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**Faculty of Graduate Studies**

**Prevalence of Malocclusion among 12 Years Old Palestinian  
Schoolchildren: Epidemiological Study**

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**This thesis was submitted in partial fulfillment of the requirements for  
the Master's degree in Health Informatics**

**July / 2022**

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By

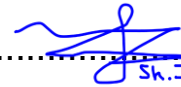
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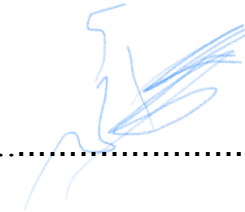
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## **Declaration**

This thesis was submitted in partial fulfillment of the requirements for the Master's degree in Health Informatics.

I declare that the content of this thesis (or any part of the same) has not been submitted for a higher degree to any other university or institution.

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### *Acknowledgments*

First and foremost, commendations and thanks to God, the almighty for blessings throughout my study work to complete the study successfully.

I would like to thank my first supervisor, **Dr. Shahenaz Najjar**, for her continuous guidance regarding every part of my studies. The friendly support helped me to tide over some of the most difficult times in my life. I also thank my co-supervisor, **Dr. Majdi Owda**, for his continued support.

I am grateful to, **Dr. Firas Elayyan**, for devoting a great deal of thought, time, and energy to my thesis and supporting me both academically and personally. I am grateful for the way he showed faith in me, helping me to finish this study in time. I doubt that I will ever be able to convey my appreciation fully, but I owe him my eternal gratitude.

I am also very grateful for the data collection, support, and advice of my colleagues and staff in the Ministry of Health. My gratitude goes to all who have supported me to complete the study work directly or indirectly.

Last, but not least, I am forever indebted to my husband, my sons, and my mum, for their support and encouragement throughout this M.H.Sc. My deepest appreciation is expressed to them for their love, understanding, and inspiration. Without their blessing and encouragement, I would not have been able to finish this work. I am blessed to have them as part of my life.

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## List of Acronyms and Abbreviations

WHO	World Health Organization
TMJ	Temporomandibular Joint
TMDs	Temporomandibular disorders
MIT	Maxillary incisor trauma
TSALD	Tooth size-arch length discrepancies
TDI	Traumatic dental injury
OI	Occlusal Index
IOTN	Index of Orthodontic Treatment need
IOTN-AC	Index of Orthodontic Treatment need- Aesthetic Component
PIDA	Psychosocial impact of dental aesthetics
OHRQoL	Oral Health related Quality of Life
DAI	Dental Aesthetic Index
FDI (COCSTOC)	World dental Federation (Commission on Classification and Statistics for Oral Conditions)
PAR	Peer assessment rating
HLD	Handicapping Labio-Lingual deviation
MOH	Ministry of Health
PCBS	Palestinian Central Bureau of Statistics
NHANES III	Third National Health and Nutrition Examination Survey
Class II div. 1	Class II division 1
Class II div. 2	Class II division 2
DMFT	Decayed, missing, filling teeth
CPITN	Community periodontal index of treatment needs
ICC	Intra-class correlation coefficient

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## **Abstract**

**Background:** The World Health Organization has recognized that malocclusion is handicapping anomalies in the dental arches and jaws that may need therapeutic intervention on the individual's aesthetics and emotional well-being. It is considered as one of the most frequently reported problems among children. Palestine has no clear registry or accurate data about the prevalence of malocclusion and its related factors. This study aims to evaluate and assess the extent of malocclusion and its related factors among school students aged 12- years in the West Bank.

**Methods:** A cross-sectional study was done using morphological examination and a questionnaire among 1384 school children aged 12 years in the WB. Data were collected from 69 public schools distributed in the northern, central, and southern regions of the WB from February to April, 2022. A pilot study was carried out to test the inter-examiner reliability by the intra-class correlation coefficient (ICC) and Cronbach's alpha test. ICC showed a high degree of inter-examiner reliability (ICCs 0.872 or above), except for overjet ICCs 0.776 and posterior crossbite ICCs 0.670. All analyses were performed with the Statistical Package for Social Sciences version 23.0. A 2-sided  $\alpha$  of  $<0.05$  was considered statistically significant. Frequencies and percentages were calculated for all variables. Chi-square test and Fisher's exact test were performed to examine the association of demographic indicators and bad oral habits with malocclusions types. Multinomial logistic regression was used to estimate the prevalence ratios of having class II or class III molar relationships according to the presence of dental anomalies, bad oral habits, and space conditions.

**Results:** 1278 schoolchildren were included with a response rate of (92.7%). Of the sample; males represented (48.5%) whereas females represented (51.5%), and northern

regions (40.5%), central regions (26.3%), and southern regions (33.2%). While (18.2%) were from cities, and (18.2%) from countryside. Mouth breathing and lip biting were the most prevalent bad oral habits with approximately 40% of the participants, with no differences among gender. 85% of our participants examined had one or more types of occlusal anomalies ranging from mild to severe. The sagittal relationship of malocclusion revealed a prevalence of 65% Class I, 23% Class II, and 12% Class II. In addition to 36% decreased overjet < 2 mm. The vertical dimension rate was in 25% of the children with an openbite, whereas 28% had a deepbite (> 4 mm). Moreover, 29% of the children had a midline shift. Significant relation between gender and midline shift, diastema, and most dental anomalies; more frequent in males. Regarding region and Class I malocclusion, Anterior Openbite, anterior crossbite, midline shift, diastema, reduced overbite, and reduced overjet, significant relations were found. Anterior and posterior openbite, and retained deciduous teeth were significantly in relation with the geographical area. A statistically significant association identified between anterior crossbite and midline shift, and bad habits. The multinomial regression analysis of angle's molar relationship and dental anomalies revealed the children who had more than one missing permanent teeth were more likely to report Class III (42.4% compared to Class I. while the probability of having an ectopic tooth was higher in Class II division 2 (58.4%) compare to Class I. Furthermore, the analysis of molar relationship and crowding revealed a probability of children without crowding in upper arch to be in Class III compare Class I decreased by 57%.

**Conclusion:** This study reported a high prevalence of malocclusion among school students. Diverse and disparate occlusal traits are related to many demographic and behavioral factors. Therefore, a collaborative effort should be directed to obtain more

monitoring and surveillance of malocclusion more frequently to prevent and control the exacerbation of the problem.

**Keywords:** Malocclusion, Prevalence, Bad habits, schoolchildren, Palestine

## **Chapter One: Introduction**

Malocclusion is described as handicapping anomalies in the dental arches and jaws that negatively affects the function of chewing and/or speech, and requiring therapeutic intervention so that its effects are not reflected on the individual's aesthetics and emotional well-being (ANDERSON, 1960; WHO, 1987). It can be considered a general oral health condition that results from genetic factors, environmental factors, or a combination of environmental and inherited factors that act together, such as adverse oral habits, caries, gingivitis & periodontal disease, and anomalies in the number of teeth. (Alhammadi et al., 2018; Alrashed & Algerban, 2020).

According to the World Health Organization, malocclusion is the third-highest oral health concern worldwide after caries and periodontal disease (Alajlan et al., 2019).

Unlike other oral health conditions, pain is rarely severe in a malocclusion. Malocclusion is associated with low quality of life of the individual, low levels of self-esteem, and social, psychological and functional disturbances such as poor oral function, poor aesthetic appearance, speech difficulties, periodontal disease, dental caries, Temporomandibular joints disorders, and unfavorable psychological disorders (Abutayyem 2016).

For proper planning, epidemiological studies of the prevalence of malocclusion and assessment of the need for orthodontic treatment are necessary. Moreover, the identification of the factors and disorders related to malocclusion implies the need to plan preventive and corrective measures to evaluate and provide appropriate treatment. Early recognition of the development of malocclusion and the possibility of harmonizing and correcting uncomplicated dental relationships can reduce future treatment costs as well as enhance the psychological and social aspects of individuals' lives.

The increasing public awareness of oral and dental health is constantly increasing the demand for orthodontic treatment, necessitating the establishment and development of a series of clearly defined qualitative and quantitative indices to describe, classify and evaluate malocclusion, designed either for study cast measures, clinical use, or both based on the applicable objectives (Gupta & Shrestha, 2014).

The prevalence of malocclusion varies from country to country and between geographical regions. In Palestine, according to the Palestinian Ministry of Health's annual report for 2018, the prevalence of malocclusion for seventh-grade students was 13.9% (MoH, 2018). The percentage is considered low compared to the surrounding countries. The results of malocclusion registration are not comparable and inaccurate owing to subjective evaluation of the features registered. There is a need for actions from policy-makers, and stakeholders to addressing these issues.

To our knowledge, no study has been conducted in Palestine that addresses identifying and comparing the prevalence of malocclusion in a population group. Therefore, it is essential to increase our understanding of occlusal characteristics, distributions, and the influencing factors, which may be useful to consider community dental health resource planning.

### **1.1 Problem statement**

As the prevalence of malocclusion is increasing internationally and locally , especially among schoolchildren, the chances of recurrent dental caries, periodontal diseases, TMJ disorders, speech difficulties as well as poor aesthetic appearance are rising in turn (Alrashed & Algerban, 2020).

Measuring the extent of malocclusion among schoolchildren is extremely important, because of its effects on improving oral health, reducing treatment costs, and raising the individual's quality of life and self-esteem.

No previous studies have been conducted in West Bank /Palestine to assess and investigate the prevalence of malocclusion. It is essential to increase our understanding of such studies in Palestinian population, which could provide information to have a central focus on policy formulation in community dental health programs in particular, and health care programs in general.

## **1.2 Significance of the study**

Malocclusion has a significant impact on the individual and society in terms of quality of life, self-esteem, and social and functional limitations. There is an urgent need for accurate data describing the prevalence of malocclusion in order to establish health interventions to improve an individual's quality of life, increase their emotional well-being, and reduce treatment costs.

Numerous studies have been conducted on the prevalence of malocclusion and the need for treatment all over the world using several indices; while our study is the first in Palestine to investigate the extent of malocclusion among 12-year-old schoolchildren.

The results will provide a basis for future research focused on understanding the factors related to malocclusion and limiting its prevalence through the use of an exploratory data analysis approach, which will assess the treatment needs among the Palestinian population and provide an epidemiological database that can be relied upon in the future.

## **1.3 Study objectives**

The study objectives have been divided into primary and secondary objectives.

### **1.3.1 Primary objective**

To determine the prevalence of malocclusion and occlusal traits among 12-year-old schoolchildren in West Bank/ Palestine.

### **1.3.2 Secondary objectives**

1. To assess the prevalence of malocclusion and its distribution by demographic characteristics.
2. To identify the various occlusal traits among 12-year-old schoolchildren in Palestine.
3. To determine the bad habits that influence the development of dental malocclusion.
4. To conduct an exploratory data analysis to highlight the highly relevant factors that contribute to the increase in malocclusion among schoolchildren.

### **1.4 Research questions**

1. What is the prevalence of malocclusion among 12-year-old schoolchildren in Palestine?
2. What is the Prevalence of clinically relevant occlusal traits among 12-year-old schoolchildren?
3. What are the bad habits that influence the development of dental malocclusion among 12-year-old schoolchildren in Palestine?

### **1.5 Expected outcomes**

To provide scientific knowledge about the prevalence of malocclusion among Palestinians, and to clarify the relationship between malocclusion and environmental factors such as bad oral habits. Our study will provide recommendations for setting up an appropriate policy and effective school dental health intervention to prioritize treatment needs based on severity of the malocclusion. We also believe that the exploratory data

analysis method will increase understanding of the situation and provide adequate awareness to guide interventions.

## **1.6 Description of thesis chapters**

This thesis is structured as follows:

**Chapter Two** is the narrative review of the literature on concepts of malocclusion; epidemiology of malocclusion and occlusal traits worldwide. It then considers the etiology of malocclusion. The chapter further details the influencing factors of malocclusion and occlusal traits, which helped to identify variables for inclusion within the study. A detailed description of Psychological, economic, physical, and social consequences of malocclusion. Finally, the classifications of malocclusion indices used worldwide, the conclusion, and the research gap are presented.

**Chapter Three** contains a conceptual framework that presents definitions of influencing factors that may affect the assessment of the occlusal characteristics.

**Chapter Four** describes the methods and materials used within the research along with details of the statistical analysis strategy and ethical considerations for the study.

**Chapter Five** presents the research results including descriptive, bivariate, and multivariate modeling findings.

**Chapter Six** discusses the research findings, limitations and strengths.

**Chapter Seven** highlights the major conclusions and summarizes recommendations for policy and research.

## **Chapter Two: Literature review**

This chapter will discuss the background and significance of the studies that led to the current investigation on the extent of the prevalence of malocclusion in Palestine. The current literature on the concept of malocclusion and the etiology of malocclusion, as well as the prevalence of malocclusion and its occlusal traits will be summarized. The influencing factors of malocclusion and the physical, psychological, social, and economic consequences of the malocclusion as presented in the current and previous scientific literature will also be discussed. The classifications of the malocclusion indices used will be discussed. Finally, a conclusion and research gap will be presented.

### **2.1 The concept of malocclusion**

#### **2.1.1 Occlusion**

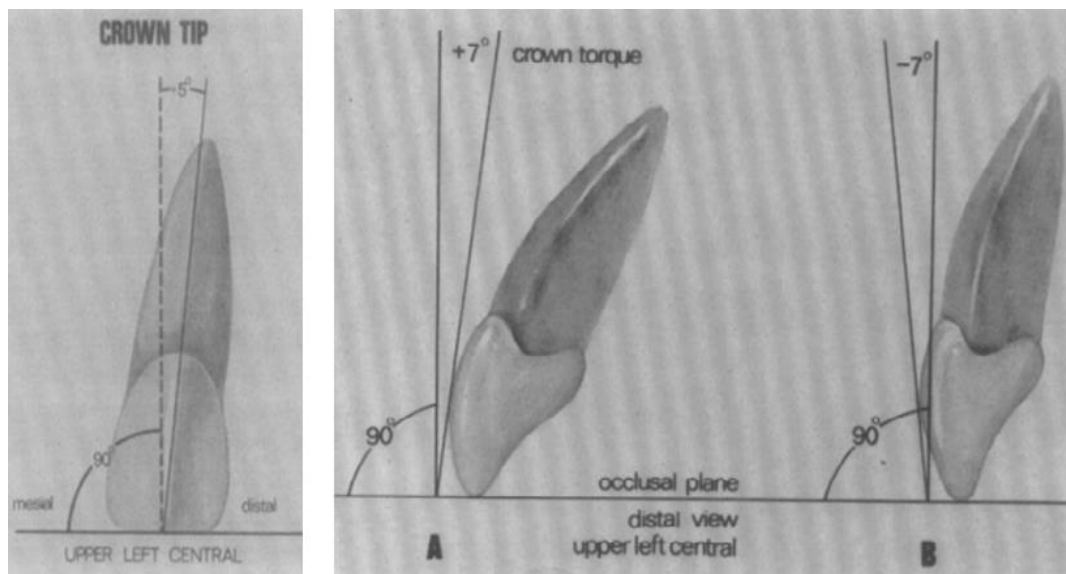
The term occlusion relates to the pattern of morphological contact between the upper and lower teeth in all positions and movements of the jaws without causing any discomfort or pain to components of the masticatory system (Hassan & Rahimah, 2007; Turb et. al, 2008). The first clear definition of normal occlusion was presented by Angle (1899). He linked the concept of malocclusion with the overlapping of the upper and lower molars with each other. Where the mesiobuccal cusp of the upper molar occluded in the buccal groove of the lower molar, while the teeth are arranged in a smoothly arching line (Angle, 1899).

Later on, Andrews (1972) put pointed out six keys of normal occlusion:

1. Molar relationship: The molar relationship is consistent with what Angle previously indicated. With the addition of the distal surface of the distobuccal cusp of the upper first molar to be in contact and occlude with the mesial surface of the mesiobuccal cusp of the lower second molar to have normal occlusion.

2. Crown angulation (mesiodistal tip): the crown long-axis angulation is defined as positive; that is, the gingival part of the long-axis of each crown of the upper jaw is distal to the occlusal part of the crown.

3. Crown inclination (labio/bucco- lingual torque): the gingival part of the long-axis of the labial surface of the upper incisors' crown is lingual to occlusal part, while the gingival part in all others crowns including the lower incisors, buccal or labial to the occlusal part of the crown as shown in Figure (2.1).



**Figure 2. 1 Crown angulation and crown inclination as described by Andrews (Andrews, 1972)**

4. Rotation: free of rotation.

5. Spaces: tight proximal contact.

6. Occlusal plane: the depth of curve of spee does not exceed 1.5 mm (flat or slightly curve) (Andrews, 1972).

When searching for the perfect "Ideal" occlusion it is rarely found in nature. Huffman et al. pointed out that the word ideal implies *"something like infinity in that it can be approached but never actually reached"* (Huffman et al., 1969) therefore, a normal occlusion that is compatible with health, and unimpaired function can suffice.

### **2.1.2 Malocclusion**

Malocclusion can be described as inconsistencies and deviations in dental arches or between teeth and jaws from normal relationships and alignments in any of the sagittal, vertical and transverse dimensions (Anderson, 1960;Walther et al., 1994)

The World Health Organization (1987) defined malocclusion as handicapping dentofacial anomalies which impede masticatory function and/or speech and require treatment in order not to negatively affect the individual's aesthetics and emotional well-being (WHO, 1987). However, malocclusion-related handicap presents a challenge because the emotional impact of malocclusion does not always seem to be directly related to the degree of deformity, resulting in an inaccurate measure of handicap (Macgregor, 1970).

While Lombardi (1982) considered that the malocclusion's term is imprecise and ambiguous, as the determination of the point at which the normal variation of the occlusion can be considered abnormal is difficult; this has been cited in the variation in the prevalence of malocclusion observed in epidemiological studies (Lombardi, 1982). To the ambiguity, occlusal deviations have been described as a condition that can lead to or promote disease, but not a disease in itself. Thus, a clearer definition of malocclusion can be obtained if occlusion variables are included in the concept. Since malocclusion is described as inconsistencies and deviations between arches and/or dental abnormalities, it represents a set of deviations from the ideal. Therefore the developing trend has been to speak of the “occlusal variation” or the “occlusal traits” to avoid the handicapping implication of the term malocclusion (Vlachos, 1995).

### **2.2 Epidemiology of malocclusion and occlusal traits worldwide**

Malocclusion and subsequent dental discrepancies are considered one of the most frequently reported problems among children and adolescents (Lombardo et al., 2020).

Most of the studies concerned with measuring the prevalence of malocclusion and the related factors in their methodology are based on epidemiological investigations. The main objective of the measurement of the occlusal traits is to determine the extent of the health problem, in addition to providing the necessary data for setting priorities and developing health policies. With the increase in interest in facial aesthetics, the focus of the publications shifted more to identifying treatment needs and outcomes based on aesthetic weakness and its dental implications, as comparisons between different population groups have become easier. The term "malocclusion" includes malrelationships of inter-dental arches (sagittal, vertical, and transverse), intra-discrepancies between jaw size and tooth (crowding, spacing, and diastema); and anomalies of individual teeth (Lombardi, 1982).

Globally, the prevalence of malocclusion among children and adolescents, regardless of gender, is around 56% (Lombardo et al., 2020). While the reported prevalence rate ranges widely. In Africa, it was 81%, while in Asia 48% (Lombardo et al., 2020), the same applies to races. The rate of 6.5% among Latino adolescents (Silva & Kang, 2001) and rises to 47.92% among Chinese school children (Lin et al., 2020). This is due to the different methods of registration, malocclusion indices used, ethnic origin, the era of research, and the stage of dental development (Salim et al., 2021).

As part of a national survey of health care problems and needs in the United States, the prevalence of malocclusion and orthodontic needs was included in the Third National Health and Nutrition Examination Survey (NHANES III) during the years 1989-1994. The percentages of the US children and adolescents population (regardless of race) who suffer from malocclusion according to Angle's classification; Class I 50%, Class II 19%,

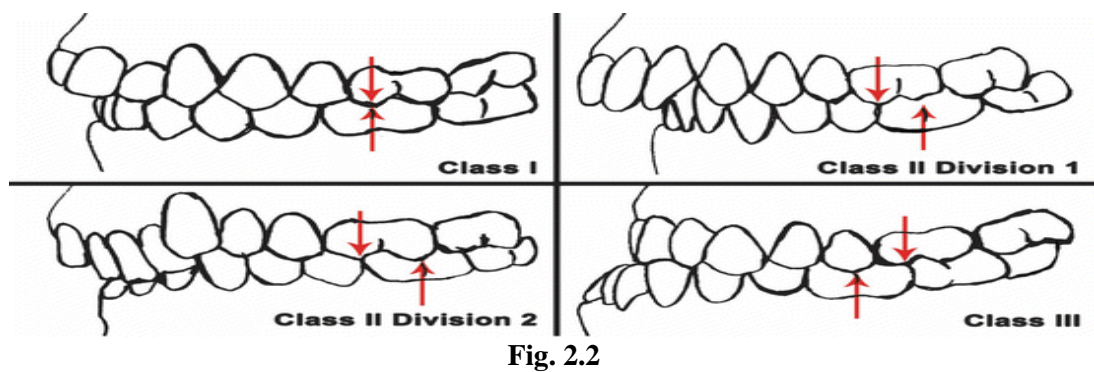
and Class III 1%. While the remaining percentage is normal occlusion. ( Proffit et al.,1998).

Edward Hartley Angle (1855-1930) who was described as "the father of modern orthodontics" elied in his classification of occlusions on anteroposterior molar relation (sagittal plane), he considered that the upper first permanent molar is occlusion's key.

Angle classified malocclusion into three main classes: Class I, Class II with division 1 or 2, and Class III malocclusion.

**Class I malocclusion:** It is characterized by the presence of a normal molar relationship along with dental irregularities, which may be accompanied by crowding, rotation, and crossbite. As for the **Class II malocclusion**, it occurs when the mesiobuccal cusp of the upper first molar occludes mesial to the mesiobuccal groove of the lower first molar, Two divisions fall under this classification based on the proclination/ retroclination of the upper central incisors; So that the **division 1** indicates proclined upper central incisors, and the **division 2** indicates retroclined upper central incisors.

When the molar relationship shows the mesiobuccal cusp of the upper first molar occluding distal to the buccal groove of the lower first molar, it can be classified as **Class III malocclusion** (Angle, 1899), as shown in Figure (2.2)



*Figure 2. 2 Angle's Classification*

A systematic review of worldwide population-based, conducted by Alhammadi et al. in mixed and permanent dentition in terms of classification of the malocclusion, found that the prevalence of class I malocclusion in permanent and mixed dentition ranked first at a rate of (74%), while the Class III malocclusion recorded at (4%). It was observed among Mongolian races. Africans showed the highest prevalence of class I malocclusion and openbite in permanent dentition, while Caucasians showed the highest prevalence of class II malocclusion in permanent and mixed dentition. For the bite, openbite was found to be the highest among Mongoloids in mixed dentition, while posterior crossbite had a higher prevalence in permanent dentition among Europeans (Alhammadi et al., 2018).

In East Asian countries, an epidemiological survey was applied by Yu et al. on 2810 schoolchildren, ages 7 to 9 in early mixed dentition; they found that class III malocclusion increased from (5%) at age 7 to (7.8%) at age 9. In South Asia, (19.9%) of those with severe malocclusion required treatment (Yu et al., 2019). The prevalence of malocclusion in Indian schoolchildren in permanent dentition ranges from 20% to 43% (Shivakumar et al., 2009).

At the level of Middle Eastern countries, most of the studies were applied to schoolchildren in permanent dentition. The aim of the studies was based on epidemiological investigation, classification, and treatment needs. Many studies found that the most common malocclusion is the class I (Al-Zubair & Almulla, 2014; Al Jadidi et al., 2018; Asiry & Alshahrani, 2019; Alajlan et al., 2019), with the exception of a study conducted by Bilgic et al. in Turkey, which found that the Class II division 1 came first with a rate of (40%), followed by the Class I malocclusion, with a difference of (6%) (Bilgic et al., 2015). While a meta-analysis study conducted in Iran during the period 1994 to 2015 for both sexes population aged 11-35 years old indicated that eastern Iranian

males suffered from class I malocclusion more than their counterparts distributed throughout Iran (Eslamipour, Afshari, & Najimi, 2018). As for the need for treatment, the percentage of students who are in urgent need of treatment ranged from 13.9% in Omani males to 28% in Turkish males (Al Jadidi et al., 2018; Bilgic et al., 2015).

Another occlusal trait can be measured in the sagittal dimension are overjet and anterior crossbite. Maxillary overjet refers to the relationship between the upper and lower incisors in the anteroposterior plane (Walther et al., 1994). It is considered the most important indicator to determine the severity of malocclusion in the sagittal dimension. The importance of overjet arises in aesthetic and functional roles, where increased overjet indicates the need for orthodontic treatment, functionally it may affect swallowing, chewing, and lip sealing (Björk, Krebs, & Solow, 1964). Overjet is usually measured from the most prominent point on the incisal edge of the maxillary central incisor to the most prominent point on the opposing mandibular incisors (Bezroukov et al., 1979). Salzmann used anterior crossbite term to describe abnormal labiolingual relationship between upper and lower incisor teeth when the posterior teeth are in contact (Salzmann, 1968). Inverted incisors usually indicate the involvement of one, two, or three incisors, while all four incisors are called reverse (mandibular) overjet (Bezroukov et al., 1979).

A meta-analysis study to investigate the global prevalence of malocclusion in all different stages of dentition showed that about 40% of children and adolescents had overjet degree (0-3mm), while the rest of the population had an increased overjet degree and a small percentage had a reverse overjet (Lombardo et al., 2020). Other study conducted on 7176 Iraqi schoolchildren aged 13-years-old reported that overjet (2-4 mm) was 67.8% (Alhuwaizi, 2005).

Other studies conducted on deciduous and early mixed dentition found that overjet was more prevalent in the early mixed stage, while the class II malocclusion amounted 26% of the children in the deciduous dentition. When measuring the needs for orthodontic treatment in the early mixed dentition, it was found that 26.2% of the children needed urgent treatment (Tschill, Bacon, & Sonko, 1997; Tausche, Luck, & Harzer, 2004).

Overbite and openbite are most important traits can be measured in the vertical dimension. Overbite refers to the overlapping between the mandibular anterior teeth and the maxillary anterior teeth in vertical plane when both arches are in centric occlusion (Walther et al., 1994). It was difficult to assess overbite on an epidemiological basis, as some investigators relied on the extent of mandibular incisor overlap by maxillary incisor depending on terms of thirds, where one-third overlap was normal (Bezroukov et al., 1979; R. S. Corruccini et al., 1983; Summers, 1971). While Crabb and his team relied on terms of halves of the lower incisors (Crabb & Rock, 1986). However, all previous methods lacked accuracy. Darker in 1960 suggested using a pencil to mark the position of the upper incisor edge on the labial surface of the lower incisors so that the distance could be measured metrically (Draker, 1960). Many researchers like Baume, Bjork, and Kinnan agreed with Draker to measure overbite using direct measurements (Baume & Maréchaux, 1974; Björk et al., 1964; Kinaan, 1986). While other investigators adopted indirect methods of measurement such as Hitchcock and Kim used cephalometric radiography (Hitchcock, 1970; Kim, 1974).

Children and adolescents showed normal overbite at a rate of 64.5 % to 69.5 % in the deciduous and permanent teeth, respectively. With a higher prevalence of deepbite compared to the openbite in deciduous teeth than in permanent teeth (Lombardo et al., 2020). While openbite could be either anterior or posterior. Posterior openbite is present

when there is no contact between the maxillary and mandibular posterior teeth, while anterior openbite was measured when all four upper incisors do not overlap any lower incisor in centric occlusion considering that the edge-to-edge position is not an anterior openbite (Bezroukov et al., 1979). In Europe (1996-1997), two studies were conducted on children in deciduous and early mixed dentitions between the ages of 4-8 years, they found that anterior openbite was the most malocclusion in those dentitions. (Tschill, Bacon, & Sonko, 1997, Tausche, Luck, & Harzer, 2004).

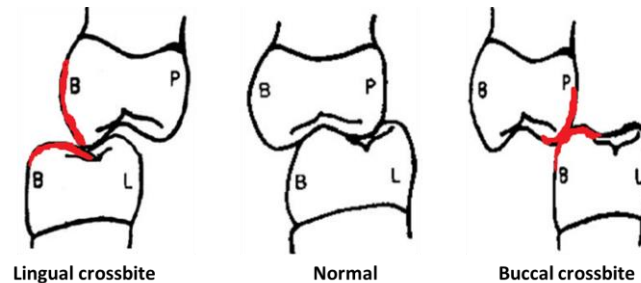
Thilander et al. conducted a longitudinal study in Colombia (2001). They included different stages of dentitions (deciduous, early and late mixed, permanent); class II malocclusion was recorded at a rate of 20.8%, 14.9% was class II division 1 malocclusion, and it was also observed that this malocclusion increases with age until the late of mixed dentition and then returns to decline slightly in the permanent dentition, and the same applies to the overjet. The results of increased openbite are consistent with the results of studies conducted in Europe; that it is more common in deciduous dentition and early mixed dentition (Thilander et al., 2001).

As for the transverse dimension, it is indicated by measuring both the posterior crossbite and midline shift.

Posterior crossbite is a discrepancy in the buccolingual relationship between maxillary and mandibular teeth in the transverse plane and they can be either unilateral or bilateral involving a single tooth or multiple teeth (Almeida et al., 2012). It is two types:

- Lingual crossbite: recorded when a buccal cusp of an upper tooth lies lingual to the maximum height of a buccal cusp of an opposing lower tooth.

- Buccal (Scissors) crossbite: recorded when a palatal cusp of an upper tooth lies buccal to the maximum height of a buccal cusp of an opposing lower tooth (Bezroukov et al., 1979).



**Figure 2. 3 Facial views of the first molars showing transverse relationships**

Crossbite may lead to abnormal speech patterns, periodontal diseases, loss of the arch's integrity, and unfavorable esthetics (Brizuela, Palla, & N, 2020). In a retrospective study of a sample consisting of 1016 subjects with Class II malocclusion, Vignesh and Jain found that the prevalence of single tooth posterior crossbite was 73.7%, while the total prevalence of posterior crossbite was about 3.8% (Vignesh & Jain, 2020). More attention should be given to crossbite especially lateral crossbite in the primary dentition, as it has an effect on malocclusion in the permanent dentition.

Midline shift represents the midline displacement of the maxillary and mandibular dental arches in the transverse plane (Baume & Maréchaux, 1974). It can be registered in more than one way; For example: Bauma, Bezroukov, and Bjork adopted the midline shift measurement using the midline of the maxilla as a reference line (Baume & Maréchaux, 1974; Bezroukov et al., 1979; Björk et al., 1964), while Jerrold used the facial midline as a reference line (Jerrold & Lowenstein, 1990), while Summers relied on his recording of this feature the distance between the maxillary and mandibular midline (Summers, 1971).

As we mentioned earlier, the term malocclusion includes the malrelationships inter-arches in the three dimensions, in addition to the space discrepancies intra-arches, such as crowding, spacing, and diastema.

Crowding or spacing is described as the difference in tooth size and arch length. Tooth size-arch length discrepancy (TSALD) is a well-established method for evaluating crowding based on subtracting the sum of the arch length from the sum of the mesiodistal tooth sizes (Correia, Habib, & Vogel, 2014).

TSALD value is calculated as follows Space Available - Space Required. Where a negative number indicates the presence of crowding (the size of the mesiodistal tooth is greater than the length of the arc) and a positive number indicates spacing (Tsiopas et al., 2013). Lombardo indicated in his meta-analysis study that crowding prevalence seemed to increase from primary (16%) to mixed (37%) to permanent dentition (39%) (Lombardo et al., 2020).

Crowding was the highest prevalence, followed by spacing, in Saudi Arabia, it was observed that males had a higher crowding than females (Alajlan et al., 2019). Deepbite was recorded at 16.2% in Saudi Arabia and 16.3% in Oman (Alajlan et al., 2019, Al Jadidi et al., 2018). While it was found that the crossbite differs in the geographical locations in the same country, it was recorded only 8% in the Abha region, and it increased to 25% in Jeddah, and it was more evident among females than males (Asiry & Alshahrani, 2019, Alajlan et al., 2019). While other studies indicated that the deepbite was more common in boys, and crowding in one or more segments was more common in females (Thilander et al., 2001, Zhou et al., 2016, Yu et al., 2019).

Oral hygiene and plaque removal may be affected by crowding and tooth misalignment, which may increase the incidence of periodontal disease and caries (Choi, 2020; Kolawole & Folayan, 2019)

While midline (median) diastema is the space greater than 2mm between maxillary central incisors (Bezroukov et al., 1979). It is most common in the deciduous stage. Where the diastema decreased from 35% in deciduous dentition to 5% in permanent dentition due to the increase in the dimensions of the maxillary central incisors (Lombardo et al., 2020).

Hussain et al. indicated that the diastema (more than 0.5 mm) was 98% at the age of 6 years, 49% at the age of 11 years, and 7% in the ages from 12 to 18 years (Hussain, Ayub, & Farhan, 2013). The presence of the median diastema is usually related to bad oral habits (Hussain et al., 2013; Bárbara et al., 2013). Other study conducted among 13-15 years old schoolchildren in Jordan found that median diastema > 2mm was (6.9%) (Al-Khateeb & Al-Nimri, 2005).

Malocclusion may be associated with other anomalies in the dental arches, which would lead to aesthetic and functional problems in the upper and lower jaws, such as an increase in the number of teeth (supernumerary), size (a tooth with increased incisal mesio-distal width), shape (peg-shape), and position of the tooth bud (ectopic eruption), which occurs as a result of genetic factors or disturbances created during tooth development. The presence of supernumerary teeth may create a variety of clinical problems such as prevention of eruption of permanent teeth and derangement of the occlusion and vice versa missing teeth either congenitally or extracted can lead to spacing, causing occlusal abnormalities (Ng'ang'a & Guthua, 2002). A study of 2897 medical records of orthodontic patients aged between 8 to 40 years in the period from 1993 to 2017, showed

that the supernumerary teeth are higher in males than females, with regard to peg-shaped teeth, ectopic, impacted, and retained teeth were more in the maxilla than in the mandible (Tunis et al., 2021).

While another study was conducted on 395 patients aged ranged between 13 to 25 years, using radiographs; Most of the congenitally missing teeth were the maxillary lateral incisors, followed by the mandibular second premolars (Jasim, 2020).

In Palestine, few studies have focused on the prevalence of malocclusion. A master thesis was conducted in Gaza strip (2006) to assess the prevalence of malocclusion in the Palestinian population and the extent of their need for orthodontic treatment using the Occlusal Index (OI) (Summers, 1971). Malocclusion was detected in (71.4%) of the sample, distributed as follows: class I malocclusion (53.4%), (13.5%) had class II; (75.4%) of this group had class II division 1, while class III malocclusion was observed in (4.3%). While (28.6%) of the subjects were free of malocclusions. The prevalence of caries was 55.4%, bad oral hygiene was found in (20.7%) of the sample. (14.5%) were found to be in definite orthodontic treatment need (Elghoul, 2007).

The Palestinian Ministry of Health in collaboration with other international organizations launched an oral health screening program in the West Bank regions to assess the current situation and future needs for oral health care in West Bank schools in 1997. The program uses the World Health Organization criteria to examine tooth decay using the DMFT index (decayed, missing, filling teeth) and for gingival health using the CPITN index (community periodontal index of treatment needs). Later, an assessment of fluorosis and malocclusion was added (WHO, 1997). Where the statistics of the Palestinian Ministry of Health for the year 2014 indicate that the rate of malocclusion for seventh grades was 14.4%, and 13.9% in 2018 (MoH, 2018). Lack of specific goals, lack of commitment to

WHO examination criteria, insufficient training, and constant staff turnover, which lead to inaccurate statistics and unreliable data (Kateeb, 2007).

### **2.3 The etiology of malocclusion**

It is believed that malocclusion is a developmental disorder rather than a disease. To date many etiologies of malocclusion remain unexplained (Leighton, 1991). Multiple theories have been proposed to explain the etiologies of malocclusion (W. R. Proffit, 2016). Proffit et al. classified the causes of malocclusion into two categories, environmental and genetic influences (Proffit et al., 1986) . On the other hand, Moyers classified the causes of malocclusion into six categories: hereditary, developmental idiopathic causes, physical factors, diseases, trauma, and habits (Moyers, 1988).

The contribution of the influence of genes and environment to malocclusion has been the subject of debate over the past century. Many authors reported that Jaws relationship and soft tissue pattern reflect the similarity between family members (Lundstrom, 1954; Schulze and Weise, 1965; Johnston and Hunter, 1989). This confirms the influence of genetics on occlusion, however, others revealed some noticeable differences between parents, children and siblings, which confirms the importance of the environmental influence in the development of occlusion (Stewart and Spence, 1976). These studies came to disagree with the prevailing belief that malocclusion is developed from only local factors (Mossey, 2019).

Xue et al. noticed a relationship between class III malocclusions and mono/polygenic inheritance, as the interaction of those genes with environmental factors would lead to the phenotype of class III malocclusions (Xue, Wong, & Rabie, 2010).

While a longitudinal study of mother-child pairs sample from the beginning of pregnancy until the 30th month after childbirth, indicated that there may be a correlation between

genetic and environmental factors and the prevalence of malocclusion, as it was found that sucking habits, nocturnal mouth breathing, and low rates of breastfeeding constitute risk factors for malocclusion (Moimaz et al., 2014). Ethnic considerations can also have an impact on the development of malocclusion. According to Todor et al. study, it showed a different distribution of morphological malocclusion classifications according to the various geographical regions and races (Todor et al., 2019).

## **2.4 Influencing factors of malocclusion**

Orofacial deformities are among the most common oral problems after dental caries and periodontal disease in children and adolescents (Petrović et al., 2013).

Due to the high prevalence of malocclusion, factors that may affect the growth and development of the craniofacial bones and teeth must be considered. Malocclusion can be considered a condition resulting from a complex interaction of several factors including genetic inheritance, genetic mutations, gender, age, ethnicity, congenital diseases, dental anomalies, muscular diseases, hormonal imbalance, diet, and behavior (M. Saghiri et al. 2021). In the following sections we will discuss some of the factors that may have a role in the prevalence of malocclusion.

### **2.4.1 Gender**

Dental arch dimensions vary according to gender. Many studies found that males, in general, have a larger arch shape and size than females (Paulino et al., 2011; Stanley et al., 1998). Other studies found significant differences in the dimensions of the dental arch between the sexes in different ethnic groups. A study was conducted in Yemen found that the width of the maxillary arch is greater in males, while the length of the palate was greater in females (Al-Zubair, 2015).

The big difference in the consistency of the tooth size with the dental arch dimensions makes it difficult to obtain an occlusion with an ideal overjet and overbite (Jakhar et al., 2017). The literature indicates that the increase in overbite, deepbite, and overjet are higher in males than their female counterparts (Ciuffolo et al., 2005; S & P, 2019; Ferro, Besostri, Olivieri, & Stellini, 2016; Helm, 1968; Yu et al., 2019; Thilander et al., 2001). A cross-sectional study conducted on 502 subjects in Iran aged 11-14 years showed that class I malocclusion was more prevalent in females (Borzabadi-Farahani et al., 2009), this is also in agreement with other study (Aikins & Onyeaso, 2014)

A study conducted by Walker and Kowalski showed that the mandible continues to grow steadily after puberty in males until late teens, while this trend does not appear in females. This lower facial growth causes a decline in the ANB angle (Walker & Kowalski, 1972). Some factors, such as mesiodistal width and arch dimensions may be closely related to the incidence of teeth crowding in males, as a study conducted on a sample of Indians at the age of 15-35 years indicated that these factors affected the incidence of crowding in males more than females (Das, Dkhar, & Pradhan, 2017).

#### **2.4.2 Age**

The relations of the dentofacial structures of the face undergoes a continuous change during growth and age development. Both the skeletal and integumental chins become more forward in relationship to the cranium, and the bony facial profile tends to become less convex with age, while the central incisor teeth tend to recede and straighten relative to the facial plane (Subtelny, 1959).

While the movements of the mandible (mandibular laterotrusion, protrusion, maximum mouth opening) and occlusal traits are affected by age, the movements of the mandible increase with age, while some occlusal features may limit the movement of the mandible

as crossbite and openbite, while deepbite and increased overjet may increase the movements of the mandible (Sepp, Vinkka-Puhakka, & Peltomäki, 2021).

Normal occlusion in primary dentition is characterized by primate spaces, lower overbite and overjet, ovoid arch form, and flush terminal plane second deciduous molar relation (Joshi & Makhija, 2019; Hegde et al., 2012). The flush terminal plane is one of the most common molar relationships in children and is considered ideal for obtaining perfect occlusions in permanent teeth, however, due to the inability to predict the growth of the dentofacial structures in the future, a class II molar relationship may be obtained (Vegesna et al., 2014).

The age of the targeted population may affect the prevalence of occlusal traits since the degree and incidence of crowding generally tend to increase with age and more frequent in the mandible (Lombardi, 1982; Mugonzibwa et al., 2004; Thilander et al., 2001). Other occlusal traits that may be affected by increase with age have also been found, such as deep bite, tooth rotation, and tipping (Thilander et al., 2001; Mugonzibwa et al., 2004). On the other hand, it has been pointed out in the literature that median diastema and posterior crossbite are more common in early mixed and deciduous dentition, then decrease in the advanced age stages (Thilander et al., 2001; Mugonzibwa et al., 2004; Lombardo et al., 2020; Ovsenik et al., 2007).

It is logical to determine the prevalence of malocclusion for a population with a different stage of dental development rather than based on chronological age since there are individual differences in the development and maturation of teeth (Thilander et al., 2001).

### **2.4.3 Diet**

Statistics show that about half of teens in the United States need orthodontic treatment (Proffit et al., 1998). Numerous studies have proven that the cause of malocclusion is

due to genetic factors that make it difficult to prevent. However, there is evidence that diet may be associated with malocclusion (Corruccini, 1990). Malocclusion was classified as a Civilian disease (Corruccini et al., 1983), due to the increase in the size of the teeth and a decrease in the growth of the jaw along with cardiovascular disease and diabetes in the modern and industrialized countries compared to the primitive population. In 1990 Corruccini et al. conducted a cases control study on a sample of Australian individuals of different birth years and matched it with dental casts of Australian Aboriginal tribes from the Yuendumu area, whose diet was based on solid rarely processed foodstuffs that required strong chewing effort. Low caries rates, high occlusal/interproximal attrition with nearly perfect occlusion (Class I) were observed. As for the younger individuals from the sample, it was noted increased overjet, overbite, and more malocclusion classification. Authors concluded that the supposed changes were caused by the dietary modification taking place in that region over the years, i.e. the shift from a primitive diet to a soft diet (Corruccini et al., 1990).

Animal experiments have shown differences in the growth of the lower and upper jaws upon induction of soft versus hard diets. In 1997 a study conducted by Ciochon et al. on pigs found that jaw development in pigs that depended on a soft diet was less prominent compared to pigs fed a normal diet. They concluded that nutritional consistency is strongly associated with dental malocclusion (Ciochon et al., 1997)

It is not only diet that may influence malocclusion, but individual components of the diet can play a role in the development of malocclusion. In a study conducted in 1979 in the United Kingdom on the island of Anglesey, where water fluoridation was introduced at that time. Goose and colleagues stated that systemic fluoride effect on the morphology and size of the teeth. They concluded that the dimensions of the offspring's teeth were

significantly larger, regardless of the limitations of not controlling genetic variation or other factors such as the influence of parents in the era of World War II and the subsequent change in the quality of the diet (Goose & Roberts, 1979).

It has been proven that the force of mastication plays a role in determining the occlusion, as four to five muscles contribute to the movements of the jaw. The most powerful muscle is the masseter muscle, which is mainly involved in the mastication process (Folkins, 1981). A study by Rohila et al. indicated that long faces individuals are associated with decreased masseter muscle thickness, increased vertical growth and anterior openbite, while shorter faces individuals are associated with increased thickness of masseter muscles, and increased transverse growth (Rohila et al., 2012).

Begg noted in 1954 that the chewing strength required by the diet is closely related to interproximal attrition (Corruccini, 1990); Where a solid diet requires high chewing forces that lead to dental friction resulting in interproximal and occlusal attrition, few tendencies for crowding of the anterior teeth with a high prevalence of the posterior crossbite due to the narrower arch widths (Blackwelder, 2013).

#### **2.4.4 Bad oral habits**

According to Buttersworth (1961) habit is "*frequent or constant practice or acquires tendency which has been fixed by frequent repetition*" (Marwah, 2018). Bad oral habits can create abnormal forces on the dental arches, which may contribute to the development of malocclusion. The degree of malocclusion depends on Graber's triad, which emphasizes the intensity, duration, and frequency of the habit in addition to being affected by nutritional conditions, age, and health of the individual (Barreto et al., 2012).

In a longitudinal study, Warren et al. suggested that continuing non-nutritive sucking habits of the child after the age of 48 months may pose a risk of developing occlusal

problems such as openbite, posterior crossbite, and increased maxillary arch length (Warren et al. , 2001). While Nutritive sucking habits, such as breastfeeding children with a long duration, are strongly associated with a posterior crossbite (Chen et al., 2015).

Barreto et al. indicated in a study conducted in Brazil between 2006 and 2009 on 93 children aged between 4 to 14 years that the presence of bad oral habits leads to the development of malocclusion; where the habit of nail-biting ranked the most frequent and widespread for the target sample, followed by lingual interposition, with a higher prevalence of crowding among children who suffer from malocclusion (Barreto et al., 2012).

In a cross-sectional study on a sample of school children in India, aged 12 and 15, Ramya and colleagues found that the most prevalent bad oral habits in that sample are tongue-thrusting, mouth-breathing, and thumb-sucking, which in turn lead to the development of malocclusion, crowding of the anterior teeth and openbite (Alla et al., 2020). Erika and colleagues indicated in a cross-sectional study on bad oral habits among adolescents in a developing area in northeastern Brazil, biting nails, lips, and objects, and bruxism are among the most common habits that cause malocclusion (Bárbara et al., 2013).

Tongue thrusting is usually observed in cases of swollen lymph nodes (adenoid hypertrophy), which in turn lead to obstruction of nasal breathing. Mouth breathing affects the displacement of the tongue from its position to the hard palate, which makes the cheek pressure affect the inclination of the upper molars, causing the development of posterior crossbite and high palate (Koca, Erdem, & Bayındır, 2016). Tongue thrusting causes crowding in anterior teeth and distortion in the shape of the arch (V- shape), with an increase in the openbite and lip incompetency (M. Saghiri et al. 2021).

Some literature indicated that there is a relationship between the persistent behavioral habits of asthmatic children and malocclusion (A. Al Ali et al., 2014; M. Saghiri et al., 2021; Venetikidou, 1993). In a study by Kumar of 44 asthmatic children using a corticosteroid inhaler aged 6-12 years, comparing them with non-asthmatic children, concluded that the asthmatic children were having increased arch length, palate depth, and openbite (Kumar & Nandlal, 2012).

## **2.5 Malocclusion and physical, psychological, social, and economic consequences**

Genetic and/or environmental factors, as well as ethnic consideration, are factors involved in the development of malocclusion, which in turn negatively affect the quality of life and other psychological and social aspects of the individual's life. A greater understanding of the physical, social, and psychological effects of malocclusion is important in many aspects. It provides insight into the consequences of malocclusion and its impact on people's lives, and a greater understanding of the demand for orthodontic treatment (Zhang et al., 2006). Since physical, social, and psychological impacts are the main reasons behind seeking orthodontic care, the best outcome measure for orthodontic treatment is an improvement in the oral health-related quality of life (Gonçalves et al., 2015).

### **2.5.1 Physical health impact**

Pain is rarely acute in the case of malocclusion however, it can lead to pain indirectly by causing temporomandibular disorders (TMDs) and trauma to the teeth, mucous membranes, and gingiva (Abutayyem, 2016; Zhang et al., 2006)

TMDs can be defined as dysfunctions and symptoms that may affect the masticatory muscles and the temporomandibular joints (TMJ), such as internal derangement, myofascial pain, joint clicking, arthralgia, and others (Ahmad & Schiffman, 2016).

A higher prevalence of TMDs has been reported in patients with malocclusion and women are more affected compared to men (Akhter, 2019). Evidence in some studies suggests that malocclusion may play a role as a contributing factor to the development of TMDs. It was found that there is a strong relationship between posterior crossbite and joint clicking and muscle tenderness, also it was found that excessive overjet may lead to a displacement in the TMJ disc (Bilgiç et al., 2017; Shroff, 2018)

Other reviews suggested a weak association between occlusal traits and TMDs (RL et al., 2021; Su et al., 2018)

In a review of other literature, it was found that there are other ways that malocclusion may cause pain. It may increase the possibility of dental trauma, especially those who suffer from class II division 1. The increase in overjet, anterior openbite, and lip incompetence in children are exposed to maxillary incisor trauma (MIT) (LC, 2020; Yaman Dosdoğru et al., 2016). A meta-study suggested that children in the deciduous stage with an overjet greater than 3 mm have a greater chance of traumatic dental injury (TDI) compared to children in the early permanent stage, where the chance of TDI is happening if the overjet exceeds 5 mm (Magno et al., 2020). While others showed that there is no strong correlation between MIT and overjet (W, ON, & J, 2000). Few studies considered malocclusion as a risk factor in the etiology of headaches in children and adolescents. Despite the lack of data available on this causal relationship and the need for further investigations, early treatment of malocclusion using occlusal splints and appliances can prevent or reduce migraines (Sivakumar et al., 2008; Takeuchi et al., 2013). Malocclusion may also lead to pain by causing injury to the gingiva and mucous membranes. Although many studies have evaluated the causal relationship between malocclusion and periodontal disease, the relationship is still controversial. However,

early diagnosis and treatment of malocclusion may prevent periodontal disease and its development (Bollen, 2008; Javali et al., 2020).

Periodontitis is an inflammatory disease characterized by the loss of supportive tissues up to the alveolar bone, with bacterial plaque being the causative agent of the disease. Studies have shown that crowding and teeth irregularity may increase the accumulation of bacterial plaque, which creates a fertile environment for the occurrence of inflammation in the gingiva and the periodontal tissues (Gusmão et al., 2011; Javali et al., 2020). Some longitudinal studies indicate that patients with increased overjets and anterior openbites are more susceptible to gingivitis and periodontitis due to the increased accumulation of plaque as a result of difficulty cleaning the teeth and mouth breathing, which results in xerostomia (Javali et al., 2020; Kolawole & Folayan, 2019). Gingival recession may also occur in cases of severe malocclusion of the Class II division 2, which is characterized by a severe deep bite, in which the upper and/or lower incisal edges of the incisors contact with the gingiva, leading to marginal and/or palatal recession (Zhang et al., 2006).

There is another physical effect of occlusal abnormalities on speech. Teeth play an important role in the expression of speech, especially in the pronunciation of consonants by sealing and obstructing the airflow, any anomaly or irregularity in the teeth may induce a speech disorder. In a literature review, researchers noted that patients with Class II malocclusion have difficulty producing consonants such as "P" "B" "M" due to difficulty in making lips sealing. Class III malocclusion patients, suffer from anomalies in the pronunciation of consonants, such as: "v" "f" "sh" "ch". As for the cases of the anterior open-bite, the letters "s" and "z" are affected. Otherwise, it rarely constitutes a speech disorder, unless it is combined with other malocclusion traits. However, it is difficult to

draw definite conclusions about the relationship between malocclusion and speech disorder, because speech is a complex process in which several organs such as the brain, tongue, lips, and pharynx, in addition to the teeth, overlap (Harini R, 2020; Zhang et al., 2006)

### **2.5.2 Psychosocial health impact**

Some patients believe that malocclusion may constitute an obstacle to their social life can't deal with it effectively as a result of being affected by the reactions of others towards them, which causes a decrease in their quality of life (Taibah & Al-Hummayani, 2017).

Adolescence is seen as the point at which the individuals begin to consider their physical appearance, untreated malocclusion at that stage may have psychological and social impacts on the quality of life of adolescents. A cross-sectional study (Robins & Trzesniewski, 2005) has been conducted among random sample of persons aged between 9 to 90 years, stated that the levels of self-esteem were high in childhood and declined during adolescence to gradually rise in adulthood and then return to a severe decline in old age. Anterior crowding and midline malalignment negatively affect the facial appearance, which in turn affects the psychological development and social acceptance of adolescents. The more severe malocclusion, the lower the quality of life of the individual. Several cross-sectional studies have reported that spacing, crowding, and overjet have a greater impact on the self-esteem of adolescents (KAIEDA et al., 2019; Kaur et al., 2017; Taibah & Al-Hummayani, 2017). Moreover, recent studies have reported that orthodontic treatment improves the individual's self-concept and quality of life (A, I, R, & S, 2015; Herkrath et al., 2019; K et al., 2019).

Dentofacial appearance may also have a psychological and social effects on life, however, the extent of the social impact is not clear (Gonçalves Vieira-Andrade et al., 2015). In a

study conducted by Beall, it was clearly shown that smiling has a significant effect on a person's physical attractiveness. There is no doubt that a smile is more critical to men than to women (Beall, 2007). This tendency towards people who are physically beautiful is not only seen in adults. It has been proven that children who have a normal facial appearance are considered more beautiful, intelligent, and more desirable as friends than those who suffer from malocclusion (Samsonyanová & Broukal, 2014). A cross-sectional study examined the association between malocclusion and self-perceived dental aesthetic in adolescents, female patients with malocclusion showed a higher negative impact of aesthetic self-perception compared to their male peers (Rodrigues et al., 2020). While another study showed that individuals with severe malocclusion had a worse aesthetic self-perception compared with those with minor malocclusion (Pasiga, Samad, & Pratiwi, 2019).

A number of studies have investigated the impact of dental appearance on psychological life, including a longitudinal study in China (Deng et al., 2018). The authors investigated the association between malocclusion and satisfaction with the dental appearance in adolescent patients. A total sample of 1090, age average 14 years, is examined. Clinical indicators were assessed at T1 (pretreatment) by using IOTN-AC, adolescents and their parents also completed questionnaires, including a Psychosocial Impact of Dental Aesthetics (PIDA) questionnaire to assess aesthetic concerns, dental self-confidence and psychosocial subscales. The results showed substantial T1 to T2 enhancements in PIDA components after being treated with a fixed appliance, confirming the positive effects of orthodontic treatment on OHRQoL.

Oral health related quality of life is not affected by aesthetic perception and self-esteem alone. It has been found that adolescents with Class II and class III malocclusion have

higher levels of anxiety about social appearance, depression, and loneliness (Atik, Önde, Domnori, Tutar, & Yiğit, 2020). Children who suffer from some traits of malocclusion may be subjected to bullying and nicknames related to facial deformity in adulthood, a systematic review of the relationship between malocclusion and bullying has suggested that the majority of bullying victims are children and adolescents with obvious malocclusion as extreme overjet 4-9 mm, extreme deepbite, and anterior spacing (Tristão et al., 2020).

### **2.5.3 Socioeconomic health impact**

Malocclusion is associated with a large economic burden. In the year 2000, United states spent up to 62 billion on dental services, and this number increased to about 135 billion US dollars in the year 2018 (Frédéric Michas, 2021). In United Kingdom, National Health Service expended around 250 million pounds on orthodontic service from the annual primary care budget., and it is estimated that this number will double as a result of the increasing demand for fixed orthodontic devices and expectations related to the appearance of the teeth (Price et al., 2017).

A cross-sectional study of preschool children found that the effect of socioeconomic background differed according to the morphological classification of malocclusion. increased overbite, and overjet, as well as class II malocclusion, were significantly more frequent among children at a higher socioeconomic status (Normando et al., 2015).

In another study of a sample of children between the ages of 7 and 10 years, it was suggested that there is association between increased overjet and low socioeconomic status (Vedovello et al., 2016). Despite prior knowledge of the importance of oral and dental health with regard to facial aesthetics and dental alignment, the trend for orthodontic treatment is still low (Ashky et al., 2019).

## **2.6 Classification of malocclusion indices**

Several methods for evaluating and classifying malocclusion for different purposes are described, including qualitative and/or quantitative methods. The qualitative methods describe the dentition and occlusal features, while the quantitative method measures the severity and complexity of malocclusion based on a scale or proportion (Ramanarayanan et al., 2020).

It has been proven that malocclusion is a common term that is difficult to define, so more than one index has been used to measure the extent of malocclusion according to the diagnosis or to determine the need for treatment or treatment outcome. However, the term “validity during time” must be applied to the indices (Summers, 1971).

In 1997, Bergström & Halling added other specifications that might be desirable to the quality of index, such as measuring the index, the purpose for which it was designed, high reliability, and ease to learn and use (Bergström & Halling, 1997).

Shaw et al. categorized the various indices of malocclusion (Shaw, Richmond, & O'Brien, 1995) as follows:

### **2.6.1 Diagnostic classification**

Angle's classification (1899) was the most widely used classification until the fifties of the last century, in which Angle relied on the molar relationship. In 1964, the Incisal relationship was described by using British standard institute classification. These two classifications are important in unifying concepts and ease of communication between dentists. Although Angle classification was originally designed as a diagnostic tool, it has been widely used for epidemiological purposes (Angle, 1899).

### **2.6.2 Epidemiological data collection**

This index describes malocclusion through the collection of epidemiological data by measuring the characteristics of malocclusion within a population. The first who describe this method was Björk (1964), by using three objective categories to define recorded symptoms namely: Dental anomalies, occlusion in (sagittal, vertical, and transverse dimensions), and space conditions (Björk et al., 1964).

It has been used in several studies, both intra-oral and on study models. During the years 1969-1972, a simplified method for assessing malocclusion in populations with permanent dentition was developed by the FDI Commission on Classification and Statistics for Oral Conditions (COCSTOC) and published by Baume in 1973 (Baume & Maréchaux, 1974). In 1979, The FDI (COCSTOC) method has been revised in cooperation with the World Health Organization and was published in the WHO bulletin (Bezroukov et al., 1979).

The objective of the assessment method was to determine the extent of malocclusion through specific well-defined criteria that include five groups involving gross anomalies, dentition, occlusion, space condition, and orthodontic treatment needs; judged subjectively, which was not addressed in the previous methods (Hassan & Rahimah, 2007; Ramanarayanan et al., 2020) . Although around that period, summers (1966-1971) designed Occlusal Index (OI) for epidemiological purpose within deciduous, mixed, and permanent dentition (Summers, 1971). However, the complexity of the registration procedures and failing to score all missing teeth prevented it from being widely used (Gupta & Shrestha, 2014).

### **2.6.3 Malocclusion treatment outcome**

Assessment of the outcome of the treatment can be considered as an additional index for occlusion. Several indices have been developed to assess treatment success as PAR index and Summer's index (Richmond et al., 1992; Summers, 1971)

#### **2.6.4 Malocclusion complexity and priority treatment needs**

The severity and complexity of malocclusion are determined by quantitative methods, the use of which reduces subjectivity related to diagnosis and outcome assessment of orthodontic treatment. Indices of treatment need aim to analyze the risks and benefits of orthodontics and allocate resources according to the severity of cases (Ramanarayanan et al., 2020).

Among those indices that were used was the Handicapping Labio-Lingual Deviations Index (HLD) by Draker (1960), which is considered the first index of measuring cleft palate and traumatic deviations along with occlusal features. It was considered unacceptable for overall field use because it tended to identify only the very worst cases. Many other indices have been developed, the most used of which are the Dental Aesthetic Index (DAI) and Index of Orthodontic Treatment Need (IOTN) (Bataringaya, 2004; Gupta & Shrestha, 2014; Ramanarayanan et al., 2020).

Where DAI was designed by Cons et al., and adopted by WHO in 1986. It is used to assess the treatment need based on aesthetics, It focused on the relationship between occlusal morphology and quality of life, including patients' perceptions (Cons, 1986). The lack of assessment of some occlusal features such as buccal crossbite, deep bite, and impacted teeth, and its invalidity in assessing the treatment need during mixed dentition, are limitations for the use of this index (Gupta & Shrestha, 2014).

As for IOTN, it was developed in 1989 by Brook and Shaw, where it used to assess the treatment need through its assessment of dental health and aesthetics, which makes it the

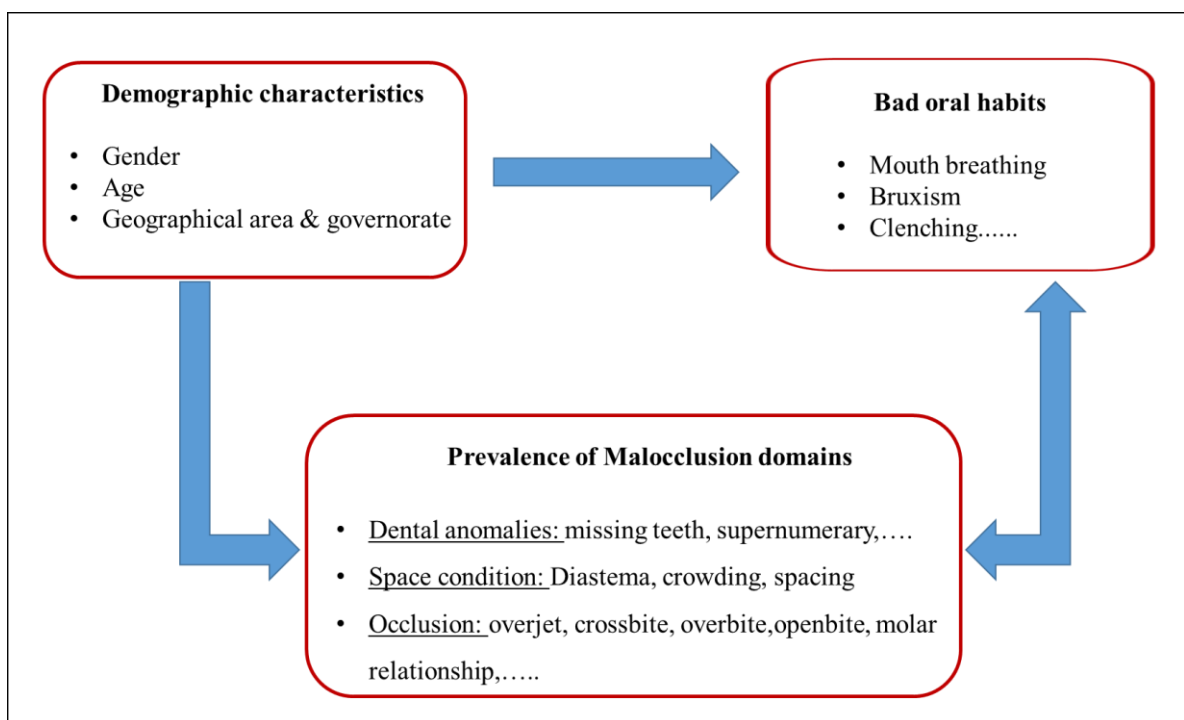
most objective and synthetic index that allows comparison between different population groups, but it requires high efficiency and appropriate training with calibration exercises to use it (Bataringaya, 2004).

## **2.7 Summary**

In summary, the evidence points to the prevalence of malocclusion globally and locally. Malocclusion is a general oral health problem with social, psychological, and economic dimensions. Every effort should be made to prevent and control the problem from getting worse. However, studies that indicate the extent of malocclusion in Palestine are very limited, and it will be the first study in West bank/ Palestine to investigate the prevalence of malocclusion and orthodontic treatment needs. The results will provide a basis for future research focused on understanding factors related to malocclusion and limiting its prevalence through the use of an exploratory data analysis approach, which will assess treatment needs among the Palestinian population and provide a reliable epidemiological database for the future. The following chapter discusses the conceptual framework and operational definitions that the researcher used in our study.

### Chapter Three: Conceptual framework

This chapter explores the operational definitions for dependent and independent variables of our study that may affect the assessment of the prevalence of malocclusion. As malocclusion and occlusal traits are dependent variables which is directly affected by independent variables of sex, geographical area, age and bad habits according to the following graph.



*Figure 3. 1 Conceptual framework*

The selected variables considered as a blueprint for the research process. The conceptual framework model was developed after reviewing previous literature on the same research topic. This study was based on a quantitative statistical measurements to find out the prevalence of malocclusion among adolescents.



Malformation	<input type="checkbox"/>
Ectopic eruption	<input type="checkbox"/>
Retained deciduous teeth	<input type="checkbox"/>

**3.1.2.2 Space discrepancies**

Crowding and spacing were specifically targeted as the key subset of malocclusion (Blackwelder, 2013). In our study, both crowding and spacing were recorded subjectively (present/ absent) according to overlapping of erupted teeth due to insufficient space more the 2 mm or lack of space for teeth to erupt in the dental arch more the 2 mm. The distance between the maxillary central incisors, known as (the central diastema), was measured objectively as 0 for none, 1 for present ( $\geq 2\text{mm}$ ), or 9 for unrecordable (missing any centrals). Where there are three items constructed to measure intra-arch occlusal traits. The selected items are represented in table (3.2).

**Table 3. 2 Space Condition Domain**

<b>Diastema ( A space of 2 mm or more)</b>		
None= 0		<input type="checkbox"/>
Present= 1		
Unrecordable= 9		
<b>Crowding/ Spacing</b>		
		Present
Crowding	Upper Lower	
Spacing	Upper Lower	

**3.1.2.3 Occlusal anomalies**

Table 3.3 shows how we measured the sagittal, vertical, and transversal anomalies in both lateral and incisal segments.

**Table 3. 3 occlusal domain**

Incisal Segments		Lateral segments	
<b>Overjet</b>		<b>Molar relationship</b>	
<0 = 0		Class I	<b>Rt.</b>   <b>Lt.</b>
0mm - < 2mm = 1	<input type="checkbox"/>	Class II div. 1	
2mm – 4 mm = 2		Class II div. 2	
>4mm – 6 mm = 3		Class III	
> 6mm = 4		Unrecordable	
Unrecordable = 9			
<b>Anterior openbite</b>		<b>Posterior openbite (present or absent)</b>	
None = 0		Rt.	<input type="checkbox"/>
Present = 1	<input type="checkbox"/>	Lt.	<input type="checkbox"/>
Unrecordable = 9			
<b>Anterior crossbite</b>		<b>Posterior crossbite (Buccal or Lingual or Normal)</b>	
None = 0		Rt.	<input type="checkbox"/>
Present = 1	<input type="checkbox"/>	Lt.	<input type="checkbox"/>
Unrecordable = 9			
<b>Overbite</b>			
<2mm = 0			
2mm – 4mm = 1	<input type="checkbox"/>		
>4mm – 6 mm = 2			
> 6 mm = 3			
Unrecordable = 9			
<b>Midline shift (2 mm or more)</b>			
None = 0			
Present = 1	<input type="checkbox"/>		
Unrecordable = 9			

## 3.1.2.3.1 Lateral segments

In our study, **Angle's classification** was adopted to describe the molar relationship in sagittal plane for both sides (right and left), classified as Class I, II, III

**Posterior openbite** was recorded when there is lack of contact between the posterior teeth (first premolar, second premolar, and first molar) in the vertical plane for both sides.

While in the transverse dimension the **posterior crossbite** for both sides was described according to the position of the buccal or lingual cusps of the maxillary teeth (first premolar, second premolar, and first molar), classified as unilateral or bilateral crossbite (buccal or lingual).

Three items were used to measure lateral segments of occlusal anomalies.

#### 3.1.2.3.2 Incisal segments

The incisal segments includes five occlusal features: maxillary overjet, anterior crossbite, overbite, anterior open bite, and midline shift.

- **Overjet** was measured metrically considering that the normal value ranged from 2 to 4 mm, increased if it is more than 4 mm and decreased if it is less than 2 mm, and reversed overjet if it is less than 0. (Abdulaziz Al Hammad DMD et al., 2019; Alogaibi et al., 2020; Kinaan, 1986)
- **Anterior openbite** was measured when all four upper incisors do not overlap any lower incisor in centric occlusion considering that the edge-to-edge position is not an anterior openbite.
- **Anterior crossbite** was recorded when one or more of the maxillary incisors occluded lingual to the mandibular incisors and coded as 1 for present and 0 for absent.
- **Overbite** was measured metrically considering that the normal value ranged from 2 to 4 mm, increased if it is more than 4 mm and decreased if it is less than 2 mm (Abdulaziz Al Hammad DMD et al., 2019; Alogaibi et al., 2020; Kinaan, 1986).

The fifth measurable feature in the incisal segments is the **midline shift**. It was recorded when the midlines of the maxillary and the mandibular arch are displaced by 2mm or more irrespective of whether the displacement occurs in the maxillary or mandibular arch.

### 3.2 Independent variables

Previous studies showed the effect of independent variables on the prevalence of malocclusion and occlusal traits. Accordingly, we selected important independent variables like gender, geographic area and bad habits.

- **Gender:** Categorized in our study into male and female schoolchildren respondents.
- **Age:** The participants had to be twelve years old as at their last birthday
- **Geographical area:** All governorates of the West Bank/ Palestine were covered to include 17 directorates of education from the north, center and south.
- **Region:** Categorized into city and countryside.
- **Bad habits:** By distributing a questionnaire consisting of eight oral habits prevalent among adolescents, each habit was measured separately and its correlation with the occlusal traits, the answer includes yes or no, which represented in table (3.4).

**Table 3. 4 Parafunctional Habits corresponding items**

Mouth breathing	Tongue thrusting
Bruxism	lip biting
Thumb sucking	Nail biting
Clenching	Biting objects

Definition of the bad oral habit:

Mouth breathing: Breathing through the mouth.

Bruxism: Excessive dynamic teeth grinding and gnashing, usually during sleep.

Thumb sucking: putting the thumb in the mouth for comfort or to relieve stress, it is type of non-nutritive sucking.

Clenching: The static contact of teeth together and tightening the jaw muscles

Tongue thrusting: Pushing the tongue forward between the upper and lower teeth when swallowing

Lip biting: Bite the upper or/ and lower lips.

Biting objects: biting things like pencil, pen...etc.

### **3.3 Summary**

In summary, the conceptual framework was presented with the operational definitions of several independent variables in this chapter. The following chapter describes the study methodology, carrying out the study, and data management.

## Chapter Four: Methodology

This chapter describes the study methodology used to measure the prevalence of malocclusion and occlusal traits. First, the study setting and population characteristics were described, followed by presenting study design, inclusion and exclusion, data collection tools, calibration, and pilot study, along with details of the data analysis. Lastly, the study was examined from an ethical standpoint.

### 4.1 Study setting

The Palestinian territories comprise of two areas separated geographically: West Bank and Gaza Strip. (Figure 4.1)



**Figure 4. 1 Map of Palestinian Territories [Source: Palestinian Central Bureau of Statistics, 2009]**

The study was conducted in the West Bank. The West Bank contains 17 regional directorates distributed in 11 governorates between the northern, central, and southern

regions of the West Bank (Statistical Yearbook, 2019). It lies within an area of 5,800 Km<sup>2</sup> west of the river Jordan, with an estimated population of about 3.05 million, of whom 50.8% are males and 49.1% females. The vast majority of the population (38%) was under the age of 15 (The status of health in Palestine, 2006; National Population and housing Census, 2020).

Data from the 2019 statistical book of the Ministry of Education indicates that the number of government schools was 1,825, 949 basic schools, and 876 secondary schools. Education is provided to 570,653 male and female students distributed among 691 male schools, 671 female schools, and 463 mixed schools. While the seventh-grade students amounted to about (53,247) distributed among 1070 schools, of which 408 female schools, 386 male schools, and 276 are mixed schools.

To meet the needs related to oral health, an oral health screening program was launched in schools for the first, seventh, and tenth grades. This program is run by the Palestinian Ministry of Health in cooperation with other international organizations. The program is implemented through 44 dental clinics affiliated with the Palestinian Ministry of Health distributed throughout the West Bank.

The program provides examination and referral of students to dental clinics run by the Palestinian Ministry of Health, in addition to providing preventive services and health education. (Kateeb, 2007; The status of health in Palestine, 2020).

#### **4.2 Study design**

The study is a descriptive cross-sectional quantitative design which used morphological examination and self-administered closed-end questionnaire to assess the bad habits. It was conducted between 17 February 2022 to 20 April 2022 among a stratified sample of

12-year-old schoolchildren in 69 public schools in 17 governorates, n= (1384). The following sections will describe the sampling methods, study tools and data analysis.

### 4.3 Sample methodology

#### 4.3.1 Target population

The cross-sectional study targets the schoolchildren from both sexes with age 12-year-old (or in seven Grade) in public/governmental schools in the West Bank.

#### 4.3.2 Sampling frame distributions

Based on 2019-2020 data from Ministry of Education, the following table (1.4) summarizes the statistics about schools, which contain the students of age groups 12 years (in seven grade) by school type and Directorate

**Table 4. 1 Distribution of the study population according to the variables of gender, educational directorate, and type of school**

Directorate	N (%)			
	Girls	Boys	Both	Total
	n (%)	n (%)	n (%)	n (%)
Jenin	37 (9)	38 (10)	18 (7)	93 (9)
Qabatya	26 (6)	24 (6)	7 (3)	57 (5)
Tubas	10 (2)	9 (2)	4 (1)	23 (2)
Tulkarem	27 (7)	24 (6)	19 (7)	70 (7)
Nablus	39 (10)	38 (10)	24 (9)	101 (9)
Nablus South	22(5)	18 (5)	14 (5)	54 (5)
Qalqiliah	19 (5)	16 (4)	21 (8)	56 (5)
Salfeet	17 (4)	11 (3)	12 (4)	40 (4)
Ramallah	46 (11)	42 (11)	42 (15)	130 (12)
Jericho	5 (1)	3 (1)	7 (3)	15 (1)
Jerusalem	12 (3)	12 (3)	4 (1)	28 (3)
Jerusalem Neighbors	15 (4)	18 (5)	8 (3)	41 (4)
Bethlehem	26 (6)	26 (7)	30 (11)	82 (8)
Hebron North	23 (6)	28 (7)	9 (3)	60 (6)
Hebron	43 (11)	36 (9)	5 (2)	84 (8)
Hebron South	26 (6)	31 (8)	32 (12)	89 (8)
Yatta	15 (4)	12 (3)	20 (7)	47 (4)

<b>Total</b>	<b>408 (38)</b>	<b>386 (36)</b>	<b>276 (26)</b>	<b>1070 (100)</b>
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\*n is the number of schools in the defined category, % is the percentage of cases in the defined category.

Based on the distribution of schools in the directorates, the study population is categorized according to the geographical areas was as follows:

**Table 4. 2 Distribution of the study population according to the variables of gender, region, and type of school**

Region	N (%)			
	Girls	Boys	Both	Total
Northern region	180 (44)	167 (43)	107 (39)	454 (42)
Central region	95 (23)	86 (22)	73 (26)	254 (24)
Southern region	133 (33)	133 (34)	96 (35)	362 (34)

#### 4.3.3 Sample size calculation

We estimated the sample size according to the following sample size equation, which is based on the population size as follows:

$$n = \frac{t^2 * s^2}{E^2} * Deff$$

Where:

**n** : sample size

**E** : Margin of error, expressed as decimal which equals 0.05

**Z** : Z value (e.g. 1.96 for 95% confidence level)

**p** : percentage of the main indicator, expressed as decimal , (0.5 used for sample size needed)

**DEFF**: design effect. The design effect was added as we used a cluster sample instead of simple or systematic random sample. It is assumed here to be =1.2 (increasing the sample size by 20%)

The result of the equation is multiplied by 3. The 3 indicated the three regions of West Bank (North, Central and South).

Based on the above formula, the total sample size was (1,384) students of Age 12 years.

#### 4.3.4 Sample allocation

To select a representative sample, we divided the target population of the study to homogeneous strata depending on some variables. In this study, the sample represents the targeted schools that have at least children of 12- years-old (Seventh- Grade).

Two variables were used to construct the strata of our the sample; directorates and gender schools. Seventeen regional directorates were identified according to 2019 data. Also, schools were classified as single-sex schools; boys or girls and mixed-sex schools. As a Two- Stages Stratified cluster sample, 69 schools were covered in West Bank cities and countryside, excluding Jerusalem; where it was not possible to reach the oral screening of the children because of the checkpoints. From each school of the sample, approximately 20 students from seventh-grades were selected. The total sample size was 1,384 students. For more details, please see tables (4.3), and (4.5) below.

**Table 4. 3 Distribution of the study sample according to the variables of gender, directorate, and type of school**

Directorate	N			
	Girls	Boys	Both	Total
Jenin	2	3	0	5
Qabatya	2	2	1	5
Tubas	2	2	0	4
Tulkarem	1	1	1	3
Nablus	2	2	1	5
Nablus South	1	1	1	3
Qalqiliah	1	1	1	3
Salfeet	1	1	1	3
Ramallah	4	3	0	7
Jericho	1	1	1	3
Jerusalem	0	0	0	0
Jerusalem Neighbors	3	2	0	5
Bethlehem	3	2	0	5

Hebron North	2	2	1	5
Hebron	2	2	1	5
Hebron South	2	2	1	5
Yatta	1	1	1	3
<b>Total</b>	<b>30</b>	<b>28</b>	<b>11</b>	<b>69</b>

\*n is the number of schools in the defined category

According to the previous distribution, schools were randomly selected from several population groups of cities and countryside. More details can be found in table (4.4)

**Table 4. 4 Distribution of the study sample according to the variables of gender, directorate, and type of school, and name of school**

School name	Directorate	School type	Locality	seventh-grade (N)	Females (N)	Males (n)	Males sample (n)	Females sample (n)
Yabad Basic upper school	Jenin	males	Yabad	54		54	22	
Amriya Elementary School	Jenin	males	Jenin	107	0	107	25	
Burqin High School	Jenin	females	Birqueen	0	75	75		23
Arana High School	Jenin	females	Arrana	25	25	0		21
Martyr Abdullah Azzam	Jenin	males	Sela al-harthya	81	0	81	19	
Beta Basic School	Nablus South	females	Beta	61	61	0		21
Assera Al-Qibliya mixed secondary school	Nablus South	mixed	Assera Al-Qibliya	27	0	27	21	
Jammaeen Basic School	Nablus South	males	Jammaeen	79	0	79	21	
Samir Abdel Hadi Elementary School	Nablus	females	Nablus	32	32	0		20
Burqa Secondary School	Nablus	males	Burqa	44	0	44	20	
Deir Sharaf mixed secondary school	Nablus	mixed	Deir Sharaf	31	0	31	21	
Tell high school	Nablus	females	Tell	67	67	0		15
Muscat Primary School	Nablus	males	Assera al-shamalya	98	0	98	21	
Salfeet high school	Salfeet	females	Salfeet	89	89	0		18
Deristya mixed secondary school	Salfeet	mixed	Deristya	46	0	46	20	
Bedya basic school	Salfeet	males	Bedya	123	0	123	19	
Deir al-Ghsoon upper elementary school	Tulkarem	females	Deir al-ghsoon	106	106	0		20
Abd al-Rahim al-Haj Muhammad High School	Tulkarem	males	Tulkarem	91	0	91	20	
Ezbet Shofa Mixed Elementary school	Tulkarem	mixed	Faroon	17	17	0		17

Qalqilya basic school	Qalqiliah	females	Qalqiliah	205	205	0		20
Al-Fundoq mixed secondary school	Qalqiliah	mixed	Al-fundoq	25	14	11	14	7
Kafr Qaddoum high school	Qalqiliah	males	Kufr qadoom	24	0	24	20	
Faisal Husseini basic school	Ramallah	females	Ramallah	111	111	0		20
Azores girl basic school	Ramallah	females	Al-bireh	118	118	0		20
Rafat basic school	Ramallah	males	Rafat	35	0	35	23	
Abu Qash High School	Ramallah	females	Abu qash	30	30	0		19
Betaine high school	Ramallah	females	Betaine	22	22	0		23
Birzeit high school	Ramallah	males	Birzeit	30	0	30	20	
Beitunia high school	Ramallah	males	Beitunia	0	0	120	18	
Jaba' high school	Jerusalem Neighbors	females	Jaba'	58	58	0		20
Al-Ram high school	Jerusalem Neighbors	males	Al-ram and Dahiat albarid	20	0	20	20	
Alqubaiba Basic upper school	Jerusalem Neighbors	females	Alqubaiba	37	37	0		20
Al-Ram high school	Jerusalem Neighbors	females	Al-ram	61	61	0		20
Beit Anan high school	Jerusalem Neighbors	males	Beit anan	57	0	57	20	
Beit Jala high school	Bethlehem	females	Beit jala	45	45	0		20
Al-awda high school	Bethlehem	females	Bethlehem	146	146	0		20
Alta'akhi basic school	Bethlehem	males	Beit sahour	104	0	104	20	
Alo'had alo'marya basic school	Bethlehem	males	Ubeidiya	122	0	122	20	
Amiryra basic school	Bethlehem	females	Za'tara	0	84	84		20
Yatta basic school	Yatta	males	Yatta	103	0	103	20	
Bayt amra high scholl	Yatta	females	Bayt amra	43	43	0		20
Alkarmel mixed basic school	Yatta	mixed	Alkarmel	84	84	0		19
Jericho high school	Jericho	females	Jericho	29	29	0		21
Abu Bakr Al Siddiq High School	Jericho	males	Jericho	68	0	68	20	
Fasa'il mixed high school	Jericho	mixed	Fasa'il	32	22	10	8	12
Al Rasheed Elementary School	Hebron North	males	Halhoul	99	0	99	21	
Musa bin Naseer Elementary School	Hebron North	males	Bani Naim	87	0	87	20	
Beit Ummar Elementary School	Hebron North	females	Beit ummar	85	85	0		22
Zahrat Al Madaen basic school	Hebron North	females	Beit ummar	51	51	0		20
Shuyukh al-arrub mixed basic school	Hebron North	mixed	Shuyukh al-arrub	38	23	15	10	10

Al Rayyan Secondary School	Hebron	females	Hebron	91	91	0		20
Abdul Qadir Qawasma mixed basic school	Hebron	mixed	Hebron	27	27	0		23
Tarqumiyah basic school	Hebron	males	Tarqumiyah	82	0	82	20	
Bayt kahil basic school	Hebron	females	Bayt kahil	33	33	0		20
Al Noor Basic school	Hebron	males	Tapuah	201	0	201	20	
Avicenna basic school	Hebron South	males	Dura	142	0	142	20	
Aisha Basic school	Hebron South	females	Addahiriya	85	85	0		20
Deir Samet High School	Hebron South	males	Dir samet	30	0	30	20	
Deir al-Asal al-Fouqa mixed secondary school	Hebron South	mixed	Dir al-asal alfoqa	20	20	0		17
Rafat's Basic school	Hebron South	females	Al-samou	27	27	0		20
Arraba Basic school	Qabatya	females	Arraba	21	21	0		21
Qabatya-western Basic school	Qabatya	males	Qabatya	89	0	89	20	
Alrama Basic school	Qabatya	mixed	Alrama	30	18	12	10	10
Siris Basic school	Qabatya	males	Siris	55	0	55	20	
Ajja high school	Qabatya	females	Ajja	73	73	0		20
Al-Biruni Basic school	Tubas	males	Tubas	12	0	16	12	
Tayseer high school	Tubas	males	Tyaseer	29	0	29	20	
Aljulan Basic school	Tubas	females	Tammon	98	98	0		20
Wadi Al Fara'a High School	Tubas	females	Wad al-fara'	58	58	0		20

\*Locality is the location of the population, there are **613** locality in Palestine, N is total number of students in the seventh grade, n is the number of sample that was examined.

As shown in the previous table; there were schools that were classified as mixed, but they were mixed only for the fourth grade, then the classes become male or female, however, it did not affect our sample.

#### 4.3.5 Sample type

The sample type is a Two- Stages Stratified cluster Sample that is covering the 69 schools.

#### 4.4 Inclusion and exclusion criteria for participants

The inclusion criteria were:

1. Schoolchildren enrolled in the seventh grade and in the defined age range from 12 years, 0 months to 12 years, 11 months.
2. Only children who presented an informed consent signed by their parents were examined.
3. Only consenting participants were included in the study and none of the schoolchildren invited for participation had cleft, syndromes, or any systemic health diseases.

Exclusion criteria: eligible schoolchildren aged 12 years were *excluded* if had any current or present history of orthodontic treatment (either interceptive or elective) or extraction of any of the first molars.

#### **4.5 Data collection**

The students examined were seated in a chair with a high backrest with their head supported in an upright position, and the examiner was standing in front of the chair. The testing area is arranged so that students entered at one point and leave at another. Students were not allowed to crowd around the examiner. Natural daylight was used as the light source for the examination, and a portable light was used to supplement the natural daylight during the examination when needed (WHO, 1997).

The following instruments and tools were used:

- A mouth mirror
- Disposable gloves
- A sharp pencil
- Triangle, set square ruler (Figure 4.2)
- Tongue depressor
- 70% alcohol spray

- Cotton
- Portable light
- Examination form
- Closed-end questionnaire

Figure 4.2 demonstrate the tools used in the study



*Figure 4. 2 Instruments for data collection*

#### **4.5.1 Data collection tools**

The data collection was conducted using two tools: a clinical examination, and a face-to-face structured questionnaire.

##### **4.5.1.1 Clinical examination**

Fourteen trained and calibrated examiners conducted all clinical examinations in a classroom setting with an assistant recording the observations.

The intraoral examination was derived from previous researches (Angle, 1899; Baume & Maréchaux, 1974; Bezroukov et al., 1979; Björk et al., 1964; Draker, 1960; Salzman,

1967). It included the objective and subjective registration of the occlusal traits which are:

- Dentition
- Space condition
- Occlusion (incisal and lateral segments)

The content of the examination form has been described in detail previously.

#### **4.5.1.2 Questionnaire**

After being clinically examined, the participants completed a questionnaire in a face-to-face encounter undertaken by 14 trained research assistants (distributed across governorates), in which the participants' demographic characteristics and bad habits were assessed. (Appendix 7)

#### **4.6 Quality control**

Obtaining accurate data requires taking the necessary measures to reduce errors in the data collection phase of the study, through training the examiners and evaluating reliability.

Prior to data collection, 14 examiners were trained and calibrated by an orthodontist with more than 15 years of experience to ensure the inter-examiner reliability and an understanding of the mechanism of measuring the occlusal traits and the variables required in the study. They were trained on cast models using examination instruments. During the training session, dentists were calibrated in evaluating all variables to reduce the level of ambiguity in the measurement.

##### **4.6.1 Calibration and pilot study**

A pilot study was carried out involving 32 schoolchildren who were not included in the final study to test the inter-examiner reliability, 18 schoolchildren were evaluated by eight

examiners (AS, MO, WA, RB, AA, NT, AJ, and ZD), and another 14 schoolchildren were evaluated by six examiners (GH, MB, SW, NI, MS, and WS) on the same day independently from each other.

The Inter-examiner reliability was assessed using the pilot data for each of the examiners by the intra-class correlation coefficient (ICC) and Cronbach's alpha test and its corresponding 95 per cent CI. Table (4.1, 4.2) shows the results of occlusion measurements for both groups: Overjet, Anterior openbite, Anterior crossbite, Overbite, Midline shift, Molar relationship, Posterior openbite, and Posterior crossbite.

All measurements showed a high degree of inter-examiner reliability (ICCs 0.872 or above, Table 4.5, 4.6), with the exception of overjet ICCs 0.776 and posterior crossbite ICCs 0.670 for the second group.

**Table 4. 5 Inter-examiner reliability for first group**

Occlusal trait	Code	Cronbach's Alpha	Average measures ICC	95% CI	P-value
<b>Incisal segments</b>					
Overjet	Ioverjet	0.940	0.940	0.887-0.974	<0.001
Anterior openbite	IAnterO	1	1		<0.001
Anterior crossbite	IAnterC	0.950	0.950	0.906- 0.978	<0.001
Overbite	IOverbite	0.928	0.928		<0.001
Midline shift	IMidline	0.940	0.940	0.886-0.974	<0.001
<b>Lateral segments</b>					
Molar relationship	LSL	0.944	0.944	0.894-0.976	<0.001
Posterior openbite	lposOR	1	1		<0.001
Posterior crossbite	lposCrosR	0.887	0.887	0.786-0.951	<0.001

\* P-value was considered significant at <.01. CI: confidence interval. ICC: intra-class correlation. Code: used in SPSS

**Table 4. 6 Inter-examiner reliability for second group**

Occlusal trait	Code	Cronbach's Alpha	Average measures ICC	95% CI	P-value
<b>Incisal segments</b>					
Overjet	Ioverjet	0.776	0.776	0.528-0.917	<0.001
Anterior openbite	IAnterO	1	1		<0.001
Anterior crossbite	IAnterC	1	1		<0.001
Overbite	IOverbite	0.872	0.872	0.729-0.953	<0.001
Midline shift	IMidline	1	1		<0.001
<b>Lateral segments</b>					
Molar relationship	LSL	0.953	0.953	0.900-0.983	<0.001

Posterior openbite	lposOR	1	1	<0.001
Posterior crossbite	lposCrosR	0.670	0.670	0.192-0.885 <0.008

\* *P*-value was considered significant at <.01. CI: confidence interval. ICC: intra-class correlation. Code: used in SPSS

#### 4.7 Statistical analysis

Descriptive measures of absolute and relative frequencies are presented for categorical variables like gender, geographic area, region and bad oral habits. Mean, median, and standard deviation was calculated for ordinal variables like dental anomalies. Independent sample T-test was used to check the differences in means between some of dental anomalies and gender. One Way ANOVA Test was conducted to check the differences between some of dental anomalies and region. Chi-square test and Fisher's exact test were performed to examine the association of demographic indicators and bad oral habits with the different types of malocclusions in the three planes (Sagittal, Vertical, and Transverse), dental anomalies, and space condition, in addition to the correlation between the occlusion variables (interrelation) through cross-tabulation. Multinomial logistic regression was used to estimate the prevalence ratios of having class II or class III molar relationships according to the presence of dental anomalies, bad oral habits, and space conditions. Finally, the study include driving *Norm Occlusion Index* (NOI), this index measure the normal occlusion status where the respondent should achieving the following characterize to be Normal case; the Overjet= (2mm-4mm), Anterior Openbite=0, Anterior crossbite =0, Overbite=(2mm-4mm), Midline shift=0, Molar relationship = class I, Posterior openbite =0, posterior cross bite= normal) ; and other case if at least one of them not satisfied (Malocclusion).

All analyses were performed with the Statistical Package for Social Sciences version 23.0 (SPSS Inc., Chicago, Illinois, USA). A 2-sided  $\alpha$  of less than 0.05 was considered statistically significant.

#### **4.8 Ethical consideration**

Ethical approval was obtained from all relevant persons, authorities, and committees in Palestine. These included Helsinki approval from the Palestinian Health Research Council under the number (PHRC/HC/998/21) (appendix 1), and the Faculty of Graduate Studies at the Arab American University of Palestine (appendix 2). Permission to examine schoolchildren were obtained from the Ministries of Health and Education (appendix 3, 4, 5). In addition, all elements of informed consent, particularly the voluntary nature of participation, confidentiality of responses, and privacy of the respondents were mentioned in the questionnaire's cover letter (appendix 6, 7).

#### **4.9 Summary**

In summary, the study methodology was described along with details of the statistical methods. The following chapter presents the study's results.

## Chapter Five: Results

### 5.1 Introduction

The total number of examined schoolchildren was 1,384. Of them, 106 cases were excluded (7.3%) due to the current or history of orthodontic treatment or due extraction of any of the first molars, giving a valid sample of 1278.

The results in this chapter are presented in three main sections:-

*Section 5.2* presents the sample with regards to demographic characteristics, bad oral habits, and occlusion data. Descriptive data are presented for all the variables.

*Section 5.3* reports the associations between independent and dependent variables. By using the cross tabulation with bivariate Pearson and Spearman's rank correlations for testing the relationships.

*Section 5.4* presents the size of impacts of dental anomalies, space discrepancies, and bad oral habits on occlusion classification results from Multinomial logistic regression (**mlogit**).

### 5.2 Descriptive analysis

#### 5.2.1 Demographic data

Of 1278 participants 51.5% were female and 48.5% were male. The majority (81.8%) of the schoolchildren lives in the countryside. About 40.5% of them lives in the northern region of the West Bank, and the rest 26.3%, and 33.2% were distributed in the central and south, respectively. More details are described in table (5.1).

**Table 5. 1 Demographic Characteristics of Samples' respondents**

Demographic variables		n	%
<b>geographical area</b>	<b>city</b>	233	18.2%
	<b>countryside</b>	1045	81.8%
<b>gender</b>	<b>male</b>	620	48.5%
	<b>female</b>	658	51.5%
<b>region</b>	<b>north</b>	518	40.5%
	<b>central</b>	336	26.3%
	<b>south</b>	424	33.2%
<b>governorate</b>	<b>Jenin</b>	196	15.3%
	<b>Nablus</b>	143	11.2%
	<b>Tubas</b>	66	5.2%
	<b>Tulkarem</b>	56	4.4%
	<b>Qalqilia</b>	57	4.5%
	<b>Salfeet</b>	56	4.4%
	<b>Jericho</b>	57	4.5%
	<b>Ramallah</b>	130	10.2%
	<b>Hebron</b>	328	25.7%
	<b>Bethlehem</b>	96	7.5%
	<b>Jerusalem</b>	93	7.3%

\*n is the number of schoolchildren occurrence in the defined category, % is the percentage of cases in defined category

### 5.2.2 Bad habits

The result showed that the percentage of total prevalence of bad oral habits like clenching, nail biting, biting objects, bruxism, tongue thrusting, and thumb sucking was 30.1%, 26.2%, 23%, 22.1%, 21.4%, and 6% of the study sample, respectively. On the other hand, mouth breathing and lip biting were more prevalent with approximately 40% of the study sample. More details on the descriptive analysis can be found in table (5.2).

**Table 5. 2 Frequency distribution of bad oral habits among the examined sample**

Bad Habits		n	%
<b>mouth breathing</b>	no	751	58.8%
	<b>yes</b>	527	<b>41.2%</b>
<b>bruxism</b>	no	996	77.9%
	<b>yes</b>	282	<b>22.1%</b>
<b>Thumb sucking</b>	no	1201	94.0%
	<b>yes</b>	76	<b>6.0%</b>
<b>clenching</b>	no	893	69.9%
	<b>yes</b>	385	<b>30.1%</b>
<b>tongue thrusting</b>	no	1005	78.6%
	<b>yes</b>	273	<b>21.4%</b>
<b>lip biting</b>	no	755	59.1%
	<b>yes</b>	523	<b>40.9%</b>
<b>nail biting</b>	no	943	73.8%
	<b>yes</b>	335	<b>26.2%</b>
<b>biting objects</b>	no	983	77.0%
	<b>yes</b>	294	<b>23.0%</b>

\*n is the number of schoolchildren occurrence in the defined category, % is the percentage of cases in defined category

The prevalence of mouth breathing in males (47%), while the prevalence of lip biting in females (47%). More details in table (5.3) below.

**Table 5. 3 Frequency distribution of bad habits according to gender**

	gender			
	male		female	
	n	%	n	%
<b>mouth breathing</b>	294	47%	233	35%
<b>bruxism</b>	159	26%	123	19%
<b>thumb sucking</b>	40	6%	36	5%
<b>clenching</b>	194	31%	191	29%
<b>tongue thrusting</b>	148	24%	125	19%
<b>lip biting</b>	216	35%	307	47%
<b>nail biting</b>	169	27%	166	25%
<b>biting objects</b>	129	21%	165	25%

\*n is the number of schoolchildren occurrence in the defined category, % is the percentage of cases in defined category

### 5.2.3 Dental anomalies and space conditions

We found that the most common of the dental anomalies were retained deciduous teeth (30%), Ectopic eruption (19%), and permanent teeth missing due to extraction, trauma or congenitally (15%). On the other hand, malformation and supernumerary were rare (0 to

4%) in our sample. The most common teeth missing in upper arch due to congenital or extraction were canine (5.2%), and second premolar (4.8%). In lower arch the most common teeth missing were second premolar (8.3%). More details are in table (5.4) below

**Table 5. 4 Distribution of missing permanent teeth**

Tooth no.	Upper Arch		Lower Arch	
	%	n	%	n
second premolar	4.80%	62	8.30%	105
first premolar	2.90%	37	2.20%	27
canine	5.20%	66	2.10%	26
lateral incisor	1.90%	24	0.40%	4
central incisor	0.30%	4	0.00%	0

\*n is the number of missing teeth occurrence in the defined category, % is the percentage of cases in defined category

Regarding space conditions, approximately 20% of the sample had both arches crowding, 35% of them had crowding in upper arch, and 12% of them had diastema, while 9% of them had spacing in both arches. More details in table (5.5)

**Table 5. 5 Distribution of spacing and crowding**

Space conditions	Total	
	n	%
crowding Upper	450	35%
crowding lower	398	31%
crowding in both arches	258	20%
spacing Upper	309	24%
spacing Lower	191	15%
spacing in both arches	109	9%
diastema(Space)	156	12%

\*n is the number of schoolchildren occurrence in the defined category, % is the percentage of cases in defined category

#### **5.2.4 Prevalence of different types of malocclusion**

Our study observed normal occlusion in 192 schoolchildren (15%). The other 1086 schoolchildren (85%) had one or more types of malocclusion.

According to Angle Classification Class I in 65% of the participants, Class II div 1 and Class II division 2 malocclusion were detected in 17% and 6% of the participants, respectively, Class III in 12%.

Prevalence of malocclusion is presented in table (5.6). The most common type of malocclusion in the sagittal direction was decreased overjet (less than 2 mm) 37%, while the most prevalent malocclusion in the vertical and transverse direction were deep bite (more than 4 mm) 28% and midline shift 29%, respectively.

**Table 5. 6 Prevalence of different types of malocclusion**

Type of malocclusion		n	Percentage (%)
<b>Sagittal</b>			
<i>molar relationship</i>	<b>Class I</b>	822	65%
	<b>Class II div 1</b>	210	17%
	<b>Class II div 2</b>	81	6%
	<b>Class III</b>	157	12%
<i>anterior crossbite</i>		177	14%
<i>Overjet</i>	<b>less than 2</b>	467	37%
	<b>More than 4</b>	211	17%
<b>Vertical</b>			
<i>Overbite</i>	<b>less than 2 mm</b>	242	19%
	<b>more than 4 mm</b>	360	28%
<i>anterior openbite</i>		113	9%
<i>posterior openbite</i>		200	16%
<b>Transverse</b>			
<i>posterior crossbite</i>	<b>bilateral Buccal</b>	22	2%
	<b>bilateral lingual</b>	37	3%
	<b>unilateral lingual</b>	114	9%
<i>midline shift</i>		365	29%

\*n is the number of schoolchildren occurrence in the defined category, % is the percentage of cases in defined category

### 5.3 Bi-variables analyses

Preliminary assessments of associations between study variables were made using appropriate bivariate analyses. (Table 5.7- Table 5.19)

#### 5.3.1 Relationship between gender, region, geographical area and occlusal traits

Tables 5.7, 5.8, and 5.9 below summarize the association between gender, region, geographical area and the various occlusal traits in sagittal, vertical, and transverse directions among respondents.

**Table 5. 7 Association between gender and different types of malocclusion**

		gender					
		male		female		Total	
		n	%	n	%	n	%
<b>Sagittal</b>							
<i>molar relationship</i>	<b>Class I</b>	387	63%	435	66%	<b>822</b>	<b>65%</b>
	<b>Class II div I</b>	102	17%	108	16%	<b>210</b>	<b>17%</b>
	<b>Class II div 2</b>	42	7%	39	6%	<b>81</b>	<b>6%</b>
	<b>Class III</b>	84	14%	73	11%	<b>157</b>	<b>12%</b>
<i>overjet</i>	<b>less than 0</b>	45	7%	32	5%	<b>77</b>	<b>6%</b>
	<b>0-2</b>	180	29%	210	32%	<b>390</b>	<b>30%</b>
	<b>2-4</b>	285	46%	315	48%	<b>600</b>	<b>47%</b>
	<b>more than 4 to 6</b>	85	14%	79	12%	<b>164</b>	<b>13%</b>
	<b>more than 6</b>	25	4%	22	3%	<b>47</b>	<b>4%</b>
<i>anterior crossbite</i>	<b>no</b>	532	86%	569	86%	<b>1101</b>	<b>86%</b>
	<b>present</b>	88	14%	89	14%	<b>177</b>	<b>14%</b>
<b>Vertical</b>							
<i>overbite</i>	<b>less than 2mm</b>	115	19%	127	19%	<b>242</b>	<b>19%</b>
	<b>2-4</b>	328	53%	347	53%	<b>675</b>	<b>53%</b>
	<b>more than 4 to 6</b>	151	24%	161	25%	<b>312</b>	<b>24%</b>
	<b>more than 6</b>	26	4%	22	3%	<b>48</b>	<b>4%</b>
<i>anterior openbite</i>	<b>no</b>	559	90%	606	92%	<b>1165</b>	<b>91%</b>
	<b>present</b>	61	10%	52	8%	<b>113</b>	<b>9%</b>
<i>posterior openbite</i>	<b>no</b>	511	82%	567	86%	<b>1078</b>	<b>84%</b>
	<b>present</b>	109	18%	91	14%	<b>200</b>	<b>16%</b>
<b>Transverse</b>							
<i>posterior crossbite</i>	<b>bilateral Buccal</b>	12	2%	10	2%	<b>22</b>	<b>2%</b>
	<b>bilateral lingual</b>	26	4%	11	2%	<b>37</b>	<b>3%</b>
	<b>normal</b>	498	80%	554	84%	<b>1052</b>	<b>82%</b>
	<b>unilateral Buccal</b>	24	4%	28	4%	<b>52</b>	<b>4%</b>
	<b>unilateral Lingual</b>	59	10%	55	8%	<b>114</b>	<b>9%</b>
<i>midline shift</i>	<b>no</b>	420	68%*	488	74%	<b>908</b>	<b>71%</b>
	<b>present</b>	196	32%*	169	26%	<b>365</b>	<b>29%</b>

- \* P-value < 0.05, \*\* P-value < 0.001 (used  $\chi^2$  person and Fisher Test)

As shown in table (5.7), there was significant association between the sex of the participants and midline shift, where this percentage increased in male than female 32%.

**Table 5. 8 Association between region and different types of malocclusion**

		region					
		north		central		South	
		n	%	n	%	n	%
<b>Sagittal</b>							
<i>molar relationship</i>	<b>Class I</b>	354	69%**	221	66%	247	59%
	<b>Class II div I</b>	58	11%**	60	18%	92	22%
	<b>Class II div 2</b>	41	8%	17	5%	23	5%
	<b>Class III</b>	60	12%	37	11%	60	14%
<i>overjet</i>	<b>less than 0</b>	34	7%**	26	8%	17	4%
	<b>0-2</b>	157	30%**	78	23%	155	36%
	<b>2-4</b>	241	46%	169	50%	190	45%
	<b>more than 4 to 6</b>	66	13%	43	13%	55	13%
	<b>more than 6</b>	20	4%	20	6%	7	2%
<i>anterior crossbite</i>	<b>no</b>	425	82%*	298	89%	378	89%
	<b>present</b>	93	18%*	38	11%	46	11%
<b>Vertical</b>							
<i>overbite</i>	<b>less than 2mm</b>	84	16%*	66	20%	92	22%
	<b>2-4</b>	287	55%	175	52%	213	50%
	<b>more than 4 to 6</b>	132	26%	79	23%	101	24%
	<b>more than 6</b>	14	3%	16	5%	18	4%
<i>anterior openbite</i>	<b>no</b>	456	88%	320	95%	389	92%
	<b>present</b>	62	12%**	16	5%	35	8%
<i>posterior openbite</i>	<b>no</b>	422	81%*	282	84%	374	88%
	<b>present</b>	96	19%	54	16%	50	12%
<b>Transverse</b>							
<i>posterior cross bite</i>	<b>bilateral Buccal</b>	11	2%	7	2%	4	1%
	<b>bilateral lingual</b>	18	3%	8	3%	11	3%
	<b>normal</b>	413	80%	280	83%	359	84%
	<b>unilateral Buccal</b>	18	3%	17	5%	17	4%
	<b>unilateral lingual</b>	58	11%	23	7%	33	8%
<i>midline shift</i>	<b>no</b>	373	72%**	206	62%	329	78%
	<b>present</b>	144	28%**	127	38%	94	22%
<b>diastema(Space)</b>	<b>no</b>	452	87%*	286	85%	384	91%
	<b>present</b>	66	13%**	50	15%	40	9%

\* P-value < 0.05, \*\* P-value < 0.001 (used  $\chi^2$  person and Fisher Test)

As shown in table (5.8) above, most of the occlusal traits were significantly associated with region. The participants who lived in northern region had highest percent of Class I (69%), anterior openbite (12%), anterior crossbite (18%) and the lowest percent of Class II div. 1 (11%). While the participants who lived in southern region had highest percent of reduced overjet (between 0 to 2 mm) and reduced overbite (less than 2 mm) 37%, 22%, respectively. The participants from central region had a highest percent of midline shift and diastema 38%, 15%, respectively.

As shown in table (5.9) below, only anterior and posterior openbite had significant differences according to geographical distribution, anterior openbite was low in city (5%). posterior openbite was low in countryside (14%).

**Table 5. 9 Association between geographical area and different types of malocclusion**

		geographical area			
		city		countryside	
		n	%	n	%
<b>Sagittal</b>					
<i>molar relationship</i>	<b>Class I</b>	158	68%	664	64%
	<b>Class II div I</b>	29	13%	181	17%
	<b>Class II div 2</b>	17	7%	46	6%
	<b>Class III</b>	27	12%	130	13%
<i>overjet</i>	<b>less than 0 mm</b>	15	6%	62	6%
	<b>0-2 mm</b>	85	37%	305	29%
	<b>2-4 mm</b>	100	43%	500	48%
	<b>more than 4 to 6</b>	25	11%	139	13%
	<b>more than 6 mm</b>	8	3%	39	4%
<i>anterior crossbite</i>	<b>no</b>	202	87%	899	86%
	<b>present</b>	31	13%	146	14%
<b>Vertical</b>					
<i>over bite</i>	<b>less than 2 mm</b>	44	19%	198	19%
	<b>2-4 mm</b>	126	54%	549	53%
	<b>more than 4 to 6</b>	56	24%	256	4%
	<b>more than 6</b>	7	3%	41	4%
<i>anterior openbite</i>	<b>no</b>	222	95%	943	90%

	<b>present</b>	11	5%*	102	10%
<i>posterior openbite</i>	<b>no</b>	183	79%*	895	86%
	<b>present</b>	50	21%	150	14%
<b>Transverse</b>					
<i>posterior crossbite</i>	<b>bilateral Buccal</b>	5	2%	17	2%
	<b>bilateral lingual</b>	6	3%	31	3%
	<b>normal</b>	194	83%	858	82%
	<b>unilateral Buccal</b>	14	6%	38	4%
	<b>unilateral Lingual</b>	13	6%	101	10%
<i>midline shift</i>	<b>no</b>	170	73%	738	71%
	<b>present</b>	62	27%	303	29%

\* P-value < 0.05, \*\* P-value < 0.001 (used  $\chi^2$  person and Fisher Test)

### 5.3.2 Relationship between gender, region, geographical area and dental anomalies

Tables (5.10- 5.14) below summarizes the association between gender, region, geographical area and the various dental anomalies among the sample.

Among the dental anomalies one or more missing permanent teeth, one or more retained deciduous teeth were significantly higher in males than females, while presence of ectopic teeth was higher in female than male. There were no significant associations between supernumerary teeth and malformation of incisors and sex. More details are shown in table 5.10

**Table 5. 10 Association between sex and dental anomalies**

		gender					
		male		female		total	
		n	%	n	%	n	%
missing permanent teeth	<b>zero</b>	509	82%*	577	88%	1086	85%
	<b>greater than zero</b>	111	18%*	81	12%	192	15%
supernumerary	<b>zero</b>	620	100%	657	100%	1277	100%
	<b>greater than zero</b>	0	0%	1	0%	1	0%
malformation	<b>zero</b>	592	95%	632	96%	1224	96%
	<b>greater than zero</b>	28	5%	26	4%	54	4%
ectopic	<b>zero</b>	520	84%*	521	79%	1041	81%
	<b>greater than zero</b>	100	16%*	137	21%	237	19%
retained	<b>zero</b>	408	66%*	491	75%	899	70%
	<b>greater than zero</b>	212	34%*	167	25%	379	30%

\* P-value < 0.05, \*\* P-value < 0.001 (used  $\chi^2$  person and Fisher Test)

Independent sample t- test reported a statistically significant difference between mean of retained deciduous teeth and sex. By comparing mean for variables, results showed that male has higher teeth's mean comparing to female regarding retained deciduous teeth. More details are shown in table (5.11)

**Table 5. 11 Association between sex and some of dental anomalies**

Group Statistics					
	gender	n	Mean	Std. Deviation	Std. Error Mean
<b>Missing permanent Teeth</b>	male	620	.3290	.86474	.03473
	female	658	.2295	.79797	.03111
<b>Retained deciduous teeth</b>	male	620	.8339*	1.55039	.06227
	female	658	.5988*	1.38709	.05407

\*Sig P-value less than .05 (comparing means using independent Sample t-test)

By region, most of dental anomalies were significantly associated with region, as the lowest percent of missing permanent teeth, ectopic teeth, and retained deciduous teeth was found in the northern region. While the southern region had the lowest percent of incisors malformation. More details in table (5.12)

**Table 5. 12 Association between region and dental anomalies**

		Region					
		north		central		South	
		n	%	n	%	n	%
missing permanent teeth	<b>zero</b>	470	91%*	285	85%	331	78%
	<b>greater than zero</b>	48	9%	51	15%	93	22%
supernumerary	<b>zero</b>	517	100%	336	100%	424	100%
	<b>greater than zero</b>	1	0%	0	0%	0	0%
malformation	<b>zero</b>	484	93%*	324	96%	416	98%
	<b>greater than zero</b>	34	7%	12	4%	8	2%
ectopic	<b>zero</b>	446	86%*	255	76%	340	80%
	<b>greater than zero</b>	72	14%	81	24%	84	20%
retained	<b>zero</b>	392	76%*	228	68%	279	66%
	<b>greater than zero</b>	126	24%	108	32%	145	34%

\* P-value < 0.05, \*\* P-value < 0.001 (used  $\chi^2$  person and Fisher Test)

One way ANOVA F-test was used to compare the means of missing permanent teeth and retained deciduous teeth by region. We found that missing permanent teeth had the

highest average in southern region, and the northern region had the lowest average of retained deciduous teeth with statistical differences (p-value < 0.001). More details in table (5.13)

**Table 5. 13 Association between region and some of dental anomalies**

		Descriptive					
		n	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean	
						Lower Bound	Upper Bound
<b>missing permanent Teeth</b>	north	518	.1371**	.49224	.02163	.0946	.1796
	central	336	.2946	.87388	.04767	.2009	.3884
	south	424	.4363**	1.06777	.05186	.3344	.5382
	Total	1278	.2778	.83220	.02328	.2321	.3234
<b>retained</b>	north	518	.5830**	1.36262	.05987	.4654	.7006
	central	336	.8214**	1.54658	.08437	.6555	.9874
	south	424	.7854	1.53252	.07443	.6391	.9317
	Total	1278	.7128	1.47270	.04120	.6320	.7937

\*Sig or P-value less than .05 and\*\* P-value less than .001 (comparing means using One way ANOVA F-test)

According to geographical area, there was no statistically differences between city and countryside for the prevalence of missing permanent teeth, supernumerary teeth, incisors malformation and ectopic teeth except retained deciduous teeth where was less occurrence in cities. More details in table (5.14)

**Table 5. 14 Association between geographical area and dental anomalies**

		geographical area			
		city		countryside	
		n	%	n	%
Missing permanent teeth	<b>Zero</b>	207	89%	879	84%
	<b>greater than zero</b>	26	11%	166	16%
Supernumerary	<b>Zero</b>	233	100%	1044	100%
	<b>greater than zero</b>	0	0%	1	0%
Malformation	<b>Zero</b>	219	94%	1005	96%
	<b>greater than zero</b>	14	6%	40	4%
Ectopic	<b>Zero</b>	195	84%	846	81%
	<b>greater than zero</b>	38	16%	199	19%
Retained	<b>Zero</b>	188	81%*	711	68%

<b>greater than zero</b>	45	19%	334	32%
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\* P-value < 0.05, \*\* P-value < 0.001 (used  $\chi^2$  person and Fisher Test)

### 5.3.3 Relationship between gender, region, geographical area and space conditions

In general, there was no significant association between sex of respondents and crowding. However, there was a significant relationship between spacing in upper arch, diastema and sex. By comparing percent of variables, results showed that males have higher upper arch spacing and diastema percent (27%, 14%) comparing to female (21%, 10%) as shown in the table (5.15).

**Table 5. 15 Relationship between gender and space conditions**

		gender					
		male		female		Total	
		n	%	n	%	n	%
<b>Crowding Upper</b>	no	414	67%	414	63%	828	65%
	present	206	33%	244	37%	450	35%
<b>Crowding lower</b>	no	425	69%	455	69%	880	69%
	present	195	31%	203	31%	398	31%
<b>Crowding in both arches</b>	no	499	80%	521	79%	1020	80%
	present	121	20%	137	21%	258	20%
<b>Spacing Upper</b>	no	451	73%*	518	79%	969	76%
	present	169	27%*	140	21%	309	24%
<b>Spacing Lower</b>	no	521	84%	566	86%	1087	85%
	present	99	16%	92	14%	191	15%
<b>Spacing in both arches</b>	No	565	91%	604	92%	1169	91%
	present	55	9%	54	8%	109	9%
<b>Diastema(Space)</b>	no	532	86%*	590	90%	1122	88%
	present	88	14%*	68	10%	156	12%

\* P-value < 0.05, \*\* P-value < 0.001 (used  $\chi^2$  person and Fisher Test)

However, no significant differences of spacing and crowding with regards to region. The only exception was for the diastema. The participants from the southern region had less prevalence of diastema (9%) compared to the central (15%) and the northern regions (13%). More details in table (5.8)

Regards to geographical area, our statistical analysis revealed that only crowding in lower arch and diastema had no significant difference between city and countryside for the relationship between spacing discrepancies and geographical area. Where the existence of other conditions (spacing in upper and lower arch, crowding in upper arch, and spacing and crowding in both arches) concentrate between countryside compare cities with significant changes as shown in the table (5.16)

**Table 5. 16 Relationship between geographical area and space conditions**

		geographical area			
		city		countryside	
		n	%	n	%
<b>Crowding Upper</b>	no	167	72%*	661	63%
	present	66	28%*	384	37%
<b>Crowding lower</b>	no	160	69%	720	69%
	present	73	31%	325	31%
<b>Crowding in both arches</b>	No	199	85%*	821	79%
	present	34	15%*	244	21%
<b>Spacing Upper</b>	no	191	82%*	778	74%
	present	42	18%*	267	26%
<b>Spacing Lower</b>	no	216	93%*	871	83%
	present	17	7%*	174	17%
<b>Spacing in both arches</b>	No	225	97%	944	90%
	Present	8	3%*	101	10%
<b>Diastema(Space)</b>	no	208	89%	914	87%
	present	25	11%	131	13%

\* P-value < 0.05, \*\* P-value < 0.001 (used  $\chi^2$  person and Fisher Test)

### 5.3.4 Relationship between bad oral habits and different type of malocclusion

In our study, there was no significant relationship between oral habits and gender, region, and geographical area. There was significant association between bad oral habits and some of malocclusion types like anterior crossbite and midline shift.

Most of the bad oral habits had significant relationship with anterior crossbite, where approximately 19.8% of participants with tongue thrusting and bruxism had anterior crossbite, and 17.6% of participants with mouth breathing had anterior crossbite with

significant relationship (P value < .001). While 38.7% of participants with thumb sucking had midline shift, and 25.1% of participants with mouth breathing had midline shift with significant relationship (p- value < 0.05). More details in table (5.17)

**Table 5. 17 Relationship between bad oral habits and some types of malocclusion**

Acting Habits	Anterior cross bite				Midline shift			
	no		present		no		present	
	n	%	n	%	n	%	n	%
<b>Mouth breathing</b>	434	82.4%	93	<b>17.6%**</b>	393	74.9%	132	<b>25.1%*</b>
<b>Bruxism</b>	226	80.1%	56	<b>19.9%**</b>	202	71.9%	79	<b>28.1%</b>
<b>Thumb sucking</b>	58	76.3%	18	<b>23.7%*</b>	46	61.3%	29	<b>38.7%*</b>
<b>Clenching</b>	323	83.9%	62	<b>16.1%</b>	271	70.4%	114	<b>29.6%</b>
<b>Tongue thrusting</b>	219	80.2%	54	<b>19.8%**</b>	197	72.2%	76	<b>27.8%</b>
<b>Lip biting</b>	440	84.1%	83	<b>15.9%*</b>	369	70.8%	152	<b>29.2%</b>
<b>Nail biting</b>	289	86.3%	46	<b>13.7%*</b>	238	71.3%	96	<b>28.7%</b>
<b>Biting objects</b>	243	82.7%	51	<b>17.3%*</b>	218	74.4%	75	<b>25.6%</b>

\* P-value < 0.05, \*\* P-value < 0.001 (used  $\chi^2$  person and Fisher Test)

### 5.3.5 Correlation between different types of malocclusion

Person's correlation was used to assess the potential relationship between spacing discrepancies and different types of malocclusion in sagittal, vertical, and transverse directions. As shown in tables (5.18) and (5.19) most of variables had significant correlation. Our statistical analysis revealed:

- 51% of participants with reverse overjet (less than 0 mm) had crowding in upper arch.
- 51% of participants with anterior crossbite had crowding in upper arch.
- Approximately half of respondents with deep overbite (more than 6 mm) had crowding in upper or lower arches.
- 56% of participants with normal overbite (2-4 mm) had normal overjet (2-4 mm), also 53% of participants with increased overbite (4- 6 mm) had normal overjet (2- 4 mm).
- 52% of participants with Class I had normal overjet (2-4 mm), while 59% of these respondents had normal overbite (2- 4 mm).

- Half of participants with Class III had crowding in upper arch or decreased overbite less than 2 mm.
- 39% of the participants with Class III had reverse overjet (less than 0 mm).
- 69% of the participants without posterior crossbite had Class I, and 55% of them had normal overbite (2-4 mm).
- 58% of the participants with posterior openbite had Class I.
- 54% of the participants with bilateral lingual crossbite had crowding in upper arch.
- 65% of the participants with crowding in lower arch had crowding in upper arch.

**Table 5. 18 Correlation between the different types of malocclusion using Pearson Chi-Square tests**

**Pearson Chi-Square Tests**

		Diastema	Crowding Upper Arc	Crowding Lower Arc	Spacing Upper Arc	Spacing Lower Arc	Overjet	Anterior Openbite	Anterior Crossbite	Overbite	Midline Shift	Molar relationship	Posterior openbite	Posterior Crossbite
<b>Diastema</b>	X <sup>2</sup>	.	46.046	5.390	484.40	17.966	12.996	11.38	3.346	12.302	26.029	1.274	.139	7.498
	Sig.	.a	.000	.020	.000	.000	.011	.001	.067	.006	.000	.866	.709	.058
<b>Crowding Upper Arc</b>	X <sup>2</sup>	46.046	.	222.18	150.89	21.539	28.689	.062	22.019	19.518	8.116	24.203	.009	12.555
	Sig.	.000	.a	.000	.000	.000	.000	.803	.000	.000	.004	.000	.926	.006
<b>Crowding Lower Arc</b>	X <sup>2</sup>	5.390	222.18	.	27.589	85.206	7.832	2.341	1.447	15.704	13.213	9.538	.002	7.685
	Sig.	.020	.000	.a	.000	.000	.098	.126	.229	.001	.000	.049	.962	.053
<b>Spacing Upper Arc</b>	X <sup>2</sup>	484.395	150.89	27.589	.	132.51	3.801	24.89	10.588	14.036	3.481	.996	.364	4.710
	Sig.	.000	.000	.000	.a	.000	.434	.000	.001	.003	.062	.910	.546	.194
<b>Spacing Lower Arc</b>	X <sup>2</sup>	17.966	21.539	85.206	132.51	.	11.884	15.21	15.884	5.453	3.349	14.151	9.283	2.670
	Sig.	.000	.000	.000	.000	.a	.018	.000	.000	.141	.067	.007	.002	.445
<b>Overjet</b>	X <sup>2</sup>	12.996	28.689	7.832	3.801	11.884	.	16.08	485.86	449.17	15.88	562.34	10.548	47.578
	Sig.	.011	.000	.098	.434	.018	.a	.003	.000	.000	.003	.000	.032	.000
<b>Anterior Openbite</b>	X <sup>2</sup>	11.377	.062	2.341	24.886	15.209	16.085	.	19.170	123.67	.273	23.907	2.934	3.648
	Sig.	.001	.803	.126	.000	.000	.003	.a	.000	.000	.601	.000	.087	.302
<b>Anterior Crossbite</b>	X <sup>2</sup>	3.346	22.019	1.447	10.588	15.884	485.86	19.17	.	148.80	.162	193.94	.004	33.406
	Sig.	.067	.000	.229	.001	.000	.000	.000	.a	.000	.687	.000	.947	.000
<b>Overbite</b>	X <sup>2</sup>	12.302	19.518	15.704	14.036	5.453	449.17	123.67	148.80	.	20.376	166.05	9.217	28.268
	Sig.	.006	.000	.001	.003	.141	.000	.000	.000	.a	.000	.000	.027	.001
<b>Midline Shift</b>	X <sup>2</sup>	26.029	8.116	13.213	3.481	3.349	15.880	.273	.162	20.376	.	7.798	4.373	25.528
	Sig.	.000	.004	.000	.062	.067	.003	.601	.687	.000	.a	.099	.037	.000
<b>Molar relationship</b>	X <sup>2</sup>	1.598	26.978	10.034	.957	6.835	475.778	19.979	156.617	151.902	8.196	.	24.598	120.654
	Sig.	.660	.000	.018	.812	.077	.000	.000	.000	.000	.042	.a	.000	.000
<b>Posterior openbite</b>	X <sup>2</sup>	.139	.009	.002	.364	9.283	10.548	2.934	.004	9.217	4.373	24.598	.	41.141
	Sig.	.709	.926	.962	.546	.002	.032	.087	.947	.027	.037	.000	.a	.000
<b>Posterior Crossbite</b>	X <sup>2</sup>	7.802	13.627	9.769	5.737	2.722	50.932	8.211	34.037	31.676	24.723	120.654	39.387	.
	Sig.	.099	.009	.045	.220	.605	.000	.084	.000	.002	.000	.000	.000	.a



	Class II div 2	44%	40%	0%	46%	40%	9%	6%	7%	20%	16%	41%	33%	10%	32%	0%	0%	100%					
	Class III	50%	38%	39%	28%	25%	7%	1%	15%	45%	50%	38%	11%	1%	35%	0%	0%	0%	100%				
<b>Posterior Openbite</b>		36%	31%	9%	29%	42%	14%	7%	12%	14%	25%	44%	27%	4%	35%	58%	12%	9%	22%	100%			
	Bi. B.	41%	41%	18%	32%	32%	14%	5%	9%	23%	45%	27%	23%	5%	45%	45%	18%	14%	23%	23%	100%		
	Bi. L.	54%	27%	16%	41%	32%	8%	3%	11%	35%	30%	41%	30%	0%	46%	31%	14%	9%	46%	38%	0%	100%	
<b>Posterior Crossbite</b>	Norm.	33%	30%	4%	30%	50%	13%	4%	8%	11%	17%	55%	25%	4%	26%	69%	17%	6%	9%	13%	0%	0%	100%
	Uni. B	48%	33%	10%	38%	38%	8%	6%	6%	29%	29%	56%	13%	2%	43%	46%	0.25	15%	13%	29%	0%	0%	100%
	Uni. L.	41%	43%	15%	29%	33%	18%	4%	0.16	20%	27%	44%	24%	4%	40%	46%	0.13	8%	34%	27%	0%	0%	100%

## 5.4 Multinomial regression models

We used a multinomial logistic regression at the bivariate level to assess how the dental anomalies, spacing discrepancies, and bad oral habits are associated with molar relationship.

### 5.4.1 Model I: relationship between dental anomalies and molar relationship

Table 5.20 presents the multinomial regression (model I) estimates of odds ratio for molar relationship classification using Class 1 participants as reference group of dental anomalies. The result showed that participants who had more than one missing permanent teeth were more likely to report Class III by 42.4% compare to Class I with significant values ( $p$ -value < 0.01).

The probability of having an ectopic teeth were higher in Class II division 1 by 43.2%, Class II division 2 by 58.4%, and Class III by 41.4% compare to Class I with significant differences (0.000), (0.000), (0.030) respectively. No significant differences was detected across the incisors malformation and retained deciduous teeth.

**Table 5. 20 Multinomial logistic regression analysis (model I)**

		Parameter Estimates					95% Confidence Interval for Exp(B)		
Molar relationship <sup>a</sup>		B	Std. Error	Wald	df	Sig.	Exp(B)	Lower Bound	Upper Bound
<b>Class II div I</b>	Intercept	-1.772	.129	190.146	1	.000			
	missing permanent teeth	.189	.098	3.692	1	.055	1.208	.996	1.465
	Ectopic teeth	.359	.103	12.183	1	.000	1.432	1.171	1.752
	retained deciduous teeth	.088	.055	2.533	1	.111	1.092	.980	1.216
<b>Class II div 2</b>	Intercept	-2.700	.193	195.059	1	.000			
	Ectopic teeth	.460	.132	12.166	1	.000	1.584	1.223	2.052
	retained deciduous teeth	.121	.078	2.434	1	.119	1.129	.969	1.314
<b>Class III</b>	Intercept	-2.124	.146	210.395	1	.000			
	missing permanent teeth	.354	.099	12.705	1	.000	1.424	1.173	1.730

Malformation	.042	.255	.027	1	.869	1.043	.633	1.720
Ectopic teeth	.346	.116	8.883	1	.003	1.414	1.126	1.775
retained deciduous teeth	.003	.067	.002	1	.969	1.003	.879	1.144

a. The reference category is: Class I.

#### 5.4.2 Model II: relationship between space discrepancies and molar relationship

Model II reveals that the respondents who didn't have crowding in upper arch has less probability to be in Class III, Class II div. 2, and Class II div. 1 to class I by 57%, 45% and 29% with significant value (0.000), (0.012), (0.040) (OR = 0.43; CI 0.31–0.61), (OR = 0.55; CI 0.34–0.87), (OR = 0.71; CI 0.52–0.98) respectively. More details in table 5.21.

**Table 5. 21 Multinomial logistic regression analysis for crowding (model II)**

Molar relationship <sup>a</sup>		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp(B)	
								Lower Bound	Upper Bound
<b>Class II div I</b>	Intercept	-1.147	.128	79.944	1	.000			
	[crowding Up=.00]	-.331	.161	4.220	1	.040	.718	.524	.985
	[crowding Up=1.00]	0 <sup>b</sup>	.	.	0	.	.	.	.
<b>Class II div 2</b>	Intercept	-1.946	.178	119.277	1	.000			
	[crowding Up=.00]	-.593	.236	6.312	1	.012	.553	.348	.878
	[crowding Up=1.00]	0 <sup>b</sup>	.	.	0	.	.	.	.
<b>Class III</b>	Intercept	-1.160	.129	80.929	1	.000			
	[crowding Up=.00]	-.829	.177	22.023	1	.000	.437	.309	.617
	[crowding Up=1.00]	0 <sup>b</sup>	.	.	0	.	.	.	.

a. The reference category is: Class I.

b. This parameter is set to zero because it is redundant.

\* (0) means didn't have crowding, (1) means had crowding.

While according to spacing in upper arch, there was no association between spacing in upper arch and reported Class II and Class III rather than Class I molar relationship. More details in table 5.22

**Table 5. 22 Multinomial logistic regression analysis for spacing (model II)**

Parameter Estimates									
Molar relationship <sup>a</sup>							95% Confidence Interval for Exp(B)		
							Lower Bound	Upper Bound	
		B	Std. Error	Wald	df	Sig.	Exp(B)		
<b>Class II div I</b>	Intercept	-1.422	.161	78.210	1	.000			
	[Spacing Upper=.00]	.075	.183	.168	1	.682	1.078	.753	1.544
	[Spacing Upper =1.00]	0 <sup>b</sup>	.	.	0	.	.	.	.
<b>Class II div 2</b>	Intercept	-2.460	.253	94.787	1	.000			
	[Spacing Upper =.00]	.184	.285	.420	1	.517	1.203	.688	2.101
	[Spacing Upper =1.00]	0 <sup>b</sup>	.	.	0	.	.	.	.
<b>Class III</b>	Intercept	-1.580	.172	84.838	1	.000			
	[Spacing Upper =.00]	-.101	.199	.258	1	.611	.904	.612	1.335
	[Spacing Upper =1.00]	0 <sup>b</sup>	.	.	0	.	.	.	.

a. The reference category is: Class I.

b. This parameter is set to zero because it is redundant.

### 5.4.3 Model III: relationship between bad oral habits and molar relationship

Model III reveals that there was no association between Bad oral habits and reported Class II and Class III rather than Class I molar relationship. More details in table 5.23

**Table 5. 23 Multinomial logistic regression analysis for Bad Oral Habits (model III)**

Parameter Estimates									
Molar relationship <sup>a</sup> Class II and III							95% Confidence Interval for Exp(B)		
							Lower Bound	Upper Bound	
		B	Std. Error	Wald	df	Sig.	Exp(B)/odds ratio		
	Intercept	-1.814	.403	20.271	1	.000			
	Bruxism [No]	-.173	.228	.581	1	.446	.841	.538	1.313
	Bruxism [Yes]	0 <sup>b</sup>	.	.	0	.	.	.	.
	Thumb sucking [No]	-.106	.371	.082	1	.774	.899	.435	1.859
	Thumb sucking [Yes]	0 <sup>b</sup>	.	.	0	.	.	.	.
	Clenching [No]	-.159	.215	.549	1	.459	.853	.560	1.299
	Clenching [Yes]	0 <sup>b</sup>	.	.	0	.	.	.	.
	Lip biting [No]	-.073	.190	.147	1	.702	.930	.640	1.350
	Lip biting [Yes]	0 <sup>b</sup>	.	.	0	.	.	.	.
	Biting objects [No]	-.240	.218	1.208	1	.272	.787	.513	1.206
	Biting objects [Yes]	0 <sup>b</sup>	.	.	0	.	.	.	.

a. The reference category is: Class I.

b. This parameter is set to zero because it is redundant.

## **5.5 Summary**

The result of the study was presented in this chapter. Descriptive analysis for demographic characteristics, occlusion data, and bad oral habits of the sample was discussed, followed by describing the prevalence of malocclusion and occlusal traits and their influencing factors in the study sample. Finally, a nominal regression analysis was conducted to predict the impact of dental anomalies, space conditions, and bad habits on angle molar classification. The next chapter discusses the findings of the study compared with the global and national situation.

## Chapter Six: Discussion

### 6.1 Introduction

This research examined the prevalence of malocclusion and occlusal characteristics among schoolchildren at the age of 12 years and their distribution according to demographic characteristics and bad oral habits in the West Bank/Palestine. Data were collected over a period of three months on occlusal variables, demographic characteristics, and bad habits. The relationships between different types of malocclusion, demographic characteristics, and bad oral habits were determined. The research indicated that there are significant and non-significant relationships between some dependent and independent variables. This is the first study to determine the prevalence of malocclusion among Palestinian children. It sheds light on how different types of malocclusion are affected by demographic characteristics and bad habits. Our study findings highlight prevention strategies and interventions that could support prioritizing treatment needs based on the severity of the malocclusion.

The discussion of these findings is divided into six parts; *Section (6.2)* describes the demographical profile for the main study *Section (6.3)* discusses the prevalence of malocclusion in children. In addition, the types of malocclusion in the three directions (sagittal, vertical, and transverse) will be discussed. *Section (6.4)* presents bad oral habits and their association with malocclusion. *Section (6.5)* presents demographic characteristics and their relationship to different types of malocclusion. *Section (6.6)* deals with the prediction of the proportion of each of the bad habits, dental anomalies, and space conditions in the molar relationships, considering Class I is the reference group. Finally, *section (6.7)* considers methodological issues and potential limitations of the

research. In addition, a subsequent chapter summarizes the conclusions and recommendations arising from these findings for policy and future research.

## **6.2 Demographical profile**

In the current study, the participants' sample was representative, despite the slight increase in favor of females (51.5%) compared to males (48.5%). The reason is due to the fact that the schools included in the statistics of the Ministry of Education as mixed schools, which numbered eleven schools in the sample, later found out that they might be mixed for the lower grades, while the higher grades become either males or females. In our sample, from (11) mixed schools were categorized into 3 males, 4 females, and 4 mixed schools. Regarding cities and countryside, 18.2% of our participants were from cities and 81.8% from the countryside. The countryside in our study cannot be considered as rural areas; according to PCBS, rural areas are areas with a population of less than 5,000 breeze with no access to roads. In our study, it was difficult to reach rural areas (PCBS, 2020.).

According to the regions, the West Bank is divided according to what is customary; North, Central and South. The northern regions include seven Directorate of Education, the southern regions include five directorate, and the center includes five directorate, while the Jerusalem directorate was excluded due to political restrictions; this explains the percentages presented in the results chapter.

## **6.3 Prevalence of malocclusion**

The prevalence of malocclusion is generally found to be high among schoolchildren in the West Bank/ Palestine. 85% of our study participants examined had one or more types of occlusal anomalies ranging from mild to severe. These findings were in agreement with that reported for children of the same age in Tanzania (Mtaya, Brudvik, & Åstrøm, 2009), Jordan (Al-Khateeb & Al-Nimri, 2005), Iran (Eslamipour et al., 2018), Saudi

Arabia (Devanna et al., 2021) , Kuwait ((Behbehani et al., 2005) Brazil (Moraes et al., 2015) and China (Wang et al., 2019). But much higher than those reported for Korean children (Hong, Kyung, Park, Yu, & Baek, 2020) and Indian children (Sharma & Bihani, 2022), and much lower than that reported for Latino individuals (Silva & Kang, 2001). Variation in ethnic groups, age groups, examination methods and classification of malocclusion may explain the variability of the findings.

### **6.3.1 Occlusion in sagittal direction**

In accordance with the findings of previous studies (Asiry & Alshahrani, 2019; Bourzgui et al., 2012; Bouserhal, Almalky, Elattar, Prevalence, & Article, 2018; Bugaighis & Karanth, 2013; Sundareswaran & Kizhakool, 2019), the predominant sagittal molar relationship among Palestinian schoolchildren was Angle Class I (65%). The prevalence of class II was (23%) distributed as Class II div. 1 (17%), and Class II div. 2 (6%) that finding was in line with previous investigations from Saudi Arabia (Class I, 61%) (Asiry & Alshahrani, 2019), Jordan (Class I, 55.3%) (Al-Khateeb & Al-Nimri, 2005) and Gaza strip (Class I, 53.4%) (Elghoul, 2007), but it was much lower than that reported from Tanzania (Class I, 93.6%) (Mtaya et al., 2009), and it was much higher than that reported in India (Class I, 13.5%) (Sharma & Bihani, 2022). Moreover, the prevalence of Angle Class III (12%) was comparable to that found in northern and southern Saudi Arabia (15.4%, 9.3%) respectively (Gudipaneni, Aldahmeshi, Patil, & Alam, 2018; Meer et al., 2016), but much lower than that reported by Barbara et al., and Wang et al. in northeastern Brazil and northern China (22.5%, 21.5%) (Bárbara et al., 2013; Wang et al., 2021). However, it was higher than that reported by Elghoul in Gaza (Class III, 4.3%)(Elghoul, 2007). The reason for these differences might be due to the study being somewhat

outdated (2007), in addition to the use of the Sammer index, which is somewhat complicated in registration method, and its failure to register missing teeth.

With regard to Overjet, approximately half of the children in the present sample had a normal overjet (47%). The occurrence of reverse overjet ( $< 0$  mm, 6%) was consistent with what was observed in Saudi and Colombian children (Alajlan et al., 2019; Thilander et al., 2001). Usually, the reverse overjet is associated with the presence of Class III molar relationship (McIntyre, 2004), it is reflected in the similarities in the current investigation between reverse overjet (6%) and Class III (12%).

The prevalence of an increased overjet ( $> 4$  mm, 17%) found in the present study was in agreement with previous studies among Saudi and Italian children (Alajlan et al., 2019; Alogaibi et al., 2020), less than that observed among Jordanian children (Al-Khateeb & Al-Nimri, 2005). The prevalence of severely increased overjet ( $> 6$  mm, 4%) was lower than that reported among Ethiopian children of the same age (Tolessa, Singel, & Merga, 2020). This difference might be attributed to ethnic differences.

### **6.3.2 Occlusion in vertical direction**

The majority of respondents had a normal overbite (53%). Deepbite that exceeded 4 mm was (28%). This was in accordance with previous investigations in Morocco and Saudi Arabia (Alogaibi et al., 2020; Bourzgui et al., 2012). But it was higher than what has been reported among Turkish children (Bilgic et al., 2015). About 30% of the children in the present sample had retained deciduous teeth; which might lead to instability of their occlusion resulting in an increased prevalence of a deepbite (Lombardo et al., 2020).

Of the vertical anomalies, the anterior openbite was less than 3 times as frequent as deepbite (overbite  $> 4$  mm), which is close to findings in studies conducted in Brazil (Bárbara et al., 2013), Colombia (Thilander et al., 2001), Yemen (Al-Zubair & Almulla,

2014) and Saudi Arabia (Alogaibi et al., 2020). While the current investigations indicated an increase in the prevalence of posterior openbite (16%). Incomplete eruption of premolars and second molars may lead to instability of the occlusion, which may explain the increase in the prevalence of deepbite and posterior openbite.

### **6.3.3 Occlusion in transversal direction**

Generally, the present study shows a lower prevalence of posterior crossbite (3%), and scissor bite (2%) which is consistent with Jordanian findings (Al-Khateeb & Al-Nimri, 2005), Indian (Shivakumar et al., 2009), and Turkish results (Bilgiç et al., 2017), but much lower than in other populations (Alogaibi et al., 2020; Bugaighis & Karanth, 2013) for which prevalence varying between 1 to 25 percent have been reported. The great majority of the current sample was unilateral lingual crossbite (9%), which is often associated with mandibular midline deviation. This was observed in our study, an increase in the prevalence of midline shift (29%). It is generally considered that the influence of thumb sucking (6%), mouth breathing (41.2%), and over-retained deciduous teeth (30%) are one aetiological factor of unilateral crossbite and the resulting midline shift (Rodríguez-Olivos, 2022)

### **6.3.4 Space conditions**

Spacing anomalies in one or both arches occurred less frequently (n= 282, 22 %) when compared to crowding anomalies (n= 332, 26%). Crowding was the second most common anomaly after occlusal anomalies (n= 1086 85%). Our results corroborate the previous investigations in Jordan (Al-Khateeb & Al-Nimri, 2005), Saudi Arabia (Asiry & Alshahrani, 2019), and Yemen (Al-Zubair & Almulla, 2014). However, it was in contrast to results found among Tanzanian children (Mtaya et al., 2009). NHANES III in USA during the years 1989 to1994, showed a frequency of crowding among ages 8 to 11 from

42.3% to 54.5% among ages 12 to 17 regardless of race (W. R. . Proffit et al., 1998). This was higher than what we found in the Palestinian sample. Ethnic differences must be taken into consideration.

The prevalence of spacing in the upper arch (24%) was higher than lower arch (15%), coinciding with the research carried out in Oman (Al Jadidi et al., 2018), Saudi Arabia (Alogaibi et al., 2020) and Kuwait (Behbehani et al., 2005). Our current study indicates that the prevalence of spacing in upper arch among males (27%) was higher than in females (21%). The reason may be due to the fact that about half of the children from the sample with maxillary spacing had diastema. Where studies indicate that the prevalence of diastema from the ages of 9 to 12 years among males was higher than that of females (Ghimire et. al, 2013), which is also observed in our study. The tooth development and eruption of lateral incisors and canines are slower in males compare to females. Hence, lower tooth eruption resulted in slower diastema closure (Ghimire et. al, 2013).

### **6.3.5 Dental anomalies**

Although many studies have been conducted to evaluate and distribute dental anomalies, it was difficult to make comparisons between them. Most of the studies reported heterogeneous and discordant findings. Genetic, environmental, and racial characteristics play an important role in this contradiction along with the diversity of registration methods and definition of dental anomalies' types.

The prevalence of missing permanent teeth as a result of extraction or congenitally was (15%), which is somewhat high when compared with Italian children's investigation of the same age in which missing permanent teeth were found (8.2%) (Laganà et al., 2017). However, Alassiry found that (21.2%) of a Saudi sample aged 8 to 34 years, had one or more congenitally missing teeth. (Alassiry, 2020). The differences in methods of

recording missing teeth and increased retained deciduous teeth may explain the diversity of the findings, as radiographs are one of the most accurate methods for determining whether a tooth is congenitally missing or impacted. The lower second premolars were found to be the most frequently missing teeth and this is in accordance with the results of the studies (Afify & Zawawi, 2012; Laganà et al., 2017; Sundareswaran & Kizhakool, 2019).

Very few previous studies have recorded the prevalence of ectopic eruptions. Our study recorded a rate of 19%, which is higher than what was recorded by other studies (Afify & Zawawi, 2012; Al-Khateeb & Al-Nimri, 2005; Al-Emran, Wisth, & Böe, 1990; Sundareswaran & Kizhakool, 2019). The differences may be due to the increase in the prevalence of crowding and retained deciduous teeth.

The retained deciduous teeth prevalence was 30%. This agreed with the study of (Al-Abdallah et al., 2015) who found that retained deciduous teeth are the most frequent dental anomaly, associated with hypodontia (ie: one or more congenital absence of teeth). Our investigation found a malformation of permanent teeth prevalence of (4%) in Palestinian children. This is in good agreement with (al-Emran, 1990) who found 3.6 % of malformed permanent teeth in Saudi children, but it was much lower than that reported in Jordanian children (7.7%) (Al-Khateeb & Al-Nimri, 2005). In this investigation, malformation mainly took the form of peg-shaped upper lateral incisors and usually it is hereditary.

Regarding supernumerary teeth, rare cases were identified (one case only) in the current study and this is consistent with the findings of other studies (Afify & Zawawi, 2012; Laganà et al., 2017).

#### **6.4 Bad habits and malocclusion**

This study examined the relationship between malocclusion and bad habits using chi-square analysis. Similar to our study findings, other researchers in Brazil (Bárbara et al., 2013), China (Wang et al., 2021), Peru (Rodríguez-Olivos, 2022), and Italy (Giugliano, Apuzzo, Jamilian, & Perillo, 2014) found that there was a direct relationship between bad habits and malocclusion. Our study showed a statistical significance between 6 out of 8 bad habits and anterior crossbite. Cao and his team in 2016 showed that children with tongue thrust habit had a higher risk of anterior crossbite (Cao, Zhang, Yu, & Tian, 2016), while Tabbaa and her team found that children with lips biting had a greater risk of suffering anterior crossbite (Tabbaa et al., 2015). Also Grippaudo et al. found that children with mouth breathing had a greater risk of suffering anterior and posterior crossbite (Grippaudo et al., 2016). Larsson in his book pointed that the duration and frequencies of bad oral habits in the long term would lead to an anterior or posterior crossbite, in addition to midline shift (Larsson, 2001). This is consistent with what we found that children with prolonged thumb sucking habits had a midline shift. The significant relationship between mouth breathing and midline shift needs future studies since there were few studies on these relationships. However, some other studies found no relationship between midline deviation and bad habits (Hamoud et al., 2018; Kasparaviciene et al., 2014). Using different tools to test bad oral habits, such as an oral examination with a questionnaire, may affect the results. The duration and frequency of the bad habit also play an important role in the strength of the relationship between oral habits and malocclusion.

The most common prevalence of bad habits was mouth breathing and lip-biting, and this is consistent with other studies (Rodríguez-Olivos, 2022; Wang et al., 2021). Academic

stress among schoolchildren can lead to clenching of teeth. For some students, stress causes other symptoms such as lip biting and nail-biting. These habits can lead to malocclusion problems.

There was no relationship between sex and bad habits, in contrast to the Garde et al. study which indicated that females had more bad oral habits than males (Garde et al., 2014). This is maybe due to the awareness of parents about bad oral habits and providing advice to their children, encouraging them for good oral behaviors. Another possible reason is that children at this age may not be inclined to resist parental demands.

### **6.5 Demographic variables (sex, region, geographical area) and malocclusion**

In this study, there was no statistically significant association between occlusal, spacing anomalies, and gender. That is similar to other studies done in Saudi Arabia, Kuwait, and Turkey (Asiry, 2015; Behbehani et al., 2005; Bilgic et al., 2015). Irrespective of diastema and spacing were higher in males than females in contrast to other studies (Fatani et al., 2019; Shivakumar et al., 2009). These discrepancies may be due to developmental differences in eruption of teeth between males and females.(Ghimire et al., 2013; Thilander et al., 2001). A significant association between midline shift and gender was found in males; this result supported the study performed by Bugaighis in Libya in 2013. She found a significantly greater numbers of males presented with midline deviation compared to females (Bugaighis & Karanth, 2013)

For dental anomalies, missing permanent teeth was significantly higher among males than females. This is in line with the other studies (Shivakumar et al., 2009; Thilander et al., 2001). In our study, radiographs were not used therefore the prevalence might be overestimated. Also retained deciduous teeth were reported in males more than in females. The tooth development and eruption of lateral incisors and canines are slower in

males compare to females (Ghimire et. al, 2013). Ectopic teeth were significantly higher in female than male in agreement with study of Jordan (Al-Khateeb & Al-Nimri, 2005). Genetic characteristics play a role in this difference, in addition to the fact that females usually have a smaller jaw than males, which may lead to disturbance in which the tooth goes out of the usual course (Paulino et al., 2011; Stanley Braun et al., 1998) .

According to the region, it was found that the prevalence of Class I molar relationship is higher while Class II div. 2 is lower in the northern region compared to the southern region. However, the children of the southern region suffered from reduced overjet (0-2 mm), and reduced overbite (less than 2 mm). Hereditary factors may play a role in reduced overjet and overbite, as the proportion of inbreeding in the southern regions is higher than in the northern regions (PCBS, 2017). As for the children of the northern region, they suffered from anterior crossbite and anterior openbite, and this is somewhat consistent with what Alajlan et al. and Asiry et al. in 2019 found of the difference in the occlusal anomalies of the different regions of Saudi Arabia (Alajlan et al., 2019; Asiry & Alshahrani, 2019), and Balachandran and his team found in different regions of India (Balachandran & Janakiram, 2021). The children from the central region had increased midline shift and diastema. These discrepancies may be due to the increase in dental anomalies, especially retained deciduous teeth, missing permanent teeth, and ectopic teeth among the children of the southern and central regions compared to the children of the northern region, and more likely due to the distinctive features of the Palestinian population in different regions. Dental caries and premature loss of primary teeth also might be play a role in occlusal anomalies in mixed and permanent dentition (Stahl & Grabowski, 2004). There was no relationship between different regions and space anomalies.

The novelty of our study lies in addressing the cities and countryside areas in one country. Most of the studies were conducted in urban or rural areas, few studies made comparisons between them, although urbanization plays an influencing factor in the prevalence of malocclusion. Where malocclusion was referred to as (a disease of civilization) (Lombardi, 1982). With the processed urban diet, little attrition of the interproximal surfaces of teeth occurs, which can lead to crowding and other types of malocclusion. Studies conducted in Peru, Romania, and China indicated a relationship between the geographical area and malocclusion (de Llano-Pérula et al., 2020; Todor et al., 2019; Wang et al., 2021). Other studies conducted among Indian schoolchildren from rural and urban areas of Calicut district and Chinese schoolchildren of Xinjiang Aletai district found no significant difference between geographical area and malocclusion (Diao et al., 2021; Sundareswaran & Kizhakool, 2019).

Based on the definition of PCBS for rural areas, rural areas are areas with a population of fewer than 5,000 breezes with no access to roads. In our study, it was difficult to reach those areas. We categorized the geographical areas as cities and countryside. The results of our study on occlusal anomalies were a decrease in the prevalence of anterior openbite and an increase in posterior openbite in the cities compared to countryside. Surprisingly, this happened despite the low incidence of retained deciduous teeth. Food consumption and environmental factors may play a role in the development of an openbite. Functional adaptation to environmental factors and their impact on the surrounding structures of teeth, bones, and soft tissues may lead to one or more types of occlusal anomalies (Alhammadi et al., 2018). Low socioeconomic status can play a role in its development. The frequency of upper and /or lower crowding in different areas may provide valuable information about malocclusion characteristics and treatment strategies. Our study

indicated that crowding, whether in upper jaw or both, and spacing are higher in the countryside than in cities, and this is consistent with the study (Sundareswaran & Kizhakool, 2019; Todor et al., 2019). As mentioned previously, food consumption and/or an early loss of deciduous teeth due to complications of dental caries, followed by eruption of permanent teeth in an insufficiently developed arch may play a role in space discrepancies.

### **6.6 Dental anomalies, space conditions, bad habits and molar relationship**

Our sample of class III children (42.4%) showed a significantly higher prevalence of missing teeth with at least one tooth compared to children with class I malocclusion. This was consistent with Ali and Hussain retrospective study in Pakistan conducted from 2005 to 2015 (B. Ali & Hussain, 2016). Few studies had addressed this relationship, more future studies are needed on this subject. Ectopic teeth were more frequent among schoolchildren with both Class II and Class III, than among those with Class I malocclusion. Contrary to the findings of the Turkish study that reported the absence of any statistically significant associations between dental anomalies and angle's molar classification (Uslu, Akcam, Evirgen, & Cebeci, 2009). Ectopic eruption of the maxillary first molar is the most common dental anomaly in the mixed dentition. This anomaly may result from the premature loss of primary second molar. Since the first permanent molar is the basis of the angle molar relationship, the angle molar classification may be affected (Hafiz, 2018).

The results of our study indicated that children of Class II and Class III showed a significantly lower prevalence of no crowding in the upper jaw compared to children with Class I. This is consistent with a cohort study performed in Northern Finland, they found that Class II malocclusion was significantly associated with crowding in the maxilla;

which was usually accompanied by narrow and tapered-shaped maxilla (Tervahauta et al., 2021). Kuntz et al. rejected the hypothesis that there is no difference between adults with Class III malocclusion and normal Class I in respect to arch width, they concluded that maxillary intermolar and alveolar width in the Class III is smaller and narrower than normal Class I people (Kuntz et al., 2008).

According to bad habits, we found that there was no association between bad habits and angle's molar classification, in contrast to recent study from Peru among 155 children aged 6-12 years in which Class II div 1 malocclusion was related to atypical swallowing and lip sucking habits (Rodríguez-Olivos, 2022). These differences might be due to the small sample size of Peru study.

### **6.7 Methodological issues and limitations**

The current research is the first large population-based study that considers the prevalence of malocclusion and its relationship to demographic factors among schoolchildren in Palestine. It could be considered as a baseline for further diagnostic and preventive projects. Comparing the characteristics of the sample with the statistics of the children's community in the West Bank on the signs of gender and geographical distribution indicates that the sample was representative of the community of the children at the age of 12 years in that region with the exception of Jerusalem (for political considerations). None of the children received elective or interceptive orthodontic treatment or extracted any first molars. It has been noted that in studies of the prevalence of malocclusion, the material must be obtained from a well-defined population and be large enough to cover non-orthodontically treated children (Ramanarayanan et al., 2020). The current sample appears to meet those requirements. The clinical investigations were based on several combined indices (Angle, 1899; Baume & Maréchaux, 1974; Bezroukov et al., 1979;

Björk et al., 1964; Draker, 1960; Salzmann, 1967) which included subjective and objective investigations of the occlusion. These indices have been used in many studies allowed for objective comparisons of the presence of malocclusion between different populations.

However, comparisons of the present results with those of other studies should be made with caution because different methods and indices have been applied at varying age ranges among the population. Furthermore, neither impression model nor radiographs were used in this study. The possibility of under or overestimating from data collectors the frequency of some criteria such as congenital missing of permanent teeth, ectopic teeth eruption and the accuracy of space discrepancies analysis cannot be overlooked. It has been shown that records that used impression models and radiographs produced more accurate results compared to direct recording (Al-Khateeb & Al-Nimri, 2005; Godara, Narain, & Kumar Mahala, 2019; Mtaya et al., 2009). Moreover, there may be confounding factors that influenced our results, especially in the occlusal examination. Nevertheless, given the sample size and selection criteria used in this study, the results provide a reasonably accurate indication of the prevalence of malocclusion in 12-year-olds in Palestine.

## **6.8 Summary**

In summary, the demographical profile of our study was described, then the prevalence of malocclusion and occlusal characteristics in the three directions were compared along with influencing factors of malocclusion with international and national studies. Finally, methodological issues and limitations were presented.

## **Chapter Seven: Conclusion and recommendations**

Malocclusion is a major public health issue with social, psychological, and economic dimensions, which is underestimated. Economic cost, aesthetic, and socio-psychological suffering are the main burdens of malocclusion. All efforts should be directed to prevent and control the exacerbation of the problem.

There is a need for local research describing the extent of malocclusion in different geographical areas, especially among schoolchildren, and further investigation of the need for orthodontic treatment. A public health policy related to oral health should be adopted by the Governments and provide resources for planning comprehensive preventive and curative programs.

In this chapter, summary of the findings, implications, and recommendations are presented

### **7.1 Summary of the findings**

This epidemiological survey determined the occlusal characteristics of Palestinian children. A total of 1278 children 12-years of age were enrolled. Our findings indicate that:

- The sagittal relationship of malocclusion revealed a prevalence of 65% for Class I, followed by 23% for Class II, and 12% for Class III. In addition to 36% decreased overjet < 2 mm.
- The vertical dimension rate was in 25% of the children with an openbite (posterior and anterior), whereas 28% had a deepbite (more than 4 mm).
- The analysis of the transverse dimension revealed that 29% of the children had a midline shift.
- Among the demographic characteristics:

1. **Gender** had an influence on:
  - Midline shift and diastema with more reported for males compared to females.
  - Males suffered from most of the dental anomalies except for ectopic teeth, which were more frequent in females compared to males.
  
2. **Region** had an impact on the prevalence of:
  - Class I malocclusion, Anterior Openbite, and anterior crossbite where the northern regions recorded the highest prevalence. As for dental anomalies except for malformation, the northern regions recorded the lowest prevalence.
  - Reduced overbite and overjet, where the southern regions recorded the highest prevalence of them.
  - Midline shifting and diastema, where the central regions had the highest prevalence of them.
  
3. **Geographical area**, anterior openbite and retained deciduous teeth recorded a lower prevalence in cities, while Posterior openbite recorded a lower prevalence in countryside.
  - Anterior crossbite was directly affected by most of the bad oral habits, while midline shifting was affected by mouth breathing and thumb sucking.
  - The analysis of angle's molar relationship and dental anomalies revealed the children who had more than one missing permanent teeth were more likely to report Class III (42.4% compared to Class I. while the probability of having an ectopic tooth was higher in Class II division 2 (58.4%) compare to Class I.
  - The analysis of molar relationship and crowding revealed a probability of children without crowding in upper arch to be in Class III compare Class I decreased by 57%.

## **7.2 Implication to public health, research, and health informatics**

The results of this study indicated that about 85% of the study sample had malocclusion. Therefore, a collaborative effort should be directed to obtain more monitoring and surveillance of malocclusion. Despite of several studies conducted in developed countries that highlighted the prevalence of malocclusion and factors related to it and the need for orthodontic treatment, the evidence in developing countries in general and Palestine, in particular, is still incomplete and inaccurate to help in making a clinical decision. Furthermore, the development of electronic oral health surveillance data that includes oral disease coding (ICD-10 CM) can help. This may lead to better-expanded monitoring and evaluation of the extent of the prevalence of malocclusion in Palestine.

## **7.3 Recommendation**

Based on our findings we formulated our recommendations for two levels; policy and research recommendations.

### **7.3.1 Recommendation for policy**

- The Palestinian Ministry of Health (MOH) should reorient its oral health care strategy to focus on health promotion and comprehensive surveillance. This can be achieved through the use of a health information system (HIS) and the development of a standardized coding of oral disease diagnosis (ICD-10 CM) which is used by the dental health service providers in different geographical areas.
- MOH should develop a standardized protocol for malocclusion screening; to avoid obtaining inaccurate or incomplete data.
- Mobile applications (mHealth) can assist dental health providers with timely data entry and no delays in oral and dental observations.

- Training dental health service providers on diagnosing oral diseases, clinical investigation, and examination methods correctly and periodically.
- Taking advantage of modern technology to educate parents, teachers, and schoolchildren about the impact of bad oral habits, unhealthy food, and other possible causes that may reflect negatively on oral health, which may lead to dental or occlusal anomalies.

### **7.3.2 Recommendation for research**

Future studies should be carried out to assess the prevalence of malocclusion between urban and rural areas to identify any differences between them. In addition to conduct studies that evaluate malocclusion complexity and priority treatment needs using different indices like the Index of Orthodontic Treatment Need (IOTN) and Dental Aesthetic Index (DAI), allowing comparisons to be made across studies. Furthermore, conducting interventional studies focusing on the effect on the occlusal traits after the intervention in reducing bad oral habits. Finally, based on the results of the study, socio-economic, and psychological factors need to be further explored as a potential framework for the prevalence of malocclusion.

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## Appendices

### Appendix 1. Helsinki approval



**المجلس الفلسطيني للبحوث الصحي**  
**Palestinian Health Research Council**

تعزيز النظام الصحي الفلسطيني من خلال مأسسة استخدام المعلومات البحثية في صنع القرار  
Developing the Palestinian health system through institutionalizing the use of information in decision making

**Helsinki Committee**  
For Ethical Approval

**Date:** 2021/12/13      **Number:** PHRC/HC/998/21

**Name:** Hamsa Yasser Mohammad Amro      **الاسم:**

We would like to inform you that the committee had discussed the proposal of your study about:      تنفيذكم علماً بأن اللجنة قد ناقشت مقترح دراستكم حول:

**Prevalence of malocclusion among 12 year old Palestinian schoolchildren:  
Epidemiological study**

The committee has decided to approve the above mentioned research. Approval number PHRC/HC/998/21 in its meeting on 2021/12/13      و قد قررت الموافقة على البحث المذكور عاليه بالرقم والتاريخ المذكوران عاليه

**Signature**

Member

*Yasser R. Abbas Shaker*  
13/12/2021

Chairman

*Dr. Yasser*  
13 12

Member

*[Signature]*  
13.12.2021

**Genral Conditions:-**

- Valid for 2 years from the date of approval.
- It is necessary to notify the committee of any change in the approved study protocol.
- The committee appreciates receiving a copy of your final research when completed.

**Specific Conditions:-**



E-Mail: pal.phrc@gmail.com

Gaza - Palestine      غزة - فلسطين  
شارع النصر - مفترق العيون

## Appendix 2. Arab American university thesis approval

Arab American University  
Faculty of Graduate Studies



الجامعة العربية الأمريكية  
كلية الدراسات العليا

2021-11-1

حضرة الدكتور وائل الشيخ المحترم

وكيل وزارة الصحة الفلسطينية

### تسهيل مهمة بحثية

تحية طيبة وبعد،

تهديكم كلية الدراسات العليا في الجامعة العربية الأمريكية أطيب التحيات، وبالإشارة إلى الموضوع أعلاه، تشهد كلية الدراسات العليا في الجامعة أن الطالبة همسة ياسر محمد عمرو والتي تحمل الرقم الجامعي 201912963 وهي طالبة ماجستير في الجامعة العربية الأمريكية تخصص المعلوماتية الصحية، ويعمل على رسالة بعنوان "مدى انتشار سوء الإطباق بين أطفال المدارس الفلسطينية في عمر 12 سنة: دراسة وبائية". تحت إشراف د. شاهيناز نجار و د. مجدي عودة. حيث سيتم فحص سمات اطباق الاسنان لطلاب وطالبات الصف السابع في عينة من المدارس الحكومية. نأمل من حضرتكم الإيعاز لمن يلزم لمساعدتها في الحصول على المعلومات اللازمة للدراسة. علماً ان المعلومات ستستخدم لغاية البحث فقط وسيتم التعامل معها بغاية السرية، وقد أعطيت هذه الرسالة بناءً على طلبه.

وتفضلوا بقبول فائق الاحترام

  
د. شاهيناز نجار

عميد كلية الدراسات العليا



Page 1 of 1

Jenin Tel: +970-4-2418888 Ext.:1471,1472 Fax: +970-4-2510810 P.O. Box:240  
Ramallah Tel: +970-2-2941999 Fax: +970-2-2941979 Abu Qash - Near Alrehan  
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## Appendix 3. Ministry of Health approval

24-NOV-2021 12:03 Front

Tel: 99417072

دولة فلسطين  
وزارة الصحة  
الإدارة العامة للتعليم الصحي  
والبحث العلمي

State of Palestine  
Ministry of Health  
General Directorate of Education in  
Health and Scientific Research

الرئيس: د. محمد سليم  
التشخيص: د. محمد سليم

Ref: .....  
Date: .....  
23/11/2021

عطفة الوكيل المساعد لشؤون الصحة العامة وصحة الأسرة المحترم،  
نعمة ولعمركم..

**الموضوع: تسهيل مهمة بحث**

يرجى التكرم بتسهيل مهمة الطالبة: همسة ياسر عمرو، ماجستير معلوماتية صحية -  
الجامعة العربية الأمريكية، لعمل بحث بعنوان:  
"مدى انتشار سوء الاطباق بين أطفال المدارس الفلسطينيين في عمر 12 سنة: دراسة وبائية"  
حيث ستقوم الطالبة بجمع معلومات من عينة من طلاب الصف السابع في المدارس الحكومية،  
ونذلك بمساعدة طاقم الصحة المنية. مع العلم أن مشرفة الدراسة: د. شاهناز النجار و د. مجدي  
عودة.

على ان يتم الالتزام بجميع تعليمات واجراءات الوقاية والسلامة الصادرة عن وزارة الصحة  
بخصوص جائحة كورونا، وتحت طائلة المسؤولية.  
على ان يتم تزويد الوزارة بنسخة PDF من نتائج البحث، التعمد بعدم النشر.  
مع الاعتزاز..

د. محمد سليم  
مدير التعليم الصحي والبحث العلمي

نسخة: عميد كلية الدراسات العليا المحترم/ الجامعة العربية الأمريكية

دولة فلسطين  
وزارة الصحة  
الإدارة العامة للتعليم الصحي  
والبحث العلمي  
1010 - 13003  
23-11-2021

ص.ب. 14  
مخ: 09-2333901

scientificresearch.dep@gmail.com

P.O .Box: 14  
Fax: 09-2333901

**Appendix 4. Ministry of Education approval**

<p>State of Palestine Ministry of Health Oral and Dental Health Unit</p>		<p>دولة فلسطين وزارة الصحة وحدة صحة الفم والأسنان</p>
<p>ODHU</p>		
<p>Ref.: HODGD22664</p>	<p>التاريخ: 2022/02/01</p>	
<p>حضرة الأخ د. إيهاب شكري المحترم مدير عام الصحة المدرسية/ وزارة التربية والتعليم</p> <p>تحية طيبة وبعد،</p> <p>تهديكم وحدة صحة الفم والأسنان أطيب تحياتها، يرجى التكرم بتسهيل مهمة طواقم الصحة السنوية في المدارس المرفقة أدناه، حيث ستقوم الطواقم الصحية بجمع معلومات من عينة من طلاب الصف السابع في المدارس الحكومية حول: مدى إنتشار سوء الإطباق بين أطفال المدارس الفلسطينيين. مع العلم بأن المدارس التي تم إختيارها هي نفس المدارس التي يطبق فيها فحص التقصي من خلال دائرة الصحة المدرسية.</p> <p style="text-align: center;">مع كل الاحترام</p>		
<p>بهدار طه</p>   <p>وحدة صحة الفم والأسنان</p>	 <p>دولة فلسطين - وزارة الصحة وحدة صحة الفم والأسنان مسار رقم: OD.OI.FO.I-664 التاريخ: 2022/12/11</p>	
<p>مرفق/ قائمة بأسماء المدارس</p>		
<p>Tel.: 02 2417072 Fax: 02 2417072 Email: dentalunit1234@gmail.com</p> <p style="text-align: right;">تلفون: 02 2417072 فاكس: 02 2417072 بريد الكتروني: dentalunit1234@gmail.com</p>		

## Appendix 5. Training course invitation for data collection

Ref.: HODGD22649 ODHU التاريخ: 2022/01/09

حضرة د. كمال الشخرة المحترم  
الوكيل المساعد للصحة العامة وصحة الأسرة  
تحية طيبة وبعد،،،

الموضوع: قياس سوء الاطباق لدى طلاب المدارس

تهدىكم وحدة صحة الفم والأسنان أملياً بتهيئتها، بناء على الكتاب رقم 162/2144/2021 بخصوص عمل دراسة بحثية حول انتشار سوء الاطباق بين أطفال المدارس الفلسطينية في عمر 12 سنة؛ (دراسة وبائية). نرجو الايمان لأطباء الصحة السنبة المدرسية لحضور دورة تدريبية بهذا الخصوص وذلك يوم الخميس الموافق 13/01/2022 الساعة التاسعة صباحاً في قاعة الرعاية الأولية/ وزارة الصحة/ رام الله.

No	التدريبية	طبيب الصحة المدرسية
1	صحة اللبس	د. أحمد جبر
2	صحة جنين	د. أحمد السوقي
3	صحة طوياس	د. زكي درازمة
4	صحة طولكرم	د. نضال طحلاري
5	صحة قلقيلية	د. نعيم عويصي
6	صحة سلفيت	د. صبري ولويل
7	صحة نابلس	د. ميس عودة
8	صحة رام الله	د. ميماء جرار
9	صحة بيت لحم	د. محمد البلبول
10	صحة الخليل	د. وهيب سلطان
11	صحة جنوب الخليل	د. أحمد عطية
12	صحة شمال الخليل	د. رعد بحر
13	صحة يطا	د. محمد حمامة
14	صحة أريحا	د. وعد العملي

مع كل الاحترام،  
د. بهادر طه  
وحدة صحة الفم والأسنان

دولة فلسطين - وزارة الصحة  
وحدة صحة الفم والأسنان  
ص.ب. رقم 2461-649  
التاريخ: 2022.1.19

تلفون: 02 2417072 فاكس: 02 2417072  
بريد الكتروني: dentalunit1234@gmail.com

Tel.: 02 2417072 Fax: 02 2417072  
Email: dentalunit1234@gmail.com

## Appendix 6. Participant's consent form



الجامعة العربية الأمريكية- فلسطين

عمادة الدراسات العليا

كلية العلوم الصحية- برنامج المعلوماتية الصحية

دراسة: مدى انتشار سوء الإطباق بين أطفال المدارس الفلسطينيين في عمر 12 سنة: دراسة وبيانية

عزيزي المشارك في هذه الدراسة

تحية طيبة وبعد:

يعرف سوء الإطباق على أنه اختلال في العلاقة بين الفك العلوي والفك السفلي وعدم انتظام الأسنان وتزاحمها.

تهدف هذه الدراسة إلى تقييم مدى انتشار سمات سوء الإطباق بين أطفال المدارس الفلسطينيين في عمر 12 سنة. كما تهدف الدراسة إلى التحقق في تأثير العادات القموية على مدى انتشار سوء الإطباق .

نود أن ننوه أن المشاركة في الدراسة طوعية، وأن هذا الاستبيان يعبر عن وجهة نظرك وهو (سري تماما) هذا يعني أن الآخرين لن يروا ما تكتبه. لذا من فضلك املاها بكل صدق، اذا كنت غير متأكد/ة من أي من الاسئلة أو كيفية الإجابة يرجى طلب المساعدة من المشرفين. هذا ليس اختبارا ( ليس هناك إجابات صحيحة أو خاطئة) فقط إجاباتك الخاصة التي تعبر عن رأيك العلمي.

علما بأن جميع البيانات المستخلصة من استمارة الدراسة سوف تستخدم لأغراض البحث العلمي فقط.

موافق على المشاركة

غير موافق على المشاركة

الباحثة: همسة عمرو / الجامعة العربية الأمريكية-فلسطين

## Appendix 7. The research tool (examination chart and questionnaire)

### Examination Chart

البيانات الشخصية	
الصف:	اسم الطالب/ة:
اسم المدرسة:	تاريخ الميلاد: 20 / ___ / ___
المنطقة الجغرافية: 1. مدينة 2. قرية	العمر: _____
الجنس: 1. ذكر 2. أنثى	اسم الفاحص: _____
التاريخ: _____	

**Unrecordable Subject:**  Due to: \_\_\_\_\_  
 Note: code "9" when a subject cannot be adequately recorded because of multiple extractions, a history of previous orthodontic treatment, or present orthodontic treatment, and terminate the examination.  
 (ضع الرمز "9" عندما لا يمكن تسجيل سوء الاطباق بسبب عدم وجود أي من أضرار 6s أو إجراء تقويم أسنان سابقاً أو علاج تقويم أسنان حالي أو وجود تشوهات خلقية مثل الشفة الارنبية أو سقف الحلق، ثم قم بانهاء الفحص).  
 النتائج السريرية Clinical Finding

### الأسنان Dentition

الأسنان الدائمة المفقودة (ضع علامة على الأسنان المفقودة بعلامة X)  
 مفقودة نتيجة قلع (extracted) أو خلقي (congenitally) أو تعرض لضربة (trauma) (Mark tooth missing with X)

Rt.	5	4	3	2	1	1	2	3	4	5	Lt.

Anomalies of tooth development (0 or enter count) (كتابة العدد أو 0)

Supernumerary (أسنان زائدة)	<input type="checkbox"/>
Malformation of incisors (اختلاف شكل السن الأمامي بالحجم أو الشكل)	<input type="checkbox"/>
Ectopic eruption (وجود السن في غير موضعه)	<input type="checkbox"/>
Retained deciduous teeth (أسنان لبنية متبقية في وقت ظهور الأسنان الدائمة)	<input type="checkbox"/>

### الفراغات Space Condition

Diastema (A space of 2 mm or more)		
None= 0		
Present= 1		<input type="checkbox"/>
Unrecordable= 9		
Crowding/ Spacing (ضع إشارة لـ حول الصفة الموجودة)		
		Present (موجود)
Crowding	Upper	
	Lower	
Spacing	Upper	
	Lower	

## Examination Chart

## Occlusion الأطباق

Incisal Segments	Lateral segments		
<b>Overjet</b> <0 = 0 (reverse overjet) 0mm - < 2mm = 1 2mm - 4 mm = 2 <input type="checkbox"/> >4mm - 6 mm = 3 > 6 mm = 4 Unrecordable = 9	<b>Molar relationship</b>	<b>Rt.</b>	<b>Lt.</b>
	Class I		
	Class II div. 1		
	Class II div. 2		
	Class III		
Unrecordable			
<b>Anterior openbite</b> None = 0 Present = 1 <input type="checkbox"/> Unrecordable = 9	<b>Posterior openbite</b> for (4,5,6) (present or absent) 0 = None 1 = Present 9 = Unrecordable	Rt. <input type="checkbox"/>	Lt. <input type="checkbox"/>
	<b>Anterior crossbite</b> None = 0 <input type="checkbox"/> Present = 1 Unrecordable = 9	<b>Posterior crossbite</b> for (4,5,6) (Buccal or Lingual or Normal)	Rt. <input type="checkbox"/>
<b>Overbite</b> <2mm = 0 2mm - 4mm = 1 <input type="checkbox"/> >4mm - 6mm = 2 > 6 mm = 3 Unrecordable = 9			
<b>Midline shift</b> (2 mm or more) None = 0 Present = 1 <input type="checkbox"/> Unrecordable = 9			

## الملخص

**الخلفية:** أدرجت منظمة الصحة العالمية سوء الإطباق من ضمن الحالات الشاذة التي قد تحتاج الى تدخل علاجي حتى لا تؤثر على جماليات الفرد ورفاهه العاطفي. يعتبر سوء الاطباق من أكثر المشاكل المبلغ عنها بين الأطفال والمراهقين. ليس لدى فلسطين سجل واضح أو بيانات دقيقة حول انتشار سوء الإطباق والعوامل المرتبطة به. تهدف هذه الدراسة إلى تقييم وتقدير مدى سوء الإطباق والعوامل المرتبطة به بين طلاب المدارس الذين تبلغ أعمارهم 12 عاما في الضفة الغربية.

**الأساليب:** أجريت دراسة مقطعية باستخدام عدة مؤشرات لفحص سمات الإطباق واستبيان ذاتي لعينة ممثلة (n= 1384) من أطفال المدارس الذين تبلغ أعمارهم 12 عام في الضفة الغربية/ فلسطين. تم جمع البيانات من 69 مدرسة حكومية موزعة في المناطق الشمالية والوسطى والجنوبية من الضفة الغربية من شهر شباط إلى شهر نيسان من العام 2022. تم التحقق من موثوقية الفاحصين بواسطة (ICC) واختبار ألفا كرونباخ. حيث كانت نسبة الموثوقية جيدة جدا.

تم اجراء تحليل البيانات باستخدام الأصدار SPSS 23.0. تم حساب الترددات والنسب المئوية لجميع المتغيرات. تم اجراء اختبار (Chi-square) لفحص العلاقات بين الخصائص الديموغرافية والعادات الفموية السيئة وسوء الأطباق. تم استخدام الانحدار اللوجستي المتعدد لتقدير نسب انتشار الصنف الثاني والثالث من سوء الأطباق وفقا لوجود شذوذ سنوي، عادات فموية سيئة ، و ازدحام أو فراغات بين الأسنان مقارنة بالصنف الأول.

**النتائج:** بلغ عدد المشاركين بعد استبعاد الطلاب الذين لم تنطبق عليهم شروط البحث 1278 طالبا بمعدل استجابة (92.7%) من العينة. مثل الذكور (48.5%) في حين مثلت الإناث (51.5%). بلغت نسبة المشاركين من المناطق الشمالية (40.5%)، والمناطق الوسطى (26.3%)، والمناطق الجنوبية (33.2%). في حين أن (18.2%) كانوا من المدن، و(18.2%) من القرى. كان التنفس عن طريق الفم وعض الشفاه أكثر العادات الفموية السيئة انتشارا في ما يقرب من 40% من المشاركين ، مع عدم وجود اختلافات بين الجنسين. 85% من المشاركين الذين تم فحصهم لديهم نوع واحد أو أكثر من حالات سوء الأطباق التي تتراوح من خفيفة إلى شديدة. بناء على تصنيف أنجيل لسوء الأطباق كان انتشار الصنف الأول 65%، الصنف الثاني 23%، والصنف الثالث 12%. في حين كان انتشار Overjet أقل من 2 ملم 36%. كان ما يقارب من ربع الطلاب يعانون من عضه مفتوحة أو لديهم عضه عميقة أكثر من 4 ملم. علاوة على ذلك، كان لدى 29% من الطلاب انحراف في خط الوسط. كان هناك علاقة ذات دلالة احصائية بين الجنس وانحراف خط الوسط والفراغ بين

الاسنان الامامية (Diastema) وسوء الاطباق الناجم عن شذوذ سنّي خاصة لدى الذكور. وعلاقة كبيرة بين مكان سكن المشارك (قرية أو مدينة) و العضة المفتوحة الامامية أو الخلفية بالاضافة الى تأخر تساقط الاسنان اللبنية. كان هناك علاقة ذات دلالة احصائية بين المنطقة الجغرافية ومعظم سمات سوء الاطباق. تم تحديد ارتباط ذو دلالة احصائية بين ( anterior crossbite and midline shift) والعادات الفموية السيئة.

كشفت تحليل الانحدار اللوجستي لسوء الاطباق حسب تصنيف انجيل وسوء الاطباق نتيجة لشذوذ سنّي؛ أن طلاب المدارس الذين يعانون من أسنان مفقودة كانوا أكثر عرضة لحدوث سوء اطباق من الصنف الثالث بنسبة 42.4% مقارنة بالصنف الأول. في حين كان احتمال وجود ( ectopic teeth) أعلى لدى الطلاب من الصنف الثاني (58.4%) مقارنة في الصنف الاول. علاوة على ذلك، كشفت التحليل اللوجستي لازدحام الاسنان وسوء الاطباق حسب تصنيف انجيل عن انخفاض احتمال أن يكون الطلاب الذين لا يعانون من ازدحام الأسنان في الفك العلوي في الصنف الثالث مقارنة بالصنف الأول بنسبة 57%.

**الخلاصة:** أفادت هذه الدراسة عن ارتفاع معدل انتشار سوء الإطباق بين طلاب المدارس. يرتبط سوء الاطباق بالعديد من العوامل الديموغرافية والسلوكية. لذلك، ينبغي توجيه جهد تعاوني للحصول على مزيد من الرصد والمراقبة لسوء الإطباق على نحو أكثر تواترا لمنع تفاقم المشكلة ومكافحته.

**الكلمات المفتاحية:** سوء الإطباق، الانتشار، العادات السيئة، طلاب المدارس، فلسطين