



REVIEW ARTICLE

Association between body mass index and dental caries in the Kingdom of Saudi Arabia: Systematic review



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Abstract *Objective:* The Kingdom of Saudi Arabia (KSA) has one of the highest prevalence of both obesity and dental caries. To date, there has not been any documented evidence linking these two factors. Therefore, the objective was to conduct a systematic review of published studies that have analysed the association between body mass index and dental caries in the KSA for both children and adults.

Methods: A systematic database search [PubMed, EMBASE, Web of Science, CINAHL and Cochrane Library] was conducted following the PRISMA guidelines. The inclusion criteria were observational studies, with no limit on the publication date. Search terms included: dental caries, obesity, overweight, body mass index, BMI 'AND' Saudi Arabia. The independent variable was body mass index (BMI), and the primary outcome measure was dental caries prevalence and severity.

Results: From 951 search results, 935 citations were identified and excluded. Of the 16 potentially eligible studies, two citations were excluded, because the studies did not meet the inclusion criteria. This left fourteen studies meeting the criteria to be included in this systematic review. Ten studies outlined children, and four studies assessed adults. For children, two studies resulted in a positive association between high BMI and caries, six studies resulted in a negative association,

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and two studies had a non-significant association. For adults, two studies resulted in a positive association between high BMI and dental caries, and two studies had a non-significant association. These were rated as having low to moderate risk of bias.

Conclusion: As a result of this equivocal outcome within the systematic review, body mass index and dental caries present as a complex association. Further long-term studies are required to translate the findings into clinical practice.

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1. Introduction

According to the World Health Organisation (WHO), the prevalence of adult obesity has risen from 4.8% in 1975 to 13% in 2016 (NCD Risk Factor Collaboration (NCD-RisC), 2016, World Health Organisation (WHO), 2018). In 2016, it was estimated that 41 million children under the age of 5 years, and 1.9 billion adults over the age of 18 years old were overweight or obese, respectively. The Kingdom of Saudi Arabia (KSA) has a population of approximately 33.4 million people (General Authority for Statistics, 2019). Despite limited information available, cross-sectional data from a national sample indicated that obesity in the KSA has a prevalence of 11.3% and 35.6% in children/adolescents (5–18 years) and adults (30–70 years) respectively (Al-Nozha et al., 2005; El Mouzan et al., 2010b). Body mass index (BMI) is defined as a person's weight in kilograms divided by the square of height in meters (kg/m^2). It is the most reproducible index of weight-for-height, and is commonly used to classify overweight and obesity (Nuttall, 2015). Because obesity can lead to metabolic complications, it may explain why the prevalence of diabetes and hypertension in the KSA is 12.1% and 40.6% respectively (Bahijri et al., 2016; El Bcheraoui et al., 2014).

Untreated caries is a global burden for both children and adults. In the permanent dentition, it affected about 2.4 billion adults in 2010, making it the most prevalent condition world-

wide (Kassebaum et al., 2015). For deciduous dentitions, it is the 10th most prevalent condition, affecting 621 million children in 2010 (Kassebaum et al., 2015). A national systematic review (from 1999 to 2010) found the prevalence of dental caries in KSA children to be 80% in the deciduous dentition, and 70% in the permanent dentition (Al Agili, 2013). According to the most comprehensive meta-analysis of dental caries severity in the KSA, in the time frame from 1998 to 2008, the mean permanent decayed, missing, and filled teeth (DMFT) score for children aged between 6 and 18 years was 3.34 (95% Confidence Interval [CI]: 1.97–4.75) and the mean deciduous dmft score for children aged between 2 and 12 years was 5.38 (95% CI: 4.31–6.34) (Khan et al., 2013). In a more recent study, the mean DMFT amongst 10–12-year-olds ($n = 314$) was 1.94 ± 2.0 standard deviation (SD), and the mean dmft amongst the 6–9-year-olds was 3.66 ± 3.13 SD (Farooqi et al., 2015). However, the authors stated that due to the limited sample size, this might have been a potential underestimation of the overall national dental caries prevalence (Farooqi et al., 2015; Khan et al., 2013). In another, more recent meta-analysis, it was found that root caries affected about 4 in 10 adults worldwide (Pentapati et al., 2019). In the KSA, dental caries is the most common reason for tooth extractions amongst people aged 10 to 30 years (Alesia and Khalil, 2013).

Several systematic reviews and meta-analysis on overweight, obese, and high BMI children and associations with

dental caries have been published. Except for one study which suggests high BMI could have a higher risk of dental caries (Angelopoulou et al., 2019), all of these studies stated the results to be inconclusive (Alshihri et al., 2019; Chen et al., 2018; Hooley et al., 2012; Kantovitz et al., 2006; Paisi et al., 2019; Shivakumar et al., 2018; Silva et al., 2013). These studies found a combination of positive, negative, and no association between BMI and dental caries. The reasoning behind the inconsistent findings is that there might have been variations and limitations of methodologies and study designs used. These reviews cover populations from different parts of the world, including some recent studies conducted in the KSA (Alshihri et al., 2019; Paisi et al., 2019). The reviews by Ashi et al. (2019) and Paisi et al. (2019) only included studies involving children and young people. There are no specific reviews however, that include studies on both adults and children in KSA.

Therefore, this study aims to conduct a systematic review of published studies that have analysed the association between BMI and dental caries in the KSA for both children and adults.

2. Methods

2.1. Study selection

The systematic review was registered on the PROSPERO database (Registration number: CRD42019138820) and conducted according to the PRISMA guidelines (Moher et al., 2009). The methodologies were in accordance with the published meta-

analyses and systematic review (Park et al., 2019; Park et al., 2018). Two authors (YA and JP) independently conducted a systematic search of the literature. The following digital databases were accessed: PubMed, Web of Science, Medline, Cochrane Library, and CINAHL, in order to assess published studies that reported body mass index (BMI) and dental caries. The search was conducted using the following keyword combinations: dental caries, obesity, overweight, body mass index, BMI 'AND' Saudi Arabia with the prefix 'AND' and 'OR'. No time of publication limit was placed, but only articles published in English were included. In the screening stage, the title and abstracts of publications were reviewed, and the duplicated studies were excluded. Subsequently, full-text copies were reviewed for eligibility for a systematic review. The independent variable was BMI, which was used according to the categories of underweight (children = BMI < 5th percentile; adults < 18.5 kg/m²), overweight (children = BMI between 85th – 95th percentile; adults = 25–29.9 kg/m²), and obese (children = BMI > 95th percentile; adults ≥ 30 kg/m²). The dependent variable was dental caries severity (mean decayed, missing, and filled score) or prevalence (% with any caries experience). The inclusion criteria were broad and consisted of all the observational studies that have analysed BMI and dental caries in the KSA regardless of the type of study, ages, gender, different clinical settings where the study was conducted, concomitant medical history, and different regions in the KSA. Studies that did not include the BMI or dental caries was excluded as it would not fulfil the criteria for the systematic review. A consensus was reached after thorough discussion if any discrepancies arose between the two examiners.

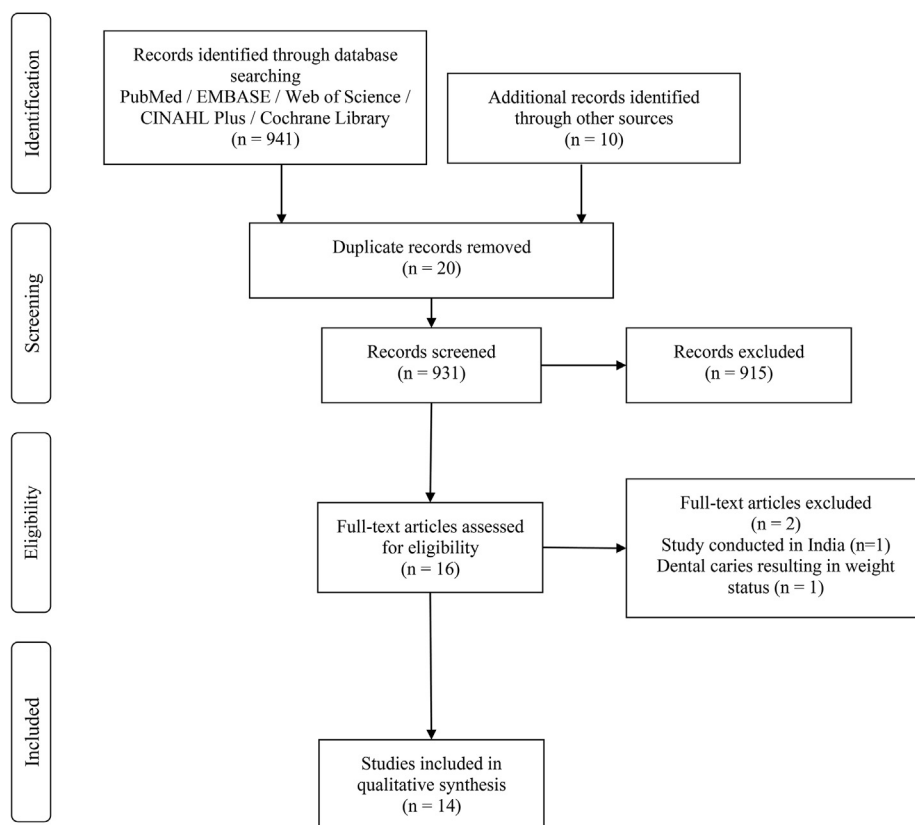


Fig. 1 Process of data collection in accordance with the PRISMA statement for systematic review.

2.2. Search outcome

From 951 search results, 935 citations were identified and excluded at the initial screening stage, as it did not contain any information pertaining to BMI or dental caries. Of the 16 potentially eligible studies, two citations were excluded as they did not meet the inclusion criteria, which was any observational studies outlining BMI and dental caries in the KSA. This left fourteen studies meeting the criteria and being suitable for inclusion in this systematic review (Abu El Qomsan et al., 2017; Alghamdi and Almahdy, 2017; Alkarimi et al., 2014; Alswat et al., 2016; Ashi et al., 2019; Ashour et al., 2019; Ashour et al., 2018; Bhayat et al., 2016; Farsi and Elkhodary, 2017; Farsi et al., 2016; Habibullah et al., 2018; Hamasha et al., 2019; Idrees et al., 2017; Quadri et al., 2017) (Fig. 1).

2.3. Data extraction

The following were analysed as variables: study design, the region in the KSA, study sample (number and age range of included participants), concomitant medical history, the outcome as per dental caries as a result of the participant's BMI. The information was extracted as per population, intervention, comparison, and outcome (PICO) criteria. In order to improve the power of the systematic review, the format of each study was collected in accordance with a global systematic review that was recently published (Paisi et al., 2019). This systematic review provided the most updated information on the association between BMI and dental caries, using a validated and study design specific tool.

2.4. Risk of bias

A critical appraisal tool to assess the quality of appropriate observation studies were utilised as per the checklist provided in the systematic review (Page et al., 2018). The checklist consisted of a series of questions in relation to the content of the Introduction, Methods, Results, Discussion, and Other sections. Furthermore, the cumulative count for these individual studies was tabulated.

2.5. Inter-agreement reliability

Inter-agreement reliability (%) was calculated between the two independent reviewers, in the data extraction (identification, screening, eligibility, and inclusion) stage. In addition, during the quality assessment stage (risk of bias), SPSS version 25.0 (IBM Company, Chicago, IL, USA) was used to compute kappa statistics as a measure to test the inter-agreement reliability amongst the reviewers (McHugh, 2012).

3. Results

3.1. Children - study characteristics and qualitative study results

All the studies were cross-sectional studies. Participants' demographic details in all of the included studies were tabulated, and a summary for children was outlined (Tables 1). Ten studies examined children (Abu El Qomsan et al., 2017;

Alghamdi and Almahdy, 2017; Alkarimi et al., 2014; Ashi et al., 2019; Ashour et al., 2018; Bhayat et al., 2016; Farsi and Elkhodary, 2017; Farsi et al., 2016; Habibullah et al., 2018; Quadri et al., 2017). The cities and regions where the studies were undertaken comprised of Al-Kharj, Jazan, Jeddah, Makkah, Medina, Qassim, and Riyadh. All of the participants were outpatients, either in a clinic or schools. For the independent variable, all the studies assessed BMI. For the dependent variable, only two studies assessed dental caries experience as decayed, missing, and filled surfaces (dmfs/DMFS) (Ashi et al., 2019; Ashour et al., 2018), and two studies assessed the dental caries prevalence (Alghamdi and Almahdy, 2017; Farsi et al., 2016). Six studies included some or all the components of decayed, missing, and filled teeth (dmft/DMFT).

Two studies resulted in a positive association between high BMI and caries (Abu El Qomsan et al., 2017; Ashour et al., 2018), six studies resulted in a negative association (Alghamdi and Almahdy, 2017; Alkarimi et al., 2014; Bhayat et al., 2016; Farsi et al., 2016; Habibullah et al., 2018; Quadri et al., 2017), and two studies showed a non-significant association (Ashi et al., 2019; Farsi and Elkhodary, 2017).

3.2. Adults - study characteristics and qualitative study results

All the studies were cross-sectional studies. Participants' demographic details in all of the included studies were tabulated, and a summary for adults was outlined (Table 2). Four studies examined adults (Alswat et al., 2016; Ashour et al., 2019; Hamasha et al., 2019; Idrees et al., 2017). The cities and regions where the studies were undertaken, comprised of Riyadh and Taif. Except for one study (Ashour et al., 2019), all of the participants were outpatients a clinic. For the independent variable, all the studies assessed BMI. For the dependent variable, four studies assessed dental caries as decayed, missing, and filled teeth (dmft/DMFT).

Two studies resulted in a positive association between high BMI, and dental caries (Ashour et al., 2019; Hamasha et al., 2019) and two studies showed a non-significant association (Alswat et al., 2016; Idrees et al., 2017).

3.3. Special populations

Four studies included patients with concomitant medical histories (Alswat et al., 2016; Ashour et al., 2019; Ashour et al., 2018; Hamasha et al., 2019). One study assessed children with special needs (Ashour et al., 2018) (Table 1), one study assessed adults with psychiatric disorders (Ashour et al., 2019), and two studies assessed adults with generalised medical conditions consisting predominantly of cardiovascular and endocrinologic conditions (Alswat et al., 2016; Idrees et al., 2017) (Table 2).

3.4. Risk of bias

Table 3 highlights the assessment of the studies included in the systematic review according to AXIS (Downes et al., 2016). All of the studies had a clear aim, appropriate methodology, appropriate outcome variable measurement, appropriate statistics, internally consistent, justifiable discussion and con-

Table 1 Characteristics of published cross-sectional studies outlining the relationship between body mass index (BMI) and dental caries in children residing in KSA.

Author(s)	City/Region	Setting	Sample Size	Age group (y)	Caries Parameter	Low BMI	High BMI	Outcome
Abu El Qomsan et al. (2017)	Al-Kharj	Outpatient (School)	386	9.4 ± 1.7	DFT	U D = 3.1 ± 1.5 U F = 0.3 ± 0.7	OW D = 3.7 ± 2.4 OW F = 0.4 ± 0.7 O D = 4.0 ± 2.6 O F = 0.7 ± 1.2	Patients with higher BMI were more likely to have higher dental caries (P < 0.001)
Alghamdi and Almahdy. (2017)	Riyadh	Outpatient (School)	610	14–16	Prevalence of DMFT (%)	U = 27%	OW = 17% O = 13%	As the BMI decreases the probability of having higher dental caries increased (P = 0.008)
Alkarimi et al. (2014)	Jeddah	Outpatient (Military school)	417	6–8	DMFT	–	–	There was an inverse linear relationship between dental caries and the children's BMI (P < 0.001)
Ashi et al. (2019)	Jeddah	Outpatient (School)	225	13–15	DMFS	U DMFS = 3.3 ± 4.7	OW DMFS = 3.5 ± 4.7 O DMFS = 2.9 ± 1.4	There was no correlation between overweight and obese children and dental caries (P = 0.873)
Ashour et al. (2018) [#]	Makkah	Outpatient (School)	275	6–11 (71%) 12–17 (29%)	dms/DMFS	U dms = 0.02 ± 0.08 U DMFS = 0.02 ± 0.06	OW dms = 2.9 ± 3.2 OW DMFS = 2.8 ± 3.1 O DMFT = 2.8 ± 3.1 O DMFS = 3.2 ± 3.6	Overweight and obese patients were 2.9 times more likely to have dental caries in comparison to underweight patients (95% CI = 1.2–4.9)
Bhayat et al. (2016)	Medina	Outpatient (School)	402	12.6 ± 0.6	DMFT	U DMFT = 2.6 ± 3.3	OW DMFT = 1.2 ± 1.9 O DMFT = 1.1 ± 1.6	Overweight and obese patients were at less likely to have dental caries in comparison to the underweight patients (P = 0.016).
Farsi and Elkhodary. (2017)	Jeddah	Outpatient (School)	801	16.5 ± 0.9	DT	U D = 4.9 ± 3.0	OW D = 4.35 ± 3.3 O D = 4.3 ± 3.5	There was a non-significant positive correlation between BMI and dental caries (P = 0.737) There was a non-significant negative correlation between BMI and dental caries (P = 0.069)
Farsi et al. (2016)	Jeddah	Outpatient (School)	915	12.6 ± 8.9	Prevalence of dmf/DMF (%)	U = 88%	OW = 86% O = 80%	As the BMI decreases the probability of having higher dental caries increased (P < 0.05)
Habibullah et al. (2018)	Qassim	Outpatient (Dental Clinic)	171	M – 8.1 ± 1.4 (59%) F – 7.8 ± 1.8 (41%)	dt	M U = 93.1% F U = 73.0%	M OW = 85% FOW = 0%	Underweight children were more likely to have dental caries in comparison to overweight patients (P = 0.024).

(continued on next page)

Table 1 (continued)

Author(s)	City/Region	Setting	Sample Size	Age group (y)	Caries Parameter	Low BMI	High BMI	Outcome
Quadri et al. (2017)	Jazan	Outpatient (School)	360	6–15	dmft/DMFT	U d = 2.0 ± 0.8 U f = 1.8 ± 0.5 U D = 2.0 ± 0.9 U M = 2.2 ± 1.3 U F = 2.4 ± 0.5	OW d = 1.9 ± 0.9 OW f = 2.0 ± 0.0 OW D = 1.8 ± 0.5 OW M = 1.8 ± 0.8 OW F = 2.7 ± 1.1 O d = 2.0 ± 0.8 O f = 3.0 ± 1.4 O D = 1.9 ± 0.8 O M = 2.5 ± 0.7 O F = 1.0 ± 0.5	There was a negative correlation between dental caries and BMI (P = 0.002)

d/D - Decayed, m/M - Missing, f/F - Filled, t/T - Teeth, s/S - Surface, F - Female, M - Male, CI - Confidence Interval, U - Underweight, O - Obese, OW - Overweight, # Concomitant Medical History - Special Needs [Mental retardation (40%), Deafness, Blindness (22.2%), Down Syndrome (18.9%), Autism (14.9%), Cerebral Palsy (6.2%).]

clusion, and declaration of conflict of interests. However, only two studies provided methods to compensate for the non-responders (Ashour et al., 2019; Ashour et al., 2018). There was no information provided on ethical approval of the study or consent provided by participants, in three out of the fourteen studies. As a result, the response in AXIS rated all the studies as having low to moderate risk of bias.

3.5. Inter-agreement reliability

The inter-agreement reliability between the two reviewers was 92.8% (identification stage), 93.1% (screening stage), 92.3% (eligibility stage), and 100% (inclusion stage). Any discrepancies were resolved through discussion until a consensus was reached. Each domain provided in AXIS tool had a strong to almost perfect inter-agreement reliability between the independent reviewers, with a kappa score of 0.840 (Introduction), 0.842 (Methods), 0.983 (Results), 0.910 (Discussion), and 0.932 (Other) respectively.

4. Discussion

Some recent international reviews on BMI and its association with dental caries in children and young people, included studies from the KSA (Alshihri et al., 2019; Paisi et al., 2019). To our knowledge however, this systematic review is the first to qualitatively evaluate the evidence on associations between BMI and dental caries in the KSA, for both children and adults. Despite not being able to determine the quantitative relationship between BMI and dental caries in the KSA, it has emphasised the complex relationships between the two conditions. Except for one meta-analysis which suggests high BMI has a higher risk of dental caries (Angelopoulou et al., 2019), our study generated the same outcome as other internationally published studies (Alshihri et al., 2019; Chen et al., 2018; Hooley et al., 2012; Kantovitz et al., 2006; Paisi et al., 2019; Shivakumar et al., 2018; Silva et al., 2013).

For children with dental caries, it was assumed that all the participants were medically sound. Only one study which examined children with special needs found that there was increased dental caries experience with increased BMI, which could also be a potential confounder due to concomitant medication use as well as impaired oral hygiene (Ashour et al., 2018). For adults, three studies had patients with metabolic complications or psychiatric problems (Alswat et al., 2016; Ashour et al., 2019; Hamasha et al., 2019). All the data from medically compromised patients could have a confounding effect on overall dental health (Brown, 2009; Timonen et al., 2010; Velasco et al., 1997). Therefore, further studies, adjusting for these confounders, could help to clarify the relationship between BMI and dental caries.

Most of these studies were conducted in Al-Kharj, Jeddah, Riyadh, Makkah, Medina, Qassim, and Taif. There are 13 different regions in the KSA and further studies from cities other than the ones previously included, are required to make it even more generalisable (Salam, 2013). Future work could also include a detailed analysis of socioeconomic factors, as high socioeconomic background may contribute to high BMI (Alazzeah et al., 2018).

A positive relationship between BMI and dental caries may be due to overconsumption of processed foods. One of the

Table 2 Characteristics of published cross-sectional studies outlining the relationship between body mass index (BMI) and dental caries in Adults residing in KSA.

Author(s)	City/Region	Setting	Sample Size	Age (y)	Caries Parameter	Low BMI	High BMI	Outcome
Alswat et al. (2016) [#]	Taif	Outpatient (University Clinic)	385	28.4 ± 11.4	DMFT	U = 5.26	OW = 6.42 O = 6.48	Overweight and obese patients had a non-statistically significant dental caries in comparison to the normal weight patients (P = 0.29)
Ashour et al. (2019) ^{##}	Taif	Inpatient (Mental Hospital)	223	42.3 ± 2.2	DMFT	U = 2.6 ± 1.6	OW = 5.2 ± 4.7 O = 4.1 ± 3.6	There is a strong association between dental caries and increased BMI (Adjusted odds ratio = 2.7; 95% CI = 1.4–4.3; P < 0.001)
Hamasha et al. (2019) ^{###}	Riyadh	Outpatient (Dental Clinic)	250	35.3	DMFT	U = 12	OW = 14 O = 16	Patients with higher BMI were more likely to have increased dental caries (P = 0.005)
Idrees et al. (2017)	Riyadh	Outpatient (Dental Hospital)	502	M – 26.5 ± 4.8 (38.2%) F – 22.8 ± 4.5 (61.8%)	DMFT	U = 14.0 ± 3.8	OW = 13.8 ± 3.1 O = 12.9 ± 4.4	There was no correlation between BMI and dental caries (P = 0.15).

d/D - Decayed, m/M - Missing, f/F - Filled, t/T - Teeth, F - Female, M - Male, CI - Confidence Interval, U - Underweight, O - Obese, OW - Overweight.

[#] Concomitant Medical History - General [Hypertension (10.2%), Diabetes (4.9%)].

^{##} Concomitant Medical History - Psychiatric [Schizophrenia (27%), Mental retardation (21.9%), Bipolar mood disorder (19.7%)].

^{###} Concomitant Medical History - General [Hypertension (10.4%), Diabetes (8.8%), Asthma (4.4%), Hypothyroidism (4.0%), Joint disease (3.2%), Migraine (1.6%), Heart disease (1.2%), Psychological (3.2), Physical disability (1.6%), Others (27.2%)].

main factors could be due to high consumption of fermentable carbohydrates (i.e. sugar), which can both contribute to dental caries and weight gain (Hooley et al., 2012). On a biological level, reduced salivary flow as a result of obesity may be a factor in causing dental caries in patients (Mod  er et al., 2010). In the KSA, in addition to eating two meals a day, frequent snacking and fried food consumption were common among obese children and young adults (Al-Rethaiaa et al., 2010; Alturki et al., 2018). Frequent snacking of processed food was also prevalent among adults (Mandoura et al., 2017). Conversely, a possible reason for the negative association may be due to malnourishment as a result of carious teeth leading to pain or discomfort when eating.

According to the Saudi Health Interview Survey (SHIS) conducted in 2013, consisting of 10,735 individuals over 15 years old in the regions of the KSA, dietary guideline recommendations were met by only by 5.2% and 7.5% for fruits and vegetables respectively (Moradi-Lakeh et al., 2017). In addition, consumption of processed foods and sugary beverages were prevalent amongst younger adults. However, in the KSA, the cost of healthier food is cheaper (Gosadi et al., 2016). It is also essential to take into consideration that underweight patients with low BMI should not be ignored as a result of the focus being on overweight and obese patients (El Mouzan et al., 2010a). Both underweight and overweight have significant adverse implications for health.

Due to significant heterogeneity, a meta-analysis could not be undertaken. Although some of the study designs were similar, not all the studies within the systematic review used com-

mon methodology, nor quantifiable data, to be able to generate a forest plot (Glasziou and Sanders, 2002). Different indices for dental caries such as DFT, dmf, DMF, dmft, DMFS, dmfs, DMFT, dt, DT, and prevalence were utilised which could have led to incomplete data in some articles. Subsequently, a meta-analysis resting on these heterogenous studies could lead to unreliable and incorrect assumptions about the associations between BMI and caries. Furthermore, even though the risk of bias was low to moderate, it is important to interpret this systematic review critically, as a degree of flaw may be generated within each study. In addition, all the studies failed to address the non-follow up responses, which could create inaccurate estimates of the population values. Therefore, recommendations for future studies could include suggestions to conduct larger population studies, as well as longitudinal studies in different regions to ensure that the participants are truly representative of the KSA and the results are meaningful (Alshihri et al., 2019).

4.1. Public implications of the findings

It is recommended that public health initiatives should be implemented to target both weight loss, as well as dental caries (Al-Hazzaa and AlMarzooqi, 2018; AlShammery et al., 2017). In addition, having a collaborative professional relationship with allied health practitioners could help optimise and improve the outcomes of these two significantly problematic health conditions (Hajj et al., 2019).

Table 3 Assessment of the studies included in the systematic review according to the Appraisal tool for Cross-Sectional Studies (AXIS).

Questions	Yes	No	Uncertain
<i>Introduction</i>			
Were the aims/objectives of the study clear?	14	0	0
<i>Methods</i>			
Was the study design appropriate for the stated aim(s)?	14	0	0
Was the sample size justified?	8	6	0
Was the target/reference population clearly defined?	9	5	0
Was the sample frame taken from an appropriate population base so that it closely represented the target/reference population under investigation?	12	2	0
Was the selection process likely to select subjects/participants that were representative of the target/reference population under investigation?	12	2	0
Were measures undertaken to address and categorise non-responders?	2	12	0
Were the risk factor and outcome variables measured appropriate to the aims of the study?	14	0	0
Were the risk factor and outcome variables measured correctly using instruments/measurements that had been trialled, piloted or published previously?	14	0	0
Is it clear what was used to determined statistical significance and/or precision estimates?	14	0	0
Were the methods (including statistical methods) sufficiently described to enable them to be repeated?	11	3	0
<i>Results</i>			
Were the basic data adequately described?	14	0	0
Does the response rate raise concerns about non-response bias?	0	14	0
If appropriate, was information about non-responders described?	0	14	0
Were the results internally consistent?	14	0	0
Were the results presented for all the analyses described in the methods?	9	5	0
<i>Discussion</i>			
Were the authors' discussions and conclusions justified by the results?	14	0	0
Were the limitations of the study discussed?	13	1	0
<i>Other</i>			
Were there any funding sources or conflicts of interest that may affect the authors' interpretation of the results?	14	0	0
Was ethical approval or consent of participants attained?	11	0	3

5. Conclusion

As a result of this equivocal result within the systematic review, BMI and dental caries is a complex association. Further long-term studies are required to translate the findings into clinical practice. Confounding factors needs to be adjusted, as socioeconomic status, as well as medical conditions, may skew the overall results.

Ethical approval

The systematic review was registered on the PROSPERO database (Registration number: CRD42019138820).

Declaration of Competing Interest

The authors declared that there is no conflict of interest.

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