EFFECTIVENESS OF ORAL HEALTH EDUCATION PROGRAMS ON KNOWLEDGE, ATTITUDE, PRACTICES TOWARDS ORAL HEALTH, DIETARY HABITS AND ORAL HEALTH-RELATED QUALITY OF LIFE AMONG UNIVERSITY STUDENTS IN LIBYA

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Submitted in Fulfilment of the Requirements for the Doctor of Philosophy (By Research) in Biomedicine

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ABSTRACT

The purpose of this study is to determine the level of knowledge, attitudes, practices (KAP)and health related quality of life of university students in Misurata, Libya, as well as the prevalence of dental caries and their perception toward oral health education. The study also evaluates the effectiveness of oral health educational program on student's KAP, and health-related quality of life (OHRQoL). The research instrument for measuring all research variables were adapted and piloted before using in main study. In phase 1, a cross-sectional study was conducted to assess the level of level of knowledge, attitudes, and practices among students and the questionnaire was distributed via random sampling to 402 students from different faculties. In phase2, based on findings of phase 1 and literature, an oral health educational program was developed and validated. Phase 3 consisted of conducting a quasi-experimental design including two arms with a sample size of n=120 for each arm (control and intervention). Data were analysed using descriptive study (Phase 1) and generalised estimation equation (Phase 2) using SPSS Ver 29. Results of Phase 1 showed that the prevalence of dental caries among university students in Misurata was 25%. Phase 1 measured the factors using survey questionnaires. Results showed low oral health knowledge and attitude, but gaps in knowledge about fluoride and sweets. At the most frequent routine check-up, 40.8% of subjects had dental caries and sought treatment rarely. The sociodemographic characteristics of the participants showed gender distribution that was relatively equal and age group representation that showed oral health behaviour patterns like high sweet consumption and low dental inspections. These findings also suggest tailored educational interventions to improve students' oral health knowledge and practices. Phase 3 tested this educational intervention's efficacy using GEE. Participants' knowledge, attitude, and practices improved significantly post-intervention, with large effect sizes ($p<0.05$). Additionally, improved oral health-related quality of life scores had a moderate effect ($p<0.05$). Our findings show that targeted education can improve oral health habits and quality of life ($p<0.05$). The outcomes of this research study will be beneficial for educational institutions and public health organisations in Misurata, Libya, as they seek to improve their awareness of oral health issues among university students. The study emphasises the importance of focused oral health education programs in improving students' knowledge, practices, and dietary habits, which can lead to better oral health outcomes and overall quality of life. Policymakers should take note of the study's implications for the effectiveness of oral health education and explore policies that encourage the introduction of regular educational programs at universities.

Keywords: dental caries, oral health education, university students, Misurata, Libya, health-related quality of life (OHRQoL), oral hygiene practices

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LIST OF ABBREVIATIONS

Abbreviation	
CG	Control Group
CVD	Cardiovascular Diseases
CVI	Content Validity Index
DMFT	Decayed, Missing, and Filled Teeth
DP	Decayed Portion
ECC	Early Childhood Caries
EG	Experimental Group
GEE	Generalised Estimating Equation
HBM	Health Belief Model
ICC	Intracluster Correlation Coefficient
KAP	knowledge, attitudes, Practices
OHE	Oral Health Education
OHEP	Oral Health Education Program
OHIP	Oral Health Impact Profile
OHRQoL	Oral Health Related Quality of Life
SDG 3	Sustainable Development Goal 3
SDGs	Sustainable Development Goals
SDF	Silver Diamine Fluoride
SES	Socioeconomic Status
TPB	Theory of Planned Behaviour
WHO	World Health Organisation

CHAPTER I

INTRODUCTION

1.1 Introduction

Oral health is an important aspect of health and quality of life. Adequate oral hygiene habits (e.g., brushing twice daily, flossing, regular dental appointments) must be performed correctly to robustly prevent dental caries, periodontal diseases, and other adverse effects in oral health (World Health Organisation [WHO], 2023). It is understood that oral hygiene will benefit individuals, yet in the literature, the oral health behaviours of university students are less than ideal, this may be due to ignorance of their role in oral health, the lack of education promoting personal oral health, and the limitations to access to preventive services (Alshahrani *et al.*, 2021). This is no different in Libya; the use of oral health education is largely untapped but has strong associations to the rates of oral diseases visit yet, high rates of avoidable oral diseases persist in young adults in Libya (Al-Tajouri, 2022).

There is considerable evidence of the impact, or lack thereof, of the conventional models of oral health education delivered in the past either in the largest form through a classroom style lecture, or the smallest form using printed materials. The research conducted has shown that while classroom lectures and printed materials have demonstrated short- term change in knowledge through pre- and post-testing, they included limited interaction opportunities for students as well as limited behaviour- driven reinforcement components (Jürgensen & Petersen, 2013). These traditional oral health education strategies, through digital learning introduction, gamification strategies, and having peer-led oral health education programs must be developed and available for university students to achieve a more meaningful oral health education program that is exciting, meaningful, and behaviour-driven in their learning.

The purpose of this study is to evaluate the level of knowledge, attitudes, practices (KAP) and health related quality of life of university students in Misurata, Libya, to evaluate the prevalence of dental caries and their perception towards oral health education. This study will assess the impact of an oral health educational program on student's KAP, and health-related quality of life (OHRQoL). The study outcomes will be fundamental in supporting the efforts related to public health, and informing public health policy, as well as to develop and maintain lasting oral health promotion programs in Libya. In addition, the present study supports the UN Sustainable Development Goals (SDGs) with particular reference to SDG 3 (good health and well-being) promoting preventative healthcare; consequently, minimising the burden of oral diseases.

1.2 Background of the Study

Dental caries, also known as tooth decay, is one of the most common chronic diseases around the world that afflicts people of all ages. Based on the World Health Organisation (WHO, 2023), over 2.3 billion people worldwide had untreated dental caries with the highest disease burden among adolescents and young adults. The main contributors to dental caries development are oral bacteria (i.e. Streptococcus mutans), and fermentable carbohydrates, followed by the demineralisation of tooth enamel (Fejerskov & Kidd, 2020). If untreated, dental caries can lead to severe pain, an infection, and complete loss of tooth structure which severely affects an individual's ability to eat, speak, and self-esteem (Sischo & Broder, 2020).

Many developing nations, such as Libya, dental caries is still a public health problem. Studies show adolescent populations are at higher risk for the rising prevalence of caries due to their ability to obtain sugar-rich food and drinks, poor oral hygiene practices, and lack of awareness of preventive dental care and lack of access to dental services (Alraqiq *et al.*, 2021). Additionally, fluoride exposure positively affects oral health outcomes in North African Countries while excessive sugar consumed has worsened oral health (Abdelaziz *et al.*, 2023). Socioeconomic status (SES) also attributes to oral health in practice as individuals from lower-SES groups access fewer preventive care options and professional dental treatment (Knorst *et al.*, 2021).

While there have been improvements in dental healthcare service in Libya, there is still a gap in research exploring education programs and or education/effectiveness in reducing dental caries in university students (Al-Tajouri, 2022). This population remains understudied despite their unique dietary behaviors and transitional lifestyle factors that influence oral health outcomes.

Oral health education has been hailed as a primary intervention for the prevention of dental caries by encouraging good oral health behaviours and increasing awareness of preventive dental care. Recent studies have indicated that educational interventions with a structure had the potential to significantly increase an individuals' knowledge, attitudes, and practices related to oral health and subsequently their oral health (Abdella-Aslan *et al.*, 2021; Urwannachotima *et al*., 2019). Typical oral health education programs are characterised by instruction regarding proper brushing and flossing, increased knowledge of fluoride and its benefits, a dietary overview of caries prevention strategies, and information about regular dental visits (Abdalla *et al.*, 2023; Abe *et al.*, 2023). School and also university interventions have demonstrated effective results with regards to knowledge and behaviour change in oral hygiene interventions. As a case in point, Urwannachotima *et al.* (2019), conducted a longitudinal study in Thailand that found oral health education implemented into the school curriculum, over 5 years, was effective in significantly decreasing prevalence of dental caries. Similarly, structured oral health programs in Egypt (Abbass *et al.*, 2019) and Saudi Arabia (Abdellatif & Hebbal, 2020), improved oral hygiene awareness and reduced sugar intake, as well as reduced dental caries amongst students.

In addition to increased oral health knowledge and improved behaviour s, educational interventions have been shown to increase oral-health related quality of life (OHRQoL). Oral health is commonly associated with overall well-being, self-confidence, and ability or capacity to engage socially and professionally. In fact, studies have shown that poor oral health results in pain, difficulties eating, social embarrassment, and deterioration in self-esteem (Antunes *et al.*, 2020; Oliveira & de Andrade, 2020). OHRQoL has become an important construct used to measure the impact of oral health on everyday life. In their research on oral health and well-being, Broomhead and Baker (2023), measured OHRQoL and found individuals who had

untreated dental conditions reported higher levels of stress, were socially anxious, and reported difficult utilization of social and professional interactions.

Abdella-Aslan *et al.* (2021) also suggested that structured oral health interventions benefitted patients with dental conditions with regards to OHRQoL. In Brazil, Gonzales-Sullcahuamán *et al.* (2013) conducted a study where they evaluated an oral health campaign and not only reduced dental caries prevalence in the adolescent population, but they also improved self-confidence and social engagement. While there is growing evidence to suggest that oral health education and consciousness with respect to OHRQoL is important, there is little research related to how educational interventions contribute to university students' OHRQoL in Libya. Thus, this is an urgent area that has not been investigated systematically.

With the increasing concern about the incidence of dental caries, greater impacts of poor oral health continue to interfere with student health, development, and overall well-being; therefore, demonstrates the need for enhanced oral health education in Libya. In this respect, this study will assess the impact of an oral health educational program on the knowledge, attitudes, practices, and OHRQoL of university students in Misurata, Libya. The findings of this study will highlight identified gaps in oral health knowledge, changes in oral hygiene behaviours as a result of the educational program, and recommendations for dental educators and policy making about oral health education initiatives in Libya. By understanding the ways education contributes to oral health behaviours, we will have much more needed research evidence gathered about the future of policymakers, educators, and health care practitioners about to implement future interventions focused on improving oral health in Libya by specifically targeted, culturally appropriate means.

1.3 Problem Statement

Oral health is an important aspect of general health, but dental caries continues to be a pervasive public health issue, particularly among students in universities in Libya. Despite advances in global preventive dentistry, research suggests that oral health education programs in Libya are not current, relevant, or effective in changing students' oral hygiene behaviours (Abdelaziz *et al.*, 2023; Alraqiq *et al.*, 2021). The rates of dental caries among young adults in North Africa are

alarming, which are ultimately exacerbated by poor oral hygiene, increased consumption of high sugar foods and drinks, as well as a lack of organised oral health education programs (Abdella-Aslan *et al.*, 2021). Oral health education is well-established as an effective way of preventing dental disease, but current oral health education programs in Libya lack strong consideration of behavioural, engagement, and long-term sustainability (Broomhead & Baker, 2023). The goal of this study is to develop a structured, evidence-based oral health education program to support the oral health needs of students at university in Misurata, Libya.

Existing oral health education programs, both globally and in Libya, primarily focus on conveying theoretical knowledge rather than fostering long-term behavioural change. Studies have shown that traditional oral health campaigns, such as pamphlets, posters, and occasional lectures, have minimal impact on students' oral hygiene practices (Gunpinar & Meraci, 2022; Urwannachotima *et al.*, 2019). Furthermore, most existing programs lack interactive components, student engagement strategies, and culturally relevant content that resonate with young adults (Abe *et al.*, 2023). Research from developing countries suggests that effective oral health programs must incorporate digital learning tools, behaviour modification models, and peer-led interventions to achieve meaningful outcomes (Brennan *et al.*, 2022). However, Libyan universities have not yet adopted such innovative strategies, leaving a critical gap in preventive oral health education (Al-Tajouri, 2022).

Another major limitation of current programs is the absence of systematic impact assessments. Effective public health interventions should include follow-up evaluations to measure knowledge retention, behaviour change, and long-term oral health outcomes (Abdelaziz *et al.*, 2023). Studies indicate that behavioural interventions combined with periodic assessments are significantly more effective in preventing dental diseases than one-time educational sessions (Knorst *et al.*, 2021). In Libya, however, oral health campaigns rarely implement post-intervention assessments, making it difficult to determine their effectiveness and sustainability (Almerich-Torres *et al.*, 2017). This highlights the urgent need for a new evidence-based oral health education program that integrates interactive learning, behaviour change theories, and systematic evaluations to ensure long-term effectiveness.

Poor oral health has been directly linked to negative social, psychological, and academic outcomes among university students. Studies have shown that dental problems such as caries and gum disease can lead to pain, speech difficulties, and reduced self-confidence, ultimately affecting students' ability to perform well in academic and social settings (Broomhead & Baker, 2023; Oliveira & de Andrade, 2020). The Oral Health-Related Quality of Life (OHRQoL) framework has become an essential tool in evaluating how oral health affects daily life, with research indicating that students with poor oral hygiene report higher levels of stress, social anxiety, and difficulty in professional interactions (Antunes *et al.*, 2020).

Although there is such evidence, little research has been conducted to study oral health education programs and their effectiveness in enhancing oral health-related quality of life (OHRQoL) of university students in Libya. Research on similar subjects has been conducted in other developing countries; the studies demonstrated structured oral health interventions led to significant changes in oral health behaviours of participants which ultimately led to improvements in OHRQoL (Brennan *et al.*, 2022). However, there is limited literature on Libyan university students so understand their specific lifestyle and oral health issues is important and justified.

Considering that dental caries is highly prevalent among university students in Libya, and that current oral health education programs have not led to desirable changes in oral health behaviours of university student populations, now is the time to create a coordinated oral health intervention that is engaging, behaviour change focused, and culturally appropriate. This research will identify the limitations of current oral health education programs in Libya in terms of content, engagement strategies and long-term effectiveness. In turn, this research will develop an oral health education intervention specifically for university students in Misurata; this intervention will incorporate innovative learning activities and behaviour change models. The study will also assess the effectiveness of the oral health intervention with regard to improving students' oral health knowledge, attitudes towards oral health, oral health practices, and their OHRQoL, using pre- and post-intervention health assessments. Therefore, the problem confronting Libyan public health is severe and multifactorial: it is the problem of a high-prevalence disease fuelled by ineffective

education; it is the problem of pedagogical models stuck in the past while the target demographic lives in a digital present; it is the problem of health initiatives operating in an evaluative vacuum; and it is the problem of a preventable condition silently degrading the quality of life and future prospects of a nation's youth.

This is not a simple gap in the literature but a compound failure of health promotion systems. This study is conceived as a direct and comprehensive response to this complex problem. It aims to break the established cycle by developing an oral health education programme that is theoretically grounded in behavioural science, pedagogically engaging through interactive and digital means, rigorously evaluated using a controlled longitudinal design, and explicitly targeted at improving both clinical behaviours and the holistic OHRQoL of university students in Misurata, Libya. The ultimate goal is to generate not just data, but a replicable model for effective, sustainable, and student-centred health promotion that can begin to rectify this longstanding systemic failure.

1.4 Research Questions

Phase 1: Current situation assessment

(a) What is the level of knowledge, attitudes, and practices (KAP) regarding oral health among university students in Misurata?

(b) What is the prevalence of dental caries among university students in Misurata?

(c) What is the student's perception regarding oral health education among university students in Misurata?

(d) Is there any significant relationship between knowledge, attitude and practice with oral health related quality of life among university students in Misurata?

Phase 2: improvement of a New Oral Health Education Program

(e) How is an oral health education program that addresses the specific needs of university students in Misurata developed?

Phase 3: Implementation and assessment of the new program

(f) What is the difference of an oral health education program to improving the KAP of oral health between the control and intervention group among university students in Misurata?

(g) What is the difference of an oral health education program to increase the OHRQoL and dietary habits between the control and intervention group among university students in Misurata?

1.5 Research Objectives

The following section will touch on the research objectives.

1.5.1 General Objective

To determine the effectiveness of Oral Health Education Program on knowledge, attitude, practices, dental caries dietary habits and Quality of Life among 18-21 years old university students in Misurata, Libya.

1.5.2 Specific Objectives

(a) To implement an oral health education program aimed at improving knowledge, attitude, and practice (KAP) regarding oral health among university students in Misurata., Libya.

(b) To identify the prevalence of dental decay among university students in Misurata, Libya.

(c) To evaluate students' perception regarding oral health education at the baseline among university students in Misurata.

(d) To evaluate the relationship between knowledge, attitude and practice with oral health related quality of life among university students in Misurata.

(e) To determine the effectiveness of oral health education program for knowledge, attitude and practice (KAP) regarding oral health between control

(f) To examine the effectiveness of oral health education program on oral health-related quality of life (OHRQoL) and dietary habits between the

control group and the intervention group among university students in Misurata.

1.6 Research Hypothesis

Therefore, this research proposes the following hypotheses:

(a) There is a high prevalence of dental decay (caries) among university students in Misurata, Libya.

(b) There is a significant and positive relationship between knowledge, attitude and practice with oral health related quality of life among university students in Misurata.

(c) Oral health education program has significant impact on oral hygiene knowledge, attitude, and practices among university students in Misurata.

(d) Oral health education programs have significant impact on dietary habits and oral health-related quality of life among university students in Misurata.

1.7 Framework of the Study

This The framework of the present study provides a conceptual structure that explains the relationships among the key variables and guides the design, implementation, and evaluation of the research. As illustrated in Figure 1.1, the framework integrates baseline determinants of oral health with an educational intervention and its expected outcomes among university students in Misurata, Libya.

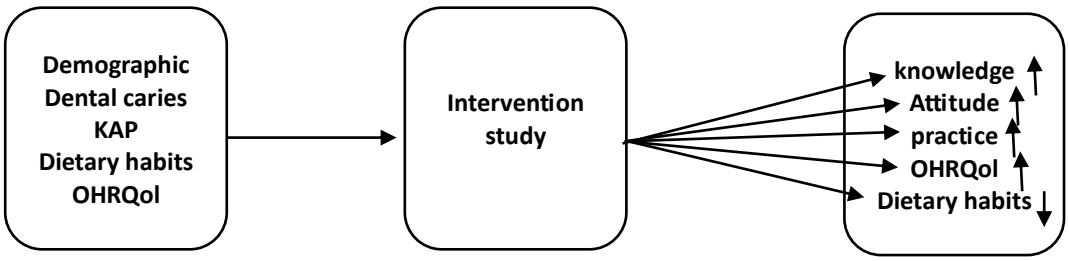
At the input stage, the framework begins with students' demographic characteristics (such as age, gender, and field of study) and baseline oral health conditions, including dental caries status, knowledge, attitudes, and practices (KAP), dietary habits, and oral health-related quality of life (OHRQoL). These factors represent the existing oral health situation and serve as the foundation for understanding students' needs. Consistent with the Knowledge–Attitude–Practice (KAP) model, knowledge influences attitudes, which in turn shape practices, while dietary habits and oral disease status directly affect perceived quality of life.

The intervention component constitutes the central mechanism of change in the framework. The oral health education program was developed based on findings from Phase 1 (baseline assessment) and informed by established health behaviour theories, particularly the Health Belief Model (HBM). The intervention addresses key HBM constructs—such as perceived susceptibility to dental caries, perceived severity of oral diseases, perceived benefits of preventive behaviours, perceived barriers, self-efficacy, and cues to action through structured educational content, demonstrations, and behaviour change strategies. By targeting these constructs, the intervention aims to bridge the gap between knowledge and actual oral health behaviours.

At the output stage, the framework posits that exposure to the oral health education intervention leads to measurable improvements in key outcomes. Specifically, the intervention is expected to result in increased knowledge, more positive attitudes, and improved oral health practices, alongside healthier dietary habits (particularly reduced consumption of sugary foods and beverages). Collectively, these behavioural changes are hypothesised to contribute to an improvement in oral health-related quality of life (OHRQoL) and, in the longer term, a reduction in the risk of dental caries.

Overall, this framework reflects a phase-based and outcome-oriented approach, linking baseline assessment (Phase 1), intervention development (Phase 2), and intervention evaluation (Phase 3). It provides a clear logical pathway for examining how an oral health education program can influence behavioural, clinical, and quality-of-life outcomes among university students, while also aligning closely with the research objectives, research questions, and hypotheses of the study.

Figure 1.1: Research Framework



1.8 Significance of the Study

This study holds significant and multifaceted value, advancing the field of oral health education and contributing tangibly to preventive dental care among university students in Misurata, Libya. Its primary contribution lies in addressing a critical public health gap: the persistent high burden of dental caries within a vulnerable yet pivotal demographic in a developing nation. By developing and empirically evaluating an interactive, evidence-based educational programme that integrates established behaviour change models with contemporary digital learning methods, this research directly confronts the inadequacy of traditional, knowledge-centric oral health campaigns. The findings are poised to fill a substantial void in the scientific literature, providing novel insights into the design and delivery of effective health promotion in low-resource, post-secondary educational settings. Furthermore, the study generates robust, locally relevant evidence that can inform national health policy and institutional practice, thereby aligning scientific inquiry with urgent practical needs.

Significantly, this research is strategically aligned with major global health and development frameworks. It makes a direct and meaningful contribution to the United Nations Sustainable Development Goals (SDGs). In relation to SDG 3 (Good Health and Well-being), the study promotes universal health coverage (Target 3.8) by advocating for and modelling accessible, preventive oral healthcare education—a service currently lacking for many Libyan students. By aiming to reduce the incidence of dental disease, it also supports targets for reducing mortality from non-communicable diseases and promoting mental health and well-being, given the established links between poor oral health and conditions like diabetes, cardiovascular disease, anxiety, and depression. Concurrently, the study advances SDG 4 (Quality Education) by exemplifying how health literacy can be effectively integrated into higher education through inclusive, equitable, and innovative pedagogical strategies. By moving beyond didactic teaching to employ interactive, experiential, and digitally-enhanced learning grounded in behavioural science, it provides a replicable model for transforming health education into a catalyst for sustainable habit formation, thereby equipping students with lifelong skills for self-care.

At the organisational level, this investigation supports the strategic objectives of the World Health Organisation's (WHO) Global Oral Health Action Plan 2023–2030. It operationalises the plan's core tenets by developing a prevention-focused intervention, integrating oral health into a primary educational setting (the university campus), and utilising a community-oriented approach to health promotion. For Libya, a nation facing challenges typical of low- and middle-income countries in implementing systematic, evidence-based health education, this research provides a timely and critical evidence base. It addresses the disconnect between high disease prevalence and limited preventive knowledge by generating data that can guide the Libyan Ministry of Health and educational authorities in designing targeted, effective oral health promotion strategies for a previously underrepresented population—university students.

The implications of this research extend across multiple stakeholder groups, ensuring its relevance and practical impact. For policymakers, the study will yield an evidence-based framework to guide the development, funding, and scaling of structured oral health initiatives within national higher education and public health strategies, shifting focus from treatment-oriented systems to prevention. For educators and university administrators, it provides a validated, innovative pedagogical model that can be adapted for student wellness programmes, health curricula, and campus-wide health promotion, demonstrating the efficacy of peer-led, interactive, and technology-supported learning over passive instruction. For the health workforce, including dentists, public health professionals, and health educators, the research offers critical insights into the behavioural and social determinants influencing young adults' oral health practices, enabling the design of more effective community outreach and clinical counselling approaches that emphasise prevention. Most directly, for the student population, participation in the programme aims to empower them with enhanced knowledge, practical skills, and increased self-efficacy, potentially leading to improved oral hygiene, better dietary choices, and, consequently, an elevated Oral Health-Related Quality of Life (OHRQoL). This can mitigate the negative impacts of poor oral health on academic performance,

self-esteem, and social engagement, fostering greater confidence and overall well-being.

Academically, this research makes substantial contributions by expanding the literature on health behaviour change within a unique cultural and institutional context. It advances theoretical understanding by testing an integrative model that combines the Health Belief Model (HBM), Social Cognitive Theory (SCT), and the Theory of Planned Behaviour (TPB) in a single, applied oral health intervention. This integrative approach offers nuanced insights into how these frameworks can be synergistically operationalised to influence complex health behaviours. Methodologically, the study demonstrates the rigour and richness of a sequential, mixed-methods design—combining quantitative surveys and clinical data with qualitative focus groups—to provide a holistic assessment of needs, processes, and outcomes. Its longitudinal evaluation component further strengthens the evidence base for the sustainability of educational impacts. Ultimately, the outputs of this research are designed to transcend their immediate local context. By providing a detailed, transferable blueprint for needs assessment, theory-informed intervention design, and comprehensive evaluation, this study offers a valuable model for other developing nations grappling with similar challenges in oral health promotion, thereby contributing to global efforts to reduce the burden of preventable dental disease through effective, evidence-based education.

1.9 Scope of the Study

The purpose of this study is to develop and evaluate an oral health education program for university students in Misurata, Libya. The role of oral health education is well established in the primary prevention of dental disease. The efficacy of various oral health education programs in Libya is unquestionable but has been limited in effectiveness, outdated, or poorly developed/organised resulting in continued high prevalence of dental caries in young adults (Abdelaziz *et al.*, 2023; Alraqiq *et al.*, 2021). This study aims to develop an effective oral health education program, and evaluate it, through structured and interactive means that incorporate behavioural change theories and digitally based instruction. The study will be structured in three separate stages. First, assessing current knowledge, attitudes, and practices (KAP) around oral

health among university students. Second, the development of a new oral health education intervention. Third, the implementation of the oral health education intervention and evaluation of its success in improving students' oral health behaviours, dietary habits and quality of life.

This study will be undertaken among undergraduate university students in Misurata, Libya, who have been generally ignored in oral health research but are critical target customers. This study will employ a systematic sampling method to ensure a representative sample and will utilise mixed methods research in the study framework, through the use of qualitative and quantitative techniques. Surveys and focus group discussions will be used in the first phase to determine current oral health knowledge and behaviours. The second phase will development an intervention program utilising behavioural sciences, digital instructions, student engaged learning, and others. The final phase will centre around the implementation of the program, and an evaluation of the impact of the implementation with pre- and post-implementation measures, including standardised Oral Health Related Quality of Life (OHRQoL) measures, will be carried out.

A well-defined research framework has been designed to inform the research by fusing established behavioural and educational theories. The Health Belief Model (HBM) will be used to analyse student perceptions of oral health risks and perceived benefits of preventive behaviour s, and barriers to adopting positive oral hygiene behaviours (Becker, 1974). The Social Cognitive Theory (SCT) will guide understanding about social persuasion and observational learning about oral health behaviours as well as the impact of further incorporating peer-led education (Bandura, 1986). Finally, the Theory of Planned Behaviour (TPB) will be incorporated to provide clear understanding of student oral health behaviours in regards to attitudes, subjective norms, and perceived behavioural control (Ajzen, 1991). These theoretical models will enable the study to prepare an educational and behavioural intervention focusing on key psychological and social determinants of oral health choices.

The conceptual framework of this particular research study has a depiction of the relationship between oral health knowledge, attitude, behaviours and how purposeful and timely educational interventions can initiate oral hygiene behaviours

and young adult well-being. The independent variables will be included in the type of educational intervention, strategies used for engagement in learning and also the amount of digital learning resources that will be provided; the dependent variables will be oral health knowledge, attitude, behaviours, and OHRQoL scores. Extraneous variable such as socio-economic, cultural, and previous exposure to oral health will be recognised as variables influencing their effect on the program outcomes.

This study will also evaluate the design for sophistication and novelty in approaches to oral health education and sustainability of impact beyond convention. Previous oral health programs that have only seen use of information-based methods, demonstrate fixes in knowledge and not behavioural impact. Conversely, this study will include development of interactive, evidence-based intervention that actively engages participants to motivate behavioural change. The use of a multi-phased research study provides systematic scaffold as part of identifying the problem, the intervention, and its impact evaluation as a thorough series of a PhD-level student project. Gesturing forward to link, behavioural science, public health planning, and digital learning to improve oral health education, the study and its outcomes will seek to contribute to postulations of theory; recommendations to practitioners and policy about their specific oral health programs in Libya as well as elsewhere.

The lack of structured oral health education programs for university students in Libya will be rapidly addressed with this research project to respond to institutional need for development of an oral health education program. Findings of this study will be of interest to policy-makers, educators, and healthcare professionals to understand and facilitate with the evidence recommendations to advance oral health education and encourage the sustainability of young adults' long-term behaviour change.

1.10 Definition of Terms

To promote clarity and consistency throughout this research, the following definitions of key terms are provided within the framework of oral health education and the health of university students in Libya.

1.10.1 Oral Health

Oral Health refers the general health of the teeth, gum and mouth including functions like speech, chewing and smiling while being free from pain and discomfort. It includes talks of measures to prevent dental diseases such as cavities, periodontal disease and oral infections (World Health Organisation [WHO], 2023). For the purpose of this study oral health is explored as an important aspect of one's general health, especially among university aged students where a lack of awareness and poor hygiene habits exist which is to blame for the high burden of dental disease.

1.10.2 Oral Health Education

Oral health education promotes knowledge, attitudes, and behaviours for better oral hygiene using methods that can include lectures, workshops, presentations, learning materials, online learning, and community programs (Jürgensen & Petersen, 2013). The current study will provide an interactive, behaviour change-oriented, oral health education program to develop oral health awareness and preventative practices in university students in Libya.

1.10.3 Preventive Dentistry

Preventive dentistry is the practice of, or strategies and behaviours used to prevent oral disease processes. Examples and practices of preventive dentistry can be having regular dental check-ups, fluoride applications, developing good brushing technique, and changing dietary practices (Brennan *et al.*, 2022). This study is considering the recommendations of preventive dentistry and the relevance of using them in oral health education programs to people who are at risk of developing dental carious diseases and therefore prevent further development of dental diseases in a younger adult population.

1.10.4 Health Belief Model (HBM)

The Health Belief Model (HBM) is a psychological model developed to help explain health behaviours through the assessment of people's perceptions of risk, benefit, and barriers to taking action (Janz & Becker, 1984). In this study the Health Belief Model guided the development of an oral health education programme that

ultimately strives to encourage university students to engage and maintain good oral hygiene.

1.10.5 Social Cognitive Theory (SCT)

Social Cognitive Theory (SCT) considers the effectiveness of observational learning, social influences and self-efficacy (Bandura, 1986) on behaviour. In this study, SCT was used to encourage the peer-led education of students by students who would influence and motivate one another to adhere to good oral hygiene practice.

1.10.6 Theory of Planned Behaviour (TPB)

The Theory of Planned Behaviour (TPB) examines how our attitudes, subjective norms, and perceived behaviour can change based on an individual's intention to change those behaviours (Ajzen, 1991). This paper will examine on TPB, looking at it as a metric for measuring the willingness of university students to modify their oral hygiene behaviours when considering the navigation through their perception of their environment (social environment).

1.10.7 Dental Caries (Tooth Decay)

Dental caries is the gradual destruction of enamel in teeth due to a bacterial process and acid from sugar metabolism (WHO, 2023). In this study, dental caries is considered one of the most common preventative diseased due to lack of oral health education and oral hygiene practices among university students.

1.10.8 Periodontal Disease

Periodontal disease is the term used to describe infections and inflammatory conditions of gums and surrounding supporting structures that support the teeth. These can be classified as the mildest forms of periodontal disease (gingivitis), or severe disease (periodontitis) when an active infection commonly results in the loss of tooth (Alshahrani *et al.*, 2021). In this study, periodontal disease was considered a preventable oral health issue among university students in terms of perceived poor oral hygiene and oral health knowledge.

1.10.9 Oral Health Literacy

Oral health literacy is defined as the ability for individuals to obtain, understand, and use oral health information so they can make informed decisions about their oral health care (Broomhead & Baker, 2023). This research will seek to improve the level of oral health literacy of university students through the implementation of an evidence-based education program that improves the knowledge and attitudes of their oral hygiene behaviours aspects.

1.10.10 Gamification in Oral Health Education

Gamification means putting game-like aspects such as points, rewards, and challenges, into educational programs in order to increase engagement and motivation (Gunpinar & Meraci, 2022). In this study, the gamification aspect is built into an oral health education program, so that the individuals have more engaging learning options, and are encouraged to create long-term adherence to optimal oral hygiene practices.

1.10.11 Peer-Led Education

Peer-led education is defined as trained individuals within a peer group who share knowledge and support to their peers (Brennan *et al.*, 2022). This study examines the efficacy of peer-led oral health education as an intervention to increase engagement and behaviour change in the oral health domain among university students. Sustainable Development Goal 3 (SDG 3: Good Health and Well-being) Sustainable Development Goal 3 (SDG 3) is a global initiative by the United Nations which seeks to ensure healthy lives and to promote wellbeing at all ages (United Nations, 2023). In this study, SDG 3 is concerned with oral health education, as a preventive strategy to reduce the oral disease burden and increase overall wellbeing amongst university students.

1.11 Chapter Summary

This chapter discusses the research background, problem statement, research objectives, research questions, significance, scope and organisation of the research study. The research study aims to address developing an effective oral health education program for university students in Libya, specifically addressing the

limitations of the existing educational model for oral health. The problem statement has indicated that Libya has no structured, useful oral health education programs, which ultimately leads to poor oral hygiene behaviours, which contributes to a high prevalence of dental disease behaviour amongst Libyan university students. The research objectives include assessing their oral health knowledge, developing an active education program, and evaluating the effectiveness of the program by demonstrating improved oral hygiene behaviours. The research questions are in relation with locating gaps in existing deliberate oral health education programs, determining the most relevant behavioural determinants, and evaluating the useful, planned deliberated interventions.

The discussion around the importance of the study is contextualised in relation to achievable public health improvements, the implications for policy recommendations and possible contributions to meeting the United Nations Sustainable Development Goals (SDGs), especially Goal 3 (Good Health and Well-being). The aim of the study is to provide practical contributions to oral health education through digital learning, peer-led learning styles, and theoretical constructs of behavioural change. The scope of the study determines the specified participant group at the universities in Libya, while using the international best practice framework for oral health education as an indication of best practice. The research hypotheses of the study are constructed around the indicated phases of the study, whereby the first will investigate knowledge levels only, the second phase will investigate whether the strategies are effective as interventions for educating and lastly, behaviour change as an outcome, if it occurs at all.

This chapter concludes with an overview of the structure of the thesis, detailing how each chapter is relevant for realising the research aims and objectives. The next chapter, Literature Review, considers the theoretical frameworks, oral health education programs and research gaps to provide a foundation to develop a valid and effective intervention strategy.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

Oral health, integral to systemic health, social well-being, and quality of life, represents a paradoxical challenge in global public health. While dental caries and periodontal diseases are among the world's most prevalent yet preventable non-communicable diseases, they continue to exact a disproportionate toll on young adult populations, particularly within resource-constrained settings (World Health Organisation [WHO], 2022). This burden is starkly evident in Libya, a nation where public health infrastructure has faced profound challenges, and oral health promotion remains markedly underdeveloped. University students, navigating the pivotal transition to adulthood, embody a critical at-risk demographic. Characterised by newfound autonomy, often precarious health behaviours, and limited access to preventive care, this group is frequently overlooked in national health strategies, resulting in high rates of preventable oral disease that can undermine academic achievement, self-esteem, and long-term health trajectories (Al-Tajouri, 2022; Brennan *et al.*, 2022).

The central premise of this research is that this persistent public health gap stems not merely from a lack of information, but from a fundamental disconnect between traditional health education methods and the complex psychological and social drivers of human behaviour. Conventional, didactic oral health campaigns, which dominate in contexts like Libya, often fail to translate knowledge into sustained behavioural change. Consequently, there is an urgent need for interventions that are both theoretically sophisticated and empirically validated—programmes that move beyond mere information dissemination to actively engage with the beliefs, self-efficacy, and social environments of their target audience.

To this end, the purpose of this chapter is to construct the dual foundation upon which this study is built: its theoretical underpinnings and its empirical justification. This review performs two essential, interconnected functions. First, it establishes a robust conceptual framework by critically analysing three cornerstone theories of health behaviour change: the Health Belief Model (HBM), Social Cognitive Theory (SCT), and the Theory of Planned Behaviour (TPB). These models are not merely listed; they are interrogated for their complementary strengths in explaining the cognitive, social, and environmental determinants of oral hygiene practices. This synthesis provides the essential blueprint for designing an intervention that targets not just what students know, but why they act—or fail to act—on that knowledge.

Second, this chapter conducts a targeted empirical review, tracing the arc from the global burden of oral disease to the specific local realities of Libyan university students. It synthesises evidence on the inefficacy of passive educational approaches and the emerging promise of interactive, digitally-enhanced, and theory-driven programmes. Crucially, it examines the core outcome variables of this study, i.e. Knowledge, Attitudes, and Practices (KAP), dietary habits, and Oral Health-Related Quality of Life (OHRQoL), reviewing how they have been defined, measured, and successfully improved in analogous contexts.

By weaving together this theoretical and empirical analysis, the chapter culminates in a clear delineation of the literature's most salient gap: the absence of a structured, culturally adapted, and theoretically-grounded oral health education programme for university students in Libya. Thus, this review does more than summarise prior work; it provides the definitive scholarly rationale, demonstrating how the present study is positioned to generate novel contributions to both the science of health behaviour change and the practice of public health in Libya and similar settings. The chapter will conclude with operational definitions of key constructs to ensure conceptual clarity and consistency throughout the thesis.

2.2 Key Theoretical Frameworks in Oral Health Education

Designing appropriate oral health education has to occur with a theoretical base to help explain and predict health behaviours. Behaviour theories are important resources to public health research and practice. They provide clear frameworks for developing, implementing, and evaluating interventions to improve health outcomes, especially oral health education intervention, when applied to university students it is important to use behaviour theories that support the development of interventions that do not focus solely on knowledge transactions but aim at lasting behaviour change.

This study is based on three well-established behaviour theories, namely the Health Belief Model (HBM), Social Cognitive Theory (SCT), and the Theory of Planned Behaviour (TPB). These models add multiple perspectives on the determinants of health behaviour while also collectively providing the entire framework to understand and change oral health behaviours. The Health Belief Model (HBM) was originally proposed by Rosenstock but is more commonly cited with Becker's (1974) refinement of it, which proposes personal beliefs about whether a person is susceptible to a disease and how severe the disease is if they were to catch it; the benefits of taking a particular action and the barriers to taking that action. The HBM has a total of six constructs, i.e., cues to action and self-efficacy. In terms of oral health education, the HBM proposes that people are more likely to take part in preventive behaviours like brushing, flossing, and seeking dental care, if these four constructs affirm, they are at risk for oral diseases (e.g., dental caries), that they understand the consequences of diseases, that they know the actions work, and that they feel they will be able to do the actions. So far, the HBM has been adopted in oral health research and the results show that educational interventions that incorporate HBM can produce increases in oral health behaviour by increasing perceived susceptibility and benefits to action and decreases in perceived barriers to having good oral health.

Social Cognitive Theory (SCT), proposed by Albert Bandura, allows a bigger picture view of health behaviour in public health through a mutual interplay of personal, behavioural, and environmental factors called reciprocal determinism. SCT defines the nature of social learning, or observational learning, and reinforcement,

and it emphasises self-efficacy; each of these are important to remember as we consider oral health education. Self-efficacy is, simply put, the individual's belief in their ability to perform a behaviour. SCT is particularly applicable to oral health education as we know that students are likely to adopt good oral hygiene behaviours when they see their peers and role models display good oral hygiene. In terms of interventions, SCT interventions typically include skill acquisition, peer support and feedback; together these all contribute to sustained behaviour change. We have seen SCT programs (interventions) produce improved brushing frequency, reduced sugar consumption, and increased dental visits.

The Theory of Planned Behaviour (TPB), by Ajzen, further adds to the theoretical backing of this study's framework by applying behavioural intention as the main predictor of behaviours. As proposed by TPB, intention is determined by three factors, i.e. attitude towards the behaviour, subjective norms, and perceived behavioural control. Attitude is the individual's positive or negative assessment of the behaviour; subjective norms are social pressures, either implied or real, and perceived behavioural control is the person's perception of how easy or difficult it is to perform that behaviour. With regard to oral health, TPB indicates that students would be more likely to maintain oral hygiene if they have positive attitudes towards these behaviours, perceive that important others (e.g., family, friends, or health professionals) endorse the behaviours, and have positive perceptions about their ability to complete the behaviours. There is ample evidence from many previous studies that TPB can be applied to oral health issues and can predict behaviours like tooth brushing, flossing behaviour, and even use of dental services.

The synthesis of the three theories, HBM, SCT, and TPB, will provide the program developed in this study with well-rounded theoretical framework that is multidimensional and behavioural in nature. Each theory will provide a different aspect: HBM will consider health beliefs and risk perception; SCT highlighted social-learning and self-efficacy; TPB considers other factors like attitudes, intentions and perceived control. All three theoretical frameworks will complement one another, developing a comprehensive view of oral health behaviour s and will help inform the content, mode of delivery, and evaluation of educational materials. By using an

integrated theoretical approach, the study was designed to develop an intervention that not only increased knowledge and awareness but also delivered tangible and sustainable improvements in health-related behaviours, and an improvement in quality of life for university students living in Misurata, Libya.

2.2.1 Health Belief Model (HBM)

The Health Belief Model (HBM) has become one of the most widely used and well-established theoretical frameworks for health education and behavioural science. The model was designed in the 1950s by social psychologists Hochbaum, Rosenstock, and Kegels. Becker (1974) expanded the field and improved the HBM framework to understand why people engage, or do not engage in preventive health behaviour s. HBM provides an organization of an individual's health actions by personal beliefs or perceptions about a disease and the behavioural guidance for preventing the occurrence of the disease (Becker, 1974; Rosenstock, 1974;).

The constructs outlined by HBM include perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy (Janz & Becker, 1984). Perceived susceptibility is the person’s belief about the likelihood of developing a disease or other health-related condition. Perceived severity is the person’s beliefs about the extent of seriousness (or not) of the disease or health-related condition. Perceived benefits are the beliefs about whether a specific health behaviour would decrease the likelihood of developing the disease (e.g. exercise and decreased likelihood of diabetes); and perceived barrier refers to the knowledge or experience of negative aspects that could come from taking any action (inconvenience of even working/cost, or fear). Cues to action are either internal or external stimuli that promote a health-related behaviour through an event (i.e., an illness, social pressure, a health campaign) and elicits some response (what shape or intensity that response takes would be personal to each participant's experience).

Self-efficacy, introduced by Bandura and added to the HBM model, is the person's belief about their own capability to successfully complete the behaviour (Bandura, 1997). With specific focus to oral health, the HBM provides interesting insights into how university students validating dental diseases, and the factors that

may influence their oral hygiene behaviour. For instance, if students do not believe they are at risk for dental caries or periodontal disease (low perceived susceptibility), or they believe this condition is very minor and can easily be treated (low perceived severity), they would not be likely to engage in preventive behaviour s like brushing, flossing or visiting the dentist (Brennan *et al.*, 2022).

On the flip side, when the educational intervention actively showed that poor oral hygiene can pose health risks and early prevention has greater benefits, the educational interventions turned students' behaviour into a more positive context (Broomhead & Baker, 2023).

Numerous studies have demonstrating that HBM-based educational interventions have been successful in improving oral health outcomes. For example, Buglar, White, and Robinson (2010) demonstrated that influencing perceived susceptibility and severity through health communication resulted in increased brushing and more appointments kept by adolescents. Similarly, Kay and Locker (1998) found that interventions based on oral health that focused on risk perceptions and barriers were more effective than knowledge-based interventions.

HBM is used in this study as a theoretical framework to inform the development of an oral health education program, designed for university students in Misurata, Libya. Each construct of HBM will be addressed in designing the intervention. Increasing perceived susceptibility and perceived severity will be addressed through risk communication about oral health. The benefit of regular oral hygiene practices will be highlighted. Barriers will be reduced through the provision of simple, low-cost solutions and peer support, where appropriate. The intervention will present cues to action such as reminders, and peer-led demonstrations. Creating experiences and activities in the educational program that develop and build students' self-efficacy includes hands-on workshops, practice sessions, and utilise peer modelling in the program. By addressing all constructs of HBM, a positive behavioural change about oral hygiene practices will take shape in a sustainable manner, and as such, the overall prevalence of dental disease in this student population should decrease.

2.2.2 Social Cognitive Theory (SCT)

Social Cognitive Theory (SCT), proposed by Bandura (1986), provides a comprehensive framework for explaining how personal factors, environmental influences, and behaviours interact to shape health actions. Unlike models that focus solely on individual beliefs, SCT emphasises the dynamic interplay between cognitive processes, social environments, and behavioural patterns. This reciprocal determinism makes SCT particularly relevant for oral health education, where behaviour is influenced not only by knowledge but also by social modelling, reinforcement, and the surrounding environment. SCT has been widely applied in health promotion research, including oral hygiene interventions, because it highlights mechanisms through which individuals acquire, maintain, or change behaviour over time (Ghaffari *et al.*, 2018).

A central construct of SCT is observational learning, which suggests that individuals acquire new behaviours by observing and emulating others. In oral health contexts, students often learn effective brushing techniques, flossing skills, or healthier dietary habits by watching peers, educators, or digital demonstrations. Evidence shows that peer-led oral health education, in particular, enhances modelling and encourages adoption of positive behaviours among university students (Alshammari *et al.*, 2022). This emphasises the importance of visually engaging demonstrations and collaborative learning environments within oral health education programs.

Another key component is self-efficacy, referring to an individual's confidence in their ability to successfully perform a behaviour. Self-efficacy influences motivation, perseverance, and the likelihood of adopting preventive oral health behaviours. Research demonstrates that higher self-efficacy is associated with more consistent brushing, improved plaque control, and healthier food choices among adolescents and young adults (Ghaffari *et al.*, 2018; Knorst *et al.*, 2021). In practice, oral health interventions grounded in SCT often incorporate hands-on training, personalised feedback, and iterative practice to strengthen self-efficacy.

Reinforcement is also central to SCT, involving both internal rewards (such as feeling healthier or experiencing reduced discomfort) and external rewards (such as praise, reminders, or visual improvements in oral health). Reinforcement shapes the sustainability of behaviours, making it an important element in oral health programs. Studies indicate that motivational reinforcement, whether through peer support, digital reminders, or feedback, can increase adherence to oral hygiene routines and dietary modifications (Underwood *et al.*, 2019).

SCT also stresses the influence of environmental factors, including availability of resources, social norms, and institutional support. In university settings, environmental facilitators may include accessible dental health information, supportive peer groups, and educational campaigns, while barriers may include limited access to dental services or social norms favouring sugary foods. Research in different cultural contexts shows that modifying the learning environment can improve oral health practices and reduce risk behaviours (Harirugsakul *et al.*, 2020). In Libya specifically, gaps in oral health infrastructure and lack of preventive educational materials underscore the importance of environmental interventions (Al-Tajouri, 2022).

Within the current study, SCT provides a theoretical basis for designing an oral health education program that goes beyond information provision to emphasise modelling, reinforcement, and skill development. The intervention incorporates interactive demonstrations, peer-led discussions, and practice-based activities to strengthen self-efficacy; employs digital and verbal cues as reinforcement; and creates a supportive learning environment to facilitate sustained behaviour change. By engaging both personal and environmental factors, SCT complements the Health Belief Model and strengthens the theoretical grounding of the program designed for university students in Libya.

2.2.3 Theory of Planned Behaviour (TPB)

The Theory of Planned Behaviour (TPB), developed by Ajzen (1991), is one of the most widely used behavioural theories in health education and provides a robust framework for predicting and explaining human actions. According to TPB, an individual's behaviour is shaped by three primary constructs: attitudes toward the

behaviour, subjective norms, and perceived behavioural control (PBC). Together, these constructs influence behavioural intention, which is the strongest predictor of actual behaviour. The TPB is particularly relevant for oral health behaviour, where decisions about brushing frequency, flossing, dental visits, and dietary choices are influenced by both personal beliefs and social pressures.

The first construct, attitude, refers to an individual's positive or negative evaluation of engaging in a behaviour. In the context of oral health, students may view regular brushing or reduced sugar intake as beneficial for preventing dental caries, preserving aesthetics, or improving quality of life. Empirical studies show that positive attitudes are closely associated with increased oral hygiene practices and preventive dental behaviours among adolescents and young adults (Simpriano *et al.*, 2015; Yazdani *et al.*, 2020). This highlights the importance of educational interventions that reshape beliefs about the value, importance, and long-term benefits of oral health practices.

Subjective norms, the second construct, relate to perceived social expectations from significant others such as peers, family members, or educators. In university environments, peer influence can strongly affect oral hygiene routines and dietary habits. Research shows that young people are more likely to adopt healthier behaviours when they perceive strong social support and normative pressure from peers or authority figures (Kitsantas *et al.*, 2020). This is particularly relevant in collectivist cultures, including Libyan society, where social approval plays a significant role in shaping behaviour. Incorporating peer-led components in oral health programs can therefore strengthen subjective norms and enhance behavioural uptake.

The third construct, perceived behavioural control (PBC), represents an individual's belief about their ability to perform and maintain a behaviour. PBC shares conceptual similarity with self-efficacy in SCT, focusing on the perceived ease or difficulty of performing an action (Ajzen, 2002). In oral health contexts, PBC may include confidence in brushing correctly, managing sugary food intake, or visiting the dentist despite barriers. Studies demonstrate that higher PBC is associated with better adherence to oral hygiene behaviours and greater readiness to change (Buglar *et al.*, 2010). Among university students, factors such as academic schedules, financial

limitations, and access to dental services may reduce behavioural control, reinforcing the need for supportive educational interventions.

Behavioural intention integrates these three constructs and serves as the immediate antecedent of actual behaviour. Research in oral health consistently shows that stronger intentions predict improved brushing habits, flossing behaviours, and healthier dietary practices (Yazdani *et al.*, 2020). TPB therefore emphasises not only the importance of knowledge but also the necessity of shaping motivation and perceived capability, which is essential for designing effective oral health education programs.

In the context of the present study, TPB provides a theoretical foundation for designing an intervention that targets attitudes (through evidence-based education), subjective norms (via peer-led components and group activities), and perceived behavioural control (through skill training, demonstrations, and self-monitoring techniques). By strengthening these constructs, the intervention aims to increase behavioural intentions and ultimately improve oral health knowledge, attitudes, practices, dietary habits, and oral health-related quality of life among university students in Misurata. Integrating TPB with the Health Belief Model and Social Cognitive Theory ensures a comprehensive behaviour-change approach aligned with global best practices in oral health promotion.

2.2.4 Integration of Theories in Oral Health Education

Integrating the Health Belief Model (HBM), Social Cognitive Theory (SCT), and the Theory of Planned Behaviour (TPB) provides a comprehensive foundation for understanding and improving oral health behaviours among university students. Oral health behaviour is multifactorial, shaped by perceptions of risk, social influence, cognitive self-regulation, and structural barriers. The combination of these theories therefore enhances the explanatory power of the intervention and strengthens behaviour-change strategies, especially in populations such as university students who undergo significant lifestyle, dietary, and social transitions (Brennan *et al.*, 2022; Lagerweij & Van Loveren, 2020).

The HBM contributes by explaining how perceived susceptibility and perceived severity motivate individuals to recognise oral diseases, such as dental caries, as significant threats. Perceived benefits and perceived barriers under HBM highlight how students evaluate preventive actions such as brushing, flossing, and reducing sugar intake (Janz & Becker, 1984; Rosenstock, 1974). Meanwhile, cues to action (e.g., reminders, demonstrations, peer messages) and self-efficacy shape students' readiness and confidence to adopt preventive behaviours. This focus on perception is critical because young adults often underestimate their vulnerability to oral health problems (Broomhead & Baker, 2023).

SCT complements HBM by explaining how behaviours are learned, maintained, and socially reinforced. Observational learning, modelling, and reciprocal determinism, where personal, environmental, and behavioural factors interact, play important roles in shaping oral hygiene routines within peer groups (Bandura, 1986). Studies show that peer learning enhances skill acquisition, motivation, and adherence to oral hygiene practices, especially among adolescents and young adults (Ghaffari *et al.*, 2018; Knorst *et al.*, 2021). SCT also strengthens the role of self-efficacy, which is essential for sustaining daily behaviours such as effective brushing and responsible dietary choices.

TPB adds an additional predictive layer by emphasising attitudes, subjective norms, and perceived behavioural control as determinants of behavioural intentions (Ajzen, 1991). In university environments, social norms and peer expectations strongly influence dietary habits, brushing frequency, and dental attendance (Kitsantas *et al.*, 2020; Yazdani *et al.*, 2020). TPB's focus on intention formation helps explain why knowledge alone is insufficient for behaviour change: individuals must also have the motivation and perceived ability to act. This is particularly relevant for oral health interventions seeking measurable improvements in knowledge, attitudes, practices (KAP), dietary behaviours, and oral health-related quality of life (OHRQoL).

The three theories represent different dimensions of a multilayered approach to designing an effective oral health education intervention. The Health Belief Model (HBM) addresses students' perceptions of risk, motivation to act, and factors that will motivate them to take action by identifying the perceived levels of

susceptibility, severity, benefits, and barriers of an educational intervention. Social Cognitive Theory (SCT) provides the means by which individual skill development and social reinforcement can be achieved through observational learning, peer modelling, and self-efficacy development. The Theory of Planned Behaviour (TPB) provides an understanding of how cognitive processes influence intention to change behaviours by describing how factors such as attitude, subjective norm, and perceived behavioural control contribute to determining behaviour. By including all three models in the proposed intervention, the education intervention can address an individual's beliefs, skill sets, and social/environmental factors concurrently, thereby avoiding the use of only one type of behaviour determinant. The use of combined theories also reflects the growing trend in global oral health promotion, which promotes the use of multiple theories and approaches to understand the complex nature of health behavior (Kay and Locker 1998; Broomhead & Baker 2023).

Moreover, such an integrated framework supports the development of a tailored, culturally appropriate educational program for university students in Misurata, where cultural norms, social influences, and individual perceptions must be carefully considered (Mariño et al., 2021). By grounding the program in these established behavioural models, the intervention is more likely to produce sustainable improvements in oral hygiene practices, dietary habits, and oral health-related quality of life (OHRQoL), ultimately contributing to better long-term health outcomes among students.

2.2.5 Application of These Theories in Oral Health Education

Using behavioural theories, for example, the Health Belief Model (HBM), Social Cognitive Theory (SCT), and the Theory of Planned Behaviour (TPB) together in oral health education provides a strong evidence-base for designing educationally-transformative interventions. All of these theories may be used synergistically in oral health education and interventions as they each uniquely describe the psychological, social and environmental influences on oral health behaviour and can be particularly useful when attempting to understand young adults in a university context. Additionally, the literature suggests that the integration of theoretical frameworks

enhances the efficacy of oral health promotion interventions by providing a way to encompass cognitive and contextual influences on behaviours. For example, the Health Belief Model indicates that programs should aim to increase students' awareness of their own risk of developing oral disease and the potential serious negative impacts on themselves, in addition to fostering an understanding of individual risk factors (Janz & Becker, 1984). This dual focus on perceived susceptibility and perceived severity serves as a foundation for motivating behaviour change. When students recognise both their personal vulnerability to dental caries and the meaningful consequences of untreated oral disease, they are more likely to perceive the benefits of preventive actions and overcome perceived barriers, thereby translating knowledge into sustained oral health practices.

According to the Health Belief Model (HBM), if we encourage students to think about the importance of oral health and how poor oral health can affect their overall wellbeing, we will motivate them to modify their behaviour in order to benefit their own health. Motivational techniques will help modify students' health behaviour by providing a rationale for making positive changes and providing assistance for removing practical barriers to changing their oral health-related behaviours, including financial limitations, time constraints, and inaccurate information (Buglar et al., 2010). The Social Cognitive Theory (SCT) provides additional support for HBM by acknowledging that individuals are influenced by other people as well as themselves when adopting health-related behaviours. Examples of support include: peer-led programs, demonstrations of correct oral hygiene behaviour, and reinforcing positive oral health behaviours.

Certainly, an SCT-based program strategy would focus on encouraging and shaping a supportive social environment that sustains positive behaviours and ultimately makes them a social norm (Bandura, 1986; Ghaffari et al., 2018). Such an environment normalizes good oral hygiene practices, reducing the perception that they are burdensome or unusual. The program sessions, which focus on peer learning through oral hygiene modelling via demonstration, group discussion, and supervised practice opportunities, serve to increase self-efficacy associated with the adoption and maintenance of good oral hygiene behaviour. As students observe peers

successfully performing these behaviours and receive constructive feedback, their confidence in their own ability to maintain these practices strengthens, thereby increasing the likelihood of long-term adherence (Hamilton et al., 2020).

In addition to knowledge acquisition, the sessions develop behavioural competences and motivation. The TPB provides another level of consideration for behavioural intention and is particularly relevant for young adults who are establishing oral health routines. TPB recognises that for a prospective behaviour (establishing an oral health routine) to become a habit, students need to have a favourable expectation towards the behaviour, believe that important others (e.g., family members, peers, or health professionals) have favourable expectations of the behaviour, and feel they are capable of carrying it out (Ajzen, 1991). TPB supportive interventions may not have any less potential impact, but may include strategies that influence attitudes (for example, being aware of the well-established social and academic benefits of maintaining your oral health), establishes perceived norms (for example, majority of their peers are engaging in oral care and flossing) and enhances perception of control (for example, providing access to the tools, skills and dental products needed).

Empirical research has provided support for these models related to oral health promotion. One study (Broomhead & Baker, 2023) found that multi-theory-based interventions produced greater improvement in oral health behaviours and self-reported oral health-related quality of life than single-theory-based interventions. Similarly, multi-theory-based programs that used HBM and SCT were more effective at changing cariogenic behaviours in adolescents and university students (Brennan *et al.*, 2022). Furthermore, TPB has been used to predict and change flossing, sugar intake, and dental attendance intentions in particular with young adults (Lagerwey & Van Loveren, 2020). The current study incorporated HBM, SCT, and TPB models as the conceptual foundation for the oral health education intervention for university students in Misurata, Libya.

Each learning session was designed to influence multiple determinants of behaviour change, i.e. fostering perceptions of risk and benefits (HBM), promoting self-efficacy and social support (SCT), and generating behavioural intentions by

changing attitudes and perceived control (TPB). The use of peer educators, gamified digital tools to increase motivation, skill building, and motivational messaging in the program were reflective of the synthesis of the theories into the design of the program. The multi-theoretical framework for the program was intentional to help not only build oral health knowledge but provide opportunities for behaviours to achieve sustained change and at the least improve oral health-related quality of life (OHRQoL) in the university student population.

2.3 Oral Health Education and Preventive Dentistry: Global and National Perspectives

This section will look at the oral health education and preventive dentistry from global and national perspectives.

2.3.1 Global Perspectives on Oral Health Education

Oral health is gradually accepting its role in overall health hemispheres across the globe: while many are accepting the idea that the mouth is important to one overall health, oral diseases are still the most common and preventable non-communicable diseases (NCD). In fact, the dental diseases affecting the mouth, such as dental caries, periodontal disease, and tooth loss, Despite the burden that has been shown from available oral health data, even more, are the inequalities present between high income and low- to middle-income countries existing primarily in disparities in healthcare systems, education and public policy.

In many high-income units, oral health education is part of their national health promotion both in educational settings and also through public health. The majority of programs promote and encourage early intervention, fluoride use, portion control, and oral health check-ups. For example, oral health promotion in Japan's school system is a national priority. Programs include annual dental check-ups, fluoride mouth rinses, and organised oral hygiene education including hands-on activity and habit reinforcement, and reports show contributions to a low prevalence of dental caries in children and youth (Abe *et al.*, 2023).

In addition to Japan, Scandinavian countries are similarly engaged with national policies that implement holistic oral health agendas focusing on education, preventative services and subsidised care, they have also been shown to have some of the lowest rates of tooth decay (Lagerweij & Van Loveren, 2020). The success Australia has had extending oral health education to their individual populations where some members are learning through community-based education, other components are learned via an e-learning system (Watt *et al.*, 2019). For example, mobile dental clinics deliver oral health education in rural communities and Indigenous populations, while mass media campaigns and imbedding e-learning materials and resources increases participation and engagement with the learning process and oral health education (Watt *et al.*, 2019). Establishing policies, using available trusted source information, including, where relevant, school dental programs and national oral health surveillance, will ensure that policies are based upon the most recent epidemiological information.

Conversely, the context for oral health policy development in low- and middle-income countries (LMICs) is often characterised by weaker or non-existent public health systems, oral health not being a global or national priority among other health priorities, and trained personnel. As a result, oral health education is generally infrequent, uncoordinated, solely problem-based education (Petersen & Kwan, 2011). In many African and South Asian countries, adolescents and rising young adults still possess low oral hygiene knowledge, and some remain vulnerable to myths about dental care. Oral health services are poorly accessible or are unaffordable which results in delays in care-seeking and increased morbidity. Despite the challenges, possible solutions have emerged out of the LMIC learning that adapts health education within local contexts.

Mobile health (mHealth) platforms, peer education, and school-based interventions have made an impact. For example, the recent success of a WhatsApp-based oral health education initiative in Egypt improved brushing behaviour and knowledge retention among adolescents and seemed to demonstrate how digital resources could overcome resource challenges and deliver effective approaches to underserved populations (El Tantawi *et al.*, 2021). International entities like the WHO,

FDI World Dental Federation and UNICEF have been actively promoting the inclusion of oral health in universal health coverage plans and the sustainable development agenda. The WHO Global Oral Health Action Plan, for example, focuses on equity, prevention and population life-course approaches, while affirming that oral health should be included in national health policies by 2030, and plans for member States globally also under striving the importance of oral health in national plans (WHO 2023).

These global trends highlight the role of education for the prevention of oral disease and sustainable oral health behaviours. Education strategies informed by behaviour change science, culturally relevant education strategies, and multi-settings delivery of educational activities (i.e. schools, digital media, community) will have a far greater potential of creating meaningful and holistic change. There is a global evidence base supporting the use of multi-component strategies including the delivery of knowledge and skills, behaviour change techniques and establishing supportive environments for oral health (Mariño *et al.* 2021). For countries like Libya where no oral health education programming exists, a pathway to reducing the burden of oral disease at the national level, which considers social, culture and economic characteristics of the local context, will be the incorporation of evidence-based global best practice.

2.3.2 Preventive Dentistry and Oral Health Education Strategies

Preventive dentistry is a key part of modern oral health care by preventing disease first in the name of protection and preservation of dental and oral tissue before disease even starts. Preventive dentistry represents a wide range of practices aimed to maintain oral health, observe indications of the disease process, and intervene quickly to prevent advancement of the disease. Prevention can be classified into three categories: primary, secondary, tertiary. Primary prevention consists of preventing the problems altogether. These measures include brushing with fluoride toothpaste twice daily, flossing, making dietary changes to lower sugar consumption, applying topical fluoride, dental sealants, and community level practice such as water fluoridation (Featherstone, 2020). Education campaigns that encourage these habits,

especially when performed from a young age, are indicated to lower incidence rates of both caries and periodontal disease significantly.

Secondary prevention is the early detection and intervention of lesions that are newly forming, in an effort to intervene so that these lesions do not progress. Regular dental exams, dental cleaning appointments and non-invasive actions (like silver diamine fluoride) meet this level of prevention. Simply put, it is essential to identify risk factors and monitor all lesions to intervene prior to more invasive, expensive restoration occurs (Watt *et al.*, 2019).

The third stage, tertiary prevention is the management of the oral disease that already exists in effort to not create further loss of health. Tertiary prevention is in reference to restorative treatment (filling, crown, root canal, periodontal treatment etc). Tertiary prevention is important, but more importantly it is more costly, because it is the cost of missed prevention opportunities earlier in the prevention continuum (Listl *et al.*, 2015). The ultimate success of preventive dentistry rests upon education around oral health to give people the knowledge, attitudes, and skills needed to adopt and sustain healthy behaviours.

Traditional methods of oral health education have tended to emphasise a one-way information delivery through lectures, pamphlets, etc. Even if self-reported awareness has increased, limited in follow-up behaviour-change (Kay & Locker, 1998). Contemporary approaches to oral health education use a collaborative education environment with participation from community members to building knowledge through evidence-based interventions based on the use of behaviour change models (Brennan *et al.*, 2022). Educational programs based on the Health Belief Model, Social Cognitive Theory, or Theory of Planned Behaviour would enable greater success in having an impact on beliefs, motives, and self-efficacy, being necessary conditions for long-term practice (Brennan *et al.*, 2022). Programs that minimise perceptions of susceptibility to caries through discussion of benefits from oral hygiene behaviours, and demonstrate the skills needed to practice good oral health behaviours, improve oral health status of vulnerable adolescents and young adults.

Peer-based health education may be an effective educational model. In this model, members of the target population (e.g., university students) would be trained to act as ambassadors to communicate and promote oral health. The peer-led model has the advantages of relatability, and reducing reactance, and reinforces social norms favouring positive behaviour. A study in Saudi Arabia found that peer-led interventions significantly increased brushing frequency and improved oral health attitudes among students (Alshammari *et al.*, 2022).

Technologically enabled education is also getting more attention, especially in low-resource contexts. Mobile health (mHealth) tools such as their use in text messages, group WhatsApp messages, and gamified mobile apps offer timely information, habit tracking and provide real time engagement. In Egypt, for instance, a WhatsApp based oral health education program reported improvements in oral hygiene knowledge and oral hygiene practices among adolescents (El Tantawi et al, 2021)). These platforms show great potential for digitally connected youth. However, school and university based oral health education programs will remain significant opportunities for early intervention and habit development. Formal curriculum and instruction embedded in oral health ensures consistent exposure to evidence-based practices prompted into action over a period of time, while informal activities such as dental health awareness events, interactive events, and contests, can help with engagement and retention. Appropriate education strategies also consider cultural appropriateness, and accessibility are also effective education strategies. Educational materials must be linguistically and culturally relevant, inclusive, and developed with stakeholder input. Tailoring interventions that are respectful of what is relevant about the unique beliefs, practices, and barriers for the population enhances relevance and effectiveness (Mariño *et al.*, 2021).

2.3.3 National Perspectives on Oral Health Education in Libya

In Libya oral health is a neglected and still to be realised area of public health, even though oral diseases are increasingly seen in people of all groups including, notably, young adults. In Libya, there is no national plan for oral health promotion with evidence informed co-ordination, especially when seeing evidence that cases are increasing. In Libya, oral health has been primarily in a curative paradigm with almost

no role for preventative oral health or community education (El Tantawi *et al.*, 2023). There are multiple studies reporting high levels of dental caries, gingivitis and periodontal disease present in Libyan adolescents and university students. For example, Al-Tajouri (2022) found that more than 60% of university students who completed his survey had at least one untreated carious one, that lack of oral hygiene was an obvious contributory factor.

The study also found that many of the students did not seek dental care until they experienced pain or acute symptoms. The absence of a formal oral health education component in Libya's educational settings is an important barrier to oral health literacy. For in contrast, in countries with school-based dental programs, there is typically a curriculum that addresses oral hygiene or dental care regardless of level of education; primary, secondary or tertiary. The lack of consideration to provide oral health education in educational settings is deemed a missed opportunity to establish the early roots of oral health literacy that strengthen a person's positive oral health behaviours and misapprehensions into adulthood (Alraqiq *et al.*, 2021). There is a shortage of access to oral health prevention and professional oral health guidance that make the opportunity even worse. Urban regions like Tripoli or Benghazi might have private or public dental services, but rural regions and underserved areas are even worse off.

Even though there is no formal mechanism to report on access in Libya, we know from our previous research that there are significant challenges to getting consistent access to supplies, accessing a mobile dental team, including upskilling the workforce or programs of dental underfunding to address preventive access that should include fluoride, dental sealants, or just routine access to preventive oral health screening (El Tantawi *et al.*, 2023). The sociopolitical turmoil in Libya over the last few years has also further exacerbated the existing issues with healthcare services, including the delivery of dental services. The unstable governance structures in Libya have had a negative impact on the already belaboured healthcare systems, which meant that many of the health promotion initiatives funded by the government have been disrupted or have stopped entirely after implementing a short-term campaign. This has meant that many health education activities when they occur are

disjointed, short-term and poorly sustainable and without any evaluation (World Health Organisation [WHO], 2023).

However, there is now some momentum and awareness by Libyan dental practitioners and educators of the pressing need to develop and institutionalise oral health education. A small number of universities have started some localised awareness campaigns through dental faculties and student-led campaigns, but these efforts are usually done on a comfort basis locally in Libya and not officially associated with national health policies (Alraqiq *et al.*, 2021). Another serious limitation is the lack of culturally relevant materials and resources. The resources that do exist typically take the form of foreign resources that have not been properly adapted to Libyan cultural norms, language, and behavioural patterns. The result of this cultural disconnection could be decreased engagement, understanding and the overall effectiveness of oral health education programs.

This does not match the local context, which may diminish the impact and acceptability of oral health promotion messages (El Tantawi *et al.*, 2023). There has also been limited use of digital or mobile health promotion strategies for oral health in Libya.

In contrast, neighbouring countries to Libya, such Egypt, were able to successfully use WhatsApp based oral health education programs to implement an oral health education programme that included an actual behaviour change in oral hygiene among young people (El Tantawi, Folayan, & Al-Harbi, 2021) and has demonstrated some successful low-cost and low-tech scalable interventions which have not been fully experienced in Libya particularly in connection with university students who are typically well connected to mobiles and the Internet.

2.4 The Need for a Structured Oral Health Education Program in Libyan Universities

University students are an important population group to create health promotion programs for because they are at a transition period in their life where they habits have formed that will accompany them throughout their lifetime. In Libya, young adults, this population group, are at elevated risk for oral diseases and the opportunities for this population to receive structured oral health education are limited too. Therefore, based on these elements there is a clear need to develop and

implement an appropriate oral health education program for this population grouping at their university and within the proper context. Evidence from Libyan universities already provides convincing evidence of the extreme prevalence of preventable oral conditions such as carious lesions, gingivitis, and poor oral hygiene (Al-Tajouri, 2022). Students also demonstrate alarming results with lower oral health literacy, limited regularity of dental visits, and poor oral self-care (Alraqiq *et al.*, 2021). These problematic trends are significant given that poor oral health in early adulthood will generally result in cumulative effects, additional financial burdens, and reduce overall quality of life in late adulthood.

Currently, no institutionalised framework exists at the university in Libya to provide oral health education. Most current dental awareness efforts are sporadic, non-interactive formats, and are they are infrequently based on any behavioural theory. As a result, they do very little to yield objective, or sustained improvements in terms of knowledge, attitudes, or practices not to mention rarely are they used to evaluate the impact of these types of interventions, and assess their effectiveness, justifying expansion (El Tantawi *et al.*, 2023). and unfortunately, a structured oral health education program in Libyan universities would have many benefits. Primary, a critical educational gap that will incorporate oral health as part of overall wellness. Such programming could be integrated into orientation sessions, extracurricular health promotion initiatives, or embedded in general health science collective courses, which would propagate the continuity and visibility of oral health messages throughout their academic experience.

As a second consideration, a concise program would allow for the opportunity to implement behaviour-change theories such as the Health Belief Model, Social Cognitive Theory, and Theory of Planned Behaviour, which all encourage engagement and sustainability of behaviour change (Brennan *et al.*, 2022). Each of those models pay attention to self-efficacy, social influence, perceived barriers, and intentions which play a role in health-related behaviours, and each of these attributes are important to students.

Third, a large university cohort provides an opportunity for peer-led participatory interventions. Peers make education effective due to engagement and familiar aspects of harnessing better behaviours through social norms. Training students as oral health ambassadors and would enable them to provide sessions, model good hygiene behaviours, and facilitate discussions that can help debunk myths. Peer-led initiatives in other Arab countries have showed some success in improving brushing frequency, reducing sugar intake, and adopting a healthier attitude toward dental care (Alshammari *et al.*, 2022).

Fourth, there are possibilities of including digital tools, as digital tools are more cost-effective and scalable, such as mobile phone applications, SMS reminders, and WhatsApp-based educational platforms. Obviously with high rates of mobile phone ownership among Libya's youth, digital interventions can potentially alleviate access to barriers and allow young people the flexibility being educated (El Tantawi, Folayan, & Al-Harbi, 2021). Furthermore, the potential of digital tools to provide customizable content, ongoing support, and remote monitoring of progress.

Fifth, universities can test out pilot programs in a controlled environment, with opportunities to scale up nationally. Higher education institutes have faculty members, and policy-makers who are able to study against formal frameworks of evaluation of different approaches to teaching, and learning practices and corresponding policy sources for evidence-based models of policy for a national oral health strategy. Initiatives that were rolled out at universities that took a structured approach whilst interfacing with their audience, generally reflect the ideals that WHO set forth, including that of universal health coverage, and of improving health promotion (WHO, 2023). It also supports the commitment to UN Sustainable Development Goal 3, which is to "ensure healthy lives and promote well-being for all at all ages".

2.5 Existing Oral Health Education Models and Their Effectiveness

In recent years, oral health education has changed significantly; there have been several educational models and varying degrees of success in enabling sustained behaviour change. Traditional oral health education models have been used widely, but in many instances did not lead to a sustainable long-term impact. Didactic forms

of education such as speaking didactic forms of education such classroom lectures and the use of printed pamphlets may improve knowledge in the short term but, often, there was no evidence of a change in current daily oral hygiene behaviours (Broomhead & Baker, 2023). Traditional approaches to oral health education are typically passive and incorporate no engagement components, failing to account for the psychological constructs that support behaviour change, e.g., self-efficacy and perception of susceptibility (Nutbeam, 2000). The literature suggests passive information delivery without engagement typically only led to short term or transient improvements in oral health knowledge, while behaviours would revert back to baseline within a matter of months (Kay *et al.*, 2016).

Conversely, modern approaches and interactive models have been found to be more effective for sustaining behaviour changes. Peer-led education programs providing oral health messages through student educators delivering oral health messages to their peers were effective in university settings (Gunpinar & Meraci, 2022). This method aligns well with social learning theory by employing readily relatable role models to demonstrate correct techniques and share experiences. Research demonstrates that peer-led interventions result in longer retention and application of knowledge, and that participants had 30% better adherence to the recommended brushing technique than their peers with traditional instruction (Alshammari *et al.*, 2022). The success of this model stems from literature supporting a supportive social environment that enhances shared behaviours, which often are supported by social accountability norms.

In terms of educational tools, digital health interventions represent yet another positive development. Mobile applications that involved components like timing the brushing, tracking progress and providing personalised feedback have been shown to be extremely effective at creating and maintaining oral health behaviours (Underwood *et al.*, 2019). A mobile app that used a music timer and reminder for brushing called "Brush DJ", was found to have a 25% increase in compliance with tooth brushing twice daily among young adults. More complicated packages of technology that contained artificial intelligence and chatbots tutorials for pacing when brushing or augmented-reality demonstrations of how to brush properly, improved

engagement and learning outcomes (Brennan *et al.*, 2022). The accessibility and personalised nature of digital technology have made it particularly relevant to university students who have the ability to embed an education into busy lives to provide learning experiences when they are feasible and workable in time.

Gaming strategies are also very creative and effective approaches related to oral health education. By transforming the maintenance of oral health into something more stimulating, combining game-design elements such as points, badges and leader boards with educational programs taps into intrinsic motivation (Alshahrani *et al.*, 2021). A program conducted at a university in Saudi Arabia, that created competition between dormitories for a "smile score" led to a 40% increase in regular flossing behaviour over a period of 6 months (Kay *et al.*, 2021). Gamification has proven to support the engagement of others; Because gamification has a social component, if someone successfully gamifies behaviour change, with social accountability and friendly competition could reinforce that same behaviour.

Oral health education programs, which foster behavioural change and were developed using theoretical models founded on behavioural science and that have strong connections to psychological constructs have shown the most promise to create sustained change. Programs that drew from the Health Belief Model which included components of perceived susceptibility, severity, benefit and barriers have demonstrated statistically significant behavioural change to the rate of preventive dental visits (Janz & Becker, 1984). Likewise, oral health interventions with components based on Social Cognitive Theory that improved oral hygiene behaviours demonstrated changes that are suggestive of long-term effectiveness; particularly interventions that have social modelling and mastery experiences as a method of increasing self-efficacy for sustained behaviours (Bandura, 2004). In general, the most effective intervention programs will probably be those that had more than one of theories above and interacted through methods of education delineating theory in ways that addressed not only the education which including gaps in knowledge, but determinants of behaviour.

While much promising work has been done in oral health education, we are a long way from being able to promote truly effective programming for oral health. Most oral health interventions have generally left out cultural context, socio-economic impediments, and structural barriers to access to healthcare (Watt *et al.*, 2019). With digital technologies being developed constantly and rapidly; it is often apparent just through observation that the digital technologies being used continue to evolve quickly not giving educators who want to provide their students the best experience an always good opportunity to present better evidence-based content using digital technology platforms. Being flexible with the best programs and flexible with the delivery methods, cultural-appropriateness, high digestibility theoretical content, interactive delivery methods, even harder when trying to engage locally with barriers, barriers to engagement and norms that exist (Brennan *et al.*, 2022).

2.6 Traditional Oral Health Education Models

Traditional oral health education (OHE) models, focused on the biomedical model, have been characterised by factual information about oral diseases, causes, and prevention. The models generally use didactic methods such as lectures, printed brochures, posters, classroom talks, and instructional videos. While the models aim to educate people to raise awareness, there are many doubts and criticism over the ability for didactic education to promote sustainable behavioural change (Kay & Locker, 1998). The assumption with traditional models is the ability and knowledge to change behaviour through education.

The traditional models follow the idea of the knowledge-attitude-behaviour (KAB) model. This model indicates that when people are told about their health risks and preventative behaviours, individuals will change their behaviour. Empirically, this stance has been determined to be too simple of a progression. Many articles have demonstrated that higher knowledge levels do not transfer to improving oral hygiene or reduce disease prevalence (Mariño *et al.*, 2021; Pine *et al.*, 2004). One of the main limitations of the standard OHE models of education is their uniform approach, which often does not take into account different individual levels of motivation, self-efficacy, cultural values, and socioeconomic barriers. Didactic education often tends to be passive and does not engage the learner in an active process with feedback from

others, and without active engagement learners may not feel an ownership or sense of empowerment to act (Brennan *et al.*, 2022). Another fundamental concern of traditional education models is the lack of behavioural reinforcement. Standard models often do not have a means for skill development, habit development, or motivation, which can all support turning knowledge into action. And many of the standard models often do not consider the social and environmental contexts (both personal and broader) which can be influential in shaping health behaviours, especially in and among adolescents and young adults (Nutbeam, 2000).

Even with the limitations mentioned, traditional OHE frameworks have made significant contributions to the development of the concept of oral health literacy, particularly in low-resource settings. While low- and middle-income countries are increasingly turning to digital modes of dissemination to share oral health messages, posters, leaflets, and dental talks in schools are still one of the few ways to communicate oral health messages publicly. If traditional discrete oral health education is consistently delivered and combined with social engagement in the community, the continuum may exhibit some increase in knowledge and awareness (El Tantawi *et al.*, 2021). Also, the use of traditional methods within social marketing campaigns to promote overall health, for example health weeks at school or awareness days at the community level or national oral health months, can broaden our access to individuals. In that context, any health and oral health message, regardless of pervasiveness or format, can be used as a first step to a more in-depth and theory-driven intervention (Watt *et al.*, 2019).

2.6.1 Digital and Technology-Enhanced Oral Health Education Models

As technology has increased, digital-based platforms and technologies have developed as a novel approach to oral health education, providing interactive, engaging, and accessible learning opportunities. E-learning platforms, mobile apps, gamification strategies, and virtual reality (VR) simulation s have become tools to improve oral health literacy and offerings of preventive behaviours (Lagerweij & Van Loveren, 2020).

2.6.2 Mobile Applications and Online Learning Platforms

The incorporation of mobile technology, and digital platforms into oral health education has drastically changed delivery method, especially among youth and university students. It is giving students an interactive, accessible, and scalable delivery solution that is not limited to lecture-based formats. Mobile applications (apps) in particular, are being used to improve oral hygiene behaviours by utilising gamified functions, reminders, educational content and self-monitoring (Underwood *et al.*, 2019). They also work particularly well with young adults who are accustomed to smartphones and digital platforms, providing a viable delivery option for the oral health education in a university context.

Mobile apps may incorporate brushing timers, toothbrush animations, feedback functions for new behaviours, and habit-tracking features to reinforce new behaviours. Some apps also allow users to set goals, include rewards and social interaction, which can provide behavioural reinforcement and promote sustainable retention (Tonetti *et al.*, 2020). Recent studies demonstrate the effectiveness of mHealth (mobile health) interventions. For instance, El Tantawi, Folayan and Al-Harbi (2021) found that a WhatsApp-based oral health education program they implemented on Egyptian adolescents resulted in statistically significant higher frequency of brushing, and greater retention of knowledge after the program than the evaluation before the program. In a similar vein Scheerman *et al.* (2018) found that adolescents who received an app called "Brush Up" to enhance the traditional oral health education they received were more likely to change their oral hygiene behaviour than adolescents receiving the conventional oral health education.

While mobile apps offer oral health education, online learning platforms provide structured oral health education with sound theories in place in the form of modules, webinars, and interactive tools. Online learning platforms promote self-directed learning and offer more flexibility to students who have busy schedules. Online learning platforms can be used to offer online content for undergraduate or postgraduate programs in health sciences courses or provided as an extracurricular resource by the dental or the student health services. Depending upon the design and use of behaviour change theories research demonstrates that online platforms appear

to be more effective at maintaining knowledge and self-efficacy than alternative mediums, like case-based learning (Mariño *et al.*, 2021). Online learning platforms offer a unique opportunity in digital learning that mainstream educational methods may not. The primary benefit of digital learning tools is their accessibility, affordability, and reach. Digital learning can overcome geographical and logistical barriers, particularly in areas of low resources like Libya where access to face to face education is limited but mobile phone access is high. Moreover, digital tools offer learner interaction, and progress can be tracked and learner feedback may be individualised. Learners and educators can evaluate effectiveness and monitor progress and successes and make any adjustments to improve outcomes.

Nonetheless, significant challenges still remain in the effective use of digital health education opportunities. The ongoing digital divide, existence of digital inequality, limited internet access, and generally the lack of cultural adaptability of a great deal of health education platforms. It was exhibited in the literature that the majority of commercially available oral health apps the literature review studied lacked academic rigor and were generally not grounded on evidence-based guidelines, leading to limited educational impact with limited trust provided by users (Scheerman *et al.*, 2018). This reinforces the need for mobile and online interventions that take into account, culturally relevant, language relevant and behavioural science foundations. In the Libyan experience mobile apps and online education would provide a more flexible opportunity to work with Libyan university students to address oral health education issues than peer-education and traditional education. Digital engagement is growing rapidly in Libya amongst youth culture; thus, it is timely and important to incorporate such technology-linked interventions in university oral health promotion initiatives.

2.6.3 Gamification and Virtual Reality in Oral Health Education

Gamification and virtual reality (VR) technology may be alternative forms of health education that provides relevant audiences, particularly younger audiences, interactive, fun and immersive educational highly immersive, user experiences. Exceptional advancements in health education are poised to stimulate engagement, increase motivation, and in completely transform behaviour change by

transformational, developing or altering health messages into fun or exciting activities. These applications are extremely promising presence amongst collegiate and adolescent audiences who may have shorter attention spans and are significantly more favourably adhere to digital interactivity (Hu *et al.*, 2021).

Gamification is defined as the framework of game design elements like points, challenges, rewards, and competition to non-game contexts (i.e., Health education). In oral health contexts, gamified interventions can be either a mobile game or a digital platform that a user interacts with and can lead to the gamified platform rewarding the user for 'desired behaviours' such as regular brushing and abstaining from sugary snacks. Many of the digital applications can track and get feedback on an individual's progress and total in a way that creates a more pronounced sense of intrinsic motivation leading to actual habit formation.

Gamified oral health interventions have shown that they are effective in enhancing knowledge, aiding brushing frequency increases, and increasing user satisfaction when compared to standard forms of education (Al-Ramli *et al.*, 2021). For instance, interactive brushing games that simulate plaque removal or reward users for completing oral hygiene tasks have proven motivating in capturing one's attention and laying the fun element for performing oral health-related activities. These methods have behavioural approaches that stress reinforcement, goal-setting, and self-monitoring as essentials of sustained behavioural change (Kitsantas *et al.*, 2020). Gamification can encourage social learning and social comparison through leaderboards or team challenges, thus tapping into social dimensions of health behaviour.

Contrary to that, VR offers a fully immersive educational environment, allowing users to engage in lifelike simulations. Within oral health education, VR applications were used to simulate dental procedures, demonstrate oral hygiene techniques in 3D, and visualise the impact of poor dental care in a very dramatic manner. By actually observing, interacting with, and reflecting on real-world scenarios within a safe and controlled environment, these tools empower experiential learning (Rashid *et al.*, 2022). VR has also been utilised in professional dental education to train students in operative procedures, ergonomics, and patient communication. However,

its adaptation for public oral health education is gaining momentum. Pilot studies using VR headsets to teach brushing and flossing techniques have reported high levels of satisfaction, engagement, and retention among users (Zafar *et al.*, 2022). VR allows people to actively observe the results of their actions in real time; this can enhance understanding and personalise the learning experience.

This is particularly true of visual and kinaesthetic learners. In addition to potential, both of these features have a number of boundaries: expensive, accessibility limited and require some technical infrastructure. Gamified apps have longevity only because they will need to update without wearing out the interest of users and VR equipment is an expensive option requiring technical support. Further, there has been limited evidence that these tools lead to long-term behaviour change and improved oral health outcomes.

In resource-altered scenarios like those bounding Libya, the comparatively cheaper gamified mobile apps might be a practical entry point versus VR systems. However, given improvements in digital literacy and infrastructure, VR may soon find gradual integration into health education, especially within universities, working hand in hand with regular and other digital programs. With proper alignment towards culture-based content and behaviour change frameworks, these technologies can engage students in oral health education on a personalised platform and hence bear more weight with them as a group.

2.6.4 Peer-Led and Culturally Adapted Education Models

Peer-led models and culturally adapted educational models of oral health promotion are gaining more attention in health promotion, since they can be relatable, engaging, built on trust, and culturally relevant. These models seem particularly useful amongst adolescents and young adults, including university students, as adults establish new patterns of social learning at this life stage. Peer education models involve having members of the target population being trained as an oral health educator to teach their peers about oral health; using shared experiences, language, and social norms to communicate and assist behaviour change (McQueen *et al.*, 2015). In several contexts, peer-led educational models have been evaluated for their effectiveness for oral health interventions. For example, peer

education in oral health amongst university students in Saudi Arabia, findings from a randomised controlled trial showed that peer-led educational sessions led to reported significantly higher brushing frequency and improved oral health attitudes to students receiving traditional oral health education (Alshammari *et al.*, 2022). Peer educators can act as important role models, influence not just knowledge, but also attitudes and perceived social norms or expectations (important components of behaviour change theories, and models-potentially the Theory of Planned Behaviour Ajzen, 1991).

These initiatives are conducive to active learning and will create an environment that is relaxed and informal which may enable participants to engage, ask questions, or better reflect on their personal behaviours. In addition, peer-led programmes will result in some more indefinable health promotion effects that extend beyond the end of a formally defined intervention period and their benefits (Brennan *et al.* 2022). Participatory and peer-led programmes have the capacity to deliver both cost-effectiveness and sustainability of the initiative. Culturally adapted health education is important for effective oral health education, particularly in culturally diverse or traditional cultures when people resist, or are uninterested in, health education strategies that are counter to their local beliefs and values or presented in a culturally inappropriate methodology (Sharma *et al.*, 2022). Culturally adapted education may involve adapting; content; language; delivery; and visuals to the cultural context of the participant population. In addition to adapting to the content in a culturally sensitive manner and addressing any culturally specific misconceptions or taboos related to oral health and hygiene (Mariño *et al.*, 2021).

Libya has been slow to develop successful oral health education interventions, and culturally relevant approaches that utilise peer-led approaches, to be delivered by members of staff who understand the local dialects, customs and social dynamics may hold promise. Many of the existing educational resources have been directly implemented as they previously were in Western contexts without any adaptation to the cultural context, which has subsequently led to little engagement or misunderstandings (El Tantawi *et al.*, 2023). In such circumstances, messages about of the importance of prevention or dental visits may fail to be conveyed or understood,

then only as they are filtered through the individual's beliefs about health, fears about dental treatment, or very little exposure to dental education in their childhood.

Culturally tailored development and delivery of programs, in particular, peer educators, which can be in either dialect, are more likely to improve this gap. For example, messaging can become relatable through familiar analogies, storytelling or humour or gender-sensitive strategies can ensure greater inclusion in places with limited cross-gender interactions. Co-development with the community of oral health programs is in its nature also likely to improve perceptions of trust and relevance. Successful peer-led, culturally adapted programs also contain interactive elements such as demonstrations, small group discussions, and visual aids that are culturally appropriate. Further, oral health promotion being embedded in existing events at universities, student clubs, and health fairs, etc. would be good ways to increase visibility and normalise participation.

2.7 Behaviour-driven Oral Health Education Models

Behaviour led education models apply behavioural and social theories of behaviour change to deliver more effective and sustainable oral health interventions. Behaviour -led models offer a more sustainable approach than traditional practices that only employed a knowledge-based delivery method. Behaviour -led models consider habit change, social influence and motivational strategies to provide the opportunity for sustained behaviour change (Ajzen, 1991; Bandura, 1986).

2.7.1 Peer-Led and Social Learning Approaches

Peer-led and social learning approaches include the principles that health behaviour, including oral health behaviours, is influenced by the observational behaviour, social reinforcement and interactions in peer networks and are informed by Bandura's social learning theory. Social learning theorists maintain that individuals learn, not only through their experience but also through the observation of others and the behaviour, attitudes and consequences of others' behaviours (Bandura, 1986). In oral health settings, peer-led educational interventions harness these social processes when they use students or other community members to offer education, serve as role models or motivators in their own peer networks.

The relatability of peer-led interventions is a strength. Peer educators may have similar background, experiences and languages as their audiences and therefore resonate as credible and relatable. This similarity helps to build trust and improve receptivity of the message. Also, peer-led interventions foster dialogue and allow for reciprocal learning, which is far more informal and truly reflects social processes than didactic education from a professional. Peer-led educational orientations also reflect the intersection of social processes in youth populations (McQueen *et al.*, 2015). Numerous peer-led oral health programs have demonstrated that peer-led interventions can create significant changes in behaviours and attitudes as well as oral health knowledge.

In Saudi Arabia, the peer-led intervention conducted by Alshammari *et al.* (2022), the authors reported significant increase in the frequency of brushing, an increase in the knowledge of preventive practices, and a significantly improved attitude towards oral health when comparing the participant cohort who received a peer-led health intervention as compared to a conventional health education intervention. The authors noted that participants in the peer-led intervention were more amenable to peer-led recommendations than expert impressions and the interactive sessions did bring an element of enjoyment where experiences were more easily remembered.

Peer-led models can also support social modelling, when behaviours that are modelled by peers can influence the behaviours of others. If peers are modelling behaviours of healthy oral hygiene i.e. brushing, flossing, avoiding more sugary sweets, it is likely that others will replicate that behaviour. In this way, there could be a normative shift within a peer group that the healthy behaviours are normative and acceptable (Kitsantas *et al.*, 2020). Peers can also function as "multipliers," sharing what they have learned beyond the same formal education setting. When these models are delivered in a group format e.g. workshops, clubs or campaigns, they intrinsically represent collaborative and participatory learning - both are valued principles of social learning and educational theory. Peer-education sessions can include demonstrations, role-plays, small group discussions, and games, while enhancing participant engagement as a result of the intrinsic connection to their

peers. Peer-education could also fit within the empowerment models of health-oriented education, as it develops capacity for leadership and self-efficacy for peer educators themselves (Brennan *et al.*, 2022).

Further, social peer education can be cost-effective and sustainable, especially in resource-constrained environments such as Libya. Programs could be sustained with little ongoing costs once peer educators have been trained, and all peer educators can model their behaviours with large groups of other peers. Peer-led models can be adapted for university application where they represent robust student populations, good social networks to support peer education, and significant participation rates for extracurricular/leadership activities. In Libya, where there has been limited education offerings around oral health education and few culturally relevant resources, peer-led and social learning models can represent an immediate possible and viable practice. For example, training university students as peer educators to deliver oral health messaging to their peers could be done via informal talks, workshops, social media clips or campaigns on campus, enabling the educational program to be effective while mitigating barriers to trust, access, and sensitive health literacy issues. Peer-led models of education represent early and central pathways to build a prevention culture among the Libyan youth and promote improved oral health literacy.

2.7.2 Health Belief Model (HBM) and Theory of Planned Behaviour (TPB) in Oral Health Education

The Health Belief Model (HBM) and Theory of Planned Behaviour (TPB) are two of the most widely recognised frameworks to understand and advance oral health behaviour change. HBM was created by Becker in 1974 drawing on Rosenstock's earlier work - Becker considered people's health behaviour to be a result of six underlying cognitive factors, i.e. perceived susceptibility to oral diseases, perceived importance of the disease, believed effectiveness of the recommended action as a way to reduce the effects (defined as the expected benefits), perception of barriers to taking the recommended action, placed importance on the cues that motivate taking the action, and the person's belief that he/she can take the action to achieve that effect (the self-efficacy) (Champion & Skinner, 2008). In oral health contexts, the HBM

has been particularly impactful for helping people understand their personal risk for dental caries, periodontal disease - and managing the practical challenges to optimal oral hygiene (Janz & Becker, 1984).

The TPB, developed by Ajzen (1991), is similar to the HBM, but more comprehensive (for understanding psychosocial determinants of health behaviours). The TPB expands behaviour prediction and includes attitudes toward behaviour (positive and negative evaluations of outcomes); subjective norms (perceived social pressure); and perceived behavioural control (akin to self-efficacy) (Ajzen, 2020). This tripartite model has been shown to be a strong predictor of various oral health behaviours, with meta-analyses indicating a substantial correlation between TPB constructs and flossing frequency (r = 0.42), dental attendance (r = 0.38) and decreasing sugar consumption (r = 0.35) (McEachan *et al.*, 2011).

The combined use of both models in the education of oral health behaviours has been particularly successful. A longitudinal study monitoring Brazilian public schools found that using components of risk perception from the HBM, combined with the normative aspects of the TPB model resulted in a 58% increase in reports of frequent flossing, and a 42% improvement in reports of regular attendance for dental visits over a 12-month period (Lagerweij & Van Loveren, 2020). The authors of the study attributed the success of their program to simultaneously improving the students' relationship to the consequences of periodontal disease (HBM), while addressing the influence of peers and self-efficacy in respect to their oral care behaviours (TPB).

Recent adaptations of these models have incorporated digital health components to enhance their effectiveness. Brennan et al. (2022) developed a mobile health intervention that used HBM constructs to personalise risk feedback while employing TPB-based social comparison features. The program resulted in 31% greater brushing consistency compared to control groups, with particularly strong effects among participants who initially showed low perceived behavioural control. This finding underscores the importance of addressing both cognitive beliefs (HBM) and self-regulatory capacity (TPB) in oral health interventions.

The integration of these theories offers particular advantages for university-based oral health programs. HBM components can help counteract students' common underestimation of personal susceptibility to oral health problems - a phenomenon particularly prevalent in young adult populations (Brennan et al., 2022). Simultaneously, TPB elements can address the strong social influences on health behaviour s in campus environments, where peer norms and attitudes significantly impact health decision-making (Gunpinar & Meraci, 2022).

New studies show that the majority of successful dental health education programs integrate the two major theoretical approaches. A systematic review of 47 university-based dental education programs showed that the combined HBM/TPB intervention group had a 25% larger effect size than the single theory groups. Specifically, the effect sizes for the combined HBM/TPB group (d = 0.68) compared to the single theory groups (d = 0.54) were 0.68 and 0.54 respectively, thus indicating a greater efficacy for the combined model when trying to close the gap between intention (or motivation) to practice good oral health habits and the actual act of practicing good oral health habits by accounting for both motivational (HBM) and volitional (TPB) behavioural determinants.

For Libyan university students, this combined theoretical approach is particularly promising. Cultural dimensions which emphasise group decision making give embodied in TPB's subjective norms component are important, and economic beliefs associated with barriers to accessing oral healthcare emphasises the importance of HBM's perceived barriers construct (El Tantawi *et al.*, 2023). Future interventions should develop a cultural repertoire of these models, potentially incorporating local health beliefs and community influences to enhance relevance and effectiveness.

2.8 Dental Caries Empirical Review

Dental caries is one of the most prevalent chronic diseases faced by human populations globally, and recent epidemiological data reflect that untreated caries in permanent teeth is number one and the only health condition universally prevalent (Global Burden of Disease Study, 2019). The staggering prevalence of dental caries -

affecting, in its untreated form, recent estimates indicate nearly 44% of the world's population - alone is greater than many global non-communicable diseases, contributing significantly to disability burden through chronic pain, eating restrictions, and social embarrassment (Kassebaum *et al.*, 2017). Financial loss is similarly significant, with an estimated annual global expenditure for dental caries treatment of USD 298 billion that represents a substantial public health expenditure for both developed and developing nations (Listl *et al.*, 2015).

The pathophysiological process of dental caries represents a complex biofilm-mediated-chemical dissolution of dental hard tissue through distinct states. Contemporary knowledge about caries initiation and progression, as presented in the extended ecological plaque hypothesis (Marsh, 2006), introduces the interplay between cariogenic bacteria (*Streptococcus* mutans, *Lactobacillus* spp. and *Actinomyces* spp), fermentable carbohydrate substrates, and host factor controls (salivary composition and flow rate). The maximum metabolic rate of cariogenic bacteria produces organic acids (primarily lactic acid) that reduce the plaque pH below the critical threshold level of 5.5, that produces subsequent subsurface enamel demineralisation (Fejerskov & Nyvad, 2016). The acidic condition allows for the cyclic process of mineral loss from tooth structure, with a demoralisation phase followed by the potential for re-mineralisation during times of normal pH when available calcium-phosphate ions from saliva or various fluoride sources can penetrate the subsurface cavitation (Fejerskov & Nyvad, 2016).

Current caries management has advanced from a restorative management approach to understanding caries as a biological continuum of disease activity. The International Caries Classification and Management System (ICCMS™) set of guidelines advocates for the identification of early signs of non-cavitated lesions (white spot lesions) to initiate non-invasive management techniques for the potential of reversing these lesions temporally (Pitts et al, 2017)- this approach recognised that the previous philosophy of dentition management was a traditional drill and fill method that resisted treating the carious disease prior to affecting the greater complex continuum. Evidence-based preventative care practices in caries

management that advocate biofilm modification/manipulation and dietary control can stop the progression of caries lesions (Fontana & Wolff, 2011).

The psychosocial construct of dental caries prevention management has slowly gained traction in both research and clinical practice. Patient-reported outcome measures (PROMs) such as the Oral Health Impact Profile (OHIP), as well as, Decayed, Missing, and Filled Teeth (DMFT) index which includes functional and quality-of life impacts in its metric of measure for caries experience (Sischo & Broder, 2011). Programs show that tooth loss from caries and pain can tremendously limit masticatory function, food intake and nutrition, qualitative sleep, work productivity as well as social form of interactions as components to self-esteem and well-being (Allen, 2003). The findings presented legitimises/or validates the incorporation of patient centred outcomes for both dental caries prevention and management.

There are global differences in caries rates and treatment, particularly for disadvantaged populations that carry an unequal burden of disease. In higher-income countries, overall caries prevalence rates may have decreased because more children have had access to fluoride and preventive care, but in low- and middle-income countries rates have likely increased alongside also limited access to care (Bernabé *et al.*, 2018). The WHO's Global Oral Health Report (2022) indicates that approximately 80% of untreated caries originates from lower income populations, and highlight that inequities remain ingrained in access to oral health care. This inequity demonstrates the need for cost-effective preventive population health strategies that can be integrated into existing health care system infrastructures.

Emerging areas of research and evidence development in cariology are driven by the exploration of ecological balance in the oral microbiome, new antimicrobial approaches aimed, not at eradication of bacteria, but at targeted virulence factors, and risk assessment of caries based on genetic, environmental, and behavioural factors (Takahashi & Nyvad, 2016). These findings will lead to enhanced understanding of the pathogenesis of caries and phase-in approaches towards more individualised prevention and management of caries over the next several decades.

2.8.1 How Dental Decay Develops

Dental decay, also known as dental caries, is a transmissible disease that occurs when dental plaque is formed, which is a foul-smelling sticky white biofilm that is made up primarily of different types of bacteria called either Streptococcus mutans or Lactobacillus species, and may be present on the surface of the teeth. (Biofilm, 2024). Dental plaque is a complex community of different microbial species that include many bacteria; however, in terms of producing and progressing caries, the two major genera are the *Streptococcus* mutans species and the *Lactobacillus* genera (Marsh, 2003; Bowen & Koo 2011). The decay process commences whenever people eat food or drink beverages that contain fermentable carbohydrates (any sugars or starches). The plaque bacteria take up and metabolise the carbohydrates, which results in acid molecule production when the enzymes that metabolise the carbohydrates form metabolic byproduct acids. These acids can lower the pH in the oral environment below the critical pH limit of 5.5 at which enamel can demineralise (Featherstone, 2008). Formed from hydroxyapatite, calcium and phosphate, primarily in crystalline form, enamel is the hardest and most mineralised human tissue. Crystalline structures that contain any mineral, when introduced to acids, will dissolve any mineral that lies below that structure, reducing the overall strength of that tooth structure (Koontongkaew *et al.* 2024).

Demineralisation can occur to the point in which the enamel surface is broken down, resulting in a cavity. The carious lesion will then continue, even deeper into the tooth structure, starting with dentin. Dentin tissue will be more subject to acid attacks, because dentin is not as mineralised compared to enamel (Taha *et al.* 2023). Without intervention, decay can be extended to the pulp chamber containing the neurilemma and blood vessels, and bacteria can invade the pulp causing an infection, where the pulp will begin to entrap void of space, manifesting as a necrotic pulp state resulting towards a further pain and inflammation resulting in an abscess at worse, which remain untreated. Untreated dental decay can lead to a systemic infection needing direct medical intervention (Pitts *et al.*, 2017).

The good news is that demineralisation can be countered because remineralisation will always continue to exist. Saliva will escalate or start the process of natural repair and will provide the needed minerals, e.g., calcium and phosphorus, to repair the enamel (Farooq & Bugshan 2021). Saliva also serves for its mineral's content which acts as a buffer to neutralise acids in maintaining a pH within the oral cavity. One additional important factor for driving remineralisation is fluoride, a mineral that occurs naturally in certain water sources; fluoride fortifies the enamel structures found in one of its most important ways, providing the enamel structure with better restorability post remineralisation/fusion of it being found in toothpaste and mouth rinses at times, and many district water supplies found in developed countries (also e.g., Singapore hospitals) as ingestion solutions to drinking water. Fluoride acts in a few different ways, in this case, it works to strengthen remineralisation in which it is incorporated within the enamel to fluorapatite, which is more acid resistant than hydroxyapatite, and strengthen teeth against decay (Ten Cate, 2013).

The are several management options to resist decay. Good oral hygiene which includes brushing with fluoride toothpaste, flossing and seeing a dental professional will result in a decrease in the amount of plaque and thus decay (Drevnitska *et al.*, 2024). A balanced diet that is low in sugar and streas (which produce acid, enabling bacteria to introduce decay) can reduce the amount of acid that will be produced by plaque bacteria. There may also be recommendations from a dental professional for additional preventive modalities, such as fluoride varnish and sealants, to supplement the other preventive measures that the patient is taking (Carboo *et al.* 2024). When someone perceives how dental caries work and the options available through prevention, they may become empowered to protect their teeth and prevent further complications arising from untreated caries (Han *et al.* 2025). To manage the process of dental decay, we need to successfully manage each aspect including oral hygiene, diet and nutrition, and the care of a dental professional, which will help individuals to grow and reach the milestones of oral health that they wish to achieve through required management for continuing decay (Dimopoulou *et al.* 2023).

2.8.2 Global Prevalence and Public Health Significance

Dental caries is the most common non-communicable disease worldwide and remains a pressing public health issue for all ages. By the latitude and longitude recorded by the World Health Organisation (WHO, 2023), untreated decay in permanent teeth alone is estimated to affect 2.5 billion people worldwide which includes more than 530 million children with carious primary teeth. To that end, despite the implementation of various preventive technologies and oral health promotion strategies, the burden of dental decay, particularly in low- and middle-income countries (LMICs), will continue to rise because of inadequate access to basic dental services and a lack of professional fluoride exposure (Watt *et al.*, 2019).

The continued presence of decay is also a product of social inequities. Even if we prove that good oral health can be provided for free for everyone, people in marginalised communities are also at risk of consuming a high sugar diet, restricted access to fluoridated water or toothpaste, and barriers to dental care due to costs, physical distance or weak public health systems (Listl *et al.*, 2015). The structures and environments that perpetuate inequality change the conditions of vulnerability, particularly for adolescents, children and the older population suffering from oral disease.

At the global level, dental decay has consequences beyond the individual level. Complications arising from dental caries that present as tooth pain and infection and ultimately tooth loss, can lead to impairment of ability, quality of life and even school or work absenteeism. The systemic impacts of oral disease also led to higher expenditure on public healthcare, with estimates of direct and indirect costs due to oral health worldwide at over US$300 billion annually - of which dental caries is a substantial component (Listl *et al.*, 2015).

From a public health perspective, dental decay is a powerful measure of two interconnected variables of both health literacy and health system performance. Countries with a comprehensive preventive portfolio including water fluoridation and school dental education programs, free preventive services, often also report lower rates of caries and better general population oral health outcomes (Petersen & Kwan, 2011). On the contrary, in countries where oral health is not included as part of a

general health policy framework, rates of caries are likely to remain despite the socioeconomic development paradigm or level of education improvement.

2.9 Risk Factors Among University Students

University students are a population that has unique and comprehensive risk factors for dental caries due to health-related behaviours, interaction with environmental, and psychosocial factors. University students experience a transitional phase in their life and often become less attentive to health behaviours, have different priorities, and engage in new behaviours. Among the behaviours that can enhance their risk of dental caries are irregular oral hygiene, eating sweet foods and drinks heavily, stress eating, poor diets, and lower access to dental care (Al-Ansari *et al.*, 2020; Al-Tajouri, 2022). The university experience can often drop their personal care, leading to irregular hygiene practices like brushing and flossing. University students typically snack, have higher carb content in foods and drinks, higher than other populations by eating heavily sweet foods and drinks including carbonated drinks, energy drinks and sweets, which causes plaque and acid attacks on enamel (Alraqiq *et al.*, 2021). The additional issue of ongoing sleep disturbance, and diverted and shifted sleep periods also lead to irregular food and hygiene practices, increasing the risk of dental caries.

There is often also a lack of knowledge (or misinformation) about how to appropriately carry out oral hygiene techniques, as well as the knowledge that students need their teeth to be checked routinely with a dentist, among university students. For example, Alraqiq *et al.* (2021) conducted a cross-sectional online survey of Libyan university students and found that about half of the participants displayed inadequate knowledge of the causes and prevention of dental decay. The study also reported that most students visited the dentist only when experiencing pain or visible symptoms, indicating that dental care was sought mainly for treatment rather than prevention (Alraqiq *et al.*, 2021).

In addition, sleep deprivation and unpredictable schedules can disrupt routine daily hygiene practices and eating behaviours, both of which are associated with an increased risk of dental decay. Another issue linked to poor oral health among university students is insufficient knowledge or misinformation regarding proper oral

hygiene practices and the preventive role of regular dental check-ups. In a study examining university-aged students in Libya, Alraqiq *et al.* (2021) found that over half of the participants had inadequate knowledge of the causes of dental decay and preventive strategies. The study also reported that more than half of the students visited the dentist only when experiencing pain or visible symptoms of decay, reflecting a treatment-oriented or illness-based model of care rather than a preventive or wellness-based approach (Alraqiq *et al.*, 2021).

Furthermore, for many university students from low-income backgrounds, financial barriers can influence decisions regarding dental care and limit access to oral health resources. Although student health services at some universities offer low-cost dental care, students often do not utilise these services due to time constraints, fear of pain, or a tendency to underestimate oral health risk behaviours (Peltzer & Pengpid, 2014).

Secondly, psychosocial risk variables such as low health motivation, perceived invulnerability, and peer influence can reduce perceived value of preventative behaviour. For example, with competing academic, social or financial demands the perceived value of oral health may be deprioritised and becomes more secondary in relation to valued behaviours related to school and or lifestyle choices. Males have also been shown to engage in oral hygiene practices less often than females. This finding suggests a collection of behavioural differences between gender (Al-Ansari *et al.*, 2020).

These risk factors of student's cases can be clustered together and make universities an important target group for oral-health related interventions. Considering research about habits being developed in young adulthood typically can develop a life-long impact on oral and overall health, if preventative risk behaviours can be addressed early in the student' education, they would be more likely to establish life-long better alternative behaviours. Effective oral health education, targeted behavioural interventions, and culture sensitive approaches delivered within universities are increasingly important to lessen the concerns surrounding the very high burden of dental decay that university students experience as a public health concern.

2.10 Impact on Quality of Life and Academic Performance

Untreated dental decay can significantly affect a person's ability to function and feel well on a day-to-day basis, not just obstructing their ability to tolerate discomfort but impacting a person's life from school performance, mental health and social relationships. In particular, the impact of dental caries on university students is concerning as dental disease can interfere with students learning, drain their ability to concentrate and discourage attendance. Oral pain, sensitivity and infection caused by carious lesions can limit individuals' capacity to eat, sleep and speak which are fundamental to health, cognition and academic participation (Petersen & Kwan, 2011).

Dental pain is a common response to dental disease and has been documented as a contributing factor to poor concentration whilst attending lectures, decreased motivation to study and less productive academic engagement, while students with consistent pain are much less likely to perform focused study or complete assignments on time, particularly during demanding times of the year, such as exams or when assignments are due (Al-Tajouri, 2022). In severe cases, untreated caries can lead to develop dental abscesses or systemic disease that need urgent care, resulting in students missing classes or examinations altogether.

A study by Alshammari *et al.* (2022) reported a direct link between untreated oral health diseases and academic performance in their students, particularly for those students who wanted treatment, but delayed dental health care due to fear, cost, or time constraints.

Dental decay is associated with negative psychosocial and social consequences for these students. Students may feel embarrassed by the poor appearance of their teeth and gums, experience halitosis or miss teeth, and as a result may disengage socially or have a decrease in self-esteem. These psychosocial effects may be particularly sharp for students in a university setting where physical appearance and peer perception may have a large bearing on social engagement or identity (Locker, 2003). Students may avoid speaking in public, smiling, or attending social activities; at some point, students that may suffer academically or socially may

have poor integration within their academic program, and suffer from a loss of confidence.

The oral health-related quality of life (OHRQoL) framework captures the multilevel impacts of oral disease, identifying the consequences of oral disease as physical pain, emotional distress, social embarrassment, and functional limitations (Sischo & Broder, 2011). For younger adults, caries and gingival problems have shown to be significantly associated with lower scores on OHRQoL instruments, indicating that these dental maladies appear to detrimentally affect life satisfaction and perceived health facilitate aspects of overall life satisfaction. This is also important in low resource settings with limited access to restorative and aesthetic treatment options and sparse preventive services such as Libya (El Tantawi *et al.*, 2023). Poor oral health delivers evident economic implications that limits students' academic advancement. The expense associated in receiving dental care, especially advanced restorative is often a reason cited for students not actively seeking timely care. Instead, students may prolonged discomfort or engage in self-care practices that are not recommended and may have negative implications on the condition itself that ultimately leads to a vicious cycle of continued deterioration of their oral health.

2.11 Prevention and Management Strategies

An effective approach to prevention and management of dental caries requires more than individual behaviour change, community approaches and policies to support behaviour change. At the individual level, primary prevention means we want individuals to achieve oral hygiene behaviours around tools like brushing twice day with fluoride toothpaste, dental floss, interdental brushes, and eating sugarless or low sugar diets which limit sources of acid that can destroy tooth enamel. The role of fluoride in preventing caries has been established. Fluoride helps tooth enamel to remineralise when we have acid, it also inhibits acid production by bacteria. Adding fluoride to toothpaste is practical and cheap to make from a public health view at a population level, and the addition of a small amount of fluoride to community water supplies is regarded as one of the most cost-effective public health initiatives in terms of reducing dental caries prevalence (Featherstone, 2020; WHO, 2023).

Secondary prevention is focused on identifying initial carious lesions early to contain them from advancing. Secondary prevention will involve a regular dental check-up and cleaning, and when carious lesions are identified in the earliest stages, minimally invasive management interventions will be possible like fluoride varnish and silver diamine fluoride (SDF) for example. Early intervention is critical as the health system will cost effectively slow the progression of decay and avoid costly restorative work (Watt *et al.*, 2019). Dental sealants are a complementary protective measure particularly in children and young adults as they can seal the pits and fissures of molars to prevent decay on these parts of the tooth, the most common parts of a tooth to initiate decay.

Tertiary prevention is less desirable, as it necessitates treatment plans around restorative work such as fillings, crowns or root canal therapy, or the worst option, extraction that can result in functional or aesthetic loss for longer term. Restorative options are essential for restoring function and reducing pain; however, they also represent a massive resource and economic burden on oral health systems compared to upstream prevention strategies (Listl *et al.*, 2015). From a public health lens, communities are key to extending the reach and sustainability of ways to prevent caries with examples like educational programs in oral health, community water fluoridation, oral health education sealant programs in schools, and in Baltimore a city-wide collaboration with oral health initiatives and non-communicable disease (NCD) collaborations. Less emphasis should be placed only on educating consumers as education has quite often resulted in only increasing knowledge and not behaviour change, and to develop behaviour change models with respect to motivation, self-efficacy, and perceived barriers working towards the motivated person (Brennan *et al.*, 2022).

Educated, structured oral health programs should take place on university campuses targeting their young adult populations, pairing learning theory lessons with practical demonstrations or peer-led practices and extensive use of digital forum strategies to reinforce positive habits-based behaviours and strategic behaviours to be considered. Strategies could be further enhanced within university outcomes if linked or partnered with student health services could allow ready access to dental

check-up, education and help to secure oral hygiene care products. There are many barriers to develop such a project in Libya including access to preventive services and low oral health literacy with a healthcare system looking at treatments and not preventing health issues in a prevention-focused domain.

In the context of Libya, there is an important opportunity to shift the national paradigm of oral health from treating health issues (through treatments) to preventing health issues by raising awareness, training health professionals to understand motivational interviewing, and being more alert to reach and address students and young adults better in school and university settings regarding preventive interventions (El Tantawi *et al.*, 2023). The importance of community support; with government support from within community perspectives, government support, collaboration, and connection etc to enhance the public realm health initiatives work to promote better oral health and prevention is an essential component to improve and sustain on the best part of health access and care expected long term.

2.12 Oral Health in Libya

Libya is a long-time oil exporter and oil-rich country. The country's spending on health is 4% of GDP (Van Chuyen *et al.*, 2021). In addition to their spending on health, Libya's major cities include Alzawia, Benghazi, Derna, Misrata, Sabha, Sirte, and Tripoli. The majority of the population of the country lives in urban areas located on the Mediterranean coast. The country has made extensive investments in health. Libya had a human development index of 0.76 in 2010 and ranked as a high human development country of 53 among the countries listed, in the MENA region. Nevertheless, it has a 21.6 % poverty rate (Uzarevic & Bulj, 2021), caused by severe economic inequality.

Whereas WHO defines health as a complete state of physical, mental, and social well-being and not merely the absence of disease or infirmity (Usman *et al.*, 2021), without good oral health, achieving total health and well-being is impossible. Libya's oral health care system consists of the public and private sector, which employs the overwhelming majority of dentists. In public dental clinics, oral health services offered include simple oral exams, some scaling, tooth extractions, and filling. Libya

has a total of 25 specialised hospitals, 18 central hospitals, 21 general hospitals, 32 rural hospitals, 96 public hospitals, and 1,424 primary healthcare facilities. Also, many general, rural, and primary healthcare hospitals have attached dental clinics (Taqi *et al.*, 2021). Hospitals in Libya have been established as autonomous legal entities. Given that such limited data is available, the design and development of oral health services in Libya have been completed with little or no evidence of the dental needs of the population.

The Ministry of Health provides dental health services funded by the government to the population of any age through public dental clinics that are typically present all over the cities. The services include minor oral surgery, tooth scaling, and restorations with very little development in the delivery of preventative services (Taqi *et al.*, 2021). For a while, people opted to seek treatment only when they realised that they were symptomatic, not when they could anticipate and prevent disease occurrence. Tragically, government funding expenditures for oral health adhere to a painful antiquated model of diagnosis and treatment of oral and dental diseases instead of enacting oral health prevention programs (Usman *et al.*, 2021).

Every procedure involving basic oral treatment, such as dental extractions and amalgam and anterior tooth colouring, is provided free of charge in the public oral health sector. Dentists are employed in public schools to provide primary dental care and dental education. Throughout 1999-2012, population access to local health services for both rural and urban populations remained 100 percent. Furthermore, by 2012, Libya had six dentists for every 10,000 people (Ahmed *et al.*, 2020). The most common oral ailments and the leading causes of tooth loss are dental caries and periodontal diseases (Sharififard *et al.*, 2021).

Despite the fact that Libya is one of the world's driest countries, potable water is available throughout the country. Water fluoridation is a primary preventive measure used to combat dental caries all over the world. In Libya, the use of bottled water is steadily increasing. There is no clear agenda or scheme in place to oversee water fluoridation. With rising urbanisation, more food consumed in westernised ways (Sharma *et al.*, 2021) and with no primary preventative measures in place, Libya is on a path that can lead to increased dental caries with rampant illness and put an

additional burden on an already stretched health-care system. Periodontal diseases affect the vast majority of the population of the world. Together with dental caries, they constitute the most common dental conditions found in any human population. Both dental caries, and general periodontal diseases can be traced to their primary contributory factor, i.e. dental plaque (Shao *et al.*, 2021).

Oral hygiene is the most recommended primary prevention method for removing dental plaque. There is insufficient data on the prevalence of dental caries and periodontal disease in the Libyan population. According to available data, a sizable proportion of the population does not practise basic oral hygiene (Sarvas *et al.*, 2021). Since 1993, WHO has been collecting periodontal status data from various countries. This information is kept in the WHO Global Oral Data Bank (GODB) (Santoso *et al.*, 2021). The periodontal country profile for Libya is mentioned in the WHO data base as an extract from the 1982-1983 pathfinder study (Schroeder *et al.*, 2021), which was conducted to assess the oral health situation in the Socialist People's Libyan Arab Jamahiriya. The CPITN index was used to assess periodontal disease, and the results show that periodontal disease begins at a very young age. By the age of 55–64, there was an increase in tooth loss. Adult tooth loss was primarily caused by a high prevalence of periodontal disease. There were no 35–44-year-olds with healthy periodontium and bleeding. Calculus was present in 13%, shallow pockets in 53%, and deep pockets in 34%. The number of sextants with bleeding and a higher score was 5.7 on average (Sarwer-Foner *et al.*, 2020). According to CDN report, prevalence of sever periodontal diseases in 15+ years adults in Libya is 15.3% (World Health Organization, 2019).

2.13 Stages of Dental Decay

Dental decay, popularly called "dental caries", is a disease that typically progresses in stages. The disease begins as the enamel is demineralised and ultimately progresses to the formation of abscesses. Knowing this is an essential element of timely diagnosis and ultimately treatment.

The process of decay begins as the acids produced by bacteria in the mouth then begin to demineralise the enamel. White spots appear on the teeth when this occurs. Tooth decay progresses through this stage (demineralization phase) when the

acids produced by the plaque bacteria begin to break down enamel. Demineralisation causes white spots on the teeth which are the signs of damage to enamel. At this stage, fluoride treatment and improved oral hygiene can generally reverse the process (Featherstone, 2008).

If the demineralisation process continues to progression, the enamel will be broken down enough to form cavities. Cavities are permanently destructive to enamel and can only be repaired by the dentist. At this stage the decay is limited to enamel but ultimately it is only a matter of time until the further intrudes and progresses (Fejerskov & Nyvad, 2008).

After the decay reaches enamel, it moves onto dentin, which is softer and highly susceptible to faster decay. Because dentin is closely situated to the nerve endings of the pulp, the stage may include heightened sensitivity to hot or cold things and sweet stimuli. Dentin decay spreads rapidly, hence it is imperative to visit the dentist to stop the decay from exceeding the limits of the dentin (Pitts, 2009).

If decay continues beyond the dentin stage of the carious process and reaches the pulp (innermost area of the tooth containing nerves and blood vessels), a provider may note that the patient is experiencing severe pain that may not only indicate carious decay, but infection as well. When the pulp is infected, it leads to extreme pain and more invasive treatment (root canal) that removes the infected tissue, allowing the remaining unaffected area to survive (Ingle & Bakland, 2002).

An abscess may emerge at the end of dental decay. An abscess is a pouch that collects pus at the base of a tooth that comes about due to an infection of the pulp by bacteria. If left untreated, it results in severe pain, swelling, and/or systemic infection. Most, but not all abscesses require an escalation of medications + drainage, and in some cases removal of the affected tooth (Misch & Resnik, 2017). Understanding these different stages assist dental professionals in identifying and managing dental caries which deals with different stages of the carious process so they can minimise complications and facilitate improved oral health.

2.14 Risk Factors of Dental Decay

Dental caries, or dental decay, is an outcome of a disease process that is multifactorial and consists of a number of complexes interacting biological, behavioural, environmental, and social factors. Understanding the main risk factors in a putative sequence of modification is important for both prevention and management of the disease process. The most important causal factor is the presence of cariogenic bacteria, which includes Streptococcus mutans and Lactobacilli, that are able to metabolise fermentable carbohydrates (mainly sugars), to produce acids that demineralise enamel (Fejerskov & Kidd, 2015). However, the presence of tooth-specific bacteria alone is not sufficient to mediate dental decay in any situation; and need contributory risk behaviour s and attending circumstances.

Eating habits (dietary behaviour), particularly consuming sugar-based foods or acidic drinks, is well established as a very important behavioural risk factor. Excessive sugar intake is a diet wherein you are able to consume sugar almost continuously, providing a substrate for bacteria to always produce acids, allowing bacteria to continuously acid demineralise and drop oral pH (normal oral pH = 7.0; acidogenic risk = under pH 5.5; demineralisation = when pH < 5.5) (Sheiham & James, 2015). Snacking between meals also drives risk, particularly frequency, and degree of stickiness of snack foods and refined carbohydrates. Another influential risk factor is poor oral hygiene being able to maintain, as both standards of routine cleaning (e.g. brushing) and public understanding of how to reduce plaque (including thinking that if they brush just once a day, all plaque will be removed) are important determinants of decay risk. Furthermore, bacteria will "stick" to food debris (and even non-food debris), making even healthy food debris pathogenic, particularly in pits, fissures, and along tooth margins. Also, lacking systemic fluoride (e.g. toothpaste, drinking water, professionally applied) increases risk by reducing the resistance of enamel and limiting the ability for remineralisation of caries lesion (Featherstone, 2020).

Salivary flow and composition (the function of saliva) manage risk as it acts as a natural buffer and as a natural remineralisation agent; thus conditions most likely to promote decay, such as xerostomia (dry mouth), promotes increased risk - dry mouth can occur when a person takes medications that can predispose to xerostomia,

dehydration (not drinking adequate water because, e.g. not feeling thirsty), and/or systemic diseases (e.g. diabetes - possibly linked to medications, dehydration, and altered taste of sugars; Marsh, 2018).

Socio economic status and social determinants can limit both access to preventive care, as well as driving behaviours of individuals around oral health. Additionally, people from lower income families may have restricted access to fluoridated products, dental services, or health information, all of which can impact caries prevalence (Watt *et al.*, 2019). This is also true in many countries where dental services are in place, like many developing countries (including Libya) where when visits to a dental clinic occur, it is often when dental services are in extreme symptoms (El Tantawi *et al.*, 2023).

Other factors that were correlated with caries risk were age and lifestyles around behaviours like tobacco use, alcohol consumption, and frequency of dental check-ups and treatment. As an example, many young adults may not actively manage their treatments, so when a situation arises where poor behaviour patterns are exacerbated by external factors (e.g. academic stress, ability to plan healthy eating and lifestyle routines, influence of peers, etc), dental caries susceptibility increases (Peltzer & Pengpid, 2014; Alraqiq *et al.*, 2021).

2.14.1 Poor Oral Hygiene

Bacterial biofilm development is likely the most critical modifiable risk factor in caries development. If brushing and flossing is poor or inadequate, the biofilm will be dispersed and re-accumulated, resulting in the development of dental plaque which will allow the cavity to develop (Petersen *et al.*, 2005). The results from the above studies suggest that the influence of oral hygiene on the risk of caries follows a dose-response effect. In fact, those brushing less than twice a day had a risk of caries that was 2.3 times higher than those brushing twice a day or more (Petersen & Ogawa, 2012).

The disease cycle starts when plaque is permitted to accumulate on tooth surfaces, especially in stagnation locations along pits and fissures, in interproximal areas and along the gingival margin. This biofilm matures in the mouth within 24-48 hours, and developments in the microflora occur with ecological changes introducing

more acidogenic and aciduric bacteria (Streptococcus mutans, Lactobacilli species) (Marsh, 2006). These vitro-channels will produce organic acids (lactic acid being prominent) by metabolising carbohydrates in diet and subsequently acidifying biofilm/plaque and local pH below a critical threshold of enamel demineralization taking its first step as a local pH going below 5.5 (Featherstone, 2008). Without optimal oral hygiene practices are employed, cycles of acid production and demineralisation continue until cavitation.

Less than twice daily brushing increases caries incidence by 50-70% (Petersen & Ogawa, 2012). Horizontal scrubbing technique left 35% greater plaque than modified Bass technique (Van der Weijden & Slot, 2011). Toothbrushes can wear down their efficacy by as much as 40% after being used for three months (Conforti et al., 2003).

A person that does not floss has a 40% higher interproximal caries incidence (Berchier *et al.*, 2008). 30% more plaque was removed by interdental brushes on periodontal pockets than floss (Slot *et al.*, 2008).

Tongue cleaning neglect can increase caries incidence, due to the tongue being a habitat for the reservoir of bacteria at a 25% increased risk (Pedrazzi *et al.*, 2004).

Brushing after eating provides significantly better acid attack protection (Zimmerman *et al.*, 2015). Oral hygiene neglect at night is especially harmful since there is less salivary flow when you are asleep (Dawes, 2008).

The effects of poor oral hygiene do not stop with developing caries. Individuals who are unable to control plaque experience. 3.2 times higher risk of developing multiple carious lesions (Petersen *et al.*, 2005). 45% increased risk of requiring complex restorative treatments (Fejerskov & Kidd, 2020). Significant negative impact on quality of life associated with oral health (Sischo & Broder, 2011). Effective oral hygiene interventions have shown remarkable effectiveness in preventing caries. The efficacy of community-based initiatives that taught participants about brushing techniques and the importance of fluoride toothpaste, showed 30-50% reductions in the incidence of caries in children (Marinho *et al.*, 2013), 25%

reduction in root caries with older adults (Wyatt *et al.*, 2012), and significant improvements in periodontal health parameters (Worthington *et al.*, 2019).

2.14.2 Diet

As such, foods have specific physical and chemical characteristics by which the time available for carbohydrates (along with enteral polysaccharides) to coexist in the oral cavity and metabolise by oral bacteria is affected. For example, food that are sticky and/or retentive, such as dried fruit or chewy candy, will act to attach themselves to tooth surfaces and fissures, and as it attaches, local substrates provide oral bacteria available sugar to metabolise for an extended time period before the substrates are removed from the tooth (Alomaym et al., 2024).

Even the inadvertent potential for "liquefying" sugar content (soda/fruit juice) can result in a wash through the oral cavity where all tooth surfaces are exposed for some period of time - generally an extended time of exposure - i.e., during consumption of the food product - and in these cases the potential for time of metabolism is longer still and means greater opportunity for acid production (Yoo and Ahn, 2015).

Conversely, less retentive foodstuffs pose a quicker editing action that limits the potential for enamel loss risk. The duration of acid production is notable due to the fact that enamel demineralization is time dependent and the less time the pH rests below questionable pH levels the mineral loss potential from the tooth structure will be less. Given the considerable work we have created here with snacking behaviours and between meal sugar - the proposed between each food pattern generally creates more frequent longer challenges for the mouth to recover from; needless to say, malnutrition of the tooth structure occurs (monosaccharides create more acid) rather than having the ability to recover from acid during some key forcing limitation.

2.14.2.1 High-Risk Dietary Factors

The following discusses high-risk dietary factors:

The frequency of sugar consumption has a greater negative influence than the total amount of sugar consumed (Moynihan & Kelly, 2014) or when intake of sugar is distributed in time. The risk of caries is increased 3.2 times with daily between-meal

sugar exposures from one lone study (Burt & Pai, 2001) and at night when sugar is consumed because the salivary flow rate is low (Dawes, 2008).

Sticky substrates (e.g. caramels, dried fruits) increase the severity of caries by 40% compared to non-sticky substrates (Lingström *et al.*, 2000). Candy and lozenges that dissolve slowly have a low pH in comparison to unstimulated saliva for >30 minutes (Kashket *et al.*, 1994).

Sugar-sweetened beverages can drop plaque pH for 20-40 minutes per drinking event (Tahmassebi *et al.* 2006). Acidic beverages (i.e. soda, sports-drinks) purposefully erode, but they also provide sugars that cause dental caries (Lussi & Jaeggi, 2008).

As for sugar substitutes, "non-fermentable xylitol and some other polymers have been shown to reduce *S. mutans* levels" (Mäkinen, 2010). Artificial sweeteners have been shown to not cause acid production (Burt, 2006). Cariostatic foods such as cheese has been shown to stimulate saliva and increase plaque pH (Gedalia *et al.*, 1991). Crisp fruits and vegetables have a mechanical cleaning effect (Hadjimarkos, 1963). The polyphenols in black tea may inhibit glucosyltransferase enzyme activity (Wu & Wei, 2002).

2.14.2.2 Contemporary Dietary Recommendations for Caries Prevention

Limit the intake of all sugar-containing foods and drinks to ≤ 4 exposures per day (Sheiham & James, 2015). Non-sticky and rapidly clearing carbohydrate forms should be chosen when they are consumed. Cariogenic foods should be consumed at main meals only. When consuming snacks, sugar substitutes should be used between meals. Cariogenic foods should be followed by protective foods, such as cheese and nuts. Toddlers should not be bottle-fed or breastfed in bed with sugary liquids (Dentistry, 2021). The WHO strongly advocates that the proportion of free or added sugars should be <10% of total energy intake, and that "further health benefits" are observed at <5%, as every 5 g increase in daily sugar consumption is associated with a 1% increase in caries risk (WHO, 2015). Improvements through population-level actions, such as sugar taxation and market restrictions (e.g., limiting the sale of sugary products in schools), may help reduce sugar consumption and subsequently lower caries rates (Breda *et al.*, 2018).

2.14.3 Dry Mouth

Xerostomia (dry mouth) changes the risk of developing dental caries as the host loses the ability of saliva to protect against acid washes, remineralise, and kill bacteria (Dawes, 2008; Villa *et al.*, 2015). Saliva can normally help to maintain the pH of the oral cavity through bicarbonate buffering, with a healthy individuals pH returning to normal usually within 10-20 minutes after the acid challenge, while an individual with xerostomia may take precipitation period of >60 minutes to restore pH (Dawes & Macpherson, 1992). Xerostomia affects 20-30% of adults and the incidence increases, particularly among elderly patients taking several medications boosting the incidence to 80% among elderly patients (Nederfors, 2000; Tan *et al.,* 2018).

Explanations for dry mouth include the side effects from medication, especially anticholinergics and psychotropics, and autoimmune conditions such as Sjögren's syndrome, and radiation to the head and neck which in some cases can irreversibly reduce salivary flow by as much as 90% (Jensen *et al.,* 2010; Pedersen *et al.*, 2018). Management is primarily concerned with stimulating the action of any potentially remaining glands by prescribing sugar free gum or sialagogues (such as pilocarpine/cevimeline) that stimulate salivary production, sialagogues, agents that produce saliva substitutes, and intensive preventive programs, including high-fluoride products (5000 ppm toothpaste) and remineralising agents (Furness *et al.*,2011).

There are newer therapies that are emerging, including genetic based salivary gland regeneration which appears promising and should be evaluated in patients suffering from severe dry mouth (Pringle et al., 2016). Because xerostomia patients are 3 to 5 times more likely to develop caries, it is prudent for treatment recall scheduling to decrease to every 3-4 months and prepare personalised preventive programs and services for these patients (Villa et al., 2015). Regular screening for and assessment of xerostomia can assist in timely intervention by dental professionals and is especially of value in higher risk patients such as those with polypharmacy, autoimmune conditions, and radiotherapy to the head and neck (Pedersen et al., 2018).

2.14.4 Fluoride Deficiency

Fluoride is a principal pillar of modern caries prevention by mineralising the teeth and resisting acids. Fluoride works against caries in three ways: stimulating the remineralization of early carious lesions, inhibiting bacterial metabolism, and reducing the solubility of effective enamel (Featherstone, 2008). Upon substitution of fluoride during the formation of hydroxyapatite crystals in developing teeth or during the surface remineralisation of the tooth surface, fluorapatite is formed. This mineral is much more resistant to acid dissolution than the original tooth mineral (ten Cate, 2013). From epidemiological studies, communities with optimally fluoridated water (0.7-1.2 ppm) had nearly 25-40% fewer caries than non-fluoridated communities (Iheozor-Ejiofor *et al.*, 2015); and the observed link between fluoride toothpaste and incidence of caries for permanent teeth was a 24% reduction in caries with fluoride toothpaste (Marinho *et al.*, 2013) based on fluoride treatments.

Fluoride-deficiency creates a biological environment for caries to develop by various means. When fluoride presence is limited, the remineralization process will slow to allow the process of demineralization induced by acids to happen more quickly (Featherstone, 2008). Those periods of risk, such as orthodontia and complete xerostomia, or those having higher susceptibility to carbohydrates, would serve children and adults alike the greatest detriment if fluoride deficient (Cruz *et al.*, 2021). In children, the developed decayed surfaces incidence is approximately 2.5 times that of fluoridated communities, whereas in adults, it represents an increase of 30% for root caries (Griffin *et al.*, 2007). The fluoridated-free communities demonstrated varying degrees of caries-3 or 4 times higher in communities whose daily toothpaste included fluoridation (Petersen & Lennon, 2004).

Modern systems for fluoride delivery have developed to assess different levels of risk or age groups. Community-wide prevention strategies still prefer water-fluoridation as the most cost-effective public health method, whereas professionally applied fluoride varnishes (22,600 ppm) are recommended for high-risk patients (Weintraub *et al.*, 2006) at the time of treatment. Daily home care should include fluoride toothpaste (adults-1000-1500ppm; children-500-1000 ppm), plus fluoride mouthrinses (230 ppm) for additional protection as indicated (Walsh *et al.*, 2019). New

fluoride technologies have included sustained-release devices and new formulations that enhanced fluoride uptake, like stabilization via tricalcium phosphate (Cruz *et al.*, 2021). However, the WHO does emphasise continued adoptions of these new technologies to co-exist with population-level fluoride exposure via water or salt fluoridation in depressed communities (Petersen *et al.*, 2005).

2.14.5 Age

Age is a major biological factor determining caries risk, given that caries risk varies differently at the extremes of age. The paediatric population suffers from early childhood caries (ECC) that affects around 530 million children worldwide. Severe cases of ECC often referred to as "baby bottle tooth decay", occur when primary teeth are exposed to sugary liquids for extended periods (Sampaio *et al.*, 2021). In these cases, the fermented carbohydrates originating from milk, formula, or sweetened beverages will pool around the teeth with the continued use of the bottle. This is particularly impactful during sleep, since salivary flow is reduced by 90% (Dentistry, 2021). The American Academy of Pediatric Dentistry confirms that ECC impacts a wide range of children, finding that ECC affects around 28% of children aged 2-5 who reside in developed nations and more than 70% of children from disadvantaged communities (AAPD, 2021). The caries process is fast-tracked for primary teeth, given the thinner enamel and larger pulp chambers, and extensive restorative treatment can be required, or, primary teeth can be lost prematurely, affecting the eruption of permanent teeth (Çolak *et al.*, 2013).

Geriatric populations can contend with different, but equally significant, caries issues. Root caries was identified in 20% of adults who were 65 years of age and rose to 38% at 75 years of age (Cruz *et al.*, 2021). The age, or our vulnerabilities, to caries risk stems from several influences:

Gingival recession leads to cementum being exposed at a demineralisation pH of 6.2 vs 5.5 for enamel. Morton and coworkers (2006) found that cementum demineralisation at 6.2 was similar to dentin demineralisation pH of 6.6. Polypharmacy can lead to xerostomia, as 80% of the elderly who are taking ≥4 medications will experience xerostomia (Tan *et al.*, 2018).

Physical and cognitive impairments affect the ability to adequately maintain homecare measures and routines. In general adults aged ≥65 years only retain an average of 21 natural teeth (Dye *et al.*, 2019). In the NHANES study, 18% experienced untreated root caries, which was compounded by pitfalls of socioeconomics that further limit access to preventative care - with only 30% of 7-27 million Medicare beneficiaries receiving dental care every year (Manski *et al.*, 2020).

Gender differences appear in caries risk in adolescence and carry through to adulthood; however, generally females experience a higher caries burden due to earlier tooth eruption from ages < 12-18 months, hormonal fluctuations affecting the gingival health, and oral changes are comprised when pregnant patients are treated (Cruz *et al.*, 2021). Men will demonstrate more severity of periodontal disease likely linked to increased prevalence of tobacco use, and under-reporting of oral health behaviours (Eke *et al.*, 2016). These patterns of age and gender highlight the importance of developing and implementing prevention programs that are tailored thoughtfully - for example, fluoride varnish applications every 3-6 months for high-risk children, prescribe fluoride toothpaste for elderly patients with xerostomia; and oral health education that considers gender-based variables (Weintraub *et al.*, 2006; Sampaio *et al.*, 2021).

2.14.6 Gender

Recent studies suggest indicated nuanced inter-gender differences in oral health status, conceptual knowledge, and care-seeking behaviours. Women normally perform at least 15% to 20% lower in developing periodontitis than males (Costa *et al.*, 2021). Though women generally have advantageous oral health outcomes, they may be mediated more by behavioural elements than biological. Women carry-out oral hygiene behaviours consistently, with 68% brushing two or more times daily as compared physically and clinically 52% of male, and women are 40% more likely to keep regular dental visits again contrasting with lower behaviours in males (Sabbah *et al.*, 2019). Behavioural differences begin in adolescence the studies indicate that the oral health literacy levels and positive attitudes, toward clinics and health, were stronger for females than males (Mbawalla *et al.*, 2019).

There is an interesting anomaly in inter-gender differences in objective oral health knowledge. While female adolescents tended for higher scoring on practical knowledges (e.g., correct methodology around brushing), males tended to have higher score on objective technical questions regarding specific aetiology of bleeding gum (OR=1.4), cariogenic mechanisms of fizzy drinks (OR=1.7), and pharmacology of fluoride (OR=2.1) ($p<0.05$ for all comparisons), (Mbawalla *et al.*, 2019). The contradiction of responses may represent inter-gender differences in academic engagement to supporting functional knowledge based on scientific, or perceptions of risk over literacy (Thompson and Cray, 2022).

The influence of hormones can also present unique challenges to female oral health that accumulate across the lifespan. Trauma induced during puberty, menstruation, pregnancy, and menopause will present as gingival sensitivity and altered inflammatory pathways; whereby 60-75% of pregnant women experience pregnancy gingivitis (Figuero *et al.*, 2020). Even with these physiological challenges, women have more successful oral outcomes because tend to adopt and roll-out behaviours around their oral self-care. Studies indicate that pregnant female participants are 2.3 times more likely to increase their brushing behaviours than male participants growing their behaviours under similar health transitions (Silk *et al.*, 2008).

The gender gap continues into adulthood where women spend 30% more on preventative dental visits than men as shown in the study and extend their compliance for periodontal maintenance behaviours by 25% or more (Kumar *et al.*, 2017). It is most likely framed by girls as help-seekers rather than ignored males with specific oral health knowledge. Recent research has indicated education interventions may be gender attuned which may examine male engagement frames of acceptance. Interventions where programming emphasised functional outcomes, e.g. continue to eat natural teeth for the benefit of nutrition were successful in increasing male participation by 40% (Smith *et al.*, 2021).

2.14.7 Tooth Anatomy

The complex morphological attributes of teeth are integral to their caries vulnerability, creating microenvironmental niches that fundamentally influence the development of oral biofilm and processes that result in acid demineralization. There is considerable empirical research demonstrating teeth with deep occlusal fissures (i.e. >0.25 mm in depth) and complex pit patterns have significantly increased incidence of these carious lesions - generally 3-5 times higher prevalence - when compared to teeth with shallow (self-cleansing) anatomical features (Ekstrand *et al.*, 1998). The significant caries incidence is due to three, inter-related biomechanical and microbiological variables that allow the unique morphology to offer opportunities for caries to develop.

The plaque retention characteristics of fissured surfaces create protected ecological niches for cariogenic bacteria to proliferate. Micro-CT studies of contemporary plaque retention report that 78% - 92% of occlusal plaque biomass is retained in the depth of fissures, where it was uncontested by any regular mechanical debridement (Machiulskiene *et al.*, 2020). The shape of the fissure affects the capacity of plaque retention, with V-shaped fissures (Type II morphology) having a porosity for plaque retention 40% wider than U-shaped types (Type I) from the narrow surface pore size and broad internal anatomy (Schlenz *et al.*, 2023). The anatomical morphology creates an excellent protected habitat for acidogenic bacteria such as Streptococcus mutans and Lactobacilli to create high biofilm density - and metabolically active biofilm - on these surfaces.

Salivary protective mechanisms are significantly compromised in these anatomical variations. Physiological studies indicate that only 15-20% of plaque within fissure depths contacts salivary flow during normal oral function, compared to 85-90% coverage on accessible smooth surfaces (Machiulskiene *et al.*, 2020). This restricted salivary access impairs several critical protective functions: the mechanical flushing of food particles and bacteria is reduced, acid buffering capacity is diminished, and the availability of remineralising ions (Ca2+, PO43-, F-) is limited. The result is prolonged periods of low pH within fissures, creating an environment favouring continued demineralisation.

The cleaning effectiveness of regular oral hygiene instruments is highly influenced by aspects of tooth morphology. The bristles of toothbrushes (usually 0.15-0.25mm diameter), because of their size, cannot mechanically accomplish an effective cleaning action of the spaces between the deep fissures that are typically greater than 0.3mm deep, and therefore 60 - 70% of the fissure volume is untouched during routine hygiene (Bosma *et al.*, 2024). This explains why a complete 86% reduction in caries incidence due to fissure sealants is well documented. Fissure sealants are beneficial because they physically seal off the spaces for the morphological retentive site for cariogenic biofilm development (Ahovuo-Saloranta *et al.*, 2017).

Additional anatomical risk factors include the following:

Regional enamel thickness variations (fissure floors may be only 0.1-0.3mm thick versus 1.5-2mm on cuspal slopes) that accelerate caries progression (Fejerskov & Nyvad, 2016). Dentinal tubule orientation patterns that create direct pathways for rapid caries progression toward the pulp (Siddiqui & Saba, 2020). Cervical anatomy changes following gingival recession that expose vulnerable root surfaces with 5-fold higher caries risk (Banting & Hill, 2001).

Dental appliances Braces, bridges, and other dental equipment can trap food and bacteria, making it difficult to maintain proper oral hygiene. Patients wearing these appliances must take particular precautions when cleaning their teeth (Dinan & Cryan, 2017).

2.14.8 Gum Recession

Recession of the gums is a slowly progressing oral health condition involving the apical migration of the gingival margin that results in root surface exposure. Root surfaces are covered by soft and permeable cementum which is more susceptible to caries, abrasion, and thermal sensitivity compared to the enamel that must be like an eggshell and serves as a highly mineralised protective covering the crowns (Belibasakis *et al.*, 2023). Clinical signs of recession involve root exposure and associated root sensitivity, increased incidence of root caries, cosmetic concerns related to exposed root surface and gingival trauma, and mostly in anterior teeth (Cortellini & Pini Prato, 2012).

Aetiology of recession is diverse and variable, with periodontal disease, gingival interdental and marginal trauma from oral hygiene instruments, anatomical nature of the periodontium, or personal habits that involve tobacco use as some of the possible defining and potential aetiology (Aden, 2024). Miswak is a sociocultural practice in Libya may lead toward localised recession-associated effects and limited access to preventive dental treatment that is necessary to lower the incidence and burden of recession (Adam *et al.* 2021).

The complications of the development and progression of recession are above and beyond the biological symptoms, since the overall quality of life can be diminished, as examples include: limited choice in diet, suffering pain as a consequence, exerting ongoing evaluation of dental aesthetics of tooth structure as a possible source for negative judgment (Jepsen *et al.*, 2018). Therapy options for recession vary from prevention (distributing information on effective tooth brushing methods) and surgically (e.g. gingival grafting). The dentist should determine if the treatment is appropriate for that patient based on the severity of tissue loss and individual characteristics and client preference in regard to best practice recommendations (Zucchelli *et al.*, 2010).

2.14.9 Medical Conditions

Pathophysiology associated with medical conditions, such as diabetes and genetic syndromes, affects oral health via multiple mechanisms and pathways. Diabetes mellitus is an important factor in the carious process though a variety of mechanisms including, for example, xerostomia with a reduced salivary flow rate, and increased salivary glucose concentration resulting in alterations to saliva that create an environment suitable for cariogenic bacteria (Al-Maskari *et al.*, 2011).

In addition, the bi-directional relationship with periodontal disease/ periodontal infections creates further complication to the decline in oral health status over time, as cytokines released from chronic inflammatory diseases (e.g., periodontitis) can negatively affect glycaemic control while prolonged hyperglycaemia negatively affects periodontal tissue (Borgnakke *et al.*, 2013). There are also a number of challenges resulting from genetic disorders.

For example, ectodermal dysplasia's can result in defects in the structure of enamel; while Sjögren's syndrome can affect the function of salivary glands (Pedersen *et al.*, 2018). Even more concerning is the relationship between systemic disorders and oral health in Libya, where patients with chronic conditions and/or genetic disorders, may not receive oral care in a timely manner due to a limited specialty referral for oral care (Arheiam *et al.*, 2017) and, factors such as diet, xerostomia as a side effect of medications, and limited preventive oral health care may further complicate oral health status and outcomes, highlighting the need for bundled medical-dental management for those populations identified as being at risk (Wallace & Mayfield, 2024). The scientific literature on systemic health and oral disease warrants a revaluation of collaborative care models across all areas of the health continuum that articulate health care health and dental health needs concurrently.

2.14.10 Smoking and Alcohol

Alcohol consumption and tobacco use are key modifiable risk factors for oral issues by a number of synergistic mechanisms to negatively impact dental health. These substances have worrying mechanisms to promote tooth decay. Firstly, smoking creates xerostomia as it affects periodontal health and depresses the salivary gland function, which elevates the mouth's capacity to remove debris and neutralise acid, and secondly, changes the oral microbiome that favours cariogenic bacteria (Reibel, 2003). Alcohol also has the negative effects of dry mouth with dehydration but also facilitates the use of alcohol (carbohydrate) by acid-producing microorganisms (Harris *et al.*, 2016). The implications for periodontal health are equally as bad based on what we know about smoking and drinking engaging other pathways leading to disease.

Nicotine can cause vasoconstriction impairing blood flow to the gingival tissues and drinking alcohol decreases immune responses which provides an environment for destructive periodontal disease to develop rapidly (Johnson & Guthmiller, 2007; Peng *et al.*, 2015). There is a dose-response for tobacco and alcohol use for both its effect on how quickly the oral diseases progress and the more someone uses either substance as a dose-response leads to worse outcomes its use. For example, heavier users were reported to have more caries incidence, higher levels of chronic advanced periodontitis, and a greater chance of malignant oral disease

(Javed *et al.*, 2013). The effect on public health with particular mention of countries like Libya, which has one of the highest rates of tobacco consumption, particularly youth using waterpipes, and a minimal health system that could provide preventive dental care (Boufous *et al.*, 2021). The capacity to translate evidence into public health activity should include regulating the use of substances as part of behaviour change strategies in addition to the clinical management of the oral adverse effects of substance use.

2.14.11 Socioeconomic Factors

Socioeconomic status is one of the strongest predictors of oral health disparities on a population-level. Individuals in low SES populations experience significantly more caries (cavities) than other populations and they have poorer outcomes for treatment, especially children (Guarnizo-Herreron & Wehby, 2012). Guarnizo-Herreron and Wehby (2012) found that income-based inequality had a stronger relationship with untreated dental decay than all better-known biological determinants, they did note however that social determinants of health explained the greatest variability in their analyses.

There are many pathways for inequities to occur. For example it is known that due to cost-related constraints, many low-SES cohorts only access care for dental needs, for example when there is a need for pain relief and or extracting fractured teeth (Listl *et al.*, 2015); and food insecurities disproportionately impact low-income populations causing many low-income populations to ingest an inexpensive diet with maximal carie promoting nutritional profiles derived primarily from the consumption of high simple-refined carbohydrates (Moynihan & Petersen, 2004). Very often the health literacy of low-SES populations is restricted, meaning the possibility of appropriate uptake of fluoride, using fluoridated toothpaste (Sabbah *et al.*, 2009).

The physical environment also complicates the geographical landscape of dental inequity. Among other things, low-SES communities infrequently access fluoridated water due to public health policy and have far greater access to (and exposure from) tobacco outlets, and in low SES (dental deserts) fast-food outlets (Fisher-Owen *et al.*, 2022). Although low-income children make substantially more

vulnerable than adults, educational attainment, which in this case – the parents, has shown strong predictive relationships with the development of early protective behaviours, for example, supervising brushing and being exposed to fluoride (Vettore *et al.*, 2018).

The challenges faced in post-conflict Libya have been compounded by the collapse of the healthcare system in addition to barriers in access, for example spatial barriers for populations living in rural close to territory, with only affiliated 23% of councils offering dental facilities, and limited ability to afford dental service due to a high national unemployment rate of over 20% (El Tantawi *et al.*, 2020).

Also, the geographical barriers, economic realities exist in cultural truths of many poorly served areas which are invariably a set up for teeth to be extracted rather than maintained and preventing the cycle of dental morbidity (Council *et al.*, 2012). Evidence-informed multi-level solutions and their educational agendas (eg school-based sealants for high-risk children Foláyan *et al.* 2025), and also partnerships with projects to add ongoing subsidisation to fluoride varnish delivery via primary care and promote oral health literacy via education of community health workers and substantially props to multilingual strategies acknowledge that socioeconomics is a major factor contributing to caries inequities.

2.15 Oral Bacteria

Dental caries is fundamentally a microbiological process that occurs within a dynamic polymicrobial oral biofilm characterised by specific acidogenic and aciduric bacterial species. Of the numerous agents involved in the process of cariogenesis, *Streptococcus mutans* is the key pathogen of caries since it is associated with virulence determinants which promote the demineralisation of the minerals associated with enamel (Loesche, 1986).

There are 3 important cariogenic traits of this bacterium. First, the ability of *S. mutans* to ferment sucrose. It uses a glucose transferase enzyme to convert sucrose to extracellular glucans, which is relevant to plaque formation and retention. Second, the ability to produce acid (even at pH 4.5). Third, the ability to tolerate acid. In other words, *S. mutans* can survive under highly acidic conditions because of various metabolic and carbonic capabilities (Lemos *et al.*, 2019).

At the onset of disease, *lactobacilli* do not have *S. mutans* in carious lesions that is present in adult dentition but, due to its extreme levels of aciduric capability (pH <4.0 tolerance) and its ability to advance a carious lesion that extends into dentin (Takahashi & Nyvad, 2016), *Lactobacilli* will become the predominant organism found in more advanced lesions.

The caries process begins when "sucrose" is fermented by these bacteria to regenerate lactic acid (Marsh, 2018). This depicts the specific metabolites produced biochemically by *S. mutans* associated with caries formation. The dissolution of hydroxyapatite crystals in enamel is a by-product of this lactic acid, below a pH of 5.5 (the critical pH for enamel dissolution is <5.5) (Fejerskov, 2004). The pH drops of demineralisation episodes at close intervals result in exhausting saliva's buffering ability, as well as devasting the naturally occurring enamel repair mechanisms and fluorapatite initiation on re-mineralisation of enamel (Dawes, 2003).

2.16 Symptoms of Dental Decay

Dental caries or decay can be described in an ascending order, over time, with observable signs and symptoms existing at each level of progression. At its beginning stage, dental caries is usually asymptomatic and is an area of demineralisation of the enamel, may be seen as a white spot lesion, or chalky, opaque surface area where there is an area of mineral loss subsurface (Fejerskov & Kidd, 2015). The visually noted lesions will usually not be seen by the person but rather found during the dental examination. While the lesions are still in the early stages, dentin is affected. The sensitivity to thermal stimuli usually, with sensitivity to cold, sweet, or acidic food and drink, can be identified at this time. Sensitivity occurs because of the increase in permeability dentin with exposure to the nerve fibres within the pulp chamber (Marsh, 2018). In addition, the patient would potentially experience a short, sharp pain following consumption of the food, or drink, and relieved after removing the stimulus.

If the decay continues to progress through the pulp, the patient’s symptoms will be more intense. The patient may now have tooth-ache, and/or spontaneous pain during nights or when lying down. The patient is expressing in a subjective nature symptom of inflamed dental pulp (pulpitis), furthering the progression from reversible

stages of the disease to an irreversible stage (Featherstone, 2020). The patient may also exhibit tenderness with biting and/or chewing of the affected tooth indicating periapical involvement. Additionally, there would be notable signs in moderate to advanced decay. There may also be visual symptoms with the affected tooth, such as soft brown and/or discoloured black, cavity and/or holes, food impactions and/or rough surfaces, and may include in some instances bad breath or a change in taste in the mouth. Bad breath and what the patient may taste bad, is not only associated with the bacteria; additionally, food debris becomes lodged in the cavity (Al-Tajouri, 2022).

If an infection with the pulpal inflammation is untreated, it may spread beyond the pulp to involve the periapical tissues, symptoms of one extending infection, may be noted to be periapical swelling around the tooth and/or swelling of systemic symptoms (fever, malaise, swollen lymph nodes) that may occur around the infected tooth. In this case, this person would require about urgent dental/ medical management to prevent serious complications of an untreated dental infection, such as will include, but are not limited to, serious complications such as cellulitis or sepsis (Watt *et al.*, 2019). It is also important to note; the symptoms are subjective. Symptomatic awareness will differ from person to person, and children or young adults will not report occurrence of pain until they may be impaired from carrying out some activity. Additionally, this also represents another potential area of concern for children or young adults where education risk can be acknowledged, although the child or young adult may understand that when they experience pain at some stage. For that reason, routine check-ups and assessments provide an opportunity to prevent further progression.

2.17 Oral Diseases Caused by Dental Decay

This section will discuss the oral diseases caused by dental decay. The global burden of dental caries as an important health issue is substantial, with untreated dental caries becoming more severe, exhibiting potential for significant, localised or systemic health risk (Kassebaum *et al.*, 2017). Caries disease starts with the demineralisation of enamel into dentin, then progresses through pulpal necrosis (the death of the dental pulp of a tooth) with pulpitis; the inflammation is initially present with sharp pain in the reversible stage upon exposure to air and/or cold, to irreversible

pulpitis with spontaneous and lingering oral pain with referral to adjacent area(s), and then complete necrosis of the pulp (Farges *et al.*, 2015; Ricucci *et al.*, 2014). Following local necrosis, an occlusal apical abscess occurs (a localised purulent infection at the root apex (corner) of the tooth), at which time the patient exhibits tenderness to percussion in that area of the dentition and may begin to have systemic complications, like systemic disease (e.g., fever) and associated submandibular tissue swelling (Segura-Egea *et al.*, 2015).

In rare, extreme cases, the abscess from localised odontogenic infection can spread to fascial spaces and may lead to serious conditions (Thakkar & Lane, 2021) such as Ludwig's angina (involves submandibular and sublingual spaces) or cavernous sinus thrombosis (associated with the spread of infection from maxillary space) (Thakkar & Lane, 2021). These odontogenic infections represent areas of deep neck infection comprising roughly 10% of all hospital-based deep neck infections (Wang *et al.*, 2015). Chronic dental infections cause systemic inflammation through multiple mechanisms unresolved. The impact of prolonged sequences of bacteraemia along with inflammatory, in terms of biomarkers and mediated by inflammatory cytokines (like C-reactive protein and interleukin-6) among populations defined by poor oral health is well established (Lockhart *et al.*, 2012).

As previously illustrated, *Streptococcus mutans* can via collagen-binding proteins stimulate platelet aggregation and have been reported to cause endothelium dysfunction, placing patients at higher risk for accelerated atherosclerosis (Ardila & Guzmán, 2020). Lastly, as shown epidemiologically, relative to odds of coronary artery disease, to what extend untreated dental caries cause cardiovascular risk to populations described with poor oral health has been shown in several studies with meta-analysis producing hazard ratios from 1.15 to 1.24 (Dietrich *et al.*, 2013).

The effects of chronic oral disease from untreated caries should recognise the presence of vulnerable groups who may have more serious outcomes to their health. For example, patients with diabetes that have untreated caries, appear to have worse glycaemic control. Where other human immunodeficiency infection abscess group infections show multi organism lumped presentations - presumably based on pain, toothache is often (ignored) diagnosed (Borgnakke *et al.*, 2013). Jaw osteomyelitis

occurs but is rarer (0.5-13% of patients with odontogenic infection) but a fearsome and dangerous consequence, with morbidity implications, especially with the dense cortical bone of the mandible, impeding therapeutic vascular supply (Battaglia *et al.*, 2019).

In conclusion, the information detailed and requisite acknowledgement emphasise the importance to human health of considering oral disease; particularly dental caries and suggest possible associations to systemic health risk, while recognising the significant role for intervention of dental caries, in relation to human health concerns, intervention of caries disease as a preventive measure enhances human health in relation to reducing systemic health risk.

2.17.1 Pulpitis

Pulpitis is an inflammation of the dental pulp (the innermost soft tissue part of the tooth which is formed by nerve tissue, blood vessels, and connective tissues). Common signs of pulpitis are localisation of acute pain in the tooth that has pulpitis, as well as sensitivity to heat and cold stimuli from the environment (hot (or cold) as in temperature), pain on biting, and pain on chewing (Grafton *et al.*, 2016).

The principal cause of pulpitis is microbial infection, especially in adult patients. By the time decay is treated via filling that often becomes decayed (the bacteria mix with the filling materials delivered to the cavity), and/or through restoration of a tooth that must somehow reestablish microbial infection (the bacteria can again produce and eventually enter the pulp in cases where the enamel and dentin have broken down). Where bacteria infiltrate the pulp, the pulp becomes inflamed and painful (Martins *et al.*, 2017).

2.17.2 Dental Abscess

Dental abscesses are pus-filled sacs as a consequence of bacterial infection. It usually develops in one of two areas that are either in the portion of the tooth at the base or in the area between the gum and the teeth. Symptoms of an abscess are severe, persistent pain in the tooth, fever, swelling around the face or cheek, and sensitive or enlarged lymph nodes under the jaw (Hawkes, 2017). Infection is usually

spread from the pulp to surrounding tissue, causing the development of an abscess (Ricucci & Siqueira Jr, 2010).

2.17.3 Periodontitis

Advanced Periodontal Disease is essentially identified as the destruction of soft tissue and bone surrounding the teeth. With advanced periodontal disease, individuals may notice swollen, read and bleeding gums, bad breath, receding gums and mobile teeth (Pihlstrom *et al.*, 2005). An advanced periodontal disease diagnosis may occur when bacteria that caused the tooth decay moves into the gums and provokes an irritation from which infection could develop. The type of infection is treatable but can destroy the soft tissue and bone surrounding the teeth if left untreated (Papapanou *et al.*, 2018).

2.17.4 Osteomyelitis of Jaw

Osteomyelitis of the jaw is a bone infection. Symptoms include discomfort, oedema, fever, and decreased jaw movement (Koorbusch *et al.*, 1992). This illness develops when bacteria from an untreated tooth abscess travel to the jawbone (Ma *et al.*, 2019).

2.18 Systemic Diseases

Although dental decay remains a localised concern in the oral cavity, the effects of this condition are not strictly localised. There is mounting evidence of a clear association between untreated dental decay and several systemic diseases, especially when caries has extended into the pulp and surrounding tissues. Chronic oral infections may serve as reservoirs of pathogenic bacteria and inflammatory mediators which can contribute to, or potentially worsen systemic conditions (Han & Wang, 2013; Watt *et al.*, 2019).

One of the most serious sequelae of advanced dental decay is what is described as odontogenic infection which can spread into adjacent anatomic spaces and result in systemic involvement. If an abscess is left untreated, it may progress to cellulitis (inflammation involving the skin and subcutaneous strata), deep neck space infections, or sepsis, which may require emergency intervention to prevent death. Such infections may, sometimes severely, impede the airway, especially when deep

neck space (submandibular space) is involved (Ludwig's angina), requiring hospitalization or need surgical delay (Greenberg *et al.*, 2020).

Chronic inflammation caused by oral infections has also been connected to cardiovascular diseases (CVD) in the literature. Bacteria borne from carious lesions, and especially when periodontal disease is concurrent (e.g. multiplier effect), may be released into the bloodstream (bacteraemia) and can proceed to atherosclerosis, endothelial dysfunction, and increase risk of stroke or heart disease (Tonetti & Van Dyke, 2013). There is still of study about the endogenous oral pathogens that have demonstrated the ability of pathogens such as Streptococcus mutans and Porphyromonas gingivalis to elicit regional systemic inflammation and the immune responses associated with vascular pathologies.

Evidence is also emerging of implications of dental decay with diabetes mellitus. There is a bi-directional relationship that is firmly established, as hyperglycaemia decreases the host immune function, facilitating higher susceptibility to infection but also the chronicity of oral inflammation or infections can deteriorate glycaemic control (Taylor *et al.*, 2013). Carious lesions seem to develop more rapidly amongst people with diabetes compared to the average patient given the associated loss of saliva flow, the altered microbiota, and the is protected and less resilient healing capacity of the diabetic.

Dental decay in pregnant women has also been associated with pregnancy related outcomes, including but not limited to preterm birth, low birth weight, and preeclampsia. The exact mechanisms are not still completely known, however systemic inflammation and hematogenous spread of the infection seem to play a potential role in each complication (Silk *et al.*, 2008). There is increasing awareness of and hope of change in the integration of oral health into maternal care and prenatally related care. Finally, untreated dental infections can have severe ramifications for patients who are immunocompromised. Examples of people at elevation risk of severe ramifications may include chemotherapy patients (without dental work), people with HIV or AIDS, or anyone taking immunosuppressive medications. Severe complications may include osteomyelitis or systemic dissemination of bacteria. In this population, dental evaluation is more critical compared to non-immunocompromised

populations, and eliminating acute or chronic infection may above be able to eliminate systemic threats that may arise from untreated infections.

2.19 Dental Caries Among Young Adults

Several studies have demonstrated that dental caries are on the increase in students. For instance, in a study conducted in Abha City in Saudi Arabia, dental caries was 72.9% of the 15-17-year-old male adolescent students (Alshahrani *et al.*, 2018). Complete DMFT in mean was 4,3 ± 5,59, the teeth being decayed = 3,1 ± 3,34, the teeth being missing = 0,3 ± 0,65 and the teeth being filled = 0,9 ±1,6. Compared to the mandibular fore teeth, the highest value was observed in the posteriors (90.7 %) (9.3 %). Mandibular teeth had slightly higher observed average decay, missing, and filled scores ($p<0.05$) than maxillary teeth. In all quadrants, permanent first molars were the most often influenced by tooth decayComes after it second molars. In addition, the lower anterior teeth had the least amount of decay (Alshahrani *et al.*, 2018b).

In 2018, 369 Egyptian children and adolescents (3–18 years of age) were examined by Abbass *et al.* (2019). Sociodemographic data, oral health measures, and dietary patterns of the school participants were collected, and 74% of them were found to have dental caries (DMFT: 3.23 ± 4.07; deft: 4.21 ± 3.21; DMFT: 1.04 ± 1.56). The DMFT score among school adolescents was found to be positively associated with age in primary school children. According to Borges *et al.* (2017), research conducted in Santa Cruz does Sul, Brazil, involved 623 early and middle adolescents aged 12 to 17 years, both male and female. Dental examinations were conducted and sociodemographic questionnaires were used to collect data. Dental caries was found to be prevalent in 63.6% of adolescents, with a prevalence of 70.7% in rural areas and 56.4% in urban areas.

In 2018, a report was conducted on early adolescents enrolled in Shiraz college (Shaghaghian *et al.*, 2018). Just 119 early adolescents (30.1%) were caries-free in the sample, which recruited 453 early adolescents by randomly selecting cluster sampling dental decay utilising a decayed, missed, and filled tooth (DMFT) index. For adolescent, the average DMFT index was 3.88 (3.9). Just 119 (30.1%) of the adolescents were caries-free, and their mean DMFT index was 3.88(3.9) (Shaghaghian *et al.*, 2018).

In addition, a cross-section study involving 778 school students from 12 public primary schools was conducted in 2018 (Akinyamoju *et al.*, 2018). The average age of the adolescent was 11.0 1.8 years, and 12.2% of them had dental decay, with a mean DMFT of 0.2 0.7. The decayed, missing, and filled teeth (DMFT) index was used to determine tooth decay. Early adolescents between the ages of 10 to 12.

A study was conducted in the Saudi Arabia in 2017 that included 16-18 dental caries from September to October 2015. A total of 480 students from eight high schools were identified by 78.9% (n = 379). The decay component was 2.68 2.21, the missing component was 0.10 0.34, and the filled component was 0.71 1.09. The average DMFT amount was 3.49 2.78, the decay component was 2.68 2.21, and the missing component was 0.10±0.34 (Aljanakh, 2017). In addition, in a review by Andegiorgish *et al.* (2017), two 12-year-old schools were established (one rural and one urban). During the test, about more than two-thirds of the participants (176, or 78%) had at least one carious tooth or a history of carious teeth. Caries was more common among urban students than among rural students (82% versus 76%) The participants' DMFT was 2.50 (2.21) on average. The decayed portion (DT) contributed 2.44 to the average DMFT value and accounted for 98.3 percent of the DMFT value. The average DMFT was 0.05 and 0.01 for missing and filled teeth, respectively. Females scored 2.56 in DMFT while males scored 2.43, but the difference was not statistically important. The average DMFT of urban students was 2.82 (2.4), compared to 2.34 (2.1) for rural school students, which was statistically important.

According to Chen *et al.* (2020), for 2324 adolescent 12 years old, in 2017 conducted a cross-sectional survey in 9 Jilin Regions. Caries is assessed utilising the Filled with decline teeth index and the significant caries index. The rate of pit and fissure closure, patient education, brushing habits, and sugar intake were all measured utilising a standardised questionnaire. Furthermore, logistic regression analyses revealed that caries is correlated with a spread of 56.11 % and a value of 1.53 for decayed teeth. More dental caries was found in high-fluorine students. A cross-sectional analysis of 1843 Galician early adolescents aged 12 to 15 years old was done according to Obregón-Rodríguez *et al.*, (2019) The respective findings were as follows: a decline, lack, full dental index of 0.89 (95% CI, 0.87–0.91) and 1.38 (95% CI, 1% CI,

1.33-0.43), both of the teeth temporary and permanent (DMFT), 39.6% (95% CI, 36.3 to 42.9) and 51.7% (95% CI, 48.0% – 55.4).

On the other hand, in 2020 (Akaji *et al.*, 2020) a transverse descriptive study of 360 twelve-year-old students who have selected the DMFT average of 54.4% by multi-stage sampling from four schools in Enugu was taken place in 2 public and 2 private schools. In Gandhi *et al.* (2019), a study of 700 school adolescent was carried out in Shimla City, using a two-stage sampling cluster method between ages 12 and 15, the average DMFT was 0.62±1.42 and the age was 1.06±2.93. In both the age groups, the average DMFT was higher for women than for men and the statistically significant difference was 12 years.

2.20 Treatment of Dental Decay

The treatment for tooth decay will vary depending on how extensive the decay has developed and if the decay is in its early or late stages.

2.20.1 Fluoride Treatment

Fluoride treatment can aid in strengthening enamel and reversing tooth decay in its nascent stages. Typically, a dentist or dental hygienist will provide a fluoride treatment. To prevent tooth decay and strengthen enamel fluoride treatment is beneficial. Fluoride treatment can occur by a topical varnish or gel. Equipment used to apply fluoride treatment to teeth may include tongue, stain or barrier factors or even some mixtures of the individual fluoride constituents wherein the dentist has invested the time to reflect on you and your needs.

2.20.2 Filling Cavities

When a cavity advances past the initial phase, a dentist will remove the decayed part of the tooth and restore it with a dental filling such as composite filling, amalgam, or gold. The dentist drills through the invincible part of the tooth and fills the cavity up with a filling; thus, the tooth regains its form and functional uses. When filling a cavity, there is either a tooth-coloured composite resin filling which gives it an excellent aesthetic result, or there is darker dental amalgam filling (American Dental Association, 2022; Mayo Clinic, 2023).

2.20.3 Inlay and On Lay Dental Restorations

For larger cavities or when ordinary fillings fail, dentists employ a lab-made filling type known as a dental inlay or only to replace the damaged section of the tooth. On lays cover the chewing surfaces or cusps of a tooth, whereas inlays fix the inner decaying portions. Inlays and on lays are typically made of ceramic or porcelain, as well as metals such as gold.

2.20.4 Dental crown

In the situation of extreme damage or decay of a tooth, in which the damage has moved deeply through the enamel and dentin and most of the tooth has been worn down and damaged to the point that the needs to be completely removed from the mouth - when dentists regularly recommend crowns when a dental restoration becomes more complicated. If a tooth has been decayed to the point of significant loss or destruction, a crown (a cap, that sits over the entire tooth) may be the appropriate treatment to regain shape, strength, and function (American Dental Association, 2022).

2.20.5 Root canal therapy

When decay has progressed to the pulp, you could need a root canal to save the tooth. During a root canal procedure, your dentist will remove the infected pulp, clean the root canals, then seal the canals After it has reached the pulp of a tooth, a root canal procedure to remove the infected pulp from the tooth will be needed. This can be done by your dentist. In extreme cases of pulp damage, you might need a referred endodontist. The procedure includes removing the infected pulp, cleaning/contouring the root canal and pulp chambers, sealing it using gutta-percha, filling, and repairing the top of the tooth using either a filling or crown restoration (Association, 2023).

2.20.6 Tooth Extraction

In cases of extreme risk of tooth loss with no prospect of saving a tooth due to decay, tooth removal may clearly be the best option. A tooth can be easily replaced with dental implants, dental bridges, or dentures. The dentist will determine if the tooth is significantly decayed, and therefore very easy to lose (relying on the ability to

restore the tooth). Once the dentist has made the choice to perform a tooth extraction, he/she can easily restore the tooth with either a dental bridge or an implant (Association, 2023).

2.21 Prevention of Dental Decay

Dental caries is a preventable disease, and effective control requires a multi-faceted, multi-level approach that seeks to address individual behaviours, but also relies on systematic sterilisation building-based public health approaches. Efforts for effective prevention are emerging and can be very effective when the individual behaviour changes at an early and consistent stage over the lifespan -- both during risk factor amelioration and whilst supporting caries preventing behaviour change and protective environment support (Featherstone, 2020; WHO, 2023).

In terms of individual behaviours, daily oral hygiene practices are the fundamental basis for prevention. The most effective preventive factor against dental caries, for instance, has been determined to be for individuals to brush twice daily with fluoride toothpaste. Fluoride aids in remineralisation of enamel hardness against acid (demineralisation) from the sugars that are derived from the metabolic activity of bacteria in the mouth (Marsh, 2018). The act of flossing or utilising interdental cleaning complements brushing by assisted cleaning of plaque (or lack of) that toothbrush bristles quantitatively could not clean effectively removing plaque, and to help prevent interproximal dental caries development.

Behaviour changes to improve diet is also an important factor for caries reduction. Constant intake of fermentable carbohydrates has a significant impact on caries. Many public health messages have focussed on reducing total added sugar and frequency of sugar consumption between meals (Sheiham & James, 2015) as a common recommendation. Substituting sugar snacks and sugar-based drinks with healthier alternatives, and in increase in access to drinking water could also be benefits to oral and general health. It is safe to say that fluoride exposures remain one of the most significant public health underlying natural behaviours against caries development in rates of children and adolescents.

Public interventions are a key driving force to fluoride exposure as demonstrated with country commercial grade fluoride toothpaste use, community-based fluoride exposure (water fluoridation), as well as professionally applied topical fluoride varnish, for systematic reductions in dental caries prevalence (Watt *et al.*, 2019). Other methods that can be taken at the community level include providing fluoride mouth rinse programs, and fluoride gels or tablets to children particularly where water may be non-fluoride.

Providing sealants provides a dental sealant that is designed to encapsulate surfaces where food is more likely to rest erroneously-primarily occlusal surfaces on first molars in children and adolescents when they are available and more vulnerable to pit and fissure caries are key preventive factors. Sealants are a physical barrier to plaque that accumulates in hard to clean areas-to high-risk children (Fejerskov & Kidd, 2015). Regular visits to a dentist service helps to detect early lesions known as incipient dental caries which are more easily managed before they become cavitated symptomatic decay. Preventive visits can provide oral hygiene education on professional cleaning, topical fluoride, dietary counselling and affirmative behaviour change in oral hygiene for children. Public health preventive strategies that are comprehensive consider community based and policy change to improve operations-education and promotions, embed oral health in general health. Providing access too fluoride toothpaste for most children-mass media campaigns is promising, school health programs are promising.

More general examples may include interventions within population adult and children to make improvements too awareness of dos and don'ts related to caries prevent (Petersen & Kwan, 2011). Public health preventive approaches have a dominant place when health systems can find the resource for a protected preventive pathway by ensuring affordability and availability of basic dental and oral hygiene services and products.

In the Libyan context, avoiding dental caries remains a difficult task because of inadequate public health, an understanding of oral health, and accessibility to preventive services. At present, Libya is working toward rebuilding the health system, and an opportunity exists to prioritise oral health in national strategies (such as

community fluoridation programs, sealant programs in schools, and university-based programs to educate oral health professionals); many of these strategies, if implemented, can reduce the caries burden (El Tantawi *et al.*, 2023). Important next steps will include integrating oral health into primary care and training will be required for health professionals to focus on preventive services and practices.

2.22 Knowledge, Attitudes, and Practices (KAP) in Oral Health

Knowledge, attitudes, and practices (KAP) are fundamental determinants of individual oral health behaviour and play a central role in shaping oral disease risk, dietary choices, and preventive habits. In oral health research, KAP constructs are widely used to assess behavioural patterns and inform the design of targeted interventions. Operationally, knowledge refers to an individual's factual understanding of oral diseases, risk factors, preventive strategies, oral hygiene techniques, and dietary contributors to dental caries. Attitude encompasses beliefs, perceptions, motivational readiness, perceived susceptibility, perceived severity, and value placed on preventive behaviour. Practice refers to the observable oral hygiene behaviours performed regularly, such as toothbrushing frequency, flossing, dietary sugar intake, and dental attendance patterns. These constructs are behaviourally interrelated and collectively influence oral health outcomes, making them essential indicators in oral health promotion research.

Empirical evidence from numerous contexts demonstrates that deficits in KAP are associated with poorer oral health status and increased risk of dental caries. International studies consistently reveal low levels of oral health knowledge among adolescents and young adults, contributing to inadequate hygiene practices such as infrequent brushing, limited flossing, and irregular dental visits (Ahmad *et al.*, 2019; Yazdani *et al.*, 2020). For instance, Ahmad *et al.* (2019) reported that suburban schoolchildren lacked awareness of correct brushing techniques and caries prevention strategies, resulting in high plaque levels and gingival inflammation. Similar patterns were observed in Brazilian and Eritrean populations, where insufficient knowledge and negative attitudes were strongly associated with higher caries experience and poor oral hygiene behaviours (Andegiorgish *et al.*, 2017b; Borges *et al.*, 2017). These

findings highlight the importance of enhancing health literacy as a key determinant of disease prevention.

Among university students, inadequate KAP has been widely documented across diverse countries. Research among Indonesian and Iranian students found that negative attitudes and low perceived behavioural control significantly predicted poor oral hygiene and dietary habits (Santoso *et al.*, 2021; Yazdani *et al.*, 2020). In Japan, international and domestic university students demonstrated differences in oral hygiene practice, attributed partly to variation in cultural attitudes and knowledge of preventive behaviours (Abe *et al.*, 2023). Across European, Asian, and Middle Eastern settings, university-aged individuals commonly report high consumption of sugary snacks and beverages, low utilisation of dental care services, and inconsistent brushing behaviour, patterns directly linked to insufficient preventive knowledge and suboptimal attitudes (Borges *et al.*, 2017; Skafida & Chambers, 2018).

Studies conducted in Libya echo these global trends. Alraqiq *et al.* (2021) found that Libyan university students demonstrated significant gaps in oral health knowledge, particularly concerning caries risk factors, fluoride use, and proper brushing techniques. Attitudinal barriers, such as perceiving dental visits as necessary only when pain is present, were common and contributed to low engagement in preventive practices. These behavioural deficits were further compounded by cultural dietary habits, limited access to professional oral health guidance, and the absence of structured oral health education programs at the university level (Al-Tajouri, 2022; El Tantawi *et al.*, 2023). As a result, many Libyan students engage in high-risk behaviours, such as frequent consumption of sugary tea and snacks, which elevate caries risk and worsen oral health outcomes.

A growing body of research also demonstrates a significant relationship between KAP and oral health-related quality of life (OHRQoL). Studies among adolescents in Brazil and China found that inadequate oral hygiene practices and negative attitudes toward oral health were associated with poorer OHRQoL scores, reflecting pain, functional limitations, and psychosocial impacts (Sun *et al.*, 2018; Colussi *et al.*, 2017). Similarly, research among diabetic and medically compromised populations revealed that insufficient knowledge and poor self-management

behaviours contribute to deteriorating oral health and reduced quality of life (Mahmood *et al.*, 2024; Carneiro *et al.*, 2024). These findings underscore the influence of behavioural determinants on broader well-being outcomes.

Collectively, empirical evidence demonstrates that strengthening oral health knowledge, improving attitudes, and reinforcing positive practices are essential for reducing caries prevalence, modifying dietary habits, and enhancing OHRQoL. The strong association between KAP and oral health outcomes provides a compelling rationale for integrating KAP-based assessment and behavioural education into oral health promotion programs. Given the clear KAP deficiencies documented among Libyan university students, addressing these behavioural determinants through a structured, theory-driven oral health education program is a critical component of the current study's intervention.

2.23 Dietary Habits Related to Dental Decay

Eating habits are defined as the collection of habitual actions an individual undertakes to nourish oneself, but are also framed and shaped by the context, the people around them, the economic availability, and the understanding of food value in terms of nutrition it may be possible to develop good and bad eating behaviours. The presence of bad eating behaviours is connected to further risk of developing multiple chronic diseases, which then affects the presence of certain oral cavity conditions. Satisfactory eating habits, presence of nutrient content, poor dental hygiene habits, and high levels of bacterial plaque are possible limits to cavities occurring.

Some studies on animals, for instance, indicate that certain foods rich in fat, proteins, calcium, and fluorine may have cariostatic qualities. An article mentioned when reviewing animal studies on foods high in fat, protein, calcium, and fluorine, "animal studies have demonstrated that foods which are higher in fat, protein, calcium and fluorine may be protective against caries." Fats should coat the tooth as to limit the retention of carbohydrate and plaque; fats can also be toxic to bacteria. Proteins help neutralise or buffer saliva, protecting enamel. Fats, and proteins help raise the pH after carbohydrate ingestion. Another category of food would be those that

stimulate a flow of saliva by chewing, therefore buffering the acid pH, creating an environment that facilitates enamel remineralization".

Sugar is a reason behind dental caries, however, applying restrictions at the population level on sugar could similarly prevent obesity and other health issues. There is good evidence to associate changes in sugar intake to caries., however, the significance of sugar interventions in the post-fluoride world has been questioned. Despite ready access to fluoride, European or Western research is the only solid evidence to support the importance of limiting sugar. Only a few studies consider the issue in developing countries.

Researchers compared caries experience data collected during the Libyan crisis using a cross-sectional survey to another caries experience data which was obtained from a previous control in the same context before conflict. We found there to be a statistically significant reduction in caries prevalence and severity among Libyan schoolchildren during the recent conflict, compared to pre-conflict levels. The reported fall in caries experience during the war coincides with the decrease in sugar consumption. Survey the population. For example, in Benghazi, we conducted a pilot study of 12-year-old Libyan pupils in which we found substantial differences in sugar consumption in wartime.

The pilot study concluded that sugar consumption decreased, compared to pre-conflict data from a similarly comparable grouping in the same environment.28 There were two studies in the pilot study that examined sugar consumption from 180 subjects, one exhibited caries experience and the other was designed identically to the pre-conflict study. For a sample size of 175 subjects, we had 95% statistical power to detect a correlation coefficient of 0.3, for a Type 1 error rate of 5%. At the time of the conflict, sugar consumption data were obtained from a random sample of 179 pupils from the 200 pupils invited to participate (89% response rate). The sugar intake decreased from 90.3 g/day to 58.8 g/day on average.28 It is likely that the reported decrease in caries is related to the levels of sugar consumption, as well as the reported availability. Earlier research has evaluated a relationship between sugar consumption and caries levels at the times of a crisis or a conflict.19,20 The current study verified

beneficial relationships between lower sugar consumption and lower levels of caries in a developing country with community water fluoridation.

2.24 Quality of Life Related to Dental Decay

There have been several hypotheses about factors affecting the quality of life in oral health (OHRQoL), but no agreement has been reached (Sun *et al.*, 2018a). In 2017Colussi *et al.* performed together with students from Passo Fundo, Brazil, public and private schools. All students were 15 to 19 years of age. In 20 high schools who had appearance questions, 736 adolescents were a proportional random sample, including whether the appearance of the teeth was not affected by the adolescent (p=0.68). More impacts on the quality of life were significantly correlated with public of school attendance (OR=1.63; CI95%:0.98-2.70) and self-reported halitosis (OR =1.48; CI95%: 1.01-2.16) (Sampaio *et al.*, 2021).

Socio economic conditions and halitosis have been concluded to show a greater effect on the quality of life of young adults. According to Sun *et al.*, (2018), 364 eligible subjects from Hong Kong have been selected for representative sample (186 girls, 178 boys). The WHO criteria examined the periodontal status and caries. According to (Oliveira & de Andrade, 2020). The most recent oral soundness survey data have been conducted in Minas Gerais, Brazil (Saldarriaga *et al.*, 2021). There are 60 cities in the province, including the capital (Belo Horizonte). Minas Gerais was Brazil's second most populous state in 2018. SB-Minas Gerais used probabilistic sampling by multi-stage conglomerates, with a relative likelihood of participation of 31.4% due to low OHRQoL; the psychological domain was the most influenced (22.6 %). On the overall OIDP and all of its domains, ache and frustration with oral health have been related to low OHRQoL. Non-whites have a worse OHRQoL than whites over the whole OIDP and physical realm (Yap *et al.*, 2021).

In 2020, Corcoran *et al.*, a study was done on a population of adolescents at Oulu University Hospital Cleft Lip & Palate Centre, Northern Finland, who were born with a CLP who have received treatment. There were 63 patients with clefts who participated in this study at Oulu University Hospital. More than half of the participants had cleft palates. More than half (OHIP-14 score 3) of participants said their OHRQoL was affected. For the participants who had bilateral cleft lips and

palates, three quarters of those who had unilateral cleft lips and palates and half of those that had a cleft palate, reported effects on their OHRQoL. Inductive content analysis revealed that despite the complexity of the procedures, one quarter of the participants had a positive result when thinking of reasons for attending the cleft center. Both participants were thankful for the cleft team too (Omara *et al.*, 2021).

Currently, oral health is understood as physiological, social, and psychological perspectives that contribute to quality of life independent of age or health status (Gomes *et al.*, 2020). Oral health-related quality of life (OHRQoL) is a complex construct that considers how oral health conditions impact every day, and quality of life (Alrashed & Alqerban, 2021). A proposed theoretical framework includes the factors of OHRQoL I.e. biological, personal, and environmental; socioeconomic status (SES) factors (Barasuol *et al.*, 2020). SES includes a range of factors that can contribute to health outcomes for different groups of people, for example income, education, occupation, power and prestige (Knorst *et al.*, 2021).

Adolescence is a meaningful life transition, consisting of biological, behavioural, and psychological aspects, and is where adolescents experience many changes through social conditions and family influences (Omara, Stamm, & Bekes, 2021). Adolescence also includes when adolescents take behaviours that are harmful to their long-term health and well-being; smoking alcohol, drugs, unprotected sex, poor nutrition or exercise (Wu *et al.*, 2021). Adolescence also includes social conditions where change from relying upon family as a support to connecting with peers and teachers as social supports; developing emotional and social factors are critical at this age, as social groups influence, and adolescents are connecting with a range of social groups. Emotional support, loyalty, understanding, and intimacy is apparent in adolescents' development at this stage (Yactayo-Alburquerque *et al.*, 2021). In addition, positive oral health beliefs and psychosocial factors like self-esteem and sense of coherence should be indicators to having a positive impact on adolescent health behaviour, health-related quality of life (OHRQoL), and mental health (Zheng *et al.*, 2021).

Factors influencing OHRQoL have become more important in a world that has moved away from health measurement in clinical aspects, and is emphasising measures that highlight subjective aspects to health such as individual perceptions of health and well-being, their perceptions of the relationships they have with health and well-being that victimised their physical, mental, and social domains (Zheng *et al.*, 2021). The interplay among socio-economic status, demographic variables, and psychosocial variables have been extensively documented in their influence on adolescent health behaviours and quality of life (Zheng *et al.*, 2021). Young people coming from low SES are at increasing risk of negative health behaviours, while young people coming from better SES are more likely to maintain good social networks and positive health behaviours in their life course, given that they have better skills to address adversity and more access to socio-economical resources (Zheng *et al.*, 2021). Research has shown that the socio-economic conditions in which some young people live their childhood could determine their behaviours in adulthood due to oral health beliefs they formed as young adults (Bramantoro *et al.*, 2021). Large studies in Europe have provided evidence that children and adolescents of low levels of parental education and family wealth suffer from poorer OHRQoL (Eriksson-Sjöö *et al.*, 2012).

The concept of social hierarchies arises in all countries, although there are differences in the way that social actors in different locations understand and express hierarchical concepts. However, it is apparent that the social hierarchies that create health inequities do exist in all forms of context. Lower economic status people encounter worse oral health conditions and, in turn, poorer OHRQoL (Knorst *et al.*, 2021). There is no question that socio-economic inequalities impact health.

Research has focused on how different measures of socioeconomic status impact Oral Health-Related Quality of Life (OHRQoL) all the way from children to adolescents to adults (Malicka, Skośkiewicz-Malinowska, & Kaczmarek, 2022). Most studies that have addressed socioeconomic measures have identified antecedent variables of performing poorly on OHRQoL, namely income, educational attainment, household crowding, and social class standing, which importantly also included an analysis of clinical attributes (Oku *et al.*, 2020). This broad trending suggests that lower socioeconomic status (SES) individuals are more susceptible to generalised and oral

health determinants that may negatively affect their health, and in turn their functional, psychological and social wellbeing. This susceptibility can likely be explained by greater exposure to risk factors that produce oral health problems and ultimately impact their general quality of life.

When considering oral health from a biopsychosocial perspective, we enhance our awareness that we should not just thinking through the health of dental tissues, but we are thinking about our understanding of how the oral cavity is functioning from a diminished quality of life standpoint (Sekulić *et al.*, 2020). This expansive understanding offers a clearer distinction of the dimensions of the oral health related quality of life (OHRQoL) to serve as an evaluative measure of oral health. OHRQoL has several dimensions, i.e. consequences of oral health problems, cultural/family context, emotional/psychological constituent, pain (e.g., toothache);, availability of treatment, satisfaction with care, and self-image (Yactayo-Alburquerque *et al.*, 2021).

OHRQoL is most useful in the perspective of youth (i.e., adolescents), since it is a time of life characterised by intense physical and psychological transformation. Health behaviours and vulnerability to oral health challenges are shifting behaviours, in a way the OHRQoL may diminish (Zheng *et al.*, 2021). Development of psychosocial ascribe and processive identities with aspects such as anxiety, coherence, etc. informed changed to self-care practices, and a change in care from parental care to self-care. The role of gender is significant since the research demonstrates strong evidence showing adolescent females overall report poorer OHRQoL compared to adolescent males. They could exhibit previous biological maturity and to experience social pressures related to appearance ahead of adolescent males (Lopes *et al.*, 2020).

Implications for OHRQoL may go beyond clinical situations to public health policy and research. Evidence for OHRQoL position on oral health conditions, treatment outcomes, and interactions between health behaviours and social /emotional well-being contexts/personal views can provide support for public health strategies aimed at reducing social disparities through prevention and education programs, supportive actions that encourage healthier choices (Tuba & İlhan, 2023).

The impact of health beliefs and health-related behaviours linked to health-related quality of life (OHRQoL) has been explored with children and adolescents (Mikkelsen *et al.*, 2020; Slabšinskienė *et al.*, 2021). These studies independently demonstrate a strong relationship between OHRQoL and positive health beliefs that lead to more preventative behaviour s, and therefore ultimately a better quality of life (Eid *et al.*, 2020). For example, a longitudinal study at six months followed up on a group of adolescents and found that participants who had positive beliefs and behaviours experienced overall better quality of life. Even after 6 months, those who clearly maintained positive health beliefs and behaviours, when they became adults, repeated the same longitudinal survey and showed significantly lower proportion of self-rated poor oral health (Eid *et al.*, 2020).

Moreover, children exhibiting poor health-related behaviours had even worse OHRQoL. This finding held true even with student sex, social context, and specific symptoms accounted for. Further national data from 12 countries supported there is an inverse relationship between good OHRQoL and risky health behaviours for children and adolescents (Yactayo-Alburquerque *et al.*, 2021).

Despite these findings, a limitation to the current literature concerning adolescents' OHRQoL risk factors is that they are mostly based on cross-sectional research, there are not enough longitudinal studies to examine the longitudinal nature of these factors. Another limitation is selection of independent variables in research examining adolescents' and OHRQoL, which often does not have a sound theoretical underpinning. There is an opportunity in the literature to use conceptual models to study the predictors and determinants of OHRQoL, which can be distinguished by structural and intermediary determinants, (e.g. structural determinants like socio-economic position (income, education), intermediary determinants like psychosocial factors and behavioural characteristics), as outlined by the World Health Organisation.

The work to improve oral health and it is tied directly to health promotion and development strategies restricted around micro and macro-level socio-economic factors, to mitigate a portion of social injustice (Sarayuthpitak *et al.*, 2022). This improvement links strongly to health education, where health education increases knowledge and attitudes towards oral health care and proactively assist with reducing

the disparity by working with structural and intermediary determinants of oral health (Zheng *et al.*, 2021).

Another insufficiency is with the more recent use of health promotion programs pertaining to oral health and the identification of systemic reviews to assess the effectiveness of adolescent oral health promotion strategies (Omara *et al.*, 2021). Although recent meta-analyses have examined oral health education and its impact to improve dental hygiene behaviours and caries in school-aged children, there are still insufficient programs which specifically target and overcome the unique difficulties and opportunities for the adolescent demographic.

Health-promoting approaches that incorporate educational components along with dental treatment are indicated as being more positive for Oral Health-Related Quality of Life (OHRQoL). As opposed to dental treatment only or only educational components (Marshall *et al.*, 2020). The authors note that adolescents receiving dental treatment only were substantially more likely to find the experience negatively affecting their daily activities, than to adolescents incorporating oral health education into their health promotion programme. These results hint at the importance of original strategies that utilise an integrated care approach (Caracho *et al.*, 2020).

Numerous studies, including one by Mashoto *et al.*, have reported that educational only groups made a smaller improvement highlighting opportunities to introduce coping and management skills that could be used as part of their OHRQoL strategies (Mashoto *et al.*, 2024). Moreover, the development of effective oral health promotional programmes has shown impactful positive changes in OHRQoL supporting holistic health promotion approaches (Grisolia *et al.*, 2021).

The review discussed substantive oral health issues for adolescents and adverse influences for OHRQoL, and the impact of acute and chronic oral health issues on daily functioning and social interactions. A plethora of research notes that social and clinical determinants predict OHRQoL. For instance, key predictors of OHRQoL mentioned in the literature were, malocclusion, dental trauma, caries and periodontal diseases (Hadler-Olsen & Jönsson, 2021). Clearly, some of the evidence regarding these predictors is inconsistent. Given these observations, the focus and attention

required for adolescents seem justified and underscores the relevance and importance of this research.

Despite limited scientific evidence on the influences from oral health promotional programmes for adolescents on their OHRQoL, evaluations of these programmes show they influence young peoples' health positively (Tuba & İlhan, 2023). These programmes are shown to reduce oral health issues and improve satisfaction with oral health. Furthermore, oral health promotional programs contribute to the adolescent's daily engagement and ability to fulfil social roles including, chewing, cleaning, mouth cleaning, speaking, emotional smiling, laying down to sleep, in all of these factors' adolescents where happier quality of life is influenced (Eid *et al.*, 2020).

2.25 Health Education Program and Dental Decay

The World Health Organisation (WHO) describes health promotion as "the process of enabling people to increase control over and to improve their health". It represents a shift from only considering individual behaviour to a broad suite of interventions which also consider social and environmental interventions. Oral health promotion comprises healthy public policy and supportive environments, developing personal skills and the reorienting of oral health services. In relation to the health belief model, (these last points should be differentiated from oral health education which is a process centred on improving oral health through the attainment of knowledge (it is the quest for knowledge through motivation that will lead to change in behaviour) (Kumar *et al.*, 2021).

The tremendous advances that have been made in oral health over the past few years suggest that there is a sound scientific basis for oral disease prevention, which has been developed in and implemented through community, clinical practice and at the home (Knorst *et al.*, 2021). Despite progress, however, many of these initiatives do not succeed fully in meeting their objectives due to negligence and inattention to the health education process - often due to poor patient-health professional relationships being formed (Kim & Lee, 2021). Some literatures have pointed to a potential impact of socioeconomic and cultural factors on oral hygiene practices. The nexus between limited information and knowledge associated with oral

health behaviours and limited access to dental care represent an explanation to the correlation between higher risk for oral diseases and lower socioeconomic status (Keels *et al.*, 2021; Knapp *et al.*, 2021).

Several studies have ascertained the degree of relation between several social, economic, behavioural risk factors, and the prevalence data with respect to oral cancer, dental caries, and destructive periodontitis, acknowledging the caution of interpretation of their associations, they underscore the necessity to bear them in mind in the formulation of health-promoting oral health policies (Karunanidhi *et al.*, 2021; Kateeb *et al.*, 2021). Countries have begun to put together comprehensive programmes involving the health and education sectors. Oral health education is an important public health issue and one that should be taught in the home and accessed in many forms in the schools. Oral health promotion is necessary for supporting the use of primary prevention strategies such as brushing teeth at least twice a day, daily dental flossing, and dental visits for oral disease prevention and early detection. Oral health education is the first step in the prevention of oral diseases to reduce socio-demographic differences and ensure equitable oral health opportunities, ultimately promoting initiatives necessary to enhancing the quality of life of populations (Karikoski *et al.*, 2021; Knack *et al.*2019).

Oral health education should also include food hygiene, which includes limiting the consumption of cariogenic foods with a high carbohydrate content, which is essential for avoiding the development of dental caries (Karki *et al.*, 2019; Khelif *et al.*, 2019). We can still confirm the existence of numerous schools with vending machines selling high-sugar foods and beverages. It is absolutely necessary to promote a reduction in the consumption of sweet foods and beverages in schools and around school buildings. As a result, school policies should take into account the necessary changes in order to prevent the consumption of sweets and to encourage the consumption of healthy foods and beverages (Hartono *et al.*, 2019; Huang *et al.*, 2019). Another important issue that should be addressed in oral health education is the unwarranted fear of dental visits. Research indicates that this is one of the primary reasons that people avoid visiting the dental office, especially individuals aged fourteen and older (Geetha *et al.*, 2019; Hanisch *et al.*, 2019).

School-based health promotion programs represent the most effective way of informing adolescents of the essential components of oral health because professionals can relay the information in a direct manner. School-based health programs can promote and further inform students of the importance of practicing good oral hygiene habits and using fluoride when at home and at the dental office. The students should be informed about fissure sealants, and about the need for re-assessment. Daily oral hygiene behaviours are key in preventing acute problems and chronic disease and thus regular dental visits, ideally twice a year is important for detecting issues and opportunities to prevent oral health issues from occurring in the first place by seeking out and using protective equipment. Educators could also promote the decrease of sugary foods and promote a balanced diet to prevent dental caries. Eating fruits and vegetables could contribute to preventing oral cancer and decreasing smoking and alcohol consumption could reduce the risk of developing oral cancer, periodontal disease and tooth loss or the loss of function of teeth. In addition to the use of fluoride rinses, ultimately, contributions to facial injuries could be decreased through consistent use of protective equipment in sport, in the workplace and when operating motor vehicles (Filius *et al.*, 2019; Friedlander *et al.*, 2019).

These critical aspects can be explained during simple oral health education sessions that use audiovisual equipment to demonstrate the best tooth-brushing techniques using mouth and teeth macro models. The use of simple and comprehensive movies, interactive plays that can be used in mobile phones, theatrical plays, puppet plays, and fairy tales to demonstrate the importance of oral hygiene aids in understanding. Advertisement on Facebook and other digital platforms, as well as the distribution of pamphlets containing a summary of the oral health education session implemented by dental and health professionals, can be an effective method for teaching and motivating adolescent and families to develop better oral health behaviours (Dos Santos *et al.*, 2019). Subjects should receive adequate oral health education in order to develop a healthy attitude and practice. The evaluation of knowledge, attitude, and practice is critical in order to generate such health education (Cunha *et al.*, 2019; Das *et al.*, 2019). Late adolescence is a stage that is close to

adulthood; they will have a stronger identity, the ability to think through ideas and express them verbally, the ability to make independent decisions, and self-reliance.

In a Malaysian study, questions about tooth appearance and tooth decay prevention through tooth brushing scored above 80% in the knowledge section. However, knowledge of dental plaque or biofilm remained limited. These findings are consistent with studies conducted on school adolescent in Jordan and Sarawak (Malaysia) (Christidis *et al.*, 2019). Cheah *et al.* (2015) proposed that a lack of knowledge about periodontal health could be a result of poor dental health education.

The American Dental Association suggests changing your toothbrush every 3-4 months (Chi & Scott, 2019). It has been established that a toothbrush with frayed bristles is ineffective for cleaning (Cheng *et al.*, 2019). In this study, 68.4 % of late adolescent participants changed their toothbrushes every 6 months. Students should be educated on the importance of changing their toothbrushes every three months at the most. Fraying toothbrushes will not properly clean the teeth, predisposing the teeth to many harmful microorganisms. It has been proposed that the primary cause of poor oral hygiene in the general population is insufficient brushing time (Chaudhary *et al.*, 2019). The commonly recommended tooth brushing times range from 120 seconds in the United States to 180 seconds in Europe (Catteau *et al.*, 2019). According to one study, bacterial plaque buildup on the tongue is a major cause of oral malodour or bad breath in adolescents. After cleaning the surface of the tongue, oral malodour levels were significantly reduced (Couto *et al.*, 2019). As a result, the adolescent should be taught how to clean his or her tongue.

A study found that repeated oral hygiene instruction significantly improves patients' awareness, attitude, and practice of plaque control (Nagraj *et al.*, 2019). Furthermore, there is a need to reduce reliance on oral health personnel in order to encourage the population to take responsibility for their own oral health, such as by increasing the implementation of oral health education in university students.

2.26 Oral Health Education Impact on Oral Hygiene Knowledge, Attitude and Practices

Recent research, carried out in Malaysia, showed that participants had generally high levels of basic oral health knowledge, with over 80% accurately identifying tooth appearance and tooth brushing protects against dental caries (Pasupuleti *et al.*, 2017). This paper hypothesised that the very high scores may be linked to Malaysia having a comprehensive national oral health promotion strategy that links. school-based education programs to community programming. However, when we examined the data in detail, there were significant gaps in more complicated oral disease knowledge, particularly around the nexus of oral diseases, and systemic health, where correct responding was as low as 45-55%. Clearly, while populations may be able to grasp the basic preventive measures, they are unlikely to associate oral health with broader connotations of overall wellbeing. This represents a significant challenge for future education programming.

Cultural traditions still greatly influence oral hygiene behaviours all the world over, for example, siwak use was very high in Saudi Arabia as 65% used siwak daily (Pasupuleti *et al.*, 2017). The miswak is a very popular traditional approach to oral hygiene regimens because of its religious and cultural value, but new science has emerged that supports clinicians in recommending this as a possible solution to dental hygiene. Laboratories have shown that miswak extracts are strongly antibacterial against important periodontal pathogens like Porphyromonas gingivalis and Aggregatibacter actinomycetemcomitans; and anti-cariogenic against Streptococcus mutans biofilms. Research has demonstrated that the mechanical cleaning action of miswak fibres when used properly is also plaque removal effective (as effective as conventional toothbrushes) in clinical trials. Dental professionals have expressed multiple limitations such as the unlikely ability to clean posterior teeth effectively, serious soft tissue trauma to gingival surfaces from improper use, and, dental professionals had reported issues with the fluoride content in miswaks which are also likely not standardised across countries and regions (we still suggested it as an appropriate oral hygiene aid in consisted messages about it as a traditional cultural aid) in public health campaigns on the role of traditional oral hygiene aids.

Toothbrush maintenance behaviours encompass another important aspect of oral health behaviours, as indicated in the study by Chen *et al.* (2019), which discovered that 68.4% of late adolescents replace their toothbrush every six months. While this is a positive indicator, considering the national recommendations are every 3-4 months or whenever the bristles appear frayed, it indicates modest compliance. There are many socio-economic variables which influence replacement frequency, but in general higher-income individuals (higher purchasing power and health awareness), tend to replace their brushes more often. Higher education level also tends to correlate with replacement compliance, as does an established routine of regularly visiting a dental professional who reinforces the maintenance of oral hygiene tools.

Interestingly, exposure to media coverage about oral health behaviour s either through television campaigns or social media influencer's messages has been particularly effective to improve toothbrush replacement behaviour at the population level among younger individuals. This provides an interesting avenue for public health initiatives.

The Libyan study has provided some particularly rich insights into the gender-based differences in oral hygiene practices in the North African context. The observation that 53.1% of female participants followed correct oral Hygiene Practices while only 46.9% of males did, reflects the overall global trend of women showing better oral health behaviour s, but also indicated some contextual differences. For example, among Libyan men a number of cultural and behavioural factors impacted their lower rates of oral hygiene, including higher rates of tobacco use (specifically the cultural practice of smoking shisha), less prioritising use of preventive dental services, and higher ratios of sweetened teas and sugar-loaded carbonated drinks. Libyan women appear to be more informed about their oral health because of cultural social data from maternal health education, the social sharing of health information, and visiting the dentist based on aesthetic outcomes (and to access the preventive services). These gender differences indicate the necessity for contextualization of oral health education which needs to include the barriers and motivations of populations.

The positive findings demonstrating the practice of repetitive oral hygiene instruction has been shown to improve patients' awareness, attitudes, and plaque control practices (Nagraj *et al.*, 2019) supports a number of important principles about oral health education. Simply repeating the educational encounter through multiple encounters is reported to take place is more successful than a single encounter, and studies have reported nearly double the knowledge retention after having a follow-up to produce reinforcement. Practical demonstration activities while patients are engaged with the physical action have been shown to be significantly better than verbal or written explanation alone. The increasing use of motivational interviewing techniques in dental settings has shown great promise because patients engage to find their own barriers to changing behaviours. However, perhaps the most important feature of effective oral health education is that it must be adapted to cultures so that the relevant population might relate to the content e.g. use similar analogies, cultural risk factors, health beliefs. These ideas collectively argue that while oral health knowledge is likely rudimentary moderate levels in many populations, implementing that knowledge into permanent practice is the major barrier, and requires a combination of culturally adaptable approaches to education and improvements in the entire health system.

2.27 Oral Health Education impact on Oral Health Related Quality of Life

OHRQoL (Oral Health-Related Quality of Life) is a key measure that indicates how dental health affects an individual’s daily functioning, feelings, and socialisation (Sekulić *et al.*, 2020). As known, OHRQoL is critical to improving an individual's life, there are many oral health education programs that exist to help knowledge, awareness, and practice (Larsson *et al.*, Bondemark, & Häggman-Henrikson, 2021).

Oral health education is to inform individuals and incite them on the importance of oral health, good dental hygiene and how good oral hygiene contributes to our overall health (Evensen *et al.*, 2021). Oral health education plans are ordinarily based on educational content that typically includes effective brushing and flossing technique and messages on the importance of regular dental visits, as well as nutrition in relation to oral health (Kizito *et al.*, 2014). Besides, increased knowledge and attitude change, oral health education has often been helpful in

motivated behaviour change too. Ren *et al.* (2017) reported that treatment that included educational sessions together with supplying specific oral hygiene aids (i.e. toothbrushes, fluoride toothpaste) did achieve improvement in oral hygiene behaviour of children and adolescents. An increase in adults brushing with more frequency and effectiveness was seen, after attending oral health workshops on a regular basis, according to findings of Kumar *et al.* (2018).

Ultimately, enhancing knowledge and behaviours through oral health education has the impact of enhancing health-related quality of life (Mitra, 2024). Many studies have outlined a positive association between oral health education in society and OHRQoL. For instance, Gomez *et al.* (2019) found a significantly higher OHRQoL among older individuals receiving oral health education, largely due to experiencing less pain and suffering from oral disease. Likewise, Lee and Ryu (2020) found that ongoing education regarding the importance of oral health was associated with improved OHRQoL among pregnant women, due to reduced gingival inflammation and tooth pain.

Improvements in Oral Health-Related Quality of Life (OHRQoL) through oral health education in adolescents is critically important due to this cohort's transitional time, which consists of rapid biological, psychological and social changes (Malicka *et al.*, 2022). Oral health education in adolescents can have a considerable and lasting impact on OHRQoL by establishing habits of good oral hygiene, avoiding oral diseases and improving self-esteem (Alvarez-Azaustre, Greco & Llena, 2021). Adolescents are more prone to exhibit cavities and gum diseases as a result of making poor dietary choices (i.e. high amounts of sugar food and drinks) coupled with oral care inconsistencies (Oku *et al.*, 2020). As an example, adolescent oral health education programs often outline the importance of brushing and flossing on a daily basis, influence of nutrition on oral health, and continued long-term purpose of maintaining good oral hygiene. When subjects, including adolescents, understand the importance of oral care and consequences of lack of care, they tend to outline preventive actions (Oku *et al.*, 2020).

Poor oral health can cause bad breath, visible cavities or crooked teeth impacting the self-esteem and relate ability of adolescents (Patterson & Ford, 2014). Specifically, adolescents with oral health education may not suffer from these visible issues, positively impacting their confidence and involvement in social activities (Sarayuthpitak *et al.*, 2022). Everyday educational materials highlight dental procedures and stress the importance of habitual dental check-ups (Pugo Gunsam & Banka, 2011). Becoming familiar with the processes involved in dental care may lessen the emotional burden of fear and anxiety when faced with dental visits, often increasing the willingness of subjects, including adolescents, to seek professional care when necessary (Patterson & Ford, 2014).

Oral diseases can cause remarkable pain and discomfort, sometimes causing students to miss school (Ozsin Ozler *et al.*, 2020). Students receiving adequate instruction of oral health are noticed to better attend school and score well academically (Kizito *et al.*, 2014). Habits formed from childhood, often last into adulthood. Placing an emphasis on oral health education now, means the adolescent will predispose themselves to a lifelong set of habits of oral habits that lead to reduction of risk factor for of chronic diseases associated with poor oral hygiene, including cardiovascular disease and guidelines for diabetes. Moreover, oral health education can translate into a higher interest in health. Adolescents, who are now aware of caring for their oral health, are more likely to value their health in general and exhibit other healthy behaviours (Amornsuradech & Vejvithee, 2019).

Despite the possible potential benefits of oral health education in adolescents, there are numerous barriers to successful teaching. The basic assumption of oral health being not as important as any other issues faced, the temptation of unhealthy diets, or simply unwillingness to change poor habits reduces the effectiveness of efforts toward teaching (Eriksson-Sjöö *et al.*, 2012). By addressing their unique needs and challenges to oral health education will serve as a tremendous positive influence on future adolescents OHRQoL, setting them up for a successful future.

2.28 Empirical Studies on Interventional Methodology

Research indicates that health education communication that succeeds is associated with changes in beliefs and attitudes toward risky behaviour and changes in that behaviour (Przybylska *et al.*, 2014). A random sample of 400 students was drawn from the semi-urban area of two government-aided schools in the Belagavi district (Kulkarni *et al.*, 2015). The students were assigned to a control group and an experimental (study) group. The study group received the oral health education intervention on two occasions. Data was collected using a pretested questionnaire. They calculated frequency and percentage. The proportion of control participants at pre-test (61.5%) had better oral health knowledge, attitudes, and practises than the study group (60.5 per cent). The study's participants were able to show a notable improvement from pre-test to post-test after the oral health education with their knowledge, attitudes, and practises of oral health increase to 62.6 per cent compared to the control participants' post-test responses, which increased only to 56.4% (Kulkarni *et al.*,2015).

In another study, a non-randomised pretest- post-test design with 600 school children was conducted in India (Karuveettil *et al.*, 2020). A number of students were randomly assigned to one of two intervention arms where one group received health education intervention provided by a dental health professional and the other group received health education provided by a school teacher. The oral health curriculum was designed for three different ages (lower primary [LP], upper primary [UP] and high school [HS]) and was conducted for one year. Oral health practises were collected at baseline, six months post-education intervention and again at one-year post-education intervention using a Knowledge, Attitude and Practice (KAP) questionnaire. Dental caries experience was measured prior to intervention in participants and also following the WOHAH intervention using deft and decayed, missing and filled teeth (DMFT) indices. There were significant improvements in KAP in the area of oral health for the Indian schoolchildren. After the intervention there were significant reductions in decayed primary teeth in the LP and UP school children (Karuveettil *et al.*, 2020).

2.29 Gaps in the Literature and Justification for the Study

Although there are many advances in let the standard of education in oral health education, considerable gaps could still be identified in the literature that would mitigate the effectiveness of existing oral health education interventions. Although much research has examined the traditional, digital, and behaviour-driven models of oral health education, effectiveness in promoting behaviour change has often been compromised by an overreliance on passive learning techniques, little consideration of behaviour changes theories, and lack of cultural-fit (Brennan *et al.*, 2022).

Furthermore, existing oral health education in low- and middle-income countries (LMICs), for example, Libya, is limited in its development and has not yet produced a standardised and coherent national framework for participants at the university level (Al-Tajouri, 2022). This section identifies that research gaps related to considering the models of effectiveness in oral health education, the consideration of behaviour changes theories, the contribution of digital learning, and the specific population of time-limited Libyan university students. Given our understanding of the research gaps, and the aim of the study that increases the need for a structured, interactive oral health education intervention specific to this target population.

2.29.1 Limited Effectiveness of Traditional Oral Health Education Programs

There remains a major gap in oral health education research due to the continued delivery of traditional oral health education that relies heavily on traditional, lecture-based methodologies that have demonstrated limited efficacy in changing behaviours over time. Oral health education is most often traditional in form as it relies on didactic lectures, pamphlets or even public awareness campaigns, which promote the transfer knowledge without engaging behaviour (Jürgensen & Petersen, 2013). While the traditional approaches may lead to short term awareness their cannot produce sustained oral hygiene behaviour change as passive learning does not involve making the learner part of the education process (Nakre & Harikiran, 2013). Furthermore, all passive learning methodologies have demonstrated lower recall of knowledge and no real learning ends, than the interactive methodologies where learners are required participate (Gunpinar & Meraci, 2022) and, as Brennan *et al.*,

(2022) conclude, passive learning methodology has no reinforcements that traditional education models will not encourage learners to adhere to recommendations for oral hygiene behaviours over time. Given the many limitations of traditional models and the lack of robust pedagogical evidence on how to deliver behaviour-driven oral health education, the time has come to explore engagement based and behaviours driven oral health educational models where the student is truly the focus of the educational experience.

2.29.2 Insufficient Integration of Behavioural Change Theories

Another major gap is the ineffectiveness of health behaviour change theories in oral health education programs. Although multiple studies acknowledge that behaviours are influenced by psychological factors, few have incorporated behaviour change theories as part of program design, including models such as the Health Belief Model (HBM), Social Cognitive Theory (SCT), and the Theory of Planned Behaviour (TPB) (Ajzen, 1991; Bandura, 1986; Janz & Becker, 1984). These models add credibility to program design and behaviour change planning. The HBM, SCT, and TPB can provide an organised conceptual framework addressing motivation, social influence, and perceived barriers, thereby guiding researchers or educators in designing interventions that promote health behaviour change.

As reported in their findings, Broomhead and Baker (2023) noted that the majority of oral health education programs examined lacked an epistemological underpinning, and the absence of alignment with established behaviour modification frameworks reduced the extent to which these programs effectively promoted behaviour change. Furthermore, although some authors demonstrate the use of behavioural theory, they often do not measure key constructs such as self-efficacy, perceived susceptibility, and social reinforcement, which ultimately limits their ability to determine the effectiveness of their programs (Alshahrani *et al.*, 2021). Overall, this gap highlights the need for oral health education models that explicitly integrate HBM, SCT, and TPB frameworks to encourage engagement and strengthen motivation, thereby improving individuals' adherence to consistent oral hygiene behaviours.

2.29.3 Limited Use of Digital and Interactive Learning Tools

The interest in digital health education has grown in recent years, but not much research has evaluated the effectiveness of mobile apps, gamification, and virtual learning environments for oral health education (Gunpinar & Meraci, 2022). The dominant public health oral health education model is primarily face-to-face work, and for many students, particularly those in some university settings, access to oral health is limited due to time and competing academic and social demands (Lagerweij & Van Loveren, 2020). While mobile apps, interactive e-learning technologies, and gamification may inherently provide alternate avenues for engagement and retention of knowledge, there is a lack of context-relevant research evaluating these approaches for oral health education for university students (Brennan *et al.*, 2022). In addition, while many digital health education programs are aimed at children, few programs are specifically aimed at young adults, and this has limited research into digital health education including oral health programs aimed at university students (Alshahrani *et al.*, 2021). This research project explicitly responds to this gap by including peer expertise in an innovative approach to oral health education.

2.29.4 Lack of Research on Oral Health Education in Libya

The literature has shown that there is a significant gap in the literature on oral health education programming in Libya. While oral health inequalities in North Africa have been studied, there has been limited emphasis given to the effectiveness of oral health education and programming for Libyan university students (Al-Tajouri, 2022). The health system in Libya is largely focused on curative health and not preventive or focused on educational oral health, nor are oral health education or oral health programs a priority in higher education (Alraqiq *et al.*, 2021).

Due to this, many students have poor oral hygiene behaviours, limited dental visits, and limited access to preventative care services (Alshahrani *et al.*, 2021). Programs for oral health awareness have been established in Libya, but they are limited, short-lived, and vary in regard to the consistency of implementation, measuring outcomes, evaluating, and managing the behavioural change which severely limits their influence in creating changes to behaviours (Al-Tajouri, 2022).

Further to this, there has been no exploration of the feasibility of a structured, behaviourally based oral health education program targeting university students in Libya. Therefore, the study builds upon existing health behaviours program to develop and evaluate a culturally relevant interactive oral health education program developed specifically for the context of university students in Libya.

2.30 Summary of Empirical Review

The empirical literature reviewed in this chapter highlights the global and regional burden of oral diseases, the importance of preventive approaches, and the central role of oral health education (OHE) in modifying risk behaviours and improving oral health outcomes. International studies consistently demonstrate that traditional, knowledge-based educational approaches have limited long-term impact on oral hygiene practices, dietary behaviours, and caries prevention. Consequently, recent research has shifted toward theory-driven, behaviourally oriented interventions incorporating models such as the Health Belief Model (HBM), Social Cognitive Theory (SCT), and the Theory of Planned Behaviour (TPB). These frameworks have been shown to enhance motivation, improve perceived susceptibility and benefits, reduce barriers, and strengthen self-efficacy, ultimately producing more sustainable behavioural change.

Multiple interventions across different population groups, particularly adolescents and university students, show that structured OHE programs significantly improve knowledge, attitudes, and practices (KAP), as well as clinical oral health outcomes and oral health-related quality of life (OHRQoL). Evidence suggests that digital learning tools, mobile applications, virtual reality simulations, and peer-led models are especially effective in increasing engagement and reinforcing preventive behaviours. These findings are particularly relevant in resource-limited contexts, where digital health platforms can expand access to cost-effective educational strategies.

In the context of Libya, empirical research reveals substantial challenges in oral health literacy, preventive behaviour, dietary habits, and access to dental services. Studies report a high prevalence of dental caries among children, adolescents, and university students, accompanied by low levels of knowledge and

poor oral hygiene practices. Despite the recognised importance of OHE, Libya lacks structured, validated, and theory-based educational programs specifically designed for university students. Existing health promotion activities are fragmented, largely treatment-oriented, and not integrated into higher education institutions. This gap is compounded by systemic barriers including economic instability, shortages of trained personnel, and insufficient policy support for preventive dentistry.

The empirical review also underscores the significance of dietary habits, especially consumption of sugary beverages and snacks, as a determinant of caries risk, yet limited research in Libya has examined dietary behaviours among university students. Similarly, while OHRQoL is increasingly studied globally, evidence from Libyan university populations remains sparse. The absence of local intervention studies evaluating OHE outcomes further highlights a critical evidence gap.

Overall, the reviewed literature affirms the need for a multi-phase research approach that includes assessing current levels of KAP, dietary habits, caries prevalence, and OHRQoL among Libyan university students (Phase 1), developing a structured, theory-driven oral health education program tailored to the needs and context of Libyan students (Phase 2), and implementing and evaluating the effectiveness of this program in improving KAP, dietary behaviours, and OHRQoL (Phase 3).

The present study directly addresses these documented gaps by providing empirical data, designing a context-specific intervention, and evaluating its impact, thereby contributing new knowledge to both Libyan oral health research and the broader field of preventive oral health education.

2.31 Justification for the Study

With the ineffectiveness of conventional oral health education programs, this study seeks to use an interactive, engagement-based education model to move beyond simply increasing knowledge and towards learning and behaviour change. This program will utilise engaging learning tools, peer-led education, and online engagement tools, and aims to eliminate the barriers to behavioural change pervasive in typical passive learning opportunities. The study will examine students' oral health behaviours through the lens of the Health Belief Model (HBM), Social Cognitive Theory

(SCT), and Theory of Planned Behaviour (TPB), and provide a framework for structured conceptual change and understanding.

As noted in earlier research, a common criticism is that social change-oriented organisations develop behaviour change programming without sufficient theoretical and methodological considerations to evaluate key relationships; the study will examine behavioural constructs like perceived susceptibility, self-efficacy, and social reinforcement, which as a result will enable the intervention to be science supported, and thus enable demonstrable positive changes in oral health behaviour.

The limited use of technology in oral health education has always been an issue to address. Within the context of this study, mobile learning tools, gamification and digital engagement will be addressed. The incorporation of technology will ultimately improve accessibility to and knowledge retention levels in learners and will enable each learner to self-direct their course of learning. Utilising electronic platforms and gamification opportunities will provide the flexibility that university students prefer, whose engagement with technology is high.

This study will be the first of its kind in assessing and developing an interactive oral health education program specifically for university students in Libya. It will be an important consideration for policymakers, educators and health care practitioners within Libya given the high incidence of oral disease in Libya, the lack of programmed oral health education, and the presence of behaviours/activities which will have the potential to impact on oral health; all of which will present an opportunity for policymakers to give consideration to the overall oral health impact on university students' study, in order to collectively develop a national oral health education model for students at university based environments to improve public health outcomes and ultimately address the burden of dental diseases in Libya.

The systematic review in Table 2.1 shows the discussed studies on oral health education and related factors, as well as global trends, intervention constructs, and research gaps in demonstrated oral health education practices. The studies included a variety of approaches such as traditional oral health education, digital and interactive learning models, response es to behavioural change theories, implications of socioeconomic factors, and zones of policy constraint. The review indicates that

traditional lecture-based oral health education studies (Jürgensen & Petersen, 2013; Nakre & Harikiran, 2013) create reasonable short-term awareness but lack long- term behavioural change support due to the passive nature of such educational program design.

In contrast, studies involving digital education, including mobile apps and gamification (Alshahrani *et al.*, 2021; Gunpinar & Meraci, 2022) generally have higher engagement levels and adherence to oral hygiene, while there are still some barriers to access. Studies using behavioural change theories such as Health Belief Model (HBM), Social Cognitive Theory (SCT), and Theory of Planned Behaviour (TPB) (Broomhead & Baker, 2023) had big measurable increases in motivation and long-term oral health behaviour change. Even in these cases, the programs needed thorough structure, a sustained monitoring plan, and timely reinforcement for the participants to exhibit sustainability of behaviours. The review also pointed out socioeconomic policy- related challenges to oral health education practices particularly relevant to low and middle-income countries (LMICs) like Libya (Al-Tajouri, 2022).

Studies in Libya have shown the combination of absent of a standardised national oral health education program, lack of awareness and poor access to preventive treatment resulted in poor oral health literacy and dental caries rates of 80% of students in university. Also, peer education models (Brennan *et al.* 2022) have also emerged as possible solutions to worked well as possible models to the lecture-based approaches since they used social influence that serves a higher level of engagement. Similarly, some of the school- based oral health programs reported from Scandinavia (Lagerweij & Van Loveren, 2020) were very effective for children and had limited application for adult university students.

Overall, many more gaps than insights came from a review of the literature for this research, including a purposeful need for a structured behaviour driven oral health education program to university students in Libya. This study utilises interactive learning pedagogies and digital learning strategies, with theory of behaviour change, to build a sustainable and effective oral health education model that would contribute and enhance the long-term sustainability of oral hygiene behaviours.

Table 2.1: Literature on Oral Health and Associated Factors

Author, Year	Objective	Method	Sampling	Results
Abu-Baker et al. 2021	1. Assessing haemoglobin levels of female adolescent students 2. Examining their knowledge, attitude, and practice regarding IDA 3. Evaluating the effect of a nutrition education program on the same.	A quasi-experimental design (pre-test – post test control group) involving	363 students from four public secondary schools in Jordan	The intervention group's total KAP scores were significantly higher than the control group ($p < .05$) post-program. Additionally, the total KAP scores within the intervention group showed significant increase from pre- to post-test ($p < .05$).
Kulkarni et al., 2015	To assess the impact of oral health education on knowledge, attitude & practices among high school students.	An interventional study was conducted in two schools	Universal sample of 400 students from two government aided schools located in semi urban area of Belagavi district	After giving oral health education there was a significant increase in knowledge, attitude and practices among study participants (62.6%) when compared to control participants (56.4%).
Karuveettil et al., 2020	To assess the effectiveness of an oral health curriculum in improving the oral health behaviour and dental caries experience in school children	Non-randomised trial with pre-test/ post-test design	600 school children. Two intervention arms were designed with one group receiving health education from a dental health professional and other from a schoolteacher.	There were significant improvements in KAP regarding oral health among Indian schoolchildren.
Aljanakh, 2017	Determination of tooth decay incidence and severity	Randomly chosen cross-sectional study	480 middle school students	Tooth decay was 3,49 ± 2,78, decay was 2,68 ± 2,21 and missing was 0.10 ± 0.34, components filled were 0.71 ± 1,09.
Andegiorgish *et al.*, 2017	To evaluate the prevalence and related dental caries factors in Eritrea	Cross sectional study	225 school adolescents among 12 years old	Tooth decay was 78%, with no major difference among male (78%) and female (79 %). Average DMFT of 2.50 (±2.21)

Author, Year	Objective	Method	Sampling	Results
Borges *et al.*, 2017	To determine the tooth decay in adolescents	Cross sectional study	623 adolescents of males and females, between 12 to 17 years old	Tooth decay was 63,6%, with adults living in rural areas prevalent in urban areas of 70,7% and 56,4%.
Akbar, F. H., et al. (2017)	To evaluate the relationship among oral health and attitudes, attitude and behaviour	Cross sectional study	The research included 1233 school adolescent. All students were among 6 to 12 years old	There was a strong connection among oral hygiene and the attitudes, attitude and actions of primary school adolescent.
Colussi *et al.*, 2017	Evaluating the effect of oral hygiene on adolescent quality of life	Cross- sectional study	736 adolescents among 15 to 19 years old, from 20 schools	The loss of tooth was not linked to quality of life, highly related to quality-of-life effects
Fontaine-Sylvestre *et al.*, 2017	Estimate the prevalence of malocclusion between adolescent with ASD and explain the most frequent malocclusion	Cross sectional study	Aged between 5 and 18 years	Results show that the incidence of malocclusion in ASD adults was significantly higher than the control group
Kaboré *et al.*, 2017	To assess the oral and dental health of pupils of the Bilbalogho A public primary school of Ouagadougou	Descriptive cross-sectional study	313 pupils, of whom 172 were female and 141 males between aged 10 -12 years	Were found Angle class I malocclusions were the most common (66.8%).
Ali *et al.*, 2017	Evaluation of the relationship between primary and permanent caries	Multistage Systematic Cluster Random sampling	3,358 among 5 to 19 years	The study found a large combination of primary and permanent tooth decay
Alshahrani *et al.*, 2018	To evaluate tooth decay prevalence	Stratified cluster random sampling was	Sample size was found to be 1997	There was 72.9 % of the sample population. The tooth decay values in the posters were found to be highest (90.7 %).
Shaghaghian *et al.*, 2018	Status of Shiraz Pre-school adolescent to assess tooth decay	Cross sectional study	Randomised sampling of 453 adolescent	Untreated tooth decay was 69.9 % prevalent. Just 119 students were classified as without decay (30.1 %).
Sun *et al.*, 2018	To evaluate the sociodemographic and clinical influences of the OHRQoL	Cross sectional study	364 (186 girls, 178 boys)	OHRQoL Impact after the possible mistakes have been adjusted. Boys were less decay and stronger than girls were OHRQoL.

Author, Year	Objective	Method	Sampling	Results
Albakri *et al.*, 2018	To assess malocclusion prevalence between male school students	Cross-sectional study	500 school adolescents with an age of 12- 15 years old	Molar class was the highest rate (71.2%) of the study, while Class II was just 23%, four times class III (5. %). In 23.2% of the study, the maxillary arch crowd was double as the distance. At 28% of the crowding was in the mandibular arch.
Goel *et al.*, 2018	The relationship between orthodontic malocclusion and periodontal status, tooth decay and socio-demographic variables	Questionnaire with examination	400 students from 11 to 14 years of age attended school	Have been discovered no statistically relevant association among tooth decay and malocclusion has been established
Abbass *et al.*, 2019	To evaluate the occurrence of tooth decay in young Egyptians	Questionnaire with examination	369 students and adults in Egypt from 3-18 years old	In Egyptian student, the prevalence of decay was higher in primary teeth than permanent teeth.
Obregón-Rodríguez *et al.*, 2019	To evaluate tooth decay prevalence and severity	Cross-sectional study	1,843 school adolescents among 12 years old	Results for a permanent and temporary dentition of 0.89 dmft aged 12 to 15 years old
Gandhi *et al.*, 2019	Assess the relationship of demographics with tooth decay	Cross-sectional study	700 students from the school. 350 12 years old early adolescents and 350 15-years old	Tooth decay in 12 years old was estimated to be 49% and tooth decay is found to be 60% in 15 years old.
Abu-Gharbieh *et al.*, 2019	To assess the level and connection among the oral hygiene and medical attitudes and health related behaviours of adolescents UAE residents	Cross sectional study	UAE resident 630 young people	Were correlated with the information score significantly
Fatani *et al.*, 2019	To develop malocclusion prevalence between early adolescents	Cross-sectional study and Molar and canine relationships were examined	400 adolescents from Saudi schools between the ages of 12 and 15, of male and female chosen randomly from 15 schools	Class I (52.3%), followed by Class II (25%), and Class III were found to be the most common form of molar relationship (20.5 %). The majority of people (74%) experienced malocclusion, and the most popular was scissor bite (2.5%).

Author, Year	Objective	Method	Sampling	Results
Chen *et al.*, 2020	To examine tooth decay within 12 years old and related risk indicators	Cross-sectional, a structured questionnaire	2,324 school students from 9 areas among 12 years old	Tooth decay was prevalent at 56.11% and the amount of decayed missing filled teeth was 1.53
Akaji *et al.*, 2020	To evaluate dental caries and related factors using decayed teeth	cross-sectional descriptive study	360 students aged 12 and up were enrolled in school.	Tooth decay was included in 54.4 %. Average dmft/SiC ratios of private and public-school participants were 2.29/0.78 and 2.83/1.59
Oliveira & de Andrade, 2020	To evaluate the oral hygiene-related quality of life and the factors that influence it.	Cross-sectional study	1,217 school adolescent aged 12 years, 996 presented complete	Bad OHRQoL was found in 31.4 %, with the psychological domain being the most affected (22.6 %). Bad OHRQoL was linked to pain and discomfort with oral health.
Corcoran *et al.*, 2020	To investigate the effect of oral hygiene on quality of life	Cross sectional study	The survey was completed by 63 to around 64 young people who were 18 years old at the time of their last follow-up visit.	Content analysis revealed that for the complexity of the procedures, one-fourth of the participants cited a positive result as a reason for attending the cleft centre. All of the participants expressed their gratitude to the cleft team.
Akmal, 2020	To determine the incidence of tooth decay in adults aged 12 to 16 who have a malocclusion	Cross sectional study	313 consecutive case records	The majority of the students (70.93 %) had Class I followed by Class II (29.07 %). When it came to crowding, mandibular crowding (57.19 %) was more common than maxillary crowding among the students (38.98 %)
Al-Awadi *et al.*, 2020	Determine the tooth decay and malocclusion by Angle's classification.	A cross-sectional study & Angle's classification.	1,079 school students from public and private schools among 7 and 12 were involved.	The connection among malocclusion and tooth decay in the primary dentition was significant because students with malocclusion were more likely to develop decay than students who did not have malocclusion.

Author, Year	Objective	Method	Sampling	Results
Akmal, 2020	To determine the incidence of tooth decay in students aged 12 to 16 who have a malocclusion	two examiners were involved	Average 313 consecutive case records 12-16 years old	There was a connection among maxillary crowding and tooth decay, but there was no correlation among tooth decay and dental malocclusion
Zheng, *et al.* (2021).	To assess the connections between oral health-related knowledge, attitudes, practices (KAP), self-rated oral health, and oral health-related quality of life (OHRQoL) among Chinese college students.	A cross-sectional study using online questionnaire	1,751 out of 2,000 participants between October 2019 and January 2020	Oral health-related knowledge and attitudes among the students were satisfactory, the actual practices were less so. The study revealed direct positive associations between oral health knowledge and attitudes, and between attitudes and practices. Oral health practices directly influenced self-rated oral health, which along with knowledge and practices, had a direct positive impact on OHRQoL. Interestingly, attitudes had a direct negative impact on OHRQoL.
Barasuol et al., (2020)	To assess how dental pain affects the oral health-related quality of life (OHRQoL) among children and adolescents.	Systematic review and meta-analysis	Articles identified from multiple databases including PubMed, Scopus, and Web of Science	There was a significant negative impact of dental pain on the OHRQoL of children and adolescents.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Introduction

This chapter focuses on the process of investigating the research problem in terms of the sampling technique, data collection instruments, and statistical techniques used to test the hypotheses of the study. The researcher has taken time to define key terms in this chapter, which includes the population of the present inquiry, the sampling technique used, the data collection techniques, data analysis techniques, the measurement instruments and other research methodology agents that were used in the study. This section starts with a definition and development of the conceptual model of this study.

3.2 Research Process

The research process for this study is organised into three phases, i.e. screening, development, and intervention. Each phase is intended to systematically assess the influence of oral health education on the knowledge, attitude, and practices (KAP) of university students in Misurata, Libya. Figure 3.1 illustrates the flow of the research process across these three phases.

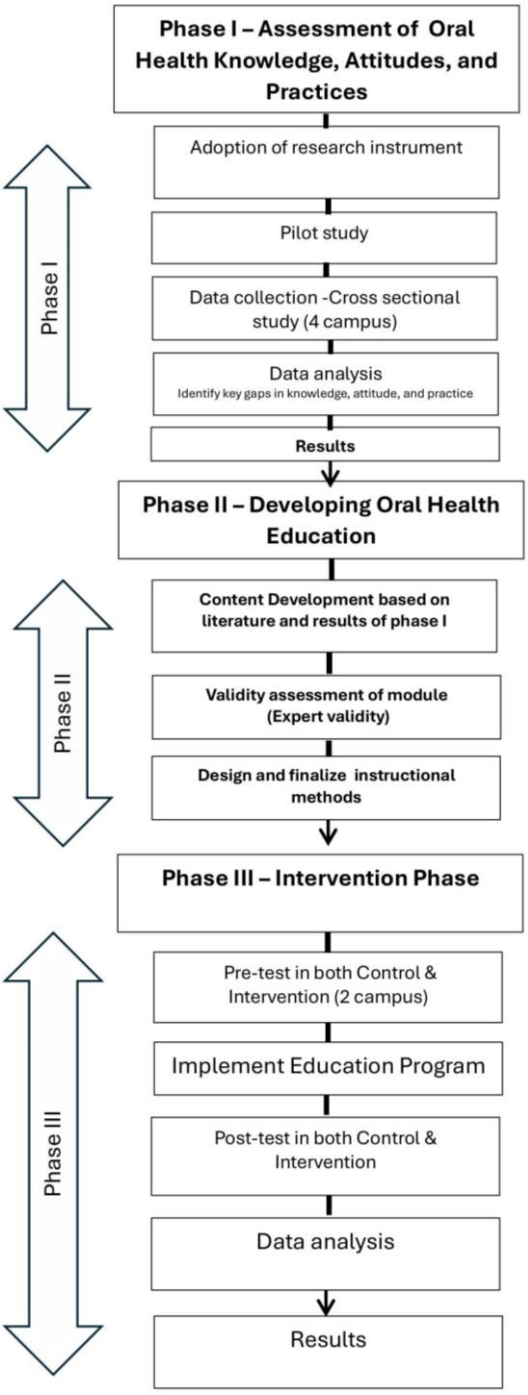
Phase 1 screening phase in with the purpose of this phase was conducting a KAP survey based on a cross-sectional survey to assess current oral health knowledge, attitudes, and practices and assessment of student's perception for oral health education among university students.

Phase 2 The goal of this phase was to develop teaching materials and techniques that addressed the gaps and needs found during the screening phase.

This phase does not involve direct engagement with participants and instead focuses on program development, i.e. to design and develop a comprehensive oral health education program that addresses the needs identified in the baseline KAP survey.

The purpose of phase 3 intervention phase was conducting a pre-post quasi experimental design using control and intervention and implementing the education program to assess any changes or improvements in participants' knowledge, attitudes, practices, dietary habits and evaluating the oral health related quality of life.

Figure 3.1: Research Process

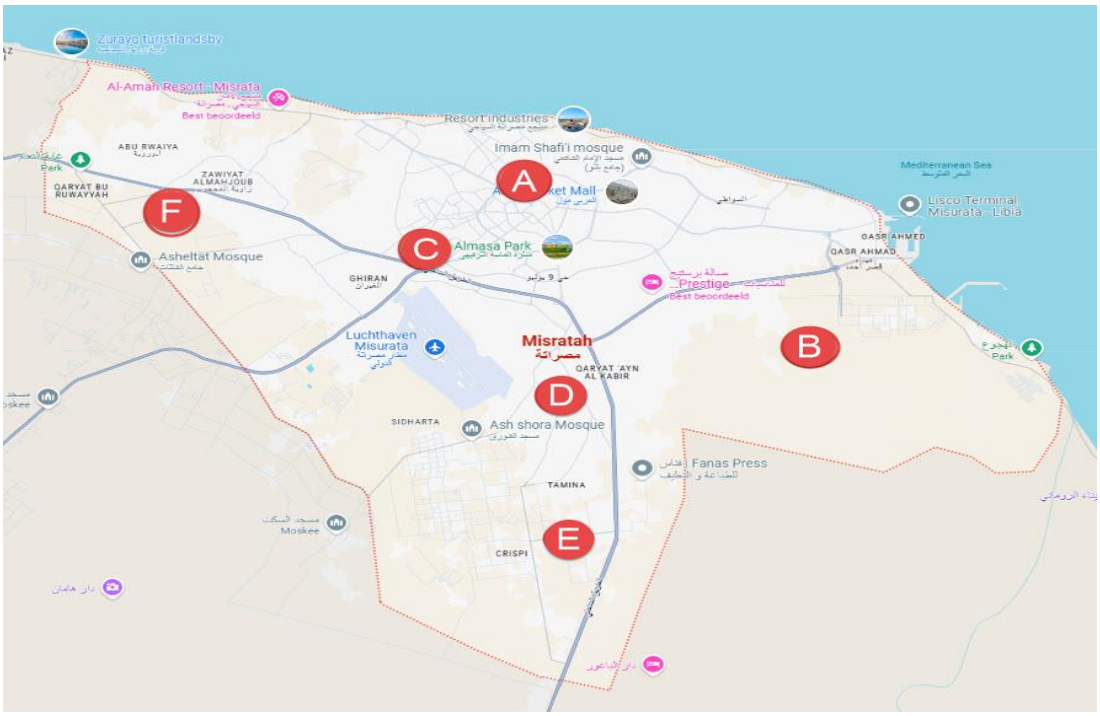


3.3 Study Location

This research was conducted in Misurata, Libya, targeting university students from various institutions within the region. The universities were selected to ensure a diverse and representative sample of the student population. The city of Misurata was chosen because no investigation has been conducted in Misurata, and only a few

investigations have been conducted in other Libyan towns. This university has 6 campus which are located in different part of town. Four campuses were randomly selected to conduct Phase 1 for cross-sectional study and two other campuses were used for Phase 3 (intervention study). The locations of the five campuses involved in the research are shown in Figure 3.2.

Figure 3.2: Location of study (Five different campus)



3.4 Study Population

Population represents the total number of people, events, or objectives that are supposed to be clearly identified in any group of interest. According to Field (2013), the population refers to a group to which the researcher is interested in generalising the research findings. Determination of the population is thus important in any study and more so inferential statistics as outlined by Creswell *et al.* (2007) require adequate sampling for generalization of findings to the population.

The term "research population" refers to a group of individuals from whom the researcher wishes to collect data on a particular subject. There are 27 public universities, 56 private universities and 255 private institutes in Libya (Libyan Universities Directory, 2021). The current study's population or research participants

were university students 18–21-year-old Libyan university students in the city of Misurata.

3.5 Phase 1 Screening Phase

This section will discuss on the methodology for Phase 1.

3.5.1 Research Design

This phase of study employs a cross-sectional design to evaluate the level of knowledge, attitude, practices, quality of life and student's perception on oral health education among university students in Libya. The study utilised surveys to measure the research outcomes.

3.5.2 Sample Size

There are 25,500 students in Misurata city of Libya. Universities were selected by reference to the list of official universities published by the Ministry of Education. According to the Sekaran (2003) table, if the study population is 25,500, the study sample is 400. The present study collected data from a sample of 400 Misurata university students. The sample size was determined by the Slovin formula (Keskin *et al.*, 2007; Sekaran *et al.* 2003).

n= N/ (1+Ne2)

n= 25500/ (1+25,500*(5%) 2)

n= 25500/ (1+25,500*0.05* 0.05) = 392

Where n = the sample size, N = the population size = (25,500), and e = the margin of error = 5%= 0.05.

3.5.3 Sampling Method

Phase 1 adopted a cross-sectional survey to collect data from among university students in Misurata city. The research required to ensure that many students were represented as much as possible across the various campuses; the university has six different campuses: A, B, C, D, E, and F.

For this phase of the study, Campus C, which accommodates over 10,000 students, and Campuses A, D, and E, each with an accommodation of between 2,000 to 3,000 students were randomly selected for phase 1. Total 720 students at these

campuses were considered for the administration of the questionnaire, taking into account non-responses from the selected respondents. The selection method was based on simple random sampling. The university administration provided a list of enrolled students across campuses and thus the researcher come up with a random list of student IDs using an online random number generator (Random.org). Such a method ensured that every student in the selected campuses had equal probability of making it to the sample-a success factor crucial in increasing representativeness and decreasing selection bias.

3.5.4 Inclusion and Exclusion Criteria

To be eligible for this study, participants must be undergraduate students aged between 18 and 21 years who are registered as full-time students at either Campus F or Campus B for the duration of the research period. They must also demonstrate an ability to read and comprehend the language used in all study materials, including the questionnaire and intervention resources. Furthermore, eligible participants are required to provide written informed consent, confirming their willingness to participate, and must be available to attend both the baseline and post-intervention assessment sessions.

Individuals are excluded from participation if they fall outside the specified age range, or if they are postgraduate, part-time, or exchange students. Additional grounds for exclusion include having taken part in any formal oral health education programme within the preceding 6 to 12 months or having a medical or cognitive condition that could hinder their ability to participate fully or understand the intervention. Students who are undergoing ongoing dental or orthodontic treatment that may significantly affect their oral health behaviours or study outcomes are also ineligible. Finally, participants will be excluded if they provide incomplete baseline data or choose to withdraw their consent at any point during the study.

3.5.5 Research Instrument

The present study employed a structured, self-administered questionnaire as the primary research instrument for collecting quantitative data across Phases 1 and 3 of the research process. The use of structured questionnaires is widely

recommended in educational and health-related research due to their efficiency, standardisation, and ability to capture perceptions, behaviours, and psychosocial constructs in large populations (Creswell & Creswell, 2018; Dillman, 2011). The instrument in this study was designed to measure university students' oral health Knowledge, Attitudes, and Practices (KAP), dietary habits, and Oral Health-Related Quality of Life (OHRQoL), as well as to provide baseline information necessary for the development of the oral health education module in Phase 2.

3.5.5.1 Demographic and Background Characteristic

The first section of the questionnaire consists of items related to participants' demographic information as well as other variables related to oral health histories. This instrument was developed for this purpose to collect this information from participants, and included items on age, sex, whether or not the participant experienced dental caries, the type of treatment received at the last visit to the dentist, smoking, the main source of drinking water and the main source of knowledge about oral health.

3.5.5.2 Knowledge

In the present study, a knowledge questionnaire that addressed oral hygiene was replicated from the questionnaire developed by Ahmad *et al.* (2019). The purpose of this survey (Table 3.1) was to conduct a school-based survey of suburban adolescents in order to assess their knowledge of oral hygiene. The questionnaire has 8 items that will assess the respondents' knowledge about basic oral health principles and the proper practice of oral hygiene. Each question of the survey is scored based on a binary scale (0: incorrect, 1: correct) whereby a correct answer represents the higher end of knowledge. The scores will be summed in order to yield an overall score of knowledge regarding oral health for that individual. The higher the score, the better the level of knowledge. The total score of knowledge ranged from 0 to 8, and higher scores indicate higher levels of knowledge.

Table 3.1: Items Related to Knowledge of Oral Hygiene

	Item	Reference
1.	Meaning of gum bleeding is inflamed gum.	Ahmad et al. (2019)
2.	Using toothbrush protects from gum bleeding.	
3.	Plaque means soft debris on the teeth.	
4.	Dental plaque causes staining of teeth.	
5.	Carious teeth affect teeth appearance.	Scale: 0 (wrong), 1 (correct)
6.	Sweets affect the teeth adversely.	
7.	Fizzy drinks affect the teeth adversely.	
8.	Using fluoride-based toothpaste strengthens the teeth.	

3.5.5.3 Attitude

The oral hygiene attitude section items are adopted from Jaber *et al.* (2017) and are intended to assess the beliefs of respondents about oral health and prevention practices. Participants responded to 8 items (Table 3.2), each scored on a binary scale ranging from 1 "Yes" to 0 "No", where "Yes" has the highest score, reflecting the higher level of positive attitude toward oral hygiene. Scores of the individual items are summed to provide an overall attitude score. The total score ranged between 0 to 8 and higher score reflect more attitude toward oral health.

Table 3.2: Items Related to Attitude toward Oral Hygiene

	Item	Reference
1.	Regular visits to the dentist are necessary	Jaber et al. (2017)
2.	There is relationship between oral health and general health.	
3.	Regular brushing of teeth prevents dental decay.	
4.	Sweets affect the teeth adversely.	Scale: 0 (No), 1 (Yes)
5.	Soft drinks affect the teeth adversely.	
6.	Using fluoride strengthens the teeth.	
7.	Dentist always explain teeth problems and propose solution No	
8.	Teeth are weakened because of repeated cleaning	

3.5.5.4 Practice

The oral hygiene practice category was comprised of 12 items taken from Ahmad *et al.* (2019) (El Mouzan *et al.*, 2010), which sought to evaluate practical behaviour in oral hygiene among suburban adolescent students. All items were written to assess specific behaviours that comprised the oral hygiene practices that the adolescent participates in on a day-to-day basis (Table 3.3) including if participants flossed, a daily brushing habit, and whether they visited a dentist regularly. Each of

the questionnaire items answers were designed to determine how frequently a participant engaged in the number and quality of oral hygiene practices, and the participants who scores higher were considered to have better oral hygiene practices aligned with genetically determined optimum oral health standards. Each of the items is scored on a binary response measure (0: No, 1: Yes), with the correct practice existing at a higher level. A participants' total practice score hovered in the range of 0 - 12, with higher score indicating a higher level of practice.

Table 3.3: Items Related to Attitude toward Oral Hygiene

	Item	Reference
1.	I brush my teeth twice per day.	Ahmad et al. (2019)
2.	I use toothbrush and toothpaste to clean my teeth.	
3.	I use floss to clean my teeth.	
4.	I use toothpick to clean my teeth.	
5.	I use mouthwash to clean my teeth	
6.	I clean my teeth after every meal.	Scale: 0 (No), 1 (Yes)
7.	I brush my teeth for more than 2 minutes.	
8.	I clean my tongue after brushing teeth.	
9.	I visit a dentist annually.	
10.	My toothpaste contains fluoride.	
11.	I don't share my toothbrush with others.	
12.	I change my toothbrush every 3-4 months	

3.5.5.5 Perception of Oral Health Education

The section on perceived attitudes towards oral health education aims to examine the participants idea and attitudes towards the inclusion and assessment of dental disciplines in a teaching or learning situation. This section contains eight items (Table 3.4) modified from Kwan *et al.* (2005), to examine the opinions regarding the inclusion of oral health courses at both the school and university levels, perceptions surrounding the importance of oral health courses, and on the eventual difference that different resources- seminars, department visits, and online material, make in students' perception of courses. Items are scored on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree) which will allow for a detailed level of understanding on the participants attitude to the importance of, and way of, delivery of oral health education.

Table 3.4: Items Related to Perception of Oral Health Education

Item	Reference
1. Oral Health Education may be included into the school curriculum as a separate topic. 2. Only dentistry course may include oral health concepts. 3. The addition of oral health topics may cause students' attention to wander away from the subject at hand. 4. Dentistry department visits should be a regular component of the university's activities. 5. The universities should make provisions for free seminars on oral health. 6. The internet has a greater impact on changing students' views about oral health education. 7. From the books they read, students learn how to maintain good oral health. 8. When Oral Health Education is taught as a separate topic in university, students will have a better understanding of the importance of oral health.	Kwan et al. (2005), Likert Scale: 1 (strongly disagree), 5 (strongly agree)

3.5.5.6 Oral Health Related Quality of Life

The Oral Health-Related Quality of Life section assesses the participants' experiences and perceptions about the effects of oral health problems on different aspects of daily life and well-being. This section includes 14 items (Table 3.5) adopted from Al Habashneh *et al.* (2012) for the assessment of the impacts of oral health problems on functional, physical, and psychologic aspects of quality of life. Items on the scale range from 0 (never) to 4 (often), which allows the participants to express the frequency of particular oral health problems they face.

Items representing Oral Health-Related Quality of Life were thus organised into seven subdomains in order to comprehensively investigate the impacts of oral health problems on various features of life. The subdomains include Functional Limitation, Physical Pain, Psychological Discomfort, Physical Disability, Psychological Disability, Social Disability and Handicap. Each subdomain represents a different dimension of the participants' experience and contributes to the total understanding of the quality-of-life impact of oral health. The responses were recorded in a 5-point Likert scale ranging from never to very often (score is 0 to 4). Then, we calculated the total scores of all domains, and the higher the score, the poorer the OHRQoL. The highest possible total. The score of all the OHIP-14 domains is 56 (14 × 4).

Table 3.5: Items Related to Perception of Oral Health Education

	Item	Reference
1.	Have you had trouble pronouncing any words because of problems with your teeth, mouth and denture?	Al Habashneh et al. (2012)
2.	Have you felt sense of taste has worsened because of problems with your teeth, mouth and denture?	
3.	Have you had painful aching in your mouth?	Likert Scale: 0 (never), 4 (very often)
4.	Have you found it uncomfortable to eat any food because of problems with your teeth, mouth and denture?	
5.	Have you been self-conscious because of problems with your teeth, mouth and denture?	
6.	Have you felt tense because of problems with your teeth, mouth and denture?	
7.	Has your diet been unsatisfactory because of problems with your teeth, mouth and denture?	
8.	Have you had to interrupt meals because of problems with your teeth, mouth and denture?	
9.	Have you found it difficult to relax because of problems with your teeth, mouth and denture?	
10.	Have you been a bit embarrassed because of problems with your teeth, mouth and denture?	
11.	Have you been a bit irritable with other people because of problems with your teeth, mouth and denture?	
12.	Have you had difficulty doing your usual jobs because of problems with your teeth, mouth and denture?	
13.	Have you felt that life in general is less satisfying because of problems with your teeth, mouth and denture?	
14.	Have you been totally unable to function because of problems with your teeth, mouth and denture?	

3.5.6 Face and Content Validity

The scale has had an extensive amount of validity checks to ensure its reliability (Zalatan, 1998; Hair, JrJF *et al.* (2010). Validity checks were made with the internal and external validity being assessed. External validity looks at whether the scale can be generalised to different populations, time periods, and contexts. Internal validity is if the instrument is measuring what it is supposed to measure (McKibbin *et al.*, 2005). In business research, both content and construct validity are important.

Face and content validity look at if the items in the scale correctly define domains in the conceptual domain Zalatan (1998). For face and content validity it is important to perform a thorough, systematic and individual judgement (JrJF *et al.*, 2010). As part of the pre-testing, content validity will depend on the above choice and advice from the subject matter experts for the study. To contain content validity

during the pre-testing process, subject matter experts were utilised. The experts then read through the excerpts pulled from a sample of the questionnaires and, beyond looking for content, spelling, phrases, and other interpretability issues, were also tasked to ensure that the content was appropriate, clear, and linguistically correct. It was overall agreed that the content was appropriate, clarity and linguistic precision.

3.5.7 Pilot Study

The pilot study enables the researcher to determine the validity of the questions and the likely reliability of the data that will be gathered. As pointed out, a pilot study is either a small-scale implementation of a design or a series of steps taken to ensure the nature of future data collection procedures. They added that a pilot study is a stage of research in which a small amount of data is collected to evaluate procedures, identify potential problems with data collection conventions, and lay the groundwork for the genuine study. A pilot study was conducted in this study to ensure that the questionnaire was appropriate and effective. Test–retest was used to check the reliability and internal consistency of the knowledge and practice questionnaire while for another questionnaire Cronbach's alpha was employed.

Forty participants were included in this pilot study to measure the reliability of the instrument used. The reliability of the attitude, perception on oral health education and oral health related quality of life was assessed using Cronbach's Alpha, a measure for testing internal consistency. In reliability analysis, values of 0.7 or higher are typically considered acceptable, while values between 0.6 and 0.7 can still be considered adequate depending on the context (Hair *et al.*, 2006). The internal consistency of each scale utilised in this research exceeded the necessary thresholds, indicating robust reliability (Table 3.6). The specific results from the reliability testing revealed the following outcomes.

Table 3.6: Cronbach's Alpha Test

Variables of study	Number of Items	Cronbach's Alpha Value
Oral hygiene attitude	8	0.744
OHRQoL	14	0.870
Oral health education	8	0.908

Since knowledge, practice and sugar consumption frequency items are not necessarily correlated and these three construct were formative, therefore a test-retest method was employed within 1 week among same students. To measure the internal consistency of knowledge, practice variables, Kappa coefficients was used while for consumption frequency items intraclass corelation (ICC) were calculated. A kappa value above 0.4 indicates acceptable agreement / result showed that all items had a Kappa value above threshold of 0.4, indication adequate consistency for all related items to the knowledge and practice (Table 3.7). ICC value above 0.7 indicates acceptable consistency between two measurement and results for consumption frequency items showed that all items had an acceptable reliability).

Table 3.7: Test-retest Reliability for Knowledge, Practice and Sugar Consumption Frequency

Construct	Items	Kappa
Knowledge	Knoweldge1	0.765
	Knoweldge2	0.730
	Knoweldge3	0.737
	Knoweldge4	0.845
	Knoweldge5	0.709
	Knoweldge6	0.747
	Knoweldge7	0.698
	Knoweldge8	0.734
Practice	Practice 1	0.935
	Practice 2	0.600
	Practice 3	0.894
	Practice 4	0.678
	Practice 5	0.817
	Practice 6	0.554
	Practice 7	0.818
	Practice 8	0.881
	Practice 9	0.899
	Practice 10	0.817
	Practice 11	0.701
	Practice 12	0.727
Sugar consumption frequency items		ICC
	SCF1	0.796
	SCF2	0.743
	SCF3	0.803
	SCF4	0.844
	SCF5	0.901
	SCF6	0.852
	SCF7	0.923
	SCF8	0.782
	SCF9	0.797

3.5.8 Data Collection

In this phase the method was quantitative - utilising a close consultation method, effective through the use of a self-regulatory questionnaire in paper and pencil format, and so that students could receive a full description of how to rate their answer. Students were notified, at the onset, that the researcher would be there for the students for a couple clauses, meaning that students were invited to consult the researcher if they needed clarification on any of the components; However, the author ensured that students did not have the opportunity to repeat their answers by instructing them to maintain at least one desk between themselves and the next student. Furthermore, cutting down on duplicate or inconsistent responses was my aim by making sure that students only completed one completed questionnaire, and that students completed all of the clauses in the questionnaire. After students finished the questionnaire, the author asked the students to stay in the classroom until the survey was finished; at the conclusion of the survey, students were enthusiastic about sharing their completed questionnaires with the examiners.

3.5.9 Data Analysis

Statistical analysis was completed using Windows SPSS 29 version software. We determined statistical significance at $p < 0.05$. We assessed all continuous variables for normality before using parametric or nonparametric statistical methods of analysis. We calculated the ratio of skewness and kurtosis to each of standard error measurements for all variables. All skewness and kurtosis ratios should fall within the ±1.96 range for normal distribution of our data (Mishra *et al.*, 2019). We also conducted Kolmogorov-Smirnov and Shapiro-Wilk tests to assess data normality. The descriptive analysis of percentages, frequencies, median, standard deviation and mean let us describe the participant characteristics in relation to all dependent variables. Additionally, correlation coefficient and also be useful to report relational contribution of variables.

3.6 Phase 2 Development of Oral Health Education

This section will explain the methodology for Phase 2.

3.6.1 Introduction

The second research objective is "To implement an oral health education program aimed at improving knowledge, attitude, and practice (KAP) regarding oral health among university students in Misurata". The intervention, based on a structured evidence-based Oral Health Education (OHE) module, was intended to increase oral health knowledge and preventive practice, and develop attitudes favourable to those behaviours in young adults (18-21 years of age). The development stage occurred in two phases; the first phase focused on development of content through the examination of published literature and content from experts and the second phase on delivery and validity assessment/modification of the module.

In Phase 2 of the oral health education (OHE) module development, the focus is implementation, validity assessment and modification. This phase involves the delivery of the OHE to a study group, the examination of the effectiveness of the OHE module, and the promotion of content validity, face validity, engagement and effect. What follows is a detailed account of the process of Phase 2, under the following subheadings: Introduction, Components, Method of Delivery, and Validity Assessment.

3.6.2 Structure and Content of the Intervention

The development process for the Oral Health Education (OHE) module was undertaken systematically utilising evidence-based practices as well as blended theoretical frameworks with tools based on international guidelines and findings from empirical research. This version of the module for young adults ages 18-21 years old was created using a variety of information sources to establish its validity and efficacy as well as contextual appropriateness.

Phase 1, the cross-sectional study, served as the underpinning foundation for the module, determined baseline oral health knowledge, attitudes and practices (KAP) of the university students as well as their assessed oral health-related quality of life (OHRQoL), and perceptions about oral health education. The research results

identified notable deficits in oral health knowledge, inconsistent oral hygiene practices, and a lack of awareness about the benefit of professional dental care. Although students demonstrated a thorough understanding of the significance of oral health education, within the perception data, students perceived that organised, evidence-based oral health programming was limited. The research results highlighted a need for educational intervention which can address knowledge gaps and misconceptions as a result of immersive, deep learning which employs comprehensive, interactive and practical pedagogies.

The framework and content of the module were created after the synthesis of findings based on best practice literature: The World Health Organization Oral Health Education Manual (WHO, 2018); the American Dental Association health education standards (ADA, 2020), and principles of health behaviour change. The module met global standards via triangulation while concurrently maintaining the contextual realities established in the preliminary study.

The completed OHE module included four thematic modules which were administered across two consecutive weeks. The modules included essential oral health domains such as:

Module 1: Offers Basic Oral Health Knowledge through lessons about dental anatomy and prevalent oral health problems.

Module 2: Examines how diet choices along with smoking habits and alcohol use affect an individual's health.

Module 3: Practical Oral Hygiene Skills teaches the correct methods of brushing and flossing.

Module 4: The module on Preventive Care and Professional Support focuses on recognising early symptoms while providing cost-effective dental care solutions.

Interactive elements including PowerPoint presentations, videos, visual aids, group discussions, and role-playing activities were included in each module to enhance participant engagement. The weekly schedule and instructional details are provided in Appendix A &B.

3.6.3 Module Validation

After designing the first draft of intervention protocol and to evaluate the validity and feasibility of intervention, a panel of experts including five dentist and oral hygiene professional assessed the content validity of module (Table 3.8). The researchers evaluated content validity of module, using a statistical measure known as the Content Validity Index (CVI). The CVI calculation for content, method and duration required ratings for each item using a four-point scale from 1 to 4 representing appropriateness levels. The CVI score for each item resulted from dividing the experts who rated the item as 3 or 4 by the total experts who participated. The researchers employed the Kappa Modified Coefficient to assess how well experts agreed on the relevance of the CVI according to the method outlined by Polit *et al.* (2007).

Table 3.8: Details of Experts for Intervention Module Evaluation

Expert	Designation	Area of Specialisation	Nationality
1	Osama Ali	Psychology	Libyan
2	Mustafa Smeo	Dental	Libyan
3	Nidal Ahmed	Material	Libyan
4	Abudlhakim Already	Technician	Libyan
5	Mohamed Ali	Dentistry	Libyan

The content validity involves the development of the instrument and the analysis and judgement of specialist (Polit & Beck, 2006). The intervention program on oral hygiene was systematically evaluated by five experts for content validity, methodology, and duration, using the Content Validity Index (CVI) and Cohen's Kappa coefficient. The overall results (Table 3.9) indicate a high level of agreement among experts across all domains, with most items achieving perfect agreement (CVI = 1.00, Kappa = 1.00). The main topics, including dental structure, common oral health issues, the role of diet, lifestyle factors, and brushing and flossing methods, were unanimously agreed upon with regard to importance, methodological appropriateness, and duration. This uniformity suggests that the module properly covers essential aspects of oral hygiene education. Nevertheless, some discrepancies were detected in several items. The "pulp" topic in dental anatomy and "alcohol"

under lifestyle factors also showed somewhat less agreement in the method of delivery (CVI = 0.80, Kappa = 0.76).

Similarly, "gum disease" under general problems and "timing of mouthwash" under flossing techniques also showed somewhat less agreement regarding duration (CVI = 0.80, Kappa = 0.76). These variations point toward areas for potential minor refinement in methodological accuracy or time allocation. Generally, the high validity scores reflect that the intervention is well-designed and ready for implementation, with slight adjustments needed to increase consistency in some sections.

Table 3.9: Results of Experts Evaluation on Content, Method and Duration of Intervention Protocol

Domain	Component	Content		Method of Delivery		Duration	
		CVI	kappa	CVI	kappa	CVI	kappa
		1.00	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
Domain 1 (Dental Anatomy)	Enamel	1.00	1.00	1.00	1.00	1.00	1.00
	Dentin	1.00	1.00	1.00	1.00	1.00	1.00
	pulp	1.00	1.00	0.80	0.76	1.00	1.00
Domain 2 (Diet and Oral Health)	Sugary Drinks	1.00	1.00	1.00	1.00	1.00	1.00
	Water and Fluoride	1.00	1.00	1.00	1.00	1.00	1.00
	Candies	1.00	1.00	1.00	1.00	1.00	1.00
Domain 2 (Lifestyle Factors)	Smoking	1.00	1.00	1.00	1.00	1.00	1.00
	Alcohol	1.00	1.00	0.80	0.76	1.00	1.00
Domain 3 (Brushing Techniques)	Brushing Recurrence	1.00	1.00	1.00	1.00	1.00	1.00
	Tools Utilised for Cleaning Teeth	1.00	1.00	1.00	1.00	1.00	1.00
	Brushing Length	1.00	1.00	1.00	1.00	1.00	1.00
	Sharing Toothbrush	1.00	1.00	1.00	1.00	1.00	1.00
	Changing Toothbrush	1.00	1.00	1.00	1.00	1.00	1.00
	Cleaning Tongue	1.00	1.00	1.00	1.00	1.00	1.00
	Subsequent to Brushing	1.00	1.00	1.00	1.00	1.00	1.00
	Toothbrush Substitution	1.00	1.00	1.00	1.00	1.00	1.00

Domain	Component	Content		Method of Delivery		Duration	
		CVI	kappa	CVI	kappa	CVI	kappa
		1.00	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
Domain 3 Flossing Techniques	Frequency of Flossing	1.00	1.00	1.00	1.00	1.00	1.00
	Types of Flossing	1.00	1.00	1.00	1.00	1.00	1.00
	Flossing Technique	1.00	1.00	1.00	1.00	1.00	1.00
	Using Mouthwash	1.00	1.00	1.00	1.00	1.00	1.00
	Timing of Mouthwash	1.00	1.00	1.00	1.00	0.80	0.76
Domain 4 Common Issues	Cavities	1.00	1.00	1.00	1.00	1.00	1.00
	Gum disease	1.00	1.00	1.00	1.00	0.80	0.76
	Oral disease	1.00	1.00	1.00	1.00	1.00	1.00

3.7 Pilot Testing Procedures

Following expert validation, the Oral Health Education (OHE) module underwent a pilot test to evaluate its clarity, usability, cultural appropriateness, and overall feasibility before full implementation in Phase 3. Pilot testing is an essential step in educational intervention development because it allows researchers to identify weaknesses, refine delivery methods, and ensure that the content is understandable and well-received by the target population (Creswell & Creswell, 2018; Dillman, 2011). In this study, a purposive sample of 30 university students aged 18–21 years from Misurata University, who met the inclusion criteria but were not part of the main study sample, participated in the pilot phase.

The pilot was conducted in a classroom setting to simulate the actual delivery environment planned for the intervention phase. During the session, students received the full module content, including knowledge-based lectures, visual demonstrations, skill-based exercises, and dietary guidance. Observational notes were taken to assess learners' engagement, comprehension, and response to interactive components. Immediately following the session, participants completed a structured feedback form assessing the module's clarity, flow, relevance, visual appeal, and perceived usefulness. They were also encouraged to express open-ended comments on any confusing concepts, culturally inappropriate examples, or logistical barriers that could affect attendance or learning outcomes.

Feedback from pilot participants revealed several important areas for refinement. Some students suggested simplifying technical dental terminology, while others recommended incorporating more locally relevant dietary examples, particularly related to sweetened beverages and traditional Libyan snacks. Additionally, students expressed a preference for shorter video demonstrations, clearer step-by-step brushing and flossing instructions, and more opportunities for hands-on practice. These suggestions align with recommendations in oral health education literature emphasising audience-centred adaptation and interactive learning strategies (Kay & Locker, 1998; Nakre & Harikiran, 2013).

Quantitative data from the pilot feedback indicated high levels of clarity, relevance, and acceptability, confirming the module's suitability for the target demographic. However, the qualitative insights were invaluable in strengthening behavioural components, enhancing visual materials, improving time allocation across topics, and ensuring the module was both pedagogically effective and culturally sensitive. The refined version incorporated all necessary adjustments, resulting in a more streamlined and engaging educational tool.

Overall, the pilot testing phase ensured that the OHE module was practical, comprehensible, and contextually adapted before implementation in Phase 3. This iterative refinement strengthened the intervention's internal validity and increased the likelihood of achieving meaningful behavioural change among university students, consistent with best practices in health education program design (Nutbeam, 2000; Polit & Beck, 2006).

3.8 Phase 3 Intervention Phase

This section will explain the methodology for Phase 3.

3.8.1 Research Design

Phase 3 was conducted as a quasi-experimental study consisting of two groups, i.e. the intervention group and the control group. A repeated measures design was employed to evaluate the intervention's effectiveness. The participants are assessed at pretest and after three months.

3.8.2 Health Education Group

The principal investigator (Dentist) imparted the oral health education module for interventional arm. Same educational materials and models were used for all grades, thus ensuring the uniformity. Each grade received reinforcement session after three months. A supervised tooth brushing activity was conducted for students.

3.8.3 Control Group

No intervention was done for control group of students.

After three months of implementing the module, all of the students on both intervention and control groups were reevaluated. The KAP questionnaire and oral health related quality of life survey was performed in the same manner as phase1.

3.8.4 Sample Size

The sample size for Phase 3 in this study was calculated using GPower 3.1 software. Prior to determining the sample size, the effect size was calculated from literature (Table 3.10) and another similar research. The smallest effect size (f = 0.12) belonged to practice-based according to Danti Narulita & Danu Aprilianto, 2022.

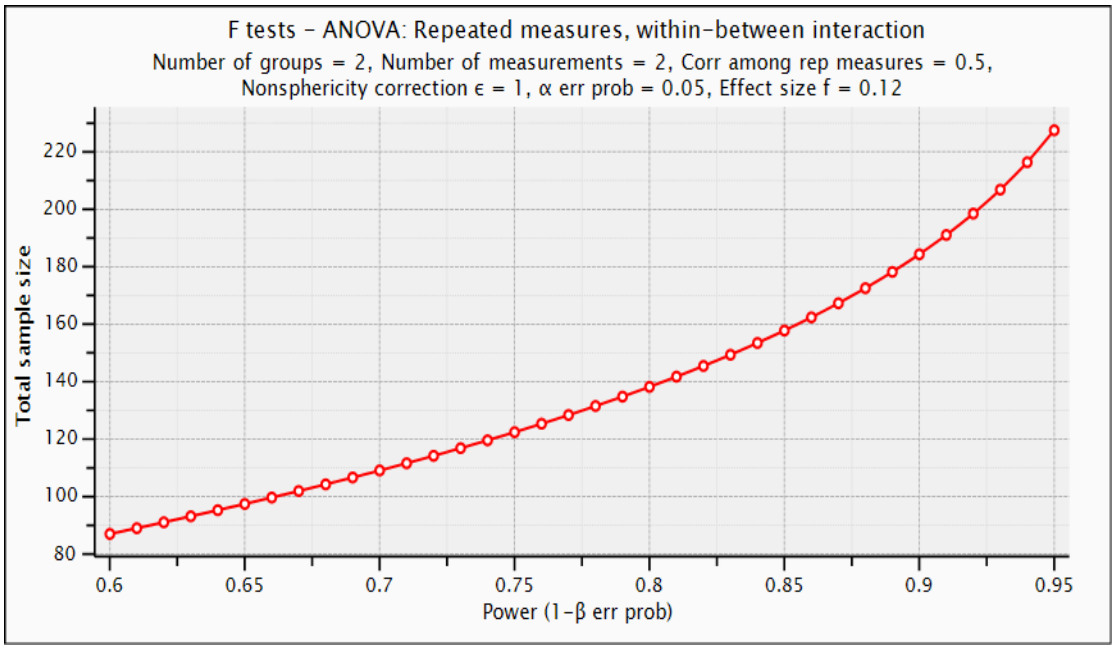
Table 3.10: Effect Size Calculation for Research Variables

Variable	Study Reference	Effect Size (f)
Knowledge	H Mohamed *et al.*, 2021	1.337
Knowledge	Tao *et al.*, 2024	0.980
Knowledge	Alotaibi, A. S.	1.081
Knowledge	Ghofranipour & Tavousi, 2018	15.841
Attitude	Ghofranipour & Tavousi, 2018	13.738
Attitude	Selvarajan *et al.*, 2019	0.460
Attitude	(H. Mohamed *et al.*, 2021	1.873
Practice	(H. Mohamed *et al.*, 2021	1.057
Knowledge	Danti Narulita, Danu Aprilianto	0.315
Attitude	Danti Narulita, Danu Aprilianto	0.205
Practice	Danti Narulita, Danu Aprilianto	0.120

The study comprised two groups (control and intervention) and two repeated assessments (pre-test and post-test). The F-test ANOVA with repeated measures within the interaction was chosen to determine the sample size. The type I error (α error probability) is 0.05, and the power (1 - β error probability) is 0.8. The sample size

calculation showed a total of 140 participants, with 70 assigned to each group, as illustrated in Figure 3.3.

Figure 3.3: Power Analysis for Sample Size Calculation Phase 3



Since this study employed a cluster design, it was required to calculate the design effect (DE) (Killip *et al.*, 2004).

$$DE = 1 + \rho(M - 1) \tag{3.1}$$

Where M is the number in a cluster and ρ means the intracluster correlation (ICC). In general, a human study's intracluster correlation coefficient (ICC) recommended as 0.01 (Donner & Klar, 2000), and in this study ICC = 0.01 was used to calculate the design effect.

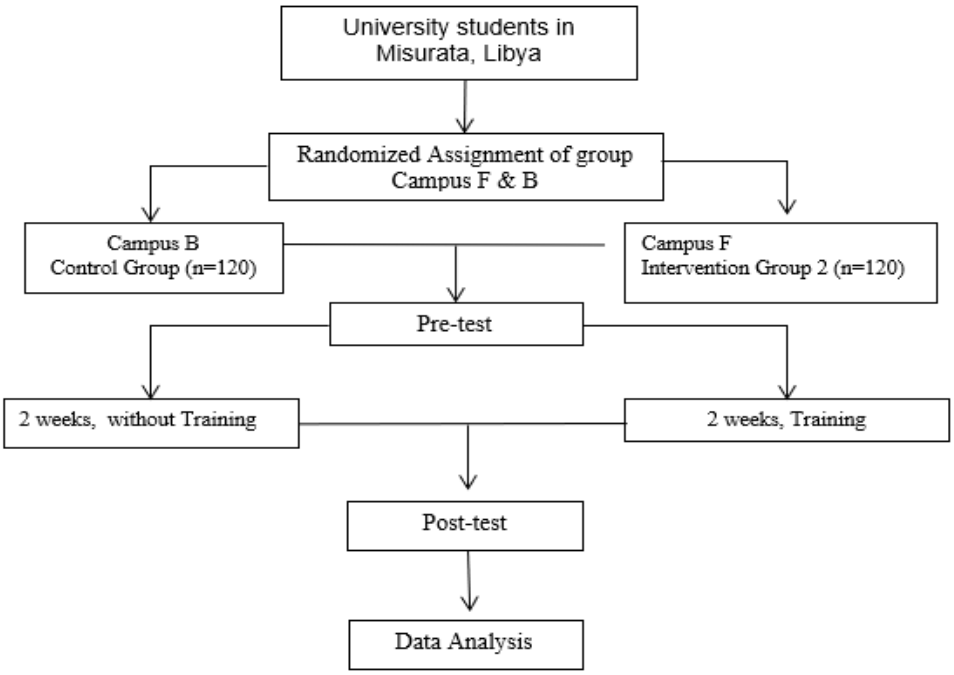
$$DE = 1 + 0.01(70 - 1) = 1.69 \tag{3.2}$$

$$ESS = DE * M * K = 1.69 * 70 * 2 = 236 \tag{3.3}$$

3.8.5 Sampling Method

In Phase 3, a quasi-experimental design was employed in establishing the effectiveness of an intervention. This phase required a cluster sampling technique where campuses F and B were randomly chosen as clusters to allocate to intervention or a control group to avoid the contamination effect. The assignment of campuses was to be done through the random process as a way of excluding or reducing any form of bias that may create an impact on the findings of the research. A sampling list was produced after Campus F was assigned to the intervention group and Campus B to the control group. Within campuses, simple random sampling using a random number generator was used to select 120 students per group, to ensure that bias in the selection was negated. This structured sampling method thus supported the quasi-experimental design by allowing comparability between groups for a more valid measure of the effects of the intervention on the targeted population. Figure 3.4 illustrates the sampling process and group allocation for Phase 3 of the study.

Figure 3.4: CONSORT Diagram Phase 3



3.8.6 Research Instrument

The same research variables and instruments were applied in Phase 3 as described in section 3.5.5.

3.8.7 Data Collection

In this phase, the same method as Phase 1 (Section 3.5.8) was employed for data collection at pre- and post-tests, in both control and intervention groups

3.8.8 Data Analysis

The statistical analyses were done in Windows SPSS 29. We set the statistical significance level at $p < 0.05$. Normality test was done using same method in Phase 1 (Section 3.5.9). The independent t-test was used to compare continuous variables between the intervention and control groups, while the chi-square test was used for categorical data. The non-parametric U Mann Whitney test was used to compare research variable homogeneity between the two groups using interval scales without a normal distribution.

The program's effectiveness (Phase 3) was assessed by comparing the mean difference of all dependent variables between pretest and post-intervention within (intragroup) and between (intergroup) the intervention and control groups using Generalised Estimating Equation (GEE). GEE was also used to compare the intervention and comparison groups' mean response over time for two time points. Pairwise comparisons between groups were made using Estimated Marginal Means and a sequential Bonferroni correction. In this study, effect size was used to assess the intervention's impact on research variables. Cohen classified effect sizes as "small," "medium," and "large" with d= 0.2, 0.5, and 0.8 (Cohen *et al.*, 2013).

3.9 Ethical Considerations

Ethical principles were upheld throughout Phase 3, in line with internationally recognised guidelines for public health research. Participation remained voluntary, and students could withdraw at any point without penalty. Anonymity was preserved through the use of coded identifiers, and all completed questionnaires were stored securely with access limited to the research team.

Additionally, the control group received the educational material after the study concluded to ensure equitable benefits, a principle recommended in intervention ethics literature (Mertens & Ginsberg, 2009). No participant was exposed to harm or invasive procedures, and the educational content aligned with established, evidence-based oral health standards endorsed by global authorities such as the World Health Organisation (WHO, 2023).

3.9.1 Research Ethics

Research ethics establishes the ethical framework within which the researcher conducts research (Mertens & Ginsberg, 2009). According to Armstrong, (2005), ethical behaviour is critical in research, as well as in other forms of human movement. Additionally, they emphasise that a researcher's failure to adhere to an appropriate code of ethics may result in legal action against the researcher. Ethical approval for the study was obtained from the Institutional Review Committee, Libya Institute of Health Sciences. Permissions for a visit and coordination to the university was obtained from the Ministry of Education in Misurata and the Principals of each selected university Appendix D. The Dean of the University for each university asked all students to inform them about the study and seven days for each university to gather the information. The student's age was confirmed from the university registries students below 18 years or over 21 years of age were not summoned to participate. They were excluded from the study. 400 students describe 5% of the full range of 18-21 -year university students in Misurata within the 2020-2021 university year, which were 25,500 university students. The researcher himself assessed the tooth decay/caries (tooth examination was carried out) to find out the prevalence of dental caries among participants. The following sections discuss the ethical issues that pertain to the study in greater detail.

3.9.2 Informed Consent

Participants received adequate information with which to understand the research and use it to make an informed decision about the project. It was specified and agreed upon at all levels how the survey was to be conducted, how confidentiality was to be maintained and what topics were covered in the survey (Walliman, 2005).

3.9.3 Confidentiality

Unless otherwise agreed upon in advance, all information obtained about a participant during the course of an investigation remained confidential. When the possibility of others obtaining access to such information existed, this possibility, along with the safeguards in place to protect confidentiality, was explained to the participant as a critical component of the procedure for obtaining informed consent (Tuten, 2010).

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Introduction

This research is characterised as a quantitative study, with the analysis chapter serving as the primary section for presenting results. Within this chapter, statistical analysis and conclusions are presented in order to create accurate data. The next chapter outlines the results from the data analysis for both phases. The first section represents the results of Phase 1 for assessment of oral health knowledge, attitude and practices as well as educational needs and oral health quality of life among students. The demographic characteristics of the respondents based on frequency, percentage and mean and standard deviation of the variables are presented.

For Phase 3, the study utilised descriptive and inferential approaches using Generalised Estimating Equation (GEE). GEE in the analysis. Besides, in the pre-test stage, an independent t-test and a Mann Whitney U test were conducted to compare the research variables in the two groups, respectively. In this regard, all statistical assumptions, including normality tests and homogeneity of variances, were checked before conducting the inferential analysis. Thereafter, GEE was used to investigate the effect of active video games on each outcome variable.

4.2 Phase 1 (Prevalence Study)

The prevalence study for Phase 1 will be discussed in this section.

4.2.1 Response Rate

In total, the researcher successfully acquired 426 questionnaires. Nevertheless, only 402 of these questionnaires were deemed usable. Ten of the survey participants did not fill out the demographic portion potentially resulting in an ineligible questionnaire.

Furthermore, it also turned out there were 24 incomplete sets of questionnaires. As a result of the 24 set of questionnaires being deemed incomplete, these 24 sets of questionnaires were discarded in order to increase the reliability and consistency within the responses.

4.2.2 Sociodemographic Characteristics

Table 4.1 provides a comprehensive overview of the demographic characteristics, oral health practices, and treatment-seeking behaviour among the study participants. The table is structured into various categories, such as gender, having dental caries, treatment during last visit to the dentist, smoking, main source of drinking water and main source of gaining information about oral hygiene.

In terms of gender distribution, participants included approximately equal proportions of female (49%) and male (51%). The distribution of participants in terms of age category showed that participants were found in all four categories, with the largest representation (32.8%) being from the age 19 group, and the secondly highest representation (27.1%), being for age 18. The remaining age groups (20 years: 19.4%; 21 years: 20.6%) shows the age distribution was balanced.

Results for having dental caries revealed that the prevalence of dental caries among student was 40.8%. Results of distribution for treatment-seeking behaviour of participants during their last dental visit shows that the most frequent treatment sought is a dental check-up (34.3%), followed closely by scaling (30.8%). Other sought treatments include fillings (11.9%), extractions (16.7%), and less commonly, other treatments (6.2%).

In summary, Table 4.1 shows the summary of respondents' demographic characteristics, oral health behaviours, and treatment-seeking behaviours. Overall, the data provided trends regarding oral health behaviours and demographic characteristics which would provide valuable information for future oral health education and intervention approaches.

Table 4.1: Socio-demography of the Respondents

Variable	Level	Frequency	Percent
Gender	Male	205	51
	Female	197	49
Age	18	109	27.1
	19	132	32.8
	20	78	19.4
	21	83	20.6
Caries	No	238	59.2
	Yes	164	40.8
Treatment	Check up	138	34.3
	Scaling	124	30.8
	Filling	48	11.9
	Extraction	67	16.7
	Others No history of dental visit	25	6.2

This is important because it reflects not only a major public health problem but also has specific implications for action by oral health education and preventive care programs within a university setting. With the prevalence being quite high at 40.8%, this is a cause for concern, especially in a reasonably young and educated population where dental caries should largely be preventable with the right knowledge, resources, and interventions. While the general figure of 40.8% is astonishing, the details according to demographic factors such as age and gender are even more worrying.

4.2.3 Personal Health Habits of the Respondents

Table 4.2 presents a comprehensive insight into various oral health behaviour s and characteristics exhibited by the study participants. The data is organised into distinct categories, including smoking status, consumption of sweets, main source of drinking water and main source of gaining information about oral hygiene. The smoking habits of the participants are outlined in the initial section. The data reveals that a notable proportion of participants identify as smokers (23.1%), while the larger majority are non-smokers (76.9%).

Table 4.2 also presents data concerning the consumption of sweets. A substantial number of participants admit to consuming sweets (77.1%), while a smaller yet noteworthy proportion abstains from consuming sweets (22.9%). This information holds significance in understanding dietary patterns and their potential

impact on oral health. Among the drinking water sources, bottled water accounts for the highest proportion at 28.9%, closely followed by tap water at 27.6%. Well water is used by 24.4% of participants, while spring water is the main source for 19.2% of participants. This diversity in water sources underscores the relevance of assessing potential impacts on oral health. The subsequent section delves into the sources from which participants gather information about oral hygiene practices.

The participants' influences are categorised into five groups, i.e. parents, school teachers, friends/relatives, dentists, and media. The most prominent source of oral hygiene information is parents, constituting 25.6% of participants. School teachers closely follow at 24.6%. Friends and relatives account for 14.2%, while information from dentists is reported by 13.4% of participants. Notably, the media serves as an influential source for oral hygiene information, with 22.1% of participants accessing knowledge through this channel.

Table 4.2: Distribution of Oral Health Behaviours and Characteristics of The Respondents

Variable	Level	Frequency	Percent
Smoking	No	309	76.9
	Yes	93	23.1
Sweet Use	No	92	22.9
	Yes	310	77.1
Source of drinking water	Tap water	111	27.6
	Bottled water	116	28.9
	Well water	98	24.4
	Spring water	77	19.2
Source of gaining information about oral hygiene	Dentist	54	13.4
	Friends	57	14.2
	Media	89	22.1
	Parents	103	25.6
	School Teacher	99	24.6

4.2.4 Knowledge of Oral Hygiene

The frequency of respondents was applied to determine the level of knowledge using 8 items regarding oral hygiene. Results (Table 4.3) showed that the highest level of knowledge was obtained on the item assessing knowledge on bleeding gums as an indicator of inflamed gums which 73.6% of the students responded correctly. This means a relatively high attitude regarding one of the common

symptoms associated with gum health. Other items with correct response include the harmful effect of sweets 63.2% and that of fizzy drinks 61.2% on teeth, indicating that a good number of students are aware of some adverse dietary factors on oral health.

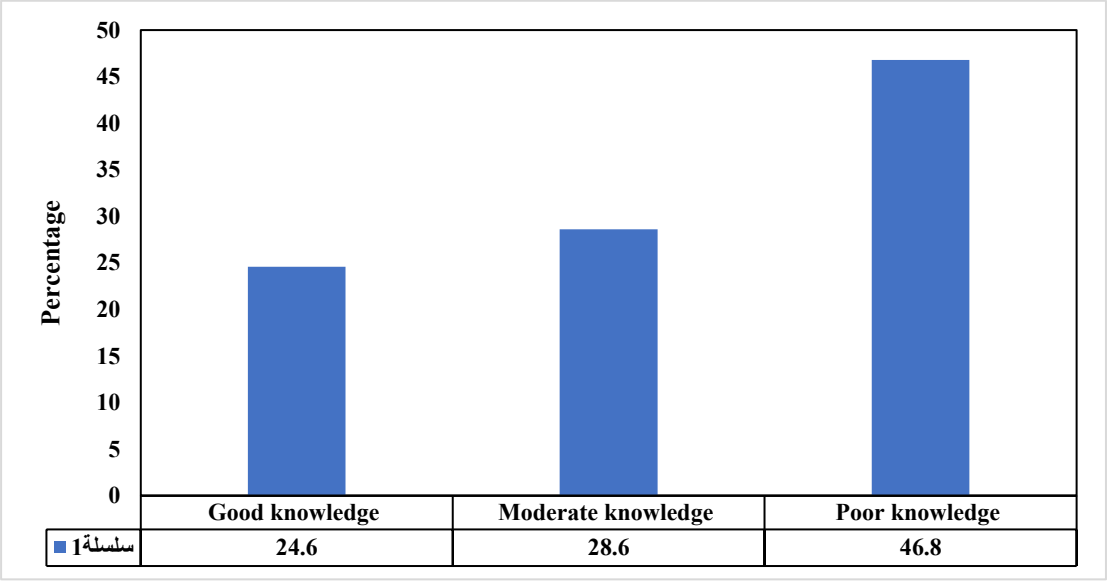
Only 51.2% answered the function of fluoride-based toothpaste correctly, further reflecting a limited attitude on prevention oral health measures. Still, very poor results were observed in questions related to dental plaque and carious teeth regarding appearance, correctly answered by the students in only 53.7% of the cases. These results show that the overall level of knowledge of oral hygiene is generally moderate, but there are areas that might need possible educational interventions.

Table 4.3: Distribution of Correct Answer to Items Related to Knowledge

No.	Items	Correct Answer	
		n	%
1.	Meaning of gum bleeding is inflamed gum.	296	73.60%
2.	Using toothbrush protects from gum bleeding.	239	59.50%
3.	Plaque means soft debris on the teeth.	216	53.70%
4.	Dental plaque causes staining of teeth.	238	59.20%
5.	Carious teeth affect teeth appearance.	216	53.70%
6.	Sweets affect the teeth adversely.	254	63.20%
7.	Fizzy drinks affect the teeth adversely.	246	61.20%
8.	Using fluoride-based toothpaste strengthens the teeth.	206	51.20%

The total score for knowledge domain was calculated based on 1 point considered for a correct answer, whereas an incorrect response received zero 0. The total score of each participant was calculated and converted into a percentage score. Results showed that the total score or knowledge had a mean vale of M= 4.75 with standard deviation of SD=2.10. Based on the original Bloom's taxonomy cut-off points, the levels of knowledge were categorised as follows: good knowledge (80–100%), moderate knowledge (60–79%), and poor knowledge (<60%). According to the results of frequency analysis (Figure 4.1) it was found that the majority of participants fell into the poor knowledge category (46.8%) followed by moderate knowledge (28.6%) and only 24.6% showed a good level of knowledge.

Figure 4.1: Distribution of the Level of Knowledge of Oral Hygiene



4.2.5 Attitude of Oral Hygiene

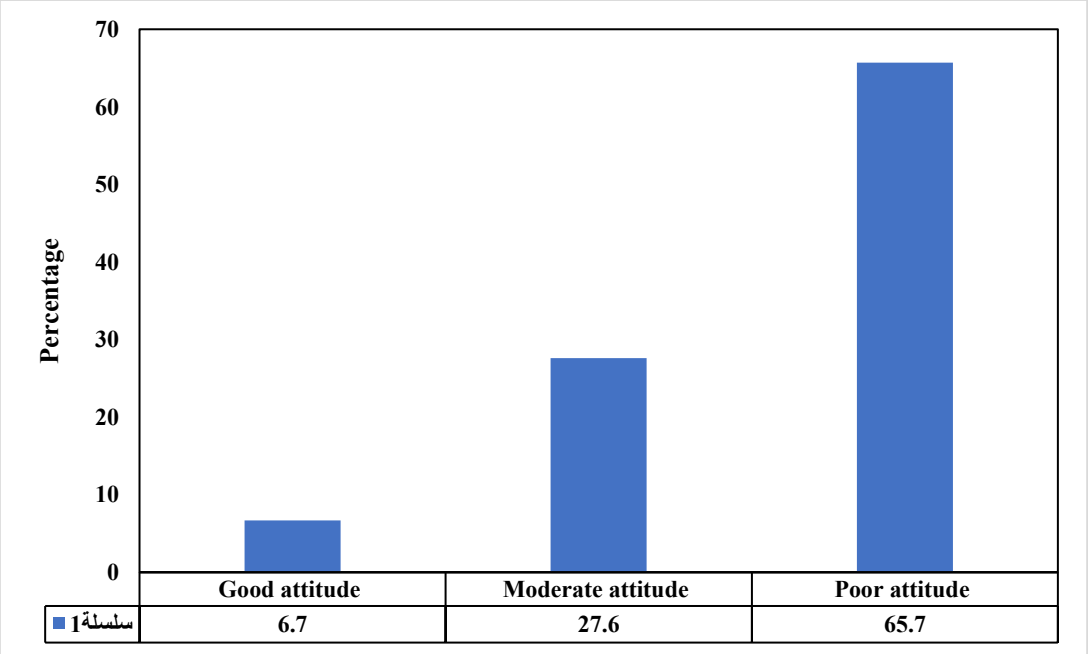
The results on frequency analysis of 8 items related to the attitude of oral hygiene (Table 4.4) showed that highest level of attitude among students belonged to the item “Teeth are weakened because of repeated cleaning,” with 54.5 followed by “soft drinks adversely affect teeth” with 49% agreement. These results showed that 48.5% recognised the adverse effect of sweets. The item “Regular brushing of teeth prevents dental decay” received 45.0% "agreement and 42.3% of students acknowledged the relationship between oral health and general health. These results showed that 41.8% of students recognised the necessity of regular dental visits, and only 40.3% agreed that using fluoride strengthens teeth. Notably, only 27.1% agreed to the item on dentists explaining teeth problems and proposing solutions, indicating the lowest level of positive response in the attitude section.

Table 4.4: Distribution of Correct Answer to Items Related to Attitude

No.	Items	Correct Answer	
		n	%
1.	Regular visits to the dentist are necessary	168	41.80%
2.	There is relationship between oral health and general health.	170	42.30%
3.	Regular brushing of teeth prevents dental decay.	181	45.00%
4.	Sweets affect the teeth adversely.	195	48.50%
5.	Soft drinks affect the teeth adversely.	197	49.00%
6.	Using fluoride strengthens the teeth.	162	40.30%
7.	Dentist always explain teeth problems and propose solution No	109	27.10%
8.	Teeth are weakened because of repeated cleaning	219	54.50%

The total score for attitude domain was calculated based on 1 point considered for a “yes” answer, whereas an “no” received zero 0. The total score of each participant was calculated and converted into a percentage score. Results showed that the total score of attitudes had a mean value of M= 3.48 with standard deviation of SD=2.02. Based on the original Bloom's taxonomy cut-off points, the levels of knowledge were categorised as follows: good knowledge (80–100%), moderate knowledge (60–79%), and poor knowledge (<60%). According to the results of frequency analysis (Figure 4.2) it was found that the majority of participants fell into the poor attitude category (65.7%) followed by moderate attitude (27.6%) and only 6.7% showed a good level of attitude.

Figure 4.2: Distribution of the Level of Attitude of Oral Hygiene



4.2.6 Practice of Oral Hygiene

The results on frequency analysis of items related to the 12 items of oral hygiene practice (Table 4.5) showed that the most commonly reported practice is not sharing a toothbrush, to which 82.3% of respondents answered positively to the item. This was followed by the use of a toothbrush and toothpaste in cleaning teeth (51.7%) and the use of fluoride-containing toothpaste (33.6%). There is also a moderate percentage of respondents who reported brushing their teeth twice a day (33.3%), using floss (33.3%), and using a toothpick to clean one's teeth (35.6%). Less frequent

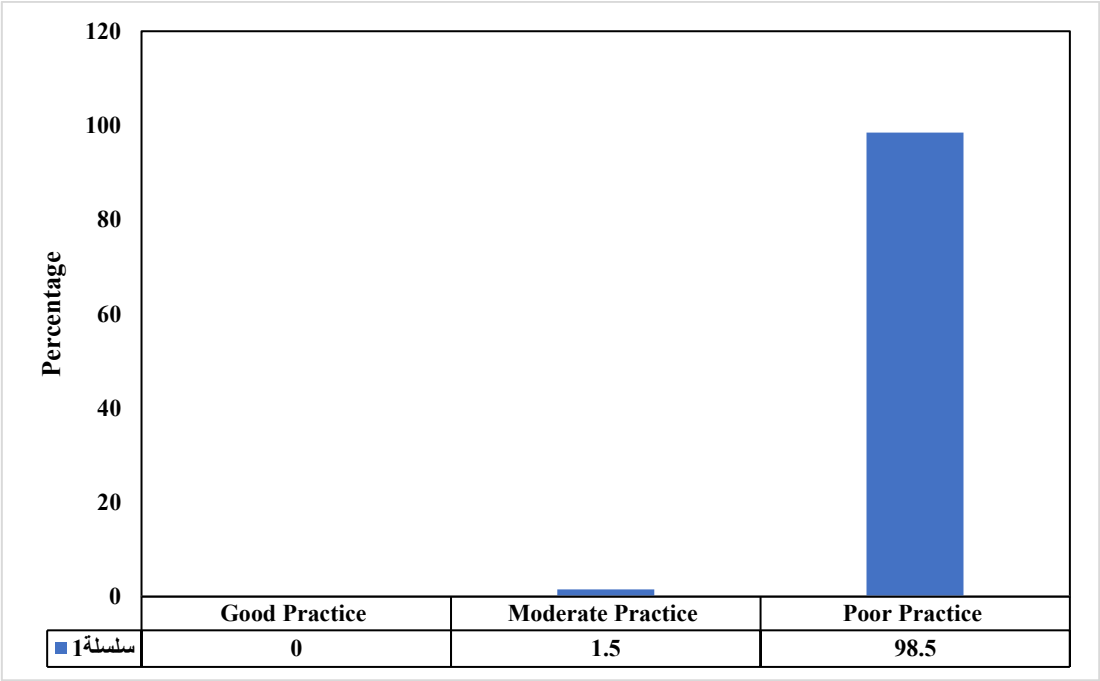
behaviour s is the brushing of teeth for longer than 2 minutes at 19.4%, cleaning the tongue after brushing at 22.6%, and changing toothbrush every 3-4 months at 20.1%. In addition, 27.4% go to a dentist yearly while 27.9% rinse their mouth with mouthwash as a part of the oral care. Cleaning after each meal was practiced by 30.8% which represents a moderate behaviour and has been consistent with regular oral care.

Table 4.5: Distribution of Correct Answer to Items Related to Practice

No.	Items	Correct Answer	
		n	%
1	I brush my teeth twice per day.	134	33.30%
2	I use toothbrush and toothpaste to clean my teeth.	208	51.70%
3	I use floss to clean my teeth.	134	33.30%
4	I use toothpick to clean my teeth.	143	35.60%
5	I use mouthwash to clean my teeth	112	27.90%
6	I clean my teeth after every meal.	124	30.80%
7	I brush my teeth for more than 2 minutes.	78	19.40%
8	I clean my tongue after brushing teeth.	91	22.60%
9	I visit a dentist annually.	110	27.40%
10	My toothpaste contains fluoride.	135	33.60%
11	I don’t share my toothbrush with others.	331	82.30%
12	I change my toothbrush every 3-4 months	81	20.10%

The total score for practice domain was calculated based on 1 point considered for a “yes” answer, whereas an “no” received zero 0. The total score of each participant was calculated and converted into a percentage score. Results showed that the total score of practice had a mean vale of M= 4.18 with standard deviation of SD=2.89. Based on the original Bloom's taxonomy cut-off points, the levels of knowledge were categorised as follows: good knowledge (80–100%), moderate knowledge (60–79%), and poor knowledge (<60%). According to the results of frequency analysis (Figure 4.3) it was found that the majority of participants fell into the poor practice category (98.5%) followed by moderate attitude (1.5%) and there was not anyone with a good level of practice.

Figure 4.3: Distribution of the Level of Practice of Oral Hygiene



4.2.7 Oral Health-Related Quality of Life

The results of responses to the OHIP-14 questionnaire (Table 4.6) showed the level of oral health-related problems for all seven different domains, focusing specifically on those who reported some level of difficulty. In the Functional Limitations domain, 17.2% occasionally had trouble pronouncing words and 6% faced it fairly or very often. Likewise, 20.9% of students reported taste changes who experiencing it occasionally (14.9%) followed by 4.5% fairly often, and 1.5% very often. These results indicate that functional challenges.

In the Physical Pain domain, a large number of participants faced discomfort, 22.9% of students occasionally or more frequently experienced an aching mouth, and 28.6% of them felt discomfort while eating and occasionally affected (21.4%). Results showed that 7.2% reporting it fairly or very often. In the Physical Disability domain, 26.9% of students occasionally or more frequently found their diet unsatisfactory due to oral health issues, however 36.8% reported meal interruptions, and 31.8% experienced it occasionally and 8% fairly or very often.

Table 4.6: Results of Frequency Analysis of Oral Health-Related Quality of Life

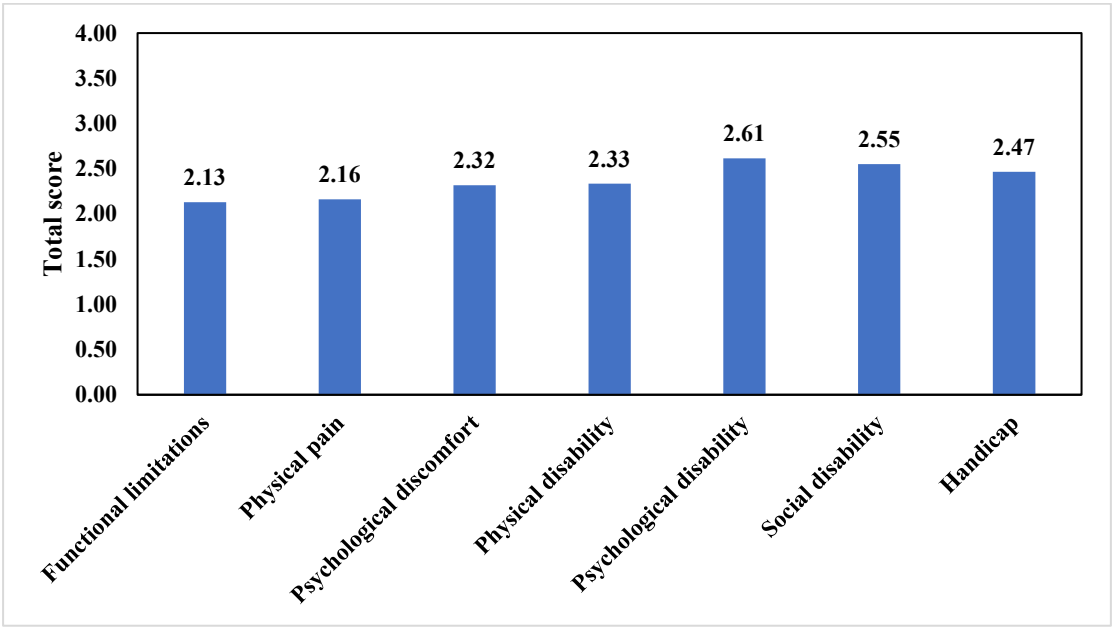
Domains	Items	n (%)				
		Never	Hardly Ever	Occasionally	Fairly Often	Very Often
Functional limitations	Trouble pronouncing words	106(26.4)	202(50.2)	69(17.2)	18(4.5)	7(1.7)
	Taste worsened	82(20.4)	236(58.7)	60(14.9)	18(4.5)	6(1.5)
Physical pain	Aching mouth	96(23.9)	218(54.2)	57(14.2)	24(6)	7(1.7)
	Discomfort in eating food	121(30.1)	166(41.3)	86(21.4)	17(4.2)	12(3)
Psychological discomfort	Being self-conscious	115(28.6)	153(38.1)	107(26.6)	21(5.2)	6(1.5)
	Feeling nervous	107(26.6)	159(39.6)	102(25.4)	22(5.5)	12(3)
Physical disability	Unsatisfactory diet	93(23.1)	201(50)	71(17.7)	31(7.7)	6(1.5)
	Interrupting meals	128(31.8)	114(28.4)	128(31.8)	20(5)	12(3)
Psychological disability	Embarrassed	108(26.9)	130(32.3)	118(29.4)	37(9.2)	9(2.2)
	Difficulty relaxing	85(21.1)	153(38.1)	122(30.3)	27(6.7)	15(3.7)
Social disability	Irritable with other people	109(27.1)	136(33.8)	110(27.4)	33(8.2)	14(3.5)
	Difficulty doing usual jobs	94(23.4)	169(42)	94(23.4)	22(5.5)	23(5.7)
Handicap	Life less satisfying	107(26.6)	179(44.5)	72(17.9)	25(6.2)	19(4.7)
	Unable to function	92(22.9)	146(36.3)	134(33.3)	17(4.2)	13(3.2)

Results of frequency analysis for Psychological Discomfort, Psychological Disability, Social Disability, and Handicap domains reveal further challenges. It was found that 33.3% of students occasionally or more often felt self-conscious, and 34.9% of students experienced nervousness. Results on social disability domain showed that 27.4% occasionally or more frequently felt irritable with others, and 34.3% of students faced difficulties with their usual tasks. Results of last domain for Handicap domain, showed that 28.9% of students found life less satisfying, and 41.6% occasionally or more frequently felt unable to function. These results indicate that almost 30% of students had problems for their overall quality of life.

The total score for oral health-related quality of life was calculated based on five-point Likert scale: 0, never; 1, hardly ever; 2, occasionally; 3, fairly often; 4, very often. The total score of each participant was calculated. Results showed that the total score of practice had a mean vale of M= 4.18 with standard deviation of SD=2.89.

Figure 4.4 represent the total score for seven domains of health-related quality of life (HQOL) based on the OHIP-14 questionnaire including functional limitations, pain, discomfort, physical disability, psychological disability, social disability, and handicap. Results showed that the highest impact was observed for Psychological Disability (M = 2.61, SD = 1.86), and Social Disability (M = 2.55, SD = 1.94) followed by Handicap domain with a mean score of (M=2.47, SD = 1.81), suggesting limitations in life satisfaction and daily functioning. These results indicated that Physical Disability domain (M = 2.33, SD = 1.74) and Discomfort domain (M = 2.32, SD = 1.75) were also moderately impacted. The lowest total score was observed for Pain (M = 2.16, SD = 1.64) and Functional Limitations (M = 2.13, SD = 1.50) which had the lowest scores, showing that these domains were the least impacted by oral health issues.

Figure 4.4: Mean Score Distribution in Different OHIP-14 Domains



4.2.8 Oral Health Education

Table 4.7 depicts the responses of the participants on incorporating oral health education into the educational system in detail which was measured using 8 were assessed using a point Likert scale that ranged from 1 to 5 on a 5- (with 1 being “strongly disagree” and 5 being “strongly agree”). The statement "Oral Health Education can be incorporated into the school curriculum as a separate subject" ranked first with the highest mean score (M = 4.18, SD = 0.75), reflecting very strong support for the incorporation of oral health education into the school curriculum as an independent subject. The next important items were “When Oral Health Education is taught as a separate topic in university, students will have a better understanding of the importance of oral health" with a mean value of (M = 3.87, SD = 1.01), and a belief that universities should provide "free seminars on oral health" (M = 3.86, SD = 0.94). In contrast, the lowest mean was for the item, "Dentistry department visits should be a regular component of the university's activities" (M = 3.34, SD = 1.14), indicating relatively lesser support for the inclusion of regular dental visits in university activities. Participants also felt "The internet has a greater impact on changing students' views about oral health education". The overall mean score of M=3.78, SD = 0.77 reflects a generally positive view toward integrating oral health topics within educational settings, though some methods were perceived as more impactful than others. The interpretation of the mean has been revised based on Landall's (1997) study. The mean value of 1.0 to 2.33, represents a low level. 2.34 to 3.67 as moderate, while a high level is represented by mean values ranging from 3.68 to 5.

Table 4.7: Results Descriptive Analysis of Item Related to Oral Health Education

Item	Mean	SD	Level
Oral Health Education may be included into the school curriculum as a separate topic.	4.18	0.75	High
Only dentistry course may include oral health concepts.	3.97	0.86	High
The addition of oral health topics may cause students' attention to wander away from the subject at hand.	3.81	0.96	High
Dentistry department visits should be a regular component of the university's activities.	3.34	1.14	Moderate
The universities should make provisions for free seminars on oral health.	3.86	0.94	High
The internet has a greater impact on changing students' views about oral health education.	3.50	1.18	Moderate
From the books they read, students learn how to maintain good oral health.	3.70	1.06	High
When Oral Health Education is taught as a separate topic in university, students will have a better understanding of the importance of oral health.	3.87	1.01	High
Total	3.78	0.77	High

The comprehensive oral health education is called for, not only among freshmen or younger students but also among older students who still face problems in oral health. In fact, studies have evidenced that even among university students, awareness about oral health and preventive practices remain unsatisfactory, and older students are particularly vulnerable to delays in seeking preventive health care. (Ali *et al.*, 2017; Sun *et al.*, 2018). The preventive programs should, therefore, be designed in a way that provides the necessary support and education for students in all grades to maintain their oral health. This is supported by Zheng *et al.* (2021) during the period of recommending continuous oral health education throughout all years of university education. Oral hygiene practices should be taught among students in higher learning institutions. This way, they will not only learn the practices but also maintain it through their stay at school.

4.2.9 Relationship between KAP and Oral Health-Related Quality of Life

The results (Table 4.8) indicate a moderate and negative correlation between knowledge and quality of life problems ($r = -0.392$, $p < 0.001$) was statistically significant at the conventional alpha level ($p > 0.05$) suggesting that higher levels of knowledge are associated with fewer quality of life issues related to oral health. Similarly, a statistically significant and negative correlation was found between attitude and quality of life problems ($r = -0.220$, $p <0.001$). This indicates that a more positive attitude towards oral health is linked to a reduction in quality-of-life problems, though the correlation is weaker than that observed with knowledge.

According to these results, it was found that there was a negative and significant relationship between the level of practice and quality of life problems ($r = -0.182$, $p < 0.001$). This means that the greater the oral health practices, the lesser the problems in the quality of life. In general, this evidence consolidates the role of KAP in the improvement of oral health-related quality of life problems, and the most strongly related is knowledge. Interventions of an educational nature that aim at improving knowledge, attitudes, and practices thus stand a potential in reducing the problems in the quality of life as related to oral health.

Table 4.8: Relationship between KAP and Oral Health-Related Quality of Life

	Health-Related Quality of Life	
	Spearman (r)	**p value**
Knowledge	-0.392**	<.001
Attitude	-0.220**	<.001
Practice	-0.182**	<.001

4.3 Phase 3 (Intervention Study)

This section presents analysis of all dependent variables from the intervention and control groups. Initial analysis begins with normality tests, homogeneity testing of background variables research variables at baseline followed by GEE results to evaluate the intervention impact on all dependent variables in Phase 3.

4.3.1 Normality Test

Data distribution is an assumption of normality that refers to the dispersion in variables, which statisticians use in measurement. Different methods can be used for testing the data normality - for instance, Kurtosis and Skewness tests and the Kolmogorov and Shapiro method. The above statistical methods have been suggested by previous studies (Field 2006; Tabachnick, 2007; Hair *et al.,* 2010; Hair *et al.,* 2006) respectively.

Based on the above, the current research tried to assess the normal distribution of the data by using skewness, kurtosis. According to Bangert (2004) (Lambert *et al.*, 2013), only a distribution with a symmetrical bell-shaped curve if the ratio of skewness and kurtosis to the standard error fell within the range from -1.96 to +1.96. Based on the results Pre.KN, Pre.PR, Pre.OHQL and Post.OHQL were normally distributed while other variables were not normally distributed. These ratios fall within the range of -5.45 to 4.97 while the range of kurtosis test ranged between -3.32 to 7.53. This was further confirmed with the use of Box Plots, which is attached in Appendix C.

4.3.2 Homogeneity Test of variance

One of the main assumptions for comparison among groups in term of statistical analysis is the homogeneity of variance, implying equality of variances in different groups. Commonly, this assumption can be checked using Levene's test which tests whether variances among groups differ significantly. Levene's test of equality of error variance in Table 4.9 indicated that the error variances for experimental and control groups were equal on all research variable except consumption of sugary foods and beverages at the pretest ($p>0.05$) except for oral health quality of life score.

Table 4.9: Results of Levene's Test for Equality of Error Variances

Variable	Levene Statistic	df1	df2	p value
Knowledge	1.479	1	238	0.225
Attitude	0.348	1	238	0.556
Practice	0.056	1	238	0.813
OHQL	6.572	1	238	.011
Foods and everages	20.336	1	238	<.001

* Significant at 0.05 level

4.3.3 Sociodemographic Characteristics

Prior to data analysis for all research hypotheses, the homogeneity between group for background variables was employed. Table 4.10 shows the baseline characteristics of student in both control and intervention group. For comparison of demographic and background variables such as gender, having dental caries, treatment during last visit to the dentist, smoking, main source of drinking water and main source of gaining information about oral hygiene, Chi-square test (χ^2) was performed to compare these categorical variables between two groups, and an independent sample t-test was used to compare the age. Results showed that the distribution of gender was almost identical between the groups without any significant difference ($\chi^2 = 0.156$, $p = 0.693$). Moreover, no significant difference was noticed in the presence of caries ($\chi^2 = 0.069$, $p = 0.793$), smoking status ($\chi^2 = 0.562$, $p = 0.454$).

According to these results it was found that types of treatment received ($\chi^2 = 1.204$, $p = 0.877$), sweet consumption ($\chi^2 = 0.202$, $p = 0.653$), and sources of drinking water ($\chi^2 = 0.853$, $p = 0.837$), also showed no significant differences between the two

groups. Age was also not significantly different between the groups (t = -1.731, p = 0.085). In summary, the results show that at baseline, the control and intervention groups were well-matched for all the characteristics assessed.

Table 4.10: Baseline Characteristics of Participants Between Intervention and Control Groups

Variable	Level	Control	Intervention	$\chi 2$/t value	P-value
Gender[a]	Male	73(60.8)	70(58.3)	0.156	0.693
	Female	47(39.2)	50(41.7)		
Having	No	49(40.8)	51(42.5)	0.069	0.793
Caries[a]	Yes	71(59.2)	69(57.5)		
Types of	Check up	43(35.8)	47(39.2)	1.204	0.877
Treatment[a]	Scaling	38(31.7)	39(32.5)		
	Filling	12(10)	11(9.2)		
	Extraction	16(13.3)	11(9.2)		
	Others	11(9.2)	12(10)		
Smoking[a]	No	88(73.3)	93(77.5)	0.562	0.454
	Yes	32(26.7)	27(22.5)		
Sweet[a]	No	28(23.3)	31(25.8)	0.202	0.653
	Yes	92(76.7)	89(74.2)		
Source of drinking	Tap water	34(28.3)	30(25)	0.853	0.837
water[a]	Bottled water	34(28.3)	31(25.8)		
	Well water	31(25.8)	36(30)		
	Spring water	21(17.5)	23(19.2)		
Source of	Dentist	22(18.3)	21(17.5)	4.578	0.333
information[a]	Friends	27(22.5)	35(29.2)		
	Media	23(19.2)	15(12.5)		
	Parents	17(14.2)	24(20)		
	School T	31(25.8)	25(20.8)		
Age	Mean (SD)	19.28(1.12)	19.52(1.04)	-1.731	0.085

a: Chi Square test (n, %)) b: Independent t test (Mean and SD),

4.3.4 Baseline Research Variables Comparison Between Control and Intervention Groups

Before hypothesis testing, a test for baseline equivalence of the intervention and control groups was performed with regard to all research variables including knowledge, attitude, practice and oral health quality of life scores to ensure homogeneity between groups. For normally distributed variables including knowledge and oral health quality of life, independent sample t-test has been performed; whereas for variables reported with median and interquartile range, attitude and practice, which did not meet the normality assumption, the Mann-Whitney U test was applied accordingly. The results, as presented in Table 4.11, indicated no significant

differences between the intervention and control groups for any of the variables at the pretest. This nonsignificant difference, therefore, could indicate that the two groups were comparable at baseline for all dependent variables.

Table 4.11: Comparison between Intervention and Control Group at Pre-test

Variable	Control	AVG	t/z value	p value
Knowledge[a]	4.89(1.64)	4.74(1.82)	0.671	0.503
Attitude[b]	4(2.75)	3(3)	-0.880	0.379
Practice[b]	3(3)	3(4)	0.642	0.521
OHQL[a]	14(12.75)	16(9)	1.473	0.141

a: Independent t test (Mean and SD), b: U Mann Whitney test (median and IQR)

4.3.5 Inferential Statistics

Generalised Estimating Equation (GEE) was utilised to examine the research objectives and assess the impact of oral health education programs on knowledge, attitude, practices and oral health related quality of life among university students in Libya. In the following sections, the results of analysis for all dependent variables are presented.

4.3.5.1 Effectiveness of Oral health Education Programs on Knowledge

The fourth research objective of this study is "to evaluate the effect of oral health education program on knowledge among university students in Libya." GEE was applied to assess the effectiveness of oral health education programs on the level of knowledge. Table 4.12 shows the descriptive statistics (Mean and Standard error) for both groups at the pre-test and post-test.

Table 4.12: Descriptive (Mean and SD) Statistics of knowledge

Time	Group	Mean	SE
Pre-test	Control	4.892	0.149
	Intervention	4.742	0.165
Post-test	Control	4.883	0.147
	Intervention	6.267	0.117

The Generalised Estimating Equations (GEE) results, as presented in Table 4.13, concerning the total score of knowledge among students, revealed significant findings. Firstly, time significantly affected the total score of knowledge ($\chi 2 = 107.226$, $p < 0.001$), indicating that knowledge exhibited notable changes over time,

encompassing the pre-test and post-test assessments. Furthermore, the group's main effect was significant ($\chi 2 = 10.236$, $p < 0.001$).

Furthermore, the interaction between time and group was significant ($\chi 2 = 109.596$, $p < 0.001$), indicating that the patterns observed in the score of knowledge over time between the control and intervention was significantly different which means groups exhibited different patterns regarding knowledge from pre-test to post-test assessments.

Table 4.13: Results of Generalised Estimating Equations (GEE) on Knowledge

Source	Wald Chi-Square	df	p-value
Time	107.226*	1	<.001
Groups	10.236*	1	0.001
Time * Group	109.596*	1	<.001

* Significant at the .05

In order to evaluate the differences in the knowledge among participants across the time for both groups (within group), the post-hoc test (Bonferroni) was applied (Table 4.14). Based on the result of the Bonferroni test, the difference in knowledge scores between the pre-test and post-test in control group was not significantly different (p=1) while the difference between post and pretest in intervention group was statistically different (p<0.001). These findings highlight substantial improvements in knowledge scores from the pre-test to the post-test in experimental group. Cohen's d values d=0.95 for experimental group suggest large effect sizes of intervention on knowledge score, indicating significant improvements observed in knowledge among students in experimental group while there was a small effect size d=0.09 in control group.

Table 4.14: Pairwise Comparison of Knowledge Score Across Time for Both Groups

Time	Test	Mean Difference	SE	*p*-value	95% CI for Difference		*Cohen d*
					LB	UB	
Control	Pre Vs post	-0.150	0.223	1.000	-0.738	0.438	0.09
Intervention	Pre Vs post	1.383*	0.188	<0.001	0.887	1.880	0.95

*: Significant at 0.05 level

In order to evaluate the differences in knowledge scores between groups at both the pre-test and post-test stages (between group), a pairwise comparison was performed. Results (Table 4.15) showed that at the pre-test, there was no statistically significant difference was observed between the experimental and control groups on knowledge scores (p = 1.000), while at the post-test, a statistically significant difference was found in knowledge scores between experimental and control groups (p < 0.001) which experimental group showed a higher mean score than the control group. The effect size indicates a large difference in knowledge score between the groups at the post-test (d=0.97).

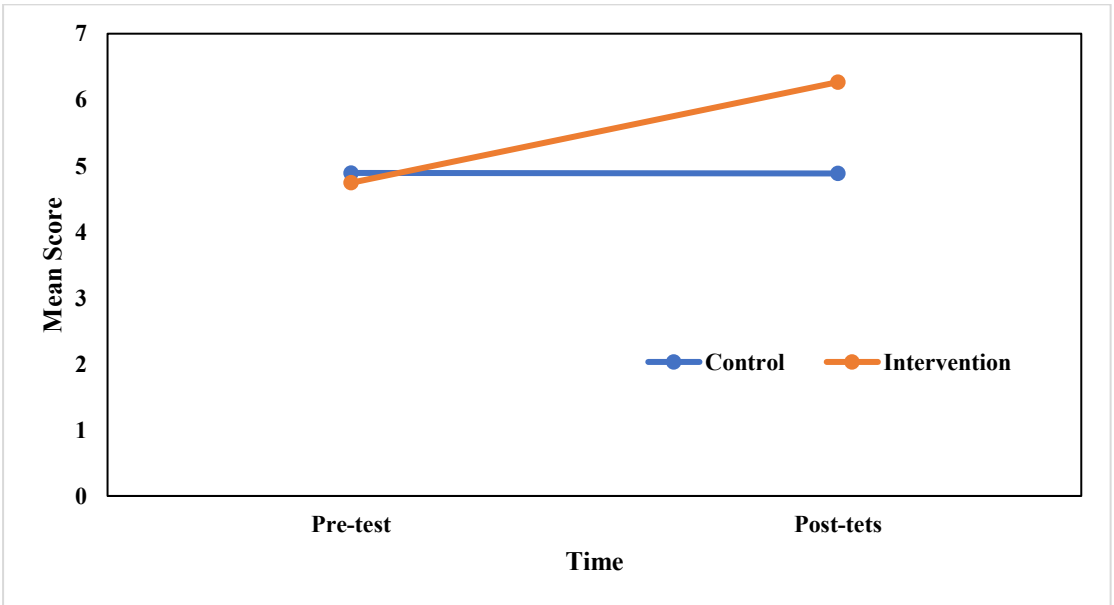
Table 4.15: Pairwise Comparison of Knowledge Score Between Groups at Pre- and Post-test

Group	Test	Mean Difference	SE	*p*-value	95%CI for Difference		*Cohen d*
					LB	UB	
Pre-test	INV vs CNT	-0.008	0.036	1.000	-0.104	0.088	-0.01
Post-test	INV vs CNT	1.525*	0.142	<0.001	1.151	1.899	0.97

*: Significant at 0.05 level, INT: Intervention group, CNT: Control group

Figure 4.5 shows the mean score of knowledge across the time, which revealed an increase at the post-test in experimental group while there were no changes in control groups.

Figure 4.5: Mean Score of Knowledge of Experimental and Control Groups at Pre- and Post-test



4.3.5.2 Effectiveness of oral health education program on attitude

The fourth research objective of this study is to assess the impact of oral health education program on attitude among university students in Libya and data were analysed using generalised estimating equations (GEE). Table 4.16 presents the descriptive statistics for both groups at the pre-test and post-test stages, precisely the mean and standard error.

Table 4.16: Descriptive (Mean and SD) Statistics of Attitude

Time	Group	Mean	SE
Pre-test	Control	3.78	0.16
	Intervention	3.65	0.18
Post-test	Control	3.91	0.14
	Intervention	6.17	0.14

The results of the generalised estimating equations (GEE), as presented in Table 4.17, concerning the total score of attitudes among students, revealed significant findings. Firstly, time significantly affected the total score of attitudes ($\chi2 = 145.828$, $p < 0.001$), indicating that attitude exhibited notable changes over time. Furthermore, the main effect of the group was found to be significant ($\chi2 = 32.52$, $p < 0.001$), suggesting a noticeable difference between the experimental group (EG) and the control group (CG) regarding their attitude. These results showed that the interaction between time and group was also significant ($\chi2 = 119.533$, $p < 0.001$), exhibiting significant difference between the EG and CG in the patterns of attitude across the time.

Table 4.17: Results of Generalised Estimating Equations (GEE) on Attitude

Source	Wald Chi-Square	df	p-value
Time	145.828*	1	<.001
Groups	32.52*	1	<.001
Time * Group	119.533*	1	<.001

* Significant at the .05

In order to evaluate the differences in the attitude among participants across the time for both groups (within group), the post-hoc test (Bonferroni) was applied (Table 4.18). Based on the result of the Bonferroni test, the difference in attitude scores between the pre-test and post-test in CG was not statistically different (p=1.000), while there was significant difference between pretest and post-test in experimental group (p<0.001). These findings highlight substantial improvements in attitude scores from the pre-test to the post-test in the experimental group. Cohen's d values of d=1.50 for the EG suggest large effect sizes, indicating considerable improvements in attitude over time while there was a small effect size for time in control group (d=0.07).

Table 4.18: Pairwise Comparison of Attitude Score Across Time for Both Groups (Within group)

Time	Test	Mean Difference	SE	*p*-value	95% CI for Difference		*Cohen d*
					LB	UB	
Control	Pre Vs post	-0.133	0.236	1.000	-0.755	0.488	0.07
Intervention	Pre Vs post	2.258*	0.194	<0.001	1.745	2.771	1.50

* Significant at the .05

In order to evaluate the differences in attitude scores between groups at both the pre-test and post-test stages (between group), a pairwise comparison was performed. The results (Table 4.19) indicate no statistically significant difference in attitude scores between the experimental and control groups at the pre-test (p = 1.000). However, at the post-test, a significant difference was observed between the groups (p< 0.001), showing that experimental group revealing higher mean attitude scores than the control group. The effect size (Cohen's d = 1.45) suggests a large effect, indicating a meaningful difference between groups at the post-test assessment.

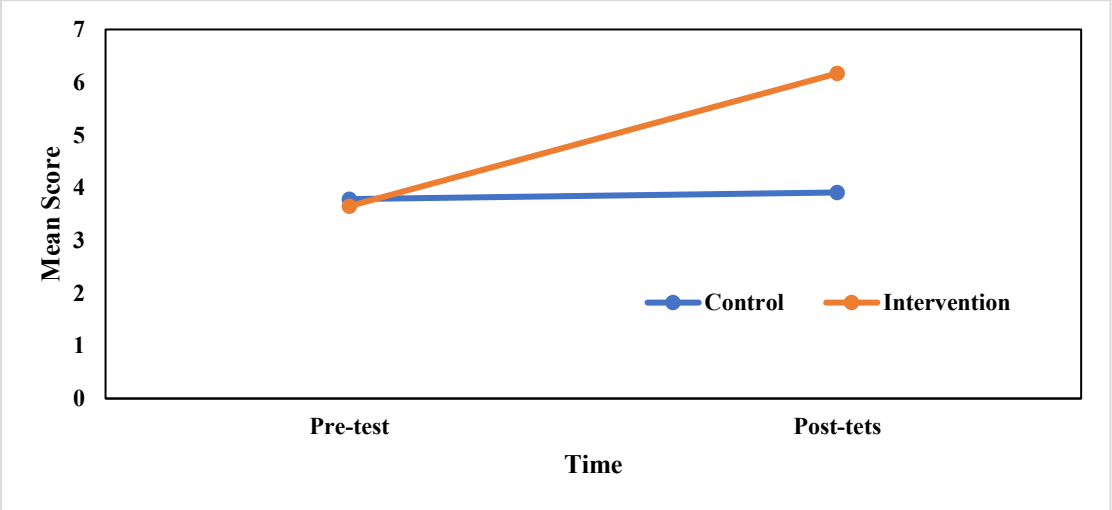
Table 4.19: Pairwise Comparison of Attitude Score Between Groups at Pre- and Post-test

Group	Test	Mean Difference	SE	*p*-value	95%CI for Difference		*Cohen d*
					LB	UB	
Pre-test	INV vs CNT	0.125	0.099	1.000	-0.136	0.386	0.08
Post-test	INV vs CNT	2.5167a	0.195	<0.001	2.002	3.031	1.45

* Significant at the .05

Figure 4.6 shows the mean score of attitudes across the time, which revealed an increase in the experimental group, while in the control group there was no changes in attitude score at the post-test.

Figure 4.6: Mean Score of Attitudes of Experimental and Control Groups Across the Time



4.3.5.3 Effectiveness of Oral Health Education Program on Practice

Evaluating the effect of oral health education program on practice among students is the fourth research objective of this study. Generalised Estimating Equations (GEE) was used to assess the effectiveness of the oral health education program on the level of practice. The descriptive statistics for both groups at the pre-test and post-test phases are shown in Table 4.20, precisely the mean and standard error.

Table 4.20: Descriptive (Mean and SD) Statistics of Practice

Time	Group	Mean	SE
Pre-test	Control	3.29	0.21
	Intervention	3.46	0.21
Post-test	Control	3.89	0.17
	Intervention	9.23	0.19

The Generalised Estimating Equations (GEE) analysis, presented in Table 4.21, showed that the main effect of time on practice was statistically significant ($\chi2=268.951$, $p<0.001$), indicating that the overall difference in practice between two pre-test and post-test was statistically significant. According to these results. the main

effect of group on practice was statistically significant ($\chi2=195.869$, $p<0.001$), revealing considerable variations in the level of practice between groups. Furthermore, the statistical analysis revealed a significant interaction effect between time and group ($\chi2=177.121$, $p<0.001$), showing that the practice pattern differed significantly between the groups at across two time points.

Table 4.21: Results of Generalised Estimating Equations (GEE) on Practice

Source	Wald Chi-Square	df	*p*-value
Time	268.951*	1	<.001
Groups	195.869*	1	<.001
Time * Group	177.121*	1	<.001

* Significant at the .05,

The post-hoc test (Bonferroni) assessed participant differences in the level of practice over time for both groups (Table 4.22). According to the Bonferroni test results, the difference in the level of practice scores between the pre-test and post-test for each experimental group was statistically different ($p<0.001$) while there was no difference between pretest and post-test in control group ($p=0.201$). These results show significant increment in the level of practice mean scores for experimental group from the pre-test to the post-test. Furthermore, Cohen's d values of $d=2.66$ for the experimental group indicating a large effect size while in control group the effect size was almost small $d=0.26$.

Table 4.22: Pairwise Comparison of Practice Score across time for Both Groups (Within Group)

Time	Test	Mean Difference	SE	*p*-value	95%CI for Difference		*Cohen d*
					LB	UB	
Control	Pre Vs post	0.600	0.282	0.201	-0.145	1.345	0.28
Intervention	Pre Vs post	5.767*	0.267	<0.001	5.063	6.470	2.66

* Significant at the .05,

A pairwise comparison was done to assess the difference in mean scores of practices between groups at both the pre-test and post-test phases. The findings (Table 4.23) show no statistically significant difference between groups on the mean scores of practices at the pre-test ($p = 1.000$, Cohen's $d = 0.07$). On the post-test,

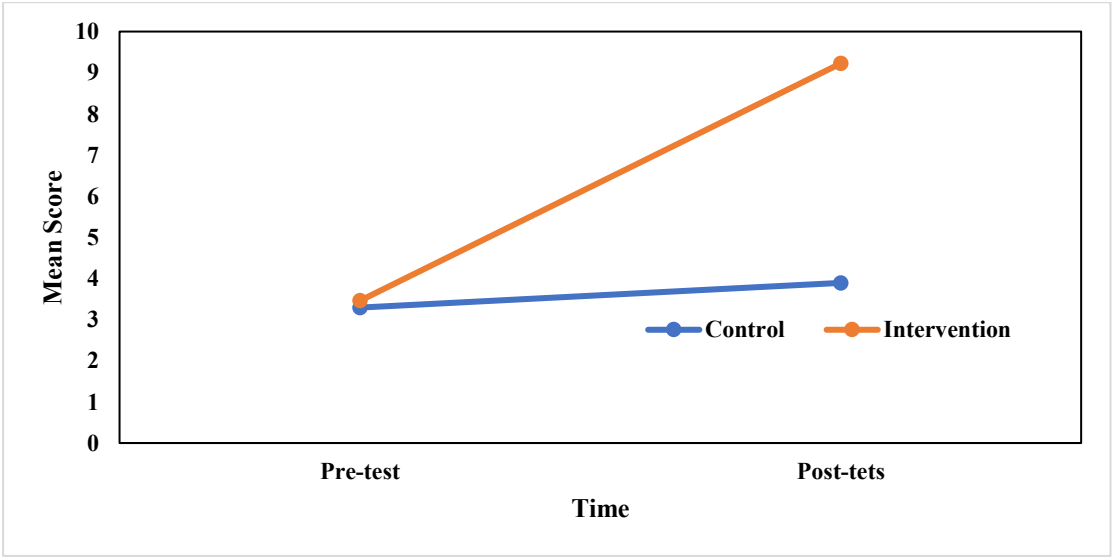
however, there was a significant difference ($p < 0.001$) between the groups, with the experimental group showing higher mean scores practice than the control group. The effect size (Cohen's d = 2.70) is notable as it indicates a significant difference between groups at the post-test evaluation, suggesting a big effect.

Table 4.23: Pairwise Comparison of Movement Demonstration Skills Score between Groups at Pre- and Post-test

Group	Test	Mean Difference	SE	*p*-value	95% CI for Difference		*Cohen d*
					LB	UB	
Pre-test	INV vs CNT	0.167	0.296	1.000	-0.614	0.947	0.07
Post-test	INV vs CNT	5.333*	0.255	<0.001	4.661	6.006	2.70

The mean score for practice over time is shown in Figure 4.7. It can be seen that experimental the experimental group shows an increase in the post-test, while no changes in control group were observed.

Figure 4.7: Mean Score of Practice in Both Experimental and Control Groups Across the Time



4.3.5.4 Effectiveness of Oral Health Education Programs on Oral Health Related Quality of Life

The fifth research objective of this study is to assess the impact of oral health education program on oral health related quality of life among university students in Libya. GEE was applied to assess the effectiveness of oral health education program on oral health related quality of life. Table 4.24 shows the descriptive statistics (Mean and standard error) for both groups at the pre-test and post-test.

Table 4.24: Descriptive (Mean and SD) statistics of Oral Health Related Quality of Life

Time	Group	Mean	SE
Pre-test	Control	16.90	0.91
	Intervention	17.15	0.64
Post-test	Control	17.11	0.88
	Intervention	14.96	0.53

The Generalised Estimating Equations (GEE) results, as presented in Table 4.25, concerning the total score of oral health related quality of life among students, revealed significant findings. Firstly, time significantly affected the total score of oral health related quality of life ($\chi2 = 51.477$, $p < 0.001$), indicating that oral health related quality of life exhibited notable changes over time, encompassing the pre-test and post-test assessments. Also, the group's main effect was not significant ($\chi2 = 0.801$, $p = 0.371$). Furthermore, the interaction between time and group was significant ($\chi2 = 75.377$, $p <0.001$), indicating that the patterns observed in oral health related quality of life over time between the experimental and control were significantly different.

Table 4.25: Results of Generalised Estimating Equations (GEE) on Oral Health Related Quality of Life

Source	Wald Chi-Square	df	p-value
Time	51.477*	1	<0.001
Groups	0.801	1	0.371
Time * Group	75.377*	1	<0.001

* Significant at the .05

In order to evaluate the differences in the oral health related quality of life among participants across the time for both groups (within group), the post-hoc test (Bonferroni) was applied (Table 4.26). Based on the result of the Bonferroni test, the difference in oral health related quality of life scores between pre-test and post-test in control group was not statistically different (p=0.247) while there was significant difference between pre-test and post-test in experimental group (p<0.001). These findings highlight substantial improvements in oral health related quality of life from the pre-test to the post-test for experimental group. Cohen's d values of d=034 for the experimental group suggest an effect size between small and medium, indicating significant practical significance in the improvements observed in oral health related quality of life over time within experimental group but there was a very smell effect size (d=0.02) in control group.

Table 4.26: Pairwise Comparison of Oral Health Related Quality of Life Score Across Time for Both Groups (Between Group)

Time	Test	Mean Difference	SE	*p*-value	95% CI for Difference		*Cohen d*
					LB	UB	
Control	Pre Vs post	0.208	0.102	0.247	-0.061	0.477	0.02
Intervention	Pre Vs post	-2.191*	0.257	<0.001	-2.870	-1.514	0.34

* Significant at the .05

In order to evaluate the differences in oral health related quality of life scores between groups at both the pre-test and post-test stages (between group), a pairwise comparison was performed.

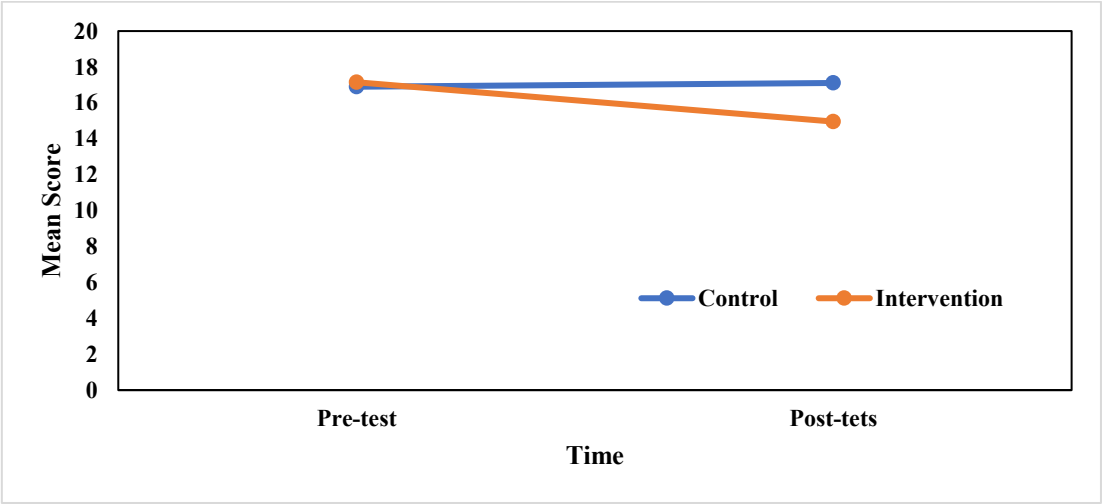
Results (Table 4.27) showed that at the pre-test stage, no statistically significant difference was observed between the experimental group and the control group in oral health related quality of life scores (p = 1.000). The effect size (Cohen's d = 0.03) suggests a small effect, indicating minimal differences in oral health related quality of life scores between groups at the pre-test. These results also showed that there was no significant difference between experimental group and the control group at the post-test, in oral health related quality of life scores (p = 0.219). Additionally, the small effect size (Cohen's d = 0.27) indicated an improvement in oral health related quality of life in the experimental group compared to the control group (Cohen's d=0.03) the post-test.

Table 4.27: Pairwise Comparison of Oral Health Related Quality of Life Score Between Groups at Pre and Post-Test (Between Group)

Group	Test	Mean Difference	SE	*p*-value	95%CI for Difference		*Cohen d*
					LB	UB	
Pre-test	INV vs CNT	0.250	1.112	1.000	-2.683	3.183	0.03
Post-test	INV vs CNT	-2.150	1.028	0.219	-4.862	0.562	0.27

Figure 4.8 illustrates the mean score of oral health related quality of life over time, revealing a decrease at the post-test stage in experimental group compared to control group.

Figure 4.8: Mean Score of Oral Health Related Quality of Life in Experimental and Control Groups across the Time



4.3.5.5 Effectiveness of Oral Health Education Programs on Consumption of Sugary Foods and Beverages

The las research objective of this study is to assess the impact of oral health education program on consumption of sugary foods and beverages among university students in Libya. GEE was applied to assess the effectiveness of oral health education program on consumption of sugary foods and beverages. Table 4.28 shows the descriptive statistics (Mean and standard error) for both groups at the pre-test and post-test for all 9 indicators and also overall mean score for this domain.

The intervention group demonstrated a significant decrease in average sugary food and drink consumption at post-test (M = 2.95, SD = 1.03) compared to their pretest average (M = 4.35, SD = 0.63). The control group experienced just a minor decrease in their mean score from 4.69 to 4.72. The items with the most significant decrease in consumption within the intervention group included biscuits/cakes and sweetened milk alongside sugary drinks.

Table 4.28: Descriptive (Mean and SD) Statistics of Consumption of Sugary Foods and Beverages

Item	Group (Mean, SD)			
	Control group		Intervention group	
	Pre-test	Post-test	Pre-test	Post-test
Biscuits, cakes, cream cakes, sweet pies, buns etc	5.3(1.058)	4.8(1.213)	4.64(1.052)	2.85(1.32)
Sweet pies, buns	4.64(1.035)	4.6(0.92)	4.22(0.862)	3.05(1.166)
Jam/honey	3.39(1.071)	3.55(0.672)	2.83(1.428)	1.85(1.018)
Chewing gum containing sugar	5.23(1.186)	5.42(0.931)	5.26(1.033)	3.4(1.469)
Sweets/candy	4.04(1.536)	4.23(1.158)	4.1(1.273)	2.45(1.401)
Lemonade, Coca Cola or other soft drinks	3.65(1.261)	3.45(0.808)	3.09(1.309)	1.8(0.875)
Tea with sugar	5.56(0.968)	5.68(1.029)	5.33(1.048)	4.8(1.213)
Coffee with sugar	4.85(0.932)	5.74(0.44)	4.77(0.827)	3.55(1.327)
Milk with sugar	5.52(1.23)	5(1.004)	4.89(1.262)	2.8(1.813)
Total	4.69(0.62)	4.72(0.42)	4.35(0.63)	2.95(1.03)

The Generalised Estimating Equations (GEE) results, as presented in Table 4.29, concerning the total score of consumption of sugary foods and beverages among students, revealed significant findings. Firstly, time significantly affected the total score of consumption of sugary foods and beverages ($\chi2 = 487.673$, $p < 0.001$), indicating that consumption of sugary foods and beverages showed notable changes over time, encompassing the pre-test and post-test assessments. Also, the group's main effect was significant ($\chi2 = 76.187$, $p < 0.001$). Furthermore, the interaction between time and group was significant ($\chi2 = 224.035$, $p <0.001$), indicating that the patterns observed in consumption of sugary foods and beverages over time between the experimental and control were significantly different.

Table 4.29: Results of Generalised Estimating Equations (GEE) on Consumption of Sugary Foods and Beverages

Source	Wald Chi-Square	df	p-value
Time	487.673*	1	<0.001
Groups	76.187*	1	<0.001
Time * Group	224.035*	1	<0.001

* Significant at the .05,

In order to evaluate the differences in the consumption of sugary foods and beverages among participants across the time for both groups (within group), the post-hoc test (Bonferroni) was applied (Table 4.30). Based on the result of the Bonferroni test, the difference in consumption of sugary foods and beverages scores between pre-test and post-test in control group was statistically different ($p<0.001$) , also there was significant difference between pre-test and post-test in experimental group ($p<0.001$). These findings highlight substantial improvements in consumption of sugary foods and beverages from the pre-test to the post-test for experimental group. Cohen's d values of $d=0.54$ for the control group suggest a medium effect size while in intervention group the effect size ($d=2.25$) , indicating significant practical significance in the improvements observed in consumption of sugary foods and beverages over time within experimental group.

Table 4.30: Pairwise Comparison of Consumption of Sugary Foods and Beverages Score Across Time for Both Groups (Between Group)

Time	Test	Mean Difference	SE	*p*-value	95%CI for Difference LB	UB	*Cohen d*
Control	Pre Vs post	-0.34*	0.05	<0.001	-0.480	-0.200	0.54
Intervention	Pre Vs post	-1.77*	0.08	<0.001	-1.979	-1.560	2.25

*Significant at the .05

In order to evaluate the differences in consumption of sugary foods and beverages scores between groups at both the pre-test and post-test stages (between group), a pairwise comparison was performed.

Results (Table 4.31) showed that at the pre-test stage, no statistically significant difference was observed between the experimental group and the control group in consumption of sugary foods and beverages scores ($p = 1.000$). The effect size (Cohen's $d = 0.06$) suggests a small effect, indicating minimal differences in

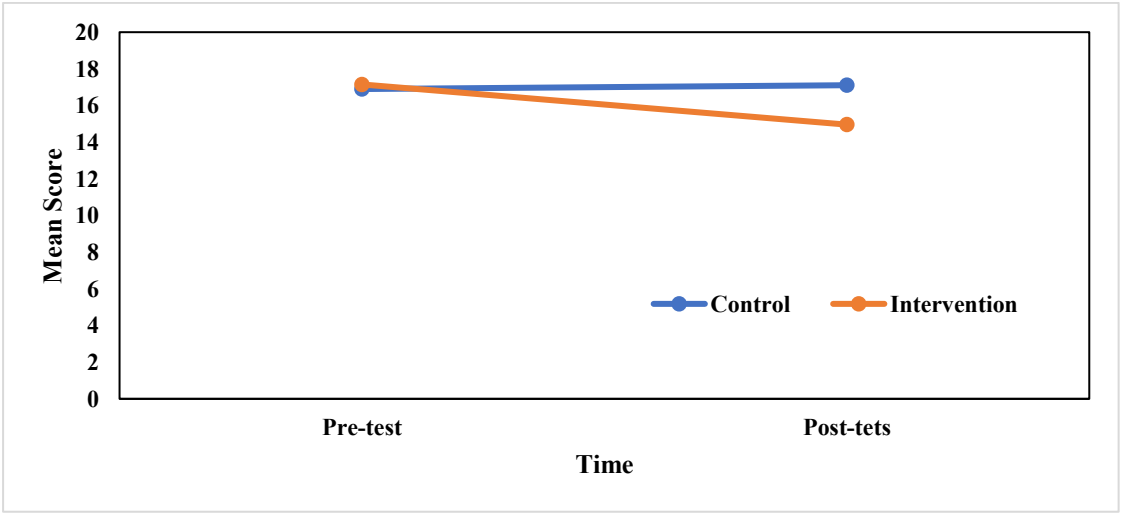
consumption of sugary foods and beverages scores between groups at the pre-test. These results showed that there was significant difference between experimental group and the control group at the post-test, in consumption of sugary foods and beverages scores ($p < 0.001$). The effect size (Cohen's d = 1.64) indicated an notable reduction in consumption of sugary foods and beverages in the experimental group compared to the control group in post-test.

Table 4.31: Pairwise Comparison of Consumption of Sugary Foods and Beverages Score Between Groups at Pre- and Post-test (Between Group)

Group	Test	Mean Difference	SE	*p*-value	95% CI for Difference		*Cohen d*
					LB	UB	
Pre-test	INV vs CNT	0.032	0.068	1.000	-0.149	0.212	0.06
Post-test	INV vs CNT	-1.40*	0.110	<0.001	-1.689	-1.107	1.64

Figure 4.9 illustrates the mean score of consumption of sugary foods and beverages over time, revealing a considerable decrease at the post-test in experimental group compared to control group.

Figure 4.9: Mean Score of Consumption of Sugary Foods and Beverages in Experimental and Control Groups across the Time



4.4 Discussion

The objective of this study was to examine the effect of an oral health education program on knowledge and attitudes, practices (KAP), dental caries, dietary habits, and oral health quality of life (OHRQoL) in 18–21-year-old university students in Misurata, Libya. This section of the thesis is organised according to the specific research objectives and brings together information from both the baseline data (Phase 1) and the intervention related data (Phase 3) to support the results within the university context in Libya. It is important to interpret and discuss these findings in reference to the literature provided, and implications for oral health education and public health initiatives in Libya will be discussed.

4.4.1 Introduction to Discussion

This chapter discusses the results in the context of research objectives and literature. To take a step back, the main focus of the thesis project was to evaluate the impact of an oral health education intervention on the knowledge, attitudes, practices (KAP), dietary behaviours and oral health related quality of life (OHRQoL) in a random sample of university students living in Misurata, Libya. This study also examined the baseline prevalence of dental caries in this population and looked into some sociodemographic factors related to oral health behaviours and also their relationship to KAP and perceived quality of life.

The study showed that students had moderately low levels of oral health knowledge at baseline and highlighted a gap between oral health knowledge and oral health behaviours, especially as it pertains to daily hygiene practices, and dietary behaviours. The prevalence of dental caries showed a 25%, which is consistent with provincial data, however, one cannot be less disheartened by having a 25% prevalence of any indicator of oral disease in an educated youth group. Sociodemographic characteristics of gender, age, and disciplinary studies influenced the shared behaviours and responses to the education intervention group, but influence was only observed in the baseline behaviour.

It is important to note, the examined and evaluated educational intervention annalist for oral health, particularly the intervention group as a whole, had a statistically significant effect on the KAP, behaviours, and self-reported quality of life improvement(s) in knowledge, attitudes, hygiene behaviours, dietary behaviours, and quality of life. This discussion examines the results related to three established theories of health behaviour the Health Belief Model (Rosenstock, 1974), Social Cognitive Theory (Bandura, 1986), and The Theory of Planned Behaviour (Ajzen, 1991), and literature on similar empirical-based studies in similar contexts and possible reasons for expect and unexpected results and implications for health policy, health practice, and future research. The aim of this chapter is to situate the results with related to the discipline of oral health promotion, and the behavioural sciences, and also to examine the pathway derived from the study at hand in fostering applicable and culturally competent sources, and accessibility to sources for university populations.

4.4.2 Sociodemographic Profile

The sociodemographic characteristics of the participants in this study should be acknowledged when interpreting baseline findings and assessing the influence of the oral health education. Most of the participants identified in the study (76%) were undergraduate students, who were between the ages of 18 to 21 when enrolled in the study, a significant period in their lives when they were experiencing increased independence and cementing behaviours for a lifetime of health. The early to mid-adult years are a chronologically significant time when young adults are particularly vulnerable to high-risk health behaviours and significant lifestyle transitions that negatively affect their oral health (i.e., high consumption of sugar, irregularly visiting a dentist/dental hygienist, low engagement with preventive care practices after a dental appointment) (Al-Tajouri, 2022; Oliveira & de Andrade, 2020). Compounded by stress associated with their educational program, an irregular schedule from university life, and unhealthy dietary habits, university students may be in a uniquely compelling situation, alone and together, that may limit their willingness to engage with optimal oral hygiene behaviour.

The gender distribution seen in the sample shows females represent the majority of many health-related professional programs in the area (Alshahrani *et al.*, 2021). When examining oral health behaviours and the intention to participate in intervention, gender distribution should be contextualised. The literature suggests that female students had greater oral health literacy, were more willing to participate in cosmetic dental care, preventative dental care and appear to have been more conscientious about their oral hygiene behaviour compared to male students (Abdellatif & Hebbal, 2020; Alraqiq *et al.*, 2021). These findings could reflect females are more aware of their health, understanding the social determinants related to female appearance, and/or females experience a higher perceived susceptibility to ill health. In this study, females performed slightly better on the baseline measures of knowledge and attitude, aligning with previous literature that suggests women score lower on the reports of oral hygiene behaviours but exhibit higher levels of health-promoting behaviours in general (Antunes *et al.*, 2020). The differences between male and female students highlight the importance of examining sex-disaggregated data in the design and assessment of oral health interventions because the motivation and behaviour recorded may require differing interventions for male and female students.

Furthermore, participants were engaged across the various faculties (e.g., health sciences, engineering, and social work); however, students from health-related disciplines had an overall higher level of baseline oral health knowledge and a more positive attitude towards oral hygiene than students from non-health disciplines (in particular, students in non-health programs were more likely to have a lower level of baseline awareness of oral health and were less likely to engage in habitual oral health behaviours). Longitudinal studies have already demonstrated that exposure to health-related materials/education would likely improve oral health literacy and actual preventive behaviours (Abbass *et al.*, 2019). This evidence suggests a need for broader inclusion of oral health education in the curriculum, particularly in non-health programs that may not currently provide students with enough exposure to information regarding preventive care. Moreover, this evidence suggests that university-level health campaigns may need to use different engagement strategies

that are specific to the faculty of the campaign audience, being most effective at the engagement stage.

Another factor worth noting is the social, economic and environmental uniformity of the student participant population, given that most of the students lived in the same multiple-unit housing and accessed the same dining and health services. Although this mitigated variability and provided adjusted comparisons for the intervention and control groups, it limited the implications of making claims that pertain to a more heterogenous or rural population of students in an economic and social strata. Prior studies have indicated that SES is an important variable for oral health populations (Knorst *et al.*, 2021), as students with low SES may have barriers to obtaining dental care, which can relate to oral health literacy among students with higher SES. Further research exploring purposeful sampling is needed to capture students from private schools and students in a rural context, or students with different SES, to explore the maximum range of possibilities along the realms of knowledge, attitudes, and practices of SES in future studies.

4.4.3 Prevalence Study

The baseline results of this study showed a dental caries prevalence of 25% for university students in Misurata, Libya. A prevalence of 25% doesn't indicate a particularly great disease burden for this population, suggesting, at this point in their lives, a relatively limited awareness and preventive behaviour towards oral health. On the whole, the prevalence of caries isn't alarmingly high; but certainly, is clinically relevant for a population that one would expect to have much more access to health information and health promoting activity. According to the World Health Organization (2023), dental caries is among the commonly reported diseases throughout the world, with an estimated 2.3 billion people in the world suffering from untreated caries. It is possible that university students at this point in their development are more at risk for an increase in caries experience due to the changes in their current life phase where they have more personal responsibility for their health, a general change of diet and routines not in a healthy way, and in some cases, abandoning accessing help for their health.

The present prevalence rate is significantly similar to those toxic studies conducted in the North African and Middle Eastern regions. The findings from Abdelaziz *et al.* (2023) with a similar study conducted within university brackets in Tunisia and Egypt and Alraqiq *et al.* (2021), that observed with urban young Libyan adults, we also noted nearly thirty percent caries. The findings show a systematic relationship between cultural and environmental risk factors, which includes traditional dietary norms (which naturally involve high levels of refined carbohydrates), limited oral hygiene practices, and poor use of preventive dental services. In particular, over forty percent of study participants reported that they only accessed the dentist when there was pain or complications present. This further indicates the tendency for oral health challenges and practices to have a largely reactive connection and not preventative. Unfortunately, this is reflected in a number of places (for example, Urwannachotima *et al.*, 2019) in Thailand, which corroborated that even in a place of access to dental services, university students rarely sought preventative dental services.

There may be several behavioural and systemic reasons that could have been related to the prevalence seen in this study. Participants reported several dietary behaviours of concern, including lots of sugary snacks and drinks (soda drinks). The dietary concern as it relates to caries development is well established; fermentable carbohydrates engage with bacteria in the mouth, leading to acid production that demineralises and dissolves enamel (Fejerskov & Kidd, 2020). These dietary behaviours are indicative; of university student consumption, where often meals occur irregularly, or are a meal on-the-go and often contain many sugary options, will certainly not assist anyone on their pathway to develop caries. Alternatively, a small number of participants indicated they engaged in oral health behaviour patterns, which involved the regular use of a fluoridated toothpaste, and many did not report even hearing about, let alone knowing about, the protective characteristics of fluoride.

Overall, fluoride exposure (in terms of both toothpastes use or community water fluoridation) is one of the single most protective frameworks for caries (WHO, 2023), and the behaviour and knowledge deficits we see among university students is

something we are trying to address through education, another notable finding was the minimal oral hygiene behaviours. Many students expressed that they only undertook brushing activities once a day, and the majority of students did not regularly engage with flossing behaviours. These behaviours would likely contribute to the accumulation of plaque, namely eroding enamel that results in earlier carious lesions. Poor oral hygiene behaviours were more marked among male students and students studying within a non-health faculty, which may be one reason for programmer or sub-group differences in caries prevalence. These findings reinforce the findings of Broomhead and Baker (2023), wherein even oral hygiene behaviours may be construed through academic discipline and/or gender; especially, whereby students studying health related courses have been observed to demonstrate more predictable behaviours and knowledge. It is also crucial to be aware of structural and institutional constraints.

Although Misurata provides dental clinics and university funded health services, students may face logistical, financial, or even motivational barriers that may hinder their ability to see the dentists routinely. Knorst *et al.* (2021) cited many social determinants of health, including, socio-economic status, cultural context and availability of healthcare, as key predictors of oral health disparities among university students in developing countries. In the context within Libya, although students have access to public dental services, it is often perceived that there are long wait times to facilities, lack of patient privacy, or unmet levels of care which may discourage students from timely treatment or preventive service usage This highlights a more global issue in the oral health care system where private dental care is not accessible to many because of costs and limited public engagement.

While considering the lack of universal oral health education within Libyan universities in relation to global examples, the disparity becomes evident. Formal university curricular or campus wellbeing initiatives implementing oral health into their strategic objectives in Saudi Arabia, Brazil and Thailand have shown that oral health education has measurable reductions in caries incidence and improved preventive behaviour (Abdellatif & Hebbal, 2020; Alves *et al.*, 2019; Urwannachotima

et al., 2019). The absence of similar institutional initiatives in Libya stands to waste a useful opportunity for early prevention.

Furthermore, the current disconnect from knowledge to action suggests that knowledge raising campaigns alone are not enough - it's been evidenced that significant change is built on strategy and behavioural change interventions that understand individuals' barriers based on cultural, social and environmental conditions.

4.4.4 Baseline Knowledge, Attitudes, and Practices (KAP)

The baseline assessment of knowledge, attitudes and practices (KAP) in respect to oral health in university students in Misurata, indicated that this content area is complex and multidimensional. The findings revealed a moderate level of knowledge in respect of KAP but it was unclear whether this was sufficient to mediate attitudes and actions towards best oral hygiene practices following the education of oral health. There is a specific issue of discordance between knowledge and action which has been well established in health-related research and is linked to the multiple barriers associated with socio-cultural influences, motivation and the environment, that mediate the transition from knowledge to action (Janz & Becker, 1984; Bandura, 1986).

While several participants were able to report oral hygiene practices of brushing two times daily every day in the morning, and the benefits of fluoride in their prevention of dental caries, they reported poor practice behaviours of not brushing every day or flossing, not routinely attending a dentist. This suggests that even if we can successfully educate this population on oral health practices, the knowledge will not result in the practice change. The Health Belief Model (HBM) can also be employed to explain the limited modifications to health behaviours in this example: health behaviours are determined not just by knowledge of a health threat, but by an individual's perceived susceptibility to that health threat, perceived severity of that health threat, perceived benefits of behaviour change, and perceived barriers to behaviour change (Rosenstock, 1974). In this example, students may have conceptually understood the oral health threats presented in class; however, they did

not perceive themselves as vulnerable to oral health issues or have perceived motivation to act, because they did not have any symptoms.

Cultural standards and health-seeking behaviours in Libya may also contribute to this divide. Al-Tajouri (2022) describes social expectations in Libya for preventative health behaviour as "social normalization". They note that preventative health behaviour (i.e., attending dental appointments on a regular basis, and actually going to the dentist) may not have been a social norm across Libyan society. While society normalised one directional use of the dental service system that enforces a habit of only going to the dentist when needed (i.e... when they had pain or decay), it does negatively influence patients' proactive dental health behaviour as medical evidence and knowledge increasingly changes. Added motivations (i.e., stress their education course puts on them, competing with time in their daily hygiene practice, complications of their daily hygiene practices) will also dictate whether they even want to develop knowledge to turn into action. For instance, students in a non-health faculty may feel that oral hygiene is not worth their time or may also have no role models in their peers who reinforce that oral hygiene is worth their time through preventative care as a role model.

Infrastructure and access are equally important. While dental access can be found in urban Misurata, many students are faced with hidden barriers including inconvenient trips, delays to access dental services and/or a low quality of care from the public dental sector. These and other barrier constraints could weaken the probability that students, who are aware of oral health importance, seek to attain dental services on a regular basis. Knorst *et al.* (2021) recently showed structural barriers to be strong contributors to inequities of oral health in the university context, with context and structures as having especially influencing results in low and middle income (LAMI) countries. Evidence from Knorst *et al.* (2021) allows for the interpretation that knowledge is only a part of the coin, and must be supported by enabling environments, additionally, at the institutional and/or community basis to allow for sustainable behaviour changes. Compared to other global studies, this current study's baseline KAP trend is similar to other findings from Thailand (Urwannachotima *et al.*, 2019) and Brazil (Ghaffari *et al.*, 2018), where university

students had moderate to good oral health knowledge but poorly implemented oral health behaviours.

Understanding the causes of caries, and the importance of brushing, Urwannachotima *et al.*, share that the students were aware of correct behaviours, however due to competing studies programmers and poor reinforcement of behaviours they did not practice these. Similarly, Yusof *et al.* (2019) conducted a study with Malaysian undergraduates with 80% of participants assessing their brushing technique as correct, they found that behaviours like brushing techniques were practiced by fewer than 50% of the participants which would map to many other international contexts and supports the belief that this gap in knowledge and behaviour is not unique to Libya, but is a global contemporary issue in health education.

However, there is one difference in the attitudes of the students. Participants in this study expressed ambivalence or indifference toward oral health as a crucial aspect of overall well-being, despite the fact that studies conducted in nations with robust health promotion infrastructure frequently report positive health attitudes despite weak practices. This might be a result of oral health professionals' low visibility in community health discussions and the absence of integration of oral health messages into larger health education campaigns in Libya. The Theory of Planned Behaviour (Ajzen, 1991) states that attitudes are important indicators of intention and subsequent behaviour. Even well-informed students may thus be unable to establish enduring routines if positive attitudes are not used to reinforce perceived value and social norms surrounding oral health.

4.4.5 Baseline KAP and Oral Health-Related Quality of Life (OHRQoL)

Overall, the relationship between KAP and OHRQoL at baseline was generally low, but statistically significant. More oral health knowledge and positive attitude towards oral health were associated with higher OHRQoL scores ($p < 0.05$); therefore, students who had knowledge of oral health concepts were associated with a higher likelihood of rating oral health as a positive contributor to the quality of their daily life. But it was not a strong, nor always linear association, meaning that simply having knowledge was not sufficient to use it as a predictor of quality of life. Given that such

complexity, there is the need for a theoretical development that helps us understand what constructs shape KAP and OHRQoL relationships.

On the basis of the Health Belief Model (HBM), and with the assumption that behavioural changes and consequently, improvements in HRQOL would occur, an individual's perceived susceptibility to disease and perceived severity, the perceived benefits of action, and perceived barriers to action are combined (Rosenstock, 1974). In our study, although a large number of students were aware about the aetiology and prevention of dental disease, such awareness may not have been accompanied by corresponding action, probably due to lack of perceived susceptibility or lack of urgency in the absence of symptoms. As a result, it seems that the inability to display proactive oral health behaviour, despite cognitive awareness, could have prevented substantial advances in oral function, aesthetics, and self-esteem, which are essential elements of OHRQoL (Sischo & Broder, 2020). This indicates that cognitive understanding has to be combined with motivational cues and risk appraisals to have an effect on quality of life.

The association with Social Cognitive Theory (SCT) has even more relevance to our discussion around self-efficacy, social modelling and reinforcement in the development of health behaviour and outcomes (Bandura, 1986). After all, students with the most knowledge may not have had the self-efficacy or social supports to consistently involve themselves in good oral hygiene. This becomes relevant in contexts that do not promote or value oral health, and often respondents do not enact their knowledge, and little oral health improvements and improvements to quality of life will result. Furthermore, SCT highlights reciprocal determinism so any and all personal, behavioural, and environmental influences impact each other continuously. Even when possessed with personal knowledge, however, environmental shortcomings such as limited or no access to health care professionals or no modelling of positive peer behaviour can diminish the inferences of knowledge on actual health and perceived well-being.

Interestingly, some students received high scores for K in the sample but presented low OHRQoL. This could be related to the affective and sensory aspects in terms of oral health. Perhaps more highly educated students have better awareness

of their oral health limitations and possibly more self-criticism or concerns towards the aesthetics and function of their oral health. Many times, health literacy education has been connected to a lower short-term self-assessment of a student's oral health but especially when they become more aware of a need that they did not have before (Oliveira and de Andrade, 2020). Also, any students have the ability to assess their own needs but lack access to a professional to help them with their needs, this could lead to feelings of frustration or feeling like they have a lack of control in their life which too can impact quality of life despite having the knowledge.

Lastly, the influences related to structural and behavioural barriers such as infrequent dental visits, high sugar intake, and irregular brushing and flossing behaviours were also noticeable in a few students who had good knowledge. They were probably prevented from experiencing the best possible clinical oral health outcomes which were also influenced by the levels of perceived benefit as defined by OHRQoL scales. All of this reinforces the notion that the simple act of knowing something is inadequate, it is the intent around that knowledge and the actions that arise from the intent that led to health quality of life. For instance, according to the Theory of Planned Behaviour (TPB) the act of intention requires positive attitudes, perceived norms and perceived control, in order for intention to be activated into action and outcomes (Ajzen, 1991). Knowledge is not activated without these enabling conditions.

4.4.6 Effects of Oral Health Education Intervention (Phase 3)

This section will discuss the effects of oral health education intervention for Phase 3.

4.4.6.1 Changes in Knowledge

The development and application of oral health education intervention significantly improved subjects' knowledge about several oral health aspects. Following the intervention, participants demonstrated significant changes in the comprehension of preventive dental care, with significant improvements in those related to fluoride, caries aetiology, plaque formation and frequency of dental visits. The improvement of the intervention group was significantly higher than that of the

control group ($p < 0.001$), indicating effectiveness of the tailored educational module. This enhancement is consistent with the results of Ghaffari *et al.* (2018), who pointed out that structured educational programmers enhance oral health literacy and enable individuals to make choices in relation to health. The success of the intervention may also be explained by its inclusion of multimodal approaches, utilising visual aids, videos and peer demonstrations, in line with Mayer (2017) cognitive theory of multimedia learning. Through involvement of more than one cognitive processing pathway, the intervention promoted enhanced comprehension and long-term recall.

Nevertheless, though there was significant knowledge gain, we need to appreciate that the mere acquisition of knowledge does not necessarily lead to behavioural change. According to Bandura (1986), knowledge needs to be linked with a belief in one's ability to engage in the advocated actions, a construct referred to as self-efficacy. This relationship was modified by the interactive nature of the intervention, including demonstration of PGD skills and question and answer periods, where students were able to clarify misunderstands and build self-confidence.

4.4.6.2 Changes in Attitude

The intervention also effected a change in attitudes toward oral health in the participants. Several of the students who had initially seen oral health as one of the less important, 'cosmetic' aspects of health came to understand the relationships with overall health, academic success, and normal social behaviour. The change in attitude was particularly evident on items about beliefs in the benefits of preventive dental visits and regular tooth brushing. This result is also consistent with the framework of the Health Belief Model (Rosenstock, 1974), specifically perceived benefits and cues to action. By incorporating oral as part of a bigger narrative about health, the intervention was able to shift students' perceptions such that oral becomes not just something that you have to do, but that it has valued investment toward your personal self-care.

Peer-led components were more successful in shifting attitudes and perceptions. Peer-led approaches can serve to provide observational learning and social reinforcement which are key components of positive behaviour internalisation as suggested by the Social Cognitive Theory (Bandura, 1986). Attitudes were also

modified by being exposed to role models (i.e., fellow students that were observed as practicing and promoting oral hygiene). This is consistent with the results of Urwannachotima *et al.* (2019), which showed that peer education can be an effective method of modifying attitudes especially when the target population is attuned to the social norms and social identity of collective.

4.4.6.3 Changes in Practice

The overall changes to oral hygiene behaviours post-intervention were both statistically significant and practically significant. Intervention students felt they had more frequently reported on the opportunities provided and identified with the recommendations of always brushing teeth twice daily, using fluoride toothpastes or fluoride programs and regularly flossing; these changes represented a transition from being passive consumers to being active participants and drivers of their oral health routine. The practical changes also serve to illustrate the benefits of experiential learning as delineated as an aspect of health education in which the education delivered knowledge, while scaffolding skills and confidence to act (Michie *et al.*, 2011). The changes in behaviours findings provided support for the Theory of Planned Behaviour (Ajzen, 1991) in that behavioural intention exists because of attitudes, subjective norms, and perceived behavioural control. The study's intervention design targeted all of these three domains, i.e. attitudes through changing their knowledge of health impacts of behaviours (i.e. stories of health impacts); subjective norms through the deployment of peer educators (i.e. known models); and perceptions of behaviour control, designed to overlap with; interventions through demonstrations and cables, new resources. Consequently, the participants felt more capable and empowered to engage in behaviours that support having oral health.

Significantly to these changes persisted at the post-test which indicates preliminary evidence for habits being established. The persistence of habits is important because sustained adherence to preventive behaviour is needed to reduce the prevalence of dental disease and improve oral health outcomes. These findings support those of Knorst and colleagues (2021) with their findings that including practical and skill-based items into behaviour, as well as when combined with motivation, can have lasting and sustained behaviour change.

4.4.6.4 Changes in Oral Health-Related Quality of Life (OHRQoL)

This study investigated whether an oral health education program could improve university students' OHRQoL, as measured by the OHIP-14 (Slade & Spencer, 1994). Altogether, the intervention led to statistically significant and clinically important improvements in overall OHIP-14 scores, which confirmed the hypothesis that thorough oral health education can improve perceived oral health and quality of life (Campos *et al.*, 2021). A unique strength of this study is that it analysed the outcome at the domain level. The OHIP-14 consists of seven domains: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap. There was variability in the improvements across the domains, which exemplifies the multidimensional effects of the intervention (Ito *et al.*, 2024).

The domain of functional limitation in the OHIP-14 health instrument reflects difficulties in everyday functioning in terms of articulating speech with the ability to use taste perception eating as one component that could be impacted by oral health conditions. In our study, participants in the intervention group saw a statistically significant reduction in these limitations ($p < 0.01$) following the oral health education program. These changes in the limitations likely result from changes in oral hygiene practices, namely, increased frequency of brushing, improving technique, and decreased accumulation of plaque on the gingiva; all of which mitigate inflammation of the gingiva and discomfort that might inhibit speech or chewing (Slade & Spencer, 1994; John *et al.*, 2009). The ability to articulate speech free of impediment and taste food without removal from the mouth is part of everyday functioning, particularly in the university setting where public presentations, group discussions, and lectures/discussions are common.

Similarly, Montero-Martín *et al.* (2009) reported improved functional limitation among young adults exposed to an oral health intervention. The developments in this area highlight how preventative care and health literacy can influence not only physiological aspects of oral health, but also broader aspects of life's communicative acts and quality of life as well. Since many university students only use dental services after a symptom appears, preventative educational means

may also ameliorate future functional impairment, before the effect changes in areas of their social-life and learning or work. Overall, these results suggest that oral health education is important for maintaining everyday functions such as eating and speaking; functions which are often taken for granted until disrupted.

The physical pain domain of the OHIP-14 includes subjective experiences such as toothache, oral soreness, and discomfort when eating or drinking. This study recorded the largest improvement in physical pain scores from pre-test to post-test following the oral health education intervention than the other measured domains. The reduction in reported pain can be explained by participants increasing their oral hygiene practices (e.g., brushing with fluoride toothpaste, flossing properly, and decreasing sugary food and beverage intake). These behaviours positively affect the increase of plaque, gingivitis, and early carious lesions, and cause pain in the mouth (Campos *et al.*, 2021; John *et al.*, 2009).

It is important to note that the focus of the intervention on the causes and consequences of dental pain would likely have given the students a better awareness of self-management strategies for tackling dental pain. The results from Montero-Martín *et al.* (2009) and Reissmann (2011) suggest that oral health education provided a significant reduction in physical pain. Further, oral pain does impact help-seeking behaviour, and its reduction via preventive education indicates that even interventions that are not clinical can have clinical impact (Heydecke *et al.*, 2003). For university students, the impact of oral pain extends beyond the mouth and can affect sleep, attention, and overall well-being. The reduction with the physical pain may ultimately benefit academic performance and mental health. These findings enhance the case for structured oral health education early when individuals may only experience discomfort and before it escalates into more significant clinical issues.

The psychological discomfort domain of the OHIP-14 included emotional responses to consequences of people's self-consciousness, anxiousness, and concerns about the state or appearance of their oral health. The learning intervention improved this domain whereby, participants reported moderate but statistically significant improvements. The decrease in feelings of embarrassment or worry about their oral aesthetics can most probably be attributed to greater awareness of their oral health,

improved or change of oral hygiene routine, and increase in visible changes in their mouth such as cleaner teeth and fresher smelling breath. For university students a very important factor in facilitating these changes could be increased self-confidence that may accompany a change in their oral health status, which can be extremely important when individuals predominantly aged 18-24 usually pay a great deal of attention to their physical appearance and accompanying peer judgments (Reissmann, 2011; Campos *et al.*, 2021).

Psychological discomfort is often caused by observable signs of poor oral hygiene such as halitosis, plaque, and stained with dental age which may lead to social avoidance and impact self-esteem. Moreover, the content of the program likely addressed these directly for the person to address, by talking about the aesthetic and social value of oral care and oral health, in connection with the health benefits. Additionally, similar studies by Montero-Martín *et al.* (2009) and Heydecke *et al.* (2003), demonstrated that, with subsequent improvement in oral health knowledge and oral health practices, came a decrease in psychological distress as well as self-esteem.

The improvements are even more impressive with respect to the age of the study participants, because young adults can be particularly sensitive to psychological discomfort associated with body image, and social scrutiny. Thus, the intervention had benefits beyond just physical health outcomes, it is reasonable to argue the intervention improved the mental and emotional well-being of the participants — expanding the psychosocial benefits of preventive oral health education.

The psychological disability domain of the OHIP-14 addresses greater emotional and cognitive implications of poor oral health, such as not being able to relax, loss of self-confidence, or emotional distress in relation to their oral condition. In this investigation, there were modest improvements, but substantial in this domain for the education and intervention group, with the oral hygiene educational program. These measures ask questions related to perceptions of internalised shame, helplessness, and inferiority, which perhaps directly towards increases in oral health literacy, education and good oral hygiene standards reduces feelings of shame. This is particularly important and indeed meaningful, as these types of issues are less visible,

and essentially promotes dysfunctional social and emotional resilience behaviours (Reissmann, 2011; John *et al.*, 2009). The change in scores relating to psychological disability may also reflect a heightened awareness of students' own control and autonomy over what happens to their health which is a crucial aspect of self-efficacy. People's sense of control over their health (as exemplified by factors such as self-efficacy) may change or begin to evolve positively following the acquisition of knowledge on how to manage their health successfully, such as mastering brushing and flossing skills (Bandura, 1986).

The reduction in psychological disability scores was less remarkable than the improvements reflected in the physical disability scores, but the trajectory of the results aligns with previous studies that showed emotional well-being usually follows the alleviation of physical symptoms (Campos *et al.*, 2021; Montero-Martín *et al.*, 2009). Considering university students are generally at a stage of life where emotional stability converges with identity development and social integration, even modest improvements in measures relating to psychological disability is meaningful when viewed through a clinical lens. The fact that the intervention had the power to reduce emotional distress through education alone speaks to the importance of embedding psychological support strategies in oral health initiatives. This would create opportunities to demonstrate how oral health promotion can provide additional benefits and effectively reduce health burden.

The physical disability domain of the OHIP-14 measures the extent to which oral health problems interfere with everyday physical functioning, including eating meals, quality of sleep, and able to fulfil one's daily responsibilities. In this study, post-intervention results revealed a significant increase in the physical disability domain, indicating that students had fewer barriers to their everyday physical activities since experiencing oral discomfort. The reduction of gingival bleeding, oral pain and sensitivity experienced by students after adopting improved oral hygiene behaviour likely contributed to this improvement (Slade & Spencer, 1994; John *et al.*, 2009).

Participants indicated they found it easier to eat well, particularly consuming foods they had previously avoided because they were hard, cold, or hot, a sign that the intervention did not just relieve discomfort but restored functional eating

behaviours. This is especially significant for students, as compromised eating or sleeping patterns because of oral health difficulties can impact on concentration, performance and well-being. Similar results have been found by Montero-Martín *et al.* (2009), and types of effective oral health education program can lead to considerable improvements on everyday task performance by reducing oral health-related life limitations. The improvement in this area of functional life participation is indicative of an evolution from comfortable participating, back to a preventive approach to behaviour, where students purposefully participated in maintaining oral health rather than reacting to symptoms that interfered with their functional participation. All of these outcomes highlight the importance of routine-based oral care and dietary advice in relation to oral health education programs - not only to manage existing problems that may exist, but also to prevent interruptions to effective functional participation.

The social disability domain of the OHIP-14 evaluates how oral health issues limit social interactions, such as participating in conversations, social events, or group activities. In this study, participants reported modest yet notable improvements in this domain following the intervention. While not as pronounced as the gains seen in the physical domains, the upward trend suggests that students began to feel more comfortable and confident engaging in social settings post-intervention. Improved oral hygiene may have reduced visible dental plaque, halitosis, and other socially sensitive indicators of poor oral health, thereby decreasing self-imposed social withdrawal (Heydecke et al., 2003; Reissmann, 2011).

However, the small degree of change was expected based on previous evidence showing social behaviour and stigma are less susceptible to a short-term change (Campos *et al.*, 2021). In general, social disability is driven by longer-held personal insecurities and cultural constructs of the aesthetics of dentistry, alongside peer norms which are not likely to change much on their own through education. Montero-Martín *et al.* (2009) found that, as an assessment outcome in a cohort of Oral Health students, oral health education changed hygiene behaviour but did not significantly increase social confidence; the authors suggested this required a more in-depth, supported intervention such as peer reinforcement, or counselling. Since

university life is inherently social, with academic success and graduate identity often derived from interactions with others, slightly improved disability in this study can influence students in the long term. In the future, group discussion, testimonials from peers, and social media platforms and/or feedback made available to peers may all be useful in providing further change within this domain. In summary, this research illustrates the importance of targeting the clinical and social aspects of oral health in order to support student participation fully in the academic and social environment.

The handicap domain of the OHIP-14 represents the broadest and most existential impact of oral health problems—namely, the extent to which individuals feel that their oral condition limits their ability to live a fulfilling life. In this study, the handicap domain scored the least improvement over the course of the study, which is consistent with existing research on disadvantage and life dissatisfaction stemming from oral health, which is complicated and could not be changed through a short educational intervention (John *et al.*, 2009; Reissmann, 2011).

Although the students made gains in the physical and psychological domains, that growth did not significantly change their global life view or role accomplishment. One possible explanation for this muted response is that the handicap domain is simply measuring more deeply held, more complex attitudes about health-related quality of life that are influenced by at least their past dental trauma, socioeconomic circumstances, and life contextualization or stressors. For instance, a student who felt shame or exclusion socially in the past because of their dental problems could hold on to that perception despite improvements in their oral health behaviours over time. Buyer and Locker (2009) highlight that changes to the handicap domain usually require a more sustained, holistic approach—such as engaging long-term counselling, having some restorative treatment done, or receiving help from a mental health professional.

Additionally, young people like university students, may not yet have a fully conceptualise understanding of how oral health affects life course, lifetime earnings potential and long-term health. Therefore, short term education may affect immediate self-care but may not yet impact life satisfaction or identity. The small movement in this area however indicates that some foundational changes may be starting. Future programs should explore combining oral-systemic health education,

as well as motivational interviewing to begin to affect these deeper psychosocial constructs.

4.4.7 Changes in Sugary Foods and Beverages Consumption

Possibly, Perhaps, the most significant behaviour change was the decrease in the consumption of treated foods and drinks. After the intervention, the intervention group had participants report using significantly less carbonated drinks, candy, and processed snacks. This is a noteworthy finding since dietary behaviours, especially the level of sugar consumption, of which sugar intake is one of the major risk factors for dental caries (Fejerskov & Kidd, 2020). The meetings illustrated very well the bottle-neck link between sugar intake, acidic environment, and decay, and even were able to include photos to show students the amount of sugar they were drinking. The photos were a powerful “cue to action” in the context of the Health Belief Model (Rosenstock, 1974) to get these students to think about instead, ultimately decrease their sugar consumption. Furthermore, we supplied students with “how to” tips on only drinking water or fruit in lieu of treated drinks and to read the ingredient lists on foods, prompting them to then action and change their eating behaviour. The activities included in the meetings also provided the opportunity for students to get "hands-on" experience with achieving their daily nutrient level to reach acceptable behaviours regarding their food consumption.

These findings are congruent to the work of Abdella-Aslan *et al.* (2021), who described dietary counselling and nutrition education very significantly improved self-reported awareness and world behaviours in practice. Considering changes made in relation to eating behaviours with regards to sugar consumption and contributes not only to oral health, but additional public health endeavours such as reducing obesity levels, diabetes and other non-communicable chronic disease. These findings highlight again the multidisciplinary dimensions of oral health care education interventions.

4.4.8 Strengths and Limitations

This study had several important advantages that increased its methodological rigor and theoretical strength. First, it was based on established health behaviour theories. The Health Belief Model (Rosenstock, 1974), Social Cognitive Theory (Bandura, 1986), and Theory of Planned Behaviour (Ajzen, 1991) provided a solid theoretical foundation for developing the intervention and interpreting the results. They also support that this study was not just descriptive (e.g., measuring behaviours), but explanatory (e.g., improved quality of life) of a health behaviour topic. Second, the study utilised a quasi-experimental design with pre-and post-assessment, and a control group, which assisted in internal validity, and the ability to specifically attribute impact to an educational intervention. Last, it used multiple outcome domains: knowledge, attitudes, oral hygiene practices, quality of life, and eating habits produced a relatively integrated outcome evaluation demonstrating a multidisciplinary perspective on oral health intervention, not often seen in oral health intervention research. With a completion factor analysis, it will provide a more holistic examination of how educational programs can impact behavioural and psychosocial outcomes.

Despite these strengths, there were several important limitations. Our study was conducted in single public university in Misurata. The uniqueness of the context and population limits the generalizability of our findings to other, geographic, institutional and demographic contexts. University students may also represent a more health-literate or health-motivated subgroup of the broader youth population and may therefore be susceptible to selection bias. Additionally, the follow-up for the intervention was relatively short, making it difficult to evaluate long-term sustained behavioural change or the impact of the intervention on clinical oral health outcomes. Lastly, a majority of the data collection, especially in the knowledge, attitudes, and practices (KAP) and dietary assessments, relied on self-report measures which may induce social desirability bias or recall error. These limitations suggest that future studies should incorporate longer follow-up periods, objective clinical measures such as decayed, missing, and filled teeth (DMFT) indices, and more diverse sample populations to enhance generalisability.

These limitations indicate that although the study illustrate significant proof for short-term intervention efficacy, caution must be indicated in trying to apply the findings to more general populations, or over longer timeframes. Future research should use the same intervention, with additional universities, which maybe include private universities or those in rural university, with a longer-term follow-up to measure how lasting some of the changes were. Using a combination of objective clinical measures and self-report measures would also improve data reliability and contribute to producing a fuller picture of intervention impact.

4.4.9 Summary of Chapter

This chapter provided a critical analysis of the study's findings against the research aims, the theoretical frameworks, and the larger literature. The analysis started with an examination of the sociodemographic data of the participants- this revealed that gender, age, and academic discipline impacted both baseline oral health behaviours and the impact of the educational intervention. There was a dental caries prevalence of 25% amongst students which, although moderate, was concerning in terms of the baseline oral health behaviours and awareness of the importance of preventative care.

The baseline KAP assessment highlighted a gap between awareness of oral health and behaviours. Empirical data demonstrated that students had moderate knowledge, however hygiene practice at baseline was inconsistent, and students consumed excessive sugar in foods and beverages. There also appeared to be a gap between the authors theoretical frameworks, the Health Belief Model, Social Cognitive Theory and the Theory of Planned Behaviour and the participants reported behaviours. It was evident, given the frameworks, that students were limited in their self-efficacy, faced perceived barriers and were influenced by the social construct of their peers. Evidence was presented to demonstrate that although a higher baseline knowledge was a predictor of better OHRQoL, students' ability to apply that knowledge into behaviours moderated that relationship.

The educational intervention led to significant progress in every outcome we measured, i.e. knowledge, attitudes, practices, dietary behaviours, and OHRQoL. Our intervention was effective in improving each of these outcomes, and closely aligned with our use of theory, peer-led learning, comprehensive and systematic approach to the learning goals. Although there were a strong statistical significance and a coherent theoretical framework to support our outcomes, it is important to recognise that while educational targeting works, allowing a timeframe that is greater than what we used in this study will provide notable behavioural and psychosocial outcomes. The limitations of the study, including a single-site study, significant reliance on self-reported data, short follow-up period, mean that overly strong conclusions cannot be drawn from these results and future research in these areas is warranted.

Lastly, the chapter discussed the implications of these findings more broadly, in terms of institutional policy and public health improvement frameworks. There are clear pathways for making recommendations for oral health learning for inclusion in university wellness policies and youth health policies nationally, as well as a strong impetus for interdisciplinary approaches to preventive care. The evidence allows us to advocate for improved, educated, informed, and culturally safe approaches to building oral health literacy and quality of life for university students, who are studying in Libya or other equivalent cultural contexts.

CHAPTER V

CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This study sought to assess oral health status and behaviours among university students in Misurata, develop a tailored Oral Health Education Programme (OHEP), and evaluate its effectiveness. The conclusions directly address the study's seven research objectives.

RO1 concluded that students demonstrated inadequate oral health knowledge, mixed attitudes, and weak hygiene practices. Misconceptions about fluoride, plaque control, and prevention were common, and inconsistent behaviours, such as low flossing rates and infrequent dental attendance, highlighted the need for targeted education.

RO2 revealed a notable prevalence of dental caries, reflecting a significant burden of oral disease. Poor hygiene practices, high sugar intake, and limited preventive behaviour contributed to this problem, consistent with regional findings.

RO3 showed that students recognised the value of oral health education but identified barriers including limited access to information and lack of structured programmes. Their preference for interactive and visually engaging materials indicated readiness for a well-designed intervention.

RO4 demonstrated significant relationships between KAP variables and OHRQoL. Students with lower knowledge and poorer practices reported worse functional, psychological, and social impacts, underscoring the broader consequences of oral health behaviour.

RO5 led to the development of the OHEP, a theory-based, culturally appropriate programme addressing the gaps identified in Phase I. Expert validation and pilot testing confirmed its clarity and feasibility.

RO6 concluded that the OHEP significantly improved knowledge, attitudes, and practices among the intervention group compared with controls, demonstrating its effectiveness in promoting behavioural change.

RO7 established that the OHEP also improved OHRQoL and dietary behaviours. Students showed reduced consumption of sugary foods and beverages and reported fewer functional and psychosocial impacts. These findings indicate that the benefits of the intervention extended beyond behaviour change to enhance overall wellbeing.

5.2 Contribution to the Body of Knowledge

This study makes several important contributions to the body of knowledge on oral health promotion, behavioural interventions, and university-based health research. Academically, the study enriches existing literature by providing comprehensive baseline evidence on oral health knowledge, attitudes, practices, dietary behaviours, and oral health-related quality of life (OHRQoL) among university students in Libya, an understudied population within oral health research. The findings add empirical depth to regional and international understanding of young adults' oral health behaviours and confirm that similar gaps identified in other countries are also present in the Libyan context. By documenting high caries prevalence, low preventive practices, and significant psychosocial impacts, the study expands global datasets and highlights the persistent unmet oral health needs of emerging adults in developing countries.

Theoretically, this study demonstrates the value of integrating multiple behavioural frameworks, namely the Health Belief Model, Social Cognitive Theory, and the Theory of Planned Behaviour, into the design of oral health interventions. The successful application of these models within the newly developed Oral Health Education Programme (OHEP) provides evidence that multi-theoretical approaches can enhance the effectiveness of educational strategies by simultaneously targeting cognitive, motivational, and behavioural determinants of oral health. The significant improvements across all measured outcomes validate the relevance and applicability of these behavioural models in oral health promotion among young adult populations,

thereby extending theoretical discourse on behaviour change in low- and middle-income settings.

Methodologically, the study contributes by adopting a rigorous, multi-phase design that includes needs assessment, theory-driven intervention development, expert validation, pilot testing, and advanced inferential analysis using Generalised Estimating Equations (GEE). This approach illustrates a replicable model for designing culturally and contextually adapted educational interventions. The application of GEE enhances methodological robustness by appropriately handling non-normal data and repeated measures, offering a strong analytical framework that future oral health researchers may adopt for evaluating complex behavioural interventions.

Contextually, the study is one of the first to systematically examine oral health behaviours and intervention outcomes among university students in Libya. By situating the programme within a North African, post-conflict, resource-constrained setting, the study highlights the unique challenges and opportunities for oral health promotion in developing countries. It demonstrates that theory-based, culturally adapted interventions can be successfully implemented even in contexts with limited oral health infrastructure. This contributes to global public health discourse by providing evidence that university settings in developing nations can serve as effective platforms for health education, behaviour change, and preventive care.

From a practical standpoint, the OHEP offers a scalable and sustainable model for improving oral health among university students. The programme's effectiveness in enhancing knowledge, attitudes, practices, dietary behaviours, and OHRQoL demonstrates its potential to be integrated into university health services, student orientation programmes, dental outreach initiatives, and public health curricula. The findings offer actionable insights for policymakers, university administrators, dental educators, and public health practitioners seeking to reduce the burden of oral disease among young adults. By demonstrating clear improvements across cognitive, behavioural, and psychosocial domains, the study provides strong justification for institutionalising oral health education within higher education and broader public health strategies.

Overall, this study contributes new empirical evidence, theoretical reinforcement, methodological innovation, and practical guidance to the field of oral health promotion. It demonstrates how a structured, theory-informed, culturally appropriate intervention can produce meaningful improvements in oral health behaviours and wellbeing, thereby advancing knowledge for both academic scholarship and public health practice.

5.3 Implications

The findings of this research have important implications for health education, clinical practice, public policy, and academic research. It clearly demonstrates that oral health education can influence not only knowledge, attitudes, and behaviours, but potentially overall well-being, to include psychological and social functioning in university-age students. This section outlines how these findings may be considered in context-specific to the Libyan context, but other low resource educational settings are also relevant.

This study's findings have important implications regarding policy development and practice in oral health promotion, specifically in higher education. The educational intervention demonstrated effectiveness supporting the idea that organised, theoretical evidence-based oral health programs have a significant role in expanding student knowledge, modifying attitudes, changing hygiene practices and hence improving oral health-related quality of life. This strengthens a growing consensus in public health that universities can be some of the most important settings for encouraging the development of lifelong health behaviours, even endorsing this notion in the WHO's Ottawa Charter for Health Promotion (WHO, 1986).

At an institutional level, universities should consider embedding aspects of oral health promotion into traditional student health services and wellness programming, especially in non-health faculties as a way of considering the greater gaps in health awareness and preventive behaviour. The multimodal, peer-led approach trialled in this study was particularly successful for the intervention and could be relied upon for developing a scalable model for health promotion targeted towards young adults. Universities should create partnerships with a public health

authority and specialised health and dental professionals, to collaboratively develop appropriate educational materials pertaining to oral health promotion that is culturally appropriate, accessible, and evidence-based based on behavioural theories.

In respect to the policy development aspect, the study emphasised a greater need for national oral health strategies that specifically identify young adults as a target population, not just with regards to school aged children and programmatic considerations for preventive care. To promote this position, oral health literacy should be included in the broader policies of youth health resources to create speed and continuity of preventive behaviours. Furthermore, it would be an opportunity for policy developers to consider developing an oral health promotion curriculum that is consistent, where all stakeholders in an educational institution could apply a base model allowing the potential for oral health promotion to be used in different educational settings including possible uniformity in messaging and content.

Additionally, the research supports the development of plans to integrate oral health into NCD prevention strategies because there was a reduction in the rate of sugary food and beverage intake, which is not only relevant to dental caries, but also to the prevention of other health conditions, including obesity and diabetes. Policy-ways to combine oral health with behaviour change related to nutrition and lifestyle modification also could be beneficial from a population health approach. Finally, funding mechanisms for routine implementation and evaluation of these types of interventions, particularly in public universities, need to be developed. Future programs should be sustainable; the methods of the implementation and follow-up engagement included digital platforms, mobile applications, and student ambassador efforts.

The substantial improvement in KAP of the experimental group provides evidence for the actionable effectiveness of purposeful theory-based educational programs in oral health. Not only did students who engaged in the program have improved knowledge of significant oral health issues (e.g., associations between caries and fluoride and between sugar-laden foods and oral health), they were also able to make meaningful behaviours changes, including engaging in less sugary food consumption and improvements in personal brushing and flossing. The change in

occurrences of the behaviours demonstrates one method for effective educational interventions may be uniquely able to address the inherent complexities of the entrenched obstacles to self-care, when purposely designed with accessibility, relevance, and potential culture in mind.

In a university context, there is an advantage for the primary health promotion with young adults. While at universities, oral health educators can bring oral health education into the welcome sessions for new students, first year or general health classes, or oral health education could be a part of peer-led programs. In addition, campaigns on digital platforms (such as social media, apps or reminder emails) can be helpful to provide ongoing single or multiple interventions to 'nudge' positive behaviours and stay connected with students. Overall, the findings from this study support the development of oral health education that is relevant, not just in terms of structure, but also in terms of educational advertised materials, to engage and inspire, empower and activate students to participate in preventive behaviours.

From a public health standpoint, this study has drawn attention to a fundamental gap in regard to oral health promotion among young adults in Libya, as they often receive no attention in national health initiatives. Not only was there an unacceptably high baseline prevalence of dental caries (40.8 percent), but they also poor behaviours noted (infrequent dental visits and low compliance with basic personal hygiene habits), supports the need for change at the systematic policy level. National health stakeholders such as the Libyan Ministry of Health and Ministry of Higher Education should think about creating more permanent bridges in this work by establishing university oral health programs across the country for which they would commit infrastructure. The primarily limited access to affordable on-campus dental care could be limited through additional intervention measures such as scheduling dental health checks annually, increasing access to subsidised dental hygiene products or second-hand offerings of prevention promotion posters at higher education institutions.

It would also be appropriate to develop health communication policies that similarly realise youth-driven means of communication, such that provide messages they can relate to (such testimonials, marketer role-models or messaging that

associate with student experiences). Policy frameworks should also consider its potential regulatory environmental influences on student behaviours, such as another very accessible source of sugary snacks in and around campuses. Regulatory policies could enhance their educational efforts and start to create a healthier university environment (including taxes on sugary drinks or restricting their sale within educational institutions).

The research has highlighted an ongoing gap in the knowledge and use of dental services among tertiary students. While a large number of participants demonstrated some knowledge of the principles of oral health, they generally attended the dentist when they were in pain, or some other complication was causing concern, typical help-seeking behaviour that is reactive rather than preventative. This suggests there should be a transition to a combined model of service delivery that is integrated, including the student, in the process, and supportive of preventative health behaviours.

With the aim of widening service uptake, health facilities on university campuses should offer prevention based dental consultations, oral hygiene information, and ideally free or low-cost annual dental consultations for all students as part of the campus health service. Universities with health facilities could link with their local dental schools or clinics in their region to potentially offer these experiences to students. The improved levels of oral health related quality of life (OHRQoL) following the intervention in psychological health and social participation, suggest oral health should be treated as an important component of overall mental health and social engagement. The bidirectional link between the physical and psychosocial outcomes should serve as supportive evidence for an interdisciplinary approach to student wellness, where oral health education is consistent with mental health professions and student services.

An important advantage of this research is acknowledging Libyan students as located socially. The results showed how much culture and socio-economic tailoring matter in health interventions. Attitudes related to dental visits, for example, may be socially normative in some contexts and, or structurally accessible, it is very easy to discover attitudes such as dental visits being only necessary in an acute experience;

that oral health is less important than an exam, lunch or a friend. James argued that "issue-interpretations coexist with contextual factors" so to develop supportive oral health programs, our task will be to develop contexts that are sensitive to the socio-cultural circumstances of student lives. Certainly, there is no singular way to infuse oral health promotion content into the lived experience of Libyan university staff and students, however, culturally appropriate narratives, the influence of religious and other community leaders, the stocktaking and implementation of activities alongside broader youth mobilisation, empowerment, and development initiatives may have more impact than conventional health promotion methods.

Gender-sensitive strategies may also be valuable. While we did not disaggregate all findings by gender, the literature indicates there are likely some marked differences in health behaviours, self-efficacy or health services use between male and female students. In future implementations, it will be mindfully beneficial to create parallel or complementary messaging to allow for differences that improve receptivity or alignment of behaviours.

The significant findings in this study opens avenues of future research. Longitudinal studies and data collection will be important to determine whether the changes in KAP and OHRQoL can be sustained and explore predictors of long-term maintenance of behaviour. Future studies should consider exploring the feasibility of this study, and how the engagement of the intervention could be adapted for use across other universities and areas in Libya, or overall region of MENA.

Mixed-methods inquiry would also provide more insight into the psychosocial drivers and barriers to oral health behaviour, as well as student subjective experiences with engaging in behaviour change interventions. Research could focus on how students conceptualise oral health, the processes that may encourage self-care decisions, and how perceived social and economic conditions related to health behaviours or decisions would provide more focus and/or targeted interventions. In addition, research exploring digital health, such as gamified mobile app interventions to improve oral health literacy and compliance or AI reminders to support compliance, could emerge as low-cost, scalable possibilities for increasing oral health literacy and compliance.

5.4 Limitations

Although the findings of the present study provide valuable insights into the impact of oral health education on university students in Libya, it is important to recognise limitations related to the interpretation of results and the planning of follow-up studies.

First, although the quasi-experimental design of the study allowed for some degree of rigor in determining the "pre" and "post intervention" effect and it allowed for comparisons to be made between the intervention and control groups, it did not permit full randomization, which is inherent in true experimental designs. Therefore, the potential had existed where certain measured characteristics (for example, motivation and prior exposure to health education) could have differed between groups and confounded the findings.

Second, the majority of the data collected in this study came from self-reported data through structured questionnaires. Self-reported data from questionnaires is a pragmatic way to collect data and it is degree to public health research, but this data can be affected by social-desirability bias, where participants are likely to over-report on positive behaviours (for example, tooth brushing frequency) and under-report on negative behaviours (for example, number of sugary foods consumed or smoking). Further, since the instrument used for this current study asked participants to recall how often they died certain behaviours, errors in self-reported data could potentially have consequences for the internal validity within the topic of behavioural change of the study's conclusions.

Third, there was a short period of time between the pre-test and post-test. The post-intervention results had both statistical significance and practical significance, but there was no way to know whether the improvements in knowledge, behaviours or quality of life would be sustained over time. The process of behaviour change in relation to oral health, is often non-linear especially for adolescents and adults, and frequently slow, with some behaviours needing reinforcement from time to time even to retain the initial proposed learning. In order to evaluate any of the gains reported were met with time, an extended follow-up, beyond only a couple of weeks, into the future would be required.

Fourth, the research has limited generalizability potential. Participants came from one urban university population in Misurata, and this population may not represent all university students throughout Libya, especially rural students are faced with limited availability of educational or dental health contact points. Any differences in culture, socioeconomics, and geographical location can moderate the effectiveness of analogous intervention within other contexts.

Further, although the study assessed OHRQoL, the study did not consider any clinical dental health outcomes (i.e., plaque index, gingival state, incidence of dental caries) using a clinical dental exam. Clinical dental outcomes would provide objective elements to complement the use of self-reported outcomes and ultimately provide a fuller account to evaluate the impact of the intervention.

Finally - fidelity of the intervention (the degree of consistency and quality of the oral health education program delivery), was not formally monitored or assessed. The delivery approach may have varied, and the engagement of the participants and their understanding of the material may have differed. Overall, the research offers many useful contributions to oral health promotion within the context of the university student population and provides a stepping stone for additional and future comparable interventions and investigations that can be better informed and wider-reaching. In conclusion, while identifying limitations is integral, the study provides a promising avenue for oral health promotion in Libyan university settings.

5.5 Recommendations

Based on the findings of this study, we propose several recommendations to enhance oral health knowledge, attitudes, practices, and oral health-related quality of life (OHRQoL) among Libyan university students. The recommendations for improvement are directed to relevant stakeholders, including educational bodies, public health authorities, dental practitioners, and the future researchers. Our intention is to use the evidence from this study to develop strategies to foster healthier oral health behaviours in young adults.

One way to bridge the knowledge gaps reported in this study is for universities to build oral health education into their university programs of study. As noted, oral health education is historically only provided to dental students or through comparative health awareness courses, however modules can also be included into general health, or life skills *type courses*, covering general knowledge related to prevention; health hazards; and healthy behaviours. Universities could also offer orientation sessions to first year students that contained information regarding oral health education. Enabling faculty (enable is a better word than allow) the opportunity to present oral health education content and trained leadership (students) to present oral health educational opportunities will also promote peer-to-peer engagement and social learning beyond the classroom.

The results of the current study confirm that oral health interventions are effective and illustrate the necessity of instituting these into policy at organisations. Health organisations and universities should continue to be advocates for oral health by implementing continued oral health and hygiene campaigns, and distributing hygiene kits (toothbrush, fluoride toothpaste and floss), and providing access to dental check-ups via either a mobile dental clinic and/or campus health service. Institutionalization of these changes would not only remove barriers to preventative care but contribute to frequent oral care behaviours.

While students demonstrated moderate levels of knowledge, their attitudes and behaviours were not in alignment suggesting a clear need for behaviour change approaches. Campaigns should be considered to increase awareness of the risks of poor oral hygiene, the ability of regular dentist visits to prevent oral disease, and the risks surrounding high sugar intake. Digital media, mobile applications, and gamified components may serve as the most effective in maintaining behaviour change. Interventions should also be framed within behavioural theory, such as, the health propose Model or Theory of Planned Behaviour to address the practice of student's motivation and perceived barriers.

Dental health professionals delivering services to young adult populations need begin to develop more active efforts to enhance prevention. At dental appointments, clinicians can reinforce advice about oral hygiene, diet and the

importance of regular appointments. Brief motivational sessions and/or visual displays can help to convey the message. Clinicians can work with university health units to ensure the dental professional can contribute to the broader oral health surveillance and education that will be provided to university students.

5.6 Research Recommendations

Future research should work to advance the limitations of the current study through longitudinal designs which assess the sustainability of behavioural changes and the longer-term effects of oral health education, and clinical oral health indicators such as DMFT, plaque scores, or periodontal status should be included in addition to self-reported data, which provides a more complete picture. Researchers should also explore differences in oral health behaviours among socioeconomic, cultural, and regional populations. Investigating the effects of different delivery modes - face-to-face, print, digital, etc. - will also provide valuable information about ways to shift behaviour and facilitate oral health interventions among various student populations.

5.7 Future Research

Overall, the study provides useful new knowledge about the success of oral health education interventions among university students in Libya, but it also identifies many opportunities for future research. To begin, future studies can make use of longitudinal designs and follow OHRQoL and the impacts on knowledge, attitudes, and practices over time (i.e., sustainability of improvements). This study clearly documented increases in knowledge and some attitudes and practices collected at post-intervention, but it is unclear whether these were sustained without any reinforcement. Assessments six months or one-year post-intervention may provide the information needed to assess behaviour retention and when to reintroduce improvement with reinforcement sessions.

Second, future studies should use clinical indicators along with self-report measures. Self-report questionnaires are subjective, but they only offer one limited view (self-reported behaviours have several bias effects including social desirability and memory effects also related to recall). Clinical indicators could provide a triangulation and corroboration of outcomes. Clinical indicators are clinical

assessments (such as DMFT (Decayed, Missing and Filled Teeth) index, periodontal assessments, plaque scores, etc) with clinical indicators it would allow researchers to be able to relate improvements in knowledge and behaviour with improvements in oral health statuses.

Third, further studies are needed to investigate whether oral health education affects different populations differently. Socio-economic status, urban/rural location, gender, discipline of study and cultural specifications might create differences in baseline oral health behaviour at the start of the study, and they also affect reaction to educational intervention. Future studies might allow researchers to stratify participants and carry out subgroup analysis, meaning these interventions could be more specific to at-risk populations and probably reduce oral health inequalities.

Furthermore, evaluations with head-to-head comparisons of different types of toothbrushes on behaviourally activating interventions, such as apps, peer-led workshops, online, gamification, etc. will begin to inform which is the most engaging and effective for university aged students. In a digital world, it will also be beneficial to complete reviews of interventions which use technology and see if these interventions are 'better' than traditional face-to-face methods; these developments may be more critical for low-resource environments.

Finally, interdisciplinary research that combines insights from behavioural science, public health, and educational psychology could begin to disentangle the motivational and cognitive influences impacting oral health behaviours. Such interdisciplinary research could use models such as the Health Belief Model, Theory of Planned Behaviour, or Social Cognitive Theory to explain how and why some students adopt and/or resist recommended behaviours, and what messages or types of delivery are most impactful in producing behaviour changes. This integrated approach would enable researchers to examine the complex interplay between individual beliefs, social norms, self-regulatory capacity, and environmental factors, ultimately informing the design of more nuanced, adaptive interventions that address the diverse needs of student populations across different cultural and educational contexts

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APPENDICES

APPENDIX A

Basic Oral Health and Diet and Lifestyle

Day	Session	Component	Descriptive	Methods	Duration
Monday	Basic of Oral Health		Introduction to oral health It is essential to take care of the mouth, teeth, and gums with the goal that issues like gum illness and rot don't happen—in general, wellbeing requires astounding oral wellbeing. Normal brushing, flossing, and dental check-ups are significant in assisting with keeping issues from happening and are the way into a sound grin. A sound eating routine and avoiding unfortunate behaviour patterns can uphold long-term dental and general wellbeing. https://youtu.be/-39sI3H3Yf4?si=WG20zs46VwpuKH5H (Krivanek, Adameyko, and Fried 2017) https://youtu.be/Wn3Lp_Wsm7Y?si=BnS8petS9eKpF2I3	Video Photo	5 minutes
		1 Dental anatomy	There are three parts contain the teeth **1**. **Enamel**: The first structure is the hard outer covering of the tooth which acts as a barrier against caries and other forms of damage. It is the strongest part of the human body but can be worn away by acid or through neglect. This is because once the enamel is chipped or cracked it cannot heal itself; thus, an extra measure of protection is needed. 2. **Dentin**: Dentin is the thick, permeable case which is situated under the polish and is the biggest piece of the tooth. It is a supporting tissue of the tooth and is likewise answerable for the vibe of temperature or strain. At the point when dentin is uncovered, the responsiveness of the tooth increments and the gamble of rot is likewise high. 3. **Pulp**: Pulp is the largest innermost part of the tooth, which has nerves and blood vessels. It is responsible for the living tooth and responding to pain or temperature. Pain or infection of the pulp can lead to pulp necrosis which may need root canal treatment. https://www.aljazeera.net/health/2013/10/3/%D8%A7%D9%84%D8%A3%D8%B3%D9%86%D8%A7%D9%86 https://www.youtube.com/watch?v=4_jiQ0UvUGM	Photo video	10 minutes

Day	Session	Component	Descriptive	Methods	Duration
		2 Common issues	Common issues (Cavities, Gum Disease, Oral Cancer). 1. **Cavities**: A pit is an opening in the polish and is brought about by plaque gathering and corrosive disintegration. Whenever left untreated, they can advance to the dentin and mash, prompting agony and contamination. 2. **Gum Sickness**: The earliest phase of this illness is gum aggravation, which can heighten to periodontitis, making harm the encompassing tissues and bones that hold the teeth set up, and in serious cases, lead to tooth misfortune. 3. **Oral disease** is a perilous problem that influences the mouth, lips, or throat. It is usually connected with tobacco use, liquor utilization, and HPV. Early ID is basic to powerful treatment. 4. Ordinary brushing, flossing, and dental check-ups are vital for keeping up with great oral wellbeing. 5. Early mediation can significantly bring down the probability of these avoidable problems. https://www.mayoclinic.org/ar/diseases-conditions/gingivitis/symptoms-causes/syc-20354453?utm_ https://www.who.int/ar/news-room/fact-sheets/detail/oral-health https://www.noor-book.com/en/ebook-%E1%B9%A2i%E1%B8%A5%E1%B8%A5at-alfam-waalasn%C4%81n-pdf	Video Photo	
		3 Preventions	Brushing, flossing, and seeing the dentist on a regular basis are all important preventative strategies for maintaining excellent oral health. 1.**Brushing**: Brushing the teeth two times each day with toothpaste that contains fluoride to take out plaque & food particles. Cleaning every surface mindfully, use a toothbrush with a soft bristle, and follow appropriate technique. This helps to prevent cavities and gum disease and additionally keeps your breath smell fresh. 2.**Flossing**: Floss regularly for cleaning among teeth and above the gumline, in which brushing cannot reach. It eliminates trapped foods and dental plaque, which lowers the risk of cavities and gum irritation. Flossing is used in conjunction with brushing to ensure a complete cleaning. **3.Regular dental visits:** Visiting your dentist every six months for a check-up and expert cleaning. Dentists look for early indicators of problems such as cavities or gum disease and remove tartar accumulation. Regular checkups promote long-term dental health and prevent major issues. https://www.youtube.com/watch?v=7FEbFTyp9vg noor-book.com/bfixl0	Video photo	10 minutes

Day	Session	Component	Descriptive	Methods	Duration
		Q&A and Discussion	Participants will have the opportunity to ask questions and discuss their experiences		(5 minutes)
Tuesday	Diet and Lifestyle		**Introduction to attitude** Oral hygiene attitudes reveal how people feel about and value maintaining their dental health & gums. In order to prevent issues like cavities and gum disease, keep a cheerful disposition and consistently brush, floss, and see the dentist. Healthy dietary choices and abstaining from harmful habits like smoking are also part of it. Neglectful conduct, however, may lead to long-term tooth decay and insufficient dental hygiene. A proactive approach promotes better oral health, feelings of worth, and overall wellness. https://damoh.gov.kw/news/29/	Photo	(5 minutes)
		Diet and Oral Health	**1. Sugary Drinks**: Sweet beverages, for example, soft drinks, caffeinated beverages, and organic product juices, are a significant eason for tooth rot. The sugar in these drinks takes care of destructive microbes in the mouth, which produce acids that assault tooth polish. Incessant utilization can prompt holes, veneer disintegration, and even gum sickness. Restricting sweet beverages and deciding on water or unsweetened drinks can fundamentally work on oral wellbeing. **2. Water and Fluoride**: Water is fundamental for oral wellbeing as it helps flush away food particles and microscopic organisms, keeping the mouth clean. Fluoridated water gives an additional advantage by fortifying tooth veneer and making it more impervious to rot. Fluoride likewise helps fix beginning phases of tooth harm and forestalls pits. Drinking fluoridated water consistently is a basic, compelling method for keeping up serious areas of strength for with, teeth. **3. Candies**: Candy, particularly sticky or chewy forms, is extremely harmful to teeth because it adheres to surfaces and crevices, prolonging sugar exposure. This sugar drives acid-producing bacteria, which causes enamel erosion and cavities. Hard candies can potentially cause chips or cracks in your teeth. Reducing candy intake and exercising proper dental care after eating sweets might help keep your teeth from decaying. https://www.bitesizepediatricdentistry.com/sugary-drinks-our-teeth/ https://nutritionfacts.org/video/why-i-changed-my-mind-on-water-fluoridation/ https://youtu.be/oIPZlXdduUA?si=BRqsO6rxHfNBadMA https://www.uoanbar.edu.iq/eStoreImages/Bank/3594.pdf	Power point Photo video	(10 minutes)

Day	Session	Component	Descriptive	Methods	Duration
		Lifestyle Factors	**1.Smoking**: Smoking is amazingly frightful to oral prosperity, growing the bet of gum affliction, tooth decay, and tooth setback. It diminishes the circulation system to the gums, crippling their ability to fight defilement and recover. Smoking likewise stains teeth, causes awful breath, and fundamentally raises the risk of oral disease. Stopping smoking is one of the most mind-blowing moves toward work on oral and by and large wellbeing. **2.Alcohol**: Unreasonable liquor utilization can adversely affect oral wellbeing by drying out the mouth, lessening spit creation, and expanding the gamble of tooth rot and gum sickness. Liquor, particularly when joined with sweet blenders, can dissolve veneer and stain teeth. It is likewise a significant gamble factor for oral malignant growth. Directing liquor consumption and keeping up with great oral cleanliness can assist with limiting these dangers.. https://www.youtube.com/watch?v=ZYUNtpNPfT8 https://www.cdc.gov/tobacco/campaign/tips/diseases/periodontal-gum-disease.html	Video Photo	(10 minutes)
		Q&A and Discussion	Participants will have the opportunity to ask questions and discuss their dietary habits		(5 minutes)
Thursday	Practice of oral hygiene (Part 1)		Importance of Good Hygiene Practices Great cleanliness rehearses are crucial for keeping up with oral wellbeing and forestalling issues like holes, gum illness, and terrible breath. Brushing two times every day with fluoride toothpaste and flossing day to day eliminate plaque and food particles, keeping teeth and gums sound. Normal dental checkups help distinguish and treat issues early, forestalling entanglements. Great oral cleanliness additionally upholds general wellbeing, lessening gambles connected to coronary illness and diabetes. Predictable consideration guarantees a sure grin, new breath, and long-haul dental prosperity. https://www.nhc.com/blog/why-adolecent-dental-health-important/ https://123dentalemergency.com/oral-hygiene-home-care/ https://youtu.be/s0ZNUaqluho?si=SilfWS8Zhi2ntNe4		(5 minutes)
		Brushing Techniques	**1. Brushing Recurrence:** Cleaning your teeth two times per day — once toward the beginning of the day and once before bed is fundamental for eliminating plaque, microbes, and food particles. This standard forestalls holes, gum sickness, and terrible breath, guaranteeing long haul oral wellbeing. **2. Tools Utilized for Cleaning Teeth:**	Power point Video	(10 minutes)

Day	Session	Component	Descriptive	Methods	Duration
			The fundamental gadget for cleaning teeth is a sensitive shivered toothbrush, which effectively cleans without hurting finish or gums. Additional gadgets consolidate fluoride toothpaste, dental floss for cleaning among teeth, and mouthwash to diminish microorganisms and reestablish breath. Swaying brushes can similarly give a more serious clean to specific individuals. **3. Brushing Length:** Brushing should keep going for something like two minutes every meeting to guarantee all surfaces of the teeth are cleaned appropriately. Burning through 30 seconds on every quadrant of the mouth (upper right, upper left, lower right, lower left) accomplishes an exhaustive clean. **4. Sharing Toothbrush:** Sharing a toothbrush is emphatically deterred as it can move microscopic organisms, infections, and different microbes between people, expanding the gamble of diseases. Every individual ought to utilize their own toothbrush to keep up with legitimate cleanliness. **5. Changing Toothbrush:** Toothbrushes ought to be supplanted each three to four months, or sooner assuming the fibres become frayed or worn. An exhausted toothbrush is less compelling at cleaning teeth and can hold onto hurtful microorganisms. **6. Cleaning Tongue Subsequent to Brushing:** Cleaning the tongue subsequent to brushing is essential to eliminate microscopic organisms and food trash that can cause awful breath and influence oral wellbeing. A tongue scrubber or the fibres of a toothbrush can be utilized to delicately clean the tongue's surface. **7. Toothbrush Substitution:** Supplanting your toothbrush regularly promises it stays convincing at cleaning your teeth. After some time, bristles separate and lose their ability to dispense with plaque beneficially. Overriding your toothbrush each three to four months, or after a sickness, stays aware of ideal oral tidiness. https://www.youtube.com/watch?v=imXA30-Dvvc https://www.slideshare.net/ibrahim8shaikh/toothbrush-a (Kamreddy 2019) (Aparna, Puranik, and Sowmya 2018) https://www.wikihow.com/Clean Your-Teeth-With-Supports On https://www.youtube.com/watch?v=imXA30-Dvvc https://www.slideshare.net/ibrahim8shaikh/toothbrush-a (Kamreddy 2019)		

Day	Session	Component	Descriptive	Methods	Duration
			(Aparna, Puranik, and Sowmya 2018) https://www.wikihow.com/Brush-Your-Teeth-With-Braces-On		
		Flossing Techniques	**1. Frequency of Flossing**: Flossing should be done at least once a day, preferably before brushing your teeth at night. Daily flossing removes plaque and food particles from between teeth and along the gumline, areas where a toothbrush cannot reach, preventing cavities and gum disease. **2.Types of Flossing**: There are several types of flossing tools available, including traditional string floss, floss picks, water flossers, and interdental brushes. Each type caters to different preferences and needs, making it easier to clean between teeth effectively. **3.Flossing Technique**: proper flossing includes delicately sliding the floss between teeth, bending it around every tooth in a C-shape, and dropping it all over to eliminate plaque. Try not to snap the floss, as it can harm gums. Be careful, however delicate, to guarantee compelling cleaning without causing aggravation. **4.Using Mouthwash**: Mouthwash is a helpful addition to oral hygiene routines, as it reduces bacteria, freshens breath, and can provide fluoride to strengthen teeth. Use mouthwash after brushing and flossing, swishing it around your mouth for 30 seconds to one minute before spitting it out. **5.Timing of Mouthwash**: Mouthwash ought to be utilized at an unexpected time in comparison to brushing to boost its advantages. For instance, use it after lunch or noontime to kill microorganisms and renew breath. Abstain from eating or drinking for 30 minutes subsequent to utilising mouthwash to permit it to successfully work. (Wynder et al. 1983) https://shawnessydental.com/how-often-should-you-floss/ https://shawnessydental.com/how-often-should-you-floss/ https://youtu.be/3Upt4sx6jV4?si=xSv6F0i8BQToVSBK https://youtu.be/m3pBA4cgdxw?si=7LUfkinMVGr3KYmY	Video photo	(10 minutes)
		Q&A and Practice	Participants will have the opportunity to ask questions		(5 minutes)

APPENDIX B

Questionnaires For KAP And OHRQOL

The Effectiveness of Oral Health Education Programs on Knowledge, Attitude, Practices, and Oral Health Related Quality of Life (OHRQOL) among University Students in Libya

Section 1: General Information

In this section please select the option that best explains your answer and status.

1. *What is your age?*

18 years	
19 years	
20 years	
21 years	

2. *Please select your gender:*

Male	
Female	

3. *Do you have dental caries?* ○ Yes ○ No

4. *The treatment(s) sought during last visit to the dentist*

Check up	
Scaling	
Filling	
Extraction	
Others	
No history of dental visit	

5. *Smoking and Chewing*

Current Smoker? ○ Yes ○ No

6. *What is your main source of drinking water?*

Tap water	
Bottled water	
Well water	
Spring water	
Other, Please specify: _____	

7. *What is your main source of gaining information about oral hygiene?*

Parents	
School Teachers	
Friends/Relatives	
Dentist	
Media	

Section 2: Knowledge of Oral Hygiene

Please rate for each statement by Yes or No.

	Knowledge of Oral Hygiene	**Yes**	**No**
1.	Meaning of gum bleeding is inflamed gum.		
2.	Using toothbrush protects from gum bleeding.		
3.	Plaque means soft debris on the teeth.		
4.	Dental plaque causes staining of teeth.		
5.	Carious teeth affect teeth appearance.		
6.	Sweets affect the teeth adversely.		
7.	Fizzy drinks affect the teeth adversely.		
8.	Using fluoride-based toothpaste strengthens the teeth.		

Section 3: Attitude of Oral Hygiene

Please rate for each statement by Yes or No.

	Attitude of Oral Hygiene	Yes	no
	Regular visits to the dentist are necessary	y	
	There is relationship between oral health and general health.	y	
	Regular brushing of teeth prevents dental decay.	y	
	Sweets affect the teeth adversely.		
	Soft drinks affect the teeth adversely.		
	Using fluoride strengthens the teeth.		
	Dentist always explain teeth problems and propose solution No		
	Teeth are weakened because of repeated cleaning		

Section 4: Practice of Oral Hygiene

Please rate how strongly you agree with each of the statement or question.

	Practice of Oral Hygiene	1	2
	I brush my teeth twice per day.		
	I use toothbrush and toothpaste to clean my teeth.		
	I use floss to clean my teeth.		
	I use toothpick to clean my teeth.		
	I use mouthwash to clean my teeth		
	I clean my teeth after every meal.		
	I brush my teeth for more than 2 minutes.		
	I clean my tongue after brushing teeth.		
	I visit a dentist annually.		
	My toothpaste contains fluoride.		
	I share my toothbrush with others.		
	I change my toothbrush every 3-4 months		

Section 5: Oral Health Education

	Oral Health Education	1	2	3	4	5
1.	Oral Health Education may be included into the school curriculum as a separate topic.					
2.	Only dentistry course may include oral health concepts.					
3.	The addition of oral health topics may cause students' attention to wander away from the subject at hand.					
4.	Dentistry department visits should be a regular component of the university's activities.					
5.	The universities should make provisions for free seminars on oral health.					
6.	The internet has a greater impact on changing students' views about oral health education.					
7.	From the books they read, students learn how to maintain good oral health.					
8.	When Oral Health Education is taught as a separate topic in university, students will have a better understanding of the importance of oral health.					

Section 5: Oral Health Related Quality of Life

		Oral Health Related Quality of Life	0	1	2	3	4
1.	Functional limitation	Have you had trouble pronouncing any words because of problems with your teeth, mouth and denture?					
2.		Have you felt sense of taste has worsened because of problems with your teeth, mouth and denture?					
3.	Physical pain	Have you had painful aching in your mouth?					
4.		Have you found it uncomfortable to eat any food because of problems with your teeth, mouth and denture?					
5.	Psychological discomfort	Have you been self-conscious because of problems with your teeth, mouth and denture?					
6.		Have you felt tense because of problems with your teeth, mouth and denture?					
7.	Physical disability	Has your diet been unsatisfactory because of problems with your teeth, mouth and denture?					
8.		Have you had to interrupt meals because of problems with your teeth, mouth and denture?					
9	Psychological disability	Have you found it difficult to relax because of problems with your teeth, mouth and denture?					
10		Have you been a bit embarrassed because of problems with your teeth, mouth and denture?					
11	Social disability	Have you been a bit irritable with other people because of problems with your teeth, mouth and denture?					
12		Have you had difficulty doing your usual jobs because of problems with your teeth, mouth and denture?					
13	Handicap	Have you felt that life in general is less satisfying because of problems with your teeth, mouth and denture?					
14		Have you been totally unable to function because of problems with your teeth, mouth and denture?					

Section 6 Sugar Intake and Fizzy Drinks

Item	Several times a day	Every day	Several times a week	Once a week	Several times a month	Seldom/Never
Biscuits, cakes, cream cakes, sweet pies, buns, etc						
Sweet pies, buns						
Jam/honey						
Chewing gum containing sugar						
Sweets/candy						
Lemonade, Coca Cola, seven up or other soft drinks						
Tea with sugar						
Coffee with sugar						
Milk with sugar						

APPENDIX C

Ethical Approval

السيد/ وكيل الشؤون العلمية بجامعة مصراته

بعد التحية،،،، مقدم الطلب إليكم / ميلاد محمد على التائب أحد الطلبة الدارسين في الساحة الماليزية أتقدم إليكم بطلبي هذا آملا فيه منكم الموافقة على إجراء الجزء العملي الخاص بدراستي الدكتوراة تحت عنوان

The Impact of Oral Health Education on Dental caries, Oral Hygiene Knowledge, Awareness and Practices among University Students in Libya

والذي سوف يكون عبارة عن إستبيان سيتم توزيعه على الفئة المستهدفة من طلبة الجامعات ثم بعد ذلك سوف يقوم دكتور متخصص في مجال الأسنان بعمل كشف على صحة الفم والأسنان

عليه آمل منكم الموافقة

تقبلو مني فائق التقدير والاحترام

وارد: وكيل الشؤون العلمية
تاريخ: 2022/12/22
(رقم) (224350)

وارد: وكيل الشؤون العلمية
تاريخ: 2022/12/21
(رقم) (222736)

مقدم الطلب/ ميلاد التائب

التوقيع/

التاريخ 2022/12/3

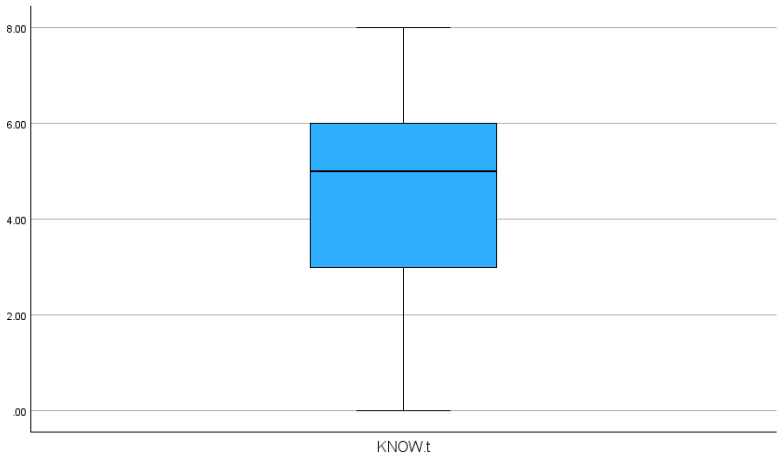
APPENDIX D

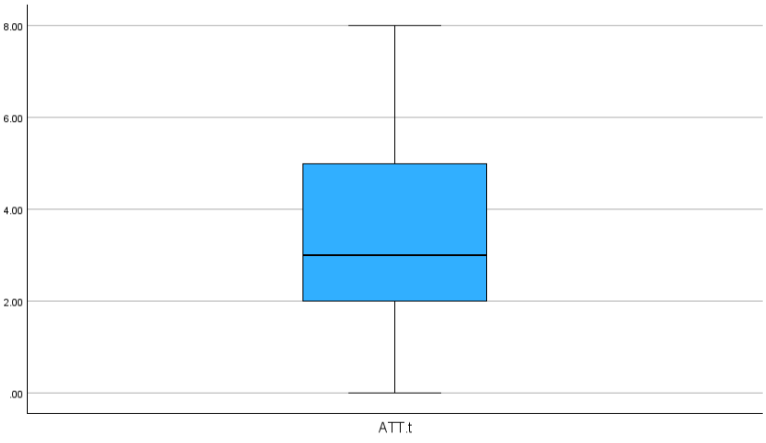
Additional Supporting Data

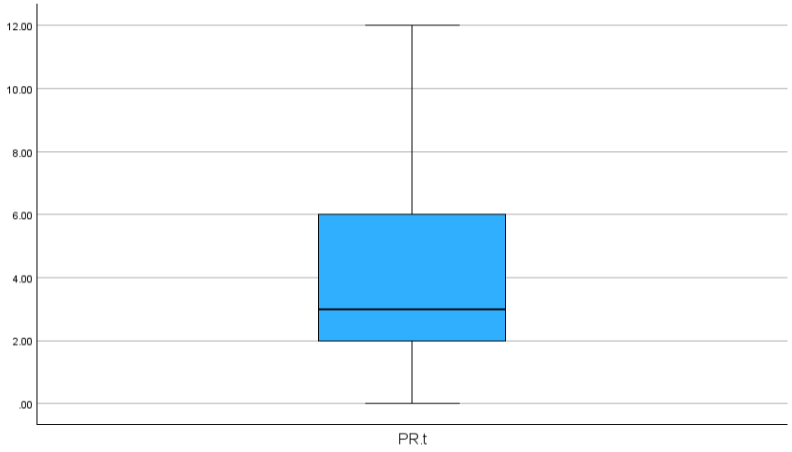
Normality test (Phase 1)

	Skewness	Std. Error	SK/SE	Kurtosis	Std. Error	KR/SE
KNOW.t	-0.064	0.122	-0.525	-0.961	0.243	-3.955
ATT.t	0.076	0.122	0.623	-0.869	0.243	-3.576
PR.t	0.642	0.122	5.262	-0.726	0.243	-2.988
OHQL.t	1.306	0.122	10.705	0.978	0.243	4.025

Box Plots



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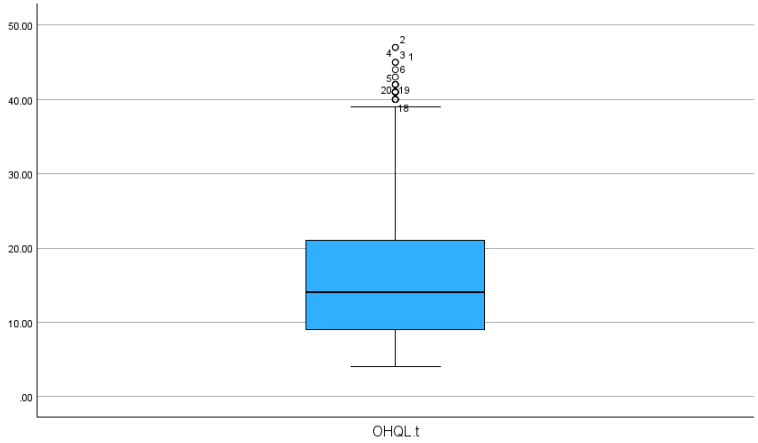
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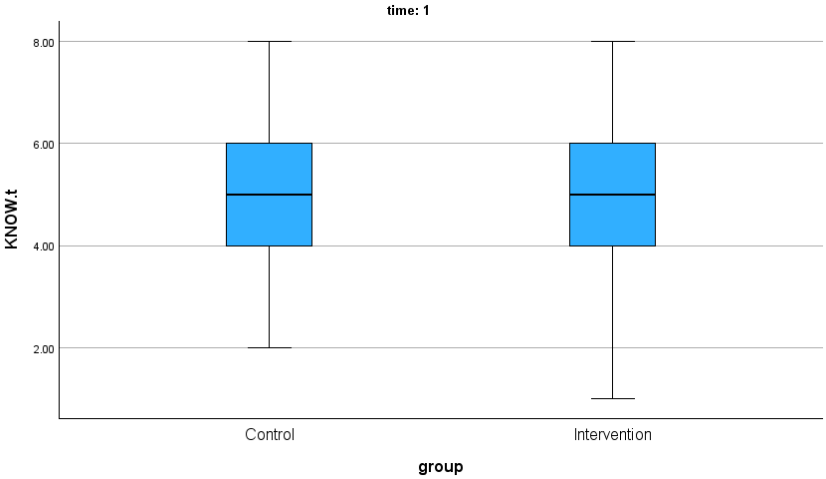
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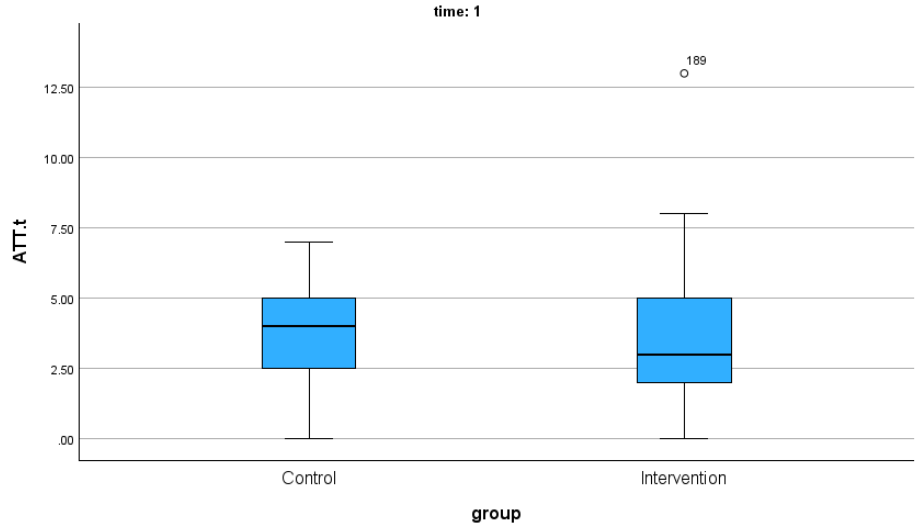
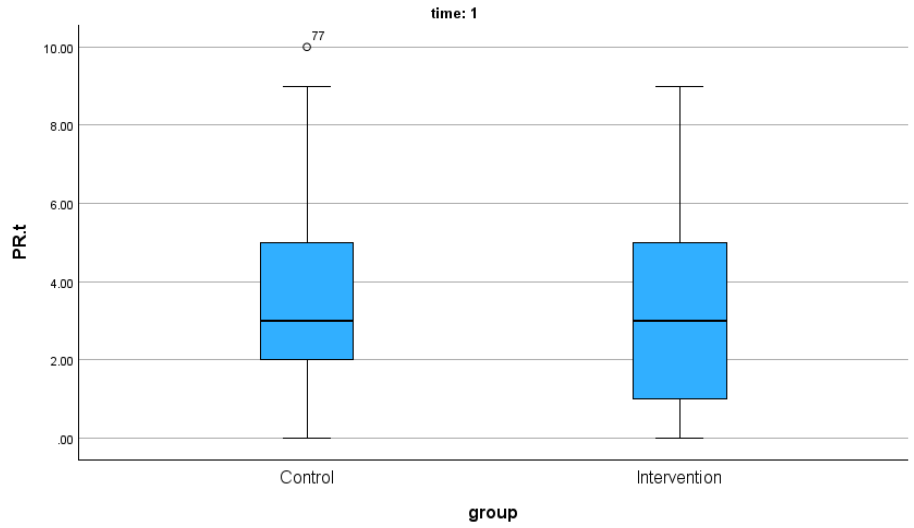
6.00
4.00
2.00
Control
Intervention
group


time: 1
189
12.50
10.00
7.50
5.00
2.50
.00
ATT.t
Control
Intervention
group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77
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8.00
6.00
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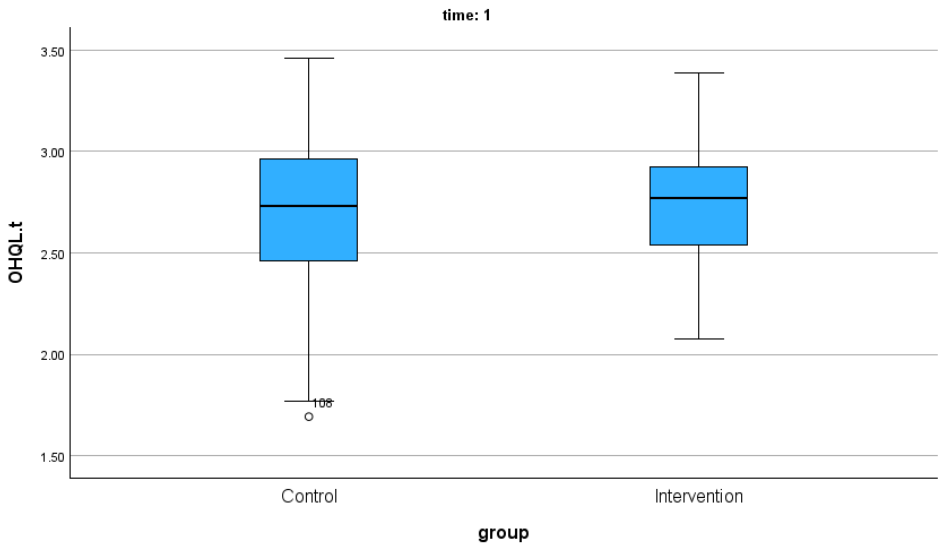
PR.t
Control
Intervention
group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3.50
3.00
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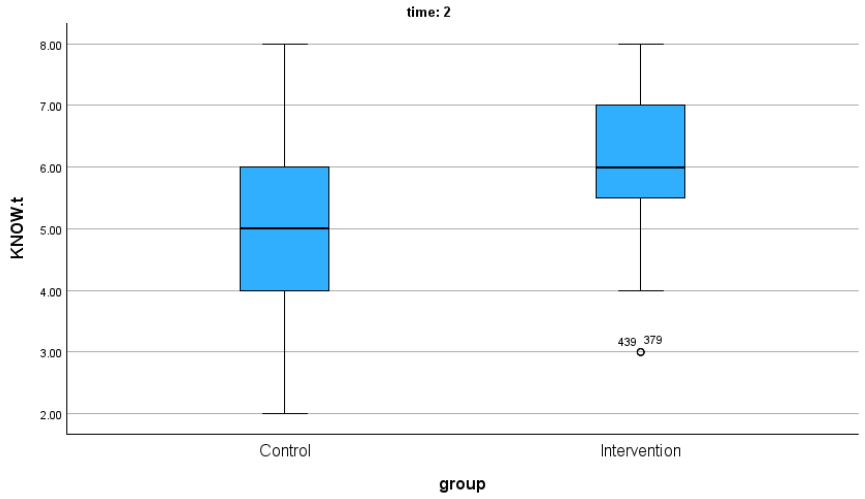
2.00
1.50
OHQL.t
Control
Intervention
group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KNOW.t
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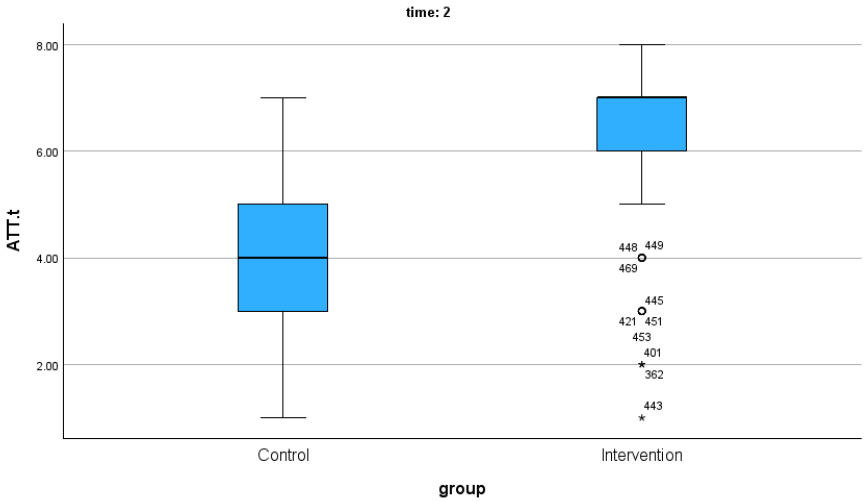
6.00
5.00
4.00
3.00
2.00
439
379
Control
Intervention
group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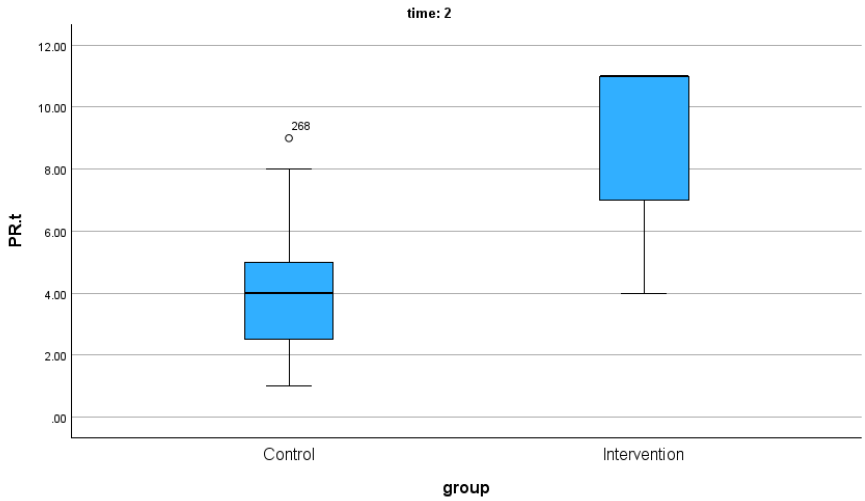
ATT.t
8.00
6.00
4.00
2.00
448
449
469
445
421
451
453
401
362
443
Control
Intervention
group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PR.t
12.00
10.00
8.00
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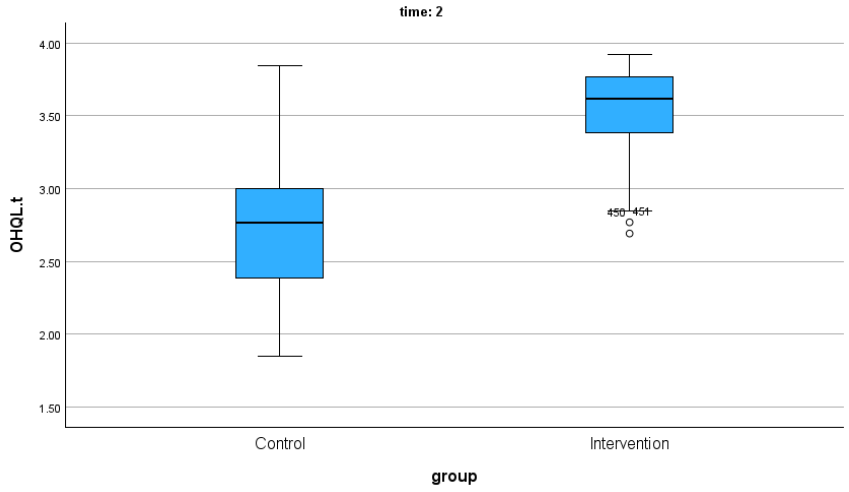
4.00
2.00
.00
268
Control
Intervention
group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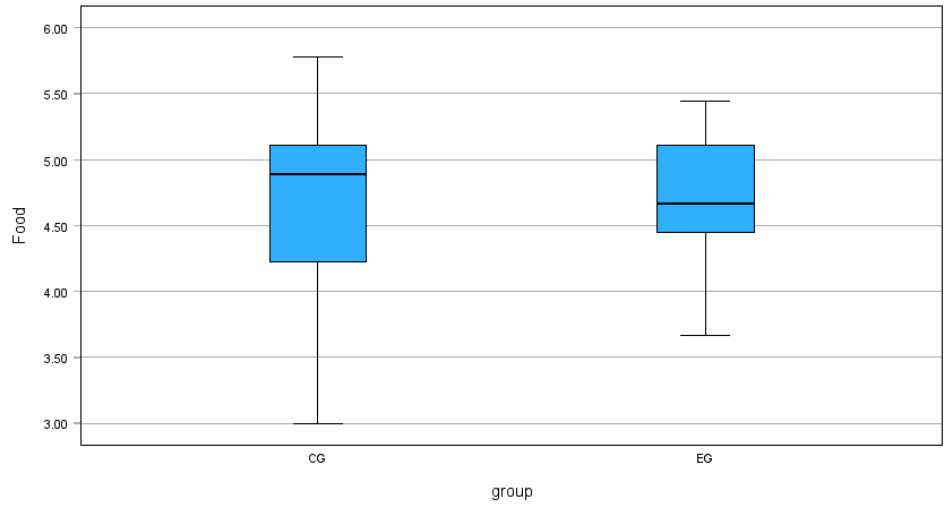
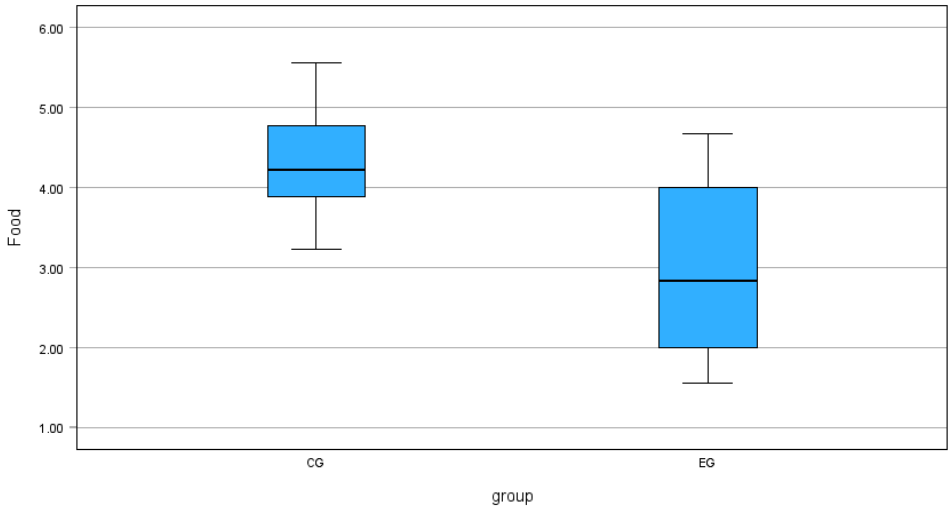
4.00
3.50
3.00
2.50
2.00
1.50
OHQL.t
450 451
Control
Intervention
group

time: 1


6.00
5.50
5.00
4.50
4.00
3.50
3.00
Food
CG
EG
group

time: 2


6.00
5.00
4.00
3.00
2.00
1.00
Food
CG
EG
group

Variable	Mean	SD	Mean	SD	F	Reference
Knowledge	2.88	2.33	7.38	0.488	1.337	(H Mohamed *et al.*, 2021)
Knowledge	8.78	2.61	13.6	2.3	0.980	(Tao *et al*., 2024)
Knowledge	4.79	2.09	8.91	1.7	1.081	Alotaibi, A S
Knowledge	13.03	0.23	20.16	0.22	15.841	(Ghofranipour & Tavousi, 2018)
Knowledge					0.315	Danti Narulita, Danu Aprilianto
Attitude					0.205	Danti Narulita, Danu Aprilianto
Attitude	21.48	0.51	34.44	0.43	13.738	(Ghofranipour and Tavousi, 2018)
Attitude	4.74	0.32	4.96	0.11	0.460	(Selvarajan *et al.,* 2019)
Attitude	4.82	1.3	9.33	1.1	1.873	(H Mohamed *et al.,* 2021)
Practice	2.82	1.9	6.63	1.7	1.057	(H Mohamed *et al.,* 2021)
Practice					0.120	Danti Narulita, Danu Aprilianto

Tests of Normality[a]

	Group	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
KNOW.t	Control	.150	120	<.001	.946	120	<.001
	Intervention	.125	120	<.001	.955	120	<.001
ATT.t	Control	.126	120	<.001	.958	120	<.001
	Intervention	.148	120	<.001	.924	120	<.001
PR.t	Control	.133	120	<.001	.950	120	<.001
	Intervention	.121	120	<.001	.950	120	<.001
OHQL.t	Control	.125	120	<.001	.969	120	.007
	Intervention	.087	120	.026	.983	120	.122
Food	Control	.159	120	<.001	.937	120	<.001
	Intervention	.133	120	<.001	.962	120	.002

a. time = 1

b. Lilliefors Significance Correction

Tests of Normality[a]

	Group	Kolmogorov-Smirnov[b]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
KNOW.t	Control	.146	120	<.001	.948	120	<.001
	Intervention	.207	120	<.001	.906	120	<.001
ATT.t	Control	.176	120	<.001	.945	120	<.001
	Intervention	.248	120	<.001	.850	120	<.001
PR.t	Control	.138	120	<.001	.950	120	<.001
	Intervention	.339	120	<.001	.742	120	<.001
OHQL.t	Control	.077	120	.080	.977	120	.035
	Intervention	.126	120	<.001	.946	120	<.001
Food	Control	.201	120	<.001	.923	120	<.001
	Intervention	.159	120	<.001	.904	120	<.001

a. time = 2 b. Lilliefors Significance Correction

Table 3.1

Table for Determining Sample Size of a Known Population

N	S	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	346
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	278	4500	354
35	32	150	108	360	186	1100	285	5000	357
40	36	160	113	380	191	1200	291	6000	361
45	40	170	118	400	196	1300	297	7000	364
50	44	180	123	420	201	1400	302	8000	367
55	48	190	127	440	205	1500	306	9000	368
60	52	200	132	460	210	1600	310	10000	370
65	56	210	136	480	214	1700	313	15000	375
70	59	220	140	500	217	1800	317	20000	377
75	63	230	144	550	226	1900	320	30000	379
80	66	240	148	600	234	2000	322	40000	380
85	70	250	152	650	242	2200	327	50000	381
90	73	260	155	700	248	2400	331	75000	382
95	76	270	159	750	254	2600	335	1000000	384

Note: N is Population Size; S is Sample Size *Source: Krejcie & Morgan, 1970*

APPENDIX E

Publication

CBS

Chronicles of Biomedical Sciences

journal homepage: https://cbsciences.us/index.php/cbs

The prevalence of dental caries among schoolchildren in Libya

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Schoolchildren

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ABSTRACT

Background: The present study has been performed to determine the dental caries prevalence: Decayed, Missing, and Filled Teeth and DMFT indexes among 13 - 15 year-old schoolchildren of Maserati in Libya. *Objective:* This study tried to assess the prevalence of dental caries and to examine there are statistically significant differences in prevalence of dental caries according to gender and age among 13 - 15-year-old schoolchildren. *Methods:* A sample of 400 individuals of both sexes (181 were females and 219 were males) their ages ranged from 12- to 15-year-old. In the current study 10 schools (5 boys and 5 Girls schools were randomly selected from different areas within the state of Maserati in Libya. *Results:* The results showed that there was statistically significant difference between male and female in Prevalence of Dental Caries. Which indicated female schoolchildren had a higher mean DMFT value 4.303 (± 3.12) than male children 2.93 (±2.94). Furthermore, the results indicated that there was statistically significant difference in (FT) and (DMFT) among age (13-15) years old. Therefore, 15-year-old children showed a significantly higher incidence of dental caries prevalence than 13- and 14-year-old ($P < 0.05$). Howoever, the results indicated that there were no signficant differences in Decayed and Missing teeth among schoolcheldern age ($P > 0.05$). *Conclusion:* High prevalent dental caries was found among schoolchildren in Libya from age 13 to 15 years especially in females. The reasons for this would mainly be lack of dental awareness, motivation, ignorance, poor oral hygiene, improper tooth brushing techniques, and inadequate exposure to fluorides. Other contributing factors could be improper dietary habits, longer outdoors stay of children at this age leading to greater consumption of in between meals snacks, cariogenic diet, and nutritional deficiencies.

https://africanjournalofbiomedicalresearch.com/index.php/AJBR
Afr. J. Biomed. Res. Vol. 27(4s) (December 2024); 6445 - 6455
Research Article

The Effectiveness of Oral Health Education Programs on Knowledge, Attitude, Practices among University Students in Libya

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Abstract
The purpose of this study is to determine the level of knowledge, attitudes, , practices (KAP) of university students in Misurata, Libya, as well as the prevalence of dental caries and their perception toward oral health education . The study also evaluates the effectiveness of oral health educational program on student's KAP. The research instrument for measuring all research variables was adapted and piloted before using in the main study. In phase 1, a cross-sectional study was conducted to assess the level of knowledge, attitudes, and practices among students and the questionnaire was distributed via random sampling to 402 students from different faculties. In phase 2, based on findings of phase 1 and literature, an oral health educational program was developed and validated. Phase 3 consisted of conducting a quasiexperimental design including two arms (control and intervention). Data was analyzed using descriptive study (phase 1) and generalized estimation equation (phase 2) using SPSS Ver 29.
Results showed that the prevalence of dental caries among university students in Misurata was 25%. Further findings showed low oral health knowledge and attitude, but gaps in knowledge about fluoride and sweets. At the most frequent routine check-up, 40.8% of subjects had dental caries and sought treatment rarely. In the intervention phase, participants' knowledge, attitude, and practices improved significantly post-intervention, with large effect sizes ($p<0.05$). Our findings show that targeted education can improve oral health habits and quality of life ($p<0.05$). The study emphasizes the importance of focused oral health education programs in improving students' knowledge, practices, and dietary habits, which can lead to better oral health outcomes and overall quality of life. Policymakers should take note of the study's implications for the effectiveness of oral health education and explore policies that encourage the introduction of regular educational programs at universities.

Keywords: dental caries, oral health education, university students, Misurata, Libya, oral hygiene practices

The Impact of Oral Health Education on Oral Hygiene Knowledge, Awareness and Practices: A Short Comprehensive Review

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Abstract

Although advances in oral illness preventive measures, tooth decay has recently approached epidemic levels and remains a major public health problem across the world. Because of their great frequency and profound societal effect, oral illnesses might be considered a public health concern. This paper discusses the role of oral health education in improving oral hygiene knowledge, awareness and practice, which is critical for the optimum oral health of young adults. Students' knowledge, awareness and practice of oral hygiene are the initial motivating factors for better oral health.

In this regard, specific research is very essential. A contribution to the establishment of an educational program with a qualified goal that increases awareness among young adults may be made. With the implementation of successful oral health education programmes among university students, their knowledge can be improved in order to motivate them to adopt a positive attitude and practice toward oral hygiene.

Review (J Int Dent Med Res 2024; 17(2): 832-838)

Keywords: Oral health education on oral hygiene, Oral hygiene education materials, Health education on oral cavity cancer, Oral health education materials.

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Introduction

Dental caries, often known as dental decay, is a common oral health condition caused by the interaction of bacteria with fermentable carbohydrates, resulting in the breakdown of tooth structures.[1] The World Health Organization (WHO) Dental caries is considered a pandemic, with incidence rates varying from 60% to 90% among school students.[2]

Global Prevalence and Disparities

Dental caries burden varies across countries.[3] Studies in Africa report prevalence rates of 24.1% in Nigeria, 40.9% in Ethiopia and 30.5% in Sudan.[4,5] These studies also documented varying DMFT (Decayed, Missing, Filled Teeth) scores, highlighting the heterogeneity of the disease burden. Additionally, In Ethiopia, two community-level studies discovered caries prevalence rates of 36.3% and 47.8%, respectively.[6]

Age-Specific Patterns and Impacts

Untreated caries is most prevalent during specific age windows: 1-4 years for deciduous teeth and 15-19 years for permanent teeth.[6] Dental caries not only affects oral health but also reduces quality of life and generates high economic costs for individuals and healthcare systems.[1] Knack KC,