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Bereich für Oralmedizin, zahnärztliche Röntgenologie und Chirurgie
der Medizinischen Fakultät Charité – Universitätsmedizin Berlin

DISSERTATION

Oral health status among newly arrived refugees in Germany

„Mundgesundheitszustand neu angekommener Flüchtlinge in Deutschland“

zur Erlangung des akademischen Grades
Doctor medicinae dentariae (Dr. med. dent.)

vorgelegt der Medizinischen Fakultät
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von

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aus Syrien

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Contents (Inhaltsverzeichnis):

List of Abbreviations (Abkürzungsverzeichnis):

AIC:	Akaike's information criterion
BIC:	Bayesian information criterion
CPI:	Community Periodontal Index
DMFS:	Decayed, Missing and Filled Surface Index
DMFT:	Decayed, Missing and Filled Teeth Index
DMS V	Fünfte Deutsche Mundgesundheitsstudie
DT:	Decayed Teeth
DZI	Institut der Deutschen Zahnärzte
FS:	Filled Surfaces
FT:	Filled Teeth
GLM:	Generalized linear model
KAP:	Knowledge, Attitude and Practice
MT:	Missing Teeth
NBRM:	Negative binomial regression model
OHI-S:	Oral Hygiene Index
OLR:	Ordered logistic regression
SD:	Standard Deviation
RC:	Regression Coefficient
WHO:	World Health Organization

Abstrakt (Deutsch):

Zielsetzung:

Ziel dieser Studie war die Bestimmung des Mundgesundheitszustands neu angekommener Flüchtlinge in Deutschland, sowie die Untersuchung ihrer Kenntnisse, Einstellungen und Verhaltensweisen bezüglich der oralen Hygiene.

Methodik:

Alle Teilnehmer (n = 386) waren Erwachsene im Alter zwischen 18 und 60 Jahren, die aus Syrien oder dem Irak stammen und innerhalb eines Jahres vor Teilnahme an der Studie in Deutschland als Flüchtlinge anerkannt wurden. Die Studie umfasste eine klinische zahnärztliche Untersuchung sowie eine Umfrage über Kenntnisse, Einstellungen und Verhaltensweisen zur Mundhygiene. Die Umfrage wurde anhand eines ins Arabische übersetzten Fragebogens durchgeführt.

Ergebnisse:

87.5% der Teilnehmer hatten unbehandelten Karies. Der durchschnittliche DMFT Wert lag bei 6.38 mit durchschnittlich 4.00 kariösen, 1.46 fehlenden und 0.92 gefüllten Zähnen. 79% der Teilnehmer hatten Plaque in allen sechs Sextanten, 60% hatten Zahnstein in mindestens drei Sextanten und sechs Prozent zeigten Zahnschmelz-Fluorose in unterschiedlichen Ausprägungsgraden. Es bestand eine signifikante Assoziation des DMFT Wertes mit dem Alter der Studienteilnehmer (Regressionskoeffizient 0.031, P-Wert <0.001) sowie mit dem Grad ihrer Ausbildung (Regressionskoeffizient -0.019, P-Wert 0.037). Frauen hatten im Vergleich zu Männern signifikant weniger fehlende Zähne (Regressionskoeffizient -0.398, P-Wert 0.001). Die Teilnehmer hatten generell ein gutes Wissensniveau und eine gute Einstellung zur Mundhygiene, es zeigte sich jedoch eine große Diskrepanz zwischen ihrem Wissen und ihren Verhaltensweisen.

Schlussfolgerung:

Die Untersuchung und Befragung der Studienteilnehmer zeigt eine hohe Prävalenz an unbehandeltem Karies sowie eine unzureichende Mundhygiene bei neu angekommenen Flüchtlingen in Deutschland. Die Studie empfiehlt daher, dass Programme zur Gesundheitsförderung von Flüchtlingen zum einen die Motivation zur Mundhygiene beinhalten sollten, zum anderen die Unterstützung der Flüchtlinge durch angemessene Orientierung, vorzugsweise in ihrer Muttersprache, um den Zugang zu zahnmedizinischer Versorgung im Aufnahmeland zu ermöglichen.

Abstract (English):

Background:

The objectives of this study were to determine the status of oral health among newly arrived refugees in Germany and to explore their knowledge, attitude and practices on oral hygiene.

Methods:

All participants (n = 386) were adults, 18-60 years of age, coming from Syria and Iraq and registered as refugees in Germany within one year prior to the enrollment in the study. Clinical oral assessments in addition to a survey on knowledge, attitude and practice were carried out. The survey was conducted through a questionnaire translated into Arabic.

Results:

Eighty seven point five percent of the participants had untreated caries. The mean DMFT score was 6.38 with DT, MT and FT showing mean scores of 4.00, 1.46 and 0.92 respectively. Seventy nine percent had bacterial plaque in all six sextants, sixty percent had calculus in at least three sextants and six percent showed various magnitudes of enamel fluorosis. DMFT score was significantly associated with age (Regression Coefficient 0.031, *P*-value <0.001) and with education (Regression Coefficient -0.019, *P*-value 0.037) and females had significantly less missing teeth (Regression Coefficient-0.398, *P*-value 0.001) compared to males. The participants had in general high levels of knowledge and attitude on oral hygiene. The findings however showed a gap between their knowledge and practice.

Conclusions:

The findings show high prevalence of untreated caries and poor oral hygiene among newly arrived refugees in Germany. The study recommends to lay emphasis on motivation in oral health promotion campaigns among refugees and to provide them with adequate guidance, preferably in their native language, on how to access oral health care in the host country.

Summary (Manteltext):

1. Introduction:

Oral health is considered to be an integral part of public health. The reciprocal interaction between the two is evident as oral diseases have impact on general health and many systematic diseases tend to have oral manifestations [1].

Studies have shown that oral diseases are highly prevalent among asylum seekers and refugees in western industrialized countries. Common oral conditions include dental caries, periodontal diseases and dental trauma [2-9].

The aim of this research was to shed light on the oral health among newly arrived refugees coming from Syria and Iraq in Germany. Likewise, the study was meant to survey their knowledge, attitude and practice on oral hygiene.

1.1. Study rationale:

Bearing in mind the recent refugee crisis in Europe, the study was among the first endeavors to address the oral health among the growing refugee populations in Germany and Europe. The study had the following rationale:

- Oral diseases could significantly reduce the quality of life of the individuals and impose a heavy economic load on the existing health services in the host county [1].
- Taking into account the large numbers of newly arrived refugees and asylum seekers, refugee health has become a major public health concern in Europe. This is particularly relevant to Germany for having the major share of asylum seekers in the European Union [10].
- Studies have shown the place of origin to have a significant impact on the status of oral health among refugee populations [6-9]. The two groups of population included in the study may represent unique characteristics including some certain dietary and cultural habits like the abundance of high-sugar [11] and tobacco consumption [12] and the paucity of alcohol abuse [13] in addition to the comparatively adequate health care and education in the country of origin before the erupt of the civil conflict. These somewhat unique characteristics could insinuate specific needs.

- Until the time of conducting this study, no data was available on the status of oral health among refugees in Germany in general, and those coming from Syria and Iraq in particular. Furthermore, very few studies have been conducted on this topic in the two countries of origin [14]. This paucity of literature proposed a gap in knowledge.
- Along with similar studies, this doctoral project could mount up evidence and assist decision-makers in Europe to develop medium- and long-term health policies for this population at risk, in addition to short-term responses for future crises.

1.2. Previous studies on oral health among refugee populations:

As shown in table 1, several studies were conducted on oral health of refugees. In general, these studies have demonstrated a higher prevalence of dental caries and periodontal diseases among refugees compared to their counterparts in the host population [2-9]. One exception however were refugees coming from Africa. A study on the newly arrived Ethiopian refugees in Israel showed the prevalence of dental caries to be significantly less among refugees compared to the host population. Over eighty percent of the Ethiopian children and adolescents included in the study had no caries [5]. Another study in the USA found that newly arrived refugees from Africa had significantly less caries compared to their Eastern European counterparts or to the host population [8]. Both studies attributed this low prevalence of dental caries to the low sugar intake in the country of origin.

In addition to the geographical region of origin, studies have shown significant associations between oral health indices and other socio-demographic characteristics including age, gender and education. In this regard, a study in Italy showed that older refugees had significantly higher mean decayed, missing and filled teeth index (DMFT) scores, as well as, significantly higher mean Oral Hygiene Index (OHI-S) scores compared to younger refugees [6]. Another study in Australia showed that younger and more educated refugees had significantly lower mean decayed, missing and filled surface (DMFS) index scores compared to their older and less educated counterparts. On the other hand, the study found males to have significantly lower mean number of filled surfaces (FS) compared to females [7].

Studies have also shown a lower utilization of health services among refugees compared to the host populations [3,6-9]. This was attributed to a variety of reasons including the lack of financial resources, the lack of guidance on how to access the health services in the host

country, the social isolation associated with not being able to speak the language and having different priorities during the resettlement period [3,6-9].

1.3. Current studies on oral health among refugee populations:

Since the beginning of our study in 2016, similar studies have been conducted in parallel to determine the status of oral health among newly arrived refuges in Germany and Europe [15-17]. In addition to the prevalence of dental caries and periodontal diseases, some of these studies aimed at putting together an estimate of the expected cost of dental care in the host country [16,17]. However, none of these studies has explicitly addressed the oral health behaviors among refugees.

- In May 2015, a cross-sectional study was conducted in Melilla, Spain. The study included 156 participants (children and adolescents coming from Syria). Three quarters of the children and half of the adolescent had dental caries. The reported mean DMFT was 3.2 for children and 1.6 for adolescent. The authors proposed the need to implement an all-embracing program for primary oral health care [15].
- Between August 2016 and July 2017, a cross-sectional study was conducted in Schleswig-Holstein, Germany. The study included 102 participants (adults, mainly males, coming from nine different countries of origin). The mean DMFT score was 6.89, almost half of the participants had dental pain and the vast majority needed dental treatment, for which the author proposed an estimate of an average cost of 205.86 Euro for conservative treatment and of 588 Euro for prosthetic treatment per refugee [16].
- Between December 2016 and February 2017, a cross-sectional study was conducted in four German federal states including Mecklenburg-Vorpommern, Berlin, Nordrhein-Westfalen and Hessen. The study included 544 participants (Children, adolescents and adults coming from twenty-eight different countries of origin). The mean DMFT scores were 2.87, 7.43, 10.55 and 14.92 for the age groups 13-17, 18-34, 35-44 and 45-64 respectively. The presence of plaque, supra-gingival calculus was abundant and the vast majority of older participants had periodontal diseases. The estimated cost of treatment for refugees varied depending on the age group ranging from 177.65 Euro for a 3 years old child to 1759.31 Euro for an adult aging between 45 and 64 years. The authors recommended early interventions and preventive measures in order to improve the oral health of this population at risk [17].

Table 1: A summary of previous studies on oral health among refugee populations in the last decades

Authors	Year of publication	Host country	Country of origin	Study population	Oral indices examined	Main findings
Selikowitz and Gjermo [2] †	1985	Norway	Vietnam	200 participants (Adolescents, adults and elderly)	Remaining teeth Presence of plaque, sub-gingival calculus, gingival bleeding and periodontal pockets	Participants had in average between 27.8 and 24.6 remaining teeth depending on the age group (fairly lower than the host population). The presence of plaque, sub-gingival calculus and gingival bleeding was abundant. Older participants had periodontal pockets with higher probing depth values.
Heidmann and Christensen [3] ††	1985	Denmark	Turkey Pakistan	446 participants (Children and adolescents)	DMFS Utilization of health services	DMFS scores among participants were higher in primary teeth and lower in permanent teeth compared to their counterparts in the host country. Participants showed lower utilization of health services (more broken or interrupted appointments).
Zimmerman et al. [4] †	1988	Sweden	Chile Poland	285 participants (Only adults)	Remaining teeth, DS, FS Presence of periodontal pockets	Higher prevalence of dental caries and periodontal diseases compared to the host population. One third of the participants had periodontal pockets with higher probing depth than 5mm.
Sgan-Cohen et al. [5] †	1992	Israel	Ethiopia	171 participants (Children, adolescents and adults)	DMFT Bacterial counts in saliva	Participants had significantly less caries compared to the host population due to the sugar free diet in the country of origin (86.8% of children, 81,8% of adolescents and 54% of adults had no caries).
Angelillo et al. [6] †	1996	Italy	Morocco Senegal Yugoslavia	252 participants (Only adults)	DMFT DMFS OHI-S	The prevalence of dental carries (DMFT and DMFS scores) significantly varied depending on the country of origin.

						Mean DMFT scores for Moroccan and Yugoslavs significantly increased with age. Older Yugoslavs had higher OHI-S scores compared to their younger counterparts.
Marino et al. [7] †	2001	Australia	Vietnam	158 participants (Only adults)	DMFS CPI	DMFS scores were significantly higher in older and less educated refugees. Females showed significantly higher FS scores. Older, less educated and male refugees tend to have higher CPI scores (could not be tested for statistical significance due to the small sample size).
Cote et al. [8] ††	2004	USA	Africa Eastern Europe	224 participants (Children and adolescents)	Presence of dental caries, oral pain, gingival bleeding and calculus	African participants had significantly less caries compared to their Eastern European counterparts or to the host population. Refugee children tend to have access to medical care before dental care. Hence, pediatricians should pay special attention to the risk of oral diseases.
Davidson et al. [9] ††	2006	Australia	Yugoslavia Iraq Kosovo Bosnia/Herzegovina Vietnam	5243 participants (Adolescents, adults and elderly)	DMFT	Higher prevalence of dental caries and periodontal diseases compared to the host population. Oral assessment and treatment should be carried out on arrival and refugees should be actively integrated in community based oral health programmes.

† Cross-sectional study
†† Retrospective secondary data analysis
CPI: Community Periodontal Index
DMFS: Decayed, Missing and Filled Surface Index
DMFT: Decayed, Missing and Filled Teeth Index
DS: Decayed Surface Index, FS: Filled Surfaces Index
OHI-S: Oral Hygiene Index

2. Patients and Methods:

The recent inquiry was designed as a cross-sectional study in late 2015. The study was carried out between July and December 2016 and comprised two parts:

- A clinical examination to determine the status of oral health
- A structured interview to identify the knowledge, attitude and practices (KAP) on oral hygiene

2.1. Study sample:

386 newly arrived refugees coming from Syria and Iraq and registered as refugees in Germany within one year prior to the enrollment in the study. Only adults between 18-60 years of age were included in the study. Other age groups including children, adolescents and elderly were excluded. Although this might be considered as a limitation of this study, nonetheless, it was knowingly decided to exclude these age groups in order to smooth the progress of the ethical approval in order to be able to begin the study at the peak of the refugee crisis. The sample size was calculated by means of the following formula for prevalence surveys [18]:

$$n = Z^2 P (1-P) / d^2$$

where:

- n = sample size
- Z = 1.96 (level of confidence 95%)
- P = 0.5 (expected proportion in population)
- d = 0.05 (precision)

The resulting number (n = 386) corresponded to a fraction of almost three percent of the total number (n = 115647) of Syrians and Iraqis who were registered as refugees in Germany in 2015 [19].

The sample size calculation was included in the initial study design and was thereof approved by the ethical committee at Charité based on the recommendation of the statistical advisor at the Institute of Biometry and Clinical Epidemiology.

2.2. Informed consent and ethical approval:

Prior to their recruitment into the study, all participants were handed out two documents:

- A written informed consent
- A study information sheet including a declaration on data privacy.

Both documents were in Arabic and German. Participants were required to sign the written informed consent before they could be enrolled in the study. At the end of their participation, they were given detailed information concerning the status of their own oral health, motivation on oral hygiene, and guidance on how to access oral health care in their locality as well as on health insurance providers and the extent of coverage they are entitled to as registered refugees in Germany. This work was approved by the ethics committee at Charité Universitätsmedizin Berlin (Ethics committee vote EA1/081/16).

2.3. Recruitment of the study participants:

Participants were recruited in refugee reception centers, shelters and private practices in Berlin (table 2). The refugee reception centers and shelters were contacted in advance seeking cooperation. Upon their consent, recruitment days were agreed upon and announcements were distributed one week in advance summarizing the study objectives as well as the inclusion criteria. In addition, a room was provided upon request to carry out the clinical examinations and the structured interviews. Potential participants were recruited on site. Upon their informed consent, clinical oral examinations were carried out. These were directly followed by a structured interview conducted in their native language to identify the knowledge, attitude and practices on oral hygiene.

Table 2: The locations where study participants were recruited

Place of recruitment	Number of participants (Percentage)
Ankunftszentrum Bundesallee	5 (1.30)
Notunterkunft für Flüchtlinge Köpenicker Allee	59 (15.28)
Notunterkunft für Flüchtlinge Marzahner Chaussee	31 (8.03)
Notunterkunft für Flüchtlinge Ruschestraße	94 (24.35)
Notunterkunft für Flüchtlinge Tempelhof *	169 (43.78)
Notunterkunft für Flüchtlinge Treskowallee	5 (1.30)
Private practices in Berlin	23 (5.96)
Total number of particpants	386 (100.00)

* Notunterkunft Tempelhof was meant as a refugee reception center *Erstaufnahmeeinrichtung*, i.e. to host asylum seekers only during the first period after their arrival in the host country. However, due to the complicated situation associated with the high influx of asylum seekers in 2015-2016, this center was also used as long term refugee shelters *Notunterkunft für Flüchtlinge*.

2.4. Clinical oral assessments:

In order to determine the status of oral health, five indicators were clinically investigated:

- DMFT index
- Bacterial plaque
- Supra-gingival calculus
- Dental trauma
- Enamel fluorosis

The clinical examination was visually conducted with naked eye following World Health Organization WHO recommendations for oral health surveys [20,21]. This was carried out by means of two flat single-use mouth mirrors (Single Sterile Dental Examination Mirror PE9710, Kerr, USA) and an artificial light (ML4 LED Head-light with Head-band, J-008.31.411, Heine, Germany). The clinical examination did not involve periodontal probing in order to avoid the risk of dental-induced bacteremia and subsequently infective endocarditis in susceptible participants [22-24].

2.4.1. Intra-examiner concordance:

The oral examinations of all participants were carried out by one examiner. He has a Master of Science degree in public health, a dental license in Germany and speaks Arabic as his native language. In order to evaluate the intra-examiner concordance, twenty-three participants, all of which recruited in private practices, were recalled for a second assessment by the same examiner. The two assessments were carried out using the same settings. Upon comparison, the resulting intra-class correlation coefficient was 0.94. This corresponded to an "*almost perfect*" level of agreement using Landis and Koch-Kappa Benchmark Scale [25].

2.4.2. DMFT Index:

The prevalence of dental caries was determined by the use of DMFT index. This index was proposed by WHO as a valuable epidemiological instrument for oral health surveys. It comprises three components [20,21]:

- D component stands for *Decayed* and includes all teeth that have primary caries or secondary caries subsequent to a filling.
- M component stands for *Missing* and includes all teeth missing due to caries among participants younger than thirty years of age, and all teeth missing due to caries or for any other reason among participants aging thirty years and older.
- F component stands for *Filled* and includes all filled teeth without subsequent caries.

Third molars, teeth with fissure sealant, crowns, bridges and unerupted teeth were not included in the scoring.

2.4.3. Bacterial plaque and supra-gingival calculus:

The periodontal status was determined by the use of two indices, bacterial plaque and supra-gingival calculus. The mouth was divided into six sextants; in each, the labial/buccal and lingual/palatinal surfaces of an index tooth were examined (figure 1).

16 or 17	**11**	**26 or 27**
46 or 47	**31**	**36 or 37**

Figure 1: Schematic outline of the index teeth in each sextant.

Sextants with no teeth were excluded. Bacterial plaque and supra-gingival calculus were accordingly recorded upon presence. This has resulted in two ordinal scales, each has seven values:

- 0 = Not observed
- 1 = Observed on one sextant
- 2 = Observed on two sextants
- 3 = Observed on three sextants
- 4 = Observed on four sextants
- 5 = Observed on five sextants
- 6 = Observed on six sextants

2.4.4. Dental Trauma:

Participants were screened for traumatic dental injuries. These were accordingly classified into six categories [20,21]:

- 0 = No sign of injury
- 1 = Treated injury
- 2 = Enamel fracture only
- 3 = Enamel and dentine fracture
- 4 = Pulp involvement
- 5 = Missing tooth due to trauma

2.4.5. Enamel fluorosis:

Participants were also screened for enamel fluorosis. Upon their presence, the associated lesions were classified into six categories based on Dean's index [20,21]:

- 0 = Normal
- 1 = Questionable "*slight aberrations from the translucency of normal enamel*"
- 2 = Very mild "*small, opaque, paper-white areas scattered irregularly over the tooth but involving less than 25% of the labial tooth surface*"
- 3 = Mild "*more extensive but covers less than 50% of the tooth surface*"
- 4 = Moderate "*marked wear and brown stain*"
- 5 = Severe "*enamel surfaces are badly affected*"

2.4.6. Intervention urgency:

Based on WHO recommendations for oral health surveys, the intervention urgency was put into five categories following the clinical assessment [20,21]:

- 0 = No treatment needed
- 1 = Preventive or routine treatment needed
- 2 = Prompt treatment (including scaling) needed
- 3 = Immediate (urgent) treatment needed due to pain or infection of dental and/or oral origin and
- 4 = Referred for comprehensive evaluation or medical/dental treatment (systemic condition)

2.5. KAP survey on oral hygiene:

In recent years, the knowledge, attitude and practices (KAP) surveys have been increasingly used as an important tool in oral health promotion, as well as, in research on practices, norms and habits associated with oral diseases [26-31]. The KAP survey in our study was conducted in the course of a structured interview. The interviews took place on site immediately after the clinical examinations. Participants were interviewed in their native language by the same examiner conducting the clinical examinations. These interviews were based on a questionnaire. This questionnaire was put forward for adults by WHO [32] and adjusted to be compatible with our study. It comprised three parts (table 3):

- Knowledge: This included three questions on participants´ knowledge concerning tooth brushing and flossing.
- Attitude: This included four questions on their attitude towards the impact of tooth brushing on oral health, the impact of oral health on general health, when to visit the dentist and how they perceived the status of their own oral health.
- Practice: This included four questions concerning their practices, including the use of toothbrush, the frequency and method of tooth brushing and the use of fluoride containing toothpaste.

2.5.1. KAP scoring scheme:

KAP surveys are conventionally used for qualitative analysis. However, in order to enable a quantitative analysis of participants' answers, a scoring scheme was applied, in which:

- Giving a correct answer was granted a plus point
- Giving a incorrect answer was granted a minus point
- Giving no answer was granted a zero point

The scoring scheme was specifically developed for the study in analogy with previous studies using KAP surveys on oral health [29-31].

This enabled the statistical analysis by creating three scores (discrete variables):

- Knowledge score: accepting a range from -3 to +3
- Attitude score: accepting a range from -4 to +4
- Practice score: accepting a range -4 to +4

Table 3: KAP survey questions, answers and points scoring scheme.

Question		Answers	Score
Knowledge	What should one use for cleaning his/her teeth?	▪ Toothbrush	+1
		▪ Miswak	-1
		▪ Others (finger, charcoal or wooden toothpicks)	-1
	When should one brush his/her teeth?	▪ Once or less a day	-1
		▪ Twice or more a day	+1
	In addition to brushing, should one floss his/her teeth?	▪ Yes	+1
		▪ No	-1
		▪ I don't know	0
Attitude	Do you think that brushing your teeth improves your dental health?	▪ Yes	+1
		▪ No	-1
		▪ I don't know	0
	Do you think dental problems can affect general health?	▪ Yes	+1
		▪ No	-1
		▪ I don't know	0
	How often should one visit a dentist?	▪ Regularly	+1
		▪ Whenever there is a problem	-1
		▪ I don't know	0
	How would you describe the state of your teeth and gums?	▪ Participant's answer showed a proper perception of his/her own oral health	+1
		▪ Participant's answer showed a considerable over or underestimation of his/her own oral health	-1
		▪ Participant answered: I don't know	0
Practice	What do you use for cleaning your teeth?	▪ Toothbrush	+1
		▪ Miswak	-1
		▪ Others (finger, charcoal or wooden toothpicks)	-1
	How do you brush your teeth?	▪ Up and down circular motion, involving gums	+1
		▪ Left to right, horizontal direction	-1
		▪ I don't know	0
	How often do you clean your teeth?	▪ Once or less a day	-1
		▪ Twice or more a day	+1
	Do you use toothpaste containing fluoride?	▪ Yes	+1
		▪ No	-1
		▪ I don't know	0

2.5. Statistical analysis:

The statistical analysis was carried out using Stata 13.0 software (Stata, Texas, USA).

With regard to the descriptive epidemiological parameters, means and standard deviations were used to present DMFT, DT, MT and FT scores, valid percentages were used to describe the presence of plaque and calculus (13 missing values that occurred due to missing indicator teeth were omitted) while percentages were used to present other indicators including fluorosis, dental trauma and intervention urgency (no missing values were present).

The study included three kinds of outcomes or dependent variables:

- Count outcomes including DMFT, DT, MT and FT:

In order to enhance the validity of the regression model used, a Count-fit test using Stata was conducted. The test compares the mean observed and predicted count using the Akaike's information criterion (AIC) and the Bayesian information criterion (BIC). It showed a preference of negative binominal regression (NBRM) over other models usually used for count outcomes (Poisson regression, zero-inflated Poisson regression and zero-inflated negative binominal regression) with a very strong evidence. Therefor NBRM was used to test for the associations of count outcomes (DMFT, DT, MT and FT) with socio-demographic characteristics of the study population (age, country of origin, gender and education).

- Ordinal outcomes including calculus and plaque:

An ordered logistic regression model (OLR) was employed to test for the associations with socio-demographic characteristics of the study population. The model is among few regession models that maintain the information conveyed in the ordering. A shortcoming of this model is the possibility of containing cells that may be small for reliable estimates. In this context, we have applied two tests of goodness of fit for ordinal logistic regression: an ordinal version of the Hosmer-Lemeshow test (P-value = 0.944 for calculus and P-value = 0.899 for plaque showing a good fit for both dependent variables) and the Lipsitz test (P-value = 0.991 for calculus and P-value = 0.368 for plaque showing a good fit for both dependent variables). With the aim of improving the validity of the analysis, we added a second model for ordinal outcomes, Multilevel mixed-effects generalized linear model (Family: ordinal, Link:

complementary log-log), to test for the associations of calculus and plaque with socio-demographic characteristics. The two models have shown matching significant associations for all characteristics.

- Discrete outcomes accepting negative values (KAP scores):

A multivariate linear regression was used to test for associations with socio-demographic characteristics of the study population. The associations resulting from the multivariate linear regression have shown a perfect matching as being tested using a Generalized linear regression for variables with negative values. However, only the multivariate linear regression is included in order to keep the results easily readable.

For all regression models used in the study, a P-value < 0.05 was considered significant.

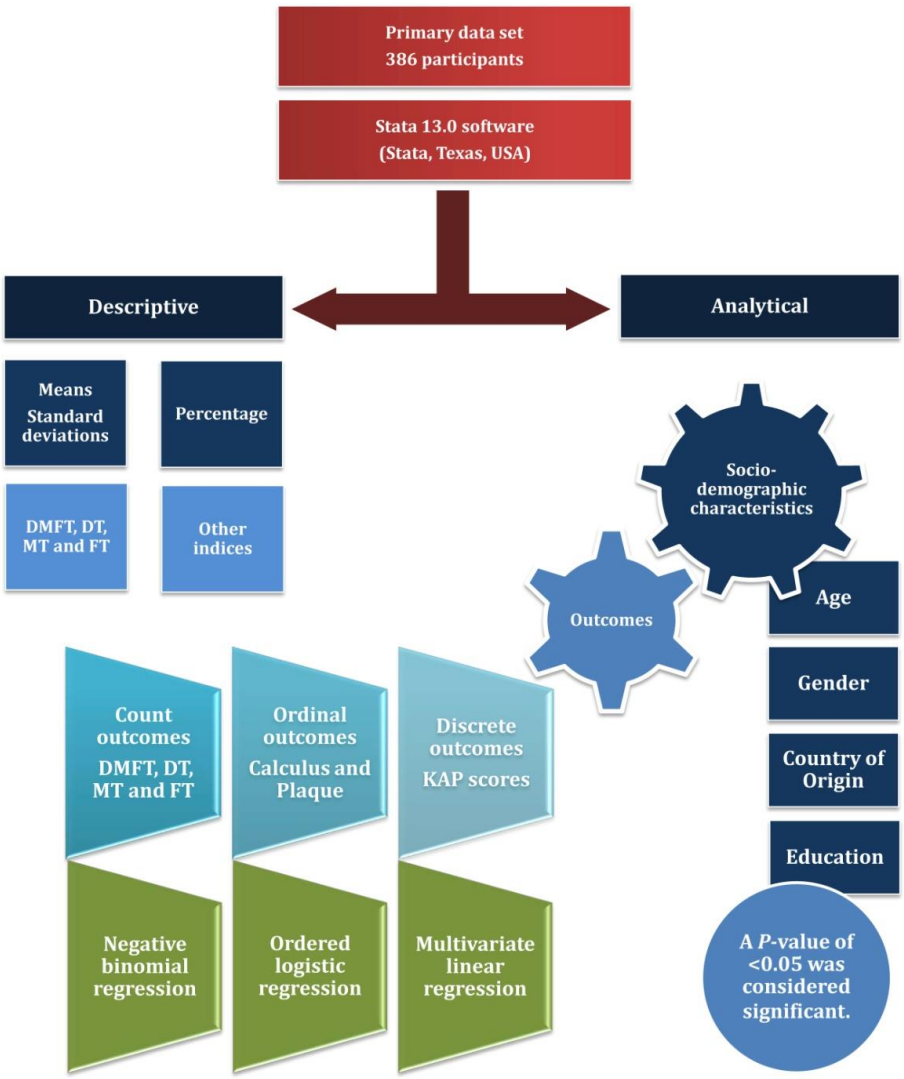

Figure 2: A flow chart illustrating the statistical analysis in the study.

3. Results:

3.1. Socio-demographic characteristics:

The socio-demographic characteristics of participants including the country of origin, gender, age and educational level are shown in detail in table 4. The majority of participants were Syrians (61.9%) while 38.1% came from Iraq. One fifth (19.9%) were females while 80.1% were males. Most participants were young adults with 42% between 18-24 years of age. Only 5.4% had no education, 18.4% had at least one year of elementary education. More than half (53.3%) had preparatory or secondary education and 22.8% had at least one year of university education (figure 3).

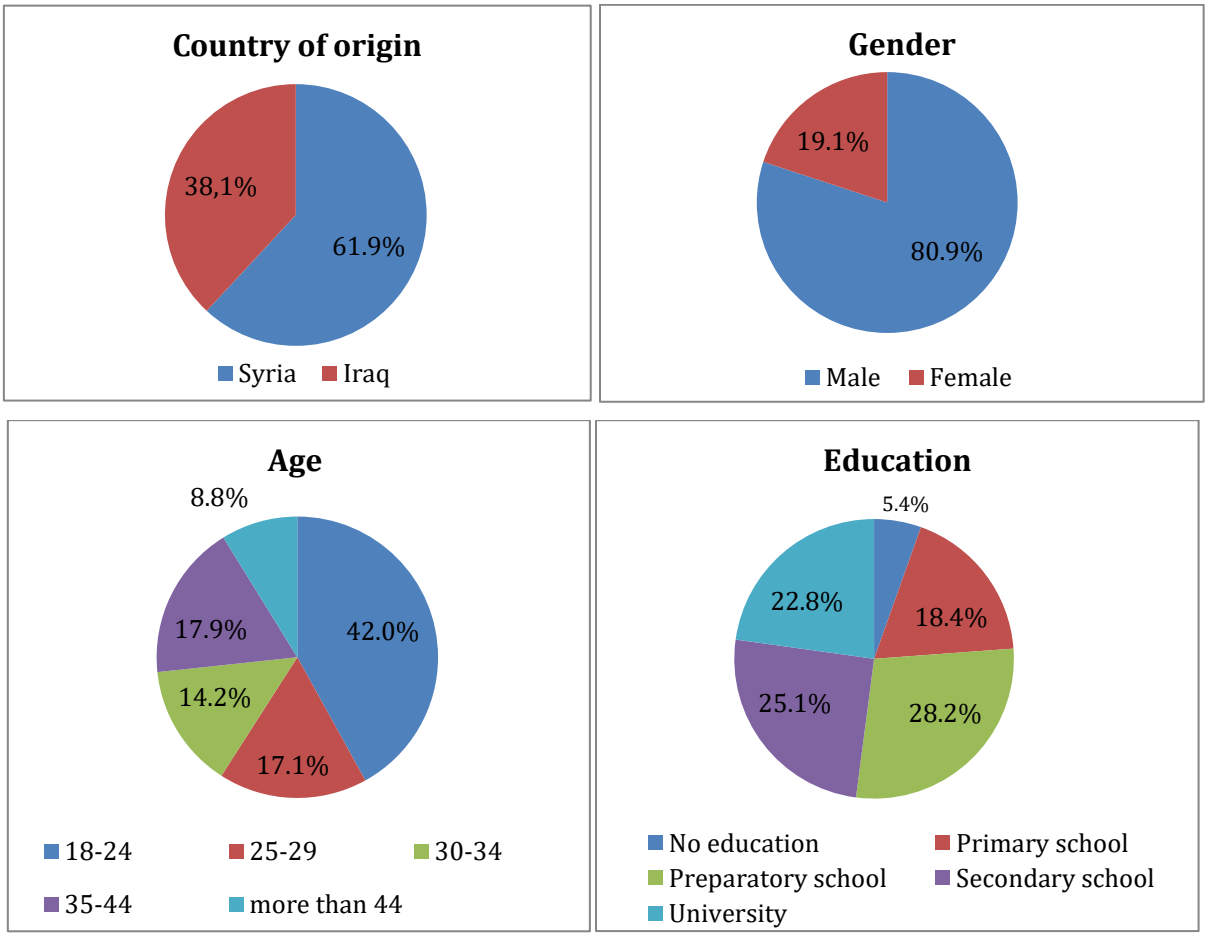

Figure 3: The socio-demographic characteristics of the study participants.

Table 4: Socio-demographic characteristics of the study participants (n = 386)

Characteristics		**Number (Percentage)**
Country of origin	Syria	239 (61.9)
	Iraq	147 (38.1)
Gender	Male	309 (80.1)
	Female	77 (19.9)
Age group in years	18-24	162 (42.0)
	25-29	66 (17.1)
	30-34	55 (14.2)
	35-44	69 (17.9)
	more than 44	34 (8.8)
Educational level (years in school)	No education	21 (5.4)
	Primary school (1-6)	71 (18.4)
	Preparatory school (7-9)	109 (28.2)
	Secondary school (10-12)	97 (25.1)
	University (more than 12)	88 (22.8)

3.2. Main findings on oral health indices and KAP survey:

A detailed epidemiological description of the main findings is shown in table 5. In general, the participants showed high prevalence of untreated caries (87.50%). On average the DMFT score was 6.38 while DT, MT and FT showed a mean value of 4.00, 1.46 and 0.92 respectively (figure 4). Most participants presented poor oral hygiene (figures 5 and 6) with a high prevalence of bacterial plaque (observed in six sextants in 78.85% of the participants) and supra-gingival calculus (observed in at least three sextants in almost 60% of the participants). Only one participant (0.26%) reported missing teeth due to dental trauma while 95.60% have shown no sign of injury (figure 7). Likewise, the vast majority of participants (94.04%) showed no enamel fluorosis while 1.04, 0.78, 2.33, 1.30 and 0.52% of the participants respectively presented questionable, very mild, mild, moderate and severe degrees of fluorosis (figure 8). About one tenth of the participants (10.88%) were in need for immediate treatment due to pain or infection, more than half (52.33%) were in need for

prompt treatment and about one third (32.12%) needed preventive or routine treatment (figure 9).

Participants were interviewed to evaluate their knowledge, attitude and practice on oral hygiene. The participants showed a considerably high level of knowledge with 98.19% reporting the need to use a toothbrush and 80.83% reporting the need to brush their teeth twice or more a day. However, only one fifth (19.17%) thought that flossing would be an important addition to tooth brushing (figure 10). Likewise, the participants have shown high levels of attitude on oral hygiene with 91.19% reporting their belief of tooth brushing improving dental health, 64.51% reporting they believe that dental problems can affect the general health and 61.92% exhibiting a proper perception of their own oral health. On the other hand, more than half (53.63%) believed that they should not regularly visit a dentist, rather only when there is a problem (figure 11). The participants showed a low level with regard to their practices with 52.85% reporting horizontal tooth brushing, 40.93% reporting tooth brushing once or less a day and only 2.85% reporting the use of a fluoride containing toothpaste. The vast majority (95.08%) however did not put emphasis on the fluoride content of their toothpaste (figure 12).”

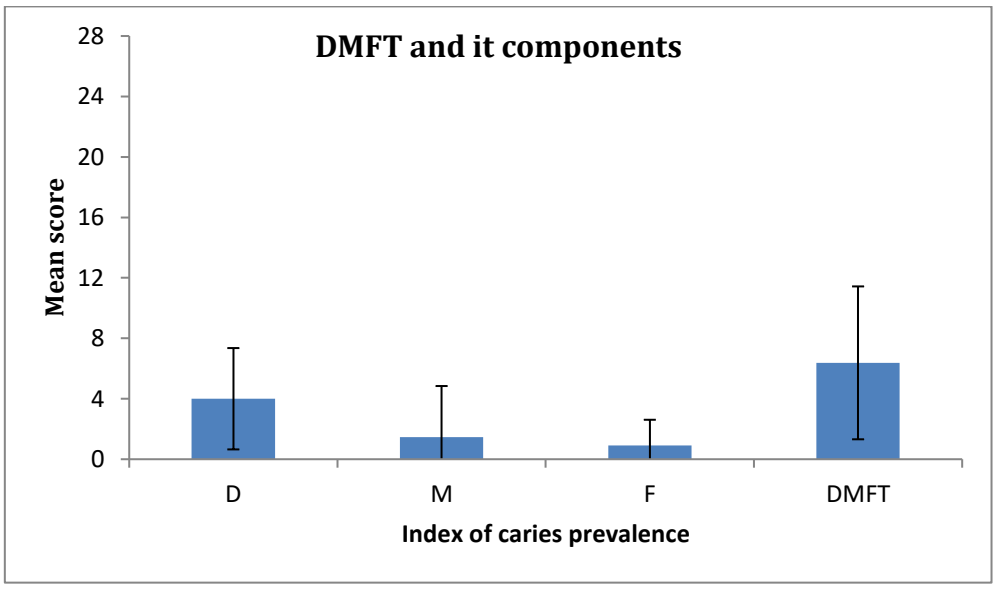

Figure 4: DMFT and its components in means.

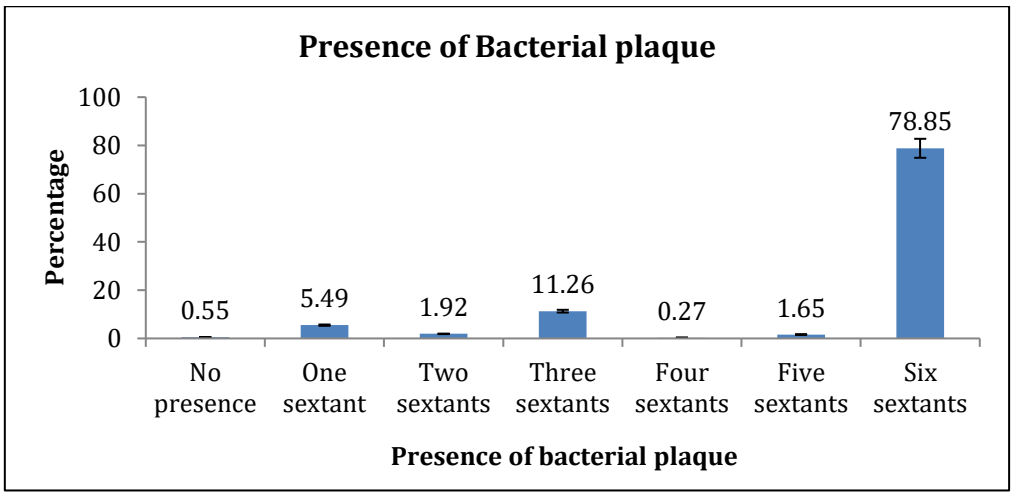

Figure 5: The presence of bacterial plaque in valid percentages.

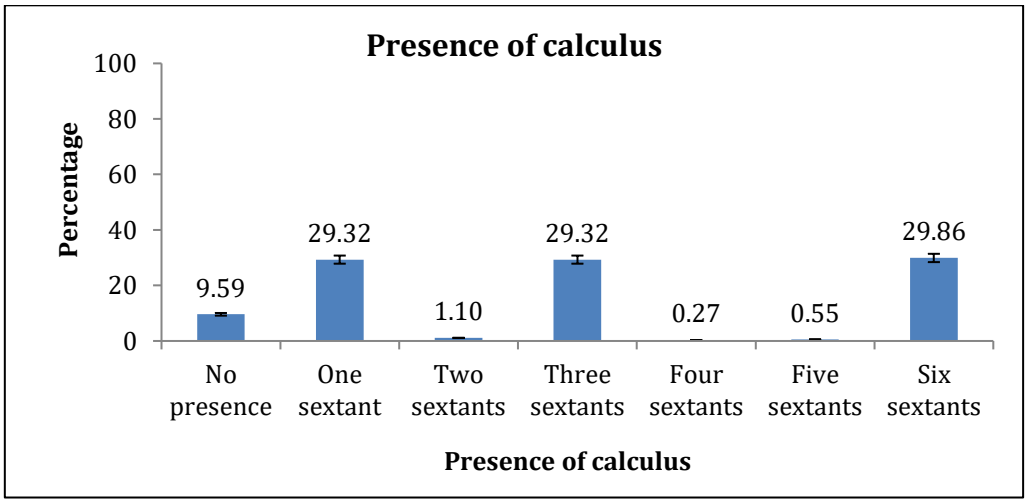

Figure 6: The presence of calculus in valid percentages.

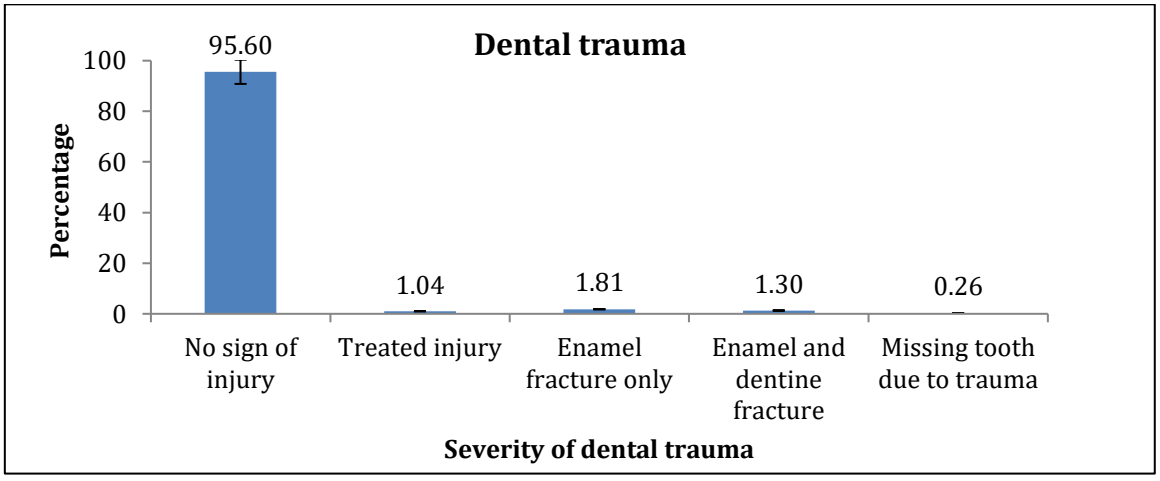

Figure 7: The presence of dental trauma in percentages.

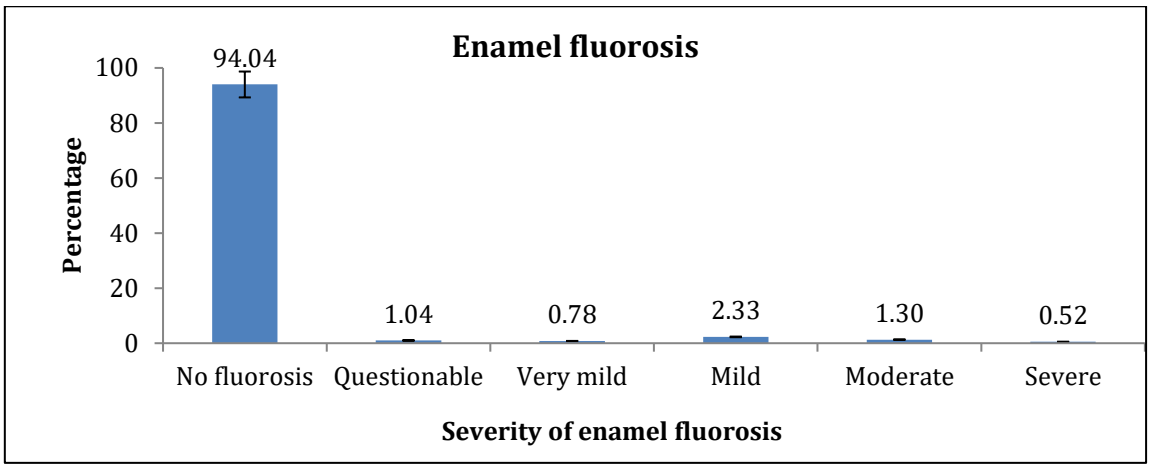

Figure 8: The presence of enamel fluorosis in percentages.

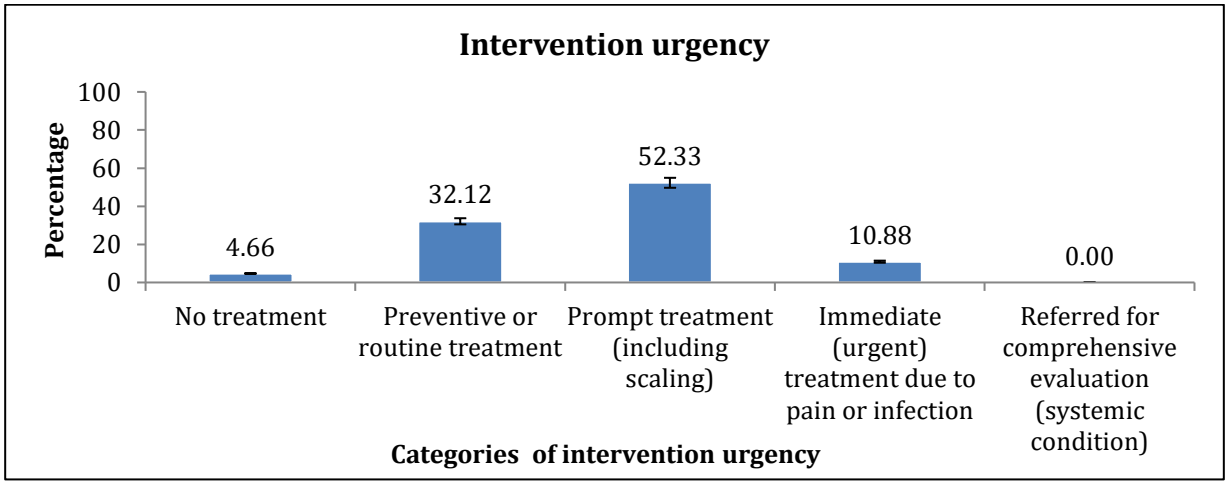

Figure 9: The intervention urgency in percentages.

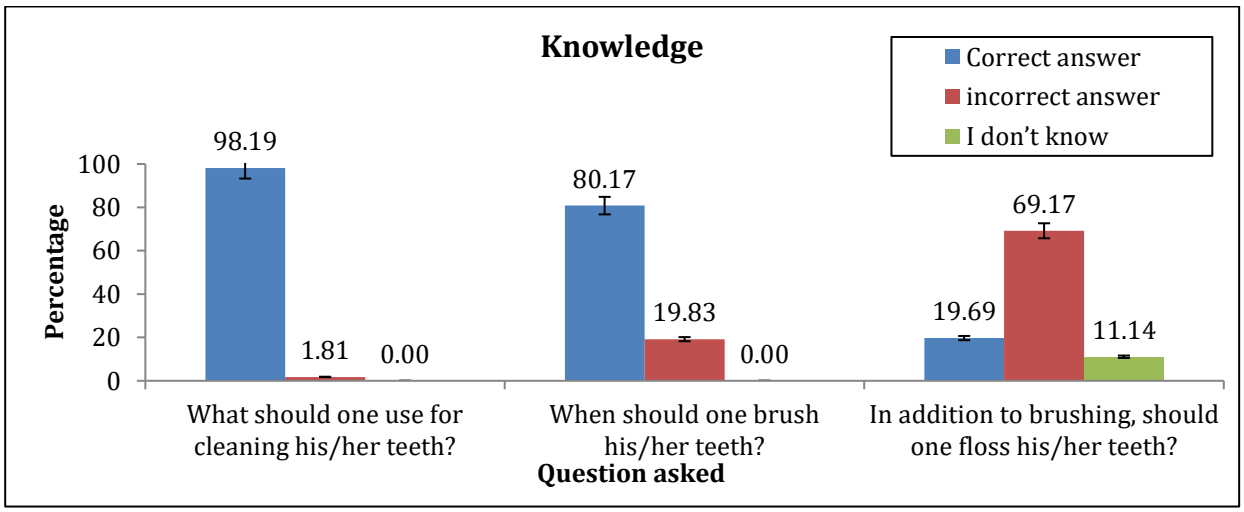

Figure 10: Percentages of participants' answers to knowledge section of KAP survey.

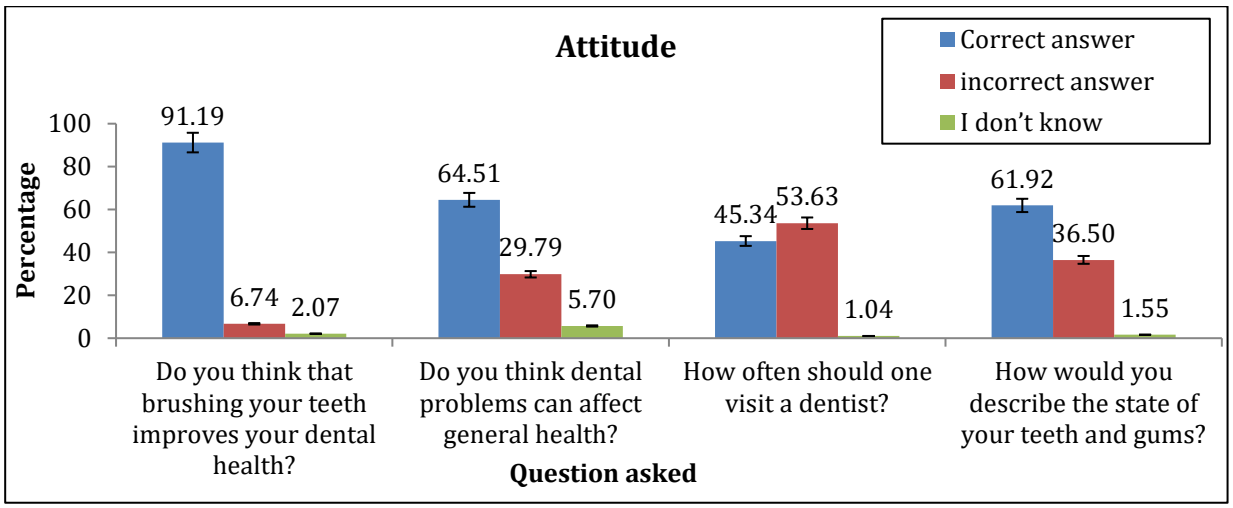

Figure 11: Percentages of participants' answers to attitude section of KAP survey.

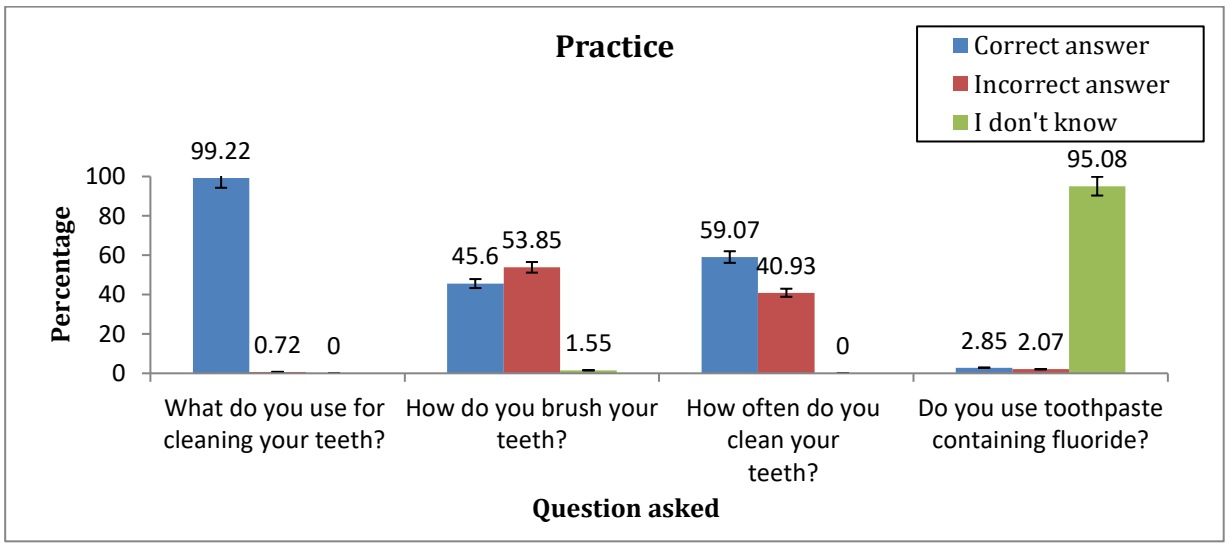

Figure 12: Percentages of participants' answers to practice section of KAP survey.

Table 5: Oral health status and KAP survey (n = 386)

Oral health index		**Number**
Caries prevalence, mean (SD)	DMFT	6.38 (5.058)
	DT	4.00 (3.352)
	MT	1.46 (3.388)
	FT	0.92 (1.694)
Presence of bacterial plaque, n (%)	No plaque observed	2 (0.55)
	Plaque observed on one sextant	20 (5.49)
	Plaque observed on two sextants	7 (1.92)
	Plaque observed on three sextants	41 (11.26)
	Plaque observed on four sextants	1 (0.27)
	Plaque observed on five sextants	6 (1.65)
	Plaque observed on six sextants	287 (78.85)
Presence of calculus, n (%)	No calculus observed	35 (9.59)
	Calculus observed on one sextant	107 (29.32)
	Calculus observed on two sextants	4 (1.10)
	Calculus observed on three sextants	107 (29.32)
	Calculus observed on four sextants	1 (0.27)
	Calculus observed on five sextants	2 (0.55)
	Calculus observed on six sextants	109 (29.86)
Dental trauma, n (%)	No sign of injury	369 (95.60)
	Treated injury	4 (1.04)
	Enamel fracture only	7 (1.81)
	Enamel and dentine fracture	5 (1.30)
	Pulp involvement	0 (0.0)
	Missing tooth due to trauma	1 (0.26)

Enamel fluorosis, n (%)	Normal	363 (94.04)
	Questionable	4 (1.04)
	Very mild	3 (0.78)
	Mild	9 (2.33)
	Moderate	5 (1.30)
	Severe	2 (0.52)
Intervention urgency, n (%)	No treatment needed	18 (4.66)
	Preventive or routine treatment	124 (32.12)
	Prompt treatment (including scaling)	202 (52.33)
	Immediate treatment due to pain or infection	42 (10.88)
	Referred for comprehensive evaluation	0 (0.0)
KAP Questionnaire		
Question	**Answer**	**Number**
What should one use for cleaning his/her teeth? n (%)	Toothbrush *	379 (98.19)
	Miswak **	7 (1.81)
	Others (finger, charcoal or wooden toothpicks) **	0.0 (0.0)
When should one brush his/her teeth? n (%)	Once or less a day **	74 (19.17)
	Twice or more a day *	312 (80.83)
In addition to brushing, should one floss his/her teeth? n (%)	Yes *	76 (19.69)
	No **	267 (69.17)
	I don’t know	43 (11.14)
Do you think that brushing your teeth improves your dental health? n (%)	Yes *	352 (91.19)
	No **	26 (6.74)
	I don’t know	8 (2.07)
Do you think dental problems can affect general health? n (%)	Yes *	249 (64.51)
	No **	115 (29.79)

	I don't know	22 (5.70)
How often should one visit a dentist? n (%)	Regularly *	175 (45.34)
	Whenever there is a problem **	207 (53.63)
	I don't know	4 (1.04)
How would you describe the state of your teeth and gums? n (%)	Participant's answer showed a proper perception of his/her own oral health *	239 (61.92)
	Participant's answer showed a considerable over or underestimation of his/her own oral health **	141 (36.5)
	Participant answered: I don't know	6 (1.55)
What do you use for cleaning your teeth? n (%)	Toothbrush*	382 (99.22)
	Miswak **	3 (0.78)
	Others (finger, charcoal or wooden toothpicks) **	0.0 (0.0)
How do you brush your teeth? n (%)	Up and down circular motion, involving gums *	176 (45.60)
	Left to right, horizontal direction **	204 (52.85)
	I don't know	6 (1.55)
How often do you clean your teeth? n (%)	Once or less a day **	158 (40.93)
	Twice or more a day *	228 (59.07)
Do you use toothpaste containing fluoride? n (%)	Yes *	11 (2.85)
	No **	8 (2.07)
	I don't know	367 (95.08)

DMFT: Decayed, Missing or Filled Teeth

DT: Decayed Teeth

MT: Missing Teeth

FT: Filled Teeth

SD: Standard Deviation

(%) All percentages in this table are valid percentages (cases with missing index teeth were excluded)

* Correct answer

** Incorrect answer

3.3. Significant associations shown in the study:

The significant associations between caries prevalence and socio-demographic characteristics are shown in table 6. In this regard, DMFT, DT, MT and FT scores were found to have significant associations with age (P-value <0.001, 0.047, <0.001 and <0.001 respectively) as well as with education (P-value 0.037, 0.047, 0.003 and 0.045 respectively). Older participants showed significantly higher DMFT, DT, MT and FT scores while those with more education showed significantly lower DMFT, DT, MT and higher FT scores. There was no significant difference between Syrians and Iraqis while females had significantly less missing teeth (P-value 0.001) (figure 13).

The significant associations of oral hygiene indices including the presence of bacterial plaque and supra-gingival calculus with socio-demographic characteristics are shown in table 7. The presence of bacterial plaque was significantly less among younger participants, those with higher education and females compared to their counterparts (P-value 0.009, 0.028 and 0.013 respectively). Likewise, the presence of calculus was significantly less among younger participants, those with higher education and females compared to their counterparts (P-value <0.001, 0.019, <0.001 respectively). No significant variation was found between Syrians and Iraqis with regard to the presence of bacterial plaque (P-value 0.576). However, Iraqis showed significantly less calculus compared to their Syrian counterparts (P-value 0.018).

The significant associations of KAP scores with socio-demographic characteristics are shown in table 8. In this regard, knowledge scores were significantly higher among females and those with higher education compared to males and those with lower education (P-value 0.034 and <0.001 respectively). Attitude scores were significantly higher among older participants, Syrians and those with higher education compared to their younger, Iraqi and less educated counterparts (P-value 0.005, 0.005 and <0.001 respectively). On the other hand, practice scores were significantly higher among females and those with higher education (P-value 0.001 and <0.001 respectively) (figure 14).

Table 6: Association of DMFT and its components with socio-demographic characteristics (Negative binomial regression model, n = 386)

Variables	DMFT	DT	MT	FT
	Regression Coefficient (Standard error), P-value			
Increase in age per year (continuous variable)	0.031 (0.003), < 0.001	0.008 (0.004), 0.047	0.089 (0.010), < 0.001	0.043 (0.013), < 0.001
Country of origin (ref. Syrians)	-0.013 (0.078), 0.873	-0.165 (0.091), 0.069	0.657 (0.203), 0.112	0.001 (0.222), 0.997
Gender (ref. Male)	0.003 (0.091), 0.975	0 .070 (0.106), 0.507	-0.398 (0.250), 0.001	0.382 (0.246), 0.121
Increase in education per year (continuous variable)	-0.019 (0.009), 0.037	-0.021 (0.010), 0.047	-0.069 (0.023), 0.003	0.050 (0.025), 0.045
Overall model Pseudo R-squared value, P-value	0.035, < 0.001	0.006, 0.022	0.093, < 0.001	0.012, 0.001

DMFT: Decayed, Missing or Filled Teeth

DT: Decayed Teeth

MT: Missing Teeth

FT: Filled Teeth

Table 7 :Association of calculus and plaque with socio-demographic characteristics (n = 365*)

Variables	Model 1 (OLR)		Model 2 (Multilevel mixed-effects GLM)	
	Calculus	**Plaque**	**Calculus**	**Plaque**
	Odds ratios (95% Confidence Interval), P-value		Regression Coefficient (Standard error), P-value	
Increase in age per year **	1.060 (1.035-1.085), < 0.001	1.046 (1.011-1.082), 0.009	0.028 (0.006), < 0.001	0.018 (0.007), 0.008
Country of origin (ref. Syrians) **	0.610 (0.410-0.917), 0.018	0.856 (0.496-1.477), 0.576	-0.350 (0.126), 0.006	-0.053 (0.123), 0.667
Gender (ref. Male) **	0.298 (0.182-0.487), < 0.001	0.471 (0.260-0.852), 0.013	-0.658 (0.151), < 0.001	-0.332 (0.144), 0.021
Increase in education per year **	0.946 (0.904-0.991), 0.019	0.930 (0.872-0.992), 0.028	-0.031 (0.013), 0.018	-0.032 (0.013), 0.019
Pseudo R-squared value, P-value	0.048, < 0.001	0.029, 0.002		
Wald Chi-squared, P-value			42.02, < 0.001	15.70, 0.003
Hosmer-Lemeshow test: Estimate, P-value ***	37.729, 0.944****	40.382, 0.899****		
Lipsitz test: Estimate, P-value ***	2.022, 0.991****	9.787, 0.368****		

OLR: Ordered logistic regression

GLM: Generalized linear model

* Cases with missing index teeth were excluded

** The two models are showing matching significant associations

*** Goodness of fit test for ordinal logistic regression model

**** P-value is showing the model to be a good fit

Table 8: Association of knowledge, attitude and practice with socio-demographic characteristics (Multivariate linear regression) (n = 386)

Variables	Knowledge	Attitude	Practice
	Regression Coefficient (Standard error), P-value		
Increase in age per year (continuous variable)	-0.002 (0.006), 0.729	0.029 (0.010), 0.005	-0.010 (0.008), 0.187
Country of origin (ref. Syrians)	-0.157 (0.124), 0.206	-0.595 (0.213), 0.005	-0.132 (0.160), 0.408
Gender (ref. Male)	0.312 (0.146), 0.034	0.093 (0.250), 0.710	0.633 (0.189), 0.001
Increase in education per year (continuous variable)	0.055 (0 .0140), < 0.001	0.0920 (0.024), < 0.001	0.086 (0.018), < 0.001
Overall model R-squared value, P-value	0.064, < 0.001	0.089, < 0.001	0.096, < 0.001

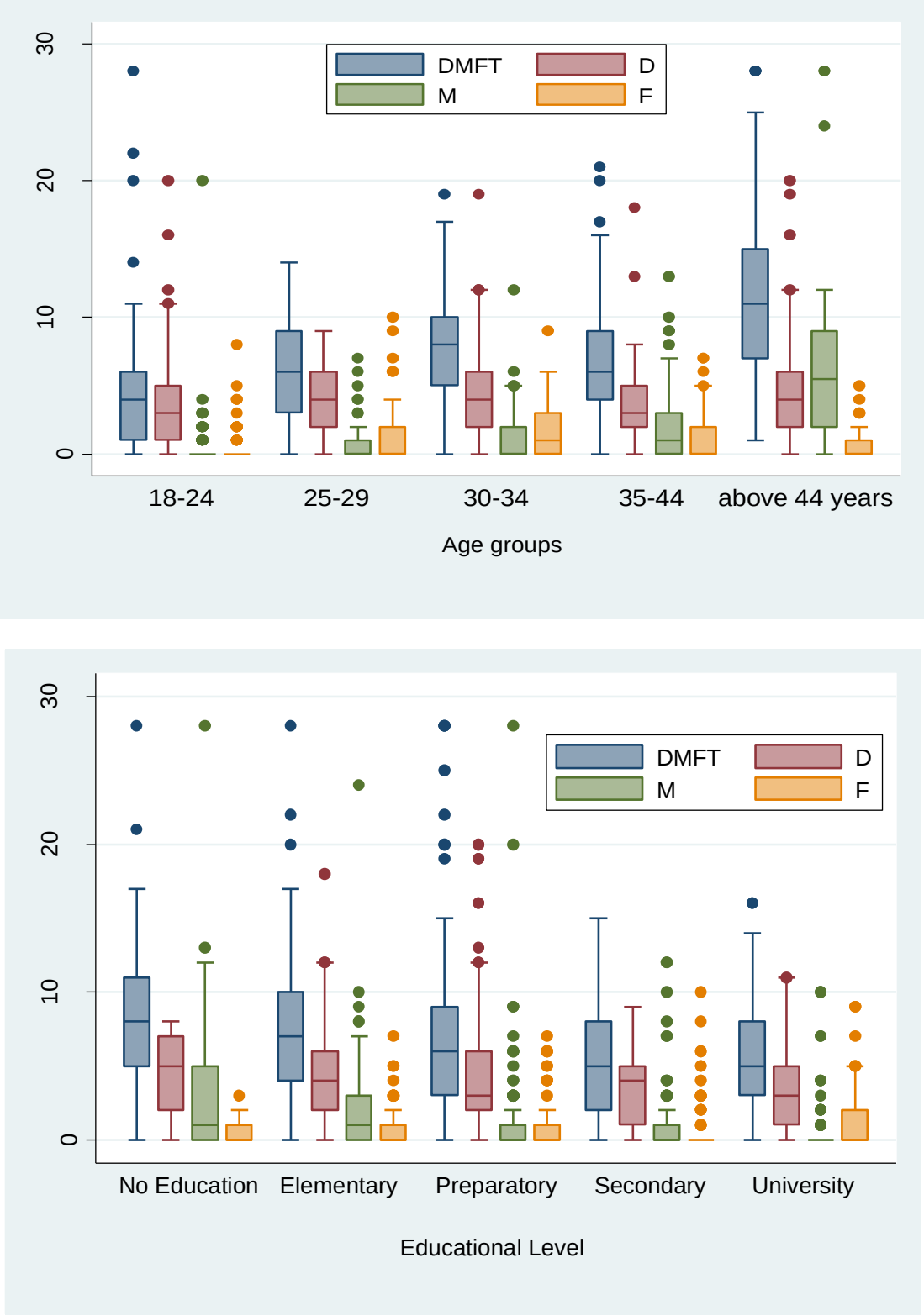

Figure 13: Box plots illustrating the variations in caries prevalence (DMFT, DT, MT and FT mean scores) among socio-demographic groups (age groups and educational level).

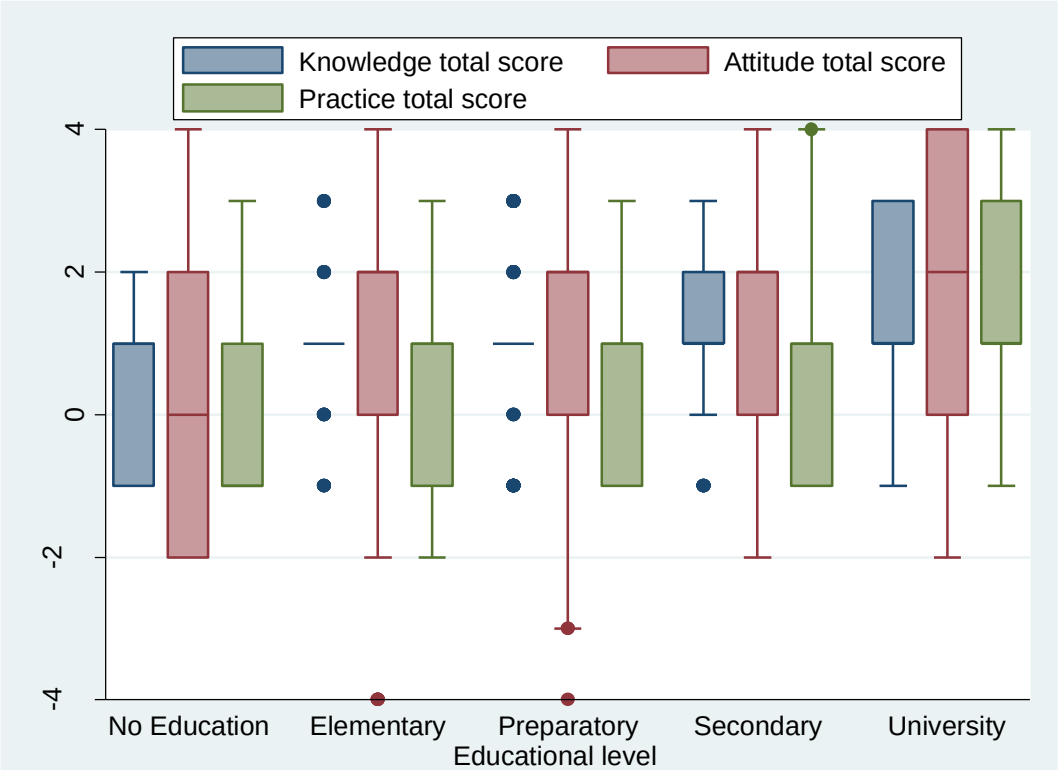

Figure 14: Box plots illustrating the variations in KAP scores according to the educational level.

4. Discussion:

4.1. Comparison with parallel studies in Germany:

As mentioned earlier, two other studies were conducted in parallel on oral health of refugees in Germany [16,17] We have found a high prevalence of untreated caries (87.5%) among adult participants (18-60 years of age). Likewise, a prevalence of 86.3% was reported by Goetz et al [16] and a prevalence of 85.5% was reported by Splieth et al [17] for comparable age groups (16-64 and 18-64 years of age respectively). On the other hand, the overall mean DMFT score in our study was 6.38. The different age groups included in our study (18-24, 25-29, 30-34, 35-44 and 44-60) were found to have different mean DMFT scores (4.28, 6.36, 7.80, 6.99 and 12.82 respectively). In this context, Goetz et al reported an almost equal overall mean DMFT score (6.89) while Splieth et al reported a slightly higher mean scores (7.43 10.55 and 14.92) for the comparable age groups (18-34, 35-44 and 45-64 respectively). This

variation could be attributed to the inclusion of refugees coming from eastern European countries of origin in the later study. The literature has suggested this group of population to have higher prevalence of caries compared to their counterparts from the middle-east.

With regard to periodontal status, we found the presence of bacterial plaque and calculus to be abundant. Most participants in our study had plaque in all six sextants (78.8%) and calculus in at least one sextant (90.4%). Similar findings were reported by Splieth et al. The authors examined the presence of bacterial plaque on the dental surfaces of the anterior maxillary teeth, for which plaque was reported to be present in 82% of young adults (18-34 years) and 73% of adults (35-44 years). Likewise, the authors found the presence of supra-gingival calculus to be abundant. A prevalence of 71.1%, 71.35 and 90.4% was reported in the age groups comparable to our study (18-34, 35-44 and 45-64 respectively). On their part, Goetz et al did not give an account on periodontal status neither did any of two studies report on the presence of dental trauma and enamel fluorosis.

Concerning the intervention urgency and treatment needs, almost eleven percent of the participants in our study were found to need immediate treatment due to pain or infection. Upon comparison, around five percent of the participants were reported by Splieth et al to need immediate treatment due to acute pain. This variation could be attributed to the different categories' definitions used by each study.

We found significant associations between socio-demographic characteristics and oral health indices. The younger and more educated participants showed significantly less caries prevalence and better oral hygiene compared to the older and less educated. Males showed significantly more missing teeth and worse oral hygiene compared to females. On their part, Splieth et al reported comparable differences in caries prevalence and periodontal status depending on the age group and the geographical region of origin. However, the authors did not test these variations for statistical significance.

4.2. Comparison with the host population in Germany:

The most recent and comprehensive data on oral health among the host population in Germany were mainly provided through the Fifth German Oral Health Study (Fünfte

Deutsche Mundgesundheitsstudie, DMS V) conducted by the Institute of German Dentists (IDZ). The study is carried out regularly and provides an important insight into oral health indicators among five age groups in Germany including adolescents (12 years), young adults (35-44 years), young elderly (65-74 years), older elderly (75-100 years) in addition to older elderly with care needs. Furthermore, the study investigates the potential associations of oral health indices with socio-demographic characteristics and behavioral settings [33].

Children, adolescents and elderly were excluded in our study. Accordingly, only oral health indices among the adult population could be compared in both studies. The mean DMFT score among young adults was shown in DMS V to be 11.2 [33]. This mean value reads considerably higher compared to DMFT mean scores among participants in our study (6.99 for young adults and 6.38 for adults as a whole). A rather accurate account however shows that the refugee population in our study has exhibited considerably higher rates of untreated caries (DT 3.81 for young adults and 4.00 for adults as a whole) and lower rates of filled teeth (FT 1.10 for young adults and 0.92 for adults as a whole) compared to its German counterparts (DT 0.5 and FT 8.6). The number of missing teeth was relatively the same between the two populations (MT 2.1 for German young adults compared to MT 2.07 for refugee young adults and 1.46 for refugee adults as a whole).

With regard to periodontal status, DMS V has surveyed the prevalence of periodontitis among the German population. This was carried out using case definitions developed by the Center for Disease Control and Prevention and the American Academy of Periodontology. As a result, the study has shown around half (52%) of the young adults to represent at least moderate periodontitis [33]. On the contrary, no periodontal probing was carried out in our study. However, our findings have shown poor oral hygiene among refugees with high presence of bacterial plaque and supra-gingival calculus.

Concerning oral health behaviors, 80.3% of German young adults reported brushing their teeth at least twice a day compared to 68.12 % of young adults and 59.07% of adults as a whole in our study. Furthermore, 72% of the German young adults reported they regularly visit a dentist for dental checkups compared to 55.07% of young adults and 45.34% of adults as a whole in our study.

Another interesting aspect to compare between the two populations are the significant associations of oral health indices and behaviors with socio-demographic characteristics provided by the two studies. In this regard, DMFT, MT and FT scores were significantly higher among young female adults compared to their male counterparts (P-value <0.001, 0.005 and 0.004 respectively) while DT scores were the other way around (P-value <0.001). However, these association were concluded using Mann–Whitney U test and no multivariate analysis including other socio-demographic characteristics was conducted, to control for potential confounders. On the other hand, young female adults in Germany seemed to have more favorable oral hygiene behaviors including on tooth brushing and regular dental checkups compared to males (P-value <0.001 and <0.001 respectively). Likewise, these associations were concluded using Pearson's chi-squared test and no multivariate analysis including other socio-demographic characteristics was conducted, to control for potential confounders.

The authors have also reported more advanced levels of gingival disease among male young adults in Germany compared to their female counterparts. Nonetheless, no test of association was reported. Concerning the educational level, the study has found higher DMFT scores as well as more advanced periodontitis among German young adults with lower education (P-value 0.001 and <0.001 respectively). These associations were concluded using Pearson's chi-squared test. A multivariate analysis was then carried out to investigate the potential associations of educational level, monthly income and occupational position with caries experience and periodontal status. As a result, no significant association was found between educational level and periodontal status among German young adults. However, those with higher education were shown to have a significantly lower caries experience compared to those with intermediate or lower education [33].

4.3. Potential implications on future health policies:

The accumulation of scientific evidence, to which our study has contributed, shows that newly arrived refugees in Germany are at high risk of oral diseases [2-9,15-17]. Our study has found a high prevalence of untreated caries and poor oral hygiene among adult refugees. Other studies have suggested similar findings among refugee children in Germany and Europe [15-17]. The studies have shown that oral health status is related to pre-arrival as well as post

arrival conditions. Among the post arrival conditions suggested are the long waiting periods asylum-seekers have to go through before being accepted as refugees in the host country, not being able to access the health services due to linguistic, legal or financial barriers and different setting of priorities as refugees tend to concentrate on the integration into the host country rather than on their own oral health [2-9, 34-38].

From a legal point of view, recognized refugees in Germany are entitled of oral health coverage equal to that of the German citizens. However, during the waiting periods before being recognized as refugees, asylum-seekers are only entitled of treatment due to pain or acute complaint [39]. In addition to the potential negative impact imposed by this lack of full access during the waiting periods on refugees' health [6,7,34-36,38], a study has suggested that it could be more economically efficient for Germany to provide full health access to asylum seekers during the waiting periods [40]. Even among those entitled of full health coverage, studies have shown lower rates of utilization of health services among refugees compared to the host population [3,6-9]. This proposes the need for active inclusion of refugees in the existing oral health services especially for the most vulnerable subgroups like children, adolescents, elderly and women. The active inclusion could be feasible through community based health services and integration of regular oral assessments within the nurseries, kindergartens, schools and residential and nursing homes for elderly [7,34]. In addition, it is important to provide refugees and asylum seekers with adequate guidance, if possible in their native language, on how to access the health services in the host country. This is especially important for asylum seekers during the first period after their arrival [7,34] as studies have suggested that a considerable percentage of them may have acute or sub-acute pain due to oral conditions [16,17].

We tried in our study to address the knowledge, attitude and practices on oral hygiene among participants. Acknowledging the fact that different refugee groups would probably insinuate different needs, our findings could however be used to set up oral health promotion campaigns especially designated for adults refugees coming from the Middle East and North Africa. These campaigns should lay emphasis on motivation focusing on tooth brushing at least twice a day, the use of fluoride-containing toothpaste, tooth flossing as a compliment to the tooth brushing and regular visits and check-ups by a dentist even in the absence of pain or acute conditions.

4.4. Potential implications on future research:

The study investigated oral health among newly arrived refugees in Germany. This could provide baseline data for future investigations in the coming years on the integration of refugees in oral health services. In the course of conducting this research, three main issues emerged as prospective themes for upcoming inquiries:

- The need for further investigations on the impact of pre-arrival conditions dependant on the geographical region of origin. These are to primarily include certain dietary and cultural habits like high sugar, tobacco or alcohol consumption.

- The need for further investigations on the impact of arrival and post-arrival conditions dependant on the host country. These are to primarily include the extent of oral health coverage for asylum seekers during the waiting periods, the utilization of existing health services and changing dietary and cultural norms associated with the integration of refugees in their new environment.

- The need to use mixed methods in order to enable the qualitative analysis of the data. This would likely enhance our understanding of the linguistic, legal and socio-economic barriers to fully integrate refugees in existing health services, and it would help to grasp the socio-cultural complexities associated with poor practices on oral hygiene.

4.5. Limitations of the study:

- The original study design has several limitations, among which the exclusion of children, adolescents and elderly. This decision was pragmatically taken to facilitate the ethical approval. However, this has narrowed the study and denied the possibility to compare the produced indices with all age groups in other refugee populations and in the host population. In addition, the recruitment of a control group among the host population would have allowed a more precise comparison. Furthermore, the absence of periodontal probing has limited the accuracy of the clinical examinations. Likewise, examining dental caries without the use of additional diagnostic aid including fluorescence and radiographs could have jeopardized the precision of DT scores. Moreover, specific risk behaviors prevalent in the

population of origin such as high sugar intake and smoking were not accounted for. This could confound any future comparison with different populations.

- The sampling could have been improved by the use of randomization. Nonetheless, it was logistically difficult to avoid a convenience sample taking into consider the limited resources with which this study was carried out. This however might have produced a selection bias.

- Social desirability bias might have altered the answers of the participants and thereof the results of the KAP survey.

With regard to the statistical analysis, the small cell size in the ordered logistical regression along with the inclusion of four independent variables might have overfitted the model. However, the two different regression models have produced matching results.

5. References:

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„Ich, Monzer Solyman, versichere an Eides statt durch meine eigenhändige Unterschrift, dass ich die vorgelegte Dissertation mit dem Thema: "Oral health status among newly arrived refugees in Germany- Mundgesundheitszustand neu angekommener Flüchtlinge in Deutschland" selbstständig und ohne nicht offengelegte Hilfe Dritter verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel genutzt habe.

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Journal Data Filtered By: **Selected JCR Year: 2017** Selected Editions: SCIE,SSCI
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Rank	Full Journal Title	Total Cites	Journal Impact Factor	Eigenfactor Score
1	PERIODONTOLOGY 2000	4,308	6.220	0.004430
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3	ORAL ONCOLOGY	8,949	4.636	0.013760
4	CLINICAL ORAL IMPLANTS RESEARCH	14,065	4.305	0.016880
5	International Journal of Oral Science	918	4.138	0.002240
6	JOURNAL OF CLINICAL PERIODONTOLOGY	13,300	4.046	0.011660
7	DENTAL MATERIALS	12,466	4.039	0.012560
8	JOURNAL OF DENTISTRY	8,247	3.770	0.012020
9	JOURNAL OF PERIODONTOLOGY	15,619	3.392	0.011420
10	Journal of Prosthodontic Research	686	3.306	0.001650
11	Clinical Implant Dentistry and Related Research	3,633	3.097	0.008520
12	INTERNATIONAL ENDODONTIC JOURNAL	7,002	3.015	0.007330
13	JOURNAL OF ENDODONTICS	16,585	2.886	0.013050
14	JOURNAL OF PERIODONTAL RESEARCH	4,100	2.878	0.004100
15	Molecular Oral Microbiology	919	2.853	0.002150
16	European Journal of Oral Implantology	960	2.809	0.002220
17	JOURNAL OF THE AMERICAN DENTAL ASSOCIATION	6,654	2.486	0.004610
18	Journal of Evidence-Based Dental Practice	478	2.400	0.001140
19	Clinical Oral Investigations	4,868	2.386	0.011460
20	JOURNAL OF PROSTHETIC DENTISTRY	10,690	2.347	0.006160
21	ORAL DISEASES	3,869	2.310	0.004930
22	JOURNAL OF ORAL PATHOLOGY & MEDICINE	4,539	2.237	0.003700
23	CARIES RESEARCH	4,173	2.188	0.003120
24	INTERNATIONAL JOURNAL OF ORAL AND MAXILLOFACIAL SURGERY	7,796	2.164	0.009660

Rank	Full Journal Title	Total Cites	Journal Impact Factor	Eigenfactor Score
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35	Journal of Prosthodontics-Implant Esthetic and Reconstructive Dentistry	2,041	1.745	0.002760
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38	Journal of Applied Oral Science	1,613	1.709	0.002460
39	INTERNATIONAL JOURNAL OF ORAL & MAXILLOFACIAL IMPLANTS	8,687	1.699	0.009060
40	JOURNAL OF ADHESIVE DENTISTRY	1,466	1.691	0.001620
41	Medicina Oral Patologia Oral y Cirugia Bucal	2,621	1.671	0.003820
42	EUROPEAN JOURNAL OF ORAL SCIENCES	3,558	1.655	0.002780
43	Korean Journal of Orthodontics	463	1.617	0.001420
44	Head & Face Medicine	687	1.606	0.001180
45	BMC Oral Health	1,769	1.602	0.004360
46	ANGLE ORTHODONTIST	6,168	1.592	0.005200

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RESEARCH ARTICLE Open Access

Oral health status among newly arrived refugees in Germany: a cross-sectional study

Monzer Solyman* and Andrea-Maria Schmidt-Westhausen

Abstract

Background: The objectives of this study were to determine the status of oral health among newly arrived refugees in Germany and to explore their knowledge, attitude and practices on oral hygiene.

Methods: All participants ($n = 386$) were adults, 18–60 years of age, coming from Syria and Iraq and registered as refugees in Germany within one year prior to the enrollment in the study. Clinical oral assessments in addition to a survey on knowledge, attitude and practice were carried out. The survey was conducted through a questionnaire translated into Arabic.

Results: Eighty seven point 5 % of the participants had untreated caries. The mean DMFT score was 6.38 with DT, MT and FT showing mean scores of 4.00, 1.46 and 0.92 respectively. Seventy nine percent had bacterial plaque in all six sextants, 60 % had calculus in at least three sextants and 6 % showed various magnitudes of enamel fluorosis. DMFT score was significantly associated with age (Regression Coefficient 0.031, *P*-value < 0.001) and with education (Regression Coefficient – 0.019, *P*-value 0.037) and females had significantly less missing teeth (Regression Coefficient-0.398, *P*-value 0.001) compared to males. The participants had in general high levels of knowledge and attitude on oral hygiene. The findings however showed a gap between their knowledge and practice.

Conclusions: The findings show high prevalence of untreated caries and poor oral hygiene among newly arrived refugees in Germany. The study recommends to lay emphasis on motivation in oral health promotion campaigns among refugees and to provide them with adequate guidance, preferably in their native language, on how to access oral health care in the host country.

Keywords: Oral health, Refugees, Decayed, missing and filled teeth index, Knowledge, attitude and practice survey

Background

Since the beginning of the internal conflicts in Syria and Iraq, the humanitarian crisis along with the collapse of the health systems in these countries have led to a dramatic increase in the influx of refugees and asylum-seekers into the European Union [1]. Of those, Germany has received the highest number of asylum applications among the member states of the European Union according to the United Nations High Commissioner for Refugees [2].

Oral conditions including dental caries and periodontal diseases have a significant impact on the quality of life of the individuals and a high economic burden on the health system in the hosting country [3]. Accordingly, many studies were carried out within the last two decades to investigate the oral health of refugee populations including Somali refugees in the USA [4], African and Eastern European refugees in the USA [5], Vietnamese refugees in Australia [6], Liberian refugees in Ghana [7] and immigrants and refugees in Italy [8]. These studies have shown a high prevalence of dental caries, periodontal diseases and poor oral hygiene. Furthermore, the status of oral health appeared to considerably differ among different refugee populations depending on the geographical region of origin [6, 8]. The studies suggested pre-arrival conditions to be equally important as

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those during the arrival and post-arrival period in determining the state of oral health of refugees.

This study is among the first to be specifically conducted on the oral health of refugees coming from Syria and Iraq in Germany and Europe. The particularity of the study population, including the existence of a functioning health and educational system in the country of origin prior to the war and the behavioral and dietary cultural norms, mainly high sugar intake [9], high prevalence of tobacco smoking [10] and low alcohol consumption [11], may suggest particular needs. Therefore, the objective of this study was to determine the status of oral health among newly arrived refugees coming from Syria and Iraq in Germany and to explore their knowledge, attitude and practice regarding oral hygiene.

Methods

A cross-sectional study was conducted between July and December 2016, in which clinical oral assessments of 386 newly arrived refugees from Syria and Iraq were carried out. Participants were recruited in refugee reception centers (174 participants), shelters (189 participants) and private practices (23 participants) in Berlin. The recruitments took place on site at the same day of the clinical examinations. Upon the informed consent of the participants, clinical oral examinations were carried out. These were directly followed by a structured interview conducted in their native language to identify the knowledge, attitude and practices (KAP) on oral hygiene. Participants were adults, 18–60 years of age, and registered as refugees in Germany within one year prior to the enrollment in the study. Children, adolescents and elderly were excluded.

Sample size calculation

The sample size was determined using the following formula for cross-sectional studies [12]:

$$n = Z^2\ P\ (1–P)/d^2$$

where n = sample size, Z = 1.96 (level of confidence 95%), $P = 0.5$ (expected proportion in population) and d = 0.05 (precision).

The sample size ($n = 386$) represented a proportion of 0.3% of the total number ($n = 115{,}647$) of Syrians and Iraqis who had their application for asylum accepted in Germany in 2015 [13].

Clinical oral assessments

The clinical examinations were carried out in artificial lighting with two mouth mirrors. All clinical examinations were done by one examiner MS (an Arabic native speaking dentist with a dental license in Germany). Participants were not explicitly asked to brush their teeth prior to the examination. The clinical assessment form for adults was initially developed by WHO and was modified accordingly for the study [14]. In this regard, invasive diagnostic procedures including periodontal probing were excluded, as several studies have suggested that patients with periodontitis may be at high risk of bacteremia following periodontal probing without preceding antibiotic prophylaxis [15–17].

Decayed, Missing and Filled Teeth Index (DMFT) was used to explore caries prevalence. Bacterial plaque and calculus were recorded as present or not present, for which the labial and lingual surfaces of 6 index teeth (16 or 17, 11, 26 or 27, 36 or 37, 31 and 46 or 47) were examined. Cases with missing index teeth were excluded and the recordings were then transferred into two scales, one for plaque and another for calculus, each has 7 ordinal values, where 0 = not present and 6 = present in all 6 sextants.

Dental trauma was recorded upon presence, for which six categories were accordingly registered, where 0 = No sign of injury, 1 = Treated injury, 2 = Enamel fracture only, 3 = Enamel and dentine fracture, 4 = Pulp involvement and 5 = Missing tooth due to trauma [18].

Enamel fluorosis was recorded using Dean's index, for which six categories were accordingly registered, where 0 = Normal, 1 = Questionable "*slight aberrations from the translucency of normal enamel*", 2 = Very mild "*small, opaque, paper-white areas scattered irregularly over the tooth but involving less than 25% of the labial tooth surface*", 3 = Mild "*more extensive but covers less than 50% of the tooth surface*", 4 = Moderate "*marked wear and brown stain*" and 5 = Severe "*enamel surfaces are badly affected*" [18].

The intervention urgency was classified based on the clinical findings into five categories, where 0 = No treatment needed, 1 = Preventive or routine treatment needed, 2 = Prompt treatment (including scaling) needed, 3 = Immediate (urgent) treatment needed due to pain or infection of dental and/or oral origin and 4 = Referred for comprehensive evaluation or medical/dental treatment (systemic condition) [18].

The intra-rater reliability was examined in a convenience sample, for which twenty three participants, all of them recruited in private practices, were examined on two different occasions. The two examinations were carried out by the same examiner conducting the study. Both examinations were done in the standard study settings. The two examinations were then compared showing an intra-class correlation coefficient of 0.94.

KAP survey on oral hygiene

The participants were interviewed immediately after the clinical assessments. The interviews were carried out in their native language (Arabic) following a questionnaire exploring their knowledge, attitude and practices on oral hygiene. Similar questionnaires were used and developed through previous studies on oral hygiene in children and

adolescents [19–22]. However, the questionnaire used in our study was proposed by WHO [23] for adults. The questionnaire was further adjusted for the purposes of this study and included eleven questions, among which:

Three question were on participants´ knowledge concerning tooth brushing and flossing:

- What should one use for cleaning his/her teeth?
- When should one brush his/her teeth?
- In addition to brushing, should one floss his/her teeth?

Four questions were on their attitude towards oral health:

- Do you think that brushing your teeth improves your dental health?
- Do you think dental problems can affect general health?
- How often should one visit a dentist?
- How would you describe the state of your teeth and gums?

Four questions were on their practices respecting oral hygiene:

- What do you use for cleaning your teeth?
- How do you brush your teeth?
- How often do you clean your teeth?
- Do you use toothpaste containing fluoride?

Participants´ answers were then scored, in which they were given + 1 for each correct answer, − 1 for each incorrect answer and 0 for giving no answer. This resulted in three scores (discrete variables accepting negative values), one for knowledge (ranging from − 3 to + 3), one for attitude (ranging from − 4 to + 4) and one for practice (ranging from − 4 to + 4).

With respect to their perception of own oral health, participants were asked to rate the state of their teeth and gums on a scale of 5 degrees, where 1 = Poor, 2 = Average, 3 = Good, 4 = Very good and 5 = Excellent. A comparison was then made between the self-perceived assessment and a clinical assessment made by the examiner on the same scale. Taking into consider the subjectivity involved in the examiner's clinical assessment and the participant's interpretation of the wording in the scale, the participant's answer was only considered incorrect (overestimation or underestimation) when it differed from the examiner's evaluation by two degrees or more.

Statistical analysis

The primary data set was analyzed using Stata 13.0 software (Stata, Texas, USA). DMFT scores were presented in means and standard deviations while other indices were presented in percentages. Negative binomial regression model NBRM was used to test for the association of count outcomes including DMFT, DT, MT and FT with the socio-demographic characteristics of the study population including age, country of origin, gender and education. Upon the comparison of mean observed and predicted count of our DMFT data using the Akaike's information criterion AIC and Bayesian information criterion BIC, the test showed a preference of NBRM with a very strong evidence over other models usually used for count outcomes.

In order to preserve the information contained in the ordering, ordered logistic regression OLR was used to test for the association of ordinal outcomes including calculus and plaque with socio-demographic characteristics. OLR may have cells that are too small for reliable estimates, nevertheless, two tests were applied to examine the goodness of fit of the model: an ordinal version of the Hosmer-Lemeshow test (P-value = 0.944 for calculus and P-value = 0.899 for plaque showing a good fit for both) and the Lipsitz test (P-value = 0.991 for calculus and P-value = 0.368 for plaque showing a good fit for both). In addition, a second model for ordinal outcomes, Multilevel mixed-effects generalized linear model (Family: ordinal, Link: complementary log-log), was added in order to enhance the validity of the analysis. The two models have shown matching significant associations for all characteristics (Table 4).

For discrete variables accepting negative values (KAP scores), multivariate linear regression was used to test for the association with socio-demographic characteristics of the study population.

A P-value of < 0.05 was considered significant.

Results

Socio-demographic characteristics of the study participants

Most of the participants were young males with 80.1% males and 42% between 18 and 24 years of age (Table 1). About 60 % were Syrians compared to 38.1% coming from Iraq. Concerning education, Only 5.4% had no education, 18.4% had primary education (1–6 years in school), 28.2% had preparatory education (7–9 years in school), 25.1% had secondary education (10–12 years in school) had 22.8% had at least one year of university.

Oral health indices and KAP survey

The mean DMFT score was 6.38 with DT, MT and FT showing mean scores of 4.00, 1.46 and 0.92 respectively. In this context, only two participants were fully edentulous. The presence of bacterial plaque and calculus was abundant with almost 80 % of the participants having plaque in all six sextants and almost 60 % having

Table 1 Socio-demographic characteristics of the study participants ($n = 386$)

Characteristics		Number (Percentage)
Country of origin	Syria	239 (61.9)
	Iraq	147 (38.1)
Gender	Male	309 (80.1)
	Female	77 (19.9)
Age group in years	18–24	162 (42.0)
	25–29	66 (17.1)
	30–34	55 (14.2)
	35–44	69 (17.9)
	more than 44	34 (8.8)
Educational level (years in school)	No education	21 (5.4)
	Primary school (1–6)	71 (18.4)
	Preparatory school (7–9)	109 (28.2)
	Secondary school (10–12)	97 (25.1)
	University (more than 12)	88 (22.8)

calculus in at least three sextants. Regarding the dental trauma, the vast majority of the participants (95.6%) had no sign of injury. Six percent of the participants showed various magnitudes of enamel fluorosis, among which only two (0.5%) were at severe stage. No participant had a systemic condition that required referral for comprehensive medical evaluation. Nonetheless, more than half needed prompt treatment and about one tenth had either pain or infection that required immediate treatment. With regard to KAP survey, most participants had good knowledge on tooth brushing. On the contrary, only one fifth answered that the additional use of dental floss is necessary. With regard to their attitude, less than one third believed in the relationship between oral and general health and less than half believed they should have regular checkups by a dentist. Almost two thirds had a proper perception of their own oral health compared to one third giving rather over or underestimations. The participants´ practices on oral hygiene were generally weak with more than half using the wrong method to brush their teeth and the majority cleaning their teeth less than twice a day. Detailed results on oral health indices and KAP survey are described in Table 2.

Association between main oral health indices and socio-demographic characteristics

Age was found to have a significant association with DMFT score (*P*-value < 0.001) and its components DT, MT and FT (*P*-values 0.047, < 0.001 and < 0.001 respectively). Older participants had higher DMFT scores compared to their younger counterparts. On the contrary, there was no significant association of the country of origin or of gender with DMFT scores (*P*-value 0.873 and 0.975 respectively) although females had significantly less missing teeth (*P*-value 0.001) compared to males. With regard to education, a significant association was found with DMFT score (RC -0.019, *P*-value 0.037). The more years in school participants had, the less decayed (RC -0.021, *P*-value 0.047), the less missing (RC -0.069, *P*-value 0.003) and the more filled teeth (RC 0.050, *P*-value 0.045) they showed (Table 3). Concerning oral hygiene, the presence of bacterial plaque was found to be significantly less with younger age (OLR *P*-value 0.009) and higher education (OLR *P*-value 0.028). It was also found to be significantly less among females (OLR *P*-value 0.013) compared to males. On the other hand, there was a significant increase in calculus presence with age (OLR *P*-value < 0.001). Females showed significantly lower levels of calculus (OLR *P*-value < 0.001) compared to males, as well as Iraqis (OLR *P*-value 0.018) compared to Syrians. In addition, those with higher education had less calculus (OLR *P*-value 0.019) compared to those with lower education (Table 4).

Association between KAP scores and socio-demographic characteristics

No significant association was found of age, neither with knowledge nor with practice. However, the older the participants were, the higher scores on attitude they showed (*P*-value 0.005). Iraqis showed significantly lower scores on attitude compared to their Syrian counterparts (*P*-value 0.005). Yet, the differences in knowledge and practice were insignificant. Females had significantly higher scores on knowledge (*P*-value 0.034) and practice (*P*-value 0.001), nonetheless, no significant difference between males and females on

Table 2 Oral health status and KAP survey (n = 386)

Oral health index		Number
Caries prevalence, mean (SD)	DMFT	6.38 (5.058)
	DT	4.00 (3.352)
	MT	1.46 (3.388)
	FT	0.92 (1.694)
Presence of bacterial plaque, n (%)	No plaque observed	2 (0.55)
	Plaque observed on one sextant	20 (5.49)
	Plaque observed on two sextants	7 (1.92)
	Plaque observed on three sextants	41 (11.26)
	Plaque observed on four sextants	1 (0.27)
	Plaque observed on five sextants	6 (1.65)
	Plaque observed on six sextants	287 (78.85)
Presence of calculus, n (%)	No calculus observed	35 (9.59)
	Calculus observed on one sextant	107 (29.32)
	Calculus observed on two sextants	4 (1.10)
	Calculus observed on three sextants	107 (29.32)
	Calculus observed on four sextants	1 (0.27)
	Calculus observed on five sextants	2 (0.55)
	Calculus observed on six sextants	109 (29.86)
Dental trauma, n (%)	No sign of injury	369 (95.60)
	Treated injury	4 (1.04)
	Enamel fracture only	7 (1.81)
	Enamel and dentine fracture	5 (1.30)
	Pulp involvement	0 (0.0)
	Missing tooth due to trauma	1 (0.26)
Enamel fluorosis, n (%)	Normal	363 (94.04)
	Questionable	4 (1.04)
	Very mild	3 (0.78)
	Mild	9 (2.33)
	Moderate	5 (1.30)
	Severe	2 (0.52)
Intervention urgency, n (%)	No treatment needed	18 (4.66)
	Preventive or routine treatment	124 (32.12)
	Prompt treatment (including scaling)	202 (52.33)
	Immediate treatment due to pain or infection	42 (10.88)
	Referred for comprehensive evaluation	0 (0.0)

Table 2 Oral health status and KAP survey (n = 386) *(Continued)*

KAP Questionnaire		
Question	Answer	Number
What should one use for cleaning his/her teeth? n (%)	Toothbrush a	379 (98.19)
	Miswak b	7 (1.81)
	Others (finger, charcoal or wooden toothpicks) b	0.0 (0.0)
When should one brush his/her teeth? n (%)	Once or less a day b	74 (19.17)
	Twice or more a day a	312 (80.83)
In addition to brushing, should one floss his/her teeth? n (%)	Yes a	76 (19.69)
	No b	267 (69.17)
	I don't know	43 (11.14)
Do you think that brushing your teeth improves your dental health? n (%)	Yes a	352 (91.19)
	No b	26 (6.74)
	I don't know	8 (2.07)
Do you think dental problems can affect general health? n (%)	Yes a	249 (64.51)
	No b	115 (29.79)
	I don't know	22 (5.70)
How often should one visit a dentist? n (%)	Regularly a	175 (45.34)
	Whenever there is a problem b	207 (53.63)
	I don't know	4 (1.04)
How would you describe the state of your teeth and gums? n (%)	Participant's answer showed a proper perception of his/her own oral health a	239 (61.92)
	Participant's answer showed a considerable over or underestimation of his/her own oral health b	141 (36.5)
	Participant answered: I don't know	6 (1.55)
What do you use for cleaning your teeth? n (%)	Toothbrusha	382 (99.22)
	Miswak b	3 (0.78)
	Others (finger, charcoal or wooden toothpicks) b	0.0 (0.0)
How do you brush your teeth? n (%)	Up and down circular motion, involving gums a	176 (45.60)
	Left to right, horizontal direction b	204 (52.85)
	I don't know	6 (1.55)
How often do you clean your teeth? n (%)	Once or less a day b	158 (40.93)
	Twice or more a day a	228 (59.07)
Do you use toothpaste containing fluoride? n (%)	Yes a	11 (2.85)
	No b	8 (2.07)
	I don't know	367 (95.08)

DMFT Decayed Missing or Filled Teeth, *DT* Decayed Teeth, *MT* Missing Teeth, *FT* Filled Teeth, *SD* Standard Deviation, (%) All percentages in this table are valid percentages (cases with missing index teeth were excluded)
[a] Correct answer
[b] Incorrect answer

attitude was found. Education was significantly associated with KAP scores; the higher education the participants had, the higher the level of knowledge, attitude and practice (P-value < 0.001) they presented (Table 5).

Table 3 Association of DMFT and its components with socio-demographic characteristics (Negative binomial regression model, $n = 386$)

Variables	DMFT	DT	MT	FT
	Regression Coefficient (Standard error), *P*-value			
Increase in age per year (continuous variable)	0.031 (0.003), < 0.001	0.008 (0.004), 0.047	0.089 (0.010), < 0.001	0.043 (0.013), < 0.001
Country of origin (ref. Syrians)	−0.013 (0.078), 0.873	− 0.165 (0.091), 0.069	0.657 (0.203), 0.112	0.001 (0.222), 0.997
Gender (ref. Male)	0.003 (0.091), 0.975	0 .070 (0.106), 0.507	−0.398 (0.250), 0.001	0.382 (0.246), 0.121
Increase in education per year (continuous variable)	−0.019 (0.009), 0.037	−0.021 (0.010), 0.047	− 0.069 (0.023), 0.003	0.050 (0.025), 0.045
Overall model Pseudo R-squared value, P-value	0.035, < 0.001	0.006, 0.022	0.093, < 0.001	0.012, 0.001

DMFT Decayed Missing or Filled Teeth, *DT* Decayed Teeth, *MT* Missing Teeth, *FT* Filled Teeth

Discussion

In accordance with previous studies on refugees in other western countries [5, 6, 8, 24, 25], the findings have shown high prevalence of dental caries and poor oral hygiene among newly arrived refugees in Germany.

Seventy nine percent of the participants had untreated caries while 78.8% showed bacterial plaque in all 6 sextants and 60% showed calculus in at least three sextants. However, the participants have surprisingly presented a lower DMFT mean score (6.99) in comparison with the mean national index (DMFT 11.2) for the comparable age group (35–44 years) in Germany [26]. Nonetheless, the magnitude of DMFT score among Germans owed its height to a rather high number of filled teeth (FT 8.6 compared to 1.10 in refugees) while it owed its height among refugees to a rather high number of untreated caries (DT 3.81 compared to 0.5 in Germans). Both had an almost equal number of missing teeth (MT 2.07 in refugees to 2.1 in Germans).

The high prevalence of untreated caries among refugees may be attributed to pre-arrival conditions, as well as to limited access to oral health care after arrival in the host country. Studies have suggested various factors contributing to the limited access, among which, not being able to afford treatment, lacking orientation within the new health system, being socially isolated, facing language barriers and a general low emphasis on oral health and promotion during the resettlement period [6, 24, 25, 27–29]. According to the German law [30], refugees in Germany have full access to dental care as German citizens after the official acknowledgment of their asylum status. During the period preceding the acceptance of their application for asylum, they are only eligible for primary care for acute conditions or pain [31].

Within the resettlement period, the priority of refugees clearly lies on the reestablishment in the host country. This would most likely lead to consequences on their oral health behavior including the low utilization of dental services [6, 8]. Therefore, it is important for decision-makers in the host country to target this population at risk as early as possible. This could be achieved through providing access to immediate oral assessment and treatment upon arrival. Likewise, it is important to establish an active inclusion of refugees in the existing health structures.

Available data on fluorosis have suggested a prevalence of about 7.1 to 11.3% among German adolescents. In comparison, our study showed a prevalence of 6%

Table 4 Association of calculus and plaque with socio-demographic characteristics ($n = 365$[a])

Variables	Model 1 (OLR)		Model 2 (Multilevel mixed-effects GLM)	
	Calculus	Plaque	Calculus	Plaque
	Odds ratios (95% Confidence Interval), *P*-value		Regression Coefficient (Standard error), P-value	
Increase in age per year [b]	1.060 (1.035–1.085), < 0.001	1.046 (1.011–1.082), 0.009	0.028 (0.006), < 0.001	0.018 (0.007), 0.008
Country of origin (ref. Syrians) [b]	0.610 (0.410–0.917), 0.018	0.856 (0.496–1.477), 0.576	− 0.350 (0.126), 0.006	−0.053 (0.123), 0.667
Gender (ref. Male) [b]	0.298 (0.182–0.487), < 0.001	0.471 (0.260–0.852), 0.013	−0.658 (0.151), < 0.001	− 0.332 (0.144), 0.021
Increase in education per year [b]	0.946 (0.904–0.991), 0.019	0.930 (0.872–0.992), 0.028	−0.031 (0.013), 0.018	− 0.032 (0.013), 0.019
Pseudo R-squared value, P-value	0.048, < 0.001	0.029, 0.002		
Wald Chi-squared, P-value			42.02, < 0.001	15.70, 0.003
Hosmer-Lemeshow test: Estimate, P-value [c]	37.729, 0.944[d]	40.382, 0.899[d]		
Lipsitz test: Estimate, P-value [c]	2.022, 0.991[d]	9.787, 0.368[d]		

OLR Ordered logistic regression, *GLM* Generalized linear model
[a] Cases with missing index teeth were excluded
[b] The two models are showing matching significant associations
[c] Goodness of fit test for ordinal logistic regression model
[d] P-value is showing the model to be a good fit

Table 5 Association of knowledge, attitude and practice with socio-demographic characteristics (Multivariate linear regression) (n = 386)

Variables	Knowledge	Attitude	Practice
	Regression Coefficient (Standard error), P-value		
Increase in age per year (continuous variable)	− 0.002 (0.006), 0.729	0.029 (0.010), 0.005	−0.010 (0.008), 0.187
Country of origin (ref. Syrians)	−0.157 (0.124), 0.206	−0.595 (0.213), 0.005	− 0.132 (0.160), 0.408
Gender (ref. Male)	0.312 (0.146), 0.034	0.093 (0.250), 0.710	0.633 (0.189), 0.001
Increase in education per year (continuous variable)	0.055 (0 .0140), < 0.001	0.0920 (0.024), < 0.001	0.086 (0.018), < 0.001
Overall model R-squared value, P-value	0.064, < 0.001	0.089, < 0.001	0.096, < 0.001

among adult refugees coming from Syria and Iraq. Fluorosis among Germans was mainly attributed to the early start of tooth brushing [32], On contrary, Fluorosis among refugees is probably due to a high-level exposure to fluoride in drinking water back in the country of origin as Syria and Iraq belong to the known fluoride belts according to WHO [33].

In general, there were no significant differences between Syrians and Iraqis on oral health indices including the prevalence of caries and bacterial plaque. Iraqis however had significantly less calculus accumulations. Although Iraq was for a longer period of time affected by war in comparison with Syria, yet most of the Iraqi refugees in Germany came from the northern part of the country. This part was until recent years relatively stable and the health system there showed similar indices to that of Syria before the eruption of the current civil conflict [34]. On the other hand, the findings have demonstrated that other socio-demographic factors including age, gender and education were statistically relevant to the status of oral health among refugees. Older and less educated participants presented more caries and poorer oral hygiene. Females had significantly less missing teeth and better oral hygiene. Previous studies on oral health in refugee populations were mostly concerned with children and adolescents. The few examining adults have shown similar trends to our study. In this context, a study in Italy [8] found a significant increase in mean DMFT scores for Moroccan and Yugoslavian refugees with age. The study has also shown a significant increase in mean Oral Hygiene Index (OHI-S) for Yugoslavian refugees with age. Another study in Australia [6] found that the decayed, missing and filled surface (DMFS) index was significantly higher in older and less educated refugees. Females showed significantly higher mean number of filled surfaces (FS) compared to males. The study used the Community Periodontal Index (CPI) to evaluate the periodontal health and oral hygiene. The results showed that older, less educated and male refugees tend to have higher CPI scores. However, the authors were not able to test for statistical significance due to the small numbers of participants in each group.

Among the purposes of this study was to assess the knowledge, attitude and practice of refugees on oral health. The participants had in general a high level of knowledge, however, an emphasis should be put on the importance of tooth flossing as a complimentary method to clean the inter-dental embrasures and the proximal tooth surfaces in addition to the tooth brushing. On average, the participants showed high scores on attitude, still they should be more informed about the established relationship between oral and general health and the importance of regular dental checkups even when they have no pain or acute complaint. On the other hand, participants have generally shown lower scores on practice presenting a gap between their knowledge and practice. This gap could be related to the adversities surrounding the pre- and post-arrival conditions. Nonetheless, it is important for health promotion campaigns to bridge the gap between knowledge and practice and to concentrate more on oral hygiene motivation among refugees in order to establish or re-establish the norms of tooth brushing at least twice a day with preferably fluoride-containing toothpaste.

This study was among the first attempts to tackle the oral health status of refugees in Germany. The study however had certain limitations, among which:

- The use of convenience sampling instead of randomized cluster sampling making the study sample less representative. In addition, the sampling procedure may have led to a selection bias, as study participants recruited in private practices may tend to have a higher occurrence of dental disease in comparison to those recruited in refugee shelters.
- The sensitivity of field oral examinations (for obtaining DMFT scores in particular) without the use of extra diagnostic methods like bitewing radiographs. This may have led to underestimating the prevalence of caries and to increased false negative values especially for caries on the proximal surfaces. In addition, it was only feasible to examine the intra-rater reliability for participants recruited in private practices (a convenience

sample). This may have put the resulting intra-class correlation coefficient at risk of bias.
- The social desirability bias with regard to KAP survey, as participants may tend to satisfy the examiner with their answers rather than to express what they believe or practice in their daily life reality.
- The study has examined the association of oral health status with certain socio-demographic characteristics. However, there are other important characteristics that were not analyzed in our study. Some of these could be associated with the population of origin like sugar intake and smoking, others are related to the post arrival adversities like waiting times associated with asylum application and linguistic barriers. These and similar potential associations could be investigated in future studies.

Conclusions

The present study shows a high prevalence of untreated caries and poor oral hygiene among newly arrived refugees in Germany. It suggests that socio-demographic factors including age, gender and education are associated with the oral health status of the refugees and partly with their knowledge, attitude and practice on oral hygiene. It is important to put emphasis on motivation in oral health promotion campaigns among refugees and to provide them with adequate guidance, preferably in their native language, on how to access oral health care in the host country.

Abbreviations

AIC: Akaike's information criterion; BIC: Bayesian information criterion; CPI: Community Periodontal Index; DMFS: Decayed, Missing and Filled Surface Index; DMFT: Decayed, Missing and Filled Teeth Index; DT: Decayed Teeth; FS: Filled Surfaces; FT: Filled Teeth; GLM: Generalized linear model; KAP: Knowledge, Attitude and Practice; MT: Missing Teeth; NBRM: Negative binomial regression model; OHI-S: Oral Hygiene Index; OLR: Ordered logistic regression; RC: Regression Coefficient; SD: Standard Deviation; WHO: World Health Organization

Availability of data and materials

The data analyzed in the current study are available from the corresponding author on reasonable request.

Authors' contributions

MS and AMSW designed the study. MS implemented the study (Clinical oral assessments and KAP survey). MS and AMSW analyzed the data. MS drafted the manuscript. AMSW critically revised the manuscript. Both authors have approved the final manuscript.

Ethics approval and consent to participate

Written informed consents (both in Arabic and German) were obtained from all individual participants before the enrollment in the study. In addition, they were handed a study information sheet that included a data privacy statement. The final study design, informed consent and participants' information sheet were approved by the ethics committee at Charite Universitatsmedizin Berlin (Ethics committee vote EA1/081/16).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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