Assessment of nationally representative dietary studies in the Gulf Cooperation Council: A scoping review

Rukshana Hoque 1, Erin Strotheide 2, Juliann Saquib 3, Nazmus Saquib Corresp. 3

1 Diabetes & Nutritional Sciences Division, King's College London, London, United Kingdom
2 Research Unit, Sulaiman Al Rajhi University, Bukayriah, Al-Qassim, Saudi Arabia
3 College of Medicine, Sulaiman Al Rajhi University, Bukayriah, Al-Qassim, Saudi Arabia

Corresponding Author: Nazmus Saquib
Email address: a.saquib@sr.edu.sa

Background. Obesity is at a record high in Gulf Cooperation Council (GCC) countries and is expected to continue increasing. Diet is a major contributor to this disease, but there is inadequate nationally representative dietary research from these countries. The aim was to quantify the number dietary studies using food frequency questionnaires (FFQs) that have been conducted in individual GCC countries and to assess the quality of eligible studies.

Methodology. Four databases (PubMed, Web of Science, MEDLINE, and DOAJ) were searched for keywords; records were screened for eligible studies and data were abstracted on study characteristics (publication year, geographical locations, sample size, units of measurement, number of foods examined, number of Arab foods and key findings). Quality was assessed using an adapted Newcastle-Ottawa Quality Assessment Scale for cross-sectional studies.

Results. Only seven studies were eligible from four of six GCC countries (Saudi Arabia, Bahrain, Kuwait and Qatar). All eligible studies used FFQs, but only 29% used a validated questionnaire, one being in Arabic, and none of the studies used any additional tools to measure diet. Fifty-seven percent of studies made an effort to include local foods. The majority of studies (71%) either measured frequency or quantity of food consumed, but only 29% attempted to account for both frequency and quantity.

Conclusions. The quality of studies varied and major weaknesses of FFQ validity and adaptability have been highlighted. More dietary investigations are needed using validated FFQs that have been adapted to the local GCC diets. Using reference tools will allow for better dietary estimations.
Assessment of nationally representative dietary studies in the Gulf Cooperation Council: A scoping review

Rukshana Hoque 1, Erin Strotheide 2, Juliann Saquib 3, Nazmus Saquib 3

1 Diabetes & Nutritional Sciences Division, King's College London, London, United Kingdom
2 Research Unit, Sulaiman Al Rajhi University, Bukayriah, Al-Qassim, Saudi Arabia
3 College of Medicine, Sulaiman Al Rajhi University, Bukayriah, Al-Qassim, Saudi Arabia

Corresponding Author:
Nazuin Saquib 3
PO Box 777, Bukayriah, Al-Qassim, 51941, Saudi Arabia

Email address: a.saquib@sr.edu.sa
Abstract

Background. Obesity is at a record high in Gulf Cooperation Council (GCC) countries and is expected to continue increasing. Diet is a major contributor to this disease, but there is inadequate nationally representative dietary research from these countries. The aim was to quantify the number dietary studies using food frequency questionnaires (FFQs) that have been conducted in individual GCC countries and to assess the quality of eligible studies.

Methodology. Four databases (PubMed, Web of Science, MEDLINE, and DOAJ) were searched for keywords; records were screened for eligible studies and data were abstracted on study characteristics (publication year, geographical locations, sample size, units of measurement, number of foods examined, number of Arab foods and key findings). Quality was assessed using an adapted Newcastle-Ottawa Quality Assessment Scale for cross-sectional studies.

Results. Only seven studies were eligible from four of six GCC countries (Saudi Arabia, Bahrain, Kuwait and Qatar). All eligible studies used FFQs, but only 29% used a validated questionnaire, one being in Arabic, and none of the studies used any additional tools to measure diet. Fifty-seven percent of studies made an effort to include local foods. The majority of studies (71%) either measured frequency or quantity of food consumed, but only 29% attempted to account for both frequency and quantity.

Conclusions. The quality of studies varied and major weaknesses of FFQ validity and adaptability have been highlighted. More dietary investigations are needed using validated FFQs that have been adapted to the local GCC diets. Using reference tools will allow for better dietary estimations.

Introduction

Obesity is an epidemic in the countries of the Gulf Cooperation Council (GCC) (that is, Saudi Arabia, Bahrain, Kuwait, Oman, Qatar, and United Arab Emirates). Approximately one out of every three adults is obese (Body Mass Index ≥30), and the obesity prevalence has been rising in every member country. For example, between 2011 and 2016, the obesity prevalence rose in Saudi Arabia (KSA) from 32.1 to 35.4%, in Bahrain from 27.1% to 29.8%, in Kuwait from 35.1% to 37.9%, in Oman from 23.7% to 27%, in Qatar from 31.8% to 35.1%, and in the United Arab Emirates (UAE) from 28.3% to 31.7% (1). Apart from obesity, the GCC countries are also leading countries in the world in diabetes and cardiovascular disease prevalence (2–4).

There is mounting evidence of a potential causal link between specific dietary factors (such as, fruit, vegetable, processed meat, and trans-fat intake) and the above mentioned chronic conditions (5–7). A recent systematic review of dietary data from 195 countries found that 22% of all adult deaths worldwide are due to unhealthy diet; more than half of diet-related deaths are attributable to a high sodium intake, low intake of whole grains, and low fruit intake (8).

Several factors likely contribute to obesity in GCC countries. With increased wealth from oil reserves, these countries have seen rapid economic growth. The urbanization of the landscape has seen a rise in international fast food chains, making it easier and quicker to consume
processed foods (9,10). This has resulted in a change of diet from traditional, locally produced goods such as wheat, vegetables and dates to fast foods high in fat, sugar and salt content (11). Whist all GCC countries have attempted to develop a national plan that addresses nutrition and physical activity, most have not followed up, which makes it difficult to evaluate the impact of such programs (12). Changes in lifestyle such as increased use of cars, electrical home appliances, television and gaming devices have resulted in a more sedentary lifestyle (9,13). The extremely hot climate found in these countries is also likely to deter outdoor activities with people opting to use cars, even for short journeys (9,14). A combination of all these is likely to play a role in the current epidemic.

Given the high prevalence of chronic conditions in the GCC, one would expect that these countries engage extensively in diet and nutrition research. However, dietary studies have been limited; only approximately 1% of global dietary research has come from Arab countries (15). Their h-indices [measurement of performance by combining productivity (number of papers) and impact (number of citations)] are much lower than neighbouring non-Arab countries (16).

One would similarly expect that assessment tools used in dietary studies from GCC countries would differ from those in European or North American studies as Middle Eastern diets vary a great deal from their western counterparts. For example, date palm fruit is highly consumed in Gulf regions, with daily consumption ranging from 68 – 164 g daily (17–19), whereas only 140 g of this fruit is consumed annually in Europe (20). Differences such as these should be accommodated for when designing dietary assessment tools.

The usual assessment tools used in dietary research are 24-hour dietary recall (open-ended, food consumed the previous day, conducted by trained interviewer), diet records (open-ended, participants trained to record own diet), and food frequency questionnaires (FFQs) (closed-ended, typically a food list and frequency of consumption in a given period). All have strength and limitations (21), but due to low cost, low respondent burden and ease of use compared to other methods, FFQs are thought to be the best choice for measuring habitual diet in large populations. The usefulness and reliability of FFQs have been demonstrated with strong correlations with diet records (22,23), dietary recalls (24–26), and objective biomarkers of diet (24,25). As an FFQ is a self-reported subjective tool, FFQs should be tested for validity alongside a reference tool.

The authors’ aimed to conduct both a quantitative and qualitative review of all dietary studies conducted within each GCC country. To be as nationally representative as possible and to provide a current and more reflective picture of diet in the GCC, only studies carried out in multiple regions (must be a minimum of two regions) were included. Dietary research that used FFQs in individual GCC countries (Bahrain, Kuwait, Oman, Qatar, KSA, UAE) over the past ten years (2009-2019) were assessed. The characteristics of the studies were described and their quality was assessed using a widely accepted scoring tool (27,28). The objectives were to (1) identify multi-regional GCC dietary studies that used FFQs, (2) assess the quality of the studies, and (3) offer recommendations for future dietary assessments.
**Method**

**SEARCH STRATEGY AND INCLUSION CRITERIA**

This review was conducted in May 2019. PubMed, Web of Science, MEDLINE, and Directory of Open Access Journals (DOAJ) databases were searched using the following terms: “diet,” “frequency questionnaire” in combination with each of the Gulf Cooperation Council countries (“Bahrain”, “Kuwait”, “Oman”, “Qatar”, “Saudi Arabia”, “UAE”). A total of 431 records were identified from PubMed (n = 241), Web of Science (n = 34), MEDLINE (n = 132) and DOAJ (n = 24). Duplicates (n=39) were removed, and the unique records (n = 392) were screened for the following inclusion criteria: (1) assessed diet using a food frequency questionnaire, (2) included data from multiple regions/cities (minimum two) of the Gulf country of focus, and (3) data were collected in the last ten years (that is, 2009 and later).

**EXCLUSION OF STUDIES**

Studies were excluded if they (1) examined data from only one specific region/city/population group and therefore were not necessarily nationally representative, (2) were multi-national studies that did not give Gulf-nation-specific results, (3) were not conducted in a GCC country, (4) were intervention studies where the diet had purposefully been changed, (5) were review or meta-analysis papers, (6) used an assessment tool other than a food frequency questionnaire, or (7) had no findings related to diet or did not report those findings. Therefore, the final analysis was limited to seven dietary studies (*Fig. 1*).

**DATA CHARTING PROCESS**

After an initial search and screening, the following data from each study were charted: publication year, author(s) name(s), geographical location, sample size, age range of participants, dietary assessment tool(s) used, units of measurement (for example, times/week, servings/day, etc.), total number of foods examined, number of Arab-specific foods (and where possible, the type and name of food), whether the questionnaire was validated, and dietary findings related to the most common foods studied. Any discrepancy was resolved through discussion and consensus among the authors.

**CRITICAL APPRAISAL OF STUDIES**

Using a scoring system adapted from Newcastle-Ottawa Quality Assessment Scale for cross-sectional studies (27), each study was scored for (1) representativeness of the sample, (2) sample size, (3) non-respondents, (4) ascertainment of the exposure, (5) adaptability, (6) assessment of the outcome, and (7) statistical test (*Appendix 1*).

**DATA ANALYSIS**

Study characteristics, along with main findings related to dietary intake/habits were tabulated. Additionally, indicators of study quality were assigned point values based on the quality
assessment scoring scale and then summed. Each study was categorized as excellent (9-12 points), satisfactory (5-8 points), or unsatisfactory (0-4 points).

Results

STUDY CHARACTERISTICS

The search resulted in seven studies published between 2009 and 2019. Tables 1 and 2 show three studies were conducted in Saudi Arabia, one in Kuwait, one in Bahrain, and two in Qatar; there were no studies from Oman or the UAE. A majority of the studies (n=6) had sample sizes greater than 1000 participants, and all studies included a sample size justification. Almost all studies had a 1:1 male: female ratio (range 1: 0.9-1.4 male: female). Fifty-seven percent (n=4) of the studies were carried out with adolescents (12-19 years of age), whereas 33% (n=2) included both adolescents and adults. One study (14%) classified participants 18 years and older as adults, thus the study was considered to be carried out on an all-adult population (29).

All studies used FFQs, but three administered the FFQ through face-to-face interviews; the rest were self-administered. One study (30) used pictures to deduce serving sizes.

The number of food items assessed ranged from two (non-specified fruits and vegetables) (31) to twenty items (29). Only two of seven studies used validated questionnaires, adapted it for local cuisine, and had it pilot tested for suitability (29,32) and from these, only one was conducted in Arabic; the other five studies did not use validated FFQs.

Key findings from each study varied based on the units of measurement. Frequency ranged from days per week, times per day, servings per day, to categories (such as, always, sometimes, never). Quantity options were servings per day, serving sizes, and serving sizes via selection of pictures.

QUALITY ASSESSMENT OF STUDIES

Only one of all included studies used a validated Arabic questionnaire (all were presented in English in the article) and none used any additional tools to measure diet. Donnelly et al. (29) translated the questionnaire to Arabic and back to English to ensure correct language usage. For relevance to local contexts, focus groups were conducted and the questionnaire pilot tested and thereafter further refined. Musaiger et al. (32) modified a previously validated questionnaire (Family Eating and Activity Habits Questionnaire) (33) and adapted it to ensure it reflected dietary habits of the target population. Contents of the FFQ were validated by experts in the field of nutrition, public health, and epidemiology and the questionnaire underwent pilot and test-retesting (32).

Table 3 shows 57% (n =4) of the studies made an effort to include local foods, scoring a point for adaptability, whereas the other three studies either did not incorporate any local foods or did not mention it in their studies.
Five studies measured either frequency or quantity, whilst two studies scored the maximum three points for ‘assessment of outcome’ by having units of measurement that took into account both frequency and quantity (that is, times/week and servings/day).

All studies used appropriate statistical analysis and 86% (n = 6) had an adequate response rate (≥ 60%). One study had 52.1% response rate (29) and one study did not compare between respondent and non-respondent characteristics or take non-responses into account (or did not mention it in their study) (34).

Discussion

With such a high prevalence of diseases to which diet is a major contributor, it is surprising that there are so few multi-regional studies that investigated diet in the GCC in the past ten years. Five out of the seven studies included in this review did not use validated FFQs.

Dietary summaries show intake of fruit and vegetables being far below the recommended three servings of vegetables and two servings of fruit per day (35). In Saudi Arabia, only 5.2% of individuals met the recommendation for fruit intake and 7.5% for vegetable intake. In contrast, consumption of sugary beverages was oversubscribed, with an average of 36% of adolescents (14-19 years old) reporting daily consumption (34) and 27% of 15-60 year olds (30), exceeding local and global recommendations of sugary-drink consumption (36–38). This low fruit and vegetable intake, combined with high sugary-beverage consumption, suggests a poor-quality diet across the GCC.

The varying methods of measuring diet made it difficult to compare consumption. For example, 57% of the studies assessed diet using frequency questions (how often), whilst 43% measured frequency and quantity (portions or serving size). At times, the response categories were too broad for in-depth analysis. For example, “Do you regularly consume meals? Yes/No” (32) does not specify which meals, how many meals, or the content of the meals. Similarly, “How often do you drink a glass of milk?” (39) does not quantify the size of the glass or the amount of milk consumed.

Adaptability was one of the main issues relating to study quality according to the quality assessment scoring scale. Studies need to make it explicit how they have categorized foods, for example, whether they have classified potatoes as starch, tuber, snack, fast food, etc. Four studies attempted to include local foods, with a maximum of two or three items added (and mentioned in the article) (29, 30, 38, 40). It is concerning that the other three studies did not mention any native foods at all. In Tabacchi’s review (41), it is suggested that an FFQ with less than 70 food items reduces the quality of nutritional information that can be deduced. None of the studies included in this review had 70 items; the most was 20, the average being 11 items. Nutritional status and dietary patterns differ over time and from region to region; without the incorporation of local foods and without categorizing them under more common food groups, it is entirely possible to mask important epidemiological links between diet and disease.
An overall poor validity of FFQs was found in this review. Only one study used a validated Arabic FFQ and scored three points out of a possible four points on the quality assessment scale. Validation in large-scale studies is especially important as FFQs are prone to measurement errors and come with inherent self-bias. FFQs rely on an individual’s memory and his/her own perception of food sizes, thus under-reporting remains a common problem (42–45). Researchers have made extensive efforts in the last two decades to mitigate some of the errors with self-reporting data (46–48), but diet and eating patterns are complex, and FFQs are still thought to have clear value and insight that solely objective measures cannot provide (49,50). One of the ways to minimize errors is to use a validated FFQ. FFQs are not one-size-fits-all, and it is integral that questionnaires be adapted/modified to suit the population with which they are being used. This includes first developing a good FFQ to standard procedure (51), FFQs being in the native language, which for GCC is predominantly Arabic, and including as many local foods as possible.

Within obesity research, two areas are deficient: understanding the role of dietary habits in the obesity epidemic and sufficient intervention studies on weight loss via dietary change. Research on dietary habits in the obesity epidemic may be lacking due to a shortage of skilled researchers and research centers (12). Obtaining accurate dietary data requires specialized nutritionists/dieticians and controlled research settings, but this is a problem across many Gulf states, where it is difficult to have sufficient numbers of well-trained staff to serve large populations and areas like Saudi Arabia (Table 1). Investments should be made in specialized university health education and research courses and training in hospital departments; this will take time and resources but is a necessary step to produce expert personnel that can adequately face the challenges of regional obesity research (12).

Research in this field may also be looking at risk factors found in Western countries and not necessarily exploring factors that are unique to the socio-cultural environment of the GCC. For example, women have been shown to be less active than men across Gulf countries (52,53) and more sedentary than their British counterparts (54,55), but reasons for this behavior was poorly understood. Only by exploring the socioeconomic, environmental and cultural contexts further was it understood that the greatest barrier to physical activity for women was a lack of facilities rather than assumed low levels of knowledge, dress codes (56) or high obese-body acceptance (57). Samara et al. suggested that future health strategies should focus on providing culturally sensitive exercise facilities for women (56). A similar approach needs to be taken for nutrition and diet, where interventions, based on survey results, acknowledge and work with, not against, local culture and social norms (58). Such intervention studies need to have tangible goals, clear action plans and sufficient follow-up to evaluate long-term effectiveness (59).

Limitations of this review are that the search was carried out on four main databases; this may have missed studies published in other journals not found within these databases, and those that are currently underway or not yet published. However, additional cross-checking was performed with reference lists to ensure the maximum number of studies were screened. The small number of studies limited the generalizability of findings. To the authors’ knowledge, there
are no other reviews similar to the current study. There are studies that have looked at other methods for country-specific dietary assessment (49) and the Newcastle-Ottawa Scale, which was adapted for this study, has been used to assess study quality but not in the same context as the current study (27,60). Finally, although studies have looked at dietary research from other parts of the world, no study has quantified the number of dietary studies coming specifically from the GCC and assessed their quality. Our review is unique in these ways, so the results of this present study cannot be easily compared to other studies.

A particular strength is the quality assessment aspect of this review. Adapting a scoring system allowed for objective assessment of studies. It highlighted that most of the included studies were either satisfactory (n=4) or excellent (n=3), whilst making it clear that the greatest weaknesses were in the number of food items and the validity and adaptability of FFQs, which researchers should take into consideration when designing future studies. Another strength is that the review focused on large-scale, multi-regional studies, which are more representative of the respective GCC nations’ populations.

RECOMMENDATIONS

As validity and adaptability were the lowest scoring categories, it is important to address this.

1. Validation can be assured by using a reference method. There are a variety of other methods used to measure diet, including self-reporting food records and 24-hour dietary recall (24-HDRs), but the most objective reference tool is food or nutrient biomarkers (21,61). In theory, biomarkers look like a promising method to remove the human error that comes with self-reported dietary data, but their widespread use is hindered because there are only a few known and validated biomarkers. One of the well-known biomarkers could be used as a reference measurement to validate FFQs and to assess their accuracy.

2. As KSA is the largest of the GCC countries, a quality assessment of all FFQs used in KSA should be undertaken. Comparisons should be made to see how similar they are, how inclusive they are of local cuisine and if the questionnaires are validated. This will be a labour-intensive task as the questionnaires are rarely attached to the articles or submitted as supplementary material; thus, authors will need to be contacted for original FFQs. This will give an overview of the versions of FFQs available and the Arabic food items included. By noting what foods are not represented in these questionnaires, additional foods can be added and attempts made to validate the FFQ. A recent FFQ developed by Gosadi et al. (2017) is a promising start for KSA (62). The Arabic FFQ had 140 food items and ensured it had a comprehensive food list by comparing it with open-ended information from 24-hour dietary recalls to find that 85% of food items recalled were covered in the FFQ. The FFQ has been piloted and its reliability assessed (Cronbach’s alpha test and test-retest) and it should now be used in other regions. This standard of FFQ development should be carried out with other GCC countries as well to better capture dietary habits.
3. The review only included cross-sectional studies because they give a current picture of diet (observations of diet at a given point in time). Carrying out a longitudinal study analysis (repeated observations of a population over time) would illuminate how diet has changed over time to make better-informed future predictions.

**Conclusions**

This is the first review to collect, quantify and critique the quality of data from dietary studies conducted in GCC countries by using an objective scoring system approach. Study quality varied, and major weaknesses of FFQ validity and adaptability have been highlighted.

Findings consistently showed that the majority of GCC populations are not meeting the recommended fruit and vegetable intake, and sugary-beverage consumption is on the rise, implying a poor diet. However, interpretations are made with caution due to the low study sample included (n=7). In these GCC countries, where obesity levels are steadily rising, more dietary investigations are necessary. The use of validated FFQs in conjunction with other instruments like biomarkers, 24-hour recalls and/or food records is likely to provide more accurate dietary estimations.

In conclusion, it is essential that researchers develop well-designed, validated FFQs that are adapted for the GCC to standardise dietary assessments across studies.

**References**

1. Global health observatory. Prevalence of obesity among adults - Estimates by country. Geneva: World Health Organization; 2017 (http://apps.who.int/gho/data/node.main.A900A?lang=en, accessed 29 May 2019).
2. M Alqarni SS. A review of prevalence of obesity in Saudi Arabia. J Obes Eat Disord. 2016; 02(02).
3. Alqurashi KA, Aljabri KS, Bokhari SA. Prevalence of diabetes mellitus in a Saudi community. Ann Saudi Med. 2011; 31(1):19–23.
4. Aljefree N, Ahmed F. Prevalence of cardiovascular disease and associated risk factors among adult population in the Gulf Region: A systematic review. Adv Public Heal. 2015; 2015:1–23.
5. Micha R, Shulkin ML, Peñalvo JL, Khatibzadeh S, Singh GM, Rao M, Fahimi S, Powles J, Mozaffarian D. Etiologic effects and optimal intakes of foods and nutrients for risk of cardiovascular diseases and diabetes: Systematic reviews and meta-analyses from the Nutrition and Chronic Diseases Expert Group (NutriCoDE). Kiechl S, editor. PLoS One. 2017;12(4):e0175149.
6. Diet, nutrition, physical activity and cancer: A global perspective. London: World Cancer Research Fund; 2018 (https://www.wcrf.org/dietandcancer, accessed 26 September 2019).
7. WCRF/AICR systematic literature review continuous update project report: The
associations between food, nutrition and physical activity and the risk of colorectal cancer.

London: World Cancer Research Fund, American Institute for Cancer Research ICL; 2010

(https://www.wcrf.org/sites/default/files/SLR_colorectal_cancer_2010.pdf, accessed 21 September 2019).

8. GBD 2017 Diet Collaborators. Health effects of dietary risks in 195 countries, 1990-2017: A systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2019;

9. Alnohair S. Obesity in Gulf countries. Int J Health Sci (Qassim). 2014; 8(1):79–83.

10. Al-Mahroos F, Al-Roomi K. Overweight and obesity in the Arabian Peninsula: An overview. J R Soc Promot Health. 1999;119(4):251–3.

11. Al-Othaimen Al, Al-Nozha M, Osman AK. Obesity: An emerging problem in Saudi Arabia. Analysis of data from the National Nutrition Survey. East Mediterr Heal J. 2007;13(2):441–8.

12. Samara A, Andersen PT, Aro AR. Health promotion and obesity in the Arab Gulf States: Challenges and good practices. J Obes. 2019: 4756260.

13. Musaiger AO. Overweight and obesity in the Eastern Mediterranean Region: Can we control it? East Mediterr Health J. 2004; 10(6):789-793.

14. Al-Kandari YY. Prevalence of obesity in Kuwait and its relation to sociocultural variables. Obes Rev. 2006; 7(2):147–54.

15. Sweileh WM, Al-Jabi SW, Sawalha AF, Zyoud SH. Bibliometric analysis of nutrition and dietetics research activity in Arab countries using ISI Web of Science database. Springerplus. 2014; 3(1):718.

16. Hirsch JE. An index to quantify an individual's scientific research output. Proc Natl Acad Sci U S A. 2005; 102(46):16569–72.

17. Al-Mssalle MQ. Consumption of dates among Saudi Adults and its association with the prevalence of type 2 diabetes. Asian J Clin Nutr. 2018; 10(2):58–64.

18. Ismail B, Henry J, Haffir I, Baalbaki R. Date consumption and dietary significance in the United Arab Emirates. J Sci Food Agric. 2006; 86(8):1196–201.

19. Aleid SM, Al-Khayri JM, Al-Bahrany AM. Date palm status and perspective in Saudi Arabia. In: Date palm genetic resources and utilization. Dordrecht: Springer Netherlands. 2015:49–95.

20. Ordines B. Study of the main European markets for dates and of the commercial potential of non-traditional varieties. Food and Agriculture Organization of the United Nations; 2000 (http://www.fao.org/3/a-y2745e.pdf, accessed 24 April 2019).

21. Shim JS, Oh K, Kim HC. Dietary assessment methods in epidemiologic studies. Epidemiol Health. 2014:e2014009.

22. Rimm EB, Giovannucci EL, Stampfer MJ, Colditz GA, Litin LB, Willett WC. Reproducibility and validity of an expanded self-administered semi-quantitative food frequency questionnaire among male health professionals. Am J Epidemiol. 1992; 135(10):1114–26.

23. Willett WC, Sampson L, Stampfer MJ, Rosner B, Bain C, Witschi J, Hennekens CH, Speizer FE. Reproducibility and validity of a semiquantitative food frequency questionnaire. Am J Epidemiol. 1985; 122(1):51–65.

24. Katsouyanni K. Reproducibility and relative validity of an extensive semi-quantitative food frequency questionnaire using dietary records and biochemical markers among Greek schoolteachers. Int J Epidemiol. 1997; 26(90001):118S – 127.
25. Brunner E, Stallone D, Juneja M, Bingham S, Marmot M. Dietary assessment in Whitehall II: Comparison of 7 d diet diary and food-frequency questionnaire and validity against biomarkers. Br J Nutr. 2001; 86(3):405–14.

26. Marques-Vidal P, Ross A, Wynn E, Rezzi S, Paccaud F, Decarli B. Reproducibility and relative validity of a food-frequency questionnaire for French-speaking Swiss adults. Food Nutr Res. 2011; 55.

27. Herzog R, Álvarez-Pasquin MJ, Díaz C, Del Barrio JL, Estrada JM, Gil Á. Are healthcare workers’ intentions to vaccinate related to their knowledge, beliefs and attitudes? A systematic review. BMC Public Health. 2013; 13:154.

28. Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. Eur J Epidemiol. 2010; 25(9):603–5.

29. Donnelly TT, Fung TS, Al-Thani A-AbM. Fostering active living and healthy eating through understanding physical activity and dietary behaviours of Arabic-speaking adults: A cross-sectional study from the Middle East. BMJ Open. 2018; 8(4):e019980.

30. Moradi-Lakeh M, El Beheraoui C, Afshin A, Daoud F, AlMazrooa MA, Al Saeedi M, Basulaiman M, Memish ZA, Al Rabeeah AA, Mokdad AH. Diet in Saudi Arabia: Findings from a nationally representative survey. Public Health Nutr. 2017; 20(06):1075–81.

31. Haj Bakri A, Al-Thani A. Disease Risk factor surveillance: Qatar STEPS Report 2012. Geneva: World Health Organization; 2012 (http://www.who.int/chp/steps/qatar/en/, accessed 2 April 2019).

32. Musaiger A, Bader Z, Al-Roomi K, D’Souza R. Dietary and lifestyle habits amongst adolescents in Bahrain. Food Nutr Res. 2011; 55(1):7122.

33. Golan M, Weizman A. Reliability and validity of the Family Eating and Activity Habits Questionnaire. Eur J Clin Nutr. 1998; 52(10):771–7.

34. Al-Hazzaa HM, Abahussain NA, Al-Sobayel HI, Qahwaji DM, Musaiger AO. Physical activity, sedentary behaviors and dietary habits among Saudi adolescents relative to age, gender and region. Int J Behav Nutr Phys Act. 2011; 8:140.

35. Saudi dietary guideline (Healthy diet palm). Riyadh: Ministry of Health Publications; 2012 (https://www.moh.gov.sa/en/Ministry/MediaCenter/Publications/Documents/finalenglish الكتاب.pdf, accessed 2 April 2019).

36. Eaton DK, Kann L, Kinchen S, Shanklin S, Flint KH, Hawkins J, Harris WA, Lowry R, McManus T, Chyen D, Whittle L, Lim C, Wechsler H, Centers for Disease Control and Prevention (CDC). Youth risk behavior surveillance - United States, 2011. MMWR Surveill Summ. 2012; 61(4):1–162.

37. Al Qaseer B, Batarseh S, Asa’ad A. Global school-based student health survey - Jordan. Geneva: World Health Organization; 2007.

38. AlBuHairan FS, Tamim H, Al Dubayee M, AlDhukair S, Al Shehri S, Tamimi W, El Bcheraoui C, Magzoub ME, de Vries N, Al Alwan I. Time for an adolescent health surveillance system in Saudi Arabia: Findings from “Jeeluna.” J Adolesc Health. 2015; 57(3):263–9.

39. Alsheridah N, Akhtar S. Diet, obesity and colorectal carcinoma risk: Results from a national cancer registry-based middle-eastern study. BMC Cancer. 2018; 18(1):1227.

40. Al Baho A, Badr HE. Global school-based health survey - Kuwait. Geneva: World Health Organization; 2011 (https://www.who.int/ncds/surveillance/gshs/GSHS_Kuwait_report_2011.pdf, accessed
428 on 2 April 2019).
429
430 41. Tabacchi G, Amodio E, Di Pasquale M, Bianco A, Jemni M, Mammina C. Validation and reproducibility of dietary assessment methods in adolescents: A systematic literature review. Public Health Nutr. 2014; 17(12):2700–14.
431
432 42. Subar AF, Kipnis V, Troiano RP, Midthune D, Schoeller DA, Bingham S, Sharbaugh CO, Trabulsi J, Runswick S, Ballard-Barbash R, Sunshine J, Schatzkin A. Using intake biomarkers to evaluate the extent of dietary misreporting in a large sample of adults: The OPEN Study. Am J Epidemiol. 2003; 158:1–13.
433
434 43. Beaton GH, Milner J, Corey P, McGuire V, Cousins M, Stewart E, de Ramos M, Hewitt D, Grambsch PV, Kassim N, Little JA. Sources of variance in 24-hour dietary recall data: implications for nutrition study design and interpretation. Am J Clin Nutr. 1979; 32(12):2546–59.
435
436 44. Freudenheim JL, Marshall JR. The problem of profound mismeasurement and the power of epidemiological studies of diet and cancer. Nutr Cancer. 1988; 11(4):243–50.
437
438 45. Kipnis V, Subar AF, Midthune D, Freedman LS, Ballard-Barbash R, Troiano RP, Bingham S, Schoeller DA, Schatzkin A, Carroll RJ. Structure of dietary measurement error: Results of the OPEN biomarker study. Am J Epidemiol. 2003; 158:14–21.
439
440 46. Freedman LS, Commins JM, Moler JE, Arab L, Baer DJ, Kipnis V, Midthune D, Moshefegh AJ, Neuhouser ML, Prentice RL, Schatzkin A, Spiegelman D, Subar AF, Tinker LF, Willett W. Pooled results from 5 validation studies of dietary self-report instruments using recovery biomarkers for energy and protein intake. Am J Epidemiol. 2014; 180(2):172–88.
441
442 47. Freedman LS, Kipnis V, Schatzkin A, Tasevska N, Potischman N. Can we use biomarkers in combination with self-reports to strengthen the analysis of nutritional epidemiologic studies? Epidemiol Perspect Innov. 2010; 7(1):2.
443
444 48. Kipnis V, Midthune D, Freedman L, Bingham S, Day NE, Riboli E, Ferrari P, Carroll RJ. Bias in dietary-report instruments and its implications for nutritional epidemiology. Public Health Nutr. 2002; 5(6A):915–23.
445
446 49. Kirkpatrick SI, Vanderlee L, Raffoul A, Stapleton J, Csizmadi I, Boucher BA, Massarelli I, Rondeau I, Robson PJ. Self-report dietary assessment tools used in Canadian research: A scoping review. Adv Nutr. 2017; 8(2):276–89.
447
448 50. Subar AF, Freedman LS, Tooze JA, Kirkpatrick SI, Boushey C, Neuhouser ML, Thompson FE, Potischman N, Guenthner PM, Tarasuk V, Reedy J, Krebs-Smith SM. Addressing current criticism regarding the value of self-report dietary data. J Nutr. 2015; 145(12):2639–45.
449
450 51. Willett W. Nutritional epidemiology. Oxford: Oxford University Press; 2012 (http://www.oxfordscholarship.com/view/10.1093/acprof:oso/9780199754038.001.0001/acprof-9780199754038, accessed 9 April 2019).
451
452 52. Al-Nozha MM, Al-Hazzaa HM, Arafa MR, Al-Khadra A, Al-Mazrou YY, Al-Maatoq MA, Khan NB, Al-Marzouki K, Al-Harthi SS, Abdullah M, Al-Shahid MS. Prevalence of physical activity and inactivity among Saudis aged 30-70 years. A population-based cross-sectional study. Saudi Med J. 2007; 28(4):559-68.
453
454 53. Mabry RM, Reeves MM, Eakin EG, Owen N. Evidence of physical activity participation among men and women in the countries of the Gulf Cooperation Council: A review. Obes Rev. 2009; 11(6):457–64.
455
456 54. Al-Hazzaa HM, Al-Nakeeb Y, Duncan MJ, Al-Sobayel HI, Abahussain NA, Musaiger
AO, Lyons M, Collins P, Nevill A. A cross-cultural comparison of health behaviors between Saudi and British adolescents living in urban areas: Gender by country analyses. Int J Environ Res Public Health. 2013; 10(12):6701–20.

55. Al-Nakeeb Y, Lyons M, Collins P, Al-Nuaim A, Al-Hazzaa H, Duncan MJ, Nevill A. Obesity, physical activity and sedentary behavior amongst British and Saudi youth: A cross-cultural study. Int J Environ Res Public Health. 2012; 9(4):1490–506.

56. Samara A, Aro AR, Alrammah T, Nistrup A. Lack of facilities rather than sociocultural factors as the primary barrier to physical activity among female Saudi university students. Int J Womens Health. 2015; 7:279.

57. Wills W, Backett-Milburn K, Gregory S, Lawton J. Young teenagers’ perceptions of their own and others’ bodies: A qualitative study of obese, overweight and “normal” weight young people in Scotland. Soc Sci Med. 2006; 62(2):396–406.

58. O’Dea JA. Gender, ethnicity, culture and social class influences on childhood obesity among Australian schoolchildren: Implications for treatment, prevention and community education. Heal Soc Care Community. 2008; 16(3):282–90.

59. Lawton J, Ahmad N, Hanna L, Douglas M, Hallowell N. “I can’t do any serious exercise”: Barriers to physical activity amongst people of Pakistani and Indian origin with type 2 diabetes. Health Educ Res. 2006; 21(1):43–54.

60. Modesti PA, Reboldi G, Cappuccio FP, Agyemang C, Remuzzi G, Rapi S, Perruolo E, Parati G, ESH Working Group on CV Risk in Low Resource Settings. Panethnic differences in blood pressure in Europe: A systematic review and meta-analysis. PLoS One. 2016; 11(1):e0147601.

61. Hedrick VE, Dietrich AM, Estabrooks PA, Savla J, Serrano E, Davy BM. Dietary biomarkers: Advances, limitations and future directions. Nutr J. 2012; 11(1):109.

62. Gosadi I, Alatar A, Otyaf M, AlJahani D, Ghabbani H, AlRajban W, Alrsheed AM, Al-Nasser KA. Development of a Saudi Food Frequency Questionnaire and testing its reliability and validity. Saudi Med J. 2017; 38(6):636–41.

Figure 1 Flow chart of study eligibility of dietary studies conducted in GCC countries.
Table 1 Background information and characteristics of Gulf Cooperation Countries (GCC)

*PubMed; Web of Science; MEDLINE; DOAJ (Directory of Open Access Journals)
|                                | Bahrain | Kuwait | Oman       | Qatar | Saudi Arabia | UAE   |
|--------------------------------|---------|--------|------------|-------|--------------|-------|
| Year country was founded/independent | 1971    | 1961   | 1951       | 1971  | 1932         | 1971  |
| Surface area (km²)              | 774     | 17,188 | 309,500    | 11,628| 2,149,690    | 77,700|
| Population (thousands) in 2016  | 1425    | 4053   | 4425       | 2570  | 32,276       | 9250  |
| Obesity prevalence in 2011 (%)   | 27.1    | 35.1   | 23.7       | 31.8  | 32.1         | 28.3  |
| Obesity prevalence in 2016 (%)   | 29.8    | 37.9   | 27         | 35.1  | 35.4         | 31.7  |
| Net change in obesity (%)        | +2.7    | +2.8   | +3.3       | +3.3  | +3.3         | +3.4  |
| Total number of hits using keywords* | 29      | 64     | 56         | 52    | 176          | 46    |
| Studies included                 | 1       | 1      | 0          | 2     | 3            | 0     |
|                                 | (Musaiger et al., 2011) (32) | (Al Baho and Badr, 2011) (40) | (Haj Bakri & Al-Thani, 2012) (31) | (Moradi-Lakeh et al., 2017) (30) | (Al-Hazzaa et al., 2011) (34) | (AlBuhairan et al., 2015) (38) |

*PubMed; Web of Science; MEDLINE; DOAJ (Directory of Open Access Journals)
Table 2 Study characteristics of national dietary assessment studies conducted in Arab Gulf countries (n=7).

*where possible, names of Arab food have been included

# number

SSB: sugar sweetened beverages
Table 2 Study characteristics of national dietary assessment studies conducted in Arab Gulf countries (n=7).

| Author                  | Country      | Age range | Sample size (Male; Female) | Type                        | # of total food items | # and type of Arab food* | Measurement                                                                 | Validated | Findings                                                                 |
|-------------------------|--------------|-----------|---------------------------|-----------------------------|-----------------------|--------------------------|----------------------------------------------------------------------------|-----------|--------------------------------------------------------------------------|
| Al Baho & Badr, 2011(40)| Kuwait       | 13 - 15   | 2674 (1399 male; 1275 female) | FFQ (2011 Kuwait GSHS)      | 6                     | 2                        | Coriander (vegetable); KDD, KDcow, Carnation (dairy) times/day in past 30 days except breakfast: how often in last 30 days: Never, Rarely, Sometimes, Mostly, Always) | Not validated | Over 30 days, 36% of students usually ate fruits (≥2 times/day); 19% ate vegetables (≥3 times/day); 75% consumed soft drink (≥1 times/day); 36% drank milk (≤2 times/day); 48% had fast food (≥3 times/week). |
| AlBuhairan et al., 2015(38) | Saudi Arabia | 12 - 19   | 12575 (6444 male; 6131 female) | FFQ (Global School-based Student Health Survey) | 8 (includes meals)     | 2                        | Fatayer (snack); molokhiya (vegetable) srvgs/day breakfast: last 30 days (never, rarely, some, most, daily) Number of main meals | Not validated | 38% of adolescents ate ≥1 srvgs/day of fruit and 54.3% ate ≥1 srvgs/day of vegetables. 38% drank ≥2 carbonated beverages/day. |
| Study                          | Country        | Age Range | Sample Size | Dietary Instrument | Days of Validation | Dietary Intake                                                                 |
|-------------------------------|----------------|-----------|-------------|--------------------|--------------------|--------------------------------------------------------------------------------|
| Al-Hazzaa et al., 2011(34)    | Saudi Arabia   | 14 - 19   | 2908        | FFQ (Arab Teen Lifestyle Survey (ATLS)) | 9 days/wk          | In Saudi adolescents, an average of 22.8% consumed vegetables daily; 12.8% had fruit daily; 29.15% had milk daily; 62.35% consumed sugar-sweetened beverages (SSB) (> 3 day/week); 27.55% fast food (> 3 day/week); 27.85% french fries/potato chips (> 3 day/week); 26.8% cake/donut/biscuit intake (> 3 day/week); 44.95% sweets/chocolates intake (> 3 day/week); 50.65% energy drinks intake (> 3 day/week); |
| Study                        | Country | Age Range | Sample Size | Survey Method | Dietary Assessment | Validation | Key Findings |
|------------------------------|---------|-----------|-------------|---------------|-------------------|------------|--------------|
| Donnelly et al., 2018 (29)   | Qatar   | ≥18        | 1606        | FFQ           | 20                | Validated  | Participants ate fruits (35.8%), green vegetables (31.8%) and other vegetables (44.1%) at least once daily. 44.7% consumed milk products and 14.4% drank carbonated soda more than once daily. 26.1% of participants on average ate pasta, snacks and cakes or pastries 2–4 times/week. An average of 32% consumed protein products 2–4 times/week. |
| Haj Bakri & Al-Thani, 2012(31)| Qatar   | 18 - 64    | 2496        | FFQ via face-to-face interviews | None | Not validated | 91% of the Qatari studied population consumes <5 srvgs/day of fruits and/or vegetables. Average number of fruit servings was 0.8 srvgs/day. Average number of vegetable servings was 0.8. |
servings was 1.4 srvgs/day. Overall average combined fruit and/or vegetable servings was 2.2 srvgs/day.

| Study                        | Country          | Age Group | Sample Size | Methodology | Serving Size | Days/Wk | Validation | Notes |
|------------------------------|------------------|-----------|-------------|-------------|---------------|---------|------------|-------|
| Moradi-Lakeh et al., 2017(30)| Saudi Arabia     | 15 - 60+  | 10735       | FFQ via interview; pictures of serving sizes | 2 Laban and labneh (yogurt products) | Not validated | 11% of subjects ate fruits daily and 26% ate vegetables daily. 27% drank SSB daily. Dietary guideline recommendations for fruits were met by only 5.2% of participants and 7.5% for vegetables. 85% met the recommended intake for meat and 80% met recommendations for processed meats. |
| Musaiger et al., 2011(32)    | Bahrain          | 15-18     | 735 subjects | FFQ (includes meals) | None | times/wk | Modified from validated questionnaire | Approximately 25% of respondents reported eating |
times/wk AND typical srvg size meals: regularly (yes/no) snacking: always, sometimes, never and pilot-tested

|         | 27.7% consumed fruit rarely (<1 time/week). | 26% consumed vegetables daily, 38% of respondents rarely (<1 time/week). | 37% consumed dairy products daily; 22% rarely (<1 time/week). | 20% consume meat daily; 21.5% rarely (<1 time/week). | 14.4% of participants ate fast food daily, 29% rarely (<1 time/week). | Soft drinks: 42.2% of participants consume soft drinks daily; 27.8% rarely (<1 time/week). |
|---------|---------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------------|--------------------------------------------------|--------------------------------------------------|------------------------------------------------------------------|
|         | fruit daily, 27.7% consumed fruit rarely (<1 time/week). | 26% consumed vegetables daily, 38% of respondents rarely (<1 time/week). | 37% consumed dairy products daily; 22% rarely (<1 time/week). | 20% consume meat daily; 21.5% rarely (<1 time/week). | 14.4% of participants ate fast food daily, 29% rarely (<1 time/week). | Soft drinks: 42.2% of participants consume soft drinks daily; 27.8% rarely (<1 time/week). |

3 where possible, names of Arab food have been included
4 # number
5 SSB: sugar sweetened beverages
Table 3 Quality assessment of national dietary assessment studies conducted in GCC countries using a scoring system (n=7).
Table 3 Quality assessment of national dietary assessment studies conducted in GCC countries using a scoring system (n=7).

| Author                     | Design          | Representative of sample | Sample size | Non-respondents | Ascertainment of exposure (validated) | Adaptability | Outcome | Assessment of outcome | Statistical test | Total Score (out of 12) |
|----------------------------|-----------------|--------------------------|-------------|-----------------|--------------------------------------|--------------|---------|-----------------------|------------------|-------------------------|
| Al Baho & Badr, 2011(40)   | cross-sectional | +                        | +           | +               | +                                    | +            |         | + +                   | +                | 8                       |
| AlBuhairan et al., 2015(38)| cross-sectional | +                        | +           | +               | +                                    | +            |         | + +                   | +                | 8                       |
| Al-Hazzaa et al., 2011(34)| cross-sectional | +                        | +           | +               | +                                    | +            |         | + +                   | +                | 6                       |
| Donnelly et al., 2018(29) | cross-sectional | +                        | +           | +               | +++                                  | +            |         | + +                   | +                | 9                       |
| Haj Bakri & Al-Thani, 2012(31) | cross-sectional | +                        | +           | +               | +                                    | +            |         | + + +                 | +                | 8                       |
| Moradi-Lakhe et al., 2017(30)| cross-sectional | +                        | +           | +               | +                                    | +            |         | + + +                 | +                | 9                       |
| Musaiger et al., 2011(32) | cross-sectional | +                        | +           | +               | ++                                   | +            |         | + + +                 | +                | 9                       |
Figure 1

Figure 1 Flow chart of study eligibility of dietary studies conducted in GCC countries.

Database search
PubMed (n= 241); Web of Science (n= 34);
MEDLINE (n=132); DOAJ (n=24)

Total retrieved records
n= 431

Duplicate records
n= 39

Screened by year (2009-2019)
n= 392

Before 2009
n= 112

Excluded: n= 269
Reasons:
• Review articles
• Data collected before 2009
• Intervention studies
• Only conducted in one region
• Conducted in non-Gulf countries
• FFQ not used

Abstracts screened
n= 280

Excluded: n= 4
• Dietary findings not mentioned in article
• Findings not relevant to diet

Full text review for eligibility
n= 11

Total eligible studies
n= 7