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The impact of oral health on diet among the ageing population in Saudi Arabia

A thesis submitted in fulfilment of the requirement for the Degree of Doctor of Philosophy

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ABSTRACT

Background: In older adults, there are many factors that determine dietary intake, including an individual's socio-economic status, physical well-being, and general state of health. Another crucial factor is dental status. The aim of this study is to explore how dental status impacts the perceived ability to eat particular foods and the nutrient intake of older adults in Saudi Arabia.

Methods: The study conducted an analysis of the sample gathered from the Saudi Demographic and Health Survey. The data were collected from an online food frequency questionnaire. Data related to health behaviour, general and oral health information, and socio-economic data were collected using an online questionnaire. The oral health status was assessed clinically. Participants in the 60 years and above age category (n = 326) attended clinical examinations, and (n =275) of them completed all elements of the study. To analyse the cross-sectional link between nutrient intake, food selection, and dental status, multiple regression methods were performed.

Results: The participants' mean age was 70.29 years (range 60-104) with an SD of 8.71. 62.6% had 20 or more teeth, 25.2% had less than 20 teeth, and 9.5% were edentulous. Participants with no dentures constituted the largest group (78.8.6%). which means the most participants had natural teeth or were edentulous without dentures. 70.8% only visited the dentist when there is a problem. The mean DMFT for older adults was 15.5 with an SD of 9.4.

The edentulous participants were more likely to report having difficulty eating all 15 examined foods listed compared to the dentate participants. There were significant differences in having difficulty eating food, with 95% CI between all 15 foods and all number of teeth groups except for cheese; there was no significant difference between people with 1-19 teeth and 20 or more teeth.

Also, the findings demonstrate that edentate, denture-wearing seniors consumed lower levels of important nutrients, which are protein, carbohydrates, fibre, and fat, also calories, compared to dentate people. However, edentulous people not wearing any dentures consumed more nutrients than denture-wearing older adults.

The subjects with natural teeth and no dentures generally had an energy intake greater than that recommended by the US government: 2513.6 Kcal compared to 2000 Kcal. This was mirrored in terms of major dietary constituents, with a protein intake of 111.9g compared to 57g and a carbohydrate intake of 341.5g compared to 130g. This population was relatively unusual in achieving the recommended intake of dietary fibre of 29.2g compared to 28g.

In contrast, the other participants with compromised oral function (teeth and partial dentures, teeth and complete dentures in one jaw, edentulous with complete dentures, and edentulous and with no denture) had lower than the recommended energy intake at 1244.3–1628.2 Kcal and lower dietary fibre intake (15.5–21.3 g). Their protein intake was close to the dietary recommendation, with participants with full dentures consuming on average 51.9g, and the edentulous without dentures and people wearing partial dentures consuming 69.6g and 67.5g, respectively. In addition, for carbohydrates all participants were above the recommended goal.

There were no observed differences between groups in relation to the perceived ability to eat and consume nutrition after socio-demographic and health behavioural had been adjusted, except for age groups.

Conclusion: In this older adult sample, it can be concluded that weakened dental status has a possible influence on the foods that the individuals choose to eat, and consequently, their consumption of crucial nutrients. Therefore, future studies could concentrate on the development of dental interventions together with dietary counselling. This is likely to encourage individuals in this high-risk population to embrace healthy eating habits.

LAY SUMMARY

In older adults, there are many factors that determine dietary intake. Examples of such factors include an individual's socio-economic status, physical well-being, and general state of health. Another crucial factor is dental status. The aim of this study was to explore how dental status impacts the perceived ability to eat particular foods, as well as the nutrient intake of older adults in Saudi Arabia.

The study conducted an analysis of the sample gathered from the Saudi Demographic and Health Survey. The data were collected from an online food frequency questionnaire. Data related to health behaviour, general and oral health information, and socio-economic data were collected using an online questionnaire. The oral health status was assessed clinically. Participants in the 60 years and above age category (n = 326) attended clinical examinations, and most (n =275) of them completed all elements of the study. To analyse the links between nutrient intake, food selection, and dental status, multiple regression methods were performed.

Compared to the dentate participants, the edentulous participants were more likely to report having difficulty eating foods for all 15 foods listed. Also, the findings demonstrate that edentate, denture-wearing seniors in Saudi Arabia consumed lower levels of important nutrients, i.e. protein, carbohydrates, fibre, fat, and calories, compared to dentate people. However, the edentulous people not wearing any dentures consumed more nutrients than denture-wearing older adults.

The subjects with natural teeth and no dentures generally had an energy intake greater than that recommended by the US government, at 2513.6 Kcal compared to 2000 Kcal. This was mirrored in terms of major dietary constituents with a protein intake of 111.9g compared to 57g and a carbohydrate intake of 341.5g compared to 130g. This population was relatively unusual in achieving the recommended intake of dietary fibre of 29.2g compared to 28g.

In contrast, the other participants with compromised oral function (teeth and partial dentures, teeth and complete dentures in one jaw and edentulous with complete

dentures, and edentulous and with no denture) had a lower than recommended energy intake of 1244.3–1628.2 Kcal as well as a low dietary fibre intake (15.5–21.3 g). Their protein intake was close to the dietary recommendation, with participants with full dentures consuming on average 51.9g, and the edentulous without dentures and people wearing partial dentures consuming 69.6g and 67.5g respectively. In addition, for carbohydrates all participants were above the recommended goal.

There were no observed differences among groups in relation to the perceived ability to eat and consume nutrition after socio-demographic and health behavioural factors had been adjusted, except for age groups.

In this older adult sample, it can be concluded that weakened dental status has a possible influence on the foods that individuals choose to eat, and consequently, the consumption of crucial nutrients, namely protein, carbohydrates, fibre, fat, and calories. Therefore, future studies could concentrate on the development of dental interventions together with dietary counselling. This is likely to encourage individuals in this high-risk population group to embrace healthy eating habits.

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DECLARATION

I, ALHUSSAIN DAGHRIRI, hereby declare that I am the author of this thesis and that all sources of information have been specifically acknowledged by means of referencing. I was the principal investigator in this study described in this thesis. This work has not been accepted or submitted in any previous application for a degree in this or any other university.

ALHUSSAIN DAGHRIRI

DEDICATION

To my Parents, my Wife, my Children, my Brothers and Sisters, and my Friends

And to anyone who knows **ALHUSSAIN DAGHRIRI**

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ABBREVIATIONS

ADHS	Adult Dental Health Survey
BPE	Basic Periodontal Examination
BEWE	Basic Erosive Wear Examination
CI	Confidence interval
CVD	Cardiovascular Disease
DDS	Dietary Diversity Score
DMFT	Decayed Missing Filled Teeth
EuroQoL	Europe Quality of Life
EQ-VAS	Europe Quality – Visual Analogue Scale
FAOSTAT	Food and Agriculture Organisation Statistics
F	Female
FFQ	Food Frequency Questionnaires
FAO	Food and Agriculture Organisation
G	Gram
GOHAI	Geriatric Oral Health Assessment Index
HRQoL	Health-Related Quality of Life
KSA	Kingdom of Saudi Arabia
KFH& RC	King Faisal Specialist Hospital and Research Centre
MSRS	Multistage Stratified Random
MOH	Ministry of Health
MET	Metabolic Equivalents
MVPA	Moderate to Vigorous Physical Activity
M	Male
NDNS	National Diet and Nutrition Survey
OR	Odds Ratio

OHQoL	Oral Health-Related Quality of Life
OIDP	Oral Impacts on Daily Performances
OHIP-49	Oral Health Impact Profile with 49 items
OHQoL-UK	Oral Health-Related Quality of Life United Kingdom
OHIP	Oral Health Impact Profile
OHIP-14	Oral Health Impact Profile with 14 items
PA	Physical Activity
PDA	Personal Digital Assistant
PEM	Protein-Energy Malnutrition
PH	Potential Hydrogen
PASE	Physical Activity Scale for the Elderly
QoL	Quality of Life
SES	Socio-economic Status
SD	Standard Deviation
SR	Saudi Riyal
SA	Saudi Arabia
SOA	Saudi Older Adult
SNSEH	Saudi National Survey for Elderly Health
T	Total
UK	United Kingdom
UN	United Nations
US	United States
WHO	World Health Organisation

CHAPTER ONE INTRODUCTION

Recently, the Saudi government introduced the policy of Vision 2020 together with the complimentary National Transformation Program for 2020. It is expected that by 2030, life expectancy in Saudi Arabia will increase to 80 years from its current 74 years, a situation that will add to the population growth and ageing (Saudi Vision 2030, 2017). Therefore, it can be expected that population growth and ageing are some of the challenges that Saudi Arabia will face in the future.

As a percentage of the general population, the older adult group in Saudi Arabia is increasing (The General Authority for Statistics, 2016). This increase creates a number of problems for the social and healthcare systems. For example, some of the results of an ageing population include an escalation in the incidence and prevalence of cardiovascular disease, dementia, chronic respiratory diseases, and cancer (Prince et al., 2015).

Diet has a crucial role to play in preventing age-related diseases. However, it has been noted that older adults often do not meet the recommended Saudi guidelines for dietary intake (Alsufiani et al., 2015; Al Moraie, 2014). A number of factors influence dietary intake among this segment of the population, including socio-economic status, psychological well-being, physical health, and living circumstances. Another vital factor is dental status (Host et al., 2016).

Older adults tend to lose a higher number of teeth, resulting in many of them being edentate (Fuller et al., 2011; Al Shammery, El Backly, and Guile, 1998), which can weaken masticatory capability. Subsequently, a reduction in masticatory ability may have an effect on dietary habits. For instance, it could lead individuals to avoid tough foods that are high in fibre, such as nuts, vegetables, and fruit (Walls and Steele, 2004; Tada and Miura, 2014). This could consequently result in a lack in the optimal nutrients required for ideal health during the process of ageing.

To improve masticatory ability, healthcare professionals often prescribe removable dentures. However, individuals who wear dentures may discover that their chewing and biting abilities are still less efficient compared to when they had natural teeth; hence, food selection can still be restricted (Nowjack-Raymer and Sheiham, 2003).

CHAPTER TWO LITERATURE REVIEW

Population Demographics and Dental Status in Older people In Saudi Arabia

The Kingdom of Saudi Arabia is located on South-Western Asia's farthest end. To the east of the kingdom are the United Arab Emirates, Qatar, and the Arabian Gulf. Oman and Yemen are to the south and the Red Sea is to the west. At the kingdom's northern end are Jordan, Iraq, and Kuwait. The 2,250,000 square kilometres of land on which Saudi Arabia sits constitute about 80% of the Arabian Peninsula. Saudi Arabia has 13 administrative regions, with each region separated into several governorates (The General Authority for Statistics, 2021).

In its general wealth indicators, such as infant mortality rates, expectancy at birth, maternal mortality rate, and infectious disease and immunisation level, Saudi Arabia has experienced extraordinary development (Yousef, 2011). The kingdom's Ministry of Health (2016) reports that Saudi Arabia's life expectancy for 2016 was 74.8 years, which is higher than both the regional and global averages (68.8 years and 71.4 years, respectively). In 2016, the kingdom's proportion of people below the age of 15 was 30.3%, the crude birth rate was 17.23 per 1,000 people, the crude death rate was 2.9 per 1,000 people, and the infant mortality rate was 4.82 per 1,000 people (The General Authority for Statistics, 2016).

Based on figures published by the General Authority of Statistics in Saudi Arabia (2016), the kingdom's population in 2016 was 31,742,308, with Saudi citizens numbering 20,064,970. Therefore, it can be noted that Saudi citizens constitute 63.2% of the kingdom's population. The number of Saudi citizens above the age of 60 in the kingdom was 853,609, accounting for 4.25% of the population (The General Authority for Statistics, 2016).

The Saudi population aged 60 years old and above is 853,609. This age group accounts for 4.25% of the total Saudi population. In contrast, there are nearly 12 million (11,989,322) people aged 65 and above in the UK, which is around 18% of total population.

Petersen (2003) cites the WHO Global Oral Health Data Bank, which reports a 31-46% edentulousness prevalence among the elderly in Saudi Arabia. Al Shammery, El Backly, and Guile (1998) report that the average tooth loss among the 65 to 74 year-old age group was 15.79, with the female rate being 17.28 and the male rate being

14.53. The same authors note that the rate in the rural areas (16.52) was higher than that of urban centres (15.49). In a recent systematic review, the mean DMFT for older adults in Saudi Arabia was reported to be around 20 (Alshammari et al., 2021).

In developing and developed countries, life expectancy at birth is rising together with life expectancy during life. The consequence of this is a rise in the world's population. For instance, between 2010 and 2016, Saudi Arabia's population grew by 16.5%, which represents 4.5 million people, an annual increase of about 2.5%. The proportion of this population above the age of 60 is 5.5%. If only people with Saudi nationality are counted, the population of people over the age of 60 constitutes 4.2% (The General Authority for Statistics, 2016)

According to UN World Population Prospects (2019), the Saudi Arabian population's growth rate is 1.59%. Also, they predict that the Saudi population growth rate will slow down to 1.09% by 2030 and subsequently to 0.027% in the three decades after that. Per woman, the Saudi fertility rate is 2.274 births, which is higher than the population replacement rate of 2.1 births per woman. In the last few years, the fertility rate has decreased every year, initially leading to a slowing and eventually to a stagnant population growth (United Nations and and Social Affairs, 2019).

Recently, the Saudi government introduced the policy of Vision 2020 together with the complimentary National Transformation Program for 2020. It is expected that life expectancy in Saudi Arabia will increase to 80 years by 2030 from its current 74 years, a situation that will add to the population growth and ageing (Saudi Vision 2030, 2017). Therefore, it can be expected that population growth and ageing are some of the challenges that Saudi Arabia will face in the future.

In the developed world, there is a considerable amount of literature relating to the health of ageing populations. However, in the Arab world, especially in Saudi Arabia, this kind of research is scarce (Altamimi, 2016), resulting in limited data in the area of oral health for older people and the effects of poor oral health within this population group.

The data from the developed world shows that among older people, oral health impacts both oral function and quality of life, especially among those with missing teeth or who have no natural teeth and people living with xerostomia (dry mouth) (Petersen, and Yamamoto, 2005). In the older population, the state of oral health impacts food

choices, which can lead to individuals eating unhealthy food with a high concentration of sugar and saturated fat while consuming low levels of fibre. This is in contrast to the proper diet recommended for an older person, which should be low in energy but high in micronutrients and protein (Walls and Steele, 2004; Host et al., 2016). There is limited literature regarding the effect of oral health status on dietary selection and food choice in the Arabian diet.

Health

The word *health* has its roots in the old English term *hoelth,* which Dolfman (1973) says means "wholeness or being sound or well." In keeping with this definition, and the World Health Organization, Shimkin (1946) defined health as "a state of complete physical, mental, and social wellbeing and not merely the absence of disease or infirmity". This definition widened the meaning of the term to include both social and psychological dimensions.

Nutrition and diet

In the last 20 years, there have been rapid changes in the Saudi Arabian food situation. There has been a progressive move away from the traditional Arabian diet consisting of fruits, vegetables, milk, dates, and whole wheat bread towards a more western diet consisting of more high energy foods, often with a lot of fat and sugar but lacking in fish, vegetables, and fruits (Khoja et al., 2007). This is a view that was earlier acknowledged by Bani and Hashim (1999), who say that it is clear that a shift is taking place where people are replacing traditional foods with fast foods that have high amounts of salt, sugar, and fat. Also, the most common type of foods eaten is fried foods, usually consumed with carbonated drinks.

Data contained in the food balance sheet shows that a high proportion of energy intake can be attributed to animal foods, whose intake increased by 143% between 1971 and 1997 (Food and Nations, 2000; Al Moraie, 2014). The Food and Agriculture organization statistics (FAOSTAT) food consumption and availability survey shows a rise from 1900 to 3068 kcal in daily consumption of protein, energy, and fat per capita in the last 30 years in Saudi Arabia (Al Moraie, 2014). FAOSTAT (2009) estimates that there has been an increase in the dietary protein intake from 49 to 85 g/day while that of fat has increased from 33 to 81 g/day (Al Moraie, 2014).

Currently, there are no data relating patterns of food consumption or diet to oral health status in the country for older adults. Therefore, it is crucial to gather data related to nutrition and diet for the elderly in Saudi Arabia because there is a dearth of data in relation to the Arabian diet.

Malnutrition

Malnutrition is the term used to describe a disorder related to poor nutrition or negative health status that can be associated with an excess or lack of nutrition. This is a definition also acknowledged by Parks (2021), who notes that even though malnutrition is often linked to undernutrition (a lack of nutrition), overnutrition (consuming more nutrients than is required) – which is a correspondingly severe problem – is also included in the definition.

Svedberg (2000) cites the WHO, which defines malnutrition as the "cellular imbalance between the supply of nutrients and energy and the body's demand for them to ensure growth, maintenance and specific functions, and is the greatest risk factor for illness and death worldwide."

Common diseases related to nutrition in Saudi Arabia

Obesity

Overweight and obesity in Saudi Arabia are on the increase, ranging from 6% to 83% (Ministry of Health 2012). From the available data, it can be clearly noted that the kingdom faces a high prevalence of adult obesity. The wide variance could be attributed to differences in health status, sex, and age. Al-Baghli et al. (2008) examined 195,874 Saudi subjects living in the eastern province. The aim of the study was to describe the participant's anthropometric characteristics and the impact of cardiovascular risk and socio-demographic factors involved in obesity prevalence. Overall, the obesity prevalence was 43.8%, and 35.1% of the subjects were categorised as overweight. The underweight prevalence was 1.3%. The highest obesity prevalence was recorded in the 50 to 59 year age group. In comparison to men, the prevalence of obesity among women was higher. Among women, housewives and the less educated tended to have higher levels of obesity.

A study by Al-Nozha et al. (2005) involved 17,232 subjects from selected households. The results showed that the overweight prevalence was 36.9%. Specifically, being

overweight was more prevalent among males (42.4%) than females (35.5%). A report produced by the Saudi Ministry of Health involving 5,000 participants from various regions in the kingdom showed a mean body mass index of 27 kg/m2 for males and 29 kg/m2 for females. The data demonstrated that the rate of obesity among males and females was 43.3% and 28.6%, respectively, with BMI higher than 30 kg/m2 (MOH, KSA, WHO and KFH & RC, 2005).

Diabetes mellitus

The increase in the rates of diabetes mellitus (DM) across the world is connected to changes in lifestyles and ageing populations, particularly when the prevalence of obesity is also increasing in the same population. The WHO (2003) reports that 177 million people across the world live with diabetes. The same source indicates that it is expected that this number will double by 2030. This is not surprising if one considers that diabetes is the fourth cause of death in Europe. Also, the risk of developing major cardiovascular complications among people living with diabetes is three to four times more when compared to those who do not. Hence, diabetes has come to be considered the leading cause of heart attacks and strokes. It is also perceived to be a leading cause of peripheral neuropathy, which often results in a heightened risk of amputation and peripheral vascular disease. For example, individuals with peripheral neuropathy are two times more likely require amputation than those who do not (Kumosani et al., 2011). In countries constituting the Arab Gulf, the prevalence of diabetes among adults is higher compared to countries in the West. A study by Musaiger (2002) concluded that the rate of diabetes among adults ranged between 12% and 23%. Added to this, the risk of developing diabetes rises as individuals grow older. This reality is of major concern if one considers that people are living longer in both Saudi Arabia and across the world (Kumosani et al., 2011).

The Saudi Ministry of Health's General Directorate of Non-Communicable Diseases reported that 17% of Saudis had fasting blood sugar higher than 7.0 mmol/L. The same source says that the levels were higher among males (19.2%) than females (16.6%) (MOH, KSA, WHO & KFH & RC, 2005). A recent community-based national epidemiological health survey involved the examination of 17.232 Saudi subjects whose ages ranged from 30 to 70 years selected from certain households over a five-year period between 1995 and 2000. From the data collected, it can be concluded that the overall DM prevalence was 23.7% in Saudi Arabia. The prevalence among males

and females was 26.2% and 21.5%, respectively, and was higher among Saudi Arabians living in urban areas (25.5%) compared to those in rural areas (19.5%). Even though healthcare access is readily available in Saudi Arabia, a large number of individuals living with diabetes did not know that they had DM (Al-Nozha et al., 2004).

Dyslipidaemia

A cross-sectional national epidemiological randomised household survey was conducted with the aim of determining the prevalence of metabolic risk factors for hypercholesterolemia, DM, obesity, and other cholesterol-linked risk factors among the Saudi population. The study involved 2,057 Saudi subjects aged between 30 and 64 years. Whether one employed cut-off levels of >5.2 mmol/l or >6.2 mmol/l, the hypercholesterolemia prevalence was the same between females and males. When compared to developed or developing countries, hypercholesterolemia was lower among age and sex-matched subjects. At >6.5 mmol/l, the prevalence of total cholesterol/high-density lipoprotein ratio was higher than in some other developing countries.

It is vital to monitor the cardiovascular disease (CVD) trend together with the risk factors that can be employed in the assessment of the effectiveness of control initiatives (Al-Nuaim et al., 1997). Al Nozha et al. (2005) performed a national epidemiological health survey based on a specific community involving Saudi subjects aged between 30 and 70 years old. The data collected for the survey shows that low HDL affects 74.8% of males and 81.8% of females, with multiple sclerosis (MS) being ahead of all other factors. This was consistent across all the other groups. The same scholars reported that metabolic syndrome is a CVD risk factor if one considers the higher prevalence of coronary artery diseases (CAD) among subjects with metabolic syndrome (6.7%) than in subjects who did not have it (4.6%) (Al Nozha et al., 2005).

Rickets and osteoporosis

Saudi Arabian scientists conducted a retrospective study at King Abdul Aziz Medical City-King Fahad National Guard Hospital in Riyadh. The study involved a review of the records of infants below the age of 14 months. These records covered a decade—starting in January 1990 and ending in January 2000. The records show that 283 infants aged between six and 14 months had been diagnosed with nutritional rickets attributed to a deficiency of vitamin D (67% males). The study concluded that

nutritional rickets is still prevalent in Saudi Arabia, with vitamin D deficiency being the primary aetiology (Al-Atawi et al., 2009).

Other scholars have also found results agreeing with the conclusion that rickets prevalence in Saudi Arabia is higher in comparison to neighbouring countries (Al-Jurayyan et al., 2002). A cross-sectional study was conducted at a university hospital covering the period of February 1, 2008, and May 31, 2008. The study involved healthy women and men in the peak bone mass (PBM) age group, and participants aged ≥ 50 years were enlisted from King Fahd University Hospital's outpatient department. From the data collected, it can be seen that among individuals with the standard 25-hydroxyvitamin D (25OHD) level, 50% of women and 7% of men in the PBM age group and 26.4% of women and 49.2% of men aged ≥ 50 years had low bone mass. Among patients with insufficient 25OHD, 84.2% of women and 88.9% of men in the PBM age group and 83.3% of women and 80% of men aged ≥ 50 years had low bone mass. The data gathered for the study leads to the conclusion that a significant positive correlation exists between BMD and 25OHD (Sadat et al., 2011). An aggregate of 122 outwardly healthy Saudi Arabian women at post-menopause were enlisted from the Center of Excellence for Osteoporosis Research in Jeddah. The majority of individuals in the sample were found to have vitamin D deficiency with a serum vitamin D level below 50 nmol/l. The mean saturated fat, total fat, and total caloric intake were found to be higher than the recommended levels. Almost three-fifths of the aggregate study population had a calcium intake below the estimated average requirements, while the entire population's vitamin D intake levels were lower than the estimated average requirements. A significant correlation could be noted between the femoral neck BMD and serum vitamin D level (ALissa et al., 2011). The use of a veil in the Arab world has been blamed for low vitamin D levels among women (ALissa et al., 2011). Nevertheless, it has been argued that the cultural and religious practice of wearing veils by females is unlikely to be the major cause of vitamin D deficiency (ALissa et al., 2011). The researchers recommended that the Saudi population should be provided with supplementary dietary vitamin D and calcium in osteopenic patients. There is also a pressing need for public education on the vital role of vitamin D in bone health, with emphasis on the importance of physical exercise and adequate sunlight exposure to avoid the complications of vitamin D insufficiency and deficiency (ALissa et al., 2011).

Tools for measuring dietary intake with their strengths and weakness

It is the view of Lee and Nieman (2018) that dietary assessment techniques are specifically designed to quantitatively produce nutrient intake approximations. Techniques for assessing dietary intake include an amalgamation of prospective and retrospective recording of daily intake. The same author notes that there are four leading techniques employed in assessing datary intake: FFQ, 24-hour, food records, and dietary history.

Methods for assessing dietary intake

Food frequency questionnaires

Food frequency questionnaires (FFQ) are used in the assessment of foods or food groups consumed over a predetermined period. In the questionnaire, there is a food list (in most cases, close-ended) and a frequency category part. These questionnaires can be interviewer- or self-administered. These questionnaires depend on a list of items from which participants select those they consider as representing their food intake over a defined period. In most cases, they include an array of 50 to 150 choices, and more in some cases (Lee & Nieman, 2010). Methods employed by FFQs, such as the 24-hour dietary technique, depend on the participant's ability to remember. FFQs provide reminders that assist respondents when making choices from the common food choices consumed. The main advantage of the method is that it puts the least amount of responsibility on the participant and can be done after a survey (Lee and Nieman, 2018; Nations, 2018).

The FFQ constitutes the most common type of diet recording employed by large-scale studies. It is the preferred method in such studies because it can be distributed by mail, as opposed to the use of the telephone or conducting the interview in person. The technique is different from other methods, such as the Harvard University FFQ (Harvard School of Public Health, 2011) or the European Prospective Investigation of Cancer FFQ (EPIC FFQ) (Bingham et al., 1997), which were designed with a focus on respondent's cognitive ease. However, the FFQ has often been criticised for the limited food choices in the questionnaire (Al Moraie, 2014). Day et al. (2001) adds that certain mistakes have been discovered in the FFQ in terms of selected nutrient intakes in research that has used the technique. There have also been reports indicating that individuals tend to overvalue their consumption of certain groups of foods, particularly

vegetables, in comparison to diaries recording weighed food (Bingham and Day, 1997; Livingstone et al., 1992). Also, the method can be challenging for people with answers to questions, about their typical dietary intake, differ over extended periods (Gibson, 2005).

The FFQ method presents several advantages. The leading benefit that can be obtained from the technique is that it can assess the typical intake over an extended period. Also, it can be employed for capturing an assortment of foods, specific nutrients, or particular categories of food, including items that are eaten on rare occasions. Added to the ability to capture specific foods, the FFQ technique also captures the sizes of portions, cooking details, and methods of preparation. Participants can add consumed foods not presented in the food list using the open section at the end of the questionnaire (Lee and Nieman, 2018; Nations, 2018).

The fact that the FFQ technique is retrospective means that it does not impact eating behaviour. Added to this, the method presents the least burden on respondents. For the researcher, the FFQ method presents a relatively easy and cost-effective method in comparison to other methods of assessment, such as dietary records or the 24-hours recall. Also, the fact that the questionnaire is interview-based means that the literacy and numeracy skills of the respondent do not get in the way when answering the questions. The technique can also be self-administered using the internet or by mail. Together with the fact that the method results in the reduction of data-entry errors because it can be administered using a machine-scannable format, it is suitable for large scale studies (Lee and Nieman, 2018; Nations, 2018).

The disadvantage of the method is that FFQ food lists do not include all the food items consumed by participants, which could result in underreporting. It also fails to provide specific data with regards to the estimated portion size. In the event that self-reporting is used, the participants need to have numeracy and literacy skills. Also, when FFQs are self-administered, questions can be misread, and respondents may omit food items they do not understand. The questionnaires have to be adapted and validated so as to reflect the purpose of the study and its population, a situation that could call for substantial resources and time (Lee and Nieman, 2018; Nations, 2018).

The FFQ is not a suitable method in populations where dietary patterns are markedly different. Also, because the method overly relies on the ability of the respondents to

remember, a lower cognitive ability could lead to errors when estimating and reporting portion size and frequency. Misrepresentation can also arise when participants report combined frequencies for food eaten both in mixed dishes and individually (Lee and Nieman, 2018; Nations, 2018).

Twenty-four hour recall

The 24-hour recall method is defined by Casey et al. (1999) as a comprehensive questionnaire used in investigating and determining an individual's consumption of food in the last 24 hours. According to Lee and Nieman (2018), diet recall over 24 hours is a commonly used method and usually needs the responsible interviewer to be trained for it to succeed.

During a 24-hour recall session, respondents answer questions from a dietician or nutritionist to recall and report all beverages and foods they consumed in the last 24 hours. The 24-hour period covers the first meal the respondent ate when they woke up in the morning up until the last meal consumed before getting up in the morning. This is the basis on which it can be said that the technique seeks to assess an individual’s actual intake. Nonetheless, one 24-hour period will not be adequate to base a full assessment of an individual’s typical intake of nutrients and food. To deal with this challenge, several non-consecutive 24-hour recalls of the same person are needed to capture daily differences (Gibson, 2005; Baranowski, 2012). To validate the data collected using the FFQ, multiple-day data collection can be employed. These multiple collections can boost quality control and reliability while lessening mistakes (Nations, 2018; Lee and Nieman, 2018).

The 24-hour recall employs an array of open-ended questions that are systematically repeated, where the participant is requested by the interviewer to recall and describe all the drink and food items they consumed in a specified 24 hours (Nelson, 1997). To determine the amounts, the interviewer can give average weight to foods, or the participant can use models or photographs to estimate portion sizes (Nelson, 1997). This measurement procedure can be done on a single basis, or it can be repeated several times to determine the intake of food at particular periods during the study. Face-to-face interviews or the telephone can be used to conduct recalls (Lee and Nieman, 2018; Nations, 2018).

The leading advantage of the 24-hour recall is its ability to assess typical food consumption in large populations (with the caveat that the aggregate population and weekdays are sufficiently represented). Added to this, the method captures vital details like meal preparation, eating patterns, and the place where the food was consumed. The administration mode used by this method affects neither eating patterns nor food choices. The questions used to capture information are open-ended, ensuring that all food patterns are covered. The fact that the method requires recall over the last 24 hours ensures that there is no burden on the respondents' memory, which could result in higher response rates and enhanced accuracy. Added to this, if the interview technique is used, the respondent's level of recall or numeracy is inconsequential (Lee and Nieman, 2018; Nations, 2018).

The main disadvantage of this method is that it requires the respondents to answer questions several times so as to capture individuals' habitual intake and accountant for seasonal variances. Apart from relying on the memory of respondents, the method also requires that the interviewers are adequately trained and sensitive to the cultures, food preparation methods, eating habits, and local recipes of the participants. The method can be expensive because of the extensive training required to prepare the interviewers and the time consumed by the data entry and matching the food to the consumption data. Recall bias is always a possibility when dealing with this method because respondents can be selective with regards to the foods they report during the recall. Also, the ability of the respondent to describe the food and estimate portion size is consequential (Lee and Nieman, 2018; Nations, 2018).

Dietary record

In the dietary record method, the respondent records the foods and beverages consumed. Several methods are used to determine the quantity of the consumed foods: estimating with household utensils, weighing, models of food (Biro et al. 2002), or pictures (Black and Welch, 1993). Usually, this method relies on a three-day record selected in a random manner so that variations across weekdays or seasons can be accounted for when gathering information related to average food consumption and its distribution across individuals within a group (Bingham et al., 1994). During the time when the food is consumed, the reporting can be done on paper or using a dicta-phone. Lee and Nieman (2018) propose that before the collection of data begins, the individuals being investigated need to be trained sufficiently with regards to how they

should describe their diet, the amounts and specifications of foods consumed, and how such foods are cooked.

Interviews done after the initial day and at the end can be used for triangulating data collected in the report. This is a view acknowledged by Biro et al. (2002), who say that this will assist a well-skilled interviewer to fill in any missing information and provide clarity to entries collected so that a more accurate report is produced. If one considers that interviews do not overly rely on memory or recall, it can be expected that missing data will be minimal. This is the reason the dietary record method is generally considered to be accurate with regards to the consumed foods. The weighing method is often used together with the dietary assessment methods. Using the recording method requires substantial cooperation from the participants, who may need encouragement (Biro et al., 2002).

Dietary history

A dietary history is a comprehensive assessment that describes typical food intake and how it varies over an extended period (usually six to 12 months). The initial dietary history put together by Burke (1947) comprised three parts (Gibson, 2005; Biro et al., 2002): an in-depth interview for assessing typical eating patterns and food intake, a food list, and three days record including estimates of portion sizes employed for cross-checking.

As a method, a dietary history relies on an open-ended interview method that involves a succession of typical questions answered by the respondent with regards to their usual patterns of food consumption over a precise timeframe. It explores the type of foods eaten, the frequency with which they are eaten, and the portion sizes. This method has been validated as a source of estimates for energy intake at the group level using a weighed record taken over seven days (Livingstone et al., 1992).

The dietary history's leading advantage is that it provides information related to the usual intake of food, individual foods consumed, and meal patterns. Information gathered using this method delivers quantitative estimates of nutrient and energy intake. It is also a useful method for describing nutrient and food intake over an extended period, making it a suitable method for estimating inadequate diet prevalence. The respondent's level of literacy is not crucial when using this method. Apart from the fact that it does not interfere with normal eating habits, it also provides

information about foods that are not consumed regularly (Nations, 2018; Lee and Nieman, 2018).

The fact that the dietary history method relies on memory presents the risk of recall bias. Added to this, the method is time-consuming and labour-intensive, making it not suitable when older adults and children are the respondents. For instance, to obtain comprehensive information, the researcher needs to conduct longer interviews, a situation that puts a burden on the respondents. The added burden can also be noted in the difficulty related to estimating the portion sizes of past meals, even when aids are used. The intricacies inherent in the method require that interviewees should be adequately trained so they have knowledge of eating patterns and cultural methods when the interview-based dietary history is used. If self-administered, the method requires that participants have the literacy to estimate the size of portions. Entering data and coding it using this method is a time-consuming exercise that presents the added expense of training personnel and administration (Nations, 2018; Lee and Nieman, 2018).

Prospective direct methods

The prospective method stipulates that the food and beverages are recorded at the time when they are consumed. The method consists of three sub-techniques: weighed food, estimated food, and duplicate meals. Prospective methods can be labour intensive, depending on the study's aims (i.e. duplicate meal method or weighed food record) when compared to retrospective methods. The prospective direct methods also rely heavily on the good numeracy and literacy skills of the respondents (Nations, 2018).

Estimated food records

When the estimated food record is used, the respondents are requested to record all beverages and foods consumed during a specified timeframe. The study’s purpose determines the number of days included in the assessment (Gibson, 2005).

The estimated food record approximates the actual and not the typical diet. Its open-ended format makes the method suitable for all patterns of eating. The method delivers specific details with regards to foods eaten, where that food was eaten, and eating patterns. Even respondents with sporadic eating habits can have their information collected using this method. Since the information is recorded at the time of

consumption, the method does not rely on the memory of the respondent and the potion size estimation is more accurate, which leads to a reduced risk of error when estimating food intake (Nations, 2018; Lee and Nieman, 2018).

The estimated food record requires that participants have literacy skills and motivation. Therefore, in low-resource countries, there is a need to train the interviewer/investigator to correctly collect data. Administering the data collected is expensive. The same applies to data entry and coding, which requires a lot of time and needs the staff to be trained. Because the method is time-consuming, it places a huge burden on the respondents, a situation that could discourage willing participants. This could result in the accuracy of data decreasing over time as respondents start to get tired. It is also possible that respondents may forget to record food items or whole meals. In the event that the respondent reports inadequate information, it can be a challenge to estimate portions. The data collection process may interfere with the eating habits of respondents and may fail to capture those foods that are not eaten frequently (Nations, 2018; Lee and Nieman, 2018).

Weighed food records

Generally, the weighed food records method is perceived as the most precise technique for estimating individuals' nutrient and food intake. The approach embraces the same methodological codes as the estimated food record method. The difference in this technique is that respondents are requested to weigh their food with weighing scales (Nations, 2018; Lee and Nieman, 2018). Marr (1971) states that this method tends to have fewer errors because respondents copy each individual food's weight as it appears on the scale, and there is no opportunity to manipulate the figures.

Depending on the number of measuring days, weighed food records method assesses the usual or actual individual intakes. When compared to other dietary methods, this method is more accurate, which has led to it being perceived as the dietary assessment gold standard. This is because the method delivers a high level of detail and specificity with regards to meal patterns and consumed food. It also delivers data related to foods that are not regularly consumed. Because the information is recorded at the time of consumption, the method does not rely on memory. Also, because the method uses the exact portion sizes, it does not rely on estimations that could be inaccurate (Nations, 2018; Lee and Nieman, 2018).

To use the weighed food records method, the study participants should be both motivated and have numeracy skills (if self-reported) to manage the process of weighing foods and recording the details. Therefore, in communities where literacy and numeracy are low, there is a need for a trained field investigator who will assist with collecting reliable data. For both the researcher and the respondent, this is a time-consuming method. Therefore, when compared to other methods, the level of burden for respondents when this method is used is higher. The burden could lead to study fatigue, which may result in respondents altering their eating habits to make the procedure simpler, especially when records for several days are required. There is also a challenge related to weighing foods consumed away from home because the method requires a suitable environment where the food is weighed (Nations, 2018; Lee and Nieman, 2018).

Duplicate meal method

The duplicate meal method involves duplicating all foods and beverages consumed and setting one potion aside for a specified timeframe. The portions set aside are then weighed, either by a field worker or the respondent, before being delivered to a laboratory that will determine the food's nutrient content. Apart from putting duplicate potions aside, respondents also keep a weighted food diary where the foods and beverages consumed during the period of assessment are recorded. The record also contains information about portion size presented as household potions or weights (Nations, 2018; Lee and Nieman, 2018). Lightowler et al. (1998) note that the food diary plays the role of validating the collected duplicate foods' comprehensiveness and the precision of the duplicate meal's portion sizes.

The main advantage of the duplicate meal method is that it collects extremely precise details regarding nutrient intake, and the food composition data limitations do not impact the method. The technique minimises the omission of consumed foods when compared to other methods (Nations, 2018; Lee and Nieman, 2018).

Preparing duplicate meals and then doing a chemical analysis of the foods is a costly task. In low-resource countries, there is the added cost of training and hiring an investigator to collect data, code it, and present it. Added to this, the method is time-consuming and requires a lot of effort from the respondents, who also need numeracy skills (if self-administered) and respondents that are motivated. This method is not

feasible when conducting a large-scale study. Because the method interferes with normal eating habits, it may lead to participants underestimating their intake (Nations, 2018; Lee and Nieman, 2018).

Integrating innovation technologies to improve the assessment of diet

The need for more specific and accurate dietary assessment methods is growing. Such methods are likely to deliver high-quality data, which is required in understanding the link between health and diet, which is in turn needed to comprehend patterns and health challenges linked to nutrition, such as cancers, diet-related chronic diseases, micronutrient deficiencies, and obesity. This is the basis for ongoing efforts to develop better dietary assessment methods (Nations, 2018; Lee and Nieman, 2018).

There are several advantages that come with developing innovative methods for collecting dietary information. For instance, innovative methods can lower the cost of data collection because they can reduce the need for human interpretation. If these methods are indeed innovative, they can increase compliance because of their convenience to participants. Accuracy could be improved because the methods do not depend on the memory of respondents. Apart from being able to also record qualitative memory, such as the time and date of recording, these methods could also have a significant impact on reducing processing time (Nations, 2018; Lee and Nieman, 2018).

Notwithstanding the advantages presented above, novel technologies require a bigger upfront investment to acquire the required gadgets. There is also a risk that the devices could get lost. Users also have to contend with technical challenges like the loss of internet connection or battery power, which could affect the collection of data. Therefore, it will be vital that a backup method for collecting information is available in the event of technical challenges (Nations, 2018; Lee and Nieman, 2018).

Personal digital assistant (PDA)

A PDA is a handheld computer that can be used in dietary assessment. It comes with software designed to register and self-monitor dietary intake. It facilitates the collection of data in real-time and the short-term evaluation of such data. Before the collection of data begins, participants need to be trained to use the device. Food intake is selected from a predetermined list and recorded as soon as it is consumed.

Today's PDAs allow users to select between 400 and 4,000 items (McClung et al., 2009).

With regards to the advantages, the PDA provides convenience as it can be easily carried by the participant. It also makes it possible for data to be collected, entered, and coded in real-time. The device also comes with the convenience of an alarm that can assist participants to remember to record their food. The device can also be programmed to permit participants access to dietary intake software only (Nations, 2018).

The PDA presents the disadvantage of requiring participants to receive face-to-face training. Also, because its food listings are recorded, it has low-level dietary data details. If the list of foods is long, the device can increase the respondent burden in comparison to pen and paper records. There are also reports that using the search function can be a challenge, and finding certain foods can be impossible (Nations, 2018).

Image-assisted dietary assessment methods

Any method that uses food images collected while the user is eating falls under the category of image-assisted dietary methods. The method enhances accuracy while reducing the respondent burden. This technique can be used as a way of supporting traditional self-report methods, or it can be used as a standalone method (Lazarte et al., 2012; Dahl Lassen et al., 2010; Martin et al., 2014).

Possibly, the leading advantage of image-assisted dietary methods is that they are easy to use. This makes them suitable for low-literacy populations. Many people now use their phones as cameras, which can assist in producing high-quality images and improve the analysis. The method can also be used by children or participants with memory impairment. When compared to other traditional methods, underreporting is lower (Nations, 2018).

The disadvantage of this method is that it depends on the participant's remembering to take images of the foods they eat. It is also difficult to capture all information using a single image. It can be a challenge to estimate portion size from a photograph of a mixed dish. This can limit accuracy in countries with a large proportion of mixed dishes like Asia. There is still a need for written records regarding foods that cannot be seen

in the photo and the ingredients used. The method also doesn't deliver details regarding the method of cooking (Nations, 2018).

Mobile-based technologies

With their growing accessibility, mobile technologies present a way of dealing with the burdens linked to collecting dietary data through means like images or voice messages. This proliferation of technologies is spurring researchers to develop dietary assessment methods based on this technology. It is a method that appeals to young people, who can be targeted in studies collecting dietary information (Boushey et al., 2015; Casperson et al., 2015).

Mobile technologies present a possibility for high-quality data because they can facilitate real-time responses. They also make it possible to send reminders. Those with access to the internet can send images instantly, a situation that lessens systematic mistakes. Notwithstanding the advantages, developing applications as an interface and software for estimating portion sizes can be costly. It may be challenging to analyse images with mixed dishes. A degree of literacy is necessary, and users need to be connected to the internet for real-time data collection to be possible (Nations, 2018).

Interactive computer and web-based technologies

Interactive computer and web-based technologies employ interactive dietary assessment programs, either through an internet-connected portable computer or a desktop. These technologies collect dietary information during a precise timeframe in the distant or recent past (long- or short-term dietary assessment). The techniques linked to these methods have their basis in the traditional pen and paper method that is included in a computer program with an array of multimedia elements like graphics, colours, audio narrations, webcams, food images, and animated guides (Nations, 2018).

Data is collected by asking participants to record their food intake during a specific period and adding the details to a provided computer software. The software can be designed to assist users to remember items that may be forgotten. Using multimedia means that the system uses the collected information to calculate intakes. Technologies based on the web can also come with functionalities that can adjust potion size images (Nations, 2018). They also make it possible to collect information

at any time or location using a language that can easily be understood by the participants (Holm, Lund, and Niva, 2015; Illner et al., 2012). However, users require a high level of computer literacy to manage web-based computer technology (Illner et al., 2012).

Some of the advantages of interactive and web-based technologies are that they introduce efficiency in data processing and increase quality control levels. The method can be applied to samples separated by large distances, and data processing can take place in real-time at any location. It is easier to use because it includes interactive audible and visual aids. The method also presents a potential for sending interactive reminders and delivering personalised feedback (Nations, 2018).

Interactive and web-based technologies present several disadvantages. For instance, some imaging algorithms do not have the sophistication to correctly identify foods or estimate foods in an image on a computer. The software needs to be adapted to the local context. Participants using these technologies need a high level of computer literacy. The method presents the potential for not collecting all the details in the foods, such as methods of cooking and the ingredients in the food. Also, web-based technologies do not work without access to the internet (Nations, 2018).

Scan- and sensor-based technologies

Scan-based technologies make it possible for participants to scan the barcodes of the foods they buy, making this method only suitable for food distributed in a formal manner (Illner et al., 2012). This method is designed to ensure that the participant does as little work as possible and does not need to apply their memory. It also ensures that participants do not change their eating habits (Nations, 2018).

The main advantage of this method is that using a barcode makes it possible to identify food automatically. The fact that the participant cannot manipulate the data presented makes this an objective assessment. It also reduces the burden on the participant (Nations, 2018).

The disadvantage of the method is that only packaged food can be scanned using a barcode. The technique has only been applied in restricted settings and in small studies (Nations, 2018).

Qualitative retrospective proxy tools for assessing dietary diversity

The Dietary Diversity Score (DDS) is a substitute instrument based on the assumption that diet quality depends on dietary diversity because when an individual's diet is varied, the potential for intake of required nutrients improves (Ruel, Harris, and Cunningham, 2013). Apart from being simple to apply, DDS is feasible, cost-effective, and can be employed to obtain results quickly. Hence, it is suitable for the assessment of dietary diversity in precise samples of participants, where challenges and capacity may make it difficult to use other methods. DDS delivers a score representing numerous foods or categories of foods consumed in a precise period of reference (Hoddinott and Yohannes, 2002).

National food balance sheets

Advantages

The national food balance sheets present a low-cost indirect nutrition data source that everyone can access, and the data is standardised and comparatively easy to analyse. Added to this, these sheets cover almost all countries across the world. These sheets also make it possible to monitor global dietary habits and nutrition patterns, including changes and trends in food availability at a national level (Nations, 2018).

Disadvantages

The national food balance sheets do not deliver disaggregate data based on various population characteristics such as demographic or socio-economic details. Estimates in the sheets are based on information obtained from specific countries, which can also be prone to methodological mistakes. Moreover, the data they contain does not provide information on seasonal differences in the food supply. These sheets do not provide data linked to foods that are not included in the national production statistics, such as food produced from subsistence farming, insects, and wild animals (Nations, 2018).

Another significant disadvantage of national food balance sheets is that they do not deliver dietary estimates specific to individuals. Also, the statistics in the sheet could be based on unreliable or incomplete estimates of the target country's population. To be valuable, the data provided needs to account for food waste (both in retail and domestic), food from non-retail sources, and foods grown at home. However, national food balance sheets do not account for these food sources. Lastly, there is a gap

between data collection and availability on FAOSTAT (FAO Statistics Division) (Nations, 2018).

Household

Household consumption and expenditure surveys.

Advantages

Household consumption and expenditure surveys offer an affordable way to collect nutrition data since this data can also be collected for other purposes unrelated to nutrition. Also, everyone can access the data, it is standardised, and relatively easy to interpret in instances where the questionnaire is designed well. These surveys are regularly done in various countries using demographically representative sample populations. The process of gathering data collects information on the demographic and socio-economic characteristics of the household's head. This kind of survey makes it possible to investigate subnational differences in patterns of consumption, which can be instrumental in the design of nutrition programs (Nations, 2018).

At the national level, household consumption and expenditure surveys produce statistically representative data, and this is also usually the case at the subnational level. The fact that this method produces detailed information about household food consumption permits direct surveillance of the farming and nutrition connection through value chains, markets, and other ways (Nations, 2018).

Disadvantages

The household consumption and expenditure surveys restrict the respondent's ability to completely respond (through record or recall) regarding the consumption of the whole household. This challenge could be solved by ensuring that the numerators are well trained and the questionnaire is well designed. The surveys are based on non-standardised units for reporting food quality. Another substantial disadvantage of this data collection method is that it does not account for food that is given away or wasted, leading to overestimating consumption (Nations, 2018).

In the household consumption and expenditure surveys, food not consumed at home is not always correctly recorded, leading to underestimating food consumed. This disadvantage could result in the wrong recording and reporting of crucial foods when a predetermined list of food items is used. The data collection method does

not account for the reality that the household's size may be different compared to the number of people who actually consumed the food within the period of reference. Consequently, it is not possible to gather data on the food consumed at an individual level or how the food is distributed among the household members using these surveys. Regarding acquisition surveys, they fail to account for the food that is purchased and consumed for long periods. The food position table's quality determines how reasonable the nutrient estimates will be (Nations, 2018).

Diet, nutrition, and oral health

Some of the common dental diseases include dental erosion, enamel developmental defects, and periodontal disease. Dental caries is the leading reason behind tooth loss, with diet playing a crucial role. Another area where diet also plays a substantial aetiological role is dental erosion, which is becoming more common (Moynihan and Petersen, 2004). Components of the diet can also make a contribution to the progression of enamel flaws such as fluorosis and enamel hypoplasia. Nonetheless, in contemporary society, the role played by diet and nutrition in periodontal disease (gum disease) aetiology is a relatively minor one. Gum disease is another reason that has been noted for loss of teeth among adults (Moynihan and Petersen, 2004).

Dental caries, tooth loss and diet

Chinese and Greek ancient civilisations believed that the cause of dental caries was worms drinking the teeth’s blood and feeding off the jaw’s roots. Over the years, several other theories related to the cause of dental caries have emerged. Nevertheless, the current dental caries aetiology is well established. It is now understood that dental caries results from localised erosion of dental hard tissues (dentine and enamel). This erosion results from the organic acids created by plaque bacteria via the anaerobic metabolism of dental sugars. Before the introduction of sugar into the diet in England during the reign of Queen Elizabeth 1st, when the Caribbean islands were initially discovered, dental caries was not common. For most of the 20th century, the disease became epidemic. However, levels started going down after 1970 as the use of fluoride became more widespread. Notwithstanding the desirable trend of dental caries decline in the developed world, decay levels are still high in many countries, even though the evidence shows improvements all around (Moynihan and Petersen, 2004).

Dietary recommendations from the World Health Organization/Food and Agriculture Organization (2003) seek to encourage an upsurge in the consumption of wholegrain foods, fruits, and vegetables to prevent several chronic conditions like cancer, cardiovascular disease (CVD), obesity, and diabetes. However, for those facing chewing challenges, the consumption of these foods could be hindered. If one considers that about half a century ago, it was common to see people getting a complete set of dentures as a 21st birthday present, it becomes apparent that some headway has been made in dental health over the years. In present times, many individuals live their entire lives without disease. However, it needs to be noted that edentulism (a situation where an individual does not have a single natural tooth) is still a challenge faced by many (Moynihan and Petersen, 2004).

Edentulism remains a challenge among older adult populations (Moynihan and Petersen, 2003). Kelly et al. (2000) and O'Mullane and Whelton (1994) report that in the UK and Ireland, 46% and 48%, respectively, of individuals aged 65 and above depend on plastic prostheses for chewing because they are edentulous. It has also been noted that people with fewer than 20 teeth have difficulty chewing (Hildebrandt et al., 1997). Nonetheless, for the first time, surveys in the UK show that most adults in each category – even those above the age of 85 – are dentate (Fuller et al., 2011). The reality that nearly half of older adults still have some natural teeth has significant connotations regarding possible good oral function (Fuller et al., 2011). When looked at together with the fact that the population of individuals aged 65 and above is growing, this factor implies that tooth loss will continue to impact a considerable part of the population for some time to come (Moynihan and Petersen, 2004).

It has been noted that tooth loss is linked to both perceived (Rusen et al., 1993) and measured (Yukstas and Emerson, 1964; Krall et al., 1998) chewing function. Compared to individuals with 20 or more natural teeth, the chewing function of someone wearing dentures is only about 20% (Michael et al., 1990). From early studies, it has been concluded that when individuals lose functional dentition, they face difficulties in chewing, leading them to avoid certain foods. Several scholars agree that this increases the risk of compromised nutritional intake (Ettinger, 1973; Berry, 1972; Osterberg and Steen, 1982; Wayner and Chauncey, 1983). Often, the foods that people with compromised chewing function find difficult to chew, like raw grain bread and raw vegetables, foods with pips like grapes, tomatoes, and raspberries, are the

recommended ones (Ettinger, 1973; Berry, 1972; Wayner and Chauncey, 1983). Osterberg and Steen (1982) report that older women in Sweden experiencing poor dental function show reduced fruit and vegetable intake compared to those with good dental function. The same authors report that when compared to those with natural teeth, a higher percentage of edentulous individuals have insufficient intake of nutrients.

Steele et al. (1998) report that the British National Diet and Nutrition Survey (NDNS) focused on older adults aged 65 and above. The survey concluded that the dental status in these older adults was linked to the perceived ability to eat numerous kinds of foods, and difficulties were noted in the quantity of vegetables, fruits, and nutrients, especially fibre, consumed. The same survey also concluded that the older adult's dental status was related to levels of retinol and serum vitamin D. In connection to public health, this study's findings have important implications. In this study, the identified poor masticators were those whose a number of teeth below 21 without replacement. Such a conclusion provides a scientific foundation for defining oral health as having 20 or more teeth (DOH, 1994).

The majority of work aimed at improving older people's diets has focused on health education. Comparatively little attention has been given to the effect of teeth, which restrict the diets that older adults can consume, leading to undesirable results in their nutritional status. It can be suggested that strategies for health promotion should also pay attention to the importance of maintaining functional dentition for life so that individuals do not end up avoiding certain foods, especially vegetables and fruits. Even though foods that are difficult to chew can be overcooked to soften them, it also needs to be noted that overcooked food has less fibre and nutrients (Marcenes et al., 2003). Marcenes et al. (2003) note that the NDNS review provides robust proof that people who maintain functional dentition into old age, perceived as having 20 or more teeth, are better able to sustain a healthy diet with adequate intake of vegetables and fruits, an acceptable body mass index, and a satisfactory nutritional status. This is also supported by conclusions drawn from a systematic review conducted by Toniazzo et al. (2018). The review concluded that there was a connection between the number of teeth present and nutritional status. Nonetheless, the clinical effect of such a connection may not be significant. On the other hand, no connection was made between nutritional status and the use of prostheses as a result of edentulism.

Dental caries

Breaking out at six months after birth, the deciduous teeth are lost by the early teens. The deciduous dentition is replaced by the permanent dentition, starting at the age of 6 and ending at 21. The risk of dental caries is at its highest soon after the teeth erupt. This is the reason the peak dental caries ages are the ages between two and five years for deciduous dentition, while that of permanent dentation happens around the early teenage years. In industrialised countries, it is becoming more common for adults to retain their teeth for longer. Nonetheless, where the gums retreat as people age, the teeth's roots become exposed and receive fewer minerals, a situation that results in decay referred to as *root caries*. During the pre-eruptive phase, the teeth are affected by nutritional status. Nonetheless, the nutritional effect at this stage is not as crucial as the post-eruptive local impact of dietary habits on the formation of caries.

A connection has been made between enamel hypoplasia, vitamin A and vitamin D deficiency, and protein-energy malnutrition (PEM). Vitamin A deficiency and PEM are also linked to atrophy of the salivary gland, which makes the mouth weaker when it comes to defending against infection and its capability to shield against plaque acids. According to Navia, malnutrition at a moderate level, especially when characterised by a shortage of proteins and shortages of specific micronutrients like iron, zinc, and vitamins, can impact the composition and quantity of saliva, weakening its protective function within the oral cavity. Nonetheless, dental caries is not linked to undernutrition in the developing world, where dietary sugars are mostly absent. A combination of undernutrition and increased daily consumption of sugars leads to degrees of caries greater than those anticipated for the degree of sugar consumption.

Dental caries is attributed to enamel and dentine (the hard tissues of the teeth) demineralisation as a result of organic acids created by dental plaque bacteria via the anaerobic metabolism of diet-derived sugars. When an individual consumes fermentable carbohydrates or sugars, they trigger a decrease in plaque pH; as a result of increasing organic acids, the result is calcium hydroxyapatite solubility in the dental hard tissues, coupled with demineralisation resulting from the loss of calcium in the surface of the tooth. Demineralisations happen at a point called the critical pH: around 5.5. One of the natural defences against this process is saliva. Saliva plays this role by facilitating remineralisation based on its ability to place minerals in porous areas affected by dentine or enamel demineralisation. The ability of saliva to deposit calcium

is connected to its high saturation with phosphate and calcium at pH7. In the event that a demineralised lesion develops, it is demineralised. However, this process can be slow and competes with the causes of demineralisation. Where the mouth's pH continues to be sufficient periods, it becomes possible for the enamel to completely demineralise. On the other hand, where the challenge posed by the acid is too high, demineralisation takes over, and the porosity of the enamel increases until a carious lesion forms. Two factors impacting the demineralisation rate are fluoride and hydrogen concentrations. Fluoride hinders the process of demineralisation and the regularity with which the plaque plummets lower than the critical level without consequent remineralisation. The manner in which remineralisation is affected by fluoride will be discussed later.

Even though caries development needs bacteria and sugars, its main influence is how susceptible the teeth are, the quality and quantity of saliva, the bacterial profile, and the length of time for which fermentable dietary carbohydrates exist for bacterial fermentation. Two of the most important bacteria in dental caries development are *Streptococcus sorbrinus* and *Streptococcus mutans*. These bacteria are efficient with regards to the use of sugar to produce organic acids. Also, like the majority of aciduric bacteria, they are able to synthesise insoluble plaque matrix polymers (extracellular dextran) from dietary sugars. This facilitates the tooth surface’s colonisation by bacteria. Fermentable monosaccharides have to exist for these streptococci to grow. Fructose and glucose are produced when sucrose is split by *S. mutans* using streptococcal invertase, which primarily produces lactic acid when metabolised. However, it can also produce other acids like formic and acetic acids. The plaque ecology is changed by the resultant drop in pH. When pH in plaque is low, acidic bacteria like bifidobacteria, lactobacilli, and streptococci thrive, considering that these do better in conditions of low pH in comparison to bacteria not linked to dental caries. Therefore, Chapple et al. (2017) conclude that for caries and periodontal diseases, fermentable carbohydrates are the most relevant common dietary risk factors; caries is mainly related to the fermentation process, which takes place in the dental biofilm, during which subsequent acids are formed.

Generally, dental caries is mostly distributed among older adults. Dentists evaluate the intensity of caries using the DT-decayed, MT-missing and FT-filled teeth (DMFT index).

The prevalence of caries in the UK is generally higher among older adults, with the incidence of caries appearing to be higher in care homes. This is not unexpected if one considers that care homes present added risk factors for caries as a result of functional limitations and deteriorating health in general. In the Adult Dental Health Survey (2009) (ADHS) aggregated sample of dentate adults, 29% had active caries. This proportion escalates to 40% in the 75 to 84 age group but drops to 33% for individuals above the age of 85. The numbers seem to be higher than in care home surveys. For care homes in West Midlands, 56% of the sample had active caries, while the proportion of residents with active caries in Wales was 73%. It appears that the prevalence of active caries in London households for people between the ages of 64 and 84 is the same as the ADHS figures for London regarding dentate adults. However, it needs to be noted that the estimate included individuals who were edentate, implying that caries prevalence could be higher. For London, in comparison to those in the age groups 65-74 and 75-84, the London survey shows that the prevalence of dental caries was higher at 35% (Moore and Davies, 2016).

The French High Health Authority (2010) report considered research on dental caries in the French population. The research concluded that the percentage of adults with at least one decayed tooth was between 33% and 50%. Regarding residents in long-term care facilities, between 30% and 60% had conservative care needs, and 44% had at least one decayed tooth. A study focusing on people residing in a care home concluded that 37% of the residents had caries (Rapp et al., 2019).

Studies done in the United States conclude that the prevalence of caries among older adult patients aged 75 years and above was higher than 40%. The studies also indicate that there is an escalation in the need for conservative care (Dye et al., 2007; Bagramian, Garcia-Godoy, and Volpe, 2009).

The incidence and prevalence of caries among older adult patients increase with age, becoming more pronounced with institutionalisation (Rapp et al., 2019). In comparison to people at home, patients in long-term care exhibit more cavities. Among older adults, the part of the tooth mostly affected by caries is the root (Randa, 2004). In comparison to other age groups, coronal fissures are not common in the older adult group. This can be accredited to physiological and anatomical changes. On the one hand, dental roots are exposed due to age-linked periodontal atrophy. On the other end, coronal relief is blunted by attrition, which also alters the interdental contact

points. For that reason, in the biofilm, food debris starts to accumulate in the interdental spaces because it is no longer being retained at the coronal level (Randa, 2004).

In the oral cavity, the distribution is characteristic. The process of caries starts at the root neck's interproximal and vestibular surfaces. Among patients that require the highest level of care, especially those with cognitive disorders, an absence of care and a lack of follow-up increase caries. Such a situation results in coronal fracture, with the tooth being eroded to the root remnant (Randa, 2004).

Dental erosion

The idea of dental erosion denotes an irreversible situation where the dental hard tissue is progressively chemically eroded by external or internal acids or chelation through a process in which bacteria is not involved. Other kinds of tooth wear, like attrition or abrasion (which could result from grinding of teeth or obsessive oral hygiene), are usually linked to erosion. It has also been suggested that in certain individuals, acid challenges could result from insufficient buffering capacity, or the low flow of saliva can worsen erosion. The sources of intrinsic acids include regurgitation and vomiting. On the other hand, extrinsic acids can emanate from the food consumed, such as citric acid, malic acid, ascorbic acid, tartaric acid and carbonic acids contained in fruit juices and fruits, still and carbonated soft drinks, some dry wines, herbal teas, and foods containing vinegar. Enamel's critical PH is 5.5. Consequently, any food or drink with a PH lower than 5.5 could lead to erosion. Erosion results in the tooth becoming smaller, and when it is severe, it can lead to a total loss of the tooth. When dental erosion becomes extensive, the restorative treatment tends to be expensive (Moynihan and Petersen, 2004).

Periodontal disease

Periodontal disease is a chronic condition that usually starts to become noticeable in middle age. Other than a severe deficiency of vitamin C, which could lead to scurvy-related periodontitis, little proof has been advanced regarding the link between periodontal disease and diet. However, Chapple et al. (2017) conclude that glucose and advanced glycation end-products cause a hyper-inflammatory state in leucocytes, which is the most likely biological mechanism for periodontal disease.

There is a growing interest among researchers in the possible preventative role that could be played by antioxidant nutrients. The leading dominant element in periodontal

disease aetiology is the existence of plaque, with prevention measures focusing on oral hygiene. Available evidence shows that the progress of periodontal disease tends to be more rapid in populations besieged by malnutrition (Moynihan and Petersen, 2004). Evidence also supports the role that can be played by nutrition in sustaining a sufficient host immune reaction. In malnourished children in Africa, studies have often singled out an overgrowth of periodontopathic organisms and yeasts. An escalation in volumes of plaque as a result of extracellular glucans production is linked to a high intake of sucrose. It has also been shown that there is a robust connection between gingivitis and plaque volume. Studies involving human intervention have concluded that diets that are high in sucrose are related to high volumes of plaque and escalated gingivitis when compared to diets low in sucrose (Moynihan and Petersen, 2004). Nonetheless, Gaengler et al. (1986) concluded that even if sugar is reduced to the minimum limits possible in the diet, the effect will not be adequate to prevent gingivitis development.

Weaknesses in the Saudi Arabian literature

Following a critical analysis of the results from the Saudi Arabian literature (Qutob, 2009), several weaknesses were identified. For instance, the majority of the non-comprehensive research assessing varying oral conditions is restricted to young people, thereby producing little information regarding oral conditions among older adults. Regionally, the unavailability of wide age distribution and comprehensive measures is evident. No data is available regarding oral health resources that can be used to improve oral health outcomes.

The Saudi Arabian literature lacks more recent information on dental education institutions and programs. Studies dealing with the topic are outdated, especially if one considers the changes since they were done. Added to this, research into dental treatment needs is lacking. Where studies are available, they suffer from a dearth of extensiveness and have participants in limited age groups, and some of them have participants from one gender. In Saudi Arabia, there is a dearth of studies estimating the difference between treatment needs and health supply. This is coupled with little to no details on the use of dental services and the factors impacting this utilisation. Finally, information regarding the aggregate service output and how busy dentists are together with patterns of dental care delivered at both the government and private sector is lacking (Qutob, 2009).

Oral health in Saudi Arabia

In most of the developed world, access to oral health services is often limited. This leaves teeth generally untreated, and in the case of excessive discomfort or pain, they are removed. Across the globe, many still believe that losing teeth is a natural part of ageing. Even though there are encouraging signs of the reduction of tooth loss among adults in current times, the percentage of edentulous adults in the 65 years and older category remains high in several countries. The WHO (2003) reports in its Global Oral Health Data Bank that in Saudi Arabia, between 31% and 46% of older adults aged 65 and above are edentulous.

A study by Al-Sinaidi (2012) focusing on older adult residents at the Riyadh Nursing Home concluded that the average loss of teeth among participants was 16. This implies that, on average, the number of remaining natural teeth among participating residents was 12 to 16 – a range below the 20 natural teeth recommended by the WHO. The same study showed that the average number of teeth lost in men was lower than that in women. This is an observation reported by several other studies, including Nordstro¨m et al. (1995), Ahlqwist (1989), Hiidenkari et al. (1996), and Takala et al. (1994). Al-Ghannam et al. (2002) did another study in the east of Saudi Arabia and concluded that one in every ten participants was wearing a denture, while over 25% needed one. Within the same sample, the same situation exists with regards to fixed prostheses. Peeran et al. (2016) conducted a similar study in Jizan and concluded that the percentage of people with prosthetic rehabilitation was low. The study, involving a comparison of different age groups, showed that there is a steady increase in tooth loss as people age: 59.1% (35–44 years), 83.2% (45–54 years), 81.3% (55–64 years), and 94.1% (65–74 years).

Saudi Arabian diet

The Arab Gulf world has experienced a drastic shift in food consumption habits, both qualitatively and quantitatively (Musaiger et al., 2012). This is a view supported by scientists, who note that the diet structure in this region is progressively moving in the direction of foods with more sugar and fat. These foods are also characterized by more saturated fats, while the intake of complex carbohydrates, vegetables, fruits, and dietary fibre is declining (Musaiger, 2012). It is these changing dietary habits that are being credited with the escalation of chronic conditions like DM and obesity in these

countries. In a list provided by the International Diabetes Federation (2007), Arab Gulf countries take three positions among the first five countries with the highest rate of diabetes and obesity (Farag and Al Wakeel, 2011).

With regards to national data on the dietary habits of Saudis, there is limited information. The inaugural report by King Abdul Aziz City for Science and Technology was published in 1995 (KACST, 1995). The data presented by the university was produced from an analysis of 19,598 individuals from different parts of Saudi Arabia. The study included sections with a dietary survey, biochemical and clinical study, and anthropometric measurement. An analysis of the data indicated that most Saudis consumed three meals a day, with the main meal being lunch. Usually, rice is consumed for the main meal with meat such as chicken or mutton and a salad. Among the respondents, less than half (38%) consumed vegetables on a daily basis. At 40% daily, the proportion of people that consumed fruit was higher. Fish consumption of between 2 and 4 times a week was low at 29.2%. Milk or milk products were consumed by more than half (60%) of the participants on a daily basis (Ministry of Health 2012).

The World Health Organization (WHO), Ministry of Health (MOH), KSA, and King Faisal Specialist Hospital and Research Center (KFH & RC) in Riyadh all supported a project involving the surveillance of risk factors of chronic diseases among Saudi Arabians. The project involved 5,000 participants aged between 15 and 64. The data from the project indicated that nine in every ten males (91.6%) and females (95.4%) said that they did not meet the recommended five servings of fruits and vegetables daily. The results also show that the mean consumption of fruits per week was 3.5 days for females and 3.4 days for males. With regards to vegetables, the mean weekly consumption for females was 4.3 days while that for males was 4.4 days (MOH, KSA, WHO, KFH & RC, 2005). These results are consistent with the view of Musaiger (2002), who says that the main source of fibre for most Saudis is vegetable-based foods (31%), with cereals and their products coming second (26%), and fruits and their products coming last (Ministry of Health, 2012).

The Saudi dietary guidelines

In the development of dietary guidelines for Saudi Arabia, the leading message is that for a diet to be healthy, it needs to be balanced through moderation and variety. Dietary guidelines are tools that take the science of nutritional requirements and turn it into an

applied arrangement of food choices recommended to be followed by ordinary people. From a national perspective, these guidelines determine the direction taken by health promotion and reduction of risk. In most cases, these guidelines are the basis of national educational programs and food and nutrition policies (Ministry of Health, 2012).

Saudi Arabia seeks to attain several objectives using its dietary guidelines. An important goal is to boost the health of the kingdom's citizens and residents through the promotion of healthy eating habits while also encouraging physical activity so that such behaviours start to be perceived by communities as normal ways of living. The authorities in the kingdom also want the benefits of having citizens and residents who consume foods with a high nutritional value. Such foods include those high in protein, minerals and vitamins, and fibre. The main objective is to reduce the consumption of foods with poor nutritional value, such as saturated and hydrogenated fat, sugars, and salt. It is expected that this will promote the healthy development of infants, children, and adolescents. The promotion of physical activity, which is central to the guidelines, seeks to lower the incidences of common ailments linked to diet in the community (Ministry of Health, 2012).

With the aim of making it easier to communicate the recommended foods and portion sizes, the Saudi dietary guidelines are presented in a graphical way. The graphic is in the form of a palm tree that has food groups spread across the trunk and leaves in the percentage of their recommended level of consumption. At the bottom and the biggest leaf of the palm tree is the largest group of food, which includes cereals and bread. This represents the most important source of carbohydrates (6–11 servings/day). With a recommendation that they should be consumed in three to five servings a day, vegetables are next because they contain high levels of minerals and vitamins. At the next level is milk and its products, where the recommendation is two to four servings daily. These provide calcium and protein. In the smallest top levels of the tree are sugar and salt, showing that the consumption of foods containing them should be minimized. An important aspect of the food palm is water because the weather in Saudi Arabia is generally hot. Considering the role played by physical activity in promoting a healthy lifestyle together with a balanced diet, the healthy food palm also recommends that people should engage in physical activity of between half an hour to an hour daily, based on their health status (Ministry of Health, 2012).

Socio-economic status

Generally, people belonging to the higher levels of the social hierarchy tend to enjoy better health compared to those in the lower levels. In the civil service in the UK, the Whitehall studies (Marmot et al., 1991) concluded that there is a gradient pattern between health and socio-economic status (SES), which can be understood that as the occupational grade of an individual improves, so does their health, resulting in lower mortality. Following these studies, there has been a greater focus on the connection between health and SES, leading to suggestions that there needs to be an effort to decrease the social gradient in health by dealing with health's social determinants (Marmot et al., 2008; Marmot and Bell, 2011).

SES can be defined as a reflection of an individual's social position. It also shows the status and resources that one enjoys (Fujishiro et al., 2010). A number of indicators can be used to determine objective socio-economic status: educational level, income, and work status (Bartley, 2004). Notwithstanding the fact that the indicators of socio-economic status overlap, it still needs to be noted that they are distinct and enumerate equally distinct elements (Adler and Snibbe, 2003). For instance, an individual's educational level is a reflection of the social networks, credentials, and the knowledge held by that individual. On the other hand, income is a reflection of an individual's access to quality food, accommodation, and healthcare, while occupation shows class or social standing (Nakao and Treas, 1994; Macintyre, 1997). Generally, research employs either a single, a composite, or all three indicators.

Several health problems are connected to the SES-health gradient, including infant mortality, oral health, mental illness, hypertension, back ailments, arthritis, cancer, kidney diseases, stroke, heart disease, infant mortality, and many others (Winkleby et al., 1992; Connolly et al., 2000; Everson et al., 2002; Gruttadauria et al., 2011; Damiani et al., 2011). The connection between oral health and socio-economic status is an established one (Watt and Sheiham, 1999; Locker, 2000; Sheiham et al., 2011a). In both young and old people, oral health differences have been frequently validated in different countries using varying oral health markers and varying objective socio-economic position indicators (Watt and Sheiham, 1999; Locker, 2000; Thomson et al., 2004; López et al., 2006; Sanders et al., 2006a; Sanders et al., 2006b; Sabbah et al., 2007).

In their study, Paulander et al. (2003) evaluated the connection between the level of education and oral disease and an SES indicator. They accomplished their objectives using a random sample consisting of individuals aged 35, 50, 65, and 75. Conclusions from the study show that people with a lower level of education in all groups also tended to have a higher number of missing teeth, fewer intact tooth surfaces, and higher attachment loss. However, there was no difference shown regarding dietary habits and tooth cleaning between the high education and low education groups. Even though a relationship between oral health and education was established, the study did not evaluate the role of confounders, impacting the reliability of the study's conclusions.

In another study similar to Paulander et al. (2003), Sabbah et al. (2009) arrived at results similar to the former. They concluded that a lower level of education and income were connected to an escalation in gingival bleeding, periodontal attachment loss, and a lower number of intact occlusal surfaces. Even after health-related behaviours had been adjusted for, the disparities in income and education in all clinical health indicators persisted. This can be read as an indication that the connection between oral health and socioeconomic status is only partly explained by health-related conduct. Sabbah et al.'s (2009) study differs from that of Paulander et al. (2003) in that it concludes that higher education and income level are linked to a higher degree of desirable health behaviours such as regular visits to the dentist, less smoking, and a healthy diet. The study concludes that there was adverse oral health-related conduct among individuals with a lower level of education and income, while individuals with higher education and income level showed more positive behaviours. Even after the potential confounders were adjusted for, income and education remained substantial oral health social determinants (Tomarken and Waller, 2003).

A report on the social determinants of oral health produced by the Australian Dental Statistics and Research Unit indicates a connection between poor oral health and low income (Tomarken and Waller, 2003). There is a tendency for individuals in the low-SES category to exhibit poor health in comparison to those whose socioeconomic status is higher, especially regarding tooth loss and periodontitis (Turrell et al., 2007; Lawrence et al., 2008; Nguyen et al., 2010). Costa et al. (2012) recently conducted a systematic review of dental caries and SES indicators among adults and produced evidence showing that indicators of SES status like an individual’s occupation, level of

education, and income, are connected to a higher dental caries severity among adults (Costa et al., 2012).

Dental behaviours

Behaviours associated with dental health, like chewing tobacco, regular visits to the dentist, and dental self-care, have been indicated to be associated with OHQoL. In its social determinants of oral health report, the Australian Dental Statistics and Research Unit indicated that low self-care and dental visit scores are connected to poorer OHQoL. A qualitative study involving adults in the UK conducted by McGrath and Bedi (2001) concluded that regular dental attendance has a positive effect on the perceptions of individuals regarding their OHQoL. The same study also proposed that the adults who only visit the dentist because they have a problem or those who do so irregularly tend to have poorer OHQoL in comparison to those who visit the dentist regularly.

Thomson et al. (2011) conducted a prospective study in New Zealand involving 932 participants. The study explored the impact of routine visits to the dentist over an extended period on missing teeth, caries, and self-rated oral health experience. The dental attendance data were recorded at different ages: 15, 18, 26, and 32. The study concluded that superior health outcomes could be predicted by routine visits to the dentist. At 32, those who routinely attended their dentist appointments had fewer caries and tooth loss and better self-reported oral health in comparison to those who did not. When socioeconomic status and gender were adjusted for, the finding still held. This study's conclusions are in keeping with those from previous research in New Zealand by Thomson et al. (2004), who focused on young adults. The study concluded that the chance of problem-oriented attenders experiencing tooth loss related to caries was three times that of those who routinely attended over a period of eight years. Both the studies cited in this paragraph deliver proof that there is a link between oral health and dental attendance. However, while both the studies employed both self-reported and clinical measures, none of them used an OHQoL measure to test the connection between OHQoL and dental attendance.

The sample used in the Savolainen et al. (2005a) study consisted of 4039 adults living in Finland aged between 30 and 64 years old. The study concludes that the participants who were more impacted (determined using OHIP-14), indicating poorer

OHQoL, attended to the dentist in an irregular manner. Nonetheless, a follow-up study conducted recently in Australia concluded that there was no significant connection between dental attendance and OHIP score. However, the same study concluded that there is a connection between a greater improvement in OHQoL and dental attendance when influenced by where an individual lives (Crocombe et al., 2011). From this longitudinal study's results, it can be inferred that dental attendance patterns could be influenced by the area, a factor that also has an impact on the accessibility of services in a particular area and the dental conduct of people residing in that location. Such a finding also brings to the fore the issue of inequalities in health based on location.

In a study related to Savolainen et al. (2005a), Brennan and Spencer (2009) conducted cross-sectional research involving 1,859 individuals with an average age of 30 years. This Australian study concluded that individuals with a high tooth brushing sequence had lower OHIP-14 scores and consequently enhanced OHQoL. Nonetheless, both studies have limitations. For instance, they are cross-sectional and do not deliver adequate evidence to propose a causal relationship. Yiengprugsawan et al. (2011) conducted a cross-sectional study involving individuals aged between 15 and 87, and the results showed that the OHQoL of smokers is poorer.

From the studies cited above, it can be inferred that various dental behaviours, such as visiting the dentist, brushing teeth, and smoking, have a relationship with OHQoL. The use of large and representative samples with a broad age range constitutes some of the main strengths of these studies. Also, the studies deliver evidence showing that there is a potential connection between OHQoL and dental behaviour. This connection has been consistently proven by results from different counties. Nonetheless, most of the studies are cross-sectional and fail to deliver proof of a causal relationship between the two. It is also noted that the variables tested by these studies are different, and the connections between them are studied in isolation, failing to account for complicated interrelationships. While the studies cited above deliver some evidence of a connection, no conclusions can be drawn from them.

The connection between differences in OHQoL and dental conduct delivers a behavioural explanation regarding oral health inequalities. Nonetheless, it has been posited that focusing only on conduct does not provide a full explanation for all the inequalities because they are impacted by and acquired through a broader array of

determinants connected to social, psychological, and environmental factors (Watt, 2007). It is on this basis that a prospective study testing the connection between OHQoL and dental behaviours, accounting for the impact of other possible factors using advanced statistical methods, is called for.

Oral hygiene practice and habits

Apart from the endorsed methods of using fluoride toothpaste and a toothbrush as effective oral hygiene tools, traditional methods like chewing sticks are also commonly used. The chewing of a stick, called *Miswak*, is common among older adults with low SES status (Al-Otaibi and Angmar-Månsson, 2004). These individuals perceive this method to be a cultural and traditional oral hygiene method. Miswak is obtained from the *Salvadora persica* (S.P.) tree, also known as the Arak tree. The tree has unique characteristics in terms of taste, hardness, and size. It contains several crucial vitamins and minerals that play an important role in preventing dental caries, including vitamin C, fluoride, and chloride (Ezoddini-Ardakani, 2010). It has been shown that these elements have an antibacterial activity that impacts *Streptococcus mutans* and *S. faecalis*, and they also have an anti-caries effect. Moreover, Miswak is exceptionally effective in reducing gingivitis and the dental caries rate (Ezoddini-Ardakani, 2010).

The fact that the use of Miswak is linked to religion means that the method will continue to be used by Saudi Arabians for oral hygiene into the foreseeable future (Al-Otaibi and Angmar-Månsson, 2004). It is generally accepted that an individual's level of education plays a vital role in maintaining good oral hygiene. For instance, educated people in Saudi Arabia tend to prefer using toothbrushes, while those with low levels or no education use the traditional Miswak (Al-Otaibi and Angmar-Månsson, 2004). This means that people generally tend to have more access to a toothbrush as they get more educated. Thus, it can be posited that as school children in Saudi Arabia get more educated, the incidence of dental caries and periodontal disease will be lowered in the general Saudi Arabian society (Al-Otaibi and Angmar-Månsson, 2004).

As a means of combating dental caries and periodontal conditions, Miswak cannot be ignored. The role of Miswak becomes even more important if one considers that although dental services are free in Saudi Arabia, many people still only visit dentists when they need emergency care. This could be a result of a lack of oral health awareness and education.

The aged population in Saudi Arabia in numbers

The Elderly Survey (2017) shows that at 1,050,885, the number of people in the elderly group (65+ years) constitutes 3.23% of the population as a whole. Males constitute 42.52%, and females account for 57.48% of this number. Specific to Saudi Arabia, the number of elderly (65+ years) is 854,281, representing 4.19% of the total population in the kingdom. Males account for 48.9% of this number, while females constitute 51.1%.

From the survey, it can be seen that the elderly (65+ years) population is categorised by sex, age group, and nationality as follows: The proportion of the 65 to 69 age group in the total population (65+ years) is 39.4%. Among these, the ratio of Saudis reaches 74.9%, of which 48.6% are male, and 51.4% are female. In the 70 to 74 year age group, the ratio of the elderly among the total population (65+ years) is 26.3%. Among these, Saudis constitute 80.8%, with males accounting for 49.4% and females 50.6%. The older adults in the age group 75 to 79 among the 65+ years population account for 15.7%, with Saudis representing 87.5%. In this number, males represent 49.4% and females 50.6%. The 80+ group represents 18.7% of the 65+ year-old population. The proportion of Saudis in this group is 90.2%, with males representing 48.3% and females representing 51.7%.

By marital status, the results of the survey show that married individuals constitute the highest percentage (70%), with widowed individuals following at 27%. Individuals that never married constitute the lowest percentage at 1%, with divorced individuals following at 2%. A comparison between female and male individuals among older adults in Saudi Arabia (65+ years) shows that men have higher marriage percentages (46% are men and 24% are women), while the proportion of widowed individuals is higher among females than males (25% are women and 2% are men).

With regards to educational status, the results of the survey show that out of the aggregate population (65+ years), among the individuals that never married, the proportion of people with a primary, intermediate, or secondary education is 14.35%. Out of these, 7.63% are males, and 6.72% are females. Among those who have been married before (married, divorced, widowed), the proportion of individuals with a primary, intermediate, or secondary education is 19.62%, of which 15.93% are male, and 3.68% are female. Out of the population that has been married before, 6.74%

have completed their undergraduate diplomas, with males representing 6.07% and females 0.67%.

The Saudi National Survey for Elderly Health (SNSEH) 2006–2015 (Khoja et al. 2018) found that in the aggregate unweighted sample, males accounted for 60%. With a standard deviation (SD) of 0.3, the mean age was 70.1. For females, the mean age was 69.33 (SD = 0.4), while that of males was 70.98 (SD = 0.3) $P < .001$. Participants came from five regions: central (23.65%), western (30.76%), eastern (13.76%), southern (25.01%), and northern (6.83%). Of these participants, 20% live in rural areas, and 80% reside in urban regions, with 1% undocumented. When it comes to education, the majority (70%) of the participants are illiterate, followed by participants who have completed university degrees. The most common marital status was monogamy (57.19%), with the widowed taking second place at 22.98%. Also, 13% of participants reported that they had married more than one wife.

With regards to income, the highest number of participants indicated that they earn more than SR2,500 (53.5%), followed by SR2,500 - SR4,999 (22.7%), SR5,000 - SR9,999 (13.5%), and greater than SR10,000 (5.6%). For most of the participants (41%), the leading source of income is the government pension, followed by degree descendent (27%), self-support (18.4%), other relatives (2.7%), other sources (5%) like organisational charities, and 6% were unknown. Asked to indicate if their income is adequate for their needs, there was a proportional connection between the response “very well” and income. On the other hand, there was an inverse relationship between the answers ‘‘poorly” or ‘‘sufficient” and the income. In comparison to those whose income is lower than SR2,500, SAO with incomes between SR5,000-7,499 were 3.04 times more likely to say that their income was sufficient for their needs [95% confidence interval (CI): 2.15, 4.29]. A similar inclination was noted among Saudi older adults (SOA) who had an income of SR7,500-9,999 as well as income higher than SR10,000.

Regarding working status, only 11% of the participants were working at the time of the interview, with 53.31% reporting that they were unemployed, 32.9% were housewives, 2.21% were retired, and 1.8% were missing. Out of the participants who indicated that they were employed, the nature of work differed. For example, 5.8% of participants were in a long-term contract, while 1.4% stated that their contracts were short term. The other 4.33% indicated that they were self-employed, worked in noncontract jobs,

or were volunteering. Out of all the participants, those with less than one job constituted less than 1%. While there was a strong association between self-support and lower odds of not working (unadjusted OR = 0.2; 95% CI: 0.16–0.26), income sources like pensions from the government (unadjusted OR = 1.4; 95% CI: 1.11–1.7), children (unadjusted OR = 3.1; 95% CI: 2.24–4.38) or relative sponsorship (unadjusted OR = 3.6; 95% CI: 1.13–11.5) were all related with higher odds of not working. The majority of participants lived in modern houses, with most of them residing in small houses (39.28%), while 27.6% lived in large houses (27.60).

With regards to education level, the collected data demonstrated that females had lower levels of education in comparison to males. For example, male illiteracy levels were 51.2%, while that of females was 87.6%. In the same vein, the proportion of females that completed elementary school was only 10%, while that of males was 33%. Generally, there were no statistically significant differences in geographic locations and site of residence (urban vs rural) by gender.

Aim

The aim of this study is to assess the impact of oral health status on oral function and dietary choice in older people in Saudi Arabia.

Objectives

The world's population is getting older: 2020 was the year when, for the first time in human history, there were more people alive in the world aged 65 and over than 5 and under.

There is also a simultaneous change in the developed world, with more older people retaining natural teeth into their old age. The historical pattern of older people being edentulous is now inaccurate.

In Saudi Arabia, about 5.4% of the population is over the age of 60 (about 850,000 people), with an average age of around 74 years. In Saudi Vision 2030, announced by the government in 2016, the aim is to increase the average age to 80 years, which means more older people in the population.

As people get older, the state of oral health impacts food choices, which can lead to individuals eating unhealthy food with a high concentration of sugar and saturated fat while having low fibre. This will be in contrast to the proper diet recommended for an older person, which should be low in energy but high in micronutrient and protein content (Walls and Steele 2004; Host et al. 2016). There is limited literature regarding the effect of oral health status on dietary selection and food choice in the Arabian diet for the elderly; hence, the necessity of this study.

The specific objectives of the proposed research work are:

- Establish the dental and oral health status of the sample of aged people, including the condition of the natural teeth along with the ability to chew and swallow, to give a nationally representative picture of the oral health status and level of function of older adults in Saudi Arabia.
- Provide some quantitative information on the food and nutrient intakes, sources of nutrients, and nutritional status of the elderly in the population of Saudi Arabia to inform government policy.
- Provide information on social and domestic circumstances that may influence participants' food consumption and nutritional status.
- To compare this research finding with previous studies in the UK and other developed countries.

The hypotheses tested in this study

Socio-economic status influences the relationship between nutritional intake and dental status in the aged population.

Null hypothesis:

There is no difference in the relationship between nutritional intake and dental status in aged people who have a higher socio-economic status compared to those who have a lower socio-economic status.

The ageing process has an effect on dietary choice.

Null hypothesis:

There is no difference in the relationship between the ageing process and dietary choice.

The oral function associated with tooth loss influences dietary choice in the Saudi aged population.

Null hypothesis:

There is no difference in the relationship between dental status and dietary choice of aged people based on their demographics.

CHAPTER THREE MATERIALS AND METHODS

Overview

This is a cross-sectional clinical examination and self-report online questionnaire study.

Study Area

An urban population in a developing country forms this research's background. Saudi Arabia will be used as an example background, representing a population of elderly individuals in an urban area of a developing country.

The Saudi Arabian General Authority for Statistics (GAStat) indicates that the kingdom's population increased by 16.5% between 2010 and 2016. This means that 6.5 million people have been added to the population in a little over six years, taking the population of the kingdom to an estimated 32 million. Put as a year-on-year growth, these numbers represent 2.5%. Out of the total population, 5.5% are above the age of 60. When considering Saudi citizens only, the population is estimated to be 20 million, with 1.4 million (4.2%) representing people aged 60 and above (Statistics, 2016).

Setting and population of the study

For the purpose of this study, an individual is defined as being elderly if they have reached the age of 60 at the time when data will be collected. The objectives of the study were achieved through the use of the cross-sectional study design. Only Saudi citizens were included in the study.

Saudi Arabia is divided into 13 administrative regions. In these regions, the number of dental centres is around 40. For this study, five representative regions were selected. These are the central (Riyadh), east (Dammam), north (Hail), south (Jazan), and west (Jeddah). From each region, one representative health centre was chosen. The initial stage involved sampling and locating the oral health centres in each of the regions. Potential participants above the age of 60 were identified using the Family Health Records in Primary Healthcare Centres, providing this study with a sampling frame. From the individuals identified, a stratified sample was then drawn so as to get the sample needed for the study. Age and gender were used to stratify the sample to ensure a representative gender structure and an adequate number of individuals to

make it possible to stratify the sample into subjects aged 60 to 74 and 75 years and above.

Once the participating elderly people had been selected, each was contacted so that a personal visit could be arranged at the closest dental healthcare centre. A predesigned data gathering form was used during each visit. All participants coming for an oral health examination were included. Each participant was asked to fill in two online questionnaires during the visit. The first questionnaire was a foods frequency questionnaire, and the second gathered information on the demographic, socioeconomic, and behavioural risk factors related to teeth, a brief oral health impact profile form (OHIP-14), general and oral health status, oral health habits and the oral health facilities used by the participant, physical activities and food types. All the study elements were done on the same day, while others completed the online questionnaire at home.

Estimates indicated that the minimum required sample for the analysis of the online dietary survey, oral health examination, physical activities survey, and OHIP should be 384 individuals aged 60 or above living independently. Also, the required sample would have approximately an equal number of people of each sex. The sample was expected to cover the different months of the year to reflect seasonal changes in dietary habits.

Population

The target population comprised citizens of Saudi Arabia aged 60 and above.

The accessible population was randomly selected based on the Saudi Demographic and Health Survey sample.

Sample design for the Saudi Demographic and Health Survey

The situation in Saudi Arabia is rather unique in that all the kingdom's regions are covered under the Primary Healthcare (PHC) centre services. The regions are divided into geographic areas based on the PHC centre serving them, which is known as the PHC centre’s catchment area.

The aim of the Demographic and Health Survey (DHS) is to attain full representation of all the regions across the kingdom through a sampling framework designed to

include age group, demographic diversity, health functioning, administrative, and geographic strata.

a) Geographic strata (GS)

The sample was planned in such a manner that it accounted for the national geographic diversity, whereby the kingdom comprises five geographic regions (strata), in the following manner:

- Northern
- Southern
- Western
- Eastern
- Middle

b) Administrative division

The five geographic divisions are further divided into 20 administrative regions. These include 13 administrative regions and a further 7 major governorates.

Inhabited Areas (IA) – Each region or governorate includes various kinds of inhabited areas:

- Metropolitan cities
- Big cities
- Medium-sized cities
- Towns
- Mother villages
- Medium-sized villages
- Small villages
- Satellites

Inhabitant subdivisions

The cities and towns are further divided onto inhabitant sub-divisions:

Many blocks: These are large populated areas surrounded by wide roads.

Blocks: These represent smaller populated areas surrounded by narrower streets inside the many blocks.

c) Health Functioning Divisions (HFD)

The Saudi Health Ministry is responsible for providing services across the kingdom using 20 directorates of health (general directorates and directorate of health affairs). Each administrative region has one directorate of health (DH).

- Directorates of Health (DH): These are responsible for running 2,282 PHC centres across the country.
- Health Services Outlets (HSO): Every PHC centre is responsible for a clearly demarcated geographic area, known as a catchment area, with a specific number of people residing in the area.
- Health Functioning units to Administrative Units: In each administrative region, there are about 2,526 neighbourhoods.

The ratio of health functioning divisions to PHC centres of 1:1.1. This implies that the enumeration units employed in census surveys and demographic units are almost the same as the enumeration lists employed in the Saudi DHS 2017 Survey.

d) Demographic strata (DS):

The demographic sample is reliant on the country's aggregate population. At the time of the DHS planning, this population was around 25 million. This totals around 5 million households.

The demographic strata are contingent on the size of the population in each PHC centre's catchment area.

- The size of the population per each PHC centre's catchment area is divided into eight strata signifying varying population densities while also reflecting geographic character (location):

Population size strata (individuals)	Possible geographic character (location)
1 – 499	Satellites
500 – 999	Small villages
1,000 – 4,999	Medium-sized villages
5,000 - 9,999	Towns
50,000 to 99,999	Big cities

100,000 +	Metropolitan cities

- Household: In the survey, a golden number of households was targeted, representing around 1% of the aggregate number of houses across the kingdom. Around 48,000 households were randomly selected prior to the interviews. This represents 98% of the targeted household size. In the sampled households, it was expected that about 250,000 individuals would be accessed. This number represents 1% of the kingdom's population. The number is achieved by assuming that an average family consists of five individuals in a household.
- Individuals: The number of individuals involved in the randomly conducted interviews was 115,000, representing around 0.5% of the entire country's population.

e) Age group strata

The age groups were categorised based on the different human lifecycles as periods based on the World Health Organisation (WHO) classification.

From each family, one person representing each age group was selected randomly.

Each age group constituting a life cycle period was employed as a sample stratum, as represented in the table below:

Life cycle period (stratum)	Age group period in months and years
Infancy	0 - 24 months
Early childhood	25 – 59 months
Middle childhood	5 – 9 years
Late childhood (early adolescent)	10 – 14 years
Middle and late adolescence	15 – 19 years
Youths	20 – 24 years
Female reproductive age (never married)	15 – 49 years

Female reproductive age (married/previously married)	15 – 49 years
Adulthood (males)	25 – 59 years
Females in post-menopause	50 – 59 years
Elderly	60+ years

f) Sample size

- Households: 50,000 households was determined to be the aggregate household sample. This number represents around 1% of the nationwide household size of about 5 million households.
- Individuals: In the 50,000 households, there are around 250,000 individuals, representing around 1% of the aggregate population of the kingdom. This is according to the estimates based on the 2010 census at the beginning of the Saudi DHS planning.
- PHC centres: 571 PHC centres were selected randomly, representing about a quarter of the aggregate PHC centres in the kingdom, which has a total of 2282 PHC centres.

g) Selection and distribution of the households sample

1. In-between regions

- The aggregate size of the households in the DHS survey (50,000) was distributed across all regions of the directorate of health nationwide. This was done with the aim of making it proportionate to the size of the population in each region.
- Saudi Arabia consists of different administrative strata:
    - Regions: The official national administrative regions (13)
    - Governorates: The main governorates (7)
    - Directorates of health: The directorates of health consist of 80 PHC centres with their catchment areas.
    - Cities, towns, villages, and satellites

2. In the regions (sample selection of PHC centres)

Using the systematic random sampling method, a sample consisting of 25% of PHC centres was selected.

3. In-between PHC centres' catchment areas

The samples of 25% of households per region were distributed to the randomly selected PHC centre equivalent to the population size in the catchment area of each PHC centre.

4. Within PHC centres' catchment areas

For each selected PHC centre, the sample size was distributed across the many blocks in the PHC centre catchment area. This was accomplished using a cartography map, obtainable in the sanitarian room of all PHC centres across the kingdom.

h) Age group samples of individual selection and distribution:

- In-between age groups

The number of individuals representing various age groups was selected randomly with the aim of ensuring that it is proportionate to each age group's size within the aggregate size of the kingdom's population.

- Within each age group

Using the systematic random sampling technique, one person was selected from every age group.

The sample for this present study comprised 600 households, with older adults selected randomly from Saudi DHS, with over 1,000 Saudis aged 60 and above.

Before taking part in the study, consent was requested from the participants. Only then would the participants be asked to fill in an online questionnaire.

Exclusion criteria

Participants who did not fill in the consent form or who declined to participate were excluded.

Recruitment

The oral health examination happened during a special visit organised by the researcher in collaboration with the dental health centres. Following the examination

was the administration of the online questionnaires. Each oral examination lasted between 5 and 20 minutes, with the time determined by the participant's oral health status. The researcher asked each participant a list of brief screening questions before starting the examination. The aim of these questions was to determine if there were any medical contra-indications that could impact any element of the oral health examination.

In the event that an individual was edentate, the data were only collected in relation to the soft tissue condition and the type and condition of any dentures that remained intact. For participants that were dentate, the examination was more comprehensive, beginning with a coronal examination. This was followed by the examination of the root surfaces so that the existence of caries, type, and state of restorations, and the presence of root exposure in case of root surfaced could be determined. Coronal and vertical wear was then measured using the Basic Erosive Wear Examination. The existence, severity, loss of attachment, and periodontal pocketing were measured using the Basic Periodontal Examination. In the event that a medical contra-indication to gingival probing was identified before the examination, the periodontal examination was skipped. Instead, an examination of the soft tissues, type, and state of any dentures was done. Each individual who took part in the survey was given assurance that their participation was voluntary and that they had the right to withdraw from the study at any time.

Rewards

To acknowledge their participation, each participant was provided with an oral hygiene appointment free of charge and was referred to a specialist in the event that dental treatment was required.

Sampling

The sample of individuals who were living independently was randomly selected from the Saudi DHS sample, which constitutes typical health and demographic survey. The Multistage Stratified Random Sampling (MSRS) method was used to conduct the cross-sectional nationwide house-to-house survey. An aggregate of 384 participants was randomly selected. Another 256 participants were identified as reserves to ensure replacement in the event that any of the original participants were unable to continue participating for any reason.

To come up with a representative sample for proportions, the equation below is proposed by Cochran (1963) for populations numbering over 100,000.

$$n_0 = \frac{Z^2 pq}{e^2}$$

Where $\boldsymbol{n_0}$ is the sample size, Z is the abscissa of the normal curve that cuts off an area α at the tails (1 - α equals the desired confidence level, e.g., 95%), e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population, and q is 1-p.

Considering that no prior study (survey) existed in connection with the effect of dental status on food choice for older adults in Saudi Arabia, it can be assumed that p=0.5 (maximum variability). It can further be supposed that the required confidence level is 95% and ±5% precision.

The subsequent sample size is presented using the equation below:

$n_0 = \frac{Z^2 pq}{e^2}$ $\quad$ $n_0 = \frac{(1.96)^2(.05)(.05)}{(.05)^2}$ $\quad$ $n_0 = 384$

Sample size

Strata:	Number of people in Strata	Sample Frame*	Target Sample
Central	M(108462)F(100705)T(209167)	157	94
North	M(35856)F(36421)T(72277)	54	32
South	M(94180)F(110487)T(204667)	153	92
East	M(46800)F(52856)T(99656)	75	45
West	M(132094)F(136420)T(268514)	201	121
Total	M(417392)F(436889)T(854281)	640	384

*40% is added to the sample size to compensate for persons who may not be successfully contacted or who may not respond,.

Conceptual framework

This study explored the connection between socio-economic factors, like family income and education level, demographics such as marital status, age, and gender, behavioural risk factors related to hygiene, smoking, and diabetes, and food type choices. The present study makes use of a shortened version of the oral health impact profile (OHIP-14) to investigate the OHRQoL of the participants. The Basic Periodontal Examination (BPE), decayed-missing-filled teeth index (DMFT), and denture status were used in the assessment of the dental status of the participants during the clinical oral examination. The Food Frequency questionnaire was used for assessing diet.

Below is a presentation of the diagnostic criteria employed across the oral examination.

The diagnostic criteria used throughout this oral examination were as follows.

Dental examination (WHO 2013)

A plane mouth mirror was used to conduct the dental caries examination. Visual evidence of caries on the surface of the tooth was confirmed using the CPU probe.

The diagnosis of a tooth status and coding was done as per the following protocol:

Sound crown and root: Where a crown indicates no evidence of untreated or treated clinical carries, it is coded as sound. A root is recorded as sound when exposed, and there is no proof of untreated or treated clinical caries.

Carious crown or root: If the lesion is a fissure or pit, a caries is entered as present. It is also recorded as present if on a smooth tooth surface the cavity is clear, the wall or floor is detectably soft, or the enamel is undermined. This category should also include a tooth that is filled temporarily or one that is sealed but also decayed. With regards to a carious root, caries is recorded as existing when a probe with a CPI indicates a lesion that feels leathery or soft. In the event that the carious lesion does not include the crown, it should be entered as root caries. Where both the root and the crown are affected by a single carious lesion, the potential location of the lesion should be entered as the site of decay. Where identifying the location of origin, the record should indicate that both root and crown are decayed.

Filled crown with caries and filled root with caries: If one or more permanent restorations exist and there are one or more decayed areas, a crown is recorded as

filled with decay. With regards to filled root with caries, a root is recorded as filled with caries if it consists of one or more decayed areas and one or more permanent restorations. Where the restoration includes both the root and crown, it becomes a challenge to identify the site of origin. Regarding any restoration that includes both the crown and the root with secondary caries, the most probable location of the primary carious lesion is entered as filled with decay. If identifying the location of origin of the primary carious lesion is not possible, both the root and the crown should be coded as filled with caries.

Filled crown, with no caries and filled root with no caries: If one or more permanent restorations exist and no part of the crown has any caries, a crown is entered as filled. This category also includes a crowned tooth as a result of earlier decay. If the crowing of the tooth resulted from reasons that do not involve caries using a fixed dental prosthesis abutment, it should be coded 7. With regards to a filled root with no caries, a root is recorded as filled, without caries, if there is an existence of one or more permanent restorations and no evidence of caries on the root. Where both the root and the crown are involved in the fillings, it is challenging to identify the site of origin. If any restoration included both the root and the crown, the most probable location of the primary carious lesion is entered as filled. Where identifying the site of origin is not possible, both the root and the crown are coded as filled.

Missing tooth due to caries: This code contains permanent teeth that are removed as a result of caries and are entered in the coronal status category. It should be noted that a tooth's root status scored as missing as a result of caries has to be placed under Codes 7 or 9. In Code 4, the only teeth that should be entered are those that are missing because of caries and for no other reason.

Missing permanent tooth due to any other reason: Coded under this category are teeth that are considered to be missing congenitally or were removed because of trauma, periodontal disease or orthodontic reasons. As is the case with Code 4, in Code 5, two entries can be connected using a line in the event of fully edentulous arches. Note: Where a tooth is scored 5, its root status should be recorded under Code 7 or 9.

Fissure sealant: Under this code belong teeth where the occlusal surface or pits are filled with fissure sealant. This is also the code for a tooth whose occlusal fissure has been made bigger using a bur (with a flame-shaped or rounded) so that a composite

material can be inserted. Where a sealed tooth also has caries, such a tooth should be placed under Code 1.

Fixed dental prosthesis abutment, special crown or veneer: This code is employed under coronal status to show that a tooth constitutes part of a fixed bridge abutment. This code is for crowns inserted for reasons that have nothing to do with caries and for laminates of veneers casing the tooth's labial surface and with no proof of restoration of caries exists. Note: Where a fixed partial denture pontic is used to replace a missing tooth, such teeth are placed in Code 4 or 5 under coronal status and Code 9 is given to the root status. Implant: Under root status, this code is used to show that an implant has been positioned as an abutment.

Unerupted tooth (crown): This is a category that is limited to permanent teeth and is only employed in the event where the tooth space has an unerupted but does not contain a primary tooth. All calculations that concern dental caries exclude all teeth entered as unerupted. Also, if a tooth was lost because of trauma or is congenitally missing, it is not placed in this category.

Not recorded: Under this code, all erupted permanent teeth that have not been examined for whatever reason are entered. Code 9 is employed under root status to show either that the existing calculus makes it impossible to examine the tooth or that the tooth has been extracted.

Coding the dentition status – permanent teeth (WHO 2013)

Code Condition		**Status**
Crown	Root	
0	0	Sound
1	1	Caries
2	2	Filled, with caries
3	3	Filled, no caries
4	–	Missing due to caries
5	–	Missing for any other reason
6	–	Fissure sealant

7	7	Fixed dental prosthesis abutment, special crown or veneer/implant
8	8	Unerupted tooth (crown)/unexposed root
9	9	Not recorded

Tooth wear

Erosive tooth wear was assessed using the Basic Erosive Wear Examination (BEWE). The tool delivers a straightforward system for scoring that can be used with all existing indices' diagnostic criteria.

As a partial system for scoring, the BEWE records a sextant's most severely affected surface. The score obtained from the tool helps a practitioner determine how to manage the condition. Using a four-level score, BEWE provides an idea of the grade of the severity of the tooth's wear or appearance using the following scale (Bartlett, Ganss et al., 2008):

Absence of surface loss.

Primary loss of surface texture on the enamel.

Clear defect, loss of hard tissue (dentine) is present but is not on more than half the tooth’s surface.

The hard tissue loss affects over half of the surface areas.

Criteria for grading erosive wear (Bartlett, Ganss et al. 2008)

0	No erosive tooth wear
1	Initial loss of surface texture
2*	Distinct defect, hard tissue loss <50% of the surface area
3*	Hard tissue loss ≥50% of the surface area

*In scores 2 and 3, dentine often is involved

The evaluation of the periodontal situation was done using the British Society of Periodontology-designed Basic Periodontal Examination (BPE).

Periodontal health was assessed using the guidance specified in the BPE. The assessment was done with World Health Organisation (WHO) BPE probes with a band from 3.5 to 5.5 mm and a 0.5 mm ball-end. The depths of the periodontal pockets was determined using a probing force of 20-25 grams.

Scores	Criteria for periodontal condition
0	No pockets >3.5 mm, no calculus/overhangs, no bleeding after probing (black band completely visible)
1	No pockets >3.5 mm, no calculus/overhangs, but bleeding after probing (black band completely visible)
2	No pockets >3.5 mm, but supra or subgingival calculus/overhangs (black band completely visible)
3	Probing depth 3.5-5.5 mm (black band partially visible, indicating pocket of 4-5 mm)
4	Probing depth >5.5 mm (black band entirely within the pocket, indicating pocket of 6 mm or more)
*	Furcation involvement

Oral mucosal lesions (WHO 2013)

All participants had their soft tissues and oral mucosa examined in and around the mouth. This organised and thorough examination was conducted as follows:

1. Labial mucosa and labial sulci (upper and lower)

2. Labial part of the commissures and buccal mucosa (right and left)

3. Tongue (dorsal and ventral surfaces, margins)

4. Floor of the mouth

5. Hard and soft palate

6. Alveolar ridges/gingiva (upper and lower).

The tissues were retracted using either one mirror or a two-plane mouth mirror together with the periodontal probe's handle.

The following codes apply to adults (WHO, 2013)

0	No abnormal condition
1	Malignant tumour (oral cancer)
2	Leucoplakia
3	Lichen planus
4	Ulceration (aphthous, herpetic, traumatic)
5	Acute necrotizing ulcerative gingivitis
6	Candidiasis
7	Abscess
8	Other conditions (specify if possible) (e.g. keratosis, and Koplick spots)
9	Not recorded

Denture status

For each jaw, if they exist, any removable dentures were recorded using the following codes (WHO 2013):

0	No denture
1	Partial denture
2	Complete denture
9	Not recorded

Food frequency questionnaires

Food frequency questionnaires (FFQs) are used as an implement for assessing diet. An FFQ contains a list of food and drink items. Usually, these lists have about a hundred items. For each item on the list, the individual answering the questionnaires

specifies how frequently they eat each type of food and the typical portion size. Usually, the consumption frequencies are indicated using classifications referred to in text, such as 1 per day. Categories also based on text are used to denote portion sizes: small, medium, or large. Individuals can also be requested to select the nearest match from an array of portion-size images of actual food. The validity of both digital and paper-based versions of FFQs has been the subject of numerous studies (Zenun Franco et al. 2018).

To make it easier for participants to complete the FFQs, the list of food items in an FFQ usually includes only the most common foods consumed in the region. The foods are divided into categories such as vegetables and fruits. Considering that the food lists and the portions connected to them could differ depending on location, it is prudent to have a system that is centralised, or one that can easily be reproduced to make sure that FFQs suitable for local food consumption habits can be created with ease. It is preferable that such a system is cheap to produce so as to ensure the deployment is not impeded by financial constraints. Also, it is important to note that making the process technical may have a detrimental effect on reproducibility. Therefore, it is vital that such assets are designed to be as easy to use as possible (Franco et al., 2017).

The primary requirements considered in designing the EatWellQ8 food frequency questionnaire are presented below.

Scalability

An important driver behind the establishment of online-based dilatory methods is the need to support studies at the population level. The possibility that system traffic will escalate is always there when operating at this level. This may not be easy to deal with. Therefore, scalability is a vital factor to be taken into consideration when designing the system architecture (Franco et al., 2017).

Mobile-friendly

If one considers the escalation in smartphone and tablet device market share, it becomes clear that deployment on these devices should be considered an important factor. Specific changes occur during the delivery of FFQs using smartphones and tablets. For instance, as a result of constraints introduced by small screens, it could be a challenge to present all the portion sizes at the same time on the screen. The

interaction design and layout have the potential to make the process of selecting food items more difficult and time-consuming. Therefore, it is important to take this into careful consideration (Franco et al., 2017).

Security

It is common for population studies to gather sensitive data since such studies often rely on personal details and medical information. From this perspective, it becomes vital to have authorisation and authentication features so that databases are protected from unauthorised access and malicious attacks (Franco et al., 2017).

Usability

For it to be possible to improve the design and improvement of future systems using evidence-based decisions, it is vital to collect data on system usability. Therefore, the system needs to be equipped with surveys about completion time and suggestions by participants on what could be improved to create a great user experience (Franco et al., 2017).

EatWellSA food frequency questionnaire

The online questionnaire that this study describes was designed and developed for the Eat Well Kuwait project (EatWellQ8, www.eatwellq8.org). The aim of that study is to determine if the effectiveness of online personalised nutrition (based on anthropometrics and dietary intake) is comparable to personalised nutrition based on face-to-face interaction in Kuwait. The project was a collaborative effort between Kuwait City's Dasman Diabetes Institute and the University of Reading. In this study, EatWellSA (www.eatwellsaudi.org) is used. It is the same Arabic EatWellQ8, however it is adapted slightly to Saudi culture (Franco et al., 2017).

In the EatWellSA FFQ, there are 146 food items and drinks. The questionnaire is a combination of items from the Food4Me FFQs, the European Prospective Investigation into Cancer Study, and EatWellQ8 to represent a typical diet of a Saudi Arabian. For every item, users provide details regarding the frequency of consumption in the previous month. They accomplish this by choosing one of 8 options: "never or less than 1 per month," "1 to 3 per month," "2 to 4 per week," "5 to 6 per week," "1 per day," "2 to 3 per day," "4 to 6 per day" and "more than 6 per day". A select element (drop-down list) is employed to help participants to make their choices. On mobile devices, the drop-down list is expanded. To reduce the amount of time taken in making

choices, the questionnaire was designed in such a way that the default choice ("never or less than 1 per month") was at the top, making it easy for participants to skip a choice if they have not consumed a particular food item. To show portion size, users selected one of three images of actual food portions (Franco et al., 2017).

Several studies have explored different possibilities to make it possible for users to identify food choices from images, including making a choice from eight images, while others used a combination of three images and radio buttons where individuals can either select from the image of press a button to indicate portion sizes that are bigger than the ones depicted in the images. The decision to use three portion size images was inspired by user data showing that images are more likely to be selected than radio button options without a linked image. The aim was also to ensure that all the images were presented to users in an efficient way, notwithstanding the size of the screen. Sometimes the labelling on potion sizes images is done using descriptive labels: small, medium, or large. In the present study, the images were presented in the absence of labels to circumvent the possibility of creating bias in user choices. Every time a user selects a food frequency, suitable portion images are automatically presented to them. Using the modal component described earlier, a pop-up window is used to implement the automatic presentation. Once the user chooses the portion size, the choices of the user are presented in three sizes: A, B, or C . Even though it is preferable for participants to complete the questionnaire in one sitting, it is vital to make it possible to save the FFQ for those instances when a user loses the internet connection, or they are interrupted for other reasons. Therefore, once the portion size has been selected, each food choice is individually saved, giving each user an option to recover the FFQ of a specific day when they return to the system. Together with every FFQ entry, a timestamp (formatted as yyyy-mm-dd) is saved in the database, following the JavaScript Date Object formatting, so that the existence of an entry from a particular day can be checked (Franco et al., 2017).

Permission and liaison

This research was approved by:

A Saudi Arabian Ministry of Health's ethical review process.

Supervisor Professor Angus Walls, University of Edinburgh.

The individuals invited to participate in the study.

Measures translation

The back-translation technique was employed to culturally and linguistically adapt all of the questionnaires into the Arabic language, with the aim of maintaining cross-cultural uniformity. The back-translation technique is a segment of the forward-backwards translation method. The process involves translating items from an original source language into the target language before the translation is done again, this time back to the initial language (Schmidt and Bullinger, 2003). A PhD student (the researcher) did the forward translations from English to Arabic. This translator was selected because they already work as a dentist and are familiar with the terminology used in dental public health and medicine in general. The PhD student requested to do the forward translation has knowledge of English-speaking culture, and their mother tongue is Arabic.

A translator with a medical background and dental public health knowledge was requested to do the backward translation. The backward translator is a Saudi Arabian completing his PhD at the University of Edinburgh, and his educational background is in dentistry. He also possesses knowledge of English speaking culture. The backward translation procedure was repeated until an acceptable Arabic version was established. Five Arabic-speaking people living in the UK were asked to pre-test the final Arabic translation. Four weeks before the study began, the final version was tested with another five people from within the Saudi older adult population. However, these five people were not among the study's final participants.

Conduct

Calibration and training

Based on the guidance of the WHO (1997), the principal researcher conducted all the clinical examinations. Dental nurses were requested to assist with the administration of the questionnaires and the recording of the clinical data. The principal researcher trained all the assistants.

Equipment

Even though the equipment required for the clinical examination was minimal, the need to control infection was high. Some of the equipment needed included a chair, tablet, good light source, pen, explorers, pencil, mouth mirrors, recording sheets,

periodontal probe, disposable gloves, cotton pliers, cotton wool, and examination trays, among other resources.

All non-disposable equipment was pre-wrapped and sterilised at the dental centres. To ensure that none of the non-disposable equipment was re-used, the number of non-exposable instruments matched the number of participants examined on a given day.

CHAPTER FOUR RESULTS

Introduction

A total of 326 people enrolled for the study at baseline, and 275 participants completed all elements of the study. Most of the dropouts occurred after the initial clinical assessment, with participants either not completing the online questionnaires or the dietary survey or both.

The results in this chapter are presented in two main sections:

Section 4.2 overviews the sample with regards to descriptive statistics. Descriptive data are presented for all the variables at baseline.

Section 4.3 reports the associations between independent and dependent variables at baseline, testing the hypothesised relationships using different types of correlations.

Descriptive analysis

Degradation of the sample

A total of 326 people enrolled for the study at baseline. We contacted around 640 subjects, a random selection of participants in the Saudi Demographic and Health Survey from 5 urban areas in Saudi Arabia, and of these 390 agreed to participate in the study and 326 attended the clinic. Of the participants who attended the clinical oral examination, 9 refused to do it: 8 women for religious reasons (they wanted a female dentist to perform the oral examination) and 1 man had to leave the clinic because of the waiting time. 275 participants completed all elements of the study. Most of the dropouts occurred after the initial clinical assessment with participants either not completing the online questionnaires or the dietary survey or both. In addition, around 50 participants from Dammam city dropped out because the local authority asked for further approval; as this took a long time to complete, Dammam city was excluded.

Table 4.1 presents the data for the various levels of participation in this study. A comparison between the participants of those who agreed to participate initially and the participants completed the study

Table 4.1 Degradation of the sample during the study						
		Contacted	Initial	Attended	Oral exam	Completed
		640		326*	317	275
Sex	Male	320	200	163	162	151
	Female	320	190	171	163	124
Age	60-74	400	290	240	231	228
	75+	240	100	86	86	47

* 9 participants came to the clinic but refused to undergo the oral clinical examination

Demographic data

The mean age of the participants was 70.29 years (range 60-104), with an SD of 8.71. Participants were male (50% n=163) and female (50% n=163) (Table 4.2). Almost three-quarters of the participants were married, around half of the participants earned less than 6,001 Saudi riyals per month, and almost 80% were unemployed or retired. More than 60% of the participants were either illiterate or educated only up to the primary level (Table 4.3).

Table 4.2 Demographic profile of the 326 participants at baseline

Participants	%
Male	50
Female	50
Age	
60-75	73.9
76+	26.1

Table 4.3 Demographic profile of the 284 participants at baseline

Participants	%
Level of education	
Illiterate	29.9
Writing and reading and primary school	31.7
Intermediate school and secondary school	23.6
University and above	14.4
Other	0.4
Marital status	
Single	5.6
Married	73.9
Divorce	2.8
Widowed	17.3
Other	0.4
Current job status	
Government or public sector	6.3
Private sector	3.9
Self-employed	9.5
Unemployed	42.6
Retired	37.3
Others	0.4
Kinds of income	
Earnings from employment	10.2
Pension from former employer	38.9
Social security subsidies	19.1
Interest from savings / investments	8.8

Earnings from spouse (husband/wife)	22.4
Others	0.4
Monthly income (SR)	
Up to 3000	26.8
3001 - 6000	23.2
6001 - 9000	21.5
9001 - 12000	12.3
More than 12001	15.8
Others	0.4

Medical status and dental behaviour

Regarding the overall dental health status, most of the participants rated themselves as having a fair constitution 36.7%. The lowest category rated themselves as very bad, making up 4.2% of the sample. The rest of the participants rated themselves as bad (25.4%), very good (9.2%), good (24.4%), and fair (36.3%). Most participants reported that their general health status was good (39%), and only 2.1% say it was very bad. The rest report that their status was very good (15.5%), fair (35.3%), and good (35.5%). Around two thirds (66.2%) of the participants reported having no diabetes, participants with diabetes type 1 comprised 13.7%, and diabetes type 2 were 13% (Table 4.4).

Table 4.4 shows that around one-third of the participants (34.1%) brushed their teeth twice a day or more. 34.5% reported brushing their teeth less than seven times a week. Most participants (70.4%) did not smoke or chew tobacco. More than two thirds (70.8%) of the participants reported visiting the dentist only when in trouble (Table 4.4.).

Table 4.4 General health and dental behaviour of the 284 participants at baseline

Participants	%
Self-reported dental health	
Very good	9.2
Good	24.4
Fair	36.7
Bad	25.4
Very bad	4.2
Other	
Self-reported general health	
Very good	5.6
Good	73.9
Fair	2.8
Bad	17.3
Very bad	0.4
Other	
Smoking	
Smokes now	10.6
Chews tobacco now	4.6
Former smoker / tobacco chewer	14.4
Never smoked or chewed tobacco	70.4
Other	
Current diabetes status	
No diabetes	66.2
Diabetes type 1	13.7
Diabetes type 2	13

Other	7
Often brush teeth	
More than twice a day	4.9
Twice a day	29.2
Once a day	26.8
Less than once a day	34.5
Other	4.6
Pattern of dental attendance	
Once every six months	13
Once every year	10.2
When having trouble with teeth/dentures	70.8
Never been to dentist	5.6
Other	0.4

OHIP-14

The mean OHIP-14 score was 6.33, with a standard deviation of 8.06. There were 30 participants with missing data in the OHIP-14 questionnaire, which means they answered ‘don’t know’ or did not answer one or more questions in the OHIP-14 questionnaire.

Physical activity

Regarding the total score for the physical activity scale for the elderly PASE of older people in Saudi Arabia, for the 284 subjects, the mean number of PASE was 78.28, with a standard deviation of 64.1.

Clinical Data

Number of teeth

Table 4.5 shows the number of teeth of all participants who managed to come for the clinical oral examination. Overall, more than half of the subjects (62.6%) had 20 or more teeth. Only (9.5%) of the participants were edentulous, and around a quarter (25.2%) of them had less than 20 teeth. In addition, 9 participants (2.8%) came to the clinic but refused to do the clinical examination.

Table 4.5 Number of teeth of 326 participants at baseline

Participants	%
Edentulous	9.5
1-19 teeth	25.2
20 or more teeth	62.6
Other	2.8

Denture status

Table 4.6 shows the denture status for all participants who managed to come for clinical oral examination. Overall, most the participants (78.8.6%) had no dentures. Only (6.1%) of participants had full complete dentures, and around (9.5%) of them had partial dentures. In addition, 9 participants (2.8%) came to the clinic but refused to do the clinical examination.

Table 4.6 Denture status of 326 participants at baseline

Participants	%
No denture	78.8
Partial denture	9.5
Complete denture 1 jaw	2.8
Full complete dentures	6.1

Other	2.8

4.2.4.3 DMFT score

Table 4.7 presents the DMFT of older people in Saudi Arabia. For all subjects, the mean number of DMFT was 15.5, with a standard deviation of 9.4. Generally, the Very Low DMFT score was 11.6%, with that of males being 7.2% and that of females being 16.7%. In the Low DMFT score, the proportion of males was 11.8%, and that of females was 13.6%, with an overall score of 12.7%. The moderate DMFT had an overall score of 22.2%, with males representing 23% and females 21.2%. For the high DMFT, the overall score was 53.5%, with males representing 57.9% and females 48.5%.

Table 4.7 DMFT among 275 participants

Participants	%
Very Low DMFT score < 5	11.6
Low DMFT score 5-8	12.7
Moderate DMFT score 9-13	22.2
High DMFT score >13	53.5
Other	

Section 2 association

4.3 Dental status

Table 4.8 shows the dental status by the socio-demographic variables. Overall, 10.6% of the total subjects were edentulous and 89.4% were dentate. In this study, subjects who had visible retained roots present were considered dentate persons. The tables below present the number of remaining teeth among the participants. The proportion of edentulous individuals, which represents 11 men and 19 women, is 10.6%. On the

other hand, 85 women and 103 men were recorded as having 20 teeth or more, representing 65.8% of the sample. Participants in the age group 75 and under had more individuals with 20 or more teeth than the 76 and above age group. The data also shows that men had more remaining teeth than the women. For participants in the 75-year and under age group, 72% had 20 or more remaining teeth. On the other hand, only 36% in the 76-year and old age group had 20 teeth or more remaining.

The level of edentulism varied only slightly by age, but these differences were not significant. The prevalence of edentulism was higher in females, about 63% of the 30 edentulous participants.

The illiterate group constitutes the highest percentage of edentulous participants with no teeth, making up 50% of the 30 edentulous participants. Out of the 283 participants examined, 32% (90) had a primary school education and could read and write, 14.5% (41) had a university education or above, 23.5% (67) had an intermediate school or secondary level education, and 30% (85) were illiterate.

Table 4.8 Dental status by socio-demographic variables

	Male	Female	Total
Edentulous	11	19	30
1-19 teeth	39	28	67
20 or more teeth	102	85	187
Total	152	132	284

Distribution of the sample by number of teeth and age			
	60-75	76+	Total
Edentulous	13	17	30
1-19 teeth	54	13	67

20 or more teeth	170	17	187
Total	237	47	284

Table 4.8 continued

Distribution of the sample by number of teeth and level of education					
	Illiterate	Writing and reading, and primary school	Intermediate school and secondary school	University and above	Total
Edentulous	15	9	2	4	30
1-19 teeth	24	26	12	5	67
20 or more teeth	46	55	53	32	186
Total	85	90	67	41	283

Note: 1 missing data in the education variable

Distribution of the sample by number of teeth and type of income							
	Earnings from employment	Pension from a former employer	Social security subsidies	Interest from savings/ investments	Earnings from a spouse (husband or wife)	Other	Total
Edentulous	1	9	12	2	6	0	30
1-19 teeth	5	26	14	6	16	0	67
20 or more teeth	23	75	28	17	42	1	186
Total	29	110	54	25	64	1	283

Note: 1 missing data in the income variable

4.2.1 Denture status

Regarding the overall prosthetic status, 7% of the participants had a fully removable prosthesis for either one jaw or both jaws, 8% had a partial prosthesis, and 85% of all participants did not have any prosthesis.

In this population, 62% of edentulous elderly had full complete dentures and the rest had no dentures at all. There are 67 participants who had less than 20 teeth, around 65.5% of them had no dentures, about 27% had partial dentures, and only 7.5% had complete dentures for one jaw. About 182 (68%) elderly had a natural dentition of 20 or more teeth, and only 5 (2.7%) of them had partial dentures.

The majority of the elderly who had complete dentures (92%) were aged 76 years and over. There were no significant differences between women and men related to wearing dentures of all types. On other hand, illiterate edentulous aged people had more complete dentures 69% than educated ones.

Table 4.9

Dentures status by socio-demographic variables

Sex	Male	Female	Total
No denture	129	105	234
Partial denture	12	11	23
Complete denture one jaw	3	2	5
Full complete dentures	7	6	13
Total	151	124	275

Age	**60-75**	**76+**	**Total**

No denture	207	27	234
Partial denture	18	5	23
Complete denture one jaw	3	2	5
Full complete dentures	1	12	13

	Illiterate	**Writing and reading, and primary school**	**intermediate school and secondary school**	**university and above**	
No denture	65	75	58	35	233
Partial denture	6	9	6	2	23
Complete denture one jaw	2	1	2	0	5
Full complete dentures	9	2	0	2	13
Total	82	87	66	39	274

Note: 9 missing data in the denture status variable

Nutrient intake

The present study's findings demonstrate that edentate, denture-wearing seniors in Saudi Arabia consume lower levels of important nutrients, namely protein, carbohydrates, fibre, fat, and calories, compared to dentate people. However, the edentulous people not wearing dentures consumed more nutrients than denture-wearing older adults.

Overall, Table 4.5 shows that the mean protein consumed by Saudi older adults was 102.2 g with SD 160.2 g, for carbohydrates the mean was 315.6 g with SD 471.1 g, the fibre mean was 26.9 g with SD 45.8 g, for fat the mean was 78.2 g with SD 148.3 g, and for calorie intake the mean was 2292.6 with SD 3706.2.

In this study, the participants with 20 or more teeth consumed the highest levels of important nutrients, which are protein, carbohydrates, fibre, fat, and calories, than people with 1-19 teeth, while the edentulous older adults consumed the least.

The results also show that the subjects with neutral teeth generally had the recommended energy intake, namely between 2057.4 and 2513.6 Kcal, while the recommended amount for older adults is between 2000 and 2800 Kcal, depending on their physical activity.

The present study's findings show that aged people with natural teeth and not wearing dentures had the highest energy intake, followed by the edentulous and no denture, then people with teeth and partial dentures; finally the lowest energy intake was for seniors with teeth and complete denture in one jaw and edentulous with complete dentures.

Table 4.10 Nutrient intake of 284 participants at baseline

Nutrient intake	Mean	Median	Std. Deviation
Protein (g)	102.2	59.1	160.2
Energy (kJ)	9686.9	5546.6	15610.5
Energy (kcal)	2292.6	1313.4	3706.2
Fat (g)	78.2	38.1	148.3
Carbohydrate (g)	315.6	192.8	471.1
AOAC fibre (g)	26.9	15.6	45.8

Table 4.11 Ability to bite, chew and swallow of 284 participants at baseline

Ability to bite foods	%
No difficulty	45.8
A little difficulty	16.9
A fair amount of difficulty	16.5

A great amount of difficulty	15.8
Can't say	4.6
Other	0.4
Ability to chew foods	**%**
No difficulty	45.4
A little difficulty	19.4
A fair amount of difficulty	19.0
A great amount of difficulty	11.6
Can't say	4.2
Other	0.4

Ability to swallow foods	**%**
No difficulty	64.8
A little difficulty	16.9
A fair amount of difficulty	12.3
A great amount of difficulty	2.1
Can't say	3.5
Other	0.4

The impact of the number of teeth on the perceived ability to eat a variety of selected foods is shown in Table 4.12. The edentulous participants compared to the edentate

were more likely to report having difficulty eating foods for all 15 foods listed. For instance, the odds of not being able to eat/being able to eat crusty bread with some difficultly in the edentulous participants was 22 times that of the participants with 20 and over teeth. For foods like raw carrots, meats, and nuts, it was 20 times that for 20 or more teeth. There were significant differences (95% CI) between all 15 foods and all number of teeth groups except for cheese, where there was no significant difference between people with 1-19 teeth and those with 20 or more teeth.

The impact of denture status on the perceived ability to eat a variety of selected foods is shown in Table 4.13. Generally, the participants with partial dentures, complete dentures in 1 jaw and full complete dentures compared to the participants with no dentures were more likely to report having difficulty eating foods for all 15 foods listed. For example, the probabilities of not being able to eat/being able to eat with some difficulty for raw carrots in the participants with partial dentures, complete dentures in 1 jaw, and full complete dentures were 24,12, and 29.5 times, respectively, that of the participants with no dentures. For sliced bread, tomatoes, lettuce, well-done steaks, oranges, crisps, and chocolates, there were significant differences (95% CI) between all these types of foods and all denture status groups.

In addition, the edentulous participants with complete dentures in 1 jaw and full complete dentures compared to the edentulous older adults with no dentures were more likely to report having difficulty eating foods for all 15 foods listed, except for roast potato and cooked green vegetables.

Table 4.12 The impact of the number of teeth on the perceived ability to eat various food types

Food type	Number of teeth	Easy to eat N (%)	With some difficulty or can't eat at all N (%)	OR	95% CI
Sliced bread	Edentulous	6 (28.6)	15 (71.4)	31.9	10.6 - 96.1
	1-19 teeth	44 (66.7)	22 (33.3)	6.4	3 - 13.7
	20 and over	166 (92.7)	13 (7.3)	Ref	
Crusty bread	Edentulous	2 (9.5)	19 (90.5)	22	4.9 - 97.7
	1-19 teeth	11 (16.7)	55 (83.3)	11.6	5.6 - 23.8
	20 and over	125 (69.8)	54 (30.2)	Ref	
Toast	Edentulous	6 (30)	14 (70)	32.7	10.6 – 100.3
	1-19 teeth	51 (77.3)	15 (22.7)	4.1	1.8 – 9.4
	20 and over	168 (93.3)	12 (6.7)	Ref	
Cheese	Edentulous	10 (47.6)	11 (52.4)	48.4	13.1 – 179.3
	1-19 teeth	61 (92.4)	5 (7.6)	3.6	.94 – 13.87
	20 and over	176 (97.8)	4 (2.2)	Ref	
Tomatoes	Edentulous	4 (19)	17 (81)	54.3	15.9 – 185.1
	1-19 teeth	33 (50)	33 (50)	12.8	6.1 – 26.8
	20 and over	166 (92.7)	13 (7.3)	Ref	

Raw carrots	Edentulous 1-19 teeth 20 and over	1 (4.8) 11 (16.7) 107 (59.4)	20 (95.2) 55 (83.3) 73 (40.6)	29.3 7.3 Ref	3.8 – 223.3 3.6 – 14.9
Roast potatoes	Edentulous 1-19 teeth 20 and over	5 (23.8) 33 (50) 155 (87.1)	16 (76.2) 33 (50) 23 (12.9)	21.6 6.7 Ref	7.2 – 64.5 3.5 – 12.9
Cooked green vegetables	Edentulous 1-19 teeth 20 and over	6 (28.6) 44 (66.7) 167 (92.8)	15 (71.4) 22 (33.3) 13 (7.2)	32.1 6.4 Ref	10.7 – 96.7 3 – 13.8
Lettuce	Edentulous 1-19 teeth 20 and over	2 (9.5) 20 (30.3) 143 (79.9)	19 (90.5) 46 (69.7) 36 (20.1)	37.7 9.1 Ref	8.4 – 169.5 4.8 – 17.3
Sliced cooked meats	Edentulous 1-19 teeth 20 and over	1 (4.8) 13 (19.7) 113 (62.8)	20 (95.2) 53 (80.3) 67 (37.2)	33.7 6.9 Ref	4.4 – 257.1 3.5 – 13.5
Well-done steaks	Edentulous 1-19 teeth 20 and over	1 (4.8) 17 (25.8) 142 (79.3)	20 (95.2) 49 (74.2) 37 (20.7)	76.7 11.1 Ref	10 – 590.7 5.7 – 21.4
Oranges	Edentulous	2 (9.5)	19 (90.5)	64.4	14.1 – 295

	1-19 teeth 20 and over	32 (48.5) 156 (87.2)	34 (51.5) 23 (12.8)	7.2 ref	3.8 – 13.8
Nuts	Edentulous 1-19 teeth 20 and over	1 (4.8) 8 (12.1) 99 (55.3)	20 (95.2) 58 (87.9) 80 (44.7)	24.7 8.9 Ref	3.2 – 188.4 4 – 19.9
Crisps	Edentulous 1-19 teeth 20 and over	2 (10) 18 (27.3) 129 (72.9)	18 (90) 48 (72.7) 48 (27.1)	24.2 7.2 Ref	5.4 – 108.2 3.8 – 13.5
Chocolates	Edentulous 1-19 teeth 20 and over	3 (14.3) 37 (56.1) 151 (84.8)	18 (85.7) 29 (43.9) 27 (15.2)	33.5 9 Ref	9.2 – 121.8 4.4 – 18.4

Table 4.13 The impact of denture status on perceived ability to eat various food types

Food type	Denture status	Easy to eat N (%)	With some difficulty or can't eat at all N (%)	OR	95% CI
Sliced bread	Teeth and no denture	194 (89.4)	23 (10.6)	Ref	
	Teeth and partial denture	14 (60.9)	9 (39.1)	5.4	2.1 – 14
	Teeth and complete denture in one jaw and edentulous with complete denture	5 (27.8)	13 (72.2)	21.9	7.2 – 67.1
	Edentulous and no denture	3 (37.5)	5 (62.5)	14	3.1 – 62.7

Crusty bread	Teeth and no denture	136 (62.7)	81 (37.3)	Ref	
	Teeth and partial denture	0 (0)	23 (100)	78.7	4.7 – 1313.5a
	Teeth and complete denture in one jaw and edentulous with complete denture	0 (0)	18 (100)	61.9	3.7 – 1042.2a
	Edentulous and no denture	2 (25)	6 (75)	5	1 – 25.5
Toast	Teeth and no denture	199 (91.3)	19 (8.7)	Ref	
	Teeth and partial denture	19 (82.6)	4 (17.4)	2.2	0.7 – 7.1
	Teeth and complete denture in one jaw and edentulous with complete denture	3 (17.6)	14 (82.4)	48.9	12.9 – 185.3
	Edentulous and no denture	4 (50)	4 (50)	10.5	2.4 – 45.2
Cheese	Teeth and no denture	211 (96.8)	7 (3.2)	Ref	
	Teeth and partial denture	22 (95.7)	1 (4.3)	1.4	0.2 – 11.7
	Teeth and complete denture in one jaw and edentulous with complete denture	9 (50)	9 (50)	30.1	9.2 – 99.3

	Edentulous and no denture	5 (62.5)	3 (37.5)	18.1	3.6 – 91.2
Tomatoes	Teeth and no denture	190 (87.6)	27 (12.4)	Ref	
	Teeth and partial denture	8 (34.8)	15 (65.2)	13.2	5.1 – 34
	Teeth and complete denture in one jaw and edentulous with complete denture	3 (16.7)	15 (83.3)	35.2	9.6 – 129.6
	Edentulous and no denture	2 (25)	6 (75)	21.1	4.1 – 109.9
Raw carrots	Teeth and no denture	117 (53.7)	101 (46.3)	Ref	
	Teeth and partial denture	1 (4.3)	22 (95.7)	25.5	3.4 – 192.4
	Teeth and complete denture in one jaw and edentulous with complete denture	0 (0)	18 (100)	42.8	2.5 – 719.7a
	Edentulous and no denture	1 (12.5)	7 (87.5)	8.1	1 - 67
Roast potatoes	Teeth and no denture	175 (81)	41 (19)	Ref	
	Teeth and partial denture	11 (47.8)	12 (52.2)	4.6	1.9 – 11.3
	Teeth and complete denture in one jaw and	5 (27.8)	13 (72.2)	11.1	3.7 – 32.9

	edentulous with complete denture Edentulous and no denture	2 (25)	6 (75)	12.8	2.5 – 65.7
Cooked green vegetables	Teeth and no denture Teeth and partial denture Teeth and complete denture in one jaw and edentulous with complete denture Edentulous and no denture	192 (88.1) 16 (69.6) 7 (14.6) 2 (25)	26 (11.9) 7 (30.4) 11 (61.1) 6 (75)	Ref 3.2 11.6 22.2	 1.2 – 8.6 4.1 – 32.6 4.2 – 115.6
Lettuce	Teeth and no denture Teeth and partial denture Teeth and complete denture in one jaw and edentulous with complete denture Edentulous and no denture	161 (74.2) 2 (8.7) 0 (0) 2 (25)	56 (25.8) 21 (91.3) 18 (100) 6 (75)	Ref 30.2 105.7 8.6	 6.9 – 132.9 6.3 – 1783.8a (1.7 – 43.9)
Sliced cooked meats	Teeth and no denture Teeth and partial denture Teeth and complete denture in one jaw and	126 (57.8) 0 (0) 0 (0)	92 (42.2) 23 (100) 18 (100)	Ref 64.3 50.6	 3.8 – 1071.9a 3 – 850.5a

	edentulous with complete denture				
	Edentulous and no denture	1 (12.5)	7 (87.5)	9.6	1.2 – 79.3
Well-done steaks	Teeth and no denture	158 (72.8)	59 (27.2)	Ref	
	Teeth and partial denture	1 (4.3)	22 (95.7)	58.9	7.8 – 446.9
	Teeth and complete denture in one jaw and edentulous with complete denture	0 (0)	18 (100)	98.6	5.8 – 1661.6a
	Edentulous and no denture	1 (12.5)	7 (87.5)	18.7	2.3 – 155.6
Oranges	Teeth and no denture	179 (82.5)	38 (17.5)	Ref	
	Teeth and partial denture	8 (34.8)	15 (65.2)	8.8	3.5 – 22.3
	Teeth and complete denture in one jaw and edentulous with complete denture	1 (5.6)	17 (94.4)	80.1	10.3 – 620.2
	Edentulous and no denture	2 (25)	6 (75)	14.2	2.7 – 72.7
Nuts	Teeth and no denture	107 (49.3)	110 (50.7)	Ref	
	Teeth and partial denture	0 (0)	23 (100)	45.7	2.7 – 762.3a
	Teeth and complete denture in one jaw and	0 (0)	18 (100)	35.9	2.1 – 604.8a

	edentulous with complete denture				
	Edentulous and no denture	1 (12.5)	7 (87.5)	6.8	0.8 – 56.3
Crisps	Teeth and no denture	145 (67.4)	70 (32.6)	Ref	
	Teeth and partial denture	2 (8.7)	21 (91.3)	21.7	4.9 – 95.4
	Teeth and complete denture in one jaw and edentulous with complete denture	0 (0)	17 (100)	72.2	4.3 – 1218.6a
	Edentulous and no denture	2 (25)	6 (75)	6.2	1.2 – 31.6
Chocolates	Teeth and no denture	176 (81.5)	40 (18.5)	Ref	
	Teeth and partial denture	11 (47.8)	12 (52.2)	4.8	2 – 11.7
	Teeth and complete denture in one jaw and edentulous with complete denture	2 (11.1)	16 (88.9)	35.2	7.8 – 159.3
	Edentulous and no denture	2 (25)	6 (75)	13.2	2.6 – 67.8

Table 4.14 The relationship between the number of teeth and nutrient intake

Nutrient	Number of teeth	N	Mean	95% CI mean difference	
Energy (kcal)	Edentulous	21	1314.9	884.5	

	1-19 teeth 20 and over	67 187	2057.4 2513.6	1317.5 1329.5
Carbohydrates	Edentulous 1-19 teeth 20 and over	21 67 187	195.5 291.9 341.4	123.2 183.3 198.2
Protein	Edentulous 1-19 teeth 20 and over	21 67 187	58.7 88.6 113.1	33.9 59.1 61.7
Fat	Edentulous 1-19 teeth 20 and over	21 67 187	38.5 67.9 87.3	28.9 38.6 40.1
Fibre	Edentulous 1-19 teeth 20 and over	21 67 187	17.4 24.9 29.1	13.8 15.5 16

Table 4.15 The relationship between denture status and nutrient intake

Nutrient	Number of teeth	N	Mean	95% CI mean difference
Energy (kcal)	Teeth and no denture Teeth and partial denture Teeth and complete denture in one jaw and	226 23 18	2504.7 1479.7 1244.3	1373 1120.2 802.8

	edentulous with complete denture Edentulous and no denture	8	1628.2	1087.4
Carbohydrate	Teeth and no denture Teeth and partial denture Teeth and complete denture in one jaw and edentulous with complete denture Edentulous and no denture	226 23 18 8	341.5 222.2 182.3 245.5	198.4 176.5 122.1 161.9
Protein	Teeth and no denture Teeth and partial denture Teeth and complete denture in one jaw and edentulous with complete denture Edentulous and no denture	226 23 18 8	111.9 67.5 51.9 69.6	62 50.4 31.3 42.6
Fat	Teeth and no denture Teeth and partial denture Teeth and complete denture in one jaw and	226 23 18	86.8 42.3 39.3	40.6 26.9 24.9

	edentulous with complete denture Edentulous and no denture	8	48	30.9
Fibre	Teeth and no denture Teeth and partial denture Teeth and complete denture in one jaw and edentulous with complete denture Edentulous and no denture	226 23 18 8	29.2 18.6 15.5 21.3	15.9 9.7 10.6 14.6

Multi-variate analysis

Before the multiple regression model was performed, the linear regression assumptions were checked. The independent variables, including fibre, fat, protein, carbohydrate, and calories, invalidated the conjecture of homoscedasticity and normality. From the data, the relationship between the independent and dependent variables was noted to be non-linear.

Considering that the data invalidated the assumption of homoscedasticity and normality, a robust regression was done with the aim of determining the controlled impact of each predictor variable on the energy intake of calories (kcal)/carbohydrate/protein/fat/fibre. Considering that they did not depend on the conjuncture of normality and homoscedasticity, the significance values and bootstrapped confidence intervals were reported in the summary statistics tables.

There were no observed differences between groups in relation to the perceived ability to eat and consume nutrition after socio-demographic and health behavioural factors had been adjusted, except for age group.

Table 4.16. Multiple regression models of predictor variables on calorie intake (kcal), with 95% bias-corrected and accelerated (BCa) confidence intervals.

Predictor variable	***Coefficient***	***p-value***	***BCa* 95% Confidence Interval**	
			Lower	**Upper**
Age	780.14	**0.039**	196.73	1326.03
Gender	376.84	0.463	-395.81	1222.21
Number of teeth	87.15	0.814	-689.52	811.07
Teeth and denture status	-303.41	0.325	-869.1	203.49

Note: $R^2 = 0.018$

Table 4.17 Multiple regression models of predictors variables on carbohydrate, with 95% bias-corrected and accelerated (BCa) confidence intervals.

Predictor variable	***Coefficient***	***p-value***	***BCa* 95% Confidence Interval**	
			Lower	**Upper**
Age	111.99	**0.025**	35.14	183.99
Gender	42.49	0.514	-72.69	189.82
Number of teeth	4.37	0.939	-105.94	121.96

Teeth and denture status	-36.26	0.353	-112.545	36.67

Note: $R^2 = 0.018$

Table 4.18 Multiple regression models of predictors variables on protein, with 95% bias-corrected and accelerated (BCa) confidence intervals.

Predictor variable	***Coefficient***	***p-value***	***BCa* 95% Confidence Interval**	
			Lower	**Upper**
Age	32.94	**0.027**	3.15	60.09
Gender	18.68	0.382	-17.87	62.09
Number of teeth	6.13	0.688	-24.78	38.4
Teeth and denture status	-13.65	0.268	-36.65	7.09

Note: $R^2 = 0.021$

Table 4.19 Multiple regression models of predictors variables on fat, with 95% bias-corrected and accelerated (BCa) confidence intervals.

Predictor variable	***Coefficient***	***p-value***	***BCa* 95% Confidence Interval**	
			Lower	**Upper**
Age	25.38	0.062	2.55	45.22

Gender	15.84	0.446	-17.34	56.25
Number of teeth	5.22	0.746	-24.36	35.82
Teeth and denture status	-12.6	0.274	-34.43	6.71

Note: $R^2 = 0.017$

Table 4.20 Multiple regression models of predictors variables on fibre, with 95% bias-corrected and accelerated (BCa) confidence intervals.

Predictor variable	***Coefficient***	***p-value***	***BCa* 95% Confidence Interval**	
			Lower	**Upper**
Age	9.51	**0.049**	0.88	17.28
Gender	4.78	0.437	-3.98	15.64
Number of teeth	-0.32	0.961	-14.49	10.88
Teeth and denture status	-3.65	0.371	-12.06	3.88

Note: $R^2 = 0.015$

CHAPTER FIVE DISCUSSION

Introduction

This study explored how oral health status impacts nutrition and oral health choices among older adults (60+ years) in Saudi Arabia. The clinical variables used in gathering the data include individual and environmental characteristics, overall quality of life, general health perceptions, food types, and food frequency intake. The impact was predicted through individual and clinical factors with food types and nutrition intake.

The present study is the first research to focus on how dental status impacts nutrition intake among older adults in Saudi Arabia. It is guided by research conducted in the developed world using a prospective design and a robust statistical process (Watson et al., 2019; Tada and Miura, 2014; Moynihan et al., 2009; Tsakos et al., 2006; Walls and Steele, 2004). In the present study, the factors that deliver potential pathways through which the variables named above could affect nutrition intake are identified. It also proposes options for establishing oral health strategies in Saudi Arabia. Furthermore, the present study emphasises the manner in which broader factors such as dentures and dental status can affect the quality of life.

The discussion of this study's findings is separated into three categories. In the first section, the general findings and baseline results in Saudi older adults are discussed. Secondly, the oral health status determinants that could impact food choices and nutritional intake for seniors are deliberated. The section also focuses on the manner in which the identified environmental, individual, and clinical factors impact nutritional intake. The same section also contains a short discussion of the factors that have been found to not have a substantial impact on food choices and intake. The third section focuses on the study’s limitations and methodological issues. The chapter that follows them provides a summary of the conclusions and recommendations for future studies and policy.

Sample

This study had a good response rate of 84.8% for participants who attended the clinical examination. However, only 71.6% completed all elements of the study. About 50 participants from Dammam City had to cease participation because the local authority

requested further (local) approval of the study protocol. It was unclear how long this would take and it would have ensured that these data could not have been captured during the data collection window, so the sample from Dammam city was excluded.

Out of all the participants who attended the clinical oral examination, nine refused to participate in the study. Eight of these participants were women and indicated that they would only accept an oral examination if a female dentist conducted it for religious reasons. One man left the clinic because he did not have the time required to wait for the examination. These are important observations that could be taken into account when designing surveys in the future so that more females can be recruited or by having a larger examining team involving both male and female dentists.

There is no clarity regarding participants that attended the clinical examination but failed to complete the questionnaires. Some of the potential reasons the participants may have refused to complete the questionnaires are that they may have felt that the study had no benefit to them and that they did not have the time required to complete the questionnaires; also, the Covid-19 pandemic may have made it challenging to communicate with participants to fill online questionnaires at home.

Also, participants had to deal with the technical challenges that come with online questionnaires because literacy is required to use a computer. Added to this, they would have needed an internet connection. This level of literacy tends to be higher in the developed world. For instance, Franco et al. (2018) indicated that in their study, the System Usability Scale score and completion time among older adults was good in the U.K. However, in a country like Saudi Arabia, the level of education among the elderly could have a negative impact on online questionnaires such as the ones used in this study.

The response rate may have been improved if the researcher had personally contacted all the potential participants who refused to attend the clinical examination. This would have provided an opportunity to explain the importance of the study. Another approach that would have improved the response rate could be encouragement through rewards. However, the resources for this were not available in this study.

Only Saudi citizens constituted the sample for this study. The study excluded individuals who were not citizens of Saudi Arabia and those under the age of 60. The

reason for this was that the resources were insufficient to employ interpreters for participants unable to speak Arabic. Also, citizens of Saudi Arabia have access to different types of healthcare, including oral health, which is not always the case with non-Saudi citizens. We were also keen to ensure that the sample would reflect the "normal" dietary patterns of the Saudi population, and immigrant families may bring their dietary preferences with them, which could have biased the results here. Lastly, the initial selection of the participants was the responsibility of the persons in charge (Saudi Demographic and Health Survey SDHS, 2017), meaning that there was no guarantee that it is devoid of bias.

For the present study, four regions in Saudi Arabia were visited, which may represent the entire kingdom. Also, these areas were chosen because they are in different parts of the kingdom and therefore cover different cultures. Other practical reasons why the areas were selected were that they have good public transport networks, are easy to access, and could be covered within the time and budget constraints. Thus, individuals outside these four areas were not included in the study.

Socio-demographic characteristics

The section below provides more details regarding the participants' socio-demographic characteristics, including gender, age, and marital status.

Age, gender, and marital status

In the present study, the participants' mean age was 70.29 years. This is close to the Saudi National Survey for Elderly Health (SNSEH) (2015) data of 70.1 years. It is also in keeping with the data published by General Authority for Statistics in Saudi Arabia (2016). However, compared to the mean age (74.1 years) of the older adult population in the U.K., as reported by the U.K. National Diet and Nutrition Survey 2008–2014, both the SNSEH and this study's mean ages are lower.

Kinsella and Velkoff (2001) identify two factors responsible for the ageing of the world population: declining fertility and an escalation in life expectancy. The decline in fertility rates in developing countries has been noted in the last three decades, while it has been an issue in the developed world for most of the 20th century, averaging 66% for males and 71% for females. In the developing world, life expectancy ranges between 76 years and 80 years. Increases have also been noted in life expectancy in the developing world since 1950, even though there is variance in the degree of increase.

The UN World Population Prospects (2019) estimates that the Saudi Arabian population's growth rate is 1.59%. The same source predicts that the Saudi population growth rate will slow down to 1.09% by 2030 and subsequently to 0.027% in the three decades after that. Per woman, the Saudi fertility rate is 2.274 births, which is higher than the population replacement rate of 2.1 births per woman. In the last few years, the fertility rate has decreased every year, initially leading to a slowing and eventually stagnant population growth (United Nations and Social Affairs, 2019).

Universally, females tend to enjoy a higher life expectancy than males. The reason people are managing to remain healthy, which prolongs life, is because healthcare and the standard of living have improved dramatically in the last few decades. From a health point of view, the objective is that people remain healthy and alive as long as possible. In this regard, health promotion and education are crucial in maintaining good health, mobility, and independent living among the older adult population. There are concerns voiced by the Saudi government about the growing levels of obesity in the population.

These are being addressed through the government's dietary guidelines, which hat are published in the form of a pictographic "food palm" (Ministry of Health, 2012). These guidelines are based on the USA's guidance about food consumption adapted for a Saudi diet but based on the reference dietary intakes from the US government (Ministry of Health, 2012; Committee, 2020).

More than two-thirds (73.9%) of the participants fall into the 60-74-year age group in the present study, and the other third belongs to the 75+ age group. There is a slight difference between these findings and the data published by Statistics Saudi Arabia (2016), which indicated a little over 62% for the 60–74 year age group and 37% for the 75+ year age group.

The lower number of participants in the 75-year age group could explain this study's findings regarding edentulism among older adults in Saudi Arabia, which was about 10% of the sample, below the number reported by the WHO (2013). The WHO Oral Health Country/Area Profile reports that the prevalence of edentulousness in the older adult population is between 31% and 46% (Malmo University, n.d.). However, it is vital to remember that there have been many improvements in medical health and the quality of life since the WHO published the data.

In the current study, the male and female participants each constituted 50% of the sample, representing a 1:1 male-to-female ratio even though there are more females in the overall older adult population. On the other hand, SNSEH (2016) reported that the male population constituted 60%. Regarding education, most (60%) of the participants were illiterate or had basic reading and writing skills. The following group was that of participants with intermediate education or secondary school (23%). These figures differ from SNSEH (2015), which concluded that 70% of the participants were illiterate.

Generally, it is accepted that education provides knowledge and other nonmaterial resources known to facilitate good health (Galobardes et al., 2006). Nevertheless, Cunha-Cruz, Hujoel, and Nadanovsky (2007) did not identify any positive indications of socioeconomic differences in edentulism among adults with a high school education. Meanwhile, those individuals with low literacy levels could meet the challenges when requested to describe their dental problems to the dentist. The same may apply when it comes to understanding the descriptions provided by the dentist, which could affect edentulousness prevalence.

In the present study, the leading marital status was married (73.9%), and in second place was widowed (17.3%). These numbers are in keeping with SNSEH (2015), which put married at 57.1% and widowed at 22.9%.

In terms of general oral health status, most participants (36.7%) rated themselves as fair. The category of participants rating themselves as very bad was the lowest (4.2%). The rest of the participants rated their oral health status as bad (25.4%), well (24.4%), and very good (9.2%). The majority of the participants rated their health status as good (39%), with only a tiny fraction selecting a rating of very bad (2.1%). The rest reported that their health status was good (35.5%), fair (35.3%), and very good (15.5%). About two-thirds (66.2%) of participants indicated that they had no diabetes. For participants with diabetes, 13.7% said they had type 1, while 13% indicated that they had type 2. On the other hand, SNSEH (2015) indicated that the proportion of DM was 32%. The Saudi Elderly Survey involving adults aged 65 and above indicated that the proportion of adults in the category of those with chronic diseases was 28.7%.

In the present study, it can be concluded that the majority (70.3%) of the participants perceived themselves to have a fair or better dental health status. However, in England

and Wales, the likelihood that older adults rate their health as good is low. This group appears to have poorer oral health linked quality of life than the general adult population (Moore & Davies 2016). Low literacy levels may affect the present study's sample, and there will be further discussion of this point in the OHIP.

From the present study, it can be noted that about one-third of individuals (34.1%) brushed their teeth two times daily or more, and 34.5% indicated that they brushed their teeth less than seven times a week. The majority of participants (70.4%) neither chewed nor smoked tobacco, and around two-thirds (70.8) indicated that they only visited the dentist when they had a problem.

Even though the present study did not ask questions about why the participants did not visit the dentist, several factors can be identified as reasons. Some of these include lack of financial resources, a lack of perceived need, and a lack of access to dental care. Added to this, older adults find it more challenging to access dental care. Another important factor is that individuals may not believe that dental therapy will improve their situation much.

Moreover, the role played by income in terms of prosthetic rehabilitation may not be a major one. This is because the government in Saudi Arabia makes free dental treatment available to the people. Notwithstanding this free dental care, many adults do not use it. This could be read to mean that attitudes towards dental care are not good. This situation could be improved by offering more dental health education.

Physical activity

In this study, older adults were more likely to have a high prevalence of inactivity. These findings are also in keeping with the result reported by Bindawas et al. (2020) Although the relationship between PA and the number of teeth or denture status and diet was not assessed in the present study, it has been recognised that physical activity may have a direct impact on nutrition and obesity.

Dentition status

Each participant's number of natural teeth was represented by the mean number of natural teeth (on average). The condition of the teeth was not taken into account. The decayed, missing, filled teeth (DMFT) index is an aggregate measure of an individual's lifetime experience regarding dental disease (World Health Organisation, 1997).

In the present study, the mean DMFT for older adults in Saudi Arabia was 15.5. On the other hand, Al-Shehri (2012) reported a DMFT of 18.6 for elderly residents of residential homes in Riyadh, Saudi Arabia. Also, another study outlined the oral health status of Saudis of 60-year-old patients attending Dammam Medical Centre, and the DMFT was 20.7 (Atieh, 2008). Meanwhile Zahrani (2005) reported a DMFT of 28.2 for elderly patients attending a dental practice in Riyadh city.

Compared to the study by Al-Shehri (2012), the mean number of retained teeth in the current study's participants was higher. In the former, the mean DMFT score was 18.6 for the residents of homes for older adults. The potential justification for this could be improved dental technology and awareness of the importance of oral care, which leads to greater retention among older adults. Also, because our study sample was independently living people, this could be the reason for the differences between the studies.

In this study, 87.8% of the participants were dentate, with the mean number of present teeth being 19. Over half (50%) of the participants had 20 or more teeth, with a little more than a quarter having fewer than 20 teeth. The proportion of edentulous participants was only 9.5%, around two-thirds of them were having full complete dentures. The edentulous participants with complete dentures in 1 jaw and full complete dentures were more likely to report having difficulty eating foods for most foods listed compared to the edentulous older adults with no dentures.

In the present study, the 11 men and 19 women constituting the edentulous adults represented 10.6% of the sample. Meanwhile, the proportion of older adults with 20 or more teeth was 65.8%, represented by 85 women and 103 men. The number of individuals with 20 or more teeth was higher in people aged 75 and younger than it was among those aged 76 and above. From the collected data, it can also be noted that women have fewer remaining teeth than men. Regarding participants in the 75 years and younger category, the proportion with 20 or more teeth was 72%. In the 76-year-old and higher age group, only 36% had 20 or more remaining teeth.

A potential reason for this finding could be that the participants in the 75 and above category may have been be convinced that declining oral health is an expected part of ageing, making them less likely to seek dental treatment. Also, with advancing age, oral health can slowly slip down the priority list, as the individual becomes frailer and

has to deal with the associated conditions. When their mobility becomes compromised, and they have to rely on family members and caregivers for transport to health facilities, and older adults may feel less motivated to seek dental care.

Regarding the general prosthetic status, the proportion of participants with fully removable prostheses for either one or both jaws was 7%. On the other hand, 8% of participants had partial prostheses, while 85% did not have any prostheses.

In the current study, dentate adults above 76 years had a higher quantity of partial prostheses than older dentate adults. This could be accredited to the increased oral healthcare awareness in the former group. Added to this, the advancement in dental technology to preserve and restore teeth has resulted in adopting a “teeth for life” ethos among professionals in the dental sector.

Food choices and nutritional intake

In the present study, about one-third of the sample reported having a fair or greater difficulty when biting or chewing food. On the other hand, less than 15% of participants self-reported having a fair or greater difficulty when swallowing food. Moreover, between 40% and 50% of participants with natural teeth indicated that they met challenges when eating raw carrots, nuts, or cooked sliced meat. These findings differ from those of Sheiham and Steele (2001), who reported that 20% of dentate individuals living independently faced challenges when eating nuts, well-done steak, apples, or raw carrots. The reason behind the difference could be that the Sheiham and Steele’s (2001) study population was healthier.

The mean calorie intake for this sample was high at 2513 Kcal. This is some 12% above the US dietary guidelines for calorie intake in this age group (2000 Kcal) (Committee, 2020). There was however significant variation in caloric intake, with a median value of 1313 Kcal, 30% less than the mean value and 35% below the US dietary guidelines. The patterns of intake for key nutrients, protein, fat and carbohydrates as well as dietary fibre followed similar patterns, with population means above recommendations but markedly lower median values for all nutrients.

The current study's findings show that edentate seniors wearing dentures in Saudi Arabia ingest lower levels of crucial nutrients (fibre, proteins, carbohydrates, and the number of consumed calories). When compared to their edentate seniors, the Saudi

Arabians were less likely to meet the dietary recommendations. These findings are in line with those of Watson et al. (2019) for older adults living in the UK.

No variance was apparent after adjusting for denture and teeth status, gender, and the number of remaining teeth. However, variances were noted when considering the age group regarding fibre intake, proteins, carbohydrates, and the number of consumed calories. Based on these results, it can be concluded that there is a link between the risk of poor nutritional intake and having no remaining natural teeth while wearing dentures. On the other hand, it can also be noted from the results that even when natural teeth support prostheses, the nutritional consumption being similar to that of individuals with natural teeth and no prosthesis is not possible.

The current study's findings are in accordance with prior research that also explored the relationship between dentition status and dietary intake (Watson et al. 2019). This shows that dental status remains an important determinant of dietary intake in older adults, independent of socio-demographic and behavioural factors, and despite overall improvements in oral health status.

Regarding older adults in the UK, Watson et al. (2019) propose that having no natural teeth left while wearing dentures escalates the potential for reduced nutrient consumption. On the other hand, the existence of natural teeth to support prostheses could result in the nutrient consumption matching that of individuals with natural teeth and no prosthesis.

The subjects with natural teeth and no dentures generally had an energy intake greater than that recommended by the US government, i.e. 2513.6 Kcal compared to 2000 Kcal. This was mirrored in terms of major dietary constituents, with a protein intake of 111.9 g compared to 57 g and a carbohydrate intake of 341.5 g compared to 130 g. This population was relatively unusual in achieving the recommended intake of dietary fibre of 29.2 g compared to 28 g.

In contrast, the other participants (teeth and partial denture, teeth and complete denture in one jaw and edentulous with complete denture, and edentulous and no denture) with compromised oral function had lower than recommended energy intake of 1244.3–1628.2 Kcal and dietary fibre intake of 15.5–21.3 g. Their protein intake was close to the dietary recommendation, with participants with full dentures consuming on average 51.9 g, and the edentulous without dentures and people wearing partial

dentures consuming 69.6 g and 67.5 g, respectively. In addition, for carbohydrates, all participants were over the recommended goal.

Compared to individuals with natural teeth, individuals wearing partial dentures that can be removed had a weakened capability to bite and chew food. Nonetheless, it should be kept in mind that poor nutritional quality cannot always be attributed to avoiding certain foods based on their difficulty to eat if one considers that it is possible to alter foods in the diet to soften their texture. In an environment where there is a dearth of research, such as dietary pattern analysis, it is difficult to conclude why these findings are contradictory.

Several extensive cross-sectional studies have used retrospective methods like the FFQ or 24-h dietary recall to assess dietary intake (Tada, Miura, & geriatrics 2014). Notwithstanding the reality that these methods are validated, their main weakness is that they rely on memory. Anything that requires older adults to remember, especially for those with memory challenges, is likely to be problematic. To deal with some of these challenges, a recent review proposed using dietary records (for example, a food diary), as employed in the current study, to assess the dietary intake of individuals suspected to have cognition challenges. The main strength of this method is that the diary is filled while the consumption is taking place (Zuniga, McAuley, and Aging, 2015).

Limitations

Several limitations need to be considered in the present study. Even though the Saudi Demographic and Health Survey (SDHS) presents a sample that can be perceived as representative of the Saudi population in private households, this study excludes adults residing in long-term residential care facilities. If one considers the fact that the percentage of edentate older adults with lowered functional dentition and DMFT is higher in care homes than in private households, this becomes a weakness (Al-Shehri, 2012). Furthermore, compared to private homes, care homes tend to have higher levels of malnutrition (Russel and Elia, 2015).

It is possible to mitigate these identified weaknesses in the dietary/dental surveys of the future by including people residing in long-term residential care facilities to ensure a nationally representative sample.

A second weakness in the current study is that the dietary intake data were gathered using a self-reported method based online. The main weakness of these methods is that they introduce social desirability bias, which could result in the erroneous reporting of energy consumption, subsequently, nutrient intake (Lee and Nieman, 2018).

Another weakness linked to the current study is related to the fact that the number of tests conducted was enormous. The challenge with this is that it can make interpreting data challenging. Moreover, the study was cross-sectional, which means establishing a cause and effect connection was not possible.

If one considers the dearth of longitudinal studies exploring the link between dentation status and nutritional intake in older adults, it becomes clear that there could be challenges associated with determining how the events occurred with regards to time (Gaewkhiew, Sabbah, and Bernabé, 2017). For instance, a bidirectional connection between dental status and nutrient intake may exist if the fact that the consumption of poor quality food may introduce the risk of tooth loss is taken into account (Palacios and Joshipura, 2015).

The length of the online questionnaire may have resulted in respondent fatigue as participants sometimes gave similar answers to all questions or left some questions unanswered. To deal with this challenge, the researcher checked whether there were sequences in the way participants answered a question or there was missing data before accepting a questionnaire. Where the researcher discovered that there was missing data, the participants would be requested to provide the missing data.

Even though the current study has its limitations, it still contributes to oral health research by being the inaugural cross-sectional study exploring the effect of dental status on the supposed capability to consume certain foods and on nutrient intake among Saudi Arabian older adults. It will be valuable to conduct further research connected to the influence of dental status and environmental and individual factors in other age categories. This will help determine whether similar or different findings will be made from different groups with different disease patterns.

Difficulties

During the pandemic, this research encountered some challenges, mainly as a result of restricted access to resources. Added to this, there were complications linked to managing personal safety and the safety of everyone involved in the study. All this had to be done while also ensuring that the researcher met their family responsibilities.

Owing to the lockdowns and social distancing measures imposed to stop the spread of Covid-19, I often had no choice but to work from home. This resulted in my team being spaced too far apart, which made collaboration between team members difficult.

The disruptions imposed by Covid-19 also resulted in delays in data gathering and analysis. The extraordinary measures imposed to stem the spread of the virus meant that I had to work from home using remote telework. Working from home was challenging because it required essential equipment and infrastructure, such as space to work, computers, access to the internet, and power.

To deal with the exposure risk linked to obtaining questionnaires from participants, we were forced to stop the recruitment of participants during the pandemic and the subsequent lockdowns. Patient recruitment only started after we had access to the participants' contact details; the oral examination had already been done before the pandemic. Notwithstanding this, the explanations to the participants were done on the phone so that the properly completed questionnaires could be included in the study.

CHAPTER SIX CONCLUSIONS AND RECOMMENDATIONS

Summary of the findings

This cross-sectional clinical and self-report online questionnaires study focused on how oral health status affects oral and nutritional health choices among Saudi Arabian adults aged 60 and above. Several clinical variables were used in gathering data, including environmental and individual characteristics, food types and frequency of intake, the general quality of life, and general health opinions. The effect was projected using clinical and individual factors in association with nutrition intake and food types.

The present study contributes to the current knowledge by ascertaining the connection between nutrition intake and oral health status. This is the inaugural study exploring this relationship among older adults in Saudi Arabia using a cross-sectional design, electronic questionnaires, national data, and robust analytical methods.

This section provides a summary of the findings and recommendations arising from the study.

Conclusions

The participants' mean age was 70.29 years (range 60-104), with a standard deviation of 8.71. The number of female participants was the same as that of males: 163 (50%).

The majority of participants (62.6%) had 20 or more teeth, 25.2% had less than 20 teeth, and 9.5% were edentulous.

Participants with no dentures constituted the largest group (78.6%), with 9.5% having partial dentures and 6.1% having complete dentures.

Over two-thirds (70.8%) said that they only visit the dentist when there is a problem.

The highest number of edentulous participants with no teeth was the illiterate group, which made up half of the 30 edentulous participants.

The mean DMFT for older adults in Saudi Arabia was 15.5.

For the physical activity scale for the elderly PASE of older people in Saudi Arabia, the mean number of PASE was 78.28, with a standard deviation of 64.1.

About one-third of the participants in the present study self-reported their ability to bite or chew as being accompanied by a fair or greater degree of difficulty.

The results showed that the edentulous participants compared to the edentate were more likely to report having difficulty eating foods for all 15 foods listed.

In addition, in this study the participants with partial dentures, complete dentures in 1 jaw and full complete dentures compared to the participants with no dentures were more likely to report having difficulty eating foods for all 15 foods listed.

The present study's findings demonstrate that edentate, denture-wearing seniors in Saudi Arabia consume lower levels of important nutrients, which are protein, carbohydrates, fibre, fat, and calories, compare to dentate people. However, the edentulous people not wearing any dentures were consuming higher nutrients than denture-wearing older adults.

In this study, the participants with 20 or more teeth consumed the highest levels of important nutrients, which are protein, carbohydrates, fibre, fat, and calories, compared to the participants with 1-19 teeth, while the edentulous older adults consumed the least.

The results also showed that the subjects with neutral teeth generally had a recommended energy intake of between 2057.4 and 2513.6 Kcal, while the recommended for intake older adults is between 2000 and 2800 Kcal, depending on their physical activity.

The present study's findings show that aged people with neutral teeth and not wearing dentures had the highest energy intake, followed by edentulous and no dentures, after that people with teeth and partial dentures, finally the lowest energy intake was for seniors with teeth and complete dentures in one jaw and edentulous with complete dentures.

The present study emphasises that strategies for improving edentate older adults' nutritional status are required, particularly if one considers the role played by diet in protection against the health conditions linked to ageing.

In addition, there were no observed differences between groups in relation to the perceived ability to eat and consume nutrition after socio-demographic and health behavioural had been adjusted, except for age group.

Recommendations

Based on this study's findings, it can be concluded that older edentate adults are still disadvantaged from a nutritional perspective when compared to their counterparts who still have natural teeth. Future studies in this area could focus on the development of dental interventions combined with dietary counselling and advice as a way of encouraging individuals in high-risk populations to embrace healthy eating habits.

Considering the high number of decaying or missing teeth and the need for medical interventions among older adults, this group needs to be aware of the importance of embracing preventative therapy while also looking for medical interventions that improve natural teeth retention into advanced age.

There is a need for policy changes to ingrain the development of oral healthcare services for older adults. The Saudi Arabian Ministry of Health needs to make oral healthcare services more affordable and accessible to older adults by making available flexible programs that facilitate visits by geriatric specialists to the homes of older adults. When older adults are provided with oral healthcare, the result will be economic savings and a reduction in the workload for caregivers.

A practical approach would be to embrace promotional programs on oral health and dietary consumption. The high DMFT prevalence indicates a substantial public health concern, and this implies a need for public health policies encouraging good oral health behaviours.

There is a general increase in older adults ageing in place, assisted by families or government-funded home support. The capability to access oral healthcare for such individuals brings about serious concerns regarding their oral health. Some of the programs that can alleviate this concern include introducing publicly funded home visits and mobile dental clinics. These could lower the barriers to oral healthcare for this group.

There is a need to assimilate oral health promotion approaches into the general health assessment of older adults. If one considers that the likelihood to visit general medical practitioners (GPs) is higher among older people, the GPs must emphasise the vital role of maintaining good oral hygiene and regular visits to dentists. The oral health promotion strategies' primary aim is to prevent oral diseases among older adults.

The current study reflects the oral healthcare situation for older Saudi Arabian adults considered from four sites. Studies exploring the oral healthcare and nutritional status of older adults receiving care in other dental departments countrywide will make a good baseline for comparing this sample to other samples of older adults. Also, these studies will make it possible for policymakers and oral healthcare professionals to allocate resources appropriately.

It is still vital to continue with the effort of attempting to comprehend the social, personal, and environmental limitations of physical activity among the people of Saudi Arabia. It can be suggested that national policies should be designed to encourage active living while discouraging sedentary lifestyles. The role of healthcare providers in encouraging physical activity is a crucial one. These providers can also play the role of encouraging individuals to embrace healthy lifestyle habits.

In terms of online questionnaires, the challenge related to the engagement of participants so that they can answer all the questions can be mitigated by making personalised online feedback available, using it as a way of rewarding participants to complete the online questionnaire.

APPENDICES

Edinburgh Dental Institute
University of Edinburgh

Study title:
The impact of oral health on diet and quality of life among the aging population in Saudi Arabia

Informed Consent Form

Please tick the box

1. I confirm that I have read and understand the information sheet for the above study. ☐

2. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

3. I agree to take part in the above study. I understand that my participation is voluntary and that I am free to withdraw at any time. ☐

4. I consent to completing questionnaires and having a clinical dental examination for the specific research project identified above. ☐

5. I agree that the information from the questionnaires and any data derived from the clinical examination will be kept securely for 10 years aftre completion PhD study. Data paper forms will be stored in locked cabinet ensuring maintenance of anonymity of the paperwork. Electronic data will be stored securely with password protection in a research data storage within the University of Edinburgh IT system. ☐

6. I agree that any data and results arising from my completion of the questionnaires and the clinical examination may be used for research purposes in preparation a PhD thesis, presentations, and research articles). ☐

7. I understand that I will not be identifiable in any of the reporting/quotes in all of those research written works. ☐

_____	_____	_____
Name of participant	Date	Signature

_____	_____	_____
Researcher	Date	Signature

Information leaflet for participants having interviews, questionnaire, and oral health examination

Study title:	The impact of oral health on diet and quality of life among the aging population in Saudi Arabia
Supervisor:	Professor Angus Walls (Principal Supervisor)
Researcher collecting data:	Alhussain Daghriri (PhD student)

You are being invited to take part in a research study. Before you decide whether or not to take part, it is important for you to understand what kind of research is being done and what it will involve. Please take your time to read the following information carefully.

Thank you for reading this.

What is this document about?

This document explains what kind of study we are doing, what your rights are, and what will be done with your data. If there are any benefits or risks, they will be explained here. Please read the information below. If you are happy to take part in this study, we will offer you an informed consent form. By filling in, signing and dating to take part in this study, you will be agreeing to participate and to let us use your data in specific ways.

What will be done in this study?

You are about to participate in a study which involves an online questionnaires and you having an examination for your teeth and gums. This study will take place in ….. We will ask you about your oral health , general health experiences, and about how the condition of your mouth affect the food you can eat or these you choose to eat.

Your questionnaires, and oral health examination will be performed on the same day.

Questionnaire:

You will complete an online dietary questionnaire about food types and frequency of consumption. Before starting the online questionnaire, you will have a demonstration about how to register your personal account in our online system and how to complete this survey. In order that we can validate our data some participants will be asked to repeat the dietary questionnaire about 4 weeks later at home. At the end of the online questionnaire, we will ask you to complete a written questionnaire about your oral health and how it impacts on your quality of life, and general information. The completion of this questionnaire takes a different amount of time for different people but commonly takes about ……..

Interview

Your interview will take form a series of questions about your oral health problems, the oral healthcare facilities you use and your oral health habits. The interview lasts at different amount of time for different people but commonly lasts about …...

Oral health examination:

The oral health examination will take place during the same visit. Each examination will take between 5 and 25 minutes, depending on the dental status of the participant. Before the examination could take place, the dentist will ask you a short set of screening questions; which are designed to ensure that it is safe for you to have this examination.

Where you have no teeth, only data on the condition of the soft tissues and the type and condition of your complete dentures will be collected. When you have some teeth the examination will be more extensive, we will look at your teeth to see if there are any fillings or artificial crowns or whether there is any sign of tooth decay. We will also examine the gums and supporting tissues for

your teeth in a standard way. This includes gently probing around the gum margin, which may be a little uncomfortable.
We will look at the surface of your teeth in case if there are any sings of wear and tear. Finally, we will examine the soft tissues of your mouth and if you also wear dentures, we will look at that to assess their quality.

What are possible risks and benefits of taking part?
There are no risks to participation in this study. If our questions at the start of the oral health questionnaire suggest that there may be any risk to you from any element of this examination we will simply not do that part for you.

The benefits: involvement in this study means you are making contribution to our knowledge about oral health, nutrition issues and quality of life in Saudi Arabia.
In addition, if we see anything that is suspicious during the oral health examination we will tell you whether you need to go to see your dentist or if it is urgent, we will refer you for care to a specialist.

Will your participation in this study be kept confidential?
Your participation in this study will be kept confidential in any published work.. No personal details that might identify you will be stored with your questionnaire/interview/oral health examination data, which will be anonymized.

What is the participation type and the withdrawal rights of this research?
Your participation is voluntary, and you may withdraw from the study at any time and for any reason.

What will happen in the end of the study?
After your participation in the interview, questionnaire completion, and oral health examination, your involvement in the study is over. We appreciate your contribution in this study. In order that we can validate our data some

participants will be asked to repeat the questionnaire and oral health examination about 4 weeks later.

What will happen to the results of the research study?

The results will be used as a part of a study of the impact of oral health on nutrient status in Saudi Arabia. All the data collected will be analysed and reported in my PhD thesis, and the findings may be used in presentations or research articles. We will take care to make sure that you cannot be identified in any reports or publications.

Who have reviewed the study?

Contact information. This research is being conducted by the above-listed researchers at the University of Edinburgh.

You may have some questions after you have read this information sheet. Please feel free to ask me, **Alhussain Daghriri**, to clear up any queries that you may have.

You will be given a copy of this information sheet and also a copy of the signed consent form to keep if you would like to participate in this study.

Thank you for your help!

Researcher contact address:

Alhussain Daghriri
PhD student in dentistry
Phone number: 00966500026560
Email: s1453786@sms.ed.ac.uk

BACKGROUND INFORMATION	**المعلومات الأساسية**
1. **How old are you? ____ years old**	**1. كم عمرك؟ ____ سنة**
2. **What is your formal educational background?**	**2. ما هو مستواك التعليمي؟**
a. Illiterate	ا. أمي (غير متعلم)
b. Writing and reading	ب. الكتابة والقراءة
c. Primary school	ج. الابتدائية
d. Intermediate school	د. المتوسطة
e. Secondary school	ه. االثانوية
f. University or above	و. جامعة أو أعلى
3. **What is your marital status?**	**3. ما هي حالتك الاجتماعية؟**
a. Single	ا. غير متوزج
b. Married	ب. متزوج
c. Divorce	ج. مطلق
d. Widowed	د. أرمل
4. **What is your current job status?**	**4. ما هو وضعك الوظيفي الحالي؟**
a. Working for government or public sector	ا. أعمل بالقطاع الحكومي
b. Working for private sector	ب. أعمل بالقطاع الخاص
c. Self-employed	ج. أعمل لحسابي الشخصي
d. Unemployed	د. عاطل
e. Retired	ه. متقاعد
f. Others (please specify):	و. غير ذلك (يرجى التحديد):

5. **Which kinds of income do you personally receive?**	**5. ما هي أنواع الدخل التي تتلقاها شخصيا؟**
a. Earnings from employment	ا. الراتب الوظيفي
b. Pension from former employer	ب. الراتب التقاعدي
c. Social Security Subsidies	ج. إعانات الضمان الاجتماعي
d. Interest from savings / investments	د. العوائد من المدخرات / الاستثمارات
e. Earnings from spouse (for example: husband/wife)	ه. العوائد من الشريك (على سبيل المثال: الزوج / الزوجة)
f. Other, please specify	و.غير ذلك (يرجى التحديد)
6. **Could you please estimate your household monthly income (SR)?**	**6. هل بالامكان تقدير دخل الأسرة الشهري (ريال)؟**
a. Up to 3000	ا. يصل إلى 3000
b. 3001 - 6000	ب. 3001 - 6000
c. 6001 - 9000	ج. 6001 - 9000
d. 9001 - 12000	د. 9001 - 12000
e. More than 12001	ه. أكثر من 12001
7. **How many people live in your household?**	**7. كم عدد الاشخاص الذين يعيشون في منزلك؟**
SMOKING AND TOBACCO USE	**التدخين واستخدام التبغ**
8. **Which of the statements matches your experience of smoking a cigarette/ a cigar/ a pipe/ chewing tobacco?**	**8. أي من العبارات يطابق تجربتك في التدخين (السجائر - السيجار - الغليون - الشيشة) مضغ التبغ (الشمة - التمباك)؟**

a. I smoke nowadays	ا. أنا أدخن في الوقت الحاضر
b. I chew tobacco nowadays	ب. أنا أمضغ التبغ في الوقت الحاضر
c. I am a former smoker / tobacco chewer	ج. أنا مدخن سابق / مضغت التبغ سابقا
d. I have never smoked or chewed tobacco → Go to Question 13	د. لم أدخن أبدا أ ولم أمضغ التبغ --- انتقل إلى السؤال 13
9. **How long have you stop smoking/ chewing tobacco?**	**9. متى توقفت عن التدخين / مضغ التبغ؟**
a. I am still smoking/chewing tobacco	ا. ما زلت أقوم بالتدخين / أمضغ التبغ
b. Less than 5 years	ب. أقل من 5 سنوات
c. 5-10 years	ج. 5-10 سنوات
d. More than 10 years → Go to Question 13	د. أكثر من 10 سنوات --- انتقل إلى السؤال 13
10. **How long have you been smoking/ chewing tobacco? / How long had you been smoking/ chewing tobacco?**	**10. منذ متى وأنت تدخن / تمضغ التبغ؟** **أو كم المدة التي كنت فيها تدخن / تمضغ التبغ سابقاً؟**
a. Less than 5 years	ا. أقل من 5 سنوات
b. 5-10 years	ب. 5-10 سنوات
c. More than 10 years	ج. أكثر من 10 سنوات
11. **How many cigarettes do you smoke per day? / How many cigarettes did you to smoke per day?**	**11.كم سيجارة تدخن في اليوم؟ / كم عدد السجائر التي كنت تدخن يوميا؟**
a. Less than 10 cigarettes/ day	ا. أقل من 10 سيجارات / يوم

b. 10-19 cigarettes/ day	ب. 10-19 سيجارة / يوم
c. More than 19 cigarettes / day	ج. أكثر من 19 سيجارة / يوم
d. I have never smoked, but I have chewed tobacco	د. لم أكن مدخن أبدا، ولكني أمضغ التبغ
12. **How many grams of tobacco do you chew per day? / How many grams of tobacco did you used to chew per day?**	**12. كم غرام من التبغ تمضغها يوميا؟ أو كم عدد جرامات التبغ التي استخدمتها سابقاً للمضغ يوميا؟**
a. Up to 5 grams	ا. تصل إلى 5 غرامات
b. More than 5 grams	ب. أكثر من 5 غرامات
c. I have never chewed tobacco, but I have smoked cigarette	ج. لم أمضغ التبغ أبدا، ولكني أدخن السجائر
DIABETES STATUS	**حالة مرض السكري**
13. **What is your current diabetes status?**	**13. ما هو وضعك الحالي لمرض السكري؟**
a. No diabetes → Go to Question 17	ا. لست مصاب بداء السكري --- انتقل إلى السؤال 17
b. Diabetes type 1 (Insulin dependent diabetes mellitus (IDDM))	ب. مريض السكري من النوع الأول (المعتمد على الأنسولين)
c. Diabetes type 2 (Non-insulin dependent diabetes mellitus (NIDDM))	ج. مريض السكري من النوع الثاني (غير معتمد على الانسولين)
d. Diabetes, but I don't know which type of diabetes I have suffered	د. مريض بالسكري، ولكن لا أعرف أي نوع من مرض السكري الذي أعانيه

14. **How old were you when first diagnosed with diabetes?**	**14. كم عمرك عند تشخيصك بمرض السكري لأول مرة؟**
a. Less than 40 years old	ا. أقل من 40 سنة
b. 40 years old and above	ب. 40 سنة فما فوق
15. **What kind of therapy do you receive for your diabetes management? (you may choose multiple option)**	**15. ما نوع العلاج الذي تتلقاه للسيطرة على مرض السكري؟** **(يمكنك اختيار أكثر من خيار)**
a. Insulin injection	ا. حقن الأنسولين
b. Oral medications tablets	ب. أقراص (حبوب) عن طريق الفم
c. Controlled diet	ج. حمية غذائية
d. Regular exercise	د. تمارين منتظمة
e. Smoking cessation	ه. الإقلاع عن التدخين
f. Other (please specify):	و. غير ذلك (يرجى التحديد):
16. **How long have you had diabetes?**	**16. منذ متى وانت مصاب بمرض السكري؟**
a. Less than 5 years	ا. أقل من 5 سنوات
b. 5-10 years	ب. 5-10 سنوات
c. More than 10 years	ج. أكثر من 10 سنوات
CURRENT ORAL HEALTH BEHAVIOUR	**عادات صحة الفم الحالية**
17. **How often do you brush your teeth nowadays?**	**17. كم مرة تفرش أسنانك في الوقت الحاضر؟**
a. More than twice a day	ا. أكثر من مرتين في اليوم
b. Twice a day	ب. مرتين فى اليوم

c. Once a day	ج. مرة واحدة في اليوم
d. Less than once a day	د. أقل من مرة واحدة في اليوم
18. **Do you use any of the following to clean your teeth? (you may choose multiple option)**	**18. هل تستخدم أي من التالي لتنظيف أسنانك؟ (يمكنك أختيار أكثر من خيار)**
a. Toothbrush	ا. فرشاة الأسنان
b. Dental floss	ب. خيط تنظيف الاسنان
c. Interdental brush/toothpicks/woodsticks	ج. فرشاة بين الأسنان / أعواد السنان
d. Mouthwash	د. غسول الفم
e. Electric toothbrush	ه. فرشاة أسنان كهربائية
f. Miswak	و.المسواك
g. Denture cleaning solution	ز. محلول تنظيف أطقم الأسنان
h. Sugar-free chewing gum	ح. العلكة (اللبان) الخالية من السكر
i. Other (please specify):	ط. غير ذلك (يرجى التحديد):
19. **If you have denture, how often do you clean your dentures nowadays? (Question refers to all types of cleaning)**	**19. إذا كان لديك أطقم أسنان اصطناعية، كم مرة تنظفها في الوقت الحاضر؟** **(السؤال يشمل جميع أنواع التنظيف)**
a. More than twice a day	ا. أكثر من مرتين في اليوم
b. Twice a day	ب. مرتين فى اليوم
c. Once a day	ج. مرة واحدة في اليوم
d. Less than once a day	د. أقل من مرة واحدة في اليوم
e. I don’t have denture	ه. ليس لدي أطقم أسنان صناعية
PATTERN OF DENTAL ATTENDANCE	**نمط ذهابك لعيادة الأسنان**

20. **How often do you go to dentist?**	**20. كم مرة تذهب إلى طبيب الأسنان؟**
a. At least once every six months	ا. مرة واحدة على الأقل كل ستة أشهر
b. At least once every year	ب. مرة واحدة على الأقل كل عام
c. Only when having trouble with teeth/dentures	ج. فقط عند وجود مشاكل مع الأسنان / أطقم الأسنان الصناعية
d. Never been to dentist	د. لم اذهب أبدا لطبيب الأسنان
GENERAL / ORAL HEALTH	**الصحة العامة وصحة الاسنان**
21. **How is your health in general; would you say it is…**	**21. كيف صحتك بشكل عام. هل تقول انها ...**
b. Very good	ا. جيد جدا
c. Good	ب. جيد
d. Fair	ج. مقبول
e. Bad	د. سيئة
f. Very bad	ه. سيئة جدا
22. **(And) would you say your dental health (mouth, teeth and/or dentures) is...**	**22. (و) هل تقول أن صحة الأسنان (الفم والأسنان / أو أطقم الأسنان) هي ...**
a. Very good	ا. جيد جدا
b. Good	ب. جيد
c. Fair	ج. مقبول
d. Bad	د. سيئة
e. Very bad	ه. سيئة جدا

OHIP

How often, in the past year:			**كم مرة تكررت هذه المشكلة خلال العام الماضي :**		
23. **Have you had trouble pronouncing any words because of problems with your teeth, mouth or dentures?**			**23. هل واجت صعوبة في لفظ كلمات معينة بسبب مشاكل في أسنانك أو فمك أو التعويض السني (الأطقم)؟**		
Very Often غالبا	Fairly Often في العادة	Occasionally أحياناً	Hardly Ever في النادر	Never أبدًا	Don't Know لا أعلم
24. **Have you felt that your sense of taste has worsened because of problems with your teeth, mouth or dentures**			**24.هل شعرت أن حاسة التذوق لديك قد ضعفت بسبب مشاكل في أسنانك أو فمك أو التعويض السني (الأطقم) ؟**		
Very Often غالبا	Fairly Often في العادة	Occasionally أحياناً	Hardly Ever في النادر	Never أبدًا	Don't Know لا أعلم
25. **Have you had painful aching in your mouth?**			**25.هل عانيت من آلام شديدة في فمك بسبب مشاكل في أسنانك أو فمك أو التعويض السني (الأطقم) ؟**		
Very Often غالبا	Fairly Often في العادة	Occasionally أحياناً	Hardly Ever في النادر	Never أبدًا	Don't Know لا أعلم
26. **Have you found it uncomfortable to eat any foods because of problems with your teeth, mouth or dentures?**			**26.هل شعرت بعدم ارتياح في تناول طعام ما بسبب مشاكل في أسنانك أو فمك أو التعويض السني (الأطقم) ؟**		
Very Often غالبا	Fairly Often في العادة	Occasionally أحياناً	Hardly Ever في النادر	Never أبدًا	Don't Know لا أعلم
27. **Have you been self-conscious because of your teeth, mouth or dentures?**			**27.هل كان لديك شعور بالخجل بسبب مشاكل في أسنانك أو فمك أو التعويض السني (الأطقم) ؟**		
Very Often غالبا	Fairly Often في العادة	Occasionally أحياناً	Hardly Ever في النادر	Never أبدًا	Don't Know لا أعلم

28. **Have you felt tense because of your teeth, mouth or dentures?**			**28.هل شعرت بتوتر بسبب مشاكل في أسنانك أو فمك أو التعويض السني (الأطقم) ؟**		
Very Often غالبا	Fairly Often في العادة	Occasionally أحياناً	Hardly Ever في النادر	Never أبدًا	Don't Know لا أعلم
29. **Has your diet been unsatisfactory because of problems with your teeth, mouth or dentures?**			**29.هل أصبح غذاؤك المعتاد غير مرضي أو ليس كما ترغب بسبب مشاكل في أسنانك أو فمك أو التعويض السني (الأطقم) ؟**		
Very Often غالبا	Fairly Often في العادة	Occasionally أحياناً	Hardly Ever في النادر	Never أبدًا	Don't Know لا أعلم
30. **Have you had to interrupt meals because of problems with your teeth, mouth or dentures?**			**30.هل كان عليك الانقطاع عن مواصلة تنوالك لوجبة طعامك بسبب مشاكل في أسنانك أو فمك أو التعويض السني (الأطقم) ؟**		
Very Often غالبا	Fairly Often في العادة	Occasionally أحياناً	Hardly Ever في النادر	Never أبدًا	Don't Know لا أعلم
31. **Have you found it difficult to relax because of problems with your teeth, mouth or dentures?**			**31.هل وجدت صعوبة بالاسترخاء بسبب مشاكل في أسنانك أو فمك أو التعويض السني (الأطقم) ؟**		
Very Often غالبا	Fairly Often في العادة	Occasionally أحياناً	Hardly Ever في النادر	Never أبدًا	Don't Know لا أعلم
32. **Have you been embarrassed because of problems with your teeth, mouth or dentures?**			**32.هل كنت محرجاً أو مرتبكاص بعض الشيئ بسبب مشاكل في أسنانك أو فمك أو التعويض السني (الأطقم)؟**		
Very Often غالبا	Fairly Often في العادة	Occasionally أحياناً	Hardly Ever في النادر	Never أبدًا	Don't Know لا أعلم
33. **Have you been irritable with other people because of problems with your teeth, mouth or dentures?**			**33.هل كنت نوعاً ما سريع الغضب أو الانفعال مع الآخرين بسبب مشاكل في أسنانك أو فمك أو التعويض السني (الأطقم) ؟**		

Very Often غالبا	Fairly Often في العادة	Occasionally أحياناً	Hardly Ever في النادر	Never أبدًا	Don't Know لا أعلم
34. **Have you had difficulty doing your usual jobs because of problems with your teeth, mouth or dentures?**			**34.هل واجهت صعوبة في أداء أعمالك المعتادة بسبب مشاكل في أسنانك أو فمك أو التعويض السني (الأطقم) ؟**		
Very Often غالبا	Fairly Often في العادة	Occasionally أحياناً	Hardly Ever في النادر	Never أبدًا	Don't Know لا أعلم
35. **Have you felt that life in general was less satisfying because of problems with your teeth, mouth or dentures?**			**35.هل كان لديك الانطباع أن حياتك بوجه عام اصبحت أقل رضا بسبب مشاكل في أسنانك أو فمك أو التعويض السني (الأطقم) ؟**		
Very Often غالبا	Fairly Often في العادة	Occasionally أحياناً	Hardly Ever في النادر	Never أبدًا	Don't Know لا أعلم
36. **Have you been totally unable to function because of problems with your teeth, mouth or dentures?**			**36.هل كنت غير قادر على القيام بأي عمل إطلاقاً بسبب مشاكل في أسنانك أو فمك أو التعويض السني (الأطقم) ؟**		
Very Often غالبا	Fairly Often في العادة	Occasionally أحياناً	Hardly Ever في النادر	Never أبدًا	Don't Know لا أعلم

Medical Screening questionnaire			**استبيان الفحص الطبي**
Has a doctor or dentist ever told you that you must take antibiotics before you get dental check-up or care	**Yes نعم**	**No لا**	هل أخبرك طبيبك أو طبيب أسنانك بأنك يجب أن تأخذ المضادات الحيوية قبل أن تحصل على فحص الأسنان أو العلاج
Before we begin, I would like to read you a list of health conditions that			قبل أن نبدأ، أود أن أقرأ عليك قائمة من الحالات الصحية التي لدى بعض الناس. كلما قرأت أحدها من

some people have. As I read off each condition, please tell me weather or not a doctor has ever told you that you have the condition.			فضلك قل لي هل سبق لطبيبك أن قال لك أنك مصاب بهذه الحالة.
Has a doctor ever told you that you have:			هل أخبرك طبيب من قبل بأن لديك:
A heart problem	**Yes نعم**	**No لا**	مشكلة القلب
If YES, Was the heart problem due to:			إذا كانت الإجابة بنعم، هل كانت مشكلة القلب بسبب:
Congenital heart murmurs	**Yes نعم**	**No لا**	نخاع القلب الخلقي
A heart valve problem	**Yes نعم**	**No لا**	مشكلة بصمامات القلب
Congenital heart disease	**Yes نعم**	**No لا**	مرض قلب خلقي
Bacterial endocarditis	**Yes نعم**	**No لا**	التهاب الشغاف الجرثومي
Has a doctor ever told you that you have:			هل أخبرك طبيب من قبل بأن لديك:
Rheumatic fever	**Yes نعم**	**No لا**	الحمى الروماتيزمية
Kidney disease requiring renal dialysis	**Yes نعم**	**No لا**	أمراض الكلى التي تتطلب غسيل الكلى
Haemophilia	**Yes نعم**	**No لا**	سيولة الدم

Do you have:			هل تمتلك..
A pacemaker or other artificial material in your heart, veins or arteries	**Yes نعم**	**No لا**	جهاز تنظيم ضربات القلب أو غيرها من المواد الاصطناعية في قلبك، الأوردة أو الشرايين؟
A hip, bone, or joint replacement	**Yes نعم**	**No لا**	أو هل تملك ورك، أو عظام أو مفاصل إصطناعية

يحتوي استبيان النظام الغذائي على 146 مادة غذائية. يستغرق إكمال الاستبيان 20 دقيقة. يُرجى محاولة إكمال جميع المواد الغذائية في جلسة واحدة. إذا كنت بحاجة إلى ترك جهاز الكمبيوتر أو إغلاق المتصفح أثناء الجلسة، فسيتم حفظ إجاباتك. يُرجى تسجيل الدخول خلال 24 ساعة لاستكمال ما تبقى من الأسئلة.

نحن مهتمون بما تناولته في الشهر الماضي فقط. بالنسبة لأي مواد غذائية لم تتناولها في الشهر الماضي، فيمكنك تخطيها (اضغط على الزر "ليس في الشهر الماضي"). بالنسبة إلى المواد الغذائية التي تناولتها، يُرجى الإشارة إلى عدد مرات تناولها في الشهر الماضي جنبًا إلى جنب مع حجم الحصص. يُسمح لك بالعودة إلى المواد الغذائية السابقة وتغيير إجاباتك باستخدام زر الرجوع (بالزاوية اليسرى السفلية).

"The diet questionnaire contains 146 food items. It will take around 20 minutes to complete. Please try to complete all the items in one session. If you need to leave your computer or close your browser during the session, your responses will be saved. Please login within 24 hours to complete the remainder of the questions.

We are only interested in what you have had in the last month. For any food items that you have not had in the last month, you can skip that item (press the 'Not in the last month' button). For items that you have had, please indicate how frequently you had that food in the last month along with the portion size. You are allowed to return to the previous food items and change your answers using the back button (bottom left corner).

>6/day >6/اليوم	4-6/day 4-6/اليوم	2-3/day 2-3/اليوم	1/day مره في اليوم	5-6/week 5-6/الإس بوع	2-4/week 2-4/الإس بوع	1/week مره في الإس بوع	1-3/month 1-3 في الشهر	Never أبداً	**foodgroup**	**arabic**	**english**
									potatoes	أرز أسمر	Brown rice
									breads	خبز لبناني أسمر خفيف	Lebanese bread thin brown
									cereals	كورن فليكس كامل الحبوب	Breakfast wholegrain
									breads	خبز لبناني أسمر	Lebnani bread brown
									breads	توست أسمر	Brown Toast
									cereals	شوفان	Muesli, oats

									breads	خبز إيراني (تميس)	Irani bread
									dairy	حليب أو لبن كامل الدسم	Milk, Laban
									dairy	حليب أو لبن قليل الدسم	Low fat milk, Laban
									dairy	حليب أو لبن خالي الدسم	Skimmed milk, laban
									dairy	زبادي كامل الدسم	Yogurt
									dairy	زبادي قليبل الدسم	Yogurt Low fat
									dairy	جبن عالي الدسم(شيدر)	High fat cheese
									dairy	جبن متوسط الدسم الحلوم,	Medium fat cheese
									dairy	الجبن السائل(كريمي)	Cream cheese

									dairy	جبن قليل الدسم , قريش	Low fat cheese
									dairy	لبنه	Lebneh
									drinks	كابتشينو , لاتيه الخ	Cappuc ino, latte
									dairy	حليب بالشوكو لاته, فراولة	Flavour ed milk
									dairy	زبادي بالفاكهه	Fruit yogurt
									Saudi	بليلة	Nakhi
									sweet s	المكسرا ت	Nuts
									Saudi	رز بالعدس	Meadd as
									Saudi	شوربة عدس	Lentil soup
									Saudi	فلافل	Falafil
									Saudi	فول مدمس	Fool
									Saudi	حمص	Hommu s
									dairy	حليب الصويا, اللوز	Soya, almond milk

									breads	توست أبيض	White toast
									breads	خبز لبناني أبيض خفيف	Lebanese bread thin white
									breads	خبز لبناني أبيض	Lebnani bread-white
									breads	خبز صامولي	Bread roll
									breads	بقصم	Baqsam
									breads	شابوره	Shaboora
									cereals	كورن فليكس حالي	Sweetened cereal
									cereals	كورن فليكس	Breakfast cereal
									potatoes	أرز أبيض	White rice
									potatoes	بطاطا مسلوقة	Potatoes, boiled

									potatoes	باستا	Pasta
									Saudi	فطاير	Fatayer
									dairy	حليب مركز حالي	Condensed milk
									dairy	صلصه السلطه الكريميه	Salad cream
									dairy	صلصه السلطه أنواع أخرى	Other salad dressing
									sweets	بسكوت حالي	Sweets biscuits
									sweets	كرواسون	Croissants
									sweets	الشوكولاته الداكنة	Dark Chocolate
									sweets	شريط شوكولاته	Chocolate bars
									sweets	ايس كريم	Ice cream, ice lollies

									sweets	كيك	Plain cake
									sweets	جيلي	Jelly
									sweets	معمول	Mamoul
									sweets	كب كيك(مافين), دونات	Muffins, donuts
									sweets	كيك مع الشوكولاته	Rich cakes
									sweets	وافلز، بانكيك	Pancakes, crepes
									sweets	حلاو التوفي	Sweets, toffee
									sweets	كنافه	Konafa
									sweets	حلو اللقيمات	lgaimat
									sweets	سكر مضاف للشاي و القهوه	Sugar added to coffee, tea

									sweets	كريمة الكاكاو والبندق	Nut or chocolate spreads
									sweets	بطاط	Chips
									sweets	مربى, عسل	Jam, honey
									sweets	مخلل, كاتشب	Pickles, ketchup
									drinks	حليب بالكاكاو الساخن	Hot chocolate
									drinks	عصير طبيعي	Pure fruit juice
									drinks	مشروبات غازيه	Fizzy drinks
									drinks	عصير بالنكتار	Juice drinks
									drinks	شوربه بالكريمه	Creamy soups
									drinks	شوربه خفيفه دون الكريمه	Non-creamy soups

									Saudi	شاويرما	Shawerma
									vegetables	زيتون	Olives
									vegetables	طماطم	Tomatoes
									fruits	أفوكادو	Avocado
									fruits	تفاح	Apple
									fruits	الموز	Banana
									fruits	تمر	Dates
									fruits	عنب	Grapes
									fruits	جوافة	Guava
									fruits	كيوي	Kiwi
									fruits	مانجو	Mango
									fruits	شمام	Melon
									fruits	أفندي برتقال,	Tangerine, Orange
									fruits	أنواع التوت	Berries
									fruits	برقوق, خوخ	Plum, Peach
									fruits	كمثرى	Pears
									fruits	رمان	Pomegranate

									fruits	بطيخ	Watermelon
									fruits	فاكهه معلبة	Tinned fruit
									Saudi	صلصة الطامطم بالفلفل (دقوس)	Tomato sauce
									vegetables	القرنبيط	Broccoli, Green leafy vegetables
									vegetables	ملفوف	Cabbage
									vegetables	جزر	Carrot
									vegetables	زهرة	Cauliflower
									vegetables	شمندر	Beetroot
									vegetables	خيار	Cucumber
									vegetables	ثوم	Garlic
									vegetables	فلفل حلو	Sweet pepper

									vegetables	بزاليا	Peas
									vegetables	هليون	Asparagus
									vegetables	فاصوليا خضراء	Green beans
									vegetables	بصل	Onions
									vegetables	السبانخ	Spinach
									vegetables	ذرة	Corn
									vegetables	مشروم	Mushroom
									vegetables	سلطة خضرة	Green salad
									Saudi	مرق بامية	Orkra stew
									Saudi	برياني خضار	Vegetable beryani
									Saudi	مرق	Marag
									Saudi	مرقوقه	Mourkokah
									Saudi	ورق عنب	Stuffed vine leaves

									potatoes	بطاطا مقلية	Fried potatoes
									potatoes	لازانيا, بشاميل	Lasagne, Bashamel
									potatoes	معكرونة	Spaghetti bolognese
									potatoes	سبرينج رول	Spring roles
									potatoes	بيتزا	Pizza
									Saudi	كبسة لحم	Machbous laham
									Saudi	كبسة دجاج	Machbous chicken
									Saudi	برياني دجاج	Biryani chicken
									Saudi	برياني لحم	Biryani
									Saudi	ربيان (مربين)	Mourabyan

									Saudi	كبسة ربيان	Mowash Robyan
									Saudi	جريش	Jareesh
									Saudi	هريس	Harrees
									Saudi	مطبق سمك	Motabak samak
									meat	سمك مقلي	Fried fish
									meat	سمك غني بالزيت غير مدخن	Non smoked oily fish
									meat	سمك غير مدخن معلب	Non Smoked oily fish canned
									meat	سمك مدخن	Smoked fish
									meat	مأكولات بحريه	Shell fish
									meat	سوشي	Sushi

									meat	لحم مشوي	Beef steak grilled
									meat	دجاج	Chicken
									meat	دجاج مقلي	Fried Chicken
									meat	لحوم بارده	Deli meats
									meat	همبرجر	Burger
									meat	سوسج	Sausages
									meat	كفتة, كبة	Kufta, Kubba
									dairy	بيض مسلوق	Eggs, boiled
									dairy	بيض مقلي	Eggs Scrambelled
									dairy	الزبده	Butter
									dairy	سمن	Margarine
									dairy	زيبت الزيتون	Olive oil
									dairy	زيت نباتي أخر	Other vegetable oil

									drinks	شاي الأحمر، الأخضر ، أعشاب	Tea black, green, herbal
									drinks	القهوه	Coffee
									drinks	مشروبات غازيه دايت	Diet fizzy drinks
									drinks	ماء	water
									drinks	هل تضيف الملح للوجبات	Add salt to meals?

REFERENCES

References

Al-Ghannam, Nadya A, Abdulla R Al-Shammery, Amjad H Wyne, and Nazeer B (2002) 'Prosthetic dental treatment needs in Northern Saudi Arabia', *Saudi Medical Journal*, 23, pp. 975-980.

Al-Otaibi, Meshari, and Birgit Angmar-Månsson (2004) 'Oral hygiene habits and oral health awareness among urban Saudi Arabians', *Oral Health Prev Dent*, 2, pp. 389-396.

Al-Sinaidi, Aljoharah A (2012) 'Periodontal health and oral hygiene practice of elderly Saudis living at Riyadh Nursing Home', *King Saud University Journal of Dental Sciences,* 3, pp. 1-5.

Al Moraie, Noha Moalla D. (2014) *Dietary patterns in Saudi Arabian adults residing in different geographical locations in Saudi Arabia and in the UK in relation to heart disease risk*, Newcastle University.

Al Shammery, Abdullah, M El Backly, and E Ernest Guile (1998) 'Permanent tooth loss among adults and children in Saudi Arabia', *Community Dental Health*, 15, pp. 277-280.

Alshammari, Falah R, Hamdan Alamri, Marwan Aljohani, Wael Sabbah, Lucy O'Malley, and Anne-Marie Glenny (2021) 'Dental caries in KSA: A systematic review', *Journal of Taibah University Medical Sciences*.

Alsufiani, HM, TA Kumosani, D Ford, and JC Mathers (2015) 'Dietary patterns, nutrient intakes, and nutritional and physical activity status of Saudi older adults: A narrative review', *Journal of Aging Research and Clinical Practice,* 4, pp. 2-11.

Altamimi, T (2016) 'Healthy aging conceptualizations in Saudi Arabia: a systematic review', *International Journal of Medical Science and Public Health*, 5, pp. 601-610.

Atieh, Momen A. 2008. 'Arabic version of the geriatric oral health assessment index', *Gerodontology*, 25, pp. 34-41.

Bagramian, Robert A, Franklin Garcia-Godoy, and Anthony R Volpe (2009) 'The global increase in dental caries. A pending public health crisis', *American Journal of Dentistry*, 22, pp. 3-8.

Bani, Ibrahim A, and Talal J Hashim (1999) 'Knowledge of nutrition and coronary heart disease in Riyadh, Saudi Arabia', *Journal of Community Health*, 24, pp. 467-473.

Baranowski, T (2012) '24-hour recall and diet record methods', *Nutritional Epidemiology,* 40, pp. 49-69.

Bindawas, Saad M, Vishal Vennu, Ayidh M Alqarni, and Tariq A Abdulrahman (2020) 'Physical performance and activity among older adults visiting primary healthcare centres in Riyadh', *Journal of International Medical Research*, 48, 0300060520956895.

Bingham, Sheila A, and Nicholas E Day (1997) 'Using biochemical markers to assess the validity of prospective dietary assessment methods and the effect of energy adjustment', *The American Journal of Clinical Nutrition*, 65, pp. 1130S-1137S.

Bingham, Sheila A, C Gill, A Welch, K Day, A Cassidy, KT Khaw, MJ Sneyd, TJA Key, L Roe, and NE Day (1994) 'Comparison of dietary assessment methods in nutritional epidemiology: Weighed records v. 24 h recalls, food-frequency questionnaires and estimated-diet records', *British Journal of Nutrition,* 72, pp. 619-643.

Bingham, Sheila A, Caroline Gill, Ailsa Welch, Aedin Cassidy, Shirley A Runswick, Suzy Oakes, Robert Lubin, David I Thurnham, TJ Key, and Lynn Roe (1997) 'Validation of dietary assessment methods in the UK arm of EPIC using weighed records, and 24-hour urinary nitrogen and potassium and serum vitamin C and carotenoids as biomarkers', *International Journal of Epidemiology,* 26, pp. S137.

Biro, G, KFAM Hulshof, L Ovesen, and JA Amorim Cruz (2002), 'Selection of methodology to assess food intake', *European Journal of Clinical Nutrition,* 56, S25-S32.

Black, William C, and H Gilbert Welch (1993) 'Advances in diagnostic imaging and overestimations of disease prevalence and the benefits of therapy', *New England Journal of Medicine*, 328, pp. 1237-1243.

Boushey, Carol Jo, Amelia J Harray, Deborah Anne Kerr, TusaRebecca E Schap, Stacey Paterson, Tanisha Aflague, Marc Bosch Ruiz, Ziad Ahmad, Edward J (2015) 'How willing are adolescents to record their dietary intake? The mobile food record', *JMIR,* 3, pp. e4087.

Burke, Bertha S (1947) 'The dietary history as a tool in research', *Journal of the American Dietetic Association*, 23, pp. 1041-1046.

Casey, Patrick H, Susan LP Goolsby, Shelly Y Lensing, Betty P Perloff, and Margaret L Bogle (1999) 'The use of telephone interview methodology to obtain 24-hour dietary recalls', *Journal of the American Dietetic Association,* 99, pp. 1406-1411.

Casperson, Shanon L, Jared Sieling, Jon Moon, LuAnn Johnson, James N Roemmich, Leah Whigham (2015), 'A mobile phone food record app to digitally capture

dietary intake for adolescents in a free-living environment: Usability study', *JMIR,* 3, e30.

Chapple, Iain LC, Philippe Bouchard, Maria Grazia Cagetti, Guglielmo Campus, Maria-Clotilde Carra, Fabio Cocco, Luigi Nibali, Philippe Hujoel, Marja L Laine, and Peter Lingström (2017) 'Interaction of lifestyle, behaviour or systemic diseases with dental caries and periodontal diseases: consensus report of group 2 of the joint EFP/ORCA workshop on the boundaries between caries and periodontal diseases', *Journal of Clinical Periodontology*, 44, pp. S39-S51.

Committee, Dietary Guidelines Advisory. 2020. *Dietary guidelines for Americans 2020-2025* (Government Printing Office).

Dahl Lassen, Anne, Sanne Poulsen, Lotte Ernst, Klaus Kaae Andersen, Anja Biltoft-Jensen, Inge Tetens (2010) 'Evaluation of a digital method to assess evening meal intake in a free-living adult population', *Food and Nutrition Research,* 54, p. 5311.

Dolfman, Michael L (1973) 'The concept of health: An historic and analytic examination', *Journal of School Health,* 43, pp. 491-497.

Dye, Bruce A, Sylvia Tan, Vincent Smith, Laurie K Barker, Gina Thornton-Evans, Paul I Eke, and Eugenio D Beltrán-Aguilar (2007) *Trends in oral health status; United States, 1988-1994 and 1999-2004*.

Ezoddini-Ardakani, Fatemeh (2010) 'Efficacy of Miswak (salvadora persica) in preventing dental caries', *Journal of Health*, 2, p. 499.

Farag, Youssef MK, and Jamal S Al Wakeel (2011) 'Diabetic nephropathy in the Arab Gulf countries', *Nephron Clinical Practice,* 119, c317-c23.

Food and Agriculture Organization of the United Nations (2000) *FAO statistical databases (FAOSTAT)*.

Franco, Rodrigo Zenun, Balqees Alawadhi, Rosalind Fallaize, Julie A Lovegrove, and Faustina Hwang (2017) 'A web-based graphical food frequency assessment system: design, development and usability metrics', *JMIR*, 4, e7287.

Fuller, E, J Steele, R Watt, and N Nuttall (2011) *Oral health and function-a report from the Adult Dental Health Survey 2009*. London: Health and Social Care Information Centre.

Gaengler, P, W Pfister, M Sproessig, and M Mirgorod (1986) 'The effects of carbohydrate-reduced diet on development of gingivitis', *Clinical Preventive Dentistry*, 8, pp. 17-23.

General Authority for statistics (2021) 'General Information about The Kingdom of Saudi Arabia'. Accessed 01/09/2021. https://www.stats.gov.sa/en/page/259.

Gibson, Rosalind S (2005) *Principles of nutritional assessment.* Oxford University Press, USA.

Hoddinott, John, and Yisehac Yohannes (2002) *Dietary diversity as a food security indicator.*

Holm, Lotte, Thomas Bøker Lund, and Mari Niva (2015) 'Eating practices and diet quality: a population study of four Nordic countries', *European Journal of Clinical Nutrition,* 69, pp. 791-798.

Host, Alison, Anne-Therese McMahon, Karen Walton, Karen Charlton (2016) 'Factors influencing food choice for independently living older people—a systematic literature review', *Journal of Nutrition in Gerontology and Geriatrics*, 35, pp. 67-94.

Illner, AK, H Freisling, H Boeing, Inge Huybrechts, SP Crispim, and N Slimani (2012) 'Review and evaluation of innovative technologies for measuring diet in nutritional epidemiology', *International Journal of Epidemiology*, 41, pp. 1187-203.

Khoja, Abdullah T, Mohammad H Aljawadi, Sulaiman A Al-Shammari, Ashry G Mohamed, Hamad A Al-Manaa, Laura Morlock, Saifuddin Ahmed, and Tawfik AM Khoja (2018) 'The health of Saudi older adults; results from the Saudi National Survey for Elderly Health (SNSEH) 2006–2015', *Saudi Pharmaceutical Journal*, 26, pp. 292-300.

Khoja, SO, JA Khan, ARA Maimani, JL Berry, and SA Lanham-New (2007) 'Influence of diet on bone health in Saudi Arabian women', In *International Congress Series*, 296-302. Elsevier.

Lazarte, Claudia E, Ma Eugenia Encinas, Claudia Alegre, and Yvonne Granfeldt. (2012) 'Validation of digital photographs, as a tool in 24-h recall, for the improvement of dietary assessment among rural populations in developing countries', *Nutrition Journal*, 11, pp. 1-14.

Lee RD and DC Nieman. (2018) *Nutritional Assessment.* McGraw-Hill Education.

Livingstone, M Barbara, Andrew M Prentice, W Andrew Coward, John J Strain, Alison E Black, PS Davies, CM Stewart, P Gerald McKenna, and Roger G Whitehead. (1992) 'Validation of estimates of energy intake by weighed dietary record and diet history in children and adolescents', *The American Journal of Clinical Nutrition*, 56, pp. 29-35.

Marmot, Michael, and Robert Bell. (2011) 'Social determinants and dental health', *Advances in Dental Research*, 23, pp. 201-206.

Marmot, Michael, Sharon Friel, Ruth Bell, Tanja AJ Houweling, Sebastian Taylor, and Commission on Social Determinants of Health (2008) 'Closing the gap in a generation: health equity through action on the social determinants of health', *The Lancet*, 372, pp. 1661-1669.

Marmot, Michael G, Stephen Stansfeld, Chandra Patel, Fiona North, Jenny Head, Ian White, Eric Brunner, Amanda Feeney, and G Davey Smith (1991) 'Health inequalities among British civil servants: the Whitehall II study', *The Lancet*, 337, pp. 1387-1393.

Marr, Jean W (1971) 'Individual dietary surveys: Purposes and methods', *World Review of Nutrition, and Dietetics,* 13, pp. 105-164.

Martin, Corby K, Theresa Nicklas, Bahadir Gunturk, John B Correa, H Raymond Allen, Catherine Champagne (2014) 'Measuring food intake with digital photography', *Journal of Human Nutrition, and Dietetics,* 27, pp. 72-81.

McClung, Holly L, Lori D Sigrist, Tracey J Smith, J Philip Karl, Jennifer C Rood, Andrew J Young, and Gaston P Bathalon (2009) 'Monitoring energy intake: a hand-held personal digital assistant provides accuracy comparable to written records', Journal of the American Dietetic Association, 109, pp. 1241-1245.

Ministry of Health. 2012. *Dietary Guidelines for Saudis: The Healthy Food Palm*. Edited by Mushary Hamad Al- Dkheel.

Moore, Deborah, and GM Davies (2016) 'A summary of knowledge about the oral health of older people in England and Wales', *Community Dental Health,* 33, pp. 262-266.

Moynihan, Paula, and Poul Erik Petersen (2004) 'Diet, nutrition and the prevention of dental diseases', *Public Health Nutrition*, 7, pp. 201-226.

Musaiger, Abdulrahman O, Hamed R Takruri, Abdelmonem S Hassan, Hamza Abu-Tarboush (2012) 'Food-based dietary guidelines for the Arab Gulf countries', *Journal of Nutrition and Metabolism,* 2012.

Musaiger, AO (2012) 'The Food Dome; dietary guidelines for Arab countries', *Nutricion Hospitalaria,* 27, pp. 109-115.

Nations, F.A.O.U. (2018) *Dietary assessment: A resource guide to method selection and application in low resource settings* (FAO).

Nelson, Michael (1997) 'The validation of dietary assessment', *Design Concepts in Nutritional Epidemiology,* 2, pp. 241-256.

Nowjack-Raymer, RE, and A Sheiham (2003) 'Association of edentulism and diet and nutrition in US adults', *Journal of Dental Research,* 82, pp. 123-226.

Organization, World Health (2003)*Diet, nutrition, and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation* (World Health Organization).

Peeran, Syed Ali, Fuad Al Sanabani, Bandar MA Al-Makramani, and Elfatih Ibrahim Elamin (2016) 'Dental prosthetic status and treatment needs of adult population in Jizan, Saudi Arabia: A survey report', *European Journal of Dentistry,* 10, 459.

Petersen, Poul Erik (2003) 'The World Oral Health Report 2003: Continuous improvement of oral health in the 21st century–the approach of the WHO Global Oral Health Programme', *Community Dentistry and Oral Epidemiology*, 31, pp. 3-24.

Petersen, Poul Erik and Tatsuo Yamamoto, and oral epidemiology (2005) 'Improving the oral health of older people: The approach of the WHO Global Oral Health Programme', *Community Dentistry,* 33, pp. 81-92.

Prince, Martin J, Fan Wu, Yanfei Guo, Luis M Gutierrez Robledo, Martin O'Donnell, Richard Sullivan, and Salim Yusuf (2015) 'The burden of disease in older people and implications for health policy and practice', *The Lancet,* 385, pp. 549-562.

Qutob, Akram Fareed (2009) *A needs-based approach for health human resources planning for dentistry in Jeddah, Saudi Arabia* (University of Toronto).

Randa, E (2004) 'Diagnosis prevention and treatment of root caries'.

Rapp, L, D Maret, F Diemer, and MH Lacoste Ferré (2019) 'Dental caries in geriatric dentistry: An update for clinicians', *International Journal of Oral and Dental Health*, 5, pp. 1-6.

Ruel, Marie T, Jody Harris, and Kenda Cunningham (2013) 'Diet quality in developing countries.' In *Diet quality.* Springer.

Saudi Vision 2030 (2017) http://vision2030.gov.sa/en.

Shimkin, Michael B (1946) 'The World Health Organization', *Science,* 104, 281-283.

Tada, Akio, and Hiroko Miura (2014). 'Systematic review of the association of mastication with food and nutrient intake in the independent elderly', *Archives of Gerontology, and Geriatrics,* 59, pp. 497-505.

The General Authority for Statistics (2016) "Demographic Survey " In *208*.

United Nations, Department of Economic, and Population Division and Social Affairs. (2019) "World Population".

Prospects (2019). Data Booklet (ST/ESA/SER.A/424).

Walls AW and JG Steele (2004) The relationship between oral health and nutrition in older people, *Mechanisms of Ageing and Development*, 125, pp. 853-857.

Watson, Sinead, Laura McGowan, Leigh-Ann McCrum, Christopher R Cardwell, Bernadette McGuinness, Ciaran Moore, Jayne V Woodside, Gerald McKenna, and Physical Activity (2019) 'The impact of dental status on perceived ability to eat certain foods and nutrient intakes in older adults: cross-sectional analysis of the UK National Diet and Nutrition Survey 2008–2014', *International Journal of Behavioral Nutrition*, 16, pp. 1-13.

WHO (2003) *WHO oral health report 2003.*

WHO (2013) *Oral health surveys: Basic methods* (World Health Organization).

Yousef, Yousef Mohammed (2011) *Medical professionals' oral health knowledge, attitudes & related practices performed for high caries-risk children*.

Zenun Franco, Rodrigo, Rosalind Fallaize, Julie A Lovegrove, and Faustina Hwang. (2018) 'Online dietary intake assessment using a graphical food frequency app (eNutri): Usability metrics from the EatWellUK study', PloS One, 13, e0202006.