

Childhood and Adolescent Overweight, Obesity and Socio-Economic Circumstances in The Gulf Cooperation Council Countries: A Systematic Review

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Abstract: The Gulf Cooperation Council (GCC) Countries are high-income but, unlike those in Europe and North America, uncertainty exists about the patterning of childhood obesity by socio-economic circumstances (SEC). This paper systematically reviews the association between overweight or obesity and SEC in children and adolescents, aged 5-19 years, in the GCC countries.

Between 2000 and May 2020, 785 papers were identified, 45 full-text articles were reviewed and ten papers of studies in Kingdom of Saudi Arabia (KSA), Bahrain, Kuwait and Qatar were included. Thirty-one SEC-overweight/obesity associations were examined with seven SEC indicators, with parental education and employment being commonly used indicators. Sixteen positive associations were reported in seven studies and two negative associations in two studies. Of the positive associations, eight were among girls, three among boys and five among girls and boys combined. Multivariable adjustments were conducted in three studies and showed that maternal employment was independently associated with just under a two-fold increase in overweight and obesity.

The small available evidence base indicates that SEC was generally either positive, more so among girls than boys, or not associated with overweight and obesity among children and adolescents. These findings signaled the importance of rapidly transitioning contexts of the GCC countries on childhood and adolescent overweight and obesity.

Keywords: obesity, overweight, adolescents, socioeconomic.

العلاقة بين زيادة الوزن والسمنة والظروف الاجتماعية والاقتصادية في مرحلة الطفولة والمرحلة في دول مجلس التعاون الخليجي: مراجعة منهجية

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المستخلص: تشهد دول مجلس التعاون الخليجي ذات الدخل المرتفع، حالة من عدم اليقين بشأن نمط سمنة الأطفال بناء على مؤشرات الظروف الاجتماعية والاقتصادية. تستعرض هذه الورقة بشكل منهجي العلاقة بين الظروف الاقتصادية وزيادة الوزن أو السمنة لدى الأطفال والمراهقين، الذين تتراوح أعمارهم بين 5-19 عامًا، في دول مجلس التعاون الخليجي.

بين عام 2000 إلى 2020، تم تحديد 785 ورقة بحثية، وتمت مراجعة 45 دراسة كاملة، وتضمنت عشر دراسات في المملكة العربية السعودية والبحرين والكويت وقطر. واحد وثلاثون ورقة علمية تم فيها قياس العلاقة بين السمنة والظروف الاقتصادية. المستوى التعليمي والوظيفة للوالدين كانت من أكثر المؤشرات استخداما لقياس العلاقة بين السمنة والظروف الاقتصادية والاجتماعية. أوجدت الدراسات إلى ان هناك علاقة إيجابية بين السمنة و16 مؤشر من الظروف الاقتصادية والاجتماعية في 7 ورقات علمية. ثماني دراسات وجدت علاقة بين السمنة والظروف الاقتصادية والاجتماعية بين الفتيات، 3 دراسات بين الأولاد و5 دراسات جمعت بين الجنسين.

تشير الدراسات إلى أن مؤشرات الظروف الاقتصادية والاجتماعية مرتبطة ارتباطاً إيجابياً بالسمنة لدى المراهقين، أكثر بين الفتيات من الأولاد. أيضاً تشير هذه النتائج إلى أهمية التحول السريع لسياقات دول مجلس التعاون الخليجي بشأن زيادة الوزن والسمنة لدى الأطفال والمراهقين.

الكلمات المفتاحية: السمنة، زيادة الوزن، المراهقون، الظروف الاجتماعية والاقتصادية.

Introduction

Childhood obesity is now pandemic with global prevalence having risen by 8-fold in the past four decades. In high-income countries, the prevalence may have plateaued (Hruby & Hu, 2015) but it continues to rise in lower- and middle-income contexts (Koletzko et al., 2020). The Middle East has also seen a significant increase in rates of obesity among young people. In the Gulf Cooperation Council (GCC) countries the prevalence of overweight and obesity for children aged (6-10 years) was 14.2% among males and 25% among females (Al Yazeedi & Berry, 2019).

The discovery of oil in the mid- 20th century fuelled rapid socioeconomic development and epidemiological transition with concomitant decreases in child and infant mortality rates. Some argue that increasing per capita income and urbanization have contributed to the rapid increase in overweight and obesity in the region (Abdul-Rasoul, 2012). Prolific marketing, availability, and affordability of energy-dense foods and sugar-sweetened beverages have infiltrated food systems and negatively impacted cultural conventions away from eating fruits, vegetables, nuts, and whole grains (Musaiger, Takruri, Hassan, & Abu-Tarboush, 2012).

Reducing socioeconomic inequalities in childhood and adolescent obesity is a global priority because of its multiple long-term adverse health consequences (Bann, Johnson, Li, Kuh, & Hardy, 2018). Socioeconomic inequalities in childhood and adolescent overweight and obesity vary by gender, age and level of development of the country (Lieb, Snow, & DeBoer, 2009; Wang & Lim, 2012). In high - income countries such as Europe and North America, an inverse relationship is usually observed with many measures of socio-economic advantage (McLaren, 2007), but uncertainty exists about the direction or magnitude of inequality in the high-income countries of the Gulf Cooperation Council (GCC) Countries.

Socio-economic circumstances (SEC) refers to the social and economic resources that people/groups have access to in society and which can influence their position in society, life chances, and health (Galobardes, Shaw, Lawlor, & Lynch, 2006; Galobardes, Shaw, Lawlor, Lynch, & Smith, 2006). Most research on health inequalities have been conducted in high-income countries and common indices used include individual- level indicators such as household income, parental education, and occupation, and area-level indicators such as composite scores that capture employment, crime, and incomes in small geographic areas. For example, in high-income countries such as the UK, childhood obesity rates are highest in areas classified as the most deprived 10% of the population, more than twice that of those classified as least deprived 10% ("National Child Measurement Programme, England 2020/21 School Year [NS]," 2021). There is also substantial evidence to show that tackling inequalities in early childhood adiposity is necessary to promote children's immediate health and well-being throughout the life course. Prospective data from 11 European countries showed that low maternal education was associated with overweight and obesity risk in children from during early childhood (Ruiz et al., 2016).

In developing countries, there are several reports of childhood obesity being more prevalent in the higher SEC groups, for example in higher- rather than lower-income families (Wang, 2001). Many have

argued that this is associated with increased exposure to obesity promoting environments (Ebbeling, Pawlak, & Ludwig, 2002; Stamatakis, Wardle, & Cole, 2010; Wang, Monteiro, & Popkin, 2002). Many factors are hypothesised to account for this 'reversal' of the gradient with increasing national affluence. A reduction in manual labour and an increase in the use of new transport reduces energy expenditure, while increased income facilitates opportunities for higher energy intake among lower SEC groups in high-income countries. The urban poor in developed countries may be especially vulnerable because of poor dietary quality and limited opportunities for physical activity. Higher SEC groups in high-income countries are less affected by food scarcity, with education mitigating the risk of obesity via health-related decision-making and lower exposures to obesogenic neighbourhoods. Understanding the social determinants of childhood obesity in different societal contexts is fundamental to the development of context-specific policy action. The overall aim of this paper is to systematically review the association between SEC and overweight or obesity in children and adolescents in the GCC Countries.

Methods

This review was conducted in accordance with the PRISMA guidelines for systematic review reporting (Moher, Liberati, Tetzlaff, & Altman, 2009).

Literature Search and Search Terms

A literature search was conducted using six different electronic databases: Embase, Global Health, Ovid Medline, Web of Science, PubMed and Science Direct. The search strategy was adapted for each database and included child/childhood OR Adolescents/Teens AND overweight AND Obesity AND parental education OR parental employment OR social class OR socio-economic status AND Gulf Countries. Additional searches were undertaken in Google scholar and the Saudi Journal of Obesity and reference lists were also hand searched to identify any studies that were not detected in the original database search. The search covered studies published between 2000 to May 2020.

Selection criteria

Using the PICOS methodology (Population, Intervention, Comparison and Outcomes) (Moher et al., 2009), the inclusion criteria for studies were: children and adolescents aged 5-19 years; data reported between 2000 and 2019 in the GCC countries (Bahrain, Kuwait, Oman, Qatar, KSA and the United Arab Emirates); objectively measured overweight or obesity, and reported associations between the prevalence of overweight and obesity, combined or separate, and at least one SEC indicator. All study designs were eligible. Studies were excluded if they were based on adults (>19 years), overweight and obesity was self-reported, and the prevalence of overweight and obesity were not reported by an SEC indicator.

Study selection and data management and assessment

Study selection and data management were undertaken systematically by one of the researchers (MA) and queries were reviewed by a second researcher (SH) and resolved by consensus agreement. Inclusion and exclusion criteria were applied in two steps. Firstly, studies were excluded if there was evidence from the abstract that at least one criterion was not satisfied. Secondly, the full texts of the remaining studies were retrieved, and the studies were screened against the inclusion criteria. Those satisfying all criteria were included in the review. Data were managed using Endnote reference manager software (Clarivate Analytics). Data was extracted under the following characteristics: author's name and year of publication, study location, year of survey, age range, sample size, definition and prevalence of overweight and obesity, and the association of SEC with overweight and obesity. Quality domains were also extracted.

Quality assessment

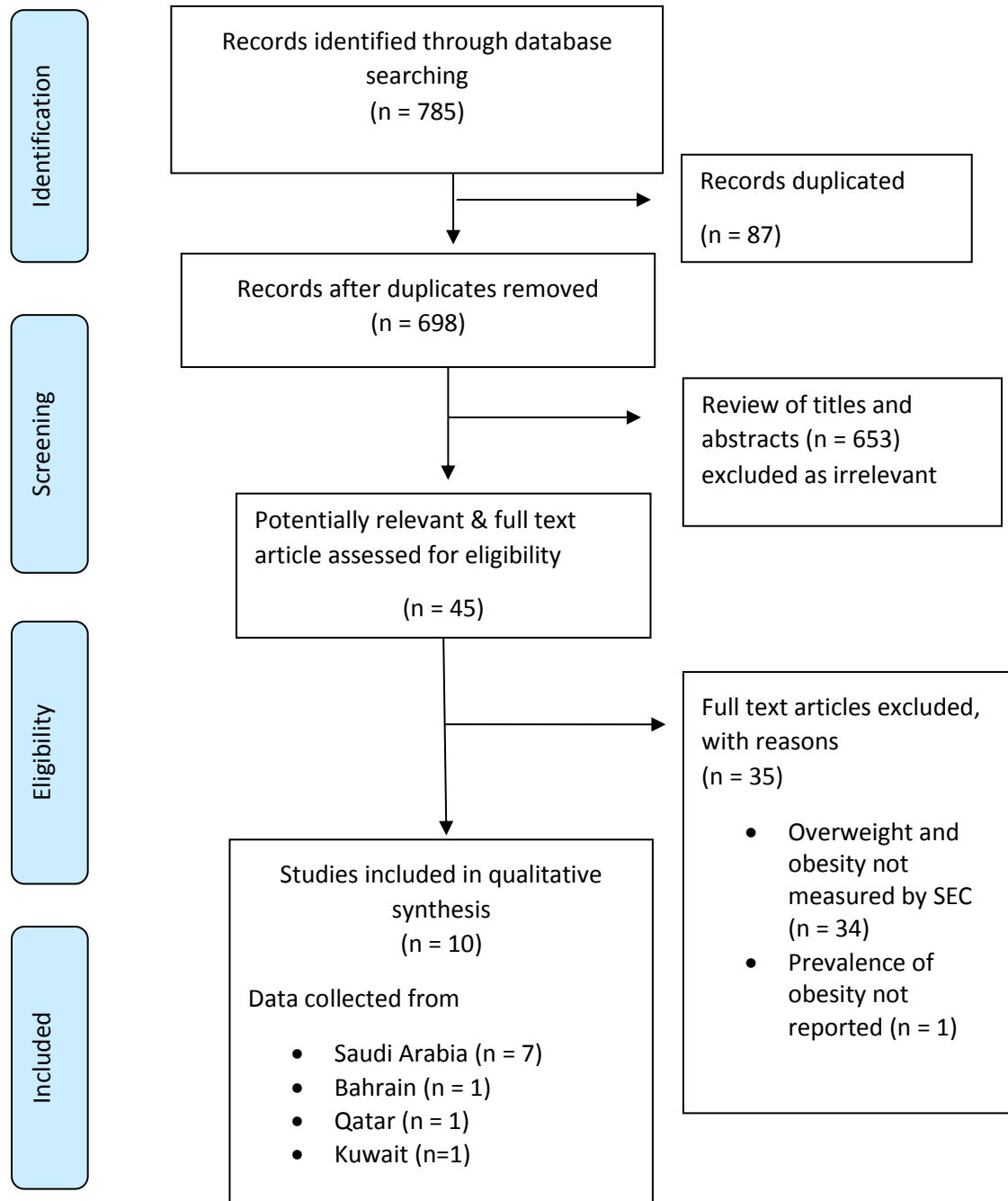
The Newcastle-Ottawa Assessment Scale (NOS) is a risk of bias assessment tool for observational studies that are recommended by the Cochrane Collaboration (Higgins, 2011) and was used to assess study quality. The scale was adapted from cohort studies to provide a quality assessment for non-randomized or observational studies (GA Wells). The NOS is a risk bias assessment tool for observational studies that are recommended by the Cochrane Collaboration (Higgins, 2011). In brief, the NOS assigns a maximum of 10 points based on the method of sampling (two points), justification of the sample size (one point), reported response rates, reported characteristics of non-responders and responders (two points), use of validated methods to measure overweight and obesity (two points), frequency/ prevalence of overweight and obesity presented by SEC (two points), and the methods of statistical analysis reported (one point).

Results

Study identification

Figure 1 outlines the PRISMA flow diagram of the study selection process. A total of 785 papers were identified in the initial search, 87 duplicates were removed, 698 titles and abstracts were reviewed, 45 full-text articles were reviewed, and of these ten papers met the inclusion criteria.

Figure 1 PRISMA flowchart for study selection.



Overview of studies

Table 1 General characteristics of studies from the Gulf Cooperation Council countries reporting an association between overweight and obesity and socioeconomic circumstance among children and adolescents (aged 5-19 years).

Author, Year	Survey year	Age range (years)	Sample size		Definition of obesity	Overweight prevalence (%)		Obesity prevalence (%)		Overweight/obesity prevalence (%)		SEC indicator	Association of SEC and with overweight /obesity	
			Boys	Girls		Boys	Girls	Boys	Girls	Boys	Girls		Boys	Girls
KSA														
Binrsheed, 2013 [†]	2008	6-12	312 (combined)		WHO	16	20	11	17	-	-	Maternal education	None	
												Paternal education	None	
												Maternal employment	None	
												Paternal employment	None	
Al Alwan <i>et al</i> , 2013	2006	6-16	542	701	WHO	21.5	21.3	17.4	9.3	-	-	Maternal education	Positive	
												Paternal education	None	
												Family income	Positive	
Maghrabi, 2012	2011	9-13	-	788	CDC	-	6.5	-	2.3	-	-	Paternal employment	-	Negative
												Type of houses	-	Positive
												Ownership pf private car	-	Positive
Amin <i>et al</i> , 2008	Not reported	10-14	1.139	-	CDC	14.2	-	9.7	-	-	-	Maternal education	Negative	-
												Paternal education	None	-
												Maternal employment	Positive	-
												Paternal employment	None	-
Al-Saeed <i>et al</i> , 2006 [‡]	2003	6-17	-	2239	CDC	-	20	-	11	-	-	Maternal education	-	Positive
												Maternal employment	-	None
												Paternal occupation	-	Positive

Author, Year	Survey year	Age range (years)	Sample size		Definition of obesity	Overweight prevalence (%)		Obesity prevalence (%)		Overweight/obesity prevalence (%)		SEC indicator	Association of SEC and with overweight /obesity	
						Boys	Girls	Boys	Girls	Boys	Girls		Boys	Girls
Mahfouz <i>et al</i> , 2007	2005	11-19	2696	-	WHO	11	-	5	-	-	-	Maternal education	None	-
												Paternal education	None	-
												Maternal employment	None	-
												Paternal employment	None	-
												Family income	None	-
Al-Enazy <i>et al</i> , 2014 [¥]	2011/2012	6-13	350 both		WHO	7.3	12.4	17	20.9	-	-	Maternal education	Positive	
												Paternal education		
												Maternal employment		
												Paternal occupation		
Author, Year	Survey year	Age range (years)	Sample size		Definition of obesity	Overweight prevalence (%)		Obesity prevalence (%)		Overweight/obesity prevalence (%)		SEC indicator	Association of SEC and with overweight /obesity	
			Boys	Girls		Boys	Girls	Boys	Girls	Boys	Girls		Boys	Girls
Kuwait														
Elkum <i>et al</i> , 2019	2012/2013	6-18	2601	3973	CDC	14.6	19.7	41.3	28.7			Maternal education	None	None
												Maternal employment	Positive	positive
												Family income	None	None
Bahrain														
Musaiger <i>et al</i> , 2013 [¥]	2006/2007	15-18	339	396	CDC	-	-	-	-	29.5	36.8	Maternal education	Positive	Positive
												Paternal education	Positive	None

Author, Year	Survey year	Age range (years)	Sample size	Definition of obesity	Overweight prevalence (%)	Obesity prevalence (%)	Overweight/obesity prevalence (%)	SEC indicator	Association of SEC and with overweight /obesity					
Qatar														
Bender, 2006	2004/2005	12-17	1968	1955	IOTF	28.6	18.9	7.9	4.7	-	-	Maternal education	None	Positive
												Paternal education	None	positive
												Type of house	None	Positive
<p>CDC, Center for Disease Control; IOTF, International Obesity Taskforce; WHO, World Health Organisation; KSA, Kingdom of Saudi Arabia; SEC, socioeconomic circumstance</p> <p>†= Maternal employment was reported as 'maternal job'.</p> <p>‡ =The distribution of parental education and family income were reported, but separate associations with overweight and with obesity were not reported.</p> <p>¥=Parental occupation was reported as 'Father's job status' with categories 'military, civilian.'</p> <p>¥=Overweight and obesity reported as using NHANES-1 growth standard, which corresponds with the CDC definitions: non-obese as <85th percentile of BMI, overweight as 85th -<95th percentile of BMI and obese as ≥ 95th percentile of BMI.</p>														

Table 1 presents a summary of the general characteristics of the included studies. Seven of the ten studies were conducted in KSA (Al Alwan, Al Fattani, & Longford, 2013; Al-Saeed, Al-Dawood, Bukhari, & Bahnassy, 2007; AlEnazy, AlEnazy, AlEnazy, & AlQahtani, 2014; Tarek Tawfik Amin, Ali Ibrahim Al-Sultan, & Ayub Ali, 2008; Binrsheed, 2013; Maghrabi, 2012; Mahfouz et al., 2007), one study was based in Bahrain (representative of the five governates) (Musaiger, Al-Roomi, & Bader, 2014), one in Qatar (representative of 22 urban and semi-urban districts) (A. Bener, 2006) and one in Kuwait(Elkum, Alarouj, Bennakhi, & Shaltout, 2019). Of the seven studies from KSA, all were conducted in urban areas. Two were based in Riyadh (Al Alwan et al., 2013; Binrsheed, 2013), and one in Jeddah (Maghrabi, 2012) , Al-Hassa (T. T. Amin, A. I. Al-Sultan, & A. Ali, 2008), Al-Khobar (Al-Saeed et al., 2007), Abha (Mahfouz et al., 2007) and Tabouk (AlEnazy et al., 2014). Two studies included girls (Al-Saeed et al., 2007; Maghrabi, 2012), two boys only (T. T. Amin et al., 2008; Mahfouz et al., 2007) and six studies included both girls and boys (Al Alwan et al., 2013; AlEnazy et al., 2014; A. Bener, 2006; Binrsheed, 2013; Musaiger et al., 2014).

All studies were cross-sectional in design and were conducted between 2004 (A. Bener, 2006) and 2013 (Elkum et al., 2019) and included children and adolescents aged 6-19 years. The total sample size of all ten studies was 19,999 and ranged from 312 (Binrsheed, 2013) to 6.574 (Elkum et al., 2019) children and adolescents.

The primary focus of the majority of studies was to investigate the prevalence of overweight and obesity of young people rather than to specifically focus on differences by SEC. One study included prevalence of underweight in addition to overweight and obesity (A. Bener, 2006). Of the ten studies, four studies also reported on dietary habits (T. T. Amin et al., 2008; Maghrabi, 2012; Mahfouz et al., 2007; Musaiger et al., 2014), one on physical activity (Musaiger et al., 2014), and two on a sedentary lifestyle (AlEnazy et al., 2014; Binrsheed, 2013) associated with excess weight.

Definitions of overweight and obesity

Overweight and obesity were defined using the cut-off points for body mass index (BMI), based on the WHO growth chart (Al Alwan et al., 2013; AlEnazy et al., 2014; Binrsheed, 2013; Mahfouz et al., 2007), Centers for Disease and prevention growth chart (CDC) (Al Magrabi, 2012; Al-Saeed et al., 2007; T. T. Amin et al., 2008; Elkum et al., 2019; Musaiger et al., 2014) and the International Obesity Task Force (IOTF) cut-offs (A. Bener, 2006).

Among girls, the prevalence of overweight varied from 6.5% in Jeddah, KSA (Al Magrabi, 2012) to 21.3% in Riyadh, KSA (Al Alwan et al., 2013). Obesity among girls ranged from 2.3% in Jeddah, KSA (Al Magrabi, 2012) to 20.9% in Tabuk, KSA (AlEnazy et al., 2014). Among boys, the corresponding results for overweight were 7.3% in Tabuk (KSA) (AlEnazy et al., 2014) to 28.6% in Qatar (A. Bener, 2006) and for obesity were 5% in Al-Ahsa city (KSA) (Mahfouz et al., 2007) to 41.3% in Kuwait(Elkum et al., 2019). Musaiger et al., 2014 reported only the combined prevalence of overweight and obesity in Bahrain which was 29.5% among boys and 36.8% among girls.

Measures of socio-economic circumstances

Socio-economic circumstances were reported by parents or guardians in eight studies (Al Alwan et al., 2013; Al-Saeed et al., 2007; AlEnazy et al., 2014; T. T. Amin et al., 2008; A. Bener, 2006; Binrsheed, 2013; Elkum et al., 2019; Mahfouz et al., 2007) and by students themselves in the remaining two studies (Maghrabi, 2012; Musaiger et al., 2014). Seven SEC indicators were used in the studies; paternal education, maternal education, paternal employment (often with some employment sector or occupation rank), maternal employment, family income, type of houses and car ownership. Parental education and employment were the two most commonly used indicators. nine studies reported on maternal education (Al Alwan et al., 2013; Al-Saeed et al., 2007; AlEnazy et al., 2014; T. T. Amin et al., 2008; A. Bener, 2006; Binrsheed, 2013; Elkum et al., 2019; Mahfouz et al., 2007; Musaiger et al., 2014), and seven on paternal education (Al Alwan et al., 2013; AlEnazy et al., 2014; T. T. Amin et al., 2008; A. Bener, 2006; Binrsheed, 2013; Mahfouz et al., 2007; Musaiger et al., 2014). Education categories varied with five studies using 'illiterate, primary, intermediate, high schooling and university degree' (Al Alwan et al., 2013; T. T. Amin et al., 2008; Abdulbari Bener, 2006; Binrsheed, 2013; Elkum et al., 2019). Al-Enazy et al. (2014) distinguished between university level education or not. Musaiger et al. 2014 and Al-Saeed et al. 2006 did not define the education categories. Maternal employment was used in six studies (Al-Saeed et al., 2007; AlEnazy et al., 2014; T. T. Amin et al., 2008; Binrsheed, 2013; Elkum et al., 2019; Mahfouz et al., 2007) and paternal employment in six studies (T. T. Amin et al., 2008; Maghrabi, 2012; Mahfouz et al., 2007), the latter included ranks in the military, and whether employed in the government or private sector (Al-Saeed et al., 2007; AlEnazy et al., 2014; Binrsheed, 2013). Three other SEC indicators used were family income (Al Alwan et al., 2013; Elkum et al., 2019; Mahfouz et al., 2007), housing type (Abdulbari Bener, 2006; Maghrabi, 2012) and car ownership (Maghrabi, 2012).

Percentage distribution of overweight and obesity by socioeconomic circumstances

Three studies presented results by SEC for overweight and obesity combined (Al Alwan et al., 2013; AlEnazy et al., 2014; Binrsheed, 2013) and seven studies presented results separately for overweight and obesity (Al-Saeed et al., 2007; T. T. Amin et al., 2008; A. Bener, 2006; Elkum et al., 2019; Maghrabi, 2012; Mahfouz et al., 2007; Musaiger et al., 2014).

Figure 2 shows the number of studies that showed positive (higher prevalence in high than low SEC categories), negative (higher prevalence in low than high SEC categories) or no association between excess weight and the type of SEC indicator. Online Table S1 presents the corresponding percentage distributions by SEC indicators for each study and we report on the broad patterns, with the reported p-values of <0.05 assumed to signal potentially significant differences in prevalence by SEC. Table 1 and Figure 1 shows that across the ten studies 31 SEC-excess weight associations were examined with the seven SEC indicators. Eighteen positive associations were reported in eight studies (Al Alwan et al., 2013; Al-Saeed et al., 2007; AlEnazy et al., 2014; T. T. Amin et al., 2008; A. Bener, 2006; Elkum et al., 2019;

Maghrabi, 2012; Musaiger et al., 2014), two negative associations in two studies (T. T. Amin et al., 2008; Maghrabi, 2012) and 22 non-significant associations in nine studies (Al Alwan et al., 2013; Al-Saeed et al., 2007; AlEnazy et al., 2014; T. T. Amin et al., 2008; A. Bener, 2006; Binrsheed, 2013; Elkum et al., 2019; Mahfouz et al., 2007; Musaiger et al., 2014). Of the 18 reported positive associations, nine were among girls (Al-Saeed et al., 2007; A. Bener, 2006; Elkum et al., 2019; Maghrabi, 2012; Musaiger et al., 2014), four among boys (Tarek Tawfik Amin et al., 2008; Elkum et al., 2019; Musaiger et al., 2014), and five among girls and boys combined (Al Alwan et al., 2013; AlEnazy et al., 2014).

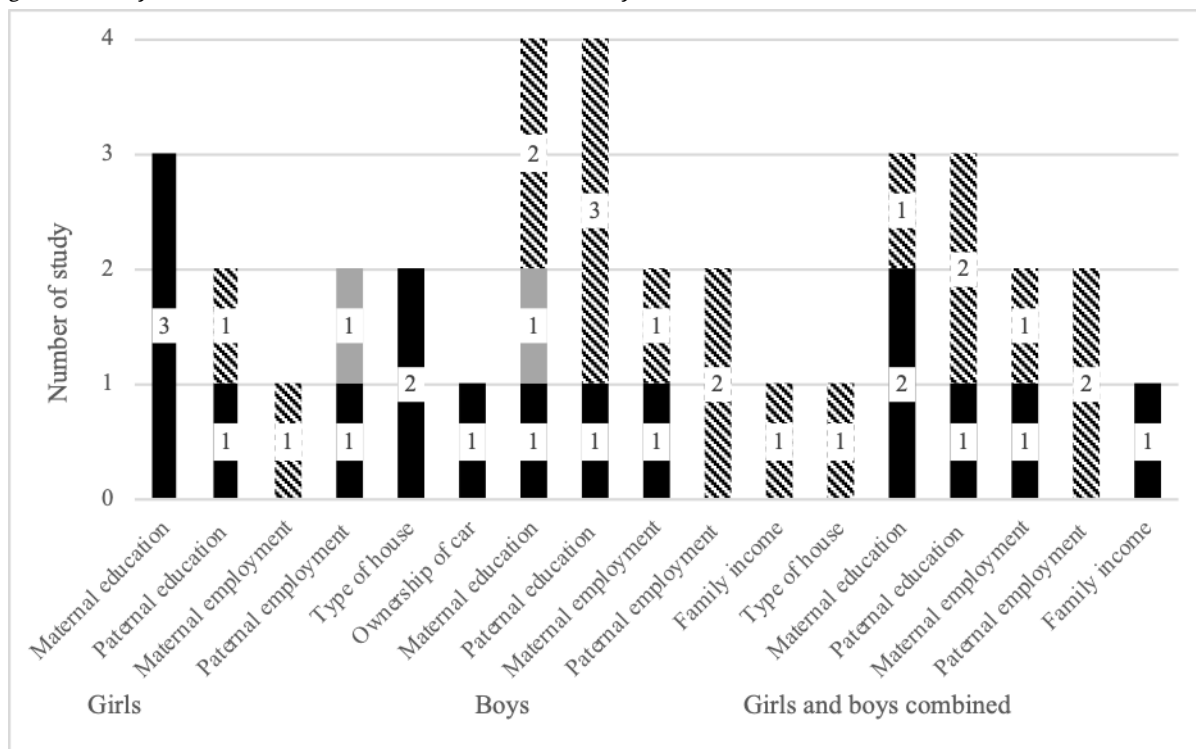


Figure 2 Summary of association between the six indicators of socio-economic circumstances and overweight and obesity. The six indicators of socio-economic circumstances included education, employment, type of housing, private car ownership, family income and occupation. Black denotes studies with a positive association; grey denotes studies with a negative association; and stripes denote studies with no association.

Among girls, a positive association was reported with maternal education (Al-Saeed et al., 2007; A. Bener, 2006; Elkum et al., 2019; Musaiger et al., 2014), maternal employment (Elkum et al., 2019), paternal education (A. Bener, 2006), paternal employment (Al-Saeed et al., 2007), type of housing (A. Bener, 2006; Maghrabi, 2012) and car ownership (Maghrabi, 2012). The prevalence of overweight and obesity combined ranged from 27.4 % (Musaiger et al., 2014) to 33.3% (Al-Saeed et al., 2007) among girls whose mothers had a ‘University level’ education. For mothers classified as ‘illiterate’, the prevalence ranged from 21.1% (A. Bener, 2006) to 26.6% (Al-Saeed et al., 2007). Corresponding prevalence for paternal education reported by Bener, 2006 was 34.1% for ‘University level’ and 20.3% for ‘illiterate level’. Al-Saeed et al. 2006 reported that the prevalence of overweight and obesity was highest among girls with fathers in private employment and lowest among those whose fathers were government employees. For

housing type the prevalence ranged from 15.3% (Maghrabi, 2012) to 26.9% (Abdulbari Bener, 2006) among those living in villas, and 15.8% (Maghrabi, 2012) to 17.8% (Abdulbari Bener, 2006) among those in other types of house. For car ownership, 9.4 % were overweight or obese among those who owned a car and 1.1 % among those who did not own car (Maghrabi, 2012). Only one study among girls (Maghrabi, 2012) reported a negative relationship and that used paternal employment, with 7.7% overweight or obese among those with fathers in work and 15% among those with fathers not in work.

Among boys, one study showed positive associations with maternal education and obesity (high 32.7% vs. low 16.8%) and paternal education (high 40.6 vs. 11.9%) (Musaiger et al., 2014). Amin et al. 2008 and Elkum et al, 2019 showed a positive association between maternal employment and overweight and obesity combined (in work 32.1%, vs. not in work 22%).

For the three studies that combined results for girls and boys (Al Alwan et al., 2013; AlEnazy et al., 2014; Binrsheed, 2013), positive associations were reported with maternal education (University level ranged 32.3-42.3% vs lower 19-26.3%) (Al Alwan et al., 2013; AlEnazy et al., 2014), paternal education by (University level 33% vs. lower 24.4%) (AlEnazy et al., 2014), maternal employment (working 34.9% vs not working 25.8%) (AlEnazy et al., 2014) and with family income (Saudi riyal/month \geq 20000 43.1 % vs. $<$ 3000 20.1%) (AlEnazy et al., 2014).

Relative socio-economic inequality with multivariable adjustments

Five studies reported odds ratios (OR) (Al Alwan et al., 2013; T. T. Amin et al., 2008; Elkum et al., 2019; Mahfouz et al., 2007; Musaiger et al., 2014) for the association between overweight and obesity and SEC, and four of the five studies reported multi-variable adjusted ORs (Al Alwan et al., 2013; T. T. Amin et al., 2008; Elkum et al., 2019; Mahfouz et al., 2007). Unadjusted for confounders, Musaiger et al 2014 confirmed that high vs low maternal education was associated with more than a two-fold increase in overweight and obesity among boys (OR 2.24, 95% confidence interval 1.09-4.63), and with under a two-fold increase among girls 1.69(0.95–3.03). Amin et al. 2008 reported for boys just under a two-fold increase in overweight and obesity associated with maternal employment (working vs non-working OR 1.85, 1.34-2.55), lower maternal education ($<$ secondary vs secondary or higher education 1.87, 1.23-2.49), and with urban residence (vs rural 1.85, 1.31-2.62), mutually adjusted in addition to age, family size, and eating away from home. Al Awan et al 2013 reported ORs adjusted for gender. For overweight, there was a general increase in ORs with income across seven income bands (Saudi Riyal/month \geq 20000 vs $<$ 3000, 3.38,1.90-6.02), and for obesity, maternal university education vs illiteracy was associated with more than a three-fold increase in obesity (3.71, 1.62-8.48). Mahfouz et al. 2007 confirmed non-significant associations, tested for paternal education (0.81, 0.54- 1.22), maternal education (0.80, 0.62-1.03), and maternal employment (1.00, 0.75-1.33), family income (0.91, 0.72-1.24), mutually adjusted with further adjustments for physical activity and dietary habits.

Study quality

Study quality is summarised in Table 3. Study quality was scored out of ten and quality of the studies ranged from five (Al-Saeed et al., 2007) to nine (T. T. Amin et al., 2008). Six studies reported power calculations (T. T. Amin et al., 2008; Binsheed, 2013; Elkum et al., 2019; Maghrabi, 2012; Mahfouz et al., 2007; Musaiger et al., 2014) but none reported power calculations based on assumptions of the magnitude or direction of SEC inequality. Six studies reported response rates (AlEnazy et al., 2014; T. T. Amin et al., 2008; A. Bener, 2006; Binsheed, 2013; Maghrabi, 2012; Mahfouz et al., 2007) and one reported on the characteristics of non-responders (T. T. Amin et al., 2008) and found that there was no difference between responders and non-responders. The three studies that reported adjusted ORs did not report on the contribution of the confounders or attenuation of the ORs on adjustments (Al Alwan et al., 2013; T. T. Amin et al., 2008; Mahfouz et al., 2007; Musaiger et al., 2014).

Table 2: Study quality assessment using the Newcastle-Ottawa Assessment Scale. The maximum score for study quality was ten.

Studies		Selection			Outcomes		
Author, year	Sample appropriate	Sample size justified	Response rate and characteristics of non-responders and responders reported	Validated method of measuring overweight and obesity/reliable definition of overweight and obesity	Frequency/prevalence presented by SEC, and by or adjusted for gender	Statistical analyses clearly explained confidence intervals or standard error presented	Overall score†
	Max: **	Max: *	Max: **	Max: **	Max: **	Max: *	Max: 10
Binsheed, 2013	**	*	*	No	**	No	6
Al Alwan, 2013	**	No	Unclear	**	**	*	7
Maghrabi, 2012	**	*	*	**	**	No	8
Amin, 2008	**	*	**	**	*	*	9
AL- Saeed et al., 2006	**	Unclear	No	**	*	No	5
Mahfouz, 2007	**	*	*	**	Unclear	*	7
Al-Enazy <i>et al.</i> 2014	**	No	*	*	**	No	6

Studies	Selection			Outcomes			
Musaiger et al., 2014	**	*	No	**	**	*	8
Bender, 2006	**	Unclear	*	**	*	No	6
Elkum et al, 2019	**	No	*	**	**	*	8

† Max overall score = 10. Two points allocated for appropriate sample, response rate, validated method, prevalence presented by SEC and adjusted for gender. One point allocated for sample size justified and statistical analysis. Overall quality classified as good quality: 10-8 stars, fair quality: 7-4 stars and poor quality: < 4 stars

Discussion

The aim of this systematic review was to assess the evidence on socio-economic inequalities in childhood and adolescent overweight and obesity in the GCC countries. Ten studies were included from three countries (KSA, Bahrain, Kuwait and Qatar). The prevalence of overweight and obesity combined was approximately 42.2% for boys and 36.8% for girls. Overall, there was a paucity of good quality studies which made it difficult to assess the credibility of the reported SEC relationship between overweight and obesity. The most commonly used indicators of SEC were parental education and parental employment. Across the ten studies 31 SEC- excess weight associations were examined with the seven SEC indicators. Eighteen positive associations were reported in seven studies, two negative associations in two studies and 22 non-significant associations in nine studies. Of the 18 reported positive associations, nine were among girls, four among boys and five among girls and boys combined. Three studies reported multivariable adjustments. These showed inconsistent associations with maternal education for overweight and obesity and just under two-fold increase in overweight and obesity with maternal employment.

Several explanations were put forward by the authors for the plausibility of a positive SEC-obesity relationship among girls. These were speculative and included higher family incomes facilitating eating away from home (Al Alwan et al., 2013), greater opportunities for consumption of cheap energy-dense fatty foods in high than low socio-economic districts of cities (Maghrabi, 2012), the long absence of working mothers from home exposure their children to opportunities for snacking and meal skipping (Al Alwan et al., 2013), provision of unhealthy foods by maids in homes with working mothers (Al Alwan et al., 2013) and little opportunity for physical activity because of the hot climate (Al-Saeed et al., 2007; A. Bener, 2006). In the other studies, there was a general lack of discussion of the null (Mahfouz et al., 2007) or negative findings (T. T. Amin et al., 2008; A. Bener, 2006), but small sample sizes were acknowledged (AlEnazy et al., 2014; Binrsheed, 2013). A recent review of adult obesity in the GCC countries (Balhareth, Meertens, Kremers, & Sleddens, 2019) reported inconsistent relationships with women's education and employment; 11 studies reported negative and one study reported positive associations with education, and four studies reported negative associations with employment.

Reviews of high-income country studies have shown that SEC, mainly education, is inversely associated with child obesity (Dinsa, Goryakin, Fumagalli, & Suhrcke, 2012). Education is usually associated with a better understanding of the health and social costs of being overweight and obese. The positive associations reported in nine studies in this review for girls in KSA, Bahrain, Kuwait and Qatar mirror those reported in reviews of low-income country studies (McLaren, 2007). A tentative explanation could be that less affluent girls are protected from obesity in the GCC contexts as they have fewer opportunities for exposure to fast food environments than their affluent counterparts (ALNohair, 2014; Maghrabi, 2012). In the conservative contexts of these countries where the movement of girls is restricted, affluent girls may also be allowed more freedom to socialise outside the home, for example in the growing fast food outlets in the malls. Exposure to aggressive marketing of fast foods coupled with the ability to purchase by affluent girls may therefore be plausible.

There was a general lack of theoretical framing of the studies. Gender is a crucial axiom of inequality globally and intersects with other indices such as education. Of the ten studies, six studies included boys and girls but only three reported on gender differences in the SEC-overweight/obesity associations (A. Bener, 2006; Elkum et al., 2019; Musaiger et al., 2014). There were no attempts to examine the intersection of other key influences (for example, maternal education and maternal employment). The level of education attempts to capture the knowledge related assets of a person and is usually a strong determinant of employment and income. The knowledge and skills attained through education may affect a person's cognitive functioning, make them more receptive to health education messages, shape their motivations for lifestyles, or enable them to negotiate access to appropriate health or social services (Galobardes, Shaw, Lawlor, Lynch, et al., 2006). Maternal employment was categorised as working or not but intensity of work or hours worked is emerging to be an important influence (Anderson, Butcher, & Levine, 2003). Occupational SEC indicators, used by Binrshedd, 2013 and Al Saeed et al. 2006 reflected ranks of military officials (e.g. officer or not) and employment sectors (e.g. government, private). Given the historical contexts of the GCC where governments or the monarchy have been the major employers (45%) (Kennedy, 2020), unpacking the intersections of education, employment and income and how these relate to knowledge and motivations for lifestyles are complex. Further research is required to understand the role of cultural literacy and practices in the GCC context of transitioning social, economic and food system environments.

The majority of studies reviewed were not designed to measure social inequalities in childhood or adolescent obesity, and so they were not powered to measure the associations. Four of the ten studies derived sample sizes on the assumptions of the overall prevalence of obesity. Stratum specific sample sizes for the SEC indicators were invariably small and were particularly problematic for interpreting ORs when the reference category was small (e.g. 'illiterate'). Among the ten studies that used parental education as an SEC indicator, four used 'illiterate' as the reference category (Al Alwan et al., 2013; T. T. Amin et al., 2008; Mahfouz et al., 2007) and only two provided the sample size of the 'illiterate' category (<300 participants)

(T. T. Amin et al., 2008; Elkum et al., 2019). There was also a general lack of clarity in the reporting of statistical methods. Of the five studies that presented ORs, four studies presented only ORs adjusted for various covariates (Al Alwan et al., 2013; T. T. Amin et al., 2008; Elkum et al., 2019; Mahfouz et al., 2007), so it was not possible to understand which adjustments accounted for the lack of SEC-overweight/obesity associations.

Conclusion

To our knowledge, this is the first systematic review conducted in the Gulf region to focus on the association between childhood- adolescents obesity and SEC. The findings signaled that SEC was generally either positively, more so among girls than boys, or inconsistently associated with overweight and obesity among children and adolescents. We caution against reliable inferences due to the small number of studies and lack of robust study designs. Also, some of the issues that need to be addressed include using common metrics across studies, and improving on operational definitions of SEC indicators. Nonetheless these findings signal the importance of rapidly transitioning contexts of the GCC region on childhood and adolescent overweight. Further research is required to verify and understand these associations, and the implications for interventions.

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