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Original Article

Patterns and predictors of tooth loss among partially dentate individuals in Jordan: A cross-sectional study

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ABSTRACT

Aim: This study aimed to examine the patterns of partial edentulism and the associated risk factors in Jordan.
Methods: A cross-sectional, epidemiological study was carried out across Jordan, and data was collected from adult partially dentate patients in various healthcare facilities. The data collected included sociodemographic data, dental and social history, and clinical examination findings for the jaw and teeth. Multivariate regression models were used to determine the predictors for the number of missing teeth.
Results: The sample consisted of 467 partially dentate participants. The leading cause of tooth loss was dental caries (85.4 %), followed by periodontal disease (13.7 %), and trauma (7.5 %). The mean number of missing teeth was significantly higher in the upper jaw (2.5 ± 3.1) compared to the lower jaw (2.2 ± 2.6, $p = 0.02$). In both jaws, the most prevalent Kennedy classification was Class 3, followed by Class 3/Modification 1 and Class 2/Modification 1. Increased age, smoking, lack of daily tooth brushing, and low education level were significantly associated with high tooth loss.
Conclusions: This study contributes to the understanding of partial edentulism in Jordan, reflecting broader oral health concerns and the factors influencing tooth loss. The findings, vital for future research and interventions, offer insights applicable to global oral health challenges, particularly for at-risk groups.

1. Introduction

Healthy teeth play an important role in maintaining quality of life due to their role in aesthetics, chewing, and speech (Lee et al., 2015). Unfortunately, tooth loss occurs due to many reasons such as trauma, caries, and periodontal diseases. This negatively affects speech, mastication, and aesthetics, which in turn affects the quality of life (Emami et al., 2013). Despite advancements in curative and preventive dental care in the last few decades, edentulism, or tooth loss, is still a challenging problem for healthcare providers (Marcenes et al., 2013).

Partial edentulism is when one or more teeth, but not all, is/are absent from a dental arch (McGarry et al., 2002). A need for a classification system was present for partially edentulous arches to facilitate effective communication about missing teeth and their replacement (Miller, 1970). Although several classification systems were proposed, the Kennedy classification, introduced by Edward Kennedy in 1925, is commonly accepted worldwide (Miller, 1970). Kennedy classification allows immediate visualization of partially edentulous jaws and identification of the relationship between teeth and edentulous ridges.

The number of individuals with tooth loss is increasing, necessitating the determination of associated risk factors. Understanding the most common patterns of partial edentulism is important for prosthodontists to provide effective treatment options for their patients. Several epidemiological studies on the prevalence of different classes of partial edentulism have been conducted in various geographical locations such as Romania, India, and Saudi Arabia, as well as in Jordan (AL-Dwairi, 2006; Fayad et al., 2016; Ghiță et al., 2019; Manimaran et al., 2017). However, generalization of the results from these studies is limited due to their contrasting and inconsistent findings. A previous literature review evaluated the discrepancies among studies and attributed that to the use of small and heterogeneous samples (Jeyapalan and Krishnan, 2015).

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Within these limitations, a need exists for studies with large and multicenter samples, considering the modification spaces for Kennedy's Classes, prosthetic status, and prosthetic needs of patients. This study aimed to provide reliable and diverse epidemiologic data on the patterns of partial edentulism and its related risk factors among the Jordanian population.

2. Materials and methods

2.1. Study design

2.1.1. Study setting

An epidemiological descriptive cross-sectional study was carried out across Jordan. Data were collected randomly from clinics all over Jordan by intern dentists and senior dental students from the Ministry of Health, Royal Medical Services, and private and dental teaching clinics. The institutional review board approval was obtained from Jordan University of Science and Technology (IRB number: 691/2021).

2.1.2. Inclusion and exclusion criteria

Patients included in this study were aged 18 years or older and partially dentate. Patients who were fully edentulous, younger than 18 years, or refused to participate in the study were excluded.

2.2. Data collection and measures

2.2.1. Data collectors training

The data collectors underwent structured training led by the primary investigator. They were trained for approaching and screening potential participants using a pilot sample of 25 patients. The training emphasized understanding the survey's sociodemographic items and the clinical examination of missing teeth. After training, they practiced on the pilot sample to ensure consistency and accuracy in data collection under the supervision of the primary investigator.

2.2.2. Data collection and measures

Data measures included 12 elements, eight of which were survey questions, and the answers were recorded. The remaining four were clinical examination elements evaluated by the data collectors. No identifying information was collected, and informed consent and approval were received from all participants.

Patients were first interviewed face-to-face about factors related to partial edentulism. These included four questions about sociodemographic data (age, sex, marital status, and level of education), and the other four were regarding dental and social history including tooth brushing, causes of tooth loss, place of living, and smoking habits. Patients were then clinically examined using a basic dental examination kit and the notes were recorded. Data collectors filled two questions about jaw skeletal classification and facial profile, and the final two were about the types and numbers of missing teeth in the upper and lower jaws.

2.3. Statistical analysis

The study variables are reported using mean and standard deviation (SD) for continuous variables and frequencies and percentages for categorical variables. No missing data was reported. Due to a lack of normality, the number of missing teeth was compared between the upper and lower jaws using a signed-rank test. Multivariate regression models using negative binomial distribution were constructed to evaluate the predictors of the number of missing teeth in the upper and lower jaws and total mouth. Predictors in the models included age, sex, jaw skeletal classification, smoking status, daily teeth brushing status, and level of education. All tests were two-sided and $p < 0.05$ was considered statistically significant. All tests were conducted using the R statistical software (version 4.1.2).

3. Results

3.1. Sample characteristics and dental history

Of the 647 patients approached, 467 agreed to participate in the study and met the inclusion criteria (response rate = 72.2 %). The mean age of the participants was 42.4 years (SD = 13.8), 54 % of which were female, 74.9 % were married, over half of the sample (54.4 %) had completed only high school or less education, more than a third of them (35.8 %) were smokers, and the majority were from the north of the country (73.2 %) (Table 1).

The majority (79.4 %) of the participants reported that they brushed their teeth daily (Table 2). Approximately 8.1 % of the participants had a Class 2 (retrognathic) jaw skeletal classification and 4.5 % had Class 3 (prognathic).

3.2. Pattern of tooth loss

The dominant cause of missing teeth was dental caries (85.4 %), followed by periodontal disease (13.7 %), and trauma (7.5 %). The mean number of missing teeth in the lower jaw (mean ± SD = 2.5 ± 3.1) was significantly higher than that for the lower jaw (2.2 ± 2.6, $p = \mathbf{0.02}$). The mean total number of missing teeth in both jaws was 4.7 ± 5.0 (Table 2). The number of missing teeth by location is listed in Table 3. The most common missing teeth, in both jaws, were the lower molars followed by the upper molars, while the least common were the lower canines followed by the lower incisors.

The pattern of Kennedy's classification and its modifications for the upper and lower jaws are depicted in Fig. 1. The most common Kennedy classification was Class 3 (42.9 % vs. 38.1 %), followed by Class 3/Modification 1 (20.7 % vs. 20.1 %), Class 2/Modification 1 (7.6 % vs. 11.2 %), and Class 1 (5.6 % vs. 9.7 %) for the upper versus lower jaws.

3.3. Predictors of tooth loss

Results from the multivariate regression models for the predictors of the number of missing teeth in the upper, lower, and full mouth (both jaws) are provided in Table 4. For the upper jaw, controlling for other variables in the model, a high number of missing teeth was directly associated with older age (adjusted incidence rate ratio [aIRR] = 1.05, 95 % confidence interval [CI] = 1.04–1.05, $p < \mathbf{0.001}$), smoking (aIRR = 1.24, 95 % CI = 1.01–1.51, $p = \mathbf{0.04}$), and low education (aIRR = 1.31, 95 % CI = 1.10–1.56, $p = < \mathbf{0.001}$), but was negatively associated with teeth brushing (aIRR = 0.78, 95 % CI = 0.64–0.96, $p = \mathbf{0.02}$).

For the lower jaw, controlling for other variables in the model, a high number of missing teeth was directly associated with older age (aIRR = 1.04, 95 % CI = 1.03–1.04, $p < \mathbf{0.001}$) and low education (aIRR = 1.33,

Table 1
Characteristics of the Sample population.

Characteristic	Full Cohort (n = 467)
Age (mean (SD))	42.4 (13.8)
Sex (%)	
Female	252 (54.0)
Sex (Male)	215 (46.0)
Marital Status (%)	
Married	350 (74.9)
Single	99 (21.2)
Widowed	18 (3.9)
Education (%)	
Low education (High school or less)	254 (54.4)
High education (Bachelor's degree or higher)	213 (45.6)
Smoker (%)	167 (35.8)
Residence Region (%)	
North	342 (73.2)
Middle	57 (12.2)
South	68 (14.6)

Table 2
Dental history and tooth loss description.

Characteristic	Full Cohort (n = 467)
Teeth Brushing Daily, yes	371 (79.4)
Jaw Skeletal Classification (%)	
Normal (Class 1)	408 (87.4)
Retrognathic (Class 2)	38 (8.1)
Prognathic (Class 3)	21 (4.5)
Reason for Loss*	
Caries (%)	399 (85.4)
Periodontal Disease (%)	64 (13.7)
Trauma (%)	35 (7.5)
Others (%)	27 (5.8)
Num Missing in Lower Jaw (mean ± SD)	2.2 ± 2.6
Num Missing in Upper Jaw (mean ± SD)	2.5 ± 3.1
Num Missing Total (mean ± SD)	4.7 ± 5.0

* The categories are not mutually exclusive and thus do not add up to 100%.

95 % CI = 1.11–1.60, p = **<0.001),** but was negatively associated with teeth brushing (aIRR = 0.76, 95 % CI = 0.61–0.95, p = **0.01**). Similarly, for the whole mouth, controlling for other variables in the model, a high number of missing teeth was directly associated with older age (aIRR = 1.04, 95 % CI = 1.04–1.05, p **< 0.001**), and low education (aIRR = 1.32, 95 % CI = 1.15–1.52, p = **< 0.001),** but was negatively associated with teeth brushing (aIRR = 0.77, 95 % CI = 0.65– 0.90, p **< 0.001**).

4. Discussion

Tooth loss affects oral well-being, function, and aesthetics. In this study, we examined the characteristics of partially dentate participants and their dental history. We discovered that dental caries was the most common cause of tooth loss, followed by periodontal disease, and trauma. The mean number of missing teeth was higher in the upper jaw compared to the lower jaw, with Class 3 being the most common Kennedy classification for both jaws. We also demonstrated that older age, smoking, lack of daily tooth brushing, and low education level were associated with a high number of missing teeth.

Our results for the most common causes of tooth loss are consistent with previous studies (Chrysanthakopoulos, 2011; Plančak et al., 2004). Broers et al. reviewed the literature for the causes of tooth loss or extraction worldwide and reported caries ranging from 36.0 % to 55.3 %, periodontitis from 24.8 % to 38.1 %, and trauma from 0.8 % to 4.4 % (Broers et al., 2022). A study in Jordan (1998–2001) explored the reasons for tooth loss in underprivileged citizens and concluded that the most common reasons for tooth loss were caries (46.9 %), periodontal disease (18 %), and a combination of both (8 %) (Sayegh et al., 2004). Our study's percentage of tooth loss from dental caries (85 %) which is much higher compared to the previously reported international average and results from Jordan at the end of the last millennium, indicates potential oral hygiene and dietary problems among Jordanians.

In accordance with majority of the studies conducted worldwide (Bharathi et al., 2014; Charyeva et al., 2012; D'Souza and Aras, 2014; Fayad et al., 2016; Fouda et al., 2017; Ghiță et al., 2019; Madhankumar et al., 2015; Sadig and Idowu, 2002; Sapkota et al., 2015; Vadavadagi et al., 2015), we identified that Class 3 was the most common Kennedy classification for both arches. On the other hand, a minority of studies reported Class 1 to be the most prevalent among other classes (Al-Angari et al., 2021; Curtis et al., 1992; Gad et al., 2020; KEYF, 2001). Variances in inclusion criteria and data collection explain the differences in Kennedy classifications; some studies included all patients, while others focused on those seeking or treated with removable partial dentures (Curtis et al., 1992; Gad et al., 2020; KEYF, 2001; Sadig & Idowu, 2002). In addition, some studies collected data using patient dental records (AL-Dwairi, 2006; Charyeva et al., 2012; Fouda et al., 2017), and most of the studies were local and limited to a single institution or clinic, which makes them less generalizable. In Jordan, Al Dwairi et al. studied the incidence of different Kennedy classes of partial edentulism among 200 laboratory authorization forms in a single institution and observed Class 3 as the most common, reflecting our findings (AL-Dwairi, 2006). Furthermore, most studies excluded modification spaces to avoid complexity.

More missing teeth were found, on average, in the upper arch than in the lower arch. This is possibly due to salivary pooling protecting the lower teeth (Cunha-Cruz et al., 2013). Similar findings were observed in other studies with more frequent extraction of maxillary teeth compared to mandibular ones (Shareef et al., 2020). However, other reports have discovered that compared to maxillary molars, mandibular molars are more frequently extracted (Sahibzada, 2016). The explanation for this is that lower molars erupt earlier than upper molars, increasing their susceptibility to caries and periodontal disease, and ultimately resulting in their loss. Molars, which are prone to caries and periodontal diseases, were least preserved in both jaws. They are also subject to significant occlusal forces and have deep pits and fissures that can accumulate food debris and bacteria, leading to caries and eventually tooth loss (Sahibzada, 2016). Such a finding also parallels our result where molars were the least preserved teeth in both jaws.

In our study, age, smoking, education, and tooth brushing were linked to tooth loss. Tooth loss tends to increase with age due to factors such as wear, periodontal disease, and other oral health issues (Bartlett and O'Toole, 2019; Marcenes et al., 2013). Fleming and colleagues reported that the percentage of adults losing teeth increased with age, from 8.9 % in the 65–69-year age group to 10.6 % in the 70–74-year age group, and finally to 17.8 % in the 75 (and over)-year age group (Fleming et al., 2020). Age also emerged as the strongest predictor of tooth loss on using a machine-learning algorithm (Elani et al., 2021).

Smoking increases the risk of tooth loss due to its association with periodontal disease, caries, and reduced bone density. Previous studies suggest a strong relationship between smoking and tooth loss. For instance, Souto et al. reviewed the literature on the effect of smoking on tooth loss and concluded that the risk of tooth loss in former smokers and individuals who had never smoked was lower compared to that in current smokers (Souto et al., 2019). Similar results were observed in a more recent systematic review (Al-Ansari, 2020).

Low education levels correlate with limited oral health awareness and preventive care utilization, resulting in more tooth loss. It has been

Table 3
Number of missing teeth by location.

Location	Number of Missing Teeth						
	0 (No Missing Data)	1	2	3	4	Mean ± SD	p-value*
Upper Incisor	374 (80.1)	43 (9.2)	21 (4.5)	3 (0.6)	26 (5.6)	0.42 ± 1.02	**< 0.001**
Lower Incisor	437 (93.6)	4 (0.9)	8 (1.7)	1 (0.2)	17 (3.6)	0.19 ± 0.80	
Upper Canine	407 (87.2)	37 (7.9)	23 (4.9)	–	–	0.18 ± 0.50	**< 0.001**
Lower Canine	443 (94.9)	14 (3.0)	10 (2.1)	–	–	0.07 ± 0.33	
Upper Premolar	246 (52.7)	99 (21.2)	55 (11.8)	30 (6.4)	37 (7.9)	0.96 ± 1.27	**< 0.001**
Lower Premolar	306 (65.5)	86 (18.4)	41 (8.8)	17 (3.6)	17 (3.6)	0.61 ± 1.03	
Upper Molar	242 (51.8)	98 (21.0)	65 (13.9)	20 (4.3)	42 (9.0)	0.98 ± 1.28	**< 0.001**
Lower Molar	173 (37.0)	125 (26.8)	76 (16.3)	44 (9.4)	49 (10.5)	1.30 ± 1.33	

* Comparison based on a signed rank test.

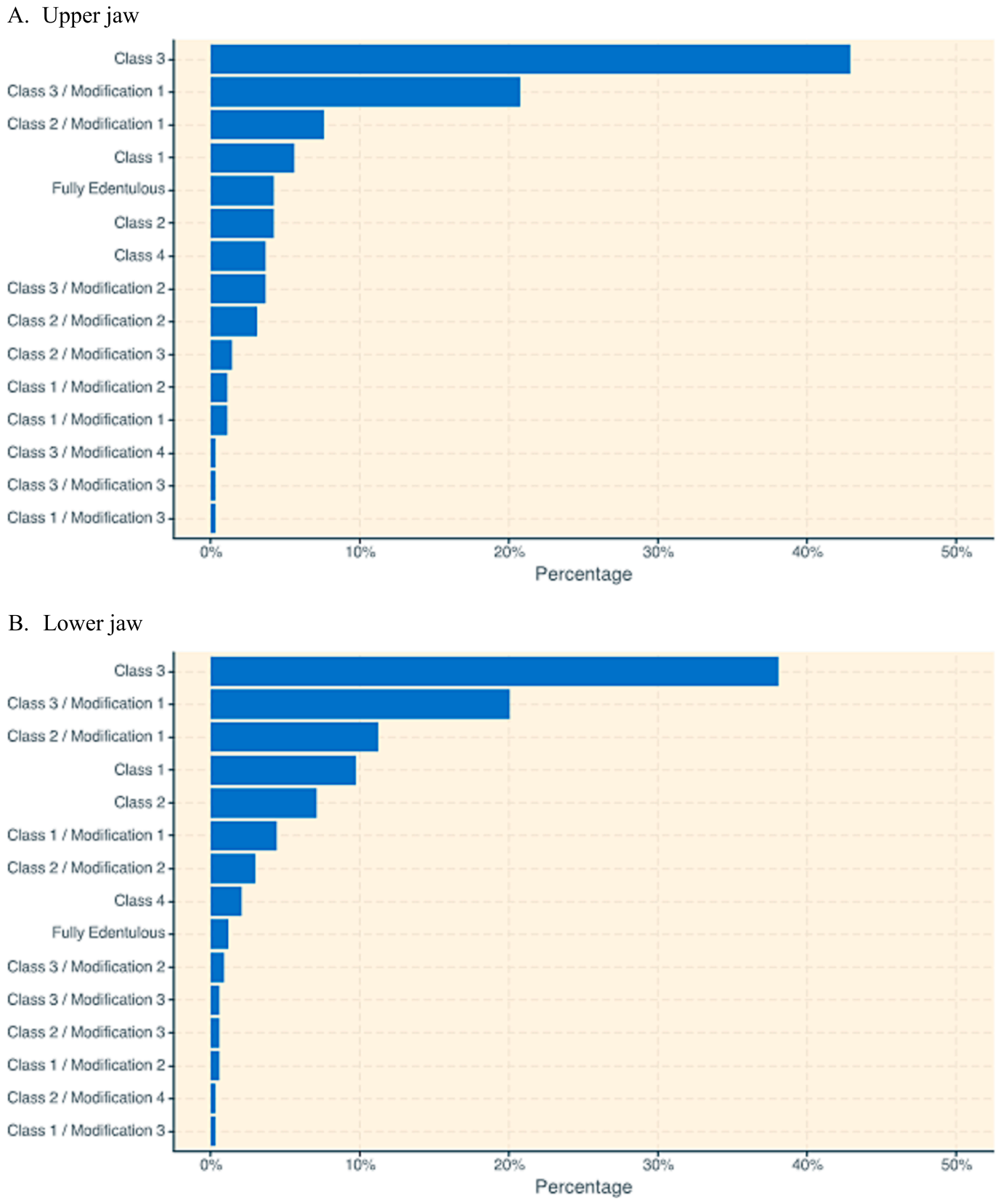

Fig. 1. The percentage of patients with Kennedy classification and modifications for the upper and lower jaws (n = 467).

Table 4
Predictors of the number of missing teeth in the upper, lower, and full mouth (both jaws) (n = 467).

Variable	Upper Jaw		Lower Jaw		Full Mouth	
	aIRR (95 % CI)	p-value	aIRR (95 % CI)	p-value	aIRR (95 % CI)	p-value
Age, years	1.05 (1.04, 1.05)	**< 0.001**	1.04 (1.03, 1.04)	**< 0.001**	1.04 (1.04, 1.05)	**< 0.001**
Sex						
Female	Reference	–	Reference	–	Reference	–
Male	1.07 (0.88, 1.3)	0.51	1.06 (0.86, 1.30)	0.61	1.07 (0.91, 1.25)	0.43
Smoker, yes	1.24 (1.01, 1.51)	**0.04**	1.11 (0.90, 1.38)	0.34	1.17 (1.00, 1.37)	**0.06**
Teeth Brushing Daily, yes	0.78 (0.64, 0.96)	**0.02**	0.76 (0.61, 0.95)	**0.01**	0.77 (0.65, 0.90)	**< 0.001**
Education						
High education (Bachelor's degree or higher)	Reference	–	Reference	–	Reference	–
Low education (High school or lower)	1.31 (1.10, 1.56)	**< 0.001**	1.33 (1.11, 1.60)	**< 0.001**	1.32 (1.15, 1.52)	**< 0.001**

documented that older adults without a high school diploma showed a higher complete tooth loss rate (31.9 %) versus those with high school or further education (9.5 %). (Fleming et al., 2020). Similarly, another study in the UK discovered an inverse relationship between the level of education and tooth loss later in life (Matsuyama et al., 2019). Providing education to promote good oral hygiene practices and preventive dental care can help increase tooth retention (Ou et al., 2022). Additionally, dental care services can also play a key role by offering accessible services to all individuals, regardless of their education level or socioeconomic status (Ghanbarzadegan et al., 2021).

Our study exhibits several strengths, including comprehensive data collection using both surveys and clinical examinations from a geographically diverse sample across Jordan, a relatively high response rate, and the structured training of data collectors by the primary investigator. However, the study has a few limitations. First, we used a cross-sectional design, which precludes establishing causality. Second, a chance was present for potential biases due to issues with self-reporting and patients' inaccurate knowledge about their pattern of tooth loss. Third, a possibility existed of unmeasured confounding factors in our observational study, which could have affected the outcomes.

5. Conclusions

In conclusion, this study sheds light on partial edentulism in Jordan and contributes to a broader understanding of oral health issues and the factors influencing tooth loss. The study underscores the necessity of comprehensive oral health education and the provision of accessible dental services, emphasizing the need for public health strategies that address both individual behaviors and broad socioeconomic factors. Future comprehensive epidemiological studies and targeted interventions by healthcare systems need to focus on at-risk groups such as older individuals, people in low socioeconomic classes, and individuals with inadequate oral hygiene practices. Findings from this study, while specific to Jordan, reflect global trends in dental health and offer influential insights for other regions facing similar challenges in oral health care.

Ethical statement

The institutional review board approval was obtained from Jordan University of Science and Technology (IRB number: 691/2021) for all procedures on humans performed in this cross-sectional study. The procedures followed the Declaration of Helsinki. The subjects were informed and asked to participate prior to inclusion and gave consent agreement for participation.

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CRediT authorship contribution statement

Anas Alibrahim: Funding acquisition, Conceptualization, Supervision, Methodology, Project administration. **Hamza Al Salieti:** Investigation, Data curation, Writing – original draft, Writing – review & editing. **Mohammad Alrawashdeh:** Methodology, Data curation, Formal analysis, Writing – original draft, Writing – review & editing. **Hisham Darweesh:** Investigation, Writing – original draft. **Hussein Alsaleh:** Investigation, Writing – original draft.

Declaration of competing interest

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

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Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sdentj.2023.12.010.

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