves as a substrate for acidogenic bacteria such as *Streptococcus mutans* (Petersen, 2003). Inadequate oral hygiene allows the accumulation of dental plaque, further contributing to acid formation and enamel breakdown (Kazemina et al., 2020). Other key risk factors include low fluoride exposure and altered salivary flow rate and composition, which reduces the natural protective effects of saliva (Borg-Bartolo et al., 2022 and Nath et al., 2023). Socioeconomic disparities also play a leading role; individuals with low income and educational levels often experience reduced access to dental care, fluoride, and nutritional awareness (Petersen, 2003 and Rodriguez et al., 2023).

On the other hand, research on the prevalence and causes of dental caries in children has identified more than one hundred risk factors (Saikia et al., 2022). Approximately 10 to 20% of infants and young children are at risk of developing symptoms of ECC, due to socioeconomic and environmental factors (Uribe et al., 2021 and Rodriguez et al., 2023). Factors such as prolonged breast feeding and overnight bottle feeding, as well as maternal alcohol consumption and poor oral health are the most common causes of ECC worldwide (Avila et al., 2015 and Anil & Anand, 2017 and Uribe et al., 2021). The differences in ECC rates among certain Indigenous and minority groups are closely linked to genetic, dietary and behavioral habits (Uribe et al., 2021).

Periodontal diseases, including gingivitis and periodontitis, are primarily caused by the accumulation of plaque biofilm on tooth surfaces (Frencken et al., 2017). One of the most powerful modifiable risk factors is tobacco use, which impairs gingival

blood flow, weakens the immune response, and accelerates periodontal destruction (Kinane et al., 2017). Systemic conditions, particularly poorly controlled diabetes mellitus, increase the severity and progression of periodontal disease due to compromised immune response and vascular changes (Kuo et al., 2008 and Kapila, 2021). Other contributors include chronic stress, which may alter the body's inflammatory response, and genetic predisposition, which can increase individual susceptibility to periodontitis despite good oral hygiene (Kinane et al., 2017 and Chen et al., 2021 and Chan et al., 2023).

Oral cancer, especially squamous cell carcinoma of the oral cavity and oropharynx, is strongly linked to lifestyle-related risk factors (Alsanosy, 2014 and Basha et al., 2019). Tobacco use, in both smoked and smokeless forms, is the leading cause, followed closely by heavy alcohol consumption (Conway et al., 2018). The combined use of tobacco and alcohol results in even greater risk (Warnakulasuriya, 2009 and Conway et al., 2018). Emerging evidence highlights the role of human papillomavirus (HPV), particularly HPV-16, in oropharyngeal cancers (Ghantous & Elnaaj ,2017 and Conway et al., 2018). Additional risks include nutritional deficiencies (especially low intake of fruits and vegetables), prolonged sun exposure (a factor in lip cancer), and chronic mechanical trauma from ill-fitting dental prostheses or sharp teeth (Warnakulasuriya, 2009 and Ghantous & Elnaaj ,2017).

## 2.2 The bidirectional relationship between oral and general health

The bidirectional relationship between oral health and general health highlights the need for integrated healthcare strategies that address both oral and systemic diseases. Medical conditions, including diabetes, autoimmune disorders, nutritional deficiencies, as well as the side effects of medications, can significantly impact oral health (Ciantelli et al., 2024). For instance, diabetes can increase the risk of periodontal disease, while autoimmune disorders such as Sjögren's syndrome may lead to xerostomia, dental caries, and oral infections (Xin et al., 2020). Nutritional deficiencies also affect oral health by impairing tissue repair and increasing risk to oral diseases; deficiencies in vitamins A, C, and D, for example, can result in changes to the oral mucosa and an increased risk of infections (de Sire et al., 2022 and Hung et al., 2024). Furthermore, cancer treatment, including chemotherapy and radiotherapy, can cause mucositis and elevate the risk of oral infections (Ciantelli et al., 2024). Many medications have side effects on the oral cavity such as xerostomia, gingival overgrowth, or altered taste (Ciantelli et al., 2024).

On the other hand, individuals with periodontal disease have higher risk of cardiovascular diseases (Kuo et al., 2008) and osteoporosis (Altamura et al., 2024) which is thought to be due to shared risk factors, altered immune response resulting

from the release of inflammatory markers and the possibility of bacteremia from oral bacteria entering the bloodstream (Kapila, 2021 and Altamura et al., 2024). Additionally, periodontal disease can affect blood glucose control among diabetic patients, and poor management of diabetes can further aggravate periodontal problems (Kapila, 2021). Furthermore, periodontal disease is linked to adverse pregnancy outcomes, including preterm birth and low birth weight, with systemic inflammation and the influence of oral bacteria on fetal development as possible explanation (Kapila, 2021). Poor oral health has also been linked to respiratory infections, as oral bacteria can be aspirated into the lungs, potentially leading to pneumonia, especially among immunocompromised patients (Jin et al., 2016).

## 2.3 Common risk factor approach

The common risk factor approach is a public health strategy that addresses shared risk factors rather than treating each disease separately. This approach is particularly effective as dental diseases share several modifiable risk factors with non-communicable diseases (NCDs) such as cardiovascular disease, diabetes, cancer, and chronic respiratory conditions (Budreviciute et al., 2020). The common risk approach provides a valuable framework for managing dental and general medical conditions through unified preventive measures and lifestyle modifications (DiPietro et al., 2020 and Ciantelli et al., 2024). By promoting collaborative care, patient education, and joined health policies, this strategy can enhance health outcomes for individuals and communities and leads to proper allocation of resources ultimately decreasing the overall disease burden (Gröne & Garcia-Barbero, 2001).

Tobacco use is a well documented risk factor to oral cancer, periodontal disease, cardiovascular disease, and chronic obstructive pulmonary disease (Ciantelli et al., 2024). Similarly, excessive alcohol consumption is linked to oral and other cancers, liver disease, and hypertension (Ciantelli et al., 2024).

In the same context, there is a direct association between dietary habits and dental diseases. For example, cariogenic diet and excessive snacking predispose the individual to dental caries, while nutritional imbalance was linked to increased risk of periodontal disease (de Sire et al., 2022). Unbalanced and unhealthy diets have also been associated with obesity and non-communicable diseases, such as cardiovascular diseases, diabetes, and osteoporosis, alongside some types of cancers (GRF Collaborators 2018).

Stress commonly is associated with oral conditions, including parafunctional habits and periodontal disease and acts as a mediator for NCDs such as diabetes, cardiovascular and respiratory diseases as well as certain cancers (Vasiliou et al., 2016). Lack of exercise is indirectly associated with periodontal diseases and a risk

factor for comorbidities such as diabetes, obesity, and cardiovascular diseases (Chan et al., 2023).

Poor hygiene and low health literacy contribute to both oral disease progression and poor management of chronic illnesses. A systematic review found that limited health literacy is associated with poorer ability to take medications properly, lower use of preventive services, and worse overall health outcomes (Berkman et al., 2011). In dental literature, it is also associated with inadequate oral hygiene practices, delayed dental visits, and higher incidence of caries and periodontal diseases (Horowitz & Kleinman, 2012).

Preventive strategies targeting common risks, such as dietary counselling or smoking cessation, can be more cost-effective than treating diseases separately, leading to more comprehensive care, better long-term health outcomes and reducing health disparities.

## 2.4 Oral and general health policies

Many policies and frameworks have been established to promote both oral and general health, including organizations that operate internationally, such as the World Health Organization, the United Nations, and the International Federation of Dentists, as well as national policies within countries.

### World Health Organization (WHO) policies

The WHO plays a key role in the implementation of global health policies that promote oral health. For example, the *Global Oral Health Action Plan* aims to alleviate the global burden of oral diseases by enhancing access to oral health services, promoting preventive measures, and control of risk factors (WHO, 2016 and WHO, 2022a). It also calls for the integration of oral health into primary health care systems and stresses the necessity for multisectoral approaches to improve oral health and general health (WHO, 2016). Similarly, *Universal Health Coverage (UHC)* agenda seeks to guarantee that all individuals receive essential health services, including dental care, with less financial burden (Wang et al., 2020). The UHC framework also calls for the integration of oral health into primary health care services and the inclusion of oral health within national health insurance plans (WHO, 2022a). While primarily concentrated on diet and physical activity, the *Global Strategy on Diet, Physical Activity, and Health* recognizes the influence of dietary habits on oral health as well and call for policies that lead to reducing the consumption of sugary foods and beverages, which are significant risk factors for dental caries and other oral diseases (DiPietro et al., 2020).

## The United Nations (UN) policies

The United Nations Sustainable Development Goals (SDGs) provided a comprehensive framework for tackling global health challenges, including oral health. Fighting poverty is essential for enhancing access to health services. Policies focused on poverty reduction (*SDG Goal 1*) can indirectly improve oral health by increasing accessibility to preventive and restorative dental care (Carlsen & Bruggemann, 2022). Given that poverty is a risk factor for poor general health, it can therefore increase the risk of early childhood caries both directly and indirectly (El Tantawi et al., 2024). Nutritional deficiencies negatively affect oral health; thus, strategies aimed at addressing food insecurity (*SDG Goal 2 Zero Hunger*) will lead to improved oral health outcomes (Carlsen & Bruggemann, 2022). Malnutrition is associated with a reported 60% higher incidence of caries in children, as well as delayed tooth eruption and enamel defects (Hung et al., 2024). Additionally, vitamin deficiencies are associated with oral health conditions such as glossitis and angular stomatitis and an increased risk of periodontitis (Hung et al., 2024). The *SDG Goal 3 (Good Health and Well-being)* aims to reduce mortality from non-communicable diseases, including oral diseases. It emphasizes the importance of universal health coverage and access to essential health services, including dental care (Carlsen & Bruggemann, 2022). *SDG 3* promotes healthy lives and enhances well-being for all by formulating national policies to prevent oral health and systemic conditions, along with their shared risk factors (Huang & Chang, 2022).

## The International Federation of Dentists (FDI) policies

The FDI vision for 2020 highlighted the importance of incorporating oral health into general health policies and promoting global initiatives to alleviate the impact of oral diseases (Lamster, 2020). In its *Global Burden of Oral Disease Report* the FDI presented data and evidence regarding the worldwide prevalence of oral diseases to guide policy development and action plans to tackle the increasing burden of oral diseases globally (Lamster, 2020).

## National policies and strategies

Many countries have established national policies that align with global frameworks while addressing their national needs and priorities.

*The United States of America (USA)*: The USA has endorsed several policies to enhance oral and general health, including the Affordable Care Act (ACA), which has facilitated access to dental care for children and eligible adults. Another example is the Healthy People 2030 initiative which aimed at improving oral health within the context of broader health goals (Burroughs et al., 2024).

*The United Kingdom (UK):* The UK's National Health Service (NHS) offers extensive dental care as part of its public health system. Policies such as the NHS Dental Contract seek to enhance access to dental care and integrate oral health within general health services (Lunt & Exworthy, 2024).

*Brazil:* Brazil's unified health system (Sistema Único de Saúde SUS) provides free access to different health services including dental care (Machado, 2024). The country has implemented policies to incorporate oral health into primary health care and improve access to services in underserved regions (Machado, 2024).

*Finland:* Dental care in Finland is delivered through the Public Dental Service (PDS) and the private sector (Niiranen et al., 2008). Established in 1972, the PDS primarily served underserved populations at the municipal level with fixed reduced fees and free services for children and young adults (Niiranen et al., 2008). While private dental services do not have fixed fees, national health insurance (NHI) significantly reduces these costs. The reforms to the Primary Health Care Act and the National Health Insurance Law in 2002 eliminated the age limit eligibility, thus enhancing access to dental care for all (Niiranen et al., 2008).

*Saudi Arabia:* Oral health in Saudi Arabia is a key component of the nation's comprehensive healthcare system, focusing on improving the population's overall oral health through preventive, educational, and clinical services (Siddiqui et al., 2021). The Saudi Ministry of Health (MOH) is the principal governmental entity responsible for developing and executing oral health policies. The MOH conducts school-based programs to promote oral hygiene and increasing awareness about the risks of oral diseases as well as about tobacco use, along with public health campaigns aimed at adults and the elderly. The MOH also manages public dental clinics that offer free dental services (Siddiqui et al., 2021). Saudi Vision 2030 seeks to enhance healthcare services, including oral health, and to promote tele-health and tele dentistry services to address general and oral health disparities (AlShammery, 2016).

## 2.5 Interprofessional engagement and integrated healthcare

Given the close relationship between oral and overall health, integrated healthcare approaches are essential (Valentijn et al., 2013 and Atchison et al., 2018). This integration acknowledges the importance of oral health as part of overall health and emphasizes that effective management of oral diseases necessitates the cooperation among different professionals and other healthcare providers (Clark & Douglass, 2010). Successful multidisciplinary approaches depend on effective communication and integration of services among team members. The advantages of interprofessional engagement include holistic patient care (Choi et al., 2020),

enhanced patient education and awareness, as well as improved efficiency and cost-effectiveness of healthcare resources (Gröne & Garcia-Barbero, 2001).

## 2.5.1 Models of interprofessional engagement

### 2.5.1.1 Integrated delivery of health care

Patient-centered medical homes (*PCMH*) is a model that integrates dental care within a primary care setting, facilitating coordinated management of both oral and general health (Barracough et al., 2021). Regular screening of dental and systemic diseases in primary care settings can help early detection and the prevention of both oral and systemic diseases through common risk approach (Budreviciute et al., 2020 and Atchison et al., 2018 and Christian et al., 2023). Another model for integrated care delivery is the “collaborative care teams”, a model that encompasses dental professionals, primary care physicians, specialists, and allied health professionals who collaborate to manage patients with complex health needs in hospital settings (Barracough et al., 2021).

### 2.5.1.2 Interprofessional education and training

Formal undergraduate programs that incorporate interprofessional education enable future healthcare professionals to comprehend the roles and contributions of various disciplines, thereby promoting collaboration and enhancing team dynamics in clinical practice (Bogossiann et al., 2023). The implementation of simulation and case-based learning scenarios can strengthen the capacity of healthcare professionals to function effectively within interdisciplinary teams (Huang et al., 2021). Bridges and colleagues discussed three models of interprofessional collaboration during formal education in the USA; a theoretical course, community-based experience and interprofessional stimulation experience (Bridges et al., 2011) and highlighted the need for supportive institutions that provide faculty training, include IPE in curriculum timings among colleges, curriculum mapping and essential physical and technological infrastructure.

### 2.5.1.3 Community-level interventions

Community initiatives involving a range of health professionals can tackle both oral health and general health concerns. For example, the school health program (Choi et al., 2020) which involves guidance on maintaining good oral hygiene, healthy diet, and regular exercise with these lifestyle changes affecting both oral and systemic health (Christian et al., 2023 and Barracough et al., 2021). School-based initiatives

that include health education as well as dental and general health screening can effectively tackle both oral and systemic health problems at an early age (Wolfenden et al., 2017). In the same context, educational programs aimed at enhancing nutrition, promoting hygiene, and improving access to health and dental care offered to pregnant women were found to have a significant impact on their offsprings oral and general health (George et al., 2019). Similarly, initiatives designed to decrease sugar intake (sugary drinks taxes and regulations on the marketing of sugary foods to children) can contribute to the prevention of dental caries and lower the incidence of obesity, diabetes, and cardiovascular disease (Itria et al., 2021). Public health initiatives aimed at preventing tobacco use can reduce the incidence of periodontal diseases, oral cancers, and other non-communicable diseases (Thrul et al., 2021).

## 2.5.2 Barriers and facilitators to interprofessional engagement

The separation between oral health and overall health policies, coupled with the separated practice across the healthcare system, hinders collaboration among multiple disciplines (Wei et al., 2022). Moreover, in countries with low and middle incomes, scarce resources, and funding present significant obstacles to delivering multidisciplinary care further intensifying disparities in access to care and disease burden among marginalized populations (Choi et al., 2020). Furthermore, inadequate interprofessional education and cultural diversity may hinder effective teamwork (Choi et al., 2020). In addition, limitations such as lack of time and competing priorities create challenges for successful collaboration (Choi et al., 2020). Unclear roles and lack of communication are also some of the reported barriers for interprofessional collaboration (Choi et al., 2020). In their handbook for nurses about communication and teamwork, the authors listed more than fifteen reasons that hinder interprofessional communication and collaboration; the primarily were related to personal values and expectations, personality characteristics, as well as racial and ethnic factors (O'Daniel & Rosenstein, 2008).

Establishing clear communication pathways is critical for effective collaboration in healthcare. Effective communication channels, including regular meetings and shared electronic health records, are essential for keeping all team members informed and engaged in patient care (Gröne & Garcia-Barbero, 2001). In the same context, clearly defined roles and responsibilities are essential for minimizing overlap and ensuring comprehensive patient care (Wei et al., 2022). Team-building activities that strengthen relationships, foster trust, and respect each professional's expertise contribute to a positive collaborative environment (Wei et al., 2022). A supportive organizational culture that values collaboration and allocates dedicated time and resources for interprofessional activities is crucial for promoting effective

teamwork (Gill et al., 2022). Furthermore, partnerships with community organizations can further enhance collaboration and maintain patient-centered care (Barracough et al., 2021). Undergraduate formal education and training programs that include interprofessional education and continuing professional development are instrumental in helping professionals adopt collaborative skills and interdisciplinary practices (Park et al., 2017).

### 2.5.3 Behaviors of health care providers towards integrated dentalcare

Healthcare providers generally show a positive attitude towards interdisciplinary dentalcare. Many healthcare providers, including physicians and pediatricians, recognize the importance of incorporating oral health into patient care and showed positive attitudes towards integrated oral health models (Rabiei et al., 2012 and Fletcher et al., 2024 and Snogrenet al., 2025). For instance, a study from Iran reported that 77% of the surveyed healthcare providers believed in promoting oral health, and nearly all felt it necessary to examine patients' oral cavities regularly as well as the willingness to attend continuing education (Rabiei et al., 2012). Even more positive attitudes (82%) were reported by nurses caring for hospitalized children in Canada who believed in their responsibility to provide oral care (Fletcher et al., 2024). Similar positive attitudes were also reported from Sweden, where healthcare providers showed a strong sense of responsibility toward oral health but faced barriers in translating that attitude into action due to limited training, confidence, and organizational support (Snogrenet al., 2025). However still a great portion of healthcare providers tend to underestimate the importance of oral health, viewing it as separate from general health (U.S. Department of Health and Human Services, 2000). This can be due to oral health been deprioritized during routine medical care or in emergency settings, especially in resource-limited environments as well as the belief of some healthcare providers that dental problems fall strictly under the responsibility of dentists (Watt et al., 2019) in addition to the structural and organizational barriers mentioned before.

In Saudi Arabia, recent studies suggest a growing awareness and willingness to contribute to oral health promotion. For example, nurses and general physicians often express a positive attitude toward the importance of oral health (Almutairi et al., 2023; Alshahrani et al., 2022). However, their behaviors (such as performing oral assessments or providing preventive education) are often infrequent and inconsistent and referral to dental services is typically reactive rather than preventive (Almutairi et al., 2023; Alshahrani et al., 2022). Many studies were conducted in Saudi Arabia exploring healthcare professionals' perceptions, current practices and perceived barriers as well as the inclusion of IP in undergraduate education (Khan et al., 2015

and Barr, 2016 and Fallatah et al., 2015 and Fallatah, 2016 and Alsheikh, 2018 and Bashatah et al., 2020). One study among nurses highlighted barriers such as limited resources, lack of onsite guidelines and protocols, conflicting priorities, communication barriers, medical hierarchies, work overload, and time constraints (Alanazi et al., 2022).

## 2.6 Role of non-dental professionals in oral health education and prevention

Health professionals from different specialties can play a vital role in providing oral health education, conducting dental screenings, and applying preventive materials.

### 2.6.1 Pharmacists

Pharmacists are in frequent contact with the public and can contribute to oral healthcare by providing guidance on over the counter (OTC) dental products, such as toothpastes, mouthwashes, and pain relief medications for oral conditions like ulcers, xerostomia, or toothaches (Dumitrache et al., 2016). They can also recognize side effects of medications in the oral cavity, recommend products to treat minor oral health problems, and refer patients to dentists for more serious concerns (Dumitrache et al., 2016). However, their most key role can be related to smoking cessation which might in turn help in reducing the risk of oral cancer and periodontal diseases (Mann et al., 2015). Studies have also highlighted the significant role pharmacists play on oral health promotion by providing valuable information on the correct use of oral hygiene products as well as in patient education (Hu et al., 2022). A study conducted in the capital city of Saudi Arabia (SA) found that pharmacists advised patients to visit the dentist in 43% of the cases and provided painkillers for 44% (Bawazir, 2014). In the same study only 38% of them reported that proper knowledge was the main factor that influenced their recommendations of oral products (Bawazir, 2014). Another study from SA, found that lack of communication with dentists was the main barrier that prevented pharmacists from providing oral health advice to the patients and only one third of their surveyed pharmacists reported having oral health care as part of their undergraduate education (Al-Saleh et al., 2017). A study from Malaysia reported that their surveyed pharmacists were more involved in providing information about OTC dental products 93.7% and 82.5% referred cases for a dentist or a medical practitioner respectively ; the same group reported barriers like lack of formal education, training and oral health educational materials (Blebil et al., 2020).

## 2.6.2 Pediatricians

Pediatricians have a vital role in children's oral health and can help in the early detection of oral conditions among children, teething problems, early childhood caries, and dental anomalies (Arevalo et al., 2023). They can also provide guidance to parents on preventive oral care, including proper brushing techniques, the importance of fluoride, and healthy dietary habits (Dickson-Swift et al., 2020). Pediatricians can also perform basic oral health screening during regular visits, encourage early dental visits for children, and refer patients to pediatric dentists for more specialized care (Emmanuel et al., 2018). As part of child medical history, they can also identify nutritional deficiencies and discuss with the parents its link to oral conditions in children (Emmanuel et al., 2018). However, a recent scoping review concluded that pediatricians have limited knowledge and understanding in important dental issues, including initial clinical signs of dental caries, recommended age for first dental visit, the role of transmission of bacteria from mother to child in the etiology of dental caries, and the recommended use of fluorides (Dickson-Swift et al., 2020). Barriers to oral health practice reported by pediatricians included inadequate education and training, time constraints, lack of clear referral pathways, and cost implications that are often complicated by medical/dental insurance schemes (Dickson-Swift et al., 2020).

## 2.6.3 Ear, Nose and Throat (ENT) specialists

ENT-specialists role in dental care was prominent during the COVID-19 outbreak, as part of their routine oral check they played a role in the detection of dental problems and referral of cases for specialized dental care (Ren et al., 2020). ENT specialists can play a vital role in oral cancer prevention and control by detecting early signs and precancerous lesions (Rocke et al., 2020 and Baba et al., 2022). Similarly, they can be involved in care of patients with cleft lip and palate (Frederick et al., 2022). In the same context, they can detect adenotonsillar hypertrophy in children a condition that can result in craniofacial changes and myofunctional challenges (Maden, 2022). Additionally, to hypertrophy of the adenoids and tonsils which is a major factor in mouth breathing among pediatric patients, leading to increased risk of dry mouth, dental caries, and gingivitis (Maden, 2022). ENT specialists can be the first to detect these problems and coordinate with dental care providers the best course of treatment (Baba et al., 2022). A recent review also highlighted the need for cooperation between dentists and ENT in the management of implants postoperative complications in maxillary jaw, namely maxillary sinus drainage, perforation, and infections after the implant (Baba et al., 2022).

## 2.6.4 Obstetricians/Gynecologists

Pregnancy is a critical period for both a mother's and child's oral health. Many women avoid dental care during pregnancy due to misconceptions that it might harm the fetus (Strafford et al., 2008). Periodontal problems were linked to pre-eclampsia, intrauterine growth restriction, and adverse pregnancy outcomes including low birth weight and preterm birth (Kuo et al., 2008 and Hashim & Akbar, 2014). Although the importance of oral health during pregnancy was acknowledged by most obstetricians, 80% did not ask about oral care during prenatal appointments, and 94% did not refer patients to a dentist (Strafford et al., 2008). Obstetricians and gynecologists can play a key role in promoting oral health during pregnancy, a period when hormonal changes can increase the risk of pregnancy gingivitis, tooth mobility, tooth erosion, dental caries, and other oral problems (Vamos et al., 2015). They can educate pregnant women about the importance of oral hygiene and encourage regular dental visits (Horowitz et al., 2019). Most importantly they can recognize oral changes during pregnancy, such as gingival inflammation, and refer patients to dentists for further care (Horowitz et al., 2019). In a Polish study, only 17.6% gynecologists referred women to a dentist, yet it was reported that women who were referred by their treating doctor were more likely to have regular dental visits (Kobylińska et al., 2018). A study from United Arab Emirates reported that their surveyed gynecologists had good knowledge on the relation between periodontal disease and pregnancy outcomes, yet they were doubtful about the safety of dental treatment during pregnancy (Hashim & Akbar, 2014).

## 2.6.5 Community health workers

Accessibility is one of the main barriers to dental care. Community health workers can either be regular members of the community with no or minimum degree of medical education or paraprofessional who are well known and trusted by the community they serve (Olaniran et al., 2017). The distribution of dental facilities or dental care providers are not equal between urban and rural areas, leaving many people deprived from regular dental care and routine checkups (Kondru, 2016). Such disparities highlight the need for community-based programs. Community health workers (CHWs) are effective in delivering oral health education and promotion in underserved communities (Glenton et al., 2021). Their training in oral health can improve their ability to provide relevant education and support to individuals with limited access to healthcare services (Glenton et al., 2021). If well trained CHWs can also perform dental screening, diagnose and provide a wide range of dental treatments (Khan et al., 2022). A recent scoping review proposed that CHWs can be utilized in oral health promotional activities in schools (Moleté et al., 2024). Their

involvement can improve access to care, the use of oral hygiene measures and overall oral health (Moleté et al., 2024).

### 2.6.6 Physicians

Patients trust their physicians and therefore usually seek medical advice and consultations about different health conditions from them (Wu et al., 2022). It was reported that 5% of complaints for physicians' visits were due to oral health problems (Lockhart et al., 2000). Physicians can participate in oral health promotion through screenings, referrals, and counseling (Maxey et al., 2017). Multiple studies from around the globe have identified a lack in physicians' knowledge about oral health and the provision of dental care (Rabiei et al., 2012 and Kumar, 2021 and Al-Habib et al., 2022). Physicians have a crucial role in their patients' health and wellbeing, especially among vulnerable populations such as the elderly and those with chronic illness (Kumar, 2021). Physicians in primary care settings can integrate oral health services with routine checkups or follow-up visits (Maxey et al., 2017 and Kumar, 2021). Although there were some reported initiatives to support such integration, for example the call by the Health Resources and Services Administration (HRSA), yet few patients with dental or oral problems received care from their physicians (Zimmerman, 2015).

### 2.6.7 Nurses

Nurses account for the majority of health task force and play a key role in the delivery of health care through different settings from primary care to intensive care units, as such their role in dental care cannot be overemphasized (Aggour, 2014 and Uppal et al., 2019). Oral health is a determinant of health, wellbeing, and quality of life. This is especially true for elderly, hospitalized patients, and patients with comorbidities (Aggour, 2014). Patients in the intensive care unit may suffer from complications such as pneumonia and infective endocarditis due to accumulation of plaque and poor oral health (Winning et al., 2021). Nurses can perform risk assessment, mechanical and chemical plaque removal as well as application of fluorides and preventive materials (Aggour, 2014). In the same context, training nurses in oral health education enhances their ability to provide effective counseling, especially to vulnerable and underserved populations where dental care access is limited (Bashirian et al., 2023). A recent study from Oulu, found that nurses working in wards perceived their practical skills as better compared to detecting oral health problems (screening) and that oral health knowledge was associated with increased confidence to provide dental care (Kivilahti et al., 2024).

## 2.7 Oral health in medical colleges curricula

Although medical education organizations recommend that oral health be part of medical education. However, oral health is not traditionally included in many medical schools or other health colleges' curricula (Gill et al., 2022). The teaching of oral health to non-dental healthcare professionals during their undergraduate studies often faces several shortcomings (Park et al., 2017 and AlRuthia et al., 2023). These include a limited curriculum focus on oral health, lack of interprofessional education, inadequate hands-on training, and limited integration of oral health with systemic health conditions (AlRuthia et al., 2023). Oral health is often taught separately from other health topics, leading to a lack of understanding of the importance of oral health in managing chronic diseases (Bhagat et al., 2020 and Wei et al., 2022). Clinical rotations for non-dental healthcare students rarely include oral health assessments or treatment, limiting students' confidence in real-world practice (Rawlinson et al., 2021 and Wei et al., 2022). Additionally, there is a lack of faculty expertise in oral health, limiting students' ability to fully grasp its importance (Rawlinson et al., 2021).

## 2.8 Interventions to promote interprofessional collaboration

### 2.8.1 Educational interventions

Many studies highlighted the importance of interprofessional education in medical schools (Park et al., 2017 Bhagat et al., 2020 and Gill et al., 2022 and AlRuthia et al., 2023 and Alqutaibi et al., 2024). Programs that bring together students from different healthcare disciplines to learn about, from, and with each other are effective in fostering a culture of collaboration (Park et al., 2017). Medical and nursing students can gain formal knowledge about oral diseases, their risk factors, and preventive measures (Bhagat et al., 2020). The common risk approach can be taught in formal education which enables medical and dental students to effectively address patients' complaints and prevent further complications (Gill et al., 2022). Workshops and simulation-based training programs designed for dental and other healthcare students have been shown to improve understanding of each other's roles, enhance teamwork skills, and build confidence in collaborative practices (Bogossian et al., 2023 and Bonabi et al., 2019 and Mohebbi et al., 2018). Although the inclusion of IPE in undergraduate formal has proven effective in bridging the gap between medical and dental teams; yet such education does not ensure long term commitment to interprofessional practice and highlights the need for continuous educational sessions and interventions (Mohebbi et al., 2018).

## 2.8.2 Structural interventions

Implementing integrated care models in clinics where dental professionals work closely with other healthcare providers, such as primary care settings, has been effective in promoting interprofessional collaboration (IPC) (Gröne & Garcia-Barbero, 2001 and Valentijn et al., 2013 and Atchison et al., 2018). These models encourage shared responsibility and improve the continuity of care for patients (Barracough et al., 2021). Establishing team-based provision of care where dental professionals collaborate regularly with other healthcare providers, fostering better communication and collaboration (Barracough et al., 2021). For example, teams working in emergency rooms or intensive care units, professionals from different specialties act together to address patients' needs from all aspects (Barracough et al., 2021). Studies on IPC interventions in dental care found that educational and structural interventions, particularly when combined, are most effective in promoting collaboration (Wei et al., 2022 and Rasmussen et al., 2022).

## 2.8.3 Policy and organizational interventions

Developing and implementing practice guidelines that emphasize collaborative care can guide professionals in working together (Quiñonez et al., 2022 and Burroughs et al., 2024). These protocols often include role clarification, referral processes, and communication strategies (Quiñonez et al., 2022). Leadership that actively promotes a culture of collaboration within dental practices or healthcare organizations is crucial (Choi et al., 2020). Organizational policies that reward teamwork and provide incentives for collaborative practices are effective in sustaining IPC (Albejaidi & Nair, 2021). The use of shared electronic health records (EHRs) across disciplines has been shown to improve communication and coordination among healthcare providers (Vos et al., 2020b). EHRs enable seamless sharing of patient information, facilitating better-informed decisions and comprehensive care planning (Vos et al., 2020b).

## 2.8.4 Studies on interventions and intervention strategies

The effectiveness of intervention strategies have been explored in different settings and contexts. For example, Clark and Douglass (2010) reported that integrating oral health into pediatric and family medicine training significantly improved behaviors such as oral screening and fluoride varnish application (Clark & Douglass, 2010). Similarly, a Swedish study found that digital oral health education increased healthcare providers' confidence and awareness, though measurable improvements in knowledge were modest (Lindmark et al., 2024). A USA-based study integrating oral health training into pediatric residency programs found improved screening and

fluoride varnish application by non-dental providers (Clark & Douglass, 2010). Similarly, digital education platforms used in Sweden enhanced provider confidence, though measurable knowledge gains were limited (Lindmark et al., 2024). Abou El Fadl et al. (2016) also evaluated interventions integrating oral health services into nursing and midwifery practice (Abou El Fadl et al., 2016), and concluded that it led to increased referrals and higher utilization of dental services among pregnant women, suggesting that the co-location of services can remove access barriers and improve coordination (Abou El Fadl et al., 2016). In Brazil inclusion of oral health teams within primary care units, enabled access to dental care to underserved populations (Nicolau et al., 2012). School-based dental programs, mobile dental clinics, and home-visit models in rural or low-income areas also serve as practical examples of integrating dental care with general health promotion (Nicolau et al., 2012). These models often involve collaboration between dental professionals, nurses, teachers, and community health workers (Nicolau et al., 2012).

The evidence supporting the success of intervention studies is promising but still emerging. Most studies are of small-scale or pilot interventions; often quasi-experimental or qualitative in nature; focused on short-term outcomes like increased referrals or improved knowledge; in addition to lacking of long-term outcome data, such as the reduction in disease burden or cost-effectiveness (Watt et al., 2019 and Abou El Fadl et al., 2016). The long term success of intervention studies depends on several key factors. Integration is more likely to succeed when health systems have established referral pathways, shared records, and team-based care structures (Watt et al., 2019). Intervention studies on IC and IP collectively agreed that even with training, providers may resist new roles due to time constraints, unclear responsibilities, or institutional culture (Watt et al., 2019).

## 2.9 Healthcare models and Interprofessional Collaboration

There are four major healthcare models with countries like the United States having more or all four models within their healthcare systems (Wallace, 2013). The type of healthcare model significantly influences access to care, preventive measures and interprofessional collaboration (Conklin, 2002 and Wallace, 2013 and Grosios et al., 2010).

### 2.9.1 The Beveridge model

Founded by Sir William Beveridge in the United Kingdom (UK) in 1948, this model of healthcare delivery is always centralized (Wallace, 2013). Funded by taxes the government is the provider of healthcare; all individuals receive free care example

the healthcare system in UK, parts of Scandinavia, Hong Kong, Cuba, and Spain (Wallace, 2013). The major concern in such healthcare models might be the over utilization of healthcare services (Grosios et al., 2010). Government-funded systems prioritize integrated care to improve patient care efficiency and collaboration among professionals (Grosios et al., 2010). These systems have well-developed pathways and centralized structures, allowing seamless communication across sectors (Wallace, 2013 and Grosios et al., 2010). However, bureaucracy and limited resources may limit collaboration and flexibility, affecting interprofessional collaboration (Grosios et al., 2010).

### 2.9.2 The Bismarck model

Also known as the "Social Health Insurance Model" this model was created by Otto von Bismarck where healthcare is delivered through the private sector, examples are healthcare systems in Germany, Belgium, Japan, Switzerland, the Netherlands, and France (Wallace, 2013). There is no universal health coverage in this model (Conklin, 2002 and Wallace, 2013). A major issue with this system is that it allows for more disparities in access to care, especially among disadvantaged populations (Conklin, 2002 and Wallace, 2013). The market-driven approach in private healthcare systems may foster competition, leading to limited cooperation (Conklin, 2002 and Wallace, 2013). Private systems offer advanced equipment and specialized treatment, but poor coordination and communication can result from independent providers' monetary interests, leading to segmented care (Conklin, 2002 and Wallace, 2013). Geese and Schmitt explored experiences of Swiss healthcare professionals regarding IPC and highlighted that structural and organizational constraints are the main barriers for integrated patient care (Geese & Schmitt, 2023). Insurance-based healthcare systems, funded by mandatory health insurance, can foster integrated payment chains by promoting collaboration among primary care physicians, specialists, and allied health professionals (Campbell et al., 2002 and Wallace, 2013). However, these systems may encounter management difficulties and complex reimbursement structures, obstructing cooperation in specialized fields or sectors (Campbell et al., 2002).

### 2.9.3 The national health insurance

Also known as the Tommy Douglas model, can be viewed as a mix of both the Beveridge and Bismarck models where the government runs insurance programs and the provider is private. Examples are healthcare systems in Canada, Taiwan, and South Korea, and Medicare in the USA (Wallace, 2013). One criticism of this model is the long waiting list and delay in treatment which might worsen patients' medical

conditions and prognosis (Conklin, 2002 and Wallace, 2013). IPC is more supported in nations with universal healthcare, where public sector funding emphasizes preventive treatment through integrated care models (Conklin, 2002 and Wallace, 2013). Governments allocate funds to primary care networks, ensuring equity for all patients (Wallace, 2013 and Frank et al., 2021 and Fredriksson, 2024). However, regional differences and financing constraints may limit resources and high patient volumes may hinder comprehensive treatment (Fredriksson, 2024 & Frank et al., 2021). In nations with combined public and private healthcare systems, IPC can be more flexible and beneficial as public sector policies encourage it, and private sector creativity benefits specialized care (Albejaidi & Nair, 2021). However, coordination can be challenging, and IPC can vary depending on the type of patient's treatment (Dixit & Sambasivan, 2018).

#### 2.9.4 The out-of-pocket model

The most common model especially in developing nations such as India, China, Africa, and South America (Wallace, 2013). This model intensifies the disparities in access to care and role of socioeconomic status in health (Wallace, 2013). Due to the financial burden this model puts on individuals, this model negatively affect adherence with medications especially for chronic diseases and the use of preventive services such as screenings, vaccinations, and counseling (Rezayatmand et al., 2013). Screenings as such those for cancer can significantly affect an individual's prognosis, mortality rate and quality of life. In the same context patients with chronic diseases under this model will find adhering to costly medications particularly challenging if not impossible (Rezayatmand et al., 2013). A Polish study reported that out of the pocket (OOP) expenses is significantly higher among children less than nine years and elderly aged 70 years and above (Łyszczarz & Abdi, 2021). This finding has serious implication on the need of specialized care for two groups (children and adults) which can be diminished among those with low income (Łyszczarz & Abdi, 2021). The same study also linked increased consumption of tobacco and alcohol with higher OOP health expenditures (Łyszczarz & Abdi, 2021).

### 2.10 Interprofessional collaboration in Saudi Arabia

When considering interprofessional collaboration (IPC) in the context of dental care in Saudi Arabia, it is important to understand the region's specific healthcare landscape, cultural factors, and the unique challenges faced by healthcare professionals in this area (Albejaidi & Nair, 2021 and AlRuthia et al., 2023). Saudi Arabia has a well-established healthcare system with both government and private healthcare facilities (MOH, 2020). The Ministry of Health (MOH) governs most

healthcare services, including dental care, with several large hospitals and clinics offering comprehensive services (MOH, 2020). There are around 163 private and 334 public hospitals according to 2020 Ministry of health data (MOH, 2020). Cultural norms in Saudi Arabia may influence how healthcare professionals interact and collaborate (Albejaidi & Nair, 2021). Gender segregation and respect for hierarchy can impact teamwork and communication within interprofessional teams (AlRuthia et al., 2023). While major cities in Saudi Arabia have access to advanced training and resources, more remote areas may struggle with limited access to specialized IPE and IPC training programs (Alamari et al., 2019). There are efforts to integrate dental care with other health services, particularly in government-run facilities (Alamari et al., 2019). For example, dental professionals can collaborate closely with physicians in managing chronic diseases that have oral health implications, such as diabetes (Alamari et al., 2019). Universities and medical colleges in Saudi Arabia are starting to incorporate IPE into their curricula (AlRuthia et al., 2023 and Alqutaibi et al., 2024). The kingdom 2030 vision is in line with interprofessional practice outcomes, i.e., decreasing health disparities and improving overall individuals' wellbeing (Fallatah, 2016). Many studies were conducted in Saudi Arabia exploring healthcare professionals' perceptions, current practices, and perceived barriers as well as the inclusion of IP in undergraduate education (Khan et al., 2015 and Barr, 2016 and Fallatah et al., 2015 and Fallatah, 2016 and Alsheikh, 2018 and Bashatah et al., 2020). One study among nurses highlighted barriers such as limited resources, lack of onsite guidelines and protocols, conflicting priorities, communication barriers, medical hierarchies, work overload, and time constraints (Alanazi et al., 2022).

# 3 Aims

The general aim of the research was to assess the current global policies with regards to oral health and current interprofessional practices (IP) in Saudi Arabia.

Mapping the scope and the presence of global oral health policies can identify coverage and gaps and enable comparison across countries therefore providing evidence for policymakers and public health advocates to implement evidence-based actions.

Evaluating knowledge, attitudes, and practices (KAP) of healthcare providers with regards to dental care is crucial for the integration of oral and general health. KAP evaluation helps identify training needs and guide policymakers on implementing tailored health initiatives and programs to address the identified gaps.

Nurses and physicians usually constitute the largest portion of the healthcare system and therefore can play a vital role in dental care. Their attitudes influence their willingness to participate in dental care as such understanding their views and the barriers they face, are crucial in implementing training programs and policies to facilitate integrated care.

Educational interventions can improve integrated healthcare. Assessing the impact of various interventions can help in further refinement and use of innovative techniques.

The research was conducted in four phases to answer the following questions: what is the extent of oral health policy coverage globally? What existing policies facilitate integrated practices and support children's oral health? And on a local level in a country like Saudi Arabia, what factors hinder IP among nurses and physicians? And what interventions can encourage IP?

## Specific objectives

1. To explore current global oral health policies targeting young children among the 158 FDI member states.
2. To investigate knowledge, attitudes and practices of 1398 health care professionals including physicians, ENT specialists, pediatricians, and nurses in Eastern Saudi Arabia with regards to dental care.

3. To understand factors that influence attitudes of 525 nurses towards their involvement in dental care in Eastern Saudi Arabia.
4. To evaluate the effects of two educational interventions a video-based Vs the traditional brochure on oral health knowledge, attitudes, and willingness to practice of nurses and physicians in Saudi Arabia.

## 4 Materials and Methods

### 4.1 Study design and setting

Phase I was an online global survey. Phases II to IV implemented a cross-sectional study design and was conducted in the Eastern Province of Saudi Arabia. The province is situated on the eastern coast of Saudi Arabia, along the Arabian Gulf and is bordered by several countries: Kuwait to the north, Qatar and the United Arab Emirates to the southeast, and Oman to the south. Covering 672,522 square kilometers, it is the largest province in the kingdom (36% of the total area), and with a population of over 4.9 million, it ranks third in terms of population density. Its residents are a diverse mix of Saudi nationals and foreigners (Population of Cities in Saudi Arabia, 2021). Ten districts make up the Eastern Province's administrative and geographical division; the biggest towns are Dammam, Al-Hasa, Al-Jubail, Ras Tanura, Dhahran, Al-Khobar, and Al-Qatif. The province is known for its strategic location, rich natural resources, and economic significance.

### 4.2 Study participants

The study's first phase focused on chief dental officers of FDI member states listed on the FDI website, oral health key informants in FDI member nations, oral health and program directors connected to the corresponding Ministries of Health (MoH).

For phases II to IV participants were healthcare providers (ENT specialists, pediatricians, nurses, and physicians) who were at the time of the study practicing in the Eastern Province of Saudi Arabia.

The nursing workforce in Eastern Saudi Arabia consists of both Saudi nationals and expatriates, particularly from countries like the Philippines, India, and other Arab nations (Harb et al., 2023). The nursing profession has a higher female participation but also includes male nurses especially in emergency care and intensive care units (Harb et al., 2023). As of recent estimates, the total nursing workforce in Saudi Arabia was over 200,000 nurses, with a huge portion working in the public sector (Albejaidi & Nair, 2021).

As of recent estimates, Saudi Arabia has a physician workforce of approximately 108,000 to 110,000 doctors (Albejaidi & Nair, 2021). This number includes both

Saudi nationals and expatriates working across public and private healthcare sectors (Albejaidi & Nair, 2021). Specialized training and residency programs are offered in collaboration with global medical institutions, while medical practicing license and certification are issued and monitored by the Saudi Commission for Health Specialties (Almalki et al., 2011).

### 4.3 Data collection tools and procedure

Phase I: Investigating the existence and extent of global oral health policies for young children.

Data was collected through a questionnaire developed by the study team. The questionnaire content was based on the review of literature on oral health policies, universal health coverage, and types of services provided through primary health care. The developed questions then underwent multiple rounds of review by the research team and experts in the field to ensure its face and construct validity. The survey included nine questions, that inquired about country membership in FDI and/or International Association of Pediatric Dentistry (IAPD), whether they had an oral health directorate or a designated dental or oral health officer, and whether they had a national oral health policy document, oral health position statement, and/or an oral health policy as part of the general health policy in addition to aspects covered by countries oral health policy. The survey questions were preceded by an introductory section explaining the study procedure and purpose, and a consent to participate in the study. The survey questions were generated online using QuestionPro and posted on the FDI website under global survey section (<https://oral-health-policy.questionpro.com/>). Emails for chief dental officers were collected from the website and an invitation was sent to all requesting their response to the survey. The survey was posted on the website for a period of one year after which no more responses were accepted.

Phase II: Evaluation of healthcare professionals' knowledge, attitudes, and practices towards their role in dentalcare.

Physicians, nurses, pediatricians, and ENT specialists were the focus of this phase. The study team gathered the target groups' contact details from public, private, and educational institutions' websites. A purposive sample was drawn from each of the four groups of medical professionals using a snowball sampling technique. Purposive sampling is a type of non-probability sampling where participants are selected based on pre-defined characteristics or criteria which allows for better matching of the participants to the research aim and objectives (Campbell et al.,

2020). This method was proven effective in both medical and nursing fields when characteristics are objectively designed (Campbell et al., 2020).

Those who consented to participate in the study and worked in the Eastern Province at that time were included, no conditions were applied for exclusion. The research team adapted a self-administered questionnaire that was taken from earlier research (Baseer et al., 2012; Andargie & Kassahun, 2019; Yimenu et al., 2020; Haresaku et al., 2018 and Haresaku et al., 2022). It consisted of forty closed-ended questions in Arabic and English that covered four areas: 1) background information 2) interprofessional oral health practices; 3) oral health knowledge; and 4) attitudes regarding oral health. Twenty medical experts who were excluded from the final analysis participated in the piloting of the questionnaire. Cronbach's alpha was used to assess the questionnaire's validity and reliability, and it was both valid and reliable ( $\alpha = 0.816$ ). Google Forms were used to disseminate the survey online, and a link to it was shared on Twitter and WhatsApp.

### Phase III: Exploring factors influencing nurses' attitudes towards their role in dental care.

Nurses employed in Eastern Saudi Arabia's public and private healthcare facilities were the focus of this phase. Previous literature (Batiha et al., 2012; Adib-Hajbaghery et al., 2013; Li et al., 2020; Haresaku et al., 2020) and focus group discussions were used to build a pre-validated 40-items questionnaire. Prior to starting the study, a pilot test of the questionnaire was conducted on 15 nurses who were later excluded from the main study. Four elements made up the questionnaire: knowledge, attitudes, participants' present practices, and participants' profile and background data. The survey was in Arabic and English and disseminated online via social media platforms Facebook, Twitter, and WhatsApp. Multiple participants helped in distributing the online survey simultaneously. The survey link was valid for one month and all responses were included in the analysis.

### Phase IV: Assessing the impact of oral health educational intervention on knowledge, attitudes, and practices of healthcare professionals towards provision of dental care.

A structured questionnaire used in phases II & III collected pre and post data from the participants in this phase. The questionnaire consisted of four sections: sociodemographic data, oral health knowledge, beliefs and the last section investigated current participants dental care practices. The questionnaire was uploaded onto a website (<https://dentaldiseasesbrochure.blog>). The first page of the questionnaire started with a brief introduction of the study and consent of

participation; after that participants were directed automatically to a page that contained the pre-survey. After the participants had completed and submitted the pre-survey, they were randomly directed to the next page which included the intervention (an educational video or an educational brochure) with the backward feature disabled. After the participants were exposed to the intervention, they were automatically transferred to the post-survey page while maintaining the inability to return to the previous page. Educational materials as well as questionnaires were available in both English and Arabic languages. The intervention consisted of two pedagogical methods, a video and a brochure. Both educational materials explained the definition, risk factors, etiological factors, clinical presentation and prevention of dental caries, gingivitis, and periodontitis. The main source of information used in both interventions was the official website of the Ministry of Health in the Kingdom of Saudi Arabia (<https://www.moh.gov.sa/en/AwarenessPlatform/OralHealth/Pages/default.aspx>) which is accessible to all healthcare workers. In addition, literature search was done to explore the content used in similar studies. The scientific content was then reviewed by the research team for coverage of major dental diseases, simplicity, and logical sequence. Ajzen's theory of planned behavior, which has been widely applied in the field to predict behavior and practice, served as the foundation for the educational intervention in this study. The theory defines intention as the outcome of three factors: the individual's views, personal standards, and perceived behavioral control (Ajzen et al., 1991). The post intervention survey also included an additional question assessing participants' satisfaction with the scientific content of both interventions.

#### 4.4 Statistical analysis

All statistical analysis was done using SPSS (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp.). A P-value of less than 0.05 determined the statistical significance.

**Phase I statistical analysis:** The quantitative variables were presented as frequencies and percentages. The open-ended questions' replies were subjected to thematic analysis, which began with an examination of related themes identified by the frequency with which a certain thematic element was mentioned in the responses. Every open-ended response was examined and sorted by the principal investigator (BG). When many respondents provided information for a given country, those responses were combined and displayed per country. The data was presented by continents and by the responding countries within each continent.

**Phase II scoring and variables:** Knowledge questions were scored as follows: if there was only one right response, each correct response received a score of one,

while incorrect or "I do not know" answers received a score of zero. When answering questions with more than one right answer, only picking the right set of answers resulted in a score of one or otherwise the participant will receive a score of zero. Then the individual's total knowledge score (out of 13) was the sum of all scores/question. Participants were categorized as having good knowledge if their overall score was 70% or higher. For the scoring of attitude questions, "agree and fully agree" responses were merged, as were "disagree and definitely disagree" responses. The mean score of the attitude statements was set as a cutoff to assess the participants' attitudes, and the individuals were classified as positive or negative depending on whether their scores were higher or lower than the mean.

**Phase II statistical analysis:** the outcome variables were participants' interdisciplinary practices (1) provision of oral health education. 2) conducting oral health examination. 3) answering questions related to oral health. 4) referral of patients to a dentist. While participants' demographics were considered as "predisposing factors" and participants' over all knowledge scores and attitude scores were considered as "facilitating factors"

The following descriptive statistics were computed: mean, median, percentages, frequencies, and standard deviations [ $\pm$ SD]. For mean comparisons, the ANOVA test was used. The interplay between variables were investigated using logistic regression analysis and Odds ratio (OR) with a 95% confidence interval.

**Phases III scoring and variables:** the scoring of knowledge about oral health was done as in the previous phase. The overall knowledge score was the sum of all correct responses out of 25 points. Knowledge scores were then categorized into good knowledge (20-25), average knowledge (12.5-19), and poor knowledge (less than 12.5). Nurses' attitudes were assessed through 14 statements (with an overall score out of 70) categorized as agree, neutral or disagree. Attitudes were also scored as in the previous phase based on the mean attitude scores and were then categorized into positive (35 or more) or negative (less than 35).

**Phases III Statistical analysis:** the dependent variable was nurses' attitudes, and the independent variables were nurses' current and previous oral health knowledge, or training. Descriptive analysis as well as inferential analysis (using Chi-square test) was conducted to present demographic characteristics, knowledge/ attitudes score and compare differences in means across groups with good knowledge Vs poor knowledge as well as between those with positive and negative attitudes.

**Phase IV statistical analysis:** The dependent variables were changes in knowledge, attitudes, and practices. The independent variable was the intervention (either the brochure or the video). The scoring of knowledge and attitude questions was done following the same methods implemented in the previous two phases. Means and standard deviations were calculated for continuous data and frequency, and percentages presented the categorical data. The Wilcoxon Signed rank test was

used to compare the pre and post educational interventions. Logistic regression was applied to investigate the factors associated with good knowledge and beliefs pre and post educational intervention.

## 4.5 Ethical considerations

Study protocols for all phases were reviewed and approved by the Deanship of Scientific research Imam Abdurahman bin Faisal University. Explanation of each study phase was provided to participants along with the data collection tool. Participants in all phases of the study had to provide consent by agreeing to the “consent statement” and choosing to respond to the survey questions. Participants confidentiality, anonymity, voluntary participation and right to withdraw were maintained in all phases of the study. Institutional Review Board for Phase I (IRB-2023-02-029), phases II and III (IRB- 201702- 048) and the last phase (IRB- 2024-02- 324). All the studies were conducted in accordance with Helsinki declaration ethical guidelines. AI tools were ethically used in the dissertation for the following: to search for relevant papers during the write-up of the literature review (Connected paper and Research Rabbit) and generation of framework for the discussion (framework writer and ChatGPT) and Grammarly and QuillBot for language check and proofreading.

# 5 Results

## 5.1 Global perspective on oral health policy integration

In total, data from sixty countries out of 158 FDI member-countries was collected (participation rate: 38%). Ten (17.9%) were from Africa (out of 56 countries), seventeen (35.4%) of 48 countries were from Asia, twenty (40%) out of 50 countries were from Europe, eight (34.8%) out of 23 countries were from North America, four (33.3%) out of 12 countries were from South America, and only one country (New Zealand) out of 14 countries was from Oceania (7.1%). Table 1 summarizes the current coverage of oral health policies across continents.

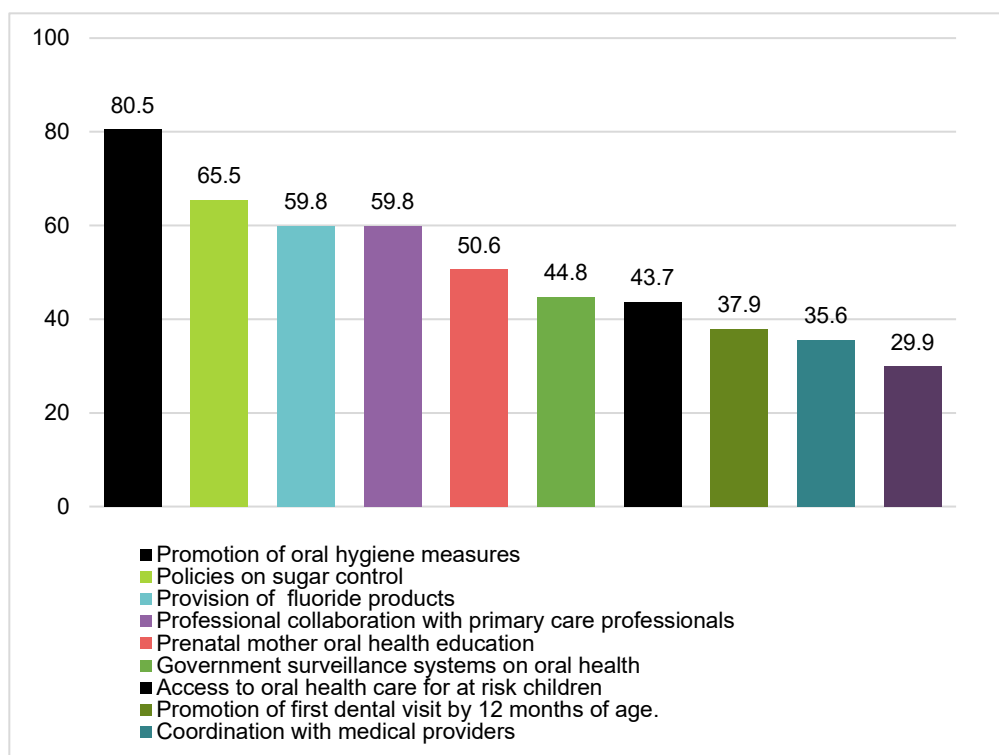
**Table 1.** Global status of national oral health policies. (Modified from publication 1).

Region	Countries with Oral Health Policies (%)	Integration with Primary Care (%)	Focus on Child Oral Health (%)	UHC with Dental Services (%)
<b>Europe</b> (=44 countries)	30/44 (68%)	28/44 (64%)	32/44 (73%)	22/44 (50%)
<b>Asia</b> (=49 countries)	28/49 (57%)	26/49 (53%)	32/49 (65%)	23/49 (47%)
<b>Africa</b> (=54 countries)	17/54 (31%)	16/54 (30%)	18/54 (33%)	12/54 (22%)
<b>North America</b> (=23 countries)	13/23 (57%)	14/23 (61%)	11/22 (50%)	13/23 (57%)
<b>South America</b> (=12 countries)	5/11 (45%)	5/11 (45%)	6/12 (50%)	5/12 (42%)
<b>Global Avg</b> (=182 total countries)	93/182 (51%)	89/182 (49%)	99/182 (54%)	78/182 (43%)

### 5.1.1 Global existence of oral health policy

We found that 48 (55.2%) of the surveyed countries have a formal national oral health policy. And an equal percentage 48 (55.2%) of countries had oral health

covered within their general health policy, including issues that are relevant to oral health such as sugar taxation were present. However, only 49.4% (n=30) of the countries reported having programs that target the oral health care needs of socially disadvantaged populations. Slightly more than half of the responding countries 35 (57.5%) had their oral health promotion programs run by dental professionals. Furthermore, 54 (62.1%) countries had a National Universal Health coverage (UHC) plan, and 42 (48.3%) had dental care included in their UHC. A primary policy thrust in 71.7% of the surveyed countries was promoting oral hygiene among children. Measures include school-based programs and public campaigns, which are essential for community-wide engagement. Figure 2 shows the type and extent of oral health policies as reported by countries.



**Figure 2.** Percentages of policy thrusts included within oral health policy/country. (From publication 1).

### 5.1.2 Policy on interprofessional collaboration and integration

Policies in 32 (53.3%) of the countries encourage collaboration between dental professionals and primary healthcare providers such as integrating oral health education and screenings into general child health assessments; of these ten countries were from Europe. Coordination with medical providers to facilitate dental counselling, dental screening, and preventive procedures to infants was part of oral health policy in 21 (35%) countries.

#### Africa

Six countries (Egypt, Ghana, Nigeria, Senegal, Sudan, Tanzania) have policies that promoted professional collaboration with primary care professionals to provide oral health education and screening as part of the overall child health assessments.

#### Asia

Eight countries (Bahrain, Hong Kong, Iran, Israel, Philippines, Thailand, Turkey, United Arab Emirates) have policy statements on professional collaboration with primary care professionals to provide oral health education/promotion/screening as part of the overall child health assessments. As well as coordination with medical providers to facilitate dental counselling, dental screening and preventive procedures to infants and prenatal oral health education (figure 3).



**Figure 3.** Asian countries (colored) with interprofessional collaboration as part of oral health policy. (From publication I).

## Europe

Nine countries (Croatia, Denmark, Estonia, Finland, Italy, Macedonia, Norway, Romania, and Serbia) had oral policy that includes professional collaboration with primary care professionals to provide oral health education/promotion/screening as part of the overall child health assessments.

## North America

Three countries (Montserrat, Trinidad and Tobago and the United States) include professional collaboration with primary care professionals to provide oral health education/promotion/screening as part of overall child health assessments. In addition, four countries (Trinidad and Tobago, Montserrat, Puerto Rico, and the United States) have a policy on coordination with medical providers to facilitate dental counselling, dental screening and preventive procedures to infants including prenatal oral health education.

## South America

None of the responding South American countries had professional collaboration with primary care professionals as part of their oral health policy.

### 5.1.3 Policy on prenatal oral health care and education

#### Africa

Prenatal oral health education was part of oral health policy in Egypt, Ghana, Namibia, Nigeria, Senegal, and Sudan; and two countries (Egypt and Namibia) advocate caries risk assessment for children.

#### Asia

Five countries (Israel, Jordan, Palestine, Saudi Arabia, and United Arab Emirates) highlighted prenatal oral health education for mothers as part of the policy requirement on professional collaboration with primary care professionals (figure 4).



**Figure 4.** Asian countries (colored) with policy on prenatal care and education. (From publication I).

## Europe

Prenatal oral health and dental homes were part of oral health policies in ten countries (Czech Republic, Estonia, Finland, Norway, Macedonia, Serbia, Italy, Lithuania, Denmark, and Romania).

## North America

Puerto Rico, Trinidad & Tobago, and the United States oral health policy includes prenatal oral health education for mothers.

## South America

None of the South American countries had a policy that includes prenatal education.

### 5.1.4 Policy on oral health promotion

#### Africa

Two countries (Ghana and Egypt) have policy that promotes first dental visit by 12 months of age. Eight countries (Egypt, Ghana, Mozambique, Namibia, Nigeria, Senegal, South Africa, Tanzania) have policies that include promotion of oral hygiene measures. Four countries (Egypt, Ghana, South Africa, Sudan) provide fluoride products like fluoride varnish for children at risk for caries. S.tomé had an oral health policy that promotes oral hygiene measures (brushing days within schools, distribution of toothpastes and toothbrushes, public campaigns).

#### Asia

Twelve countries (Bangladesh, Bahrain, Hong Kong, Iran, Japan, Jordan, Mongolia, Palestine, Philippines, Thailand, Turkey, United Arab Emirates) have policies that promote oral hygiene measures and first dental visits by first year of age.

Six of these twelve countries (Hong Kong, Mongolia, Palestine, Jordan, Thailand, Turkey) include oral hygiene measures such as brushing days within schools, distribution of toothpastes and toothbrushes and public oral health promotion campaigns as specific activities in their policy (figure 5).



**Figure 5.** Asian countries (colored) with policy on oral health promotion. (From publication I).

## Europe

Eight countries (Bosnia, Estonia, Herzegovina, Lithuania, Romania, Serbia, Slovakia, Spain, and Switzerland) promote oral hygiene measures, and eight countries (Croatia, Estonia, Finland, Lithuania, Romania, Slovakia, Spain, and Switzerland) provide fluoride products for children at risk for caries.

## North America

Five countries (Mexico, Montserrat, Puerto Rico, Trinidad and Tobago and the United States) have policy that promotes oral hygiene measures (brushing days within schools, distribution of toothpastes and toothbrushes, public campaigns). Three countries (Mexico, Puerto Rico, and the United States) provide fluoride varnish for children to reduce the risk for caries, and the United States promotes first dental visit by 12 months of age. Three countries (Puerto Rico, Trinidad and Tobago, and the United States) provide access to early childhood oral health promotion for at-risk populations of children (special needs and minorities).

## South America

Only Colombia had oral policy that included the promotion of oral hygiene measures such as brushing days within schools, distribution of toothpastes and toothbrushes, and public campaigns.

## 5.2 Interdisciplinary practices among healthcare providers in Saudi Arabia

A total of 1,398 health professionals (nurses, physicians, pediatricians, and ENT specialists) working in Eastern Saudi Arabia were included in this phase of the study. More than half 63% (n= 873) were males, 537 (39%) were in their twenties, majority were Saudi nationals 1062 (76%), mainly working in healthcare centers 525 (38%) and most of them 478(34%) were with less than 3 years of experience.

The main source of oral health knowledge as reported by healthcare professionals was formal education 679(48.6%) while a quarter 25% (n=350) admitted they lack previous oral healthcare knowledge and 862 (61.7%) did not attend any continuous educational session or training.

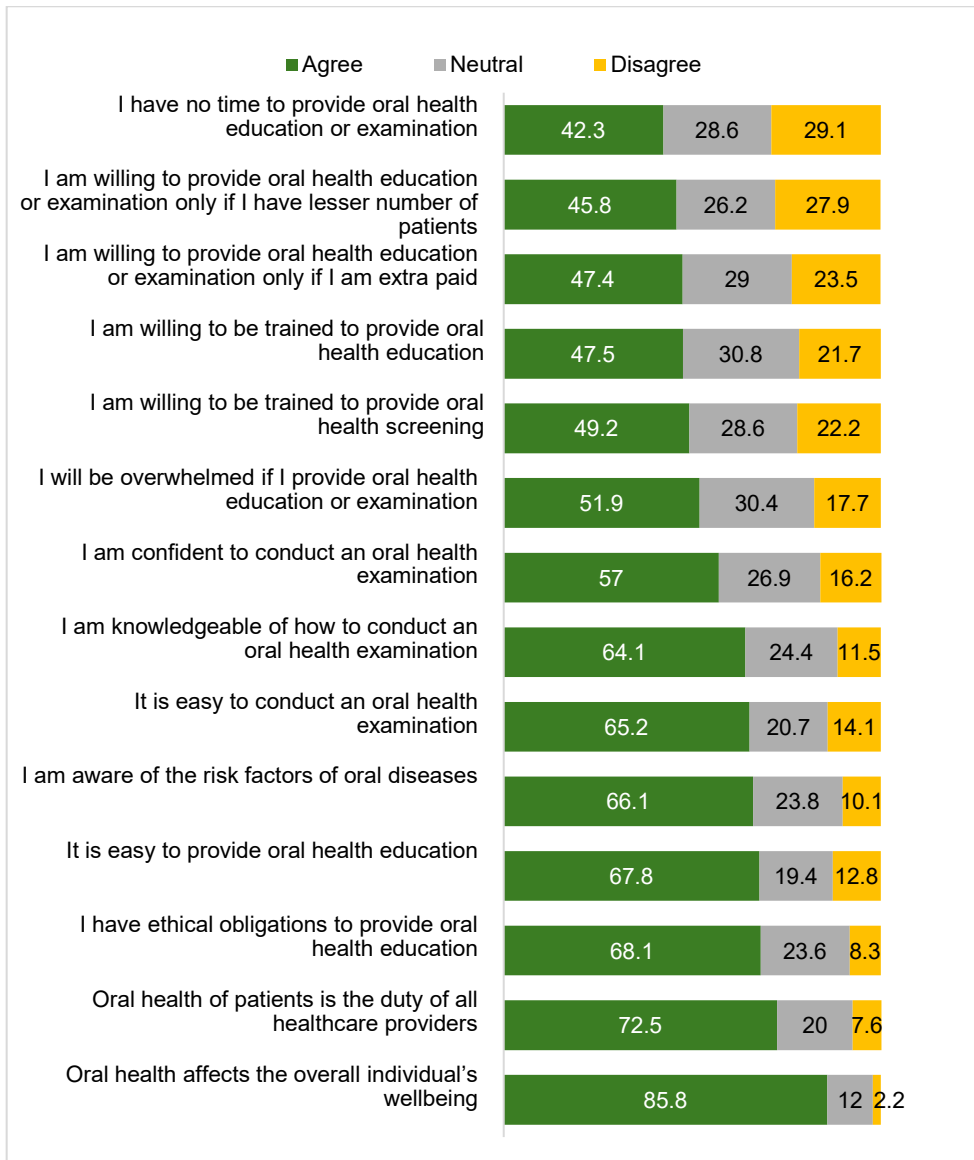
The mean score of oral health knowledge among health professionals was (7.1±2.1) which significantly differed among healthcare professionals (P<0.001) with physicians showing the highest knowledge scores (7.46 ±2.21). Affiliation and year of experience were also significantly associated with differences in knowledge scores (P<0.001); those working in academia and those with more than ten years of

experience demonstrating better knowledge scores ( $7.54 \pm 1.95$ ) and ( $7.55 \pm 2.06$ ) respectively (table 2).

**Table 2.** Differences in knowledge score among study participants. (From publication II).

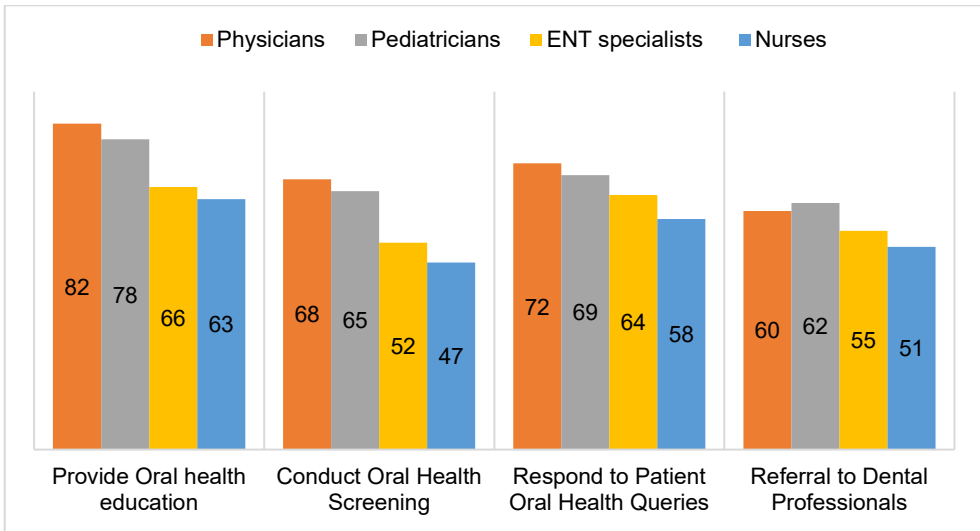
Demographic variables	N (%)	Mean Knowledge Score	P-value
<b>Age</b>			
Twenties	131 (61)	$7.08 \pm 2.11$	0.339
Thirties	55 (27)	$7.15 \pm 2.09$	
Forties	18 (8)	$6.96 \pm 2.11$	
Fifty and above	9 (4)	$7.34 \pm 2.40$	
<b>Gender</b>			
Male	127 (59)	$7.08 \pm 2.08$	0.538
Female	86 (41)	$7.15 \pm 2.22$	
<b>Nationality</b>			
Saudi	154 (72)	$7.18 \pm 2.12$	<b>0.019</b>
Non-Saudi	59 (28)	$6.87 \pm 2.13$	
<b>Health professionals</b>			
Nurses	94 (44)	$6.79 \pm 2.03$	<b>&lt;0.001</b>
Physicians	119 (56)	$7.46 \pm 2.21$	
<b>Affiliations</b>			
Public hospitals/health centers	156(73)	$7.24 \pm 2.13$	<b>&lt;0.001</b>
Teaching institutes	23 (11)	$7.54 \pm 1.95$	
Private hospitals	26 (12)	$6.51 \pm 2.16$	
Both private and public	8 (4)	$7.03 \pm 1.96$	
<b>Years of experience</b>			
< 3 years	123 (58)	$6.92 \pm 2.10$	<b>&lt;0.001</b>
3-6 years	33 (15)	$6.78 \pm 2.23$	
7-9 years	17 (8)	$7.28 \pm 2.05$	
≥ 10 years	40 (19)	$7.55 \pm 2.06$	

The mean attitude score towards oral healthcare among health professionals was ( $22.2 \pm 3$ ) which also differed significantly ( $P < 0.0001$ ) among the different specialties; the most positive attitudes were observed among ENT specialists ( $23.3 \pm 2.8$ ) while nurses showed less favourable attitudes ( $21.46 \pm 2.88$ ) towards oral healthcare. The majority of healthcare professionals (85.8%) agreed that oral health affects the overall general health, 72.5% agreed that oral health of patients is the duty of all healthcare providers and 68.1% agreed that they have ethical obligations to provide oral health education to their patients (Figure 6).



**Figure 6.** Healthcare professionals' attitudes to oral health statements. (From publication II).

The type and extent of interdisciplinary practices as reported by the participants are presented in figure 7. The most reported interdisciplinary practice was the provision of oral health education (74.6%) and the least reported practices by healthcare professionals were dental screening (59.6%) followed by referral to dental care (58.7%).



**Figure 7.** Percentage of interdisciplinary practices among health professionals in Saudi Arabia. (From publication II).

Factors that influenced referral practices by healthcare professionals are displayed in table 3. Years of experience, affiliation, specialty, oral health knowledge, and continuous education in oral health were all significantly associated with more referral practices ( $P < 0.000$ ). Similarly, those who provided oral health education were significantly more likely to refer their patients to dental care. Although those who performed dental screening also showed higher odds of referral, this association did not reach statistical significance after adjustment.

**Table 3.** Factors associated with dental referrals by healthcare professionals. (From publication II)

Variables	Unadjusted odds ratio	P-value	Adjusted odds ratio	P-value
<b>Gender</b>				
Male	0.81	0.078	1.03	0.844
*Female	(0.65, 1.02)		(0.78, 1.35)	
<b>Nationality</b>				
Saudi	0.84	0.200	0.75	0.101
*Non-Saudi	(0.65, 1.09)		(0.53, 1.06)	
<b>Years of experience</b>				
> 6 years	1.86	<0.001	1.96	<0.001
*≤ 6 years	(1.49, 2.34)		(1.48, 2.60)	
<b>Affiliations</b>				
Public sector/Teaching institutes	2.18	<0.001	2.28	<0.001
*Private sector	(1.67, 2.86)		(1.64, 3.16)	
<b>Health Professionals</b>				
Physicians/pediatricians/ENT	1.78	<0.001	2.27	<0.001
*Nurses	(1.42, 2.23)		(1.73, 2.99)	
<b>Oral health knowledge score</b>				
High	1.35	0.008	1.37	0.028
*Low	(1.08, 1.69)		(1.05, 1.78)	
<b>Attended oral health education training</b>	1.99	<0.001	1.37	0.034
	(1.57, 2.53)		(1.02, 1.83)	
<b>Provided oral health education</b>	3.88	<0.001	3.15	<0.001
	(2.97, 5.06)		(2.24, 4.42)	
<b>Conducted oral health screening</b>	2.29	<0.001	1.33	0.074
	(1.83, 2.87)		(0.97, 1.81)	
<b>Believed that oral health is the duty of all health care providers</b>	1.32	0.025	1.10	0.525
	(1.04, 1.69)		(0.82, 1.46)	

\*Reference Category

Dental referrals differed significantly ( $P > 0.000$ ) between healthcare professionals -with more referrals reported by nurses- as well as reasons for dental referrals (table 4).

**Table 4.** Difference between health professionals with regard to reason of dental referrals. (From publication II).

Reason for referral		Mean( $\pm$ SD)	P-value
Pain	Nurses	0.37( $\pm$ 0.5)	<b>0.002*</b>
	Physicians	0.44( $\pm$ 0.5)	
	Pediatricians	0.49( $\pm$ 0.5)	
	Ent	0.36( $\pm$ 0.5)	
Cavitation	Nurses	0.16( $\pm$ 0.4)	<b>0.000*</b>
	Physicians	0.26( $\pm$ 0.4)	
	Pediatricians	0.36( $\pm$ 0.6)	
	Ent	0.25( $\pm$ 0.4)	
Swelling	Nurses	0.19( $\pm$ 0.4)	<b>0.025*</b>
	Physicians	0.24( $\pm$ 0.4)	
	Pediatricians	0.2( $\pm$ 0.4)	
	Ent	0.3( $\pm$ 0.5)	
Broken tooth	Nurses	0.17( $\pm$ 0.4)	0.147
	Physicians	0.22( $\pm$ 0.4)	
	Pediatricians	0.23( $\pm$ 0.4)	
	Ent	0.18( $\pm$ 0.4)	
Abscess	Nurses	0.15( $\pm$ 0.4)	<b>0.000*</b>
	Physicians	0.28( $\pm$ 0.5)	
	Pediatricians	0.31( $\pm$ 0.5)	
	Ent	0.3( $\pm$ 0.5)	
Facial trauma	Nurses	0.08( $\pm$ 0.3)	<b>0.001*</b>
	Physicians	0.14( $\pm$ 0.4)	
	Pediatricians	0.12( $\pm$ 0.3)	
	Ent	0.18( $\pm$ 0.4)	
Prophylaxis	Nurses	0.07( $\pm$ 0.3)	<b>0.05*</b>
	Physicians	0.11( $\pm$ 0.3)	
	Pediatricians	0.09( $\pm$ 0.3)	
	Ent	0.14( $\pm$ 0.3)	

\*Statistically Significant at 0.05

### 5.3 Nurses' attitudes and their role in dental care provision

For this phase of the study, 525 nurses were surveyed. The majority 255 (48.6%) were in their twenties, 419 were males (79.8%), and 381 were Saudis (72.6%), mainly working in the Ministry of Health 175 (33.5%) with less than 3 years of experience 221 (42.1%). A total of 267 nurses (50.9%) reported not having an oral

health undergraduate curriculum, while 258 (49.1%) stated that they had received such an education (Table 5).

**Table 5.** Demographic profile of recruited nurses in phase III (N= 525). (From publication II).

<b>Study variables</b>	<b>N (%)</b>
<b>Age</b>	
Twenties	255 (48.6)
Thirties	193 (36.8)
Forties	56 (10.7)
Fifties and above	21 (4)
<b>Gender</b>	
Male	419 (79.8)
Female	106 (20.2)
<b>Nationality</b>	381 (72.6)
Saudi	144 (27.4)
Non-Saudi	
<b>Affiliation (N= 523)</b>	
Public hospital	119 (22.8)
Ministry of health	175 (33.5)
Teaching institute	77 (14.7)
Private hospital	120 (22.9)
Both private and public	32 (6.1)
<b>Years of experience</b>	
Less than 3 years	221 (42.1)
3-6 years	105 (20)
more than 6 less than 10 years	88 (16.8)
more than 10 years	111 (21.1)
<b>Attended educational session</b>	
Yes	220 (42.2)
No	305 (57.8)
<b>Have formal education of OH</b>	
Yes	258 (49.1)
No	267 (50.9)

The mean ( $\pm$ SD) attitude of participants was 52.8 ( $\pm$ 8.2), indicative of positive attitudes towards dental care. The most positive attitude was regarding the impact of oral health on overall well-being and was reported by 454 (86.8%). The majority of nurses were positively inclined to get trained in oral health education 398 (76.4%) as well as their willing to be trained to provide oral health screenings 388 (74.3%). Slightly more than half of nurses felt knowledgeable or confident enough to provide oral health screening 281 (53.5%) and 299 (57%) respectively. An almost equal number of participants agreed they were willing to provide oral health education or

screening if they were extra paid 250 (47.8%) or had a lower number of patients to take care of 239 (45.8%). On the other hand, 195 nurses (37.3%) felt they have no time to provide oral health education or screening (Table 6). Table 7 shows that none of the demographic variables influenced nurses' attitudes towards dentalcare ( $P<0.000$ ).

**Table 6.** Nurses' attitude towards oral health in phase III (N=525).(From publication III).

Statement	Agree (%)	Neutral (%)	Disagree (%)
Oral health affects the overall individual's well-being.	454 (86.8)	55 (10.5)	14 (2.7)
Oral health of patients is the duty of all healthcare providers.	370 (70.5)	102 (19.4)	51 (9.7)
I have ethical obligations to provide oral health education.	372 (70.9)	110 (21.0)	42 (8.0)
It is easy to provide oral health education.	382 (72.8)	105 (20.0)	38 (7.2)
I am aware of oral diseases risk factors.	349 (66.7)	124 (23.7)	50 (9.6)
It is easy to conduct an oral health screening.	335 (63.8)	114 (21.9)	72 (13.8)
I am knowledgeable of how to conduct an oral health screening.	281 (53.5)	148 (28.2)	93 (17.7)
I am confident to conduct an oral health screening.	299 (57.0)	146 (27.9)	79 (15.0)
I will be overwhelmed if I provided oral health education or screening.	272 (51.8)	148 (28.7)	95 (18.1)
I am willing to be trained to provide oral health screening.	377 (72.0)	95 (18.2)	51 (9.8)
I am willing to be trained to provide oral health education.	398(76.4)	85 (16.3)	38 (7.3)
I am willing to provide oral health education or screening only if I am extra paid.	250 (47.8)	138 (26.4)	135 (25.7)
I am willing to provide oral health education or screening only if I have lesser number of patients.	239 (45.8)	147 (28.2)	136 (26.1)
I have no time to provide oral health education or screening.	170 (32.4)	-	195 (37.3)

**Table 7.** Association between nurses' attitude towards dental care and demographic characteristics. (From publication III).

Demographic characteristics		Positive (N = 220)	Negative (N = 305)	P-value
Age (years)	20-29 years old	97 (44.1)	158 (51.8)	0.377
	30-39 years old	88 (40.0)	105 (34.4)	
	40-49 years old	25 (11.4)	31 (10.2)	
	≥ 50 years old	10 (11.4)	11 (3.6)	
Gender	Male	175 (79.5)	244 (80.0)	0.898
	Female	45 (20.5)	61 (20.0)	
Nationality	Saudi	166 (75.5)	215 (70.5)	0.209
	Non-Saudi	54 (24.5)	90 (29.5)	
Affiliation	Public hospital	52 (23.9)	67 (22.0)	0.482
	Ministry of health	74 (33.9)	101 (33.1)	
	Teaching institute	27 (12.4)	50 (16.4)	
	Private hospital	48 (22.0)	72 (23.6)	
	Both private & public	17 (7.8)	15 (4.9)	
Experience	<3 years	89 (40.5)	132 (43.3)	0.875
	3-6 years	44 (20.0)	61 (20.0)	
	>6 to 10 years	37 (16.8)	51 (16.7)	
	>10 years	50 (22.7)	61 (20.0)	

Nurses demonstrated an average oral health knowledge mean ( $\pm$ SD) score was 13.4 ( $\pm$ 3.9). Table 8 shows the oral health knowledge score for each dental disease, risk factors and clinical presentation. We found that among nurses who had the correct knowledge of caries occurrence at any age was significantly associated with positive attitudes ( $P=0.001$ ). All other items of knowledge scores were either not associated with positive attitudes ( $P>0.000$ ) or was inversely associated with positive attitudes, where we observed that those who had the incorrect information of gingivitis affecting only adults had more positive attitudes. On the other hand, those who had formal education in oral health or attended continuous education session in oral health had significantly positive attitudes ( $P=0.001$ ).

**Table 8.** Association between participants attitudes and the source of oral health Knowledge, or training. (From publication III).

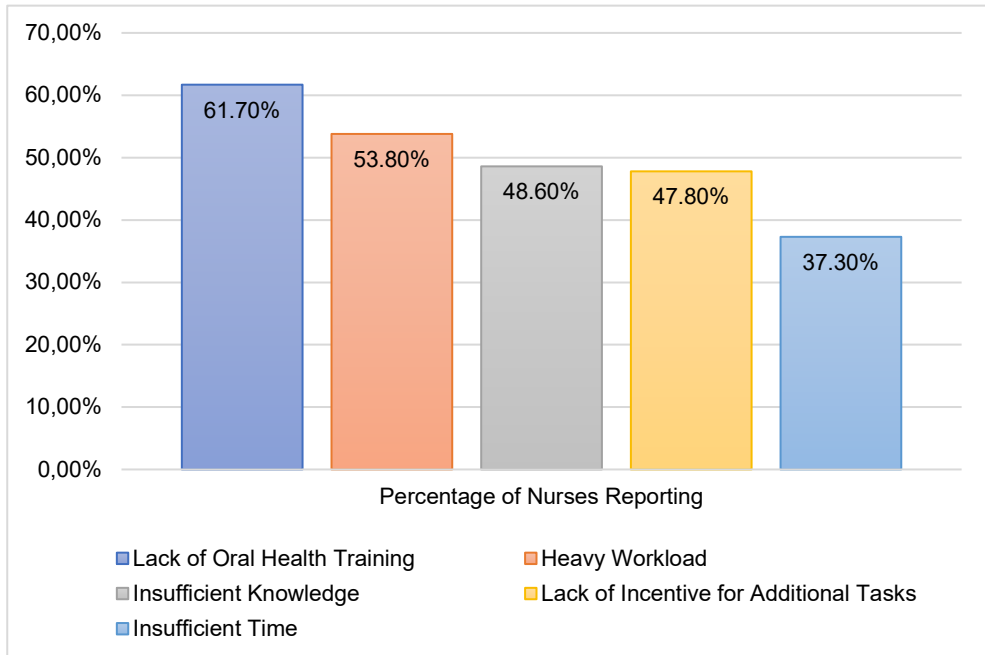
Type/source of Oral health knowledge	Attitude towards oral health			P- Value
	Items	Positive (N = 305)	Negative (N = 220)	
Knowledge of oral health	Knowledge of dental caries	7 (2.3)	5 (2.3)	0.987
	Diet is a risk factor	114(37.4)	67 (30.5)	0.100
	Poor hygiene	226(74.1)	154 (70.0)	0.300
	Dental caries can occur at any age.	283(92.8)	179 (81.4)	<b>0.001</b>
	Dental caries can be prevented.	292(95.7)	192 (87.3)	<b>0.001</b>
	Dental caries can lead to tooth loss.	268(87.9)	177 (80.5)	<b>0.020</b>
	Prevention from dental caries.	77 (25.2)	51 (23.2)	0.587
	Knowledge about gingivitis.	57 (18.7)	35 (15.9)	0.409
	Risk factors of gingivitis.	70 (23.0)	41 (18.6)	0.323
	Gingivitis affects adults only.	229(75.1)	146 (66.4)	<b>0.029</b>
	Gingivitis can lead to tooth loss.	96 (31.5)	57 (25.9)	0.166
	Periodontitis is the same as gingivitis.	182(59.7)	127 (57.7)	0.655
	Knowledge about periodontitis.	6 (2.0)	10 (4.5)	0.090
	Periodontitis can lead to tooth loss.	248(81.3)	173 (78.6)	0.448
	<b>Attended lecture/ training on oral health</b>	68(31.1)	152 (50.3)	<b>0.001</b>
<b>Have formal education of OH</b>	89 (40.5)	169 (55.4)	<b>0.001</b>	

Table 9 shows nurses' current practices in terms of dental care and its association with attitudes. More than two thirds of nurses (70.3%) replied that they responded to patients' questions about oral health conditions, but this practice was not associated with positive attitudes towards dental care ( $P=0.108$ ). On the other hand, conducting oral health screening and oral health education was practiced to a lesser extent by nurses, reported by 47.1% and 19.7%, respectively; but these practices were significantly associated with positive attitudes among nurses ( $P=0.001$ ). Half the participants 50.7% (=266) reported referral practices; however, these practices were not associated with nurses' attitudes nor with the cause of referral.

**Table 9.** Association between nurses' dental care practices and their attitudes. (From publication III).

Practice of oral health	Attitude towards oral health		P-value
	Positive (n = 305)	Negative (n = 220)	
Always conduct an oral health screening	69 (22.8)	34 (15.5)	<b>0.001</b>
Sometimes conduct an oral health screening.	156 (51.5)	90 (41.1)	<b>0.001</b>
Responded to a patient question about an oral health condition.	222 (73.0)	145 (73.0)	0.108
Referred a patient to a dentist.	163 (53.4)	103 (46.8)	0.134

Key barriers to nurses' participation in dental care are displayed in figure 8 with the main barrier stated being lack of oral health training (61.7%) followed by heavy workload (53.8%).



**Figure 8.** Key barriers to nurses' participation in dental care. (From publication III).

## 5.4 Evaluating the effectiveness of an educational intervention targeting nurses and physicians

A total of 213 healthcare providers (physicians accounted for 119 (56%) and 94 (44%) were nurses) participated in this study. Most of the participants were in their twenties 131 (61%), females 127 (59%) and the majority 154 (72%) were Saudi and 140 (65%) were from the public sector. Overall demographic information is presented in Table 10.

**Table 10.** Demographical characteristics of participants recruited for phase IV (N=213). (From paper IV).

Variable	Responses	Frequency (%)
Age	Twenties	131 (61)
	Thirties	55 (27)
	Forties	18 (8)
	Fifty and above	9 (4)
Gender	Female	127 (59)
	Male	86 (41)
Nationality	Saudi	154 (72)
	Non-Saudi	59 (28)
Specialty	Nurse	94 (44)
	Physicians	119 (56)
Affiliation	Public Hospital	140 (65)
	Ministry of Health	16 (8)
	Teaching institute	23 (11)
	Private hospital	26 (12)
	Both private and public	8 (4)
Years of practice	Less than 3 years	123 (58)
	3 - 6 years	33 (15)
	> 6 and less than 10 years	17 (8)
	> than 10 years	40 (19)

Table 11 shows the comparison of knowledge scores by demographic characteristics of the participants using bivariate analysis. The overall knowledge scores increased across all demographic variables. Improvement of knowledge scores was greatest among the participants in their twenties (17 vs. 19.7,  $p < 0.001$ ). Improvement of knowledge scores was higher in females after the intervention (16.86 to 19.54) when compared to males, but the change was significant for both genders in the pre and post knowledge scores ( $p < 0.001$ ). Similarly, although both nurses and physicians showed significant improvements in oral health knowledge after the intervention, the knowledge gain was greater among physicians (an increase from 17.59 to 19.76) compared to nurses (16.09 to 19.30) and both improvements were statistically significant within the specialty ( $p < 0.001$ ).

**Table 11.** Oral health knowledge (OHK) before and after the educational intervention across different demographic characteristics. (From paper IV).

Demographical characteristics		OHK		
		Before	After	p-value
Age	Twenties	17±3.8	19.7±3.9	<b>0.0001*</b>
	Thirties	16.87±3.99	19.42±4.08	<b>0.0001*</b>
	Forties	16.11±4.34	18.78±3.84	<b>0.024*</b>
	Fifty and above	18.56±3.84	19.78±4.63	0.435
Gender	Female	16.86±3.79	19.54±4.12	<b>0.001*</b>
	Male	17.05±4.01	19.59±3.65	<b>0.0001*</b>
Nationality	Saudi	17.14±3.94	20.05±3.76	<b>0.0001*</b>
	Non-Saudi	16.41±3.67	18.29±4.11	<b>0.009*</b>
Specialty	Nurse	16.09±3.9	19.30±4.21	<b>0.001*</b>
	Doctors	17.59±3.7	19.76±3.69	<b>0.001*</b>
Affiliation	Public Hospital	16.81±3.86	19.53±3.93	<b>0.0001*</b>
	Ministry of Health	16.94±3.53	18.69±4.16	0.061
	Teaching institute	17.87±4.31	21.09±2.41	<b>0.0001*</b>
	Private hospital	17.15±4	19.92±4.3	<b>0.007*</b>
	Both private and public	15.75±3.49	16.38±4.34	0.521
Years of practice	Less than 3 years	16.79±3.75	19.68±3.85	<b>0.0001*</b>
	3 - 6 years	17.58±4.44	19.61±4.21	<b>0.017*</b>
	more than 6 and less than 10 years	17.18±3.45	18.41±3.86	0.296
	more than 10 years	16.75±4	19.65±4.07	<b>0.001*</b>

The overall belief scores for providing OHE did not change significantly after both interventions (34.4 to 34.01, respectively) ( $p=0.545$ ). Table 12 shows the belief score variations by the demographic characteristics. The average belief score across age, gender and specialty did not change significantly post intervention. For doctors, the belief score decreased slightly after the intervention (34.07 to 32.84) ( $p=0.644$ ) but this decrease was not statistically significant. Whereas, there was a significant decrease in the belief score among Saudi nationals after both interventions (34.95 to 33.51, respectively) ( $p=0.041$ ). Similarly, participants working in private settings also scored less after the intervention (37.62 to 33.08, respectively) ( $p=0.007$ ).

**Table 12.** Beliefs before and after the educational intervention across different demographic characteristics. (From paper IV).

Demographical variables		Beliefs		
		Before	After	P-value
Age	Twenties	33.9±8.8	33.6±10.2	0.774
	Thirties	34.87±9.01	35.38±9.82	0.724
	Forties	37±9.49	32.72±7.7	0.15
	Fifty and above	34.44±4.9	33.67±4.24	0.604
Gender	Female	34.35±8.32	34.45±9.93	0.906
	Male	34.5±9.41	33.3±9.39	0.308
Nationality	Saudi	34.95±9.24	33.51±9.64	<b>0.041*</b>
	Non-Saudi	32.98±7.23	35.24±9.87	0.187
Specialty	Nurse	34.84±9.8	35.43±11.01	0.644
	Doctors	34.07±32.84	32.84±8.40	0.093
Affiliation	Public Hospital	34.09±8.86	34.56±9.91	0.619
	Ministry of Health	33±8.59	32±7.15	0.592
	Teaching institute	33.13±8.49	33.57±7.99	0.781
	Private hospital	37.62±9.02	33.08±12.03	<b>0.007*</b>
	Both private and public	36.13±5.77	32.13±7.45	0.107
Years of practice	Less than 3 years	33.97±8.81	33.46±10.28	0.5967
	3 - 6 years	33.97±8.29	34.03±7.95	0.965
	more than 6 and less than 10 years	33.71±7.36	32.24±7.74	0.484
	more than 10 years	36.43±9.47	36.3±9.88	0.946

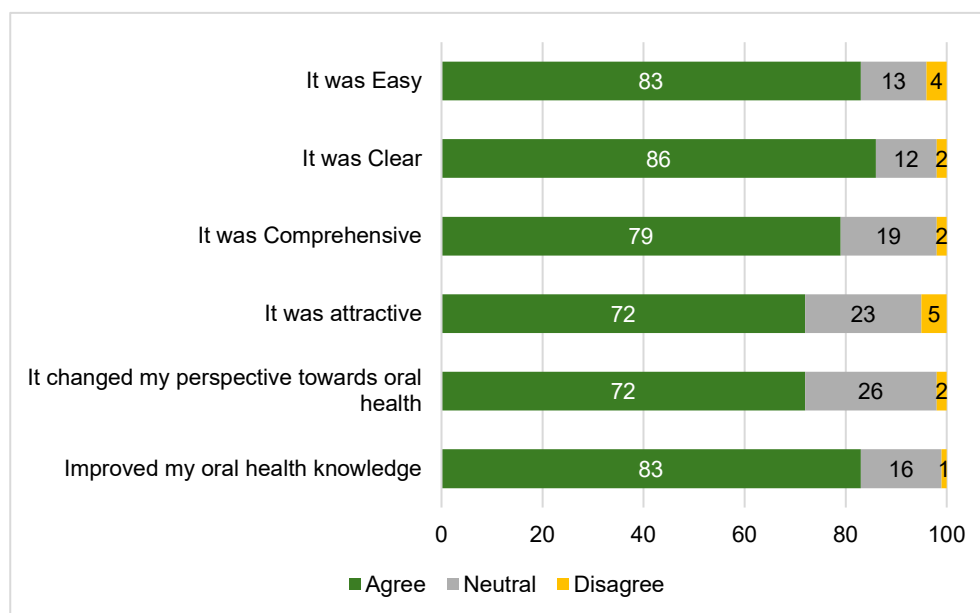
\*Statistically significant at 0.05

The willingness to provide OHE to the patients and conduct oral health screening increased slightly after the intervention (44.6% to 55.4% and 44.6% to 55.4%, respectively). Table 13 shows that the knowledge score was significantly higher among the participants who participated in the video education (20.3±3.6) compared to those who got the brochure education (18.4±4.2) ( $p=0.001$ ). The belief score did not differ significantly between the two educational groups (video =34.4±9.1 vs. brochure=33.3±10.6) ( $p=0.435$ ).

**Table 13.** Differences in OHK, beliefs, and willingness after both interventions. (From paper IV).

Study outcomes		Education Material		p-value
		Brochure	Video	
Knowledge score (mean ± SD)		18.4(+4.2)	20.3(+3.6)	<b>0.001*</b>
Beliefs (mean ± SD)		33.3(±10.6)	34.4(+9.1)	0.435
Willingness	Willingness to provide oral health education to patients	42.2%	57.8%	0.082
	Willingness to conduct dental screening	42.1%	57.9%	0.1
	Willingness to respond to patient's question about an oral health condition	43.0%	57.0%	0.072
	Willingness to refer a patient to a dentist	37.2%	62.8%	0.477

Feedback about the provided educational intervention is shown in figure 9. Most participants agreed that the educational materials were easy to read/understand (83%), the intervention was clear (86%), comprehensive (79%) and it helped to improve their knowledge (83%).



**Figure 9.** Perception of the study participants about the educational intervention. (From paper IV).

# 6 Discussion

## 6.1 Main findings

The global study (*publication 1*) highlights significant regional variations in oral health policies. Among the surveyed countries, just over half have formal national oral health policies. Therefore, the support for interprofessional engagement and the access to comprehensive oral health care for young children differed globally across countries. Specifically, only 35% of the surveyed countries incorporated non-dental professionals in oral health education, promotion, and screening.

Healthcare professionals demonstrated acceptable oral health knowledge. Of them 74.6 % provided oral health education, 59.6% conducted oral health screening, 66.7% responded to patients' questions and 58.7% referred patients to dentists. Pediatricians and physicians were more involved in interdisciplinary practices compared to other health professionals. Professionals who depended mainly on Ministry of Health and formal education as a source of oral health knowledge were more likely to have interdisciplinary practices. Participants with good oral health knowledge had greater odds of responding to patients' oral health questions as well as having more referral practices.

Nurses had satisfactory attitudes, average knowledge, and minimum practices with regards to dental care. Positive attitudes were observed among those who had undergraduate oral health component, attended continuous education and those who provided oral health screening.

Video-based intervention was more effective than the traditional brochure. Healthcare knowledge and perceptions about interdisciplinary practices improved after the intervention; however, attitudes did not change significantly ( $p=0.545$ ). Physicians benefited more from the intervention compared to nurses (19.76 vs. 19.30;  $p<0.001$ ).

## 6.2 Global policies: extension and existence

### Oral health policy presence and geographical variations

We found that 55.2% (48 countries) had a national oral health policy or position statement and 47 (54%) countries had general health policies that were relevant to oral health such as sugar taxation, obligatory dental checkups within pediatric visits. Oral health policies varied significantly between high- and low-income countries, with high-income and European nations more likely to have formalized, well-funded oral health programs integrated into national health systems. In contrast, many low-income and African or Asian countries lack comprehensive policies, often prioritizing emergency care over prevention. These disparities can be linked to differences in health financing, workforce capacity, and political commitment (Petersen, 2008). In the same context, Jiang and colleagues examined the existence and depth of oral health policies targeting elderly in nine countries and identified that disparities existed between countries (Jiang et al., 2021). Campbell, 2002 compared policies in German and Japan and reported similar differences in its coverage (Campbell, 2002). The disparity reported in these studies suggest an urgent need for universal policy standards that recognize oral health as integral to public health, as well as strengthening policy frameworks in low-resource settings to achieve global oral health equity (Wei et al., 2022).

Interprofessional collaboration (IPC) was identified as a key policy thrust, particularly in *Europe, Asia, North America* but not the case for *African and Southern American* countries. For instance, European countries, in particular, were active in reducing sugar consumption and enhancing oral hygiene measures. While *Asian countries* policies facilitate the coordination with healthcare providers to deliver dental counseling and screening services as part of general child health assessments. Similarly, *North American* policies showed greater structured collaboration with primary healthcare professionals, for example, countries like the *United States* implemented programs that involved a wide range of healthcare providers to educate and screen children for oral health diseases (Atchison et al., 2018). The prioritization of IPC in Europe, Asia and North America reflects stronger health system integration, structured policy frameworks, and funding for multidisciplinary care models, often driven by their aging populations and chronic disease burdens (Jiang et al., 2021 and Fredriksson, 2024). In contrast, Africa and South America face fragmented health systems, resource constraints, and competing priorities (e.g., infectious diseases, infrastructure gaps), downgrading IPC to a secondary policy focus (Barraclough et al., 2021 and Rawlinson et al., 2021). Additionally, Europe/Asia benefit from centralized governance and cross-sector partnerships, while African and South American regions often struggle with decentralized systems

and limited interprofessional training infrastructure (Petersen, 2008 and Rawlinson et al., 2021).

Integrated oral healthcare has demonstrated positive effects on overall health outcomes and cost efficiency by preventing and controlling dental diseases before they progress to more serious health conditions (Alamari et al., 2019 and Budreviciute et al., 2020 and Bencze et al., 2021). Uncontrolled oral diseases have well-documented associations with systemic diseases, leading to a cycle of preventable health complications and increased healthcare costs (Budreviciute et al., 2020 and Chen et al., 2021 and Altamura et al., 2024). Investing in such preventive and integrated approaches would ultimately reduce the long-term economic burden on healthcare systems (Choi et al., 2020).

### Universal Health Coverage (UHC) and dental services

The study also found that 54 (62.1%) had universal health care (UHC) plans of which 48.3% (42 countries) included dental care. Commonly included services were regular dental checkups (56.3%), extractions (49.4%), and restorations (43.7%). Programs targeting disadvantaged children existed in only less than half of responding countries. Countries with comprehensive coverage often demonstrated higher levels of interprofessional practices, ensuring that oral health assessment and preventive measures were well integrated into pediatric healthcare (Gröne, & Garcia-Barbero, 2001 and Fredriksson, 2024). UHC is crucial for promoting health equity and that everyone can access essential health services without facing financial difficulties, similarly, the exclusion of oral health from UHC will increase health inequalities especially among at-risk groups (Wang et al., 2020). For example, in Brazil, incorporating oral health into UHC enhanced equity and decreased oral health disparities with an overall improvement in the quality of life (Wang et al., 2020). The differences in UHC adoption across countries stem from different political priorities, economic capacities, and health system infrastructures (Verma et al., 2025). Wealthier nations often implement UHC through tax-funded or social insurance models, while low and middle income countries face financial constraints, informal labor markets, and fragmented governance (Verma et al., 2025). These disparities highlight how structural inequities and policy choices determine UHC coverage globally.

### Policy thrusts for children

Promotion of oral hygiene measures was the most common policy thrust, reported by 71.7% of countries. Half (53.3%) of the countries provided fluoride products for children at risk of caries however, only 6.9% of countries offered comprehensive

oral health care for young children as part of UHC. Similarly, half (50%) of the countries reported that their oral health policies included prenatal oral health education. Two previous Nordic studies reported that children's use of general practitioner (GP) services increased between 1984 and 1996, while dental service use declined in four countries, with Finland as the exception (Virtanen et al., 2006 and Virtanen et al., 2007). These differences reflect health policy priorities and service delivery models. The increase in GP visits reflects policies enhancing accessibility and integrated child health programs, while the decline in dental visits reflects preventive oral health policies and improved caries prevention measures. Finland's increase in dental visits may be due to a policy emphasis on universal and accessible dental care (Linden, 2023). On the other hand low- and middle-income countries (LMICs) often prioritize low cost, population level measures (e.g., hygiene promotion) over comprehensive care due to budget constraints and competing health demands on the other hand, high-income countries (e.g., Nordic states) adopt more comprehensive policies (Watt et al., 2019). Prenatal education gaps (50% coverage) suggest lack of maternal and oral health services, particularly in regions where oral health is excluded from primary care. Untreated oral diseases in childhood increase the risk of dental problems in adulthood, thereby increasing the financial burden especially for low income families and underserved communities (Kazeminia et al., 2020 and Kotha, 2022). One of the key evidence-based approaches to prevent childhood oral diseases is educating pregnant women on prenatal and infant oral health as well as a comprehensive dental coverage for pregnant women for at least one year after birth (APHA, 2020). By engaging obstetricians, pediatricians, and midwives, these policies can facilitate early intervention and education on oral health leading to better health for both mothers and children (Hashim & Akbar, 2014 and Kobylińska et al., 2018 and George et al., 2019 and Horowitz et al., 2019 and Arevalo et al., 2023).

### 6.3 Knowledge gaps and current interdisciplinary practices

#### Healthcare professionals current knowledge

Research on interdisciplinary practices among Saudi healthcare providers, including nurses, pediatricians, and ENT specialists, highlighted a gap in oral health related knowledge and practices across different specialties. The overall mean knowledge score among all healthcare providers was  $7.1 \pm 2.1$  (out of 13), with the highest score by physicians ( $7.46 \pm 2.2$ ) and lowest score by nurses ( $6.8 \pm 2.04$ ). Physicians usually have broader medical education and exposure to oral-systemic health connections during their formal education (Rabiei et al., 2012 and Al-Habib et al., 2022), on the

other hand nurses usually have limited oral health education in nursing curricula, which is consistent with the findings of previous studies (Adib-Hajbaghery et al., 2013 and Andargie & Kassahun, 2019 and Li et al., 2020 and Kivilahti et al., 2024). In a study from Finland although all of the surveyed nurses were aware of the oral - systemic link, yet their practical knowledge was similarly inadequate (Kivilahti et al., 2024).

The research identified key gaps, for example only 7% knew the clinical features of dental caries. The exceptionally low awareness of dental caries clinical features is a critical finding. Similar studies in Nigeria and South Africa found equally poor knowledge, with less than 10% of nurses identifying caries early signs (Thema & Singh, 2013 and Oyetola et al., 2016). In contrast, studies in developed countries like Japan and the U.K showed higher recognition rates (above 50%) among nurses, mainly due to integrated oral health modules in their formal education (Haresaku et al., 2018 and Uppal et al., 2019).

On the other hand, most healthcare professionals (87%) were aware that caries can lead to tooth loss, a promising finding that aligns with global reports. For instance, studies in Japan and the U.S.A reported over 80% of healthcare providers recognized that caries could lead to tooth loss (Shimpi et al., 2016 and Haresaku et al., 2018).

Overall Saudi healthcare providers scored lower on oral health knowledge than their counterparts in countries with established IPE frameworks, such as the U.K and Australia (Thema & Singh, 2013 and Gibney et al., 2019). Barriers to knowledge in the current study can be due to lack of training as only 37.2% of healthcare providers had attended oral health training, paralleling findings from Jordan where fewer than 40% of nurses and physicians had formal oral health education (Batiha et al., 2012). The findings highlight an urgent need for capacity building initiatives in Saudi Arabia, emphasizing interprofessional collaboration and training. While these gaps are not unique to Saudi Arabia, the variation across disciplines and the overall low knowledge underscore the importance of targeted interventions to improve oral health awareness and practice among healthcare providers.

### Healthcare professionals current attitudes

The study highlighted generally positive attitudes among healthcare professionals toward involvement in dental care, with a mean attitude score of  $22.2 \pm 3$  out of 28. ENT specialists showed the most positive attitudes ( $23.3 \pm 2.79$ ), while nurses scored the lowest. ENT specialists' positive attitude scores can be due to their frequent encounters with oral and oropharyngeal health issues in clinical practice (Maden, 2022). Similar findings were also reported from Riyadh, where pediatricians and ENT specialists showed dedicated support for interdisciplinary dental care (Baseer et

al., 2012). Physicians also demonstrated positive attitudes in previous national studies, often due to their understanding of systemic health connections (Maxey et al., 2017). However, it was highlighted that the lack of structured oral health policies can limit the practical implementation despite the positive attitudes (Fallatah, 2016).

National studies reporting less favorable attitude among nurses can be due to limited exposure to oral health during formal education as mentioned earlier along with many reported barriers such as workloads, lack of training and institutional support (Baseer et al., 2012 and Ashour, 2020 and Harb et al., 2023). Internationally, nurses' attitudes varied widely for example in the U.S.A and U.K, nurses demonstrated more positive attitudes (mean scores above 24 out of 28), and was attributed to oral health training during nursing programs (Shimpi et al., 2016 and Uppal et al., 2019). While In Ethiopia and India, nurses showed attitudes similar to those in Saudi Arabia, limited by insufficient training and institutional factors (Andargie et al., 2019 and Ahmed et al., 2018).

We found that oral health training was associated with more positive attitudes but only 42.2% of healthcare providers had formal oral health education, while in countries with established interprofessional care models (e.g., the Netherlands), nurses and specialists were actively involved in oral health promotion and showed more positive attitudes (Nielsen et al., 2021). Saudi Arabia could benefit from initiatives like mandatory oral health training programs for all healthcare providers, like those implemented in the U.S.A and Australia (Shimpi et al., 2016 and Gibney et al., 2019). Institutional support and workload redistribution could enhance nurses' attitudes by reducing perceived barriers. In the same context, joint workshops and team-based care models can also enhance positive attitudes across all specialties.

### Healthcare professionals current interdisciplinary practices (IDP)

Provision of oral health education (OHE) was reported by 74.6%, this percentage is higher than what was reported in previous Saudi studies, where in Riyadh (56%) and only half (50%) in Taif reported providing OHE (Baseer et al., 2012 and Ashour, 2020). Again it was observed that in countries with stronger interprofessional education (IPE) models, such as the U.S.A, U.K, and Australia healthcare providers showed higher engagement in oral health education (Uppal et al., 2019 and Shimpi et al., 2016 and Gibney et al., 2019). For instance, in the U.S.A 85% of pediatricians routinely provided oral health education as part of anticipatory guidance (Shimpi et al., 2016). In Finland, 90% of healthcare professionals provided oral health education during patient visits, supported by the national guidelines for the promotion of preventive care (Aro et al., 2018).

In the current study only 59.6% provided oral screening, which varied by specialty. Pediatricians and ENT specialists are more likely to conduct screenings

compared to nurses. Screening rates in Saudi Arabia (59.6%) are comparable to rates in developing countries like India and Ethiopia, where 50-60% of healthcare providers performed screenings, for high risk populations (Andargie et al., 2019 and Ahmed et al., 2018). On the other hand, developed countries like Japan and the Netherlands reported higher screening rates, often exceeding 80%, due to structured training and institutional policies (Haresaku et al., 2018 and Niesten et al., 2021).

Responding to patient questions about oral or dental problems was reported by 66.7% in the current study. Globally, healthcare providers in countries with integrated oral-systemic health practices are more likely to address patient questions. For example, a U.K study reported that over 75% of general practitioners engaged in oral health discussions (Uppal et al., 2019).

Referral rates (58.7%) observed in the current study were consistent with findings from Riyadh, where about 55% of healthcare professionals referred patients to dentists (Baseer et al., 2012). However, the reasons for referral, such as dental pain (41.5%), highlight the reactive nature of referrals, focusing on treatment rather than prevention. Underutilized referral practices can be due to poorly defined healthcare systems. In developed countries like the U.S.A and Australia, referral rates exceed 70%, and are often for preventive or early interventions can due to the well established frameworks and referral systems (Shimpi et al., 2016 and Gibney et al., 2019). We found that certain factors influenced IDP; for instance, Pediatricians had 2.6 times greater odds of providing OHE compared to nurses as well as participants with formal education had 1.8 times greater odds of engaging in IDP and those affiliated with the Ministry of Health had significantly increased odds of IDP (3.6 times). As discussed earlier, limited formal oral health training reduces healthcare professionals' confidence in providing oral health education and screening in addition to factors such as organizational barriers and workload constraints (Park et al. ,2017). These findings highlight the need for curriculum reforms within medical and nursing colleges as well as a call for action for ministries of health to address structural and organizational barriers.

### Current Status on training and education

We found that of the surveyed healthcare professionals only 37.2% had attended oral health training. Less than half (48.6%) relied on formal education and 37.3% gained information from social media, while a quarter (25%) reported no previous knowledge of oral health. Although most healthcare professionals have favorable attitudes toward interdisciplinary practices, gaps remain in knowledge and training, which can hinder effective integration of oral health into primary care. Enhancing oral health training for healthcare providers through curricula adjustments and ongoing professional education may improve interprofessional collaboration and

patient referrals to dental care (Fallatah, 2016 and Park et al., 2017 and Bhagat et al., 2020 and Gill et al., 2022). There is a need for ongoing, structured professional development focused on oral health training for non-dental providers. To foster effective interdisciplinary practices, health ministries could create standardized oral health modules for all healthcare specialties, establish referral protocols, and promote routine screenings, which would support providers in recognizing and addressing oral health problems in primary care settings.

## 6.4 Nurses and their role in dentalcare: barriers and facilitators

### Knowledge on oral health

The study found that nurses in Saudi Arabia had average oral health knowledge, with a mean score of  $13.4 \pm 3.9$  (out of 25). Key areas of understanding included high awareness of dental caries prevention (92.2%), caries leading to tooth loss (84.8%), and periodontitis as a cause of tooth loss (80.2%). These findings are encouraging but also highlight a room for improvement when compared to global studies. The recognition that dental diseases and their consequences can be prevented, reflects basic understanding of oral health issues. Higher awareness scores were usually linked to structured education on oral-systemic connections, such as links between periodontal disease and diabetes (Kuo et al., 2008 and Hashim & Akbar, 2014 and Kapila, 2021). Although nurses in Saudi Arabia exhibit good knowledge in certain areas, such as caries prevention, but there are certain gaps especially about periodontal disease awareness. Similar findings were reported from Africa, as the majority of nurses demonstrated poor to moderate knowledge regarding oral health (Thema & Singh, 2013). However, the comparisons with global studies highlight the need for enhanced education and training, particularly in countries where oral health is not yet a significant focus in nursing curricula (Park et al., 2017). By adopting best practices from countries with integrated oral health education, Saudi Arabia can strengthen nurses' contributions to preventive dental care.

### Attitudes towards dental care

The study reveals favorable attitudes among nurses in Saudi Arabia toward their role in dental care, with a mean attitude score of  $52.8 \pm 8.2$  (out of 70). The highest agreement rates were for the impact of oral health on overall well-being (86.8%) and the ethical obligation to provide oral health education (70.9%). Positive attitudes were strongly associated with factors such attending oral health training, formal oral health education, and conducting oral health screenings. Formal education was a

strong predictor of positive attitudes, reflecting the importance of foundational knowledge. For instance, studies from Australia (Gibney et al., 2019) and Japan (Haresaku et al., 2018) showed that nurses exposed to oral health during their formal education were more likely to integrate oral health into their practice and advocate for its importance.

Engagement in oral health screenings was significantly linked to favorable attitudes, as practice fosters skills and confidence (Wu et al., 2020). In Finland, similar findings were noted, with nurses who performed screenings reporting greater motivation to promote oral health (Kivilahti et al., 2024). On the other hand, in countries with limited infrastructure, like South Africa, fewer opportunities for screenings were associated with lower interdisciplinary practices and attitudes (Thema & Singh, 2013).

Nurses' recognition of oral health impact on overall well-being (86.8%) and their ethical obligation to educate patients (70.9%) reflects a general awareness of oral-systemic health connections. Such recognition is essential as nurses are in frequent contact with patients enabling them to identify the early signs of oral diseases and provide timely education and referrals. By acknowledging their ethical responsibility, nurses can contribute significantly to preventive care and the promotion of healthy behaviors.

### Practices in dentalcare

About 70.3% of the nurses surveyed mentioned that they responded to patients' oral health questions, less than half (47.1%) conducted oral health screenings and even less than a quarter (19.7%) provided oral health education. Only half (50.7%) referred patients to dentists, with pain being the primary reason (37%). Again, as mentioned earlier these results reveal a reactive rather than initiative-taking approach to oral health, shaped by structural, educational, and cultural factors. Countries with national oral health programs, such as the U.K and the Netherlands, nurses are actively involved in school and community screening initiatives as part of public health strategies and policies mandating oral health assessments during general checkups (Uppal et al., 2019 and Niesten et al., 2021). Robust public health campaigns, such as the " Healthy Smile Happy Child " initiative provide resources and training, enabling nurses to take a more active role in oral health education (Macintosh et al., 2010).

The reported reactive reasons for referrals (mainly due to dental pain), are usually seen in countries with limited resources, where referrals are largely driven by treatment needs rather than preventive needs (Haresaku et al., 2020). In contrast, referral patterns in developed nations are for preventive reasons, reflecting a stronger focus on early intervention (George et al., 2019). Globally, barriers to referrals

include unclear referral pathways and inadequate communication between general healthcare providers and dental professionals (Horowitz et al., 2019 and Haresaku et al. 2020 and Al-Habib et al., 2022 and Wei et al., 2022). Implementing shared electronic health records can facilitate real-time information exchange and coordinated care (Vos et al., 2020b). Additionally, fostering interprofessional education and joint case discussions can build mutual understanding and streamline referral pathways, as well as enhancing patient outcomes through integrated services (Wei et al., 2022 and Alanazi et al., 2022).

### Training/Education and barriers to IDP

Nurses, often at the frontline of patient care, play a crucial role in promoting oral health. As highlighted earlier, nurses with formal oral health education or training are more likely to engage positively in dental care. Yet, barriers such as lack of time, heavy workload, and insufficient knowledge are commonly cited as obstacles (Wei et al., 2022). In the current study we found that only 42.2% nurses had attended oral health training or lectures and around half (49.1%) had formal oral health education. From the surveyed nurses (37.3%) reported time constraints as a barrier to participating in dental care. Furthermore, nearly half of the nurses surveyed expressed the belief that oral health education adds to their existing workload and should be compensated. These findings are in line with what was reported by Adib-Hajbaghery and colleagues (2013) who found that 60% of nurses who had not attended any oral care training reported that their skills needed improvement, suggesting a direct link between formal training and perceived competency (Adib-Hajbaghery et al., 2013). Similarly, a study from Ethiopia reported that nurses who had received training on oral care were significantly more likely to exhibit positive attitudes toward providing oral care compared to those who had not been trained and that having training on patient oral care was one of the key predictors of improved attitudes among nurses (Andargie & Kassahun, 2019). These findings collectively highlight the need for formal education in oral health, as well as the need for policies that acknowledge the additional responsibilities of nurses in primary care by providing incentives, such as financial compensation or reduced patient loads, to encourage participation in oral health (Adib-Hajbaghery et al., 2013 and Alanazi et al., 2022).

## 6.5 Impact of Interventions

Significant improvement was observed in knowledge; the mean OH knowledge scores increased from  $9.5 \pm 2.3$  pre-intervention to  $10.9 \pm 2.2$  post-intervention for both groups of the intervention ( $p < 0.0001$ ). This finding aligns with prior studies

highlighting the effectiveness of structured educational programs in improving healthcare professionals' knowledge. For example, Mohebbi et al. (2018) found that targeted oral health education interventions for primary care physicians led to significant improvements in knowledge scores (Mohebbi et al., 2018); reinforcing the idea that well-designed education programs can bridge gaps in OH knowledge. Hasanica and colleagues also proved the effectiveness of leaflets and posters in improving oral health literacy (Hasanica et al., 2020).

Video education led to greater improvement ( $20.3 \pm 3.6$ ) compared to brochures ( $18.4 \pm 4.2$ ). Audiovisual methods are more engaging and effective than traditional methods such as brochures (Knapp et al., 2022). Previous studies emphasized that videos enhance learning by reducing cognitive load, maximizing engagement, and promoting active learning (Brame, 2017 and Knapp et al., 2022). Videos also fit diverse learning styles, making them particularly impactful for younger healthcare providers and those with limited time.

Females reported significantly higher knowledge scores post-intervention (16.86 to 19.54) compared to males (17.05 to 19.59). The higher post-intervention scores in females compared to males are consistent with findings in health education literature, where female participants often exhibit greater engagement and therefore greater improvement in knowledge after training (Deeks et al., 2009 and Bogossian et al., 2023). Shimpi et al. (2016) also observed that female healthcare providers demonstrated better OH knowledge and attitudes than their male counterparts (Shimpi et al., 2016). This may be attributed to females' higher interest in preventive care and their active participation in learning activities (Deeks et al., 2009). While females exhibited higher scores, the significant improvement across both genders suggests that the educational content was overall effective. Future interventions could further explore whether gender-specific tailoring of content or delivery methods would enhance better outcomes.

On the other hand, physicians benefited more than nurses (19.76 vs. 19.30,  $p < 0.001$ ) from the intervention. The greater improvement among physicians reflects findings from other studies, such as Shimpi et al. (2016), which reported that physicians typically possess higher baseline OH knowledge due to formal medical education that often includes oral health topics (Rabiei et al., 2012). Moreover, physicians may encounter oral health issues more frequently in their practice, which could make the content of such interventions more immediately relevant. Despite significant improvement, nurses' relatively lower scores suggest the need for more tailored or extended interventions to address specific gaps in their OH knowledge. Previous research showed that targeted training programs for nurses can significantly enhance their ability to perform OH assessments and provide patient education (Mohebbi et al., 2018).

Belief scores remained unchanged (34.4 to 34.01,  $p=0.545$ ), though Saudi nationals and those affiliated to private sector showed a slight decline. Beliefs are often shaped by a combination of cognitive understanding and practical application (Knapp et al., 2022). Mohebbi and colleagues demonstrated that longer, hands-on interventions with follow-up assessments were more effective in improving both knowledge and attitudes (Mohebbi et al., 2018). The short duration of the current intervention may have limited participants' ability to fully appraise the importance of oral health care in their practice. This indicates a need for longer interventions or more different strategies to influence attitudes. Educational interventions that fail to emotionally engage participants or connect the content to their personal and professional experiences often have limited impact on beliefs. Research by Knapp et al. (2022) highlighted the importance of interactive and emotionally engaging educational tools, such as storytelling or real-life case studies, in changing attitudes (Knapp et al., 2022).

Willingness to provide oral health (OH) education increased from 44.6% to 55.4% post-intervention, as well as conducting OH screenings (44.6% to 55.4%). The observed increase in the willingness to provide OH education and conduct OH screenings is consistent with findings from similar studies where educational interventions improved healthcare professionals' readiness to engage in oral health-related practices (Mohebbi et al., 2018). The post-intervention increase in willingness (around 11%) is also comparable to results from other short-term interventions such as the one by Haber et al. (2020), where healthcare providers showed about 12–15% increase in oral health practices after receiving structured training but lower than multi-session or longitudinal studies, where an increase of 20–30% have been reported (e.g., Mohebbi et al., 2018). This improvement suggests that even short-term interventions can positively influence practice, though the magnitude of the change depends on the content and delivery mode. Longer-term studies (e.g., Shimpi et al., 2016) have shown that initial improvements in willingness often require reinforcement to sustain over time. Without follow-up interventions, the improvements observed in the current study may plateau or diminish. Knowledge gain is a critical driver for willingness to perform OH-related tasks, knowledge improvements would have enhanced participants' confidence, motivating them to provide education and screenings. Comparable results were reported in studies by Shimpi et al. (2016) and Wu et al. (2020), where healthcare providers with higher knowledge scores were more likely to perform OH-related practices. In the current study, private-sector participants showed lower belief scores, which could influence their uptake of OH practices despite knowledge gains. Rabiei et al. (2012) noted that organizational support, such as policies and resources for OH care, plays a crucial role in sustaining behavior change. Private healthcare settings

often lack such organizational support, which might explain the observed lower engagement in dental care (Barraclough et al., 2021).

### Factors associated with better outcomes after the intervention

The findings on factors associated with better outcomes post-intervention offer valuable insights into how demographic and professional variables influence knowledge acquisition. Being male, Saudi, working in academia, and having over 10 years of experience were predictors of good post-intervention knowledge. While our study identified males as having better outcomes, many previous studies suggest females often perform better in health-related education, citing higher engagement and interest in preventive care. For instance, Shimpi et al. (2016) observed higher baseline knowledge and learning outcomes among female healthcare providers in oral health training programs. However, the greater improvement among males in our study could stem from cultural or contextual factors in Saudi Arabia, where male healthcare professionals may have more access to training opportunities or leadership roles that emphasize continued education.

Saudi participants showed significantly better knowledge improvement. This aligns with findings from studies like Rabiei et al. (2012), which showed that local participants often benefit more from culturally tailored educational interventions. In our study, the content was aligned with local healthcare practices, making it more relatable and effective for Saudi participants. On the opposite, non-Saudi participants may face barriers like less familiarity with local healthcare systems, or fewer opportunities for professional development in the region. Cultural relevance, as highlighted in our study, has been consistently shown to enhance learning outcomes. For example, tailored interventions in Saudi Arabia have previously demonstrated greater impact on local participants compared to expatriates (Shimpi et al., 2016). To maximize the benefits of such interventions and future studies can investigate specific barriers faced by expatriates and private-sector workers to develop tailored strategies for expats and those in the private sector.

Participants working in academia were more likely to gain better good knowledge post-intervention. Academic professionals often have greater exposure to educational resources and a stronger emphasis on evidence-based practices. Studies like Mohebbi et al. (2018) have highlighted that healthcare professionals in academic institutions are more receptive to educational interventions due to their routine involvement in training and research. Academic environments usually foster a culture of learning and openness to new knowledge, further enhancing the impact of educational programs. Working in academia often correlates with better educational outcomes, as academic professionals are more accustomed to engaging with structured training, a finding also reported by Mohebbi et al. (2018).

Having more years of experience was a significant predictor of better knowledge outcomes. This finding contrasts with some studies suggesting that less experienced professionals are more adaptable and open to added information (e.g., Wu et al., 2020). However, more experienced professionals may benefit from their baseline knowledge, allowing them to integrate added information more effectively (Oyetola et al., 2016). Additionally, experienced professionals might be more motivated to update their knowledge to maintain competence (Oyetola et al., 2016). The controversial findings on the relationship between experience and knowledge gain open the eyes that oral health educational interventions cannot be a “one size that fits all” but rather tailored to individuals based on formal education and years in practice.

### Participant perception

The majority (83%) found both materials were clear and helpful, with the video being rated more effective for knowledge improvement than brochures. For instance, Knapp et al. (2022) reported that healthcare providers preferred materials that were simple, concise, and directly applicable to their practice. Effective educational tools are often characterized by user-friendly formats and culturally relevant examples, which contributed to the positive reception of the materials used in the current study. Knapp (2022) and Mohebbi et al. (2018) both reported that video-based education is superior in enhancing knowledge retention due to its ability to engage multiple senses and present dynamic, visual content. Videos can simplify complex topics through animations, demonstrations, and storytelling, making them more impactful than static materials like brochures. Studies such as those by Bashirian et al. (2023) have shown that video education improves engagement and comprehension, particularly among younger professionals or those with diverse learning preferences.

In contrast, brochures, while informative, often fail to hold attention and may be less engaging for learners who prefer interactive or audiovisual formats. Studies by Knapp et al. (2022) suggest that audiovisual materials are particularly effective for complex or skill-based topics, as they offer step-by-step demonstrations that text cannot convey. On the other hand, brochures appeal to learners who prefer reading at their own pace and revisiting information as needed. Hasanica et al. (2020) observed that brochures are still valued by some professionals, particularly those with traditional learning styles or time constraints.

Given its demonstrated effectiveness, video-based education should be prioritized in oral health training programs, particularly for topics requiring visualization or step-by-step guidance. Combining videos with supplementary materials like brochures or interactive modules could accommodate diverse learning preferences and reinforce key messages (Bashatah et al., 2020). Ensuring that videos

are professionally designed, engaging, and culturally relevant will further enhance their impact (Knapp, 2022).

Efforts to educate healthcare providers about oral health not only improve their ability to identify early symptoms of dental diseases but also empower them with confidence that they can improve IDP practices (Mohebbi et al., 2018 and Bonabi et al., 2019 and Wu et al., 2020 and Huang et al., 2022 and Knapp et al., 2022 and Lindmark et al., 2024). Although knowledge and willing improved, the study does not provide substantial evidence of actual behavioral changes in clinical practice over time. The immediate post-intervention assessment may not capture long-term retention of knowledge or sustained changes in beliefs and practices. Implementing multi-session interventions delivered over time could allow participants to reflect, apply, and appraise the educational content, leading to a more profound shift in beliefs.

### Strengths and limitations

*Phase I* offers a valuable and unique global mapping of national oral health policies, with a specific focus on young children, providing foundational insight for policymakers, researchers, and international bodies. One of its key strengths lies in its wide geographic representation and use of a rigorously developed and expert-reviewed questionnaire, which enhances the validity of the data collected. Additionally, the integration of open-ended responses allowed for richer contextual understanding across diverse health systems. However, several limitations must be acknowledged in this phase. The overall country-level response rate was modest (38%), potentially limiting the generalizability of the findings. Some countries with active oral health programs may have been underrepresented due to language barriers or decentralized healthcare systems that were not fully captured by national-level informants. Furthermore, policy updates occurring during or after the data collection period may have not be reflected in the analysis.

The significant strength of this thesis lies within its comprehensive and multifaceted approach in exploring interdisciplinary oral health practices among healthcare professionals in Saudi Arabia. By integrating three distinct II-IV studies (each employing robust methodologies such as cross-sectional surveys, pre-post interventional designs, and validated questionnaires) the research provides a holistic understanding of the gaps and opportunities in oral health collaboration. Additional strengths can be relied on to the large sample size, diverse participant pools (physicians, nurses, pediatricians, ENT specialists), and rigorous statistical analysis ensuring generalizability and reliability. Additionally, the emphasis on practical implications, such as policy recommendations for curriculum enhancements and interprofessional training, strengthens its contribution to both academic and clinical

settings. Collectively, this work advances the discourse on integrated care and offers actionable insights to bridge the oral-systemic health divide in Saudi Arabia and beyond.

However certain limitations related to the study design and data collection methods should be acknowledged. First, the reliance on self-reported data in all three studies introduces potential biases, such as social desirability bias and recall bias, particularly in assessing knowledge, attitudes, and practices. Second, the cross-sectional design of two studies (II and III) limits causal inferences, as it only captures a snapshot of participants' perspectives at a single point in time. The intervention study (IV), though innovative, had a short follow-up period, preventing an assessment of long-term knowledge retention or behavioral changes among healthcare providers. Additionally, the use of snowball sampling may have resulted in selection bias, as participants with stronger opinions or prior interest in oral health might have been overrepresented. The closed ended question-type survey used in study II–IV might have limited the ability to detect other gaps in knowledge and more in-depth analysis of barriers to interdisciplinary practices. The studies were primarily conducted in Eastern Saudi Arabia, which may limit generalizability to other regions with differing healthcare infrastructures or cultural characteristics. Finally, while the intervention demonstrated improvements in knowledge, its impact on actual clinical practices and patient outcomes remains unexplored. Future research could address these gaps by incorporating longitudinal designs, objective clinical measures, and broader geographic sampling to strengthen the validity and applicability of the findings.

The primary outcomes across studies II-IV were 1) knowledge (e.g., understanding of dental caries, gingivitis, periodontitis), 2) attitudes/beliefs (e.g., willingness to provide oral health education, perceived barriers) and 3) practices (e.g., conducting oral screenings, referrals to dentists). While knowledge and attitudes were well-measured, actual clinical practices (e.g., frequency of referrals, patient outcomes) were not objectively verified, and relied instead on self-reported data. Future studies could incorporate clinical audits or electronic health record (EHR) data to validate the reported behaviors.

Key explanatory variables in studies (II -IV) were 1) demographics (age, gender, nationality, specialty), 2) professional factors (years of experience, workplace setting) and 3) educational exposure (formal training, attendance at oral health workshops). These variables effectively explained variations in outcomes, but contextual factors (e.g., institutional policies, workload constraints) were not deeply explored. Qualitative interviews or mixed-methods approaches could provide richer insights into why certain groups (e.g., pediatricians, experienced professionals) showed better practices.

While trends (e.g., gaps in knowledge, differences between specialties) are valid, absolute rates (e.g., "74% always provide oral health education") may be inflated. Correlational insights are still useful but claims about educational interventions improving care should be interpreted as preliminary evidence rather than definitive proof and although proven effective for short-term learning, but sustainability is unconfirmed. Policies based on these findings may need reinforcement strategies. Overall, the findings are trustworthy for informing policy and education, but not definitive for behavior change without further validation.

## 7 Summary/Conclusions

Europe and Asia are prominent regions in implementing policies promoting oral hygiene, sugar reduction, and access to dental care. Specifically, Europe leads in policies related to sugar reduction, oral hygiene measures, fluoride provision, and early dental visits, while Asia leads in professional collaboration and coordination with medical providers. Africa, North America, and Oceania also demonstrate significant engagement in oral health policy implementation, but to a lesser extent compared to Europe and Asia.

The findings highlight critical factors influencing healthcare providers' knowledge, attitudes, and practices, including the impact of formal education, continuous training, and institutional policies. Notably, the intervention study reveals the effectiveness of video-based education in improving oral health knowledge, while the nurse-focused research underscores the importance of integrating oral health into nursing curricula.

Interprofessional and interdisciplinary practices are emerging as essential components in national oral health policies, with many countries recognizing the need for broader healthcare collaboration to address oral health needs. However, there is considerable variability in the extent of these practices, with Europe and North America showing more developed integration efforts compared to other regions. Strengthening interprofessional engagement remains a key area for global improvement to ensure comprehensive and effective oral health strategies.

The studies suggest that supportive policies alone are insufficient without practical frameworks that facilitate implementation especially at the primary care level and that training and formal education significantly influenced interdisciplinary practices, emphasizing the need for integrating oral health into formal education and continuous professional development.

### Relevance and implementation of the findings

This thesis holds significant relevance for both national and international stakeholders in healthcare policy, education, and clinical practice. In Saudi Arabia, the findings provide actionable insights for policymakers to integrate oral health into medical and nursing curricula, as well as for hospital administrators to implement

standardized oral health screening and referral protocols. Medical educators can utilize the demonstrated effectiveness of video-based training to enhance interprofessional education, while healthcare providers specifically physicians and nurses can apply these insights to improve patient counseling and early detection.

Globally, the studies offer a scalable model for low-resource settings where dental care access is limited, suggesting that non-dental healthcare workers can be trained to deliver basic oral health education and referrals. International organizations, such as the WHO and FDI, may use these findings to advocate for oral health integration in primary care settings. The research also sets a foundation for comparative studies in other regions to examine the effect of cultural and structural barriers on interdisciplinary collaboration. Future studies should include piloting hospital-based oral health programs in Saudi Arabia and adapting the intervention framework for diverse healthcare systems worldwide.

## Recommendations

The findings of the global survey highlight the urgent need for more inclusive and comprehensive national oral health policies, particularly those that prioritize early childhood oral health. It is recommended that countries develop or update their national oral health frameworks to ensure that preventive and restorative oral health services are integrated into general health systems and universal health coverage (UHC). Special attention should be given to vulnerable groups such as infants, preschool-aged children, and socially disadvantaged populations. Policymakers are encouraged to adopt evidence-based strategies including prenatal oral health education, early dental visits, sugar reduction measures, and collaboration with primary healthcare providers. Regional and international bodies, such as the FDI and IAPD, should support capacity building efforts and promote policy coordination to address global disparities in child oral health outcomes.

The integration of oral health into medical and nursing curricula is essential to address the current gaps in knowledge among healthcare professionals. Foundational oral health modules should be incorporated into undergraduate programs, covering common oral diseases, their systemic connections, and preventive strategies. Additionally, accredited continuing education programs should be developed to reinforce these concepts, ensuring that physicians, nurses, and other healthcare providers remain updated on best practices in oral health care. These programs should be mandatory and regularly revised to reflect the latest evidence-based guidelines.

Standardized training programs, particularly video-based interventions, have demonstrated effectiveness in improving oral health knowledge and practices among healthcare professionals. These should be prioritized as a flexible and scalable

method for delivering education, supplemented by hands-on workshops to build practical skills in oral health screening and patient counseling. Practical training sessions can enhance confidence, particularly among nurses and physicians, who play a crucial role in early detection and prevention of oral diseases.

Policy and institutional support are essential to overcoming barriers such as time constraints and lack of resources. Clear referral protocols should be established to facilitate continuous collaboration between medical and dental professionals, supported by electronic systems for efficient patient management. Workplace policies must also be revised to allocate dedicated time for oral health activities, ensuring that healthcare providers can incorporate screenings and education into routine patient care without being overwhelmed by overlapped responsibilities. It is also recommended that healthcare professionals involved in oral healthcare care be provided with incentives (morally or monetary) to encourage further participation.

There is a need for public health initiatives that focus on raising awareness about the link between oral and systemic health. National campaigns targeting both healthcare professionals and the public can help in highlighting the importance of oral health and its impact on general health.

Finally, further research is needed to evaluate the long-term impact of these interventions on healthcare practices and patient health. Longitudinal studies can assess sustained improvements in knowledge and behavior, while contextual research can identify regional variations in oral healthcare challenges. By addressing these areas, healthcare systems can move toward a more integrated approach, ensuring that oral health is recognized as a fundamental component of overall well-being.

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# Appendices

**Appendix 1. Global policy survey (study I).**



**Appendix 2. KAP Healthcare professional survey (study II - IV)**





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