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RESEARCH ARTICLE

PREVALENCE AND RISK FACTORS OF OBESITY AMONG CHILDREN AND ADOLESCENTS IN SAUDI ARABIA: A META-ANALYSIS

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Abstract

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Background: Although there is a plethora of studies concerning obesity in Saudi Arabia, there is a lack of a systematic analytical approach of obesity prevalence among children and adolescents.

Objectives: To assess the prevalence and risk factors of obesity among children and adolescents in Saudi Arabia. The trend of obesity prevalence over the past two decades was additionally investigated.

Methods: A meta-analysis was conducted involving cross-sectional studies published between 2000 and 2020 in PubMed, Embase, and Google Scholar. Pooled logit-transformed prevalence rates were computed for all studies and for subgroups based on the used diagnostic criteria, period of data collection, and region. Personal and parental sociodemographic risk factors were collected and expressed as odds ratio and 95% confidence intervals (95% CIs). Trend analysis was performed using a chi-squared test for linear trend, and a meta-regression was applied to assess the sources of heterogeneity.

Results: Twenty-six studies met the inclusion criteria (43,187 subjects, 54.3% males). The pooled prevalence of obesity was 14.13%, and it increased significantly in 2016-2020 compared to 2000-2005 (OR=2.58, $p<0.0001$). Obesity was significantly associated with male sex (OR=1.36, p=0.007), performing a physical activity <3 times/week (OR=1.59, p=0.025), consuming soft drinks ≥2 times/day (OR=1.73, p=0.014), having a working mother (OR=1.20, p=0.036), and living in an urban region (OR=1.44, p=0.033). Between-study heterogeneity was significant, and it was explained by regional variation ($F(2,5)=12.519$, p=0.028).

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Conclusion: The high obesity prevalence among young populations in Saudi Arabia underscores the importance of implementing intensified school- and community-based preventive programs, focusing on the established risk factors.

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Introduction:-

Obesity is a significantpublic health problem characterized by abnormal accumulation of fat in the body. In multiple regions worldwide, obesityhas been associated with negative health consequences, such as coronary heart disease, diabetes, and metabolic disorders (Csige et al., 2018). Since 1975, the global prevalence of obesity has tripled, reaching up to13%of the adult population and 18% of children and adolescents in 2016 (World Health Organization, 2020). In childhood, obesity can lead to hyperlipidemia, abnormal glucose tolerance, and hypertension as well as unfavorable neurological, gastrointestinal, and endocrine consequences(Di Bonito et al., 2017; Falkner, 2017; Turer et al., 2018). Moreover, there an association between obesity in childhood and adolescence and future obesity in adulthood(Llewellyn et al., 2016). Obesity among children and adolescent populations is also a preventable cause for premature death(Lindberg et al., 2020). This way, childhood obesity and its consequences would ultimately represent a significant burden on patients, families, and healthcare systems(Ash et al., 2017; Hayes et al., 2016).

The clinical classification of obesity in adults relies on using the body mass index (BMI) at a cutoff point of 30 kg/m2for both sexes as defined by the World Health Organization (WHO)(World Health Organization, 1998). However, obesity cannot be defined using such a cutoffin children and adolescents because BMI is greatly influenced by the age and sex during the early stage of life(Hajian-Tilaki and Heidari, 2013). Therefore, a number of classification criteria have been officially released by the WHO(de Onis et al., 2007; World Health Organization, 2006), Center for Disease Control and Prevention (CDC)(Centres for disease control and prevention, 2000), and the International Obesity Task Force (IOTF)(Cole et al., 2000). The variation in these definitions might have created a discrepancy in the estimated prevalence rates across different studies worldwide.

In Saudi Arabia, data regarding obesity in children and adolescents are derived from individual cross-sectional studies; therefore, prevalence estimates may be inconsistent, particularly with the variation in obesity definitions, lifestyle characteristics, and study settings. The effects of personal and social characteristics on the epidemiological patterns of obesity have notbeen systematically in a systematic manner so far. There is a need to get an insight into obesity prevalence to identify the current burden and to extrapolate the future status of related consequences. As such, we sought to investigate the prevalence of obesity and its associated risk factors among children and adolescents in Saudi Arabia, considering the differences in the prevalence attributable to gender, lifestyle characteristics, and region. In addition, we aimed to identify the national trend of obesity over the past two decades.

Methods:-

Eligibility Criteria

The present meta-analysis followed the guidelines of the the Preferred Reporting Items for Systematic reviews and Meta-analyses (PRISMA) statement(Moher et al., 2009). Eligible studies included all original articles (cross-sectional studies) which have reported the prevalence of obesity among apparently healthy children and adolescents (aged less than 20 years) in Saudi Arabia during the period between 2000 and 2020. Such articles should have been published in peer-reviewed journals and written in English language.Case-control studies, systematic reviews, narrative reviews, and meta-analyses were excluded.Screening studies carried out in pediatric/primary care clinics and/or hospitals were not considered to exclude the effect of confounding diseases on the prevalence rates of obesity.

Types of outcome measures

The primary outcomes included the proportion of children and/or adolescents with obesity. The secondary outcomes included the proportion of obesity based on gender, as well as proportion of obese children/adolescents in each study group of other personal characteristics (eating and lifestyle characteristics) and demographic variables (region of residence, mother education, mother work status, etc.).

Diagnostic criteria of obesity

The primary outcomes in the included studies should have been defined according to the following official guidelines: 1) the WHO, where obesity was defined at BMI values of >3 or >2 standard deviations (SDs) above the median growth standard among children aged < 5 or between 5 and 19 years, respectively (de Onis et al., 2007; World Health Organization, 2006); 2) CDC 2000, where obesity was diagnosed at > 95^{th}BMI percentiles among children aged 2-19 years(Centres for disease control and prevention, 2000); 3) IOTF, where a set of distinct age- and sex-specific BMI cut points could be used to define obesity in the 2-18 year age category, corresponding to adult BMI values(Cole et al., 2000).

Search Strategy

A specific search strategy was developed to search for eligible studies in PubMed, Embase, and Google Scholar as of September 25, 2020.The search process was limited to studies published between 2000 and 2020. Two independent authors (KAB and AHA) performed the search process across all databases using predefined keywords and Boolean operators. An example of the used strategy in the PubMed database is shown in Appendix 1.

Study Selection and Data Collection

The obtained search results were extensively screened by two authors (AJA and MGA), and the reference lists of the screened articles were searched for potentially eligible articles. The full articles of eligible studies were downloaded and checked for the consistency with the predetermined criteria of inclusion and the suitability of the reported outcomes for further analysis. Any disagreement was resolved by discussions and consultation with a third author (MMA). Data of included articles were extracted in a Microsoft Excel spreadsheet (Microsoft Excel 2016) containing the following headers: 1) characteristics of studies: the last name of the first author, year of publication, study design, Province in Saudi Arabia, and setting (schools, household surveys, etc.) 2)the method of obesity diagnosis, 3) participants' characteristics: sample size, number of males and females, andage range 4) obesity-related outcomes: the frequency of obese participants in the whole population, in males and females, and the frequency of obesity in various lifestyle and parental-related groups (watching TV, physical activity, maternal education and employment status, and family income).

Assessment of the methodological quality

The Joanna Briggs Institute's Critical Appraisal Checklist forPrevalence Studies(Munn et al., 2015) was used to assess the methodological quality.The appraisal tool includes the assessment of the relevance of the target population, participants' recruitment, sampling, description of subjects, the validity of the diagnostic method and its consistency for all participants, and the appropriateness of the statistical analysis. A quality score ranging between 0 and 9 was assigned to each study based on the appraisal process, and the methodological quality was judged as "low", "moderate" and "high" for scores ranging between 1-4, 5-7,and 8-9, respectively. Two independent authors performed the appraisal process (YMA and AHA).

Statistical Analysis

Statistical analysis was performed using the meta package in R software (R i386 version 4.0.0)(Harrer et al., 2019). The primary outcome was analyzed by pooling the proportion of obese children/adolescents in relation to sample size. The obtained proportions were transformed using a logit transformation(Warton and Hui, 2011)to compute an effect size and its respective Clopper-Pearson 95% confidence interval (95%CI) using the metaprop command.National trend of obesity prevalence was based on stratifying the following time periods of field study (rather than considering the year of publication): 2000-2005, 2006-2010, 2011-2015, and 2016-2020. A chi-squared test for linear trend in proportions was applied using the *prop.trend.test* function in R software.Gender-based differences in the prevalence of obesity were analyzed by computing the pooled odds ratio (OR) and 95%CI in studies presenting comparative outcomes in males and females (in the metabin command). Risk factors for obesity were extracted from each individual study using the results of univariate and multivariate correlation analyses(expressed as ORs and 95%CIs). These variables were then pooled based on the estimates of logORs and their standard errors using the generic inverse variance method (in the metagen command).Higgin's $I^2$was used to assess the between-study heterogeneity, which was substantial at I^2> 50%. Consequently, a random-effects model was applied to estimate the effect sizes. Subgroup analyses were performed based the province where each study was conducted in Saudi Arabia, categories of the year of publication, and the methods of BMI calculation. Variables with subgroup-based significant differences were entered in a meta-regression model to further explain the sources of between-study heterogeneity. Publication bias was assessed visually and statistically by producing a funnel plot and interpreting the outcomes of an Egger's test, respectively. Statistical significance was considered at $p< 0.05$.

Results:-

Results of the Search Process

Initially, 3797 titles were identified from different sources, of which 306 duplicates were omitted.The remaining records (n = 3491) were screened, and the full version of 32 articles met the eligibility criteria. Six studies were excluded owing to reporting data on participants with overweightonly(Al-Muhaimeed et al., 2015), including a subgroup of students recruited from outpatient clinics(Al-Dossary et al., 2010), including participants aged > 20 years,(Farghaly et al., 2007)reporting of combined data on overweight and obesity(Mahfouz et al., 2012), reporting the results of a field study carried out before the year 2000(El-Hazmi and Warsy, 2002), and the lack of access to a full article(Alam, 2008). Therefore, ultimately, 26 studies were included in the present study (Figure 1).

Characteristics of the Included Studies

Table 1 demonstrates the characteristics of the included studies. The studies were published between 2003 and 2019, whereas the time periods of data collection (field study) ranged between 2001 and 2018. Two studies included multiple regions of the Kingdom(Al-Hazzaa et al., 2014; El Mouzan et al., 2012), wherethe outcomes of each region were analyzed separately. BMI values were calculated based on the CDC 2000 guidelines in ten studies, IOTF in eight studies, and WHO 2007 in seven studies. Overall, 43,187 children and adolescents were included (54.26% were males). Male subjects were exclusively recruited in eight studies(Al-Rukban, 2003; Alazzeh et al., 2018; Alenazi et al., 2015; Amin et al., 2008; Bandy et al., 2019; Fakeeh et al., 2019; Mahfouz et al., 2008; Shatoor et al., 2011), females in four studies(Abahussain, 2011; Al-Saeed et al., 2007; Bajamal et al., 2017; Fatima and Ahmad, 2018), and the remaining studies included both genders. Quality assessment indicated that the studies were of moderate to high methodological quality.

Primary outcomes and the between-studyheterogeneity

Using a random-effects model, the pooled prevalence of obesity across all studies was 14.13% (95%CI, 11.90% to 16.69%) with a substantial between-study heterogeneity (I^2 = 97.9%, df = 29, p< 0.0001, Figure2).Compared to the baseline time period (2000-2005), the prevalence of obesity increased in 2006-2010 (OR = 1.44), in 2011-2015 (4.52), and in 2016-2020 (OR = 2.58), with a significant linear trend (Chi-square = 1710.17, p < 0.0001).

To investigate the variables which might have accounted for the heterogeneity, subgroup analysis was carried out.Residual heterogeneity remained significant for subgroups of regions, BMI calculations, and the year of study (Table 2). Notably,region-based differences were significant (p = 0.0005), where the highest pooled prevalence was reported in the Northern region (18.61%, 95%CI, 9.52% to 33.18%), while the lowest combined rate was in the Southern region(7.10%, 95%CI, 4.62% to 10.75%).To further confirm the sources of heterogeneity, the results of the meta-regression analysis indicated that regional groups were associated with effect size differences, $F(2,5)$ = 12.519, p = 0.028(Table 3). More specifically, the low prevalence rates of obesity in the Southern province have significantly accounted for the variation in effect sizes (β = -0.844, 95%CI, -1.445 to -0.244, p= 0.006).

Publication bias

The produced funnel plot (Figure 3) revealed an equal distribution of the weighted linear regression of prevalence rates around the mean effect estimate. The outcomes of the Egger's test confirmed the absence of a publication bias (intercept = -2.2 [CI, -7.69 to -3.29], t = -1.32, p = 0.43).

The association between gender and the prevalence of obesity

The prevalence of obesity in both male and female children and adolescents was reported in 14 studies, which recruited 31,210 subjects(47.25% males). The pooled proportion of obese males was significantly higher than that of females (OR = 1.36, 95% CI, 1.10 to 1.68, p =0.007), and the heterogeneity between studies was significant (I^2 = 82.6%, df = 17, p< 0.0001, Figure4). This was corroborated in the results of the regression analysis adjusted for confounding variables in the study of Al Alwan et al.(Al Alwan et al., 2013), where male gender was a significant independent risk factor of obesity. Gender-based multivariate regression analysis was not carried out in other studies.

Other associated factors with obesity

Risk factors for obesity were analyzed and pooled when the available data were reported in at least three studies (Figure 5). The analysis of personal factors revealed higher odds of obesity among children/adolescents performing physical activitiesless than 3 times per week(OR = 1.59, 95%CI, 1.06 to 2.39, p = 0.025) and those consuming soft drinks more frequently(OR = 1.73, 95%CI, 1.12 to 2.68, p = 0.014)compared to their peers.In addition, having a working mother(OR = 1.20, 95%CI, 1.01 to 1.42, p = 0.036) and living in an urban region (OR = 1.44, 95%CI, 1.03 to 2.01, p = 0.033) were significantly associated with childhood obesity.

Discussion:-

Investigating the prevalence of obesity among young populations is a critical aspect of public healthcare owing to the expected consequences on the health of adults and national economies in the near future. Additionally, obesity burden can be alleviated by targeting the associated risk factors via dedicated preventive programs/approaches carried out on a national level. In the present study, the pooled prevalence of obesity over two decades was 14.13%in Saudi Arabia, with a significant rise in the most recent time period compared to the reference period (14.6% in 2016-2020 versus 10.3% in 2000-2005). Obesity prevalence was associated with male gender, physical inactivity, consuming soft drinks, having a working mother, and living in an urban region.

Based on a random-effects model, the estimated prevalence in the current study was higher than the estimated regional figures in Asia (5.5% among the 5-19 age group in 2018)(Mazidi et al., 2018), and in the Middle East (11.6% among the 5-19 age group in 2016)(Di Cesare et al., 2019). These values exceed the global estimates released by the WHOin 2016 (8% and 6% in males and females aged 5-19 years, respectively)(World Health Organization, 2020). Nationally, there was also a rising trend in childhood obesity at an alarming level. Although these observations are consistent with theten-fold increase of the number of school-age children and adolescents with obesity over the past four decades(World Health Organization, 2018), recent estimates showed that the national trends have been decreased or plateaued in high-income countries, such as France, Denmark, the United States, Australia, and Japan since the early 2000s(Abarca-Gómez et al., 2017; Rokholm et al., 2010). However, the rising trends in low- and middle-income countries in Asia are accelerating, with no clear associations with the trends among adults(Lim et al., 2020).

The present study underscored the impact of personal demographic and lifestyle factors on obesity in the young populations.For example, obesity was significantly higher in males than females. This might be attributable to sex-based differences in the levels of steroid hormones and serum leptin, which would impact the body composition, appetite, and energy utilization(Campbell, 2016; Garnett et al., 2004). Sociocultural effects may also drive a tendency of boys to consume calorie-dense foods more frequently than girls, and feeding practices by females are generally governed by “thinness” as a cultural ideal (Keller et al., 2019). However, it has been recently shown that obesity among girls remain high in many countries in the Middle East and North Africa, including Egypt, Kuwait, and Saudi Arabia, relative to worldwide estimates(Abarca-Gómez et al., 2017). Interestingly, unhealthy nutritional choices have also negative effects on the body composition irrespective of gender. As reported in the current study, the consumption of calorie-dense soft drinks was associated with higher odds of obesity among Saudi children and adolescents.It has been well-established that such practices can be associated with stunted growth and weight gain, which would increase BMI values and raise the likelihood of worse health outcomes later in the adulthood (Abarca-Gómez et al., 2017). We have also shown that low levels of physical activity were associated with obesity, and this was in agreement with the negative correlation between vigorous-intensity physical activity and total and central body fat (Farooq et al., 2020; Moliner-Urdiales et al., 2009). Farooq et al.(2020) have recently demonstrated a significant decline in the levels of moderate-to-vigorous-intensity physical activity at age 9 for both boys and girls based on the results of a systematic review, and the authors recommended promoting the physical exercise before adolescence to reduce the rates of obesity.

Indeed, sedentary practices among Saudi individuals should be the main target of future interventions aiming to reduce obesity. More specifically, causes of reduced physical activity and unhealthy nutritional choices are of primary concern. These include cultural barriers, lack of social support, lack of robust physical activity programs at schools, and increased urbanization. The latter was a significant problem as per the results of the current meta-analysis. Intriguingly, the distribution of urban settlement in Saudi Arabia might have accounted for the variation in obesity prevalence across different provinces. Cultural factors could have interacted with the effect of urbanization on the regional distribution of obesity. Nevertheless, these interactionsshould be the scope of future research to understand the main drivers of obesity and to tailor effective preventive approaches.

Based on the aforementioned observations, and considering the fact that childhood obesity is more likely to develop when the most rapid weight gain takes place between 2 and 6 years of age(Geserick et al., 2018), it is imperative to implement preventive measures that start as early as during the infancy. For instance, the WHO recommends that governments should encourage breastfeeding in the first six months along with adopting strict measures to prevent the promotion of commercial complementary foods for infants and unhealthy food to children and adolescents(World Health Organization, 2018). However, these measures were only considered by three countries ofthe WHO's Eastern Mediterranean Regional Office (out of 21)(World Health Organization, 2018). Furthermore, the consumption of sugar-sweetened beverages can be restricted by implementing various forms of taxes or levies, a matter which has recently been considered by the General Authority of Zakat and Tax in Saudi Arabia(Alsukait et al., 2020). Other recommendations include promoting physical activity, improving healthy food and drink options at schools, and regular monitoring of children's bodyweight on a national level(World Health Organization, 2018).

The present meta-analysis was limited by a number of study-level factors. First, there was significant heterogeneity between studies, which has been partly explained by the regional variation in obesity prevalence.Second, the use of non-representative samples consisting of exclusive male or female students might have affected the direct comparison of obesity between both sexes. Third, obesity might have been under- or over-estimated due tothe use of different cut-off reference standards for obesity definition despite the lack of significant effects on heterogeneity. Finally, the low number of studies investigating specific risk factors, such as the monthly family income, might have caused a lack of a significant difference in the pooled effect estimates between groups. Furthermore, other factors were scarcely investigated, and thus their results could not be effectively pooled in the meta-analytical approach.Hence, a unified protocol should be developed for future studies to assess the burden of obesity among children and adolescents based on including both boys and girls, specifying distinct definition criteria for obesity diagnosis across the kingdom, and setting up a number of sociodemographic characteristics to be assessed as potential risk factors for obesity.

In conclusion,obesity was prevalent among 14.13% of children/adolescents in Saudi Arabia, and the rate of obesity has consistently increased over the past two decades. Obesity was significantly associated with male sex, low levels of physical activity, consuming soft drinks >2 times/day, having a working mother, and living an urban region.Regional variation in obesity prevalence was significant, and it explained the heterogeneity in the estimated prevalence. There is a need to implement more intensified national actions to address obesity among children and adolescents, including promoting physical activities at schools, improving healthy nutritional choices, providing social support, and increasing the parental and personal awareness regarding obesity and its associated health risks.

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Appendix 1:

The search strategy used in the PubMed database.

#1 "children" OR "childhood" OR "adolescent*"

#2 "Saudi" OR "Saudi Arabia"

#3 "obesity" OR "obese"

#4 "Prevalence" OR "proportion"

#5 #1 AND #2 AND #3 AND #4

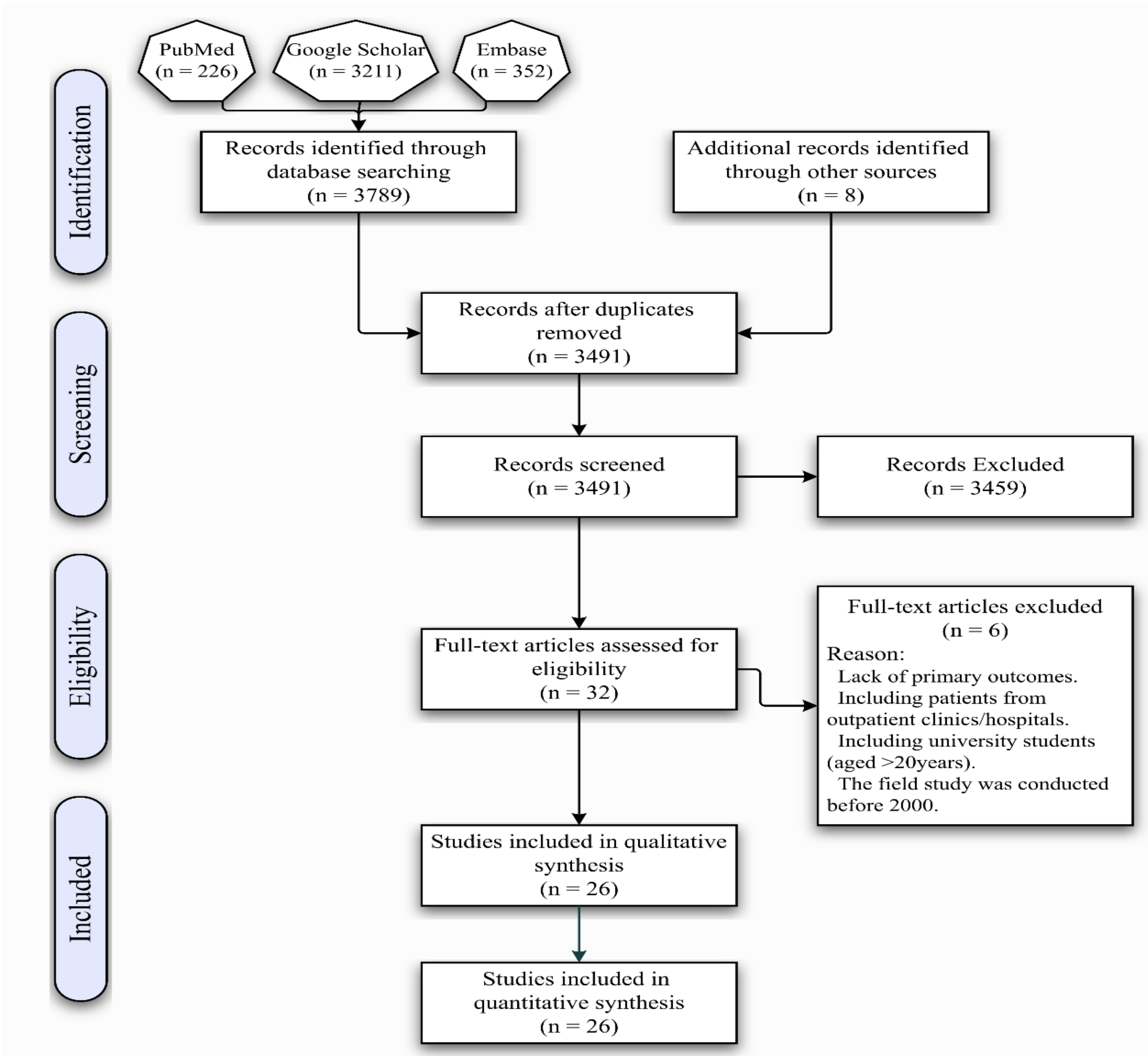

Figure 1:- A flowchart showing the search process used in the current study.

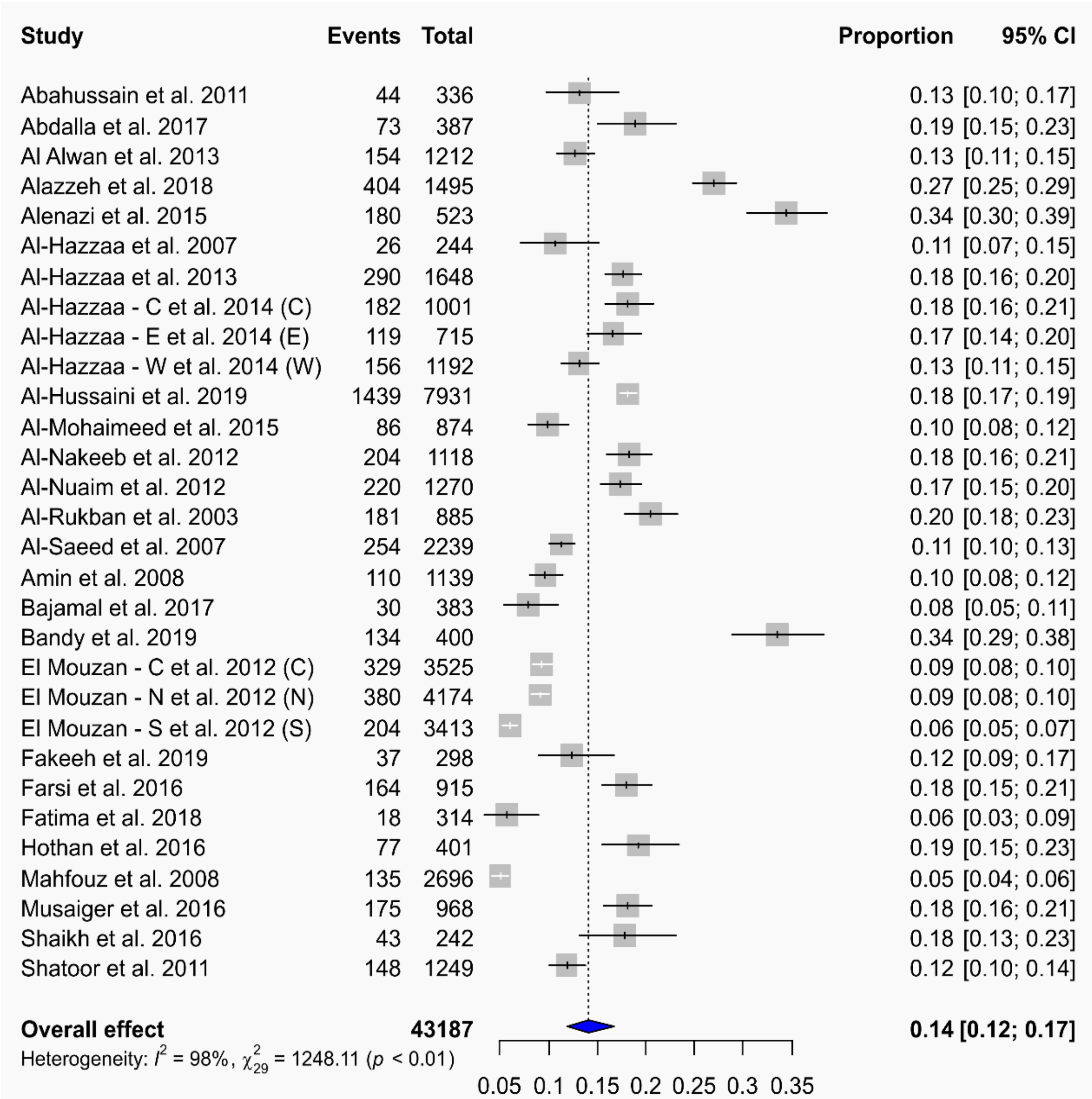

Figure 2:- A forest plot depicting the prevalence of obesity among children and adolescents in Saudi Arabia.

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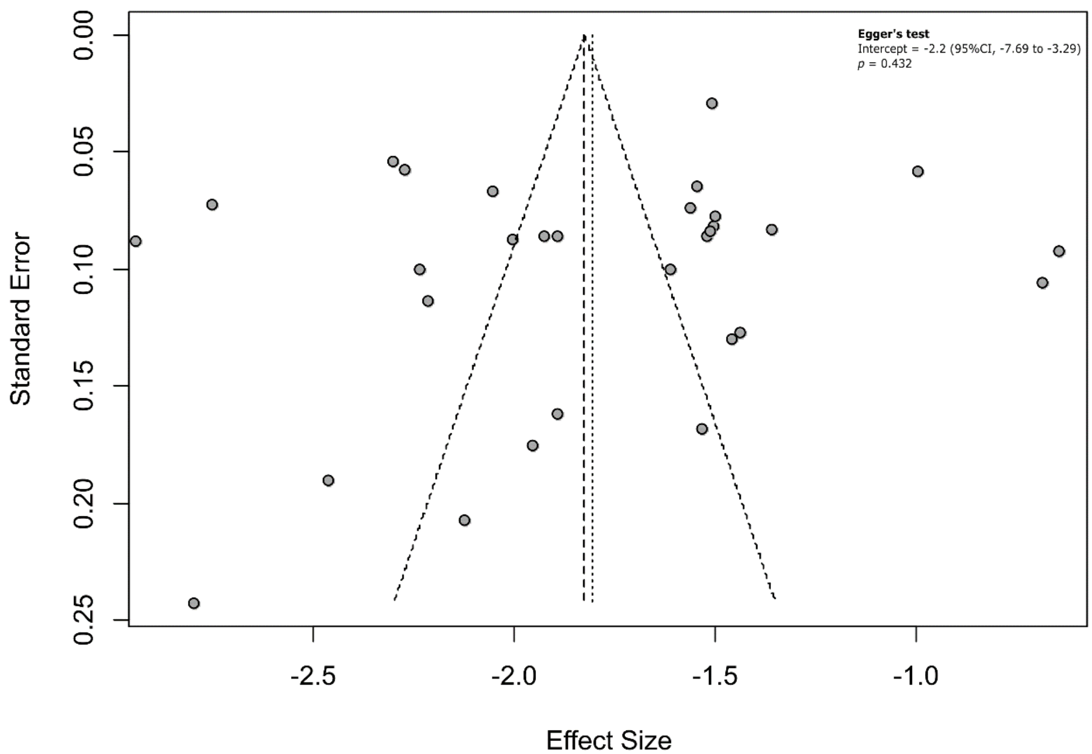

Figure 3:- A funnel plot showing the assessment of the publication bias.

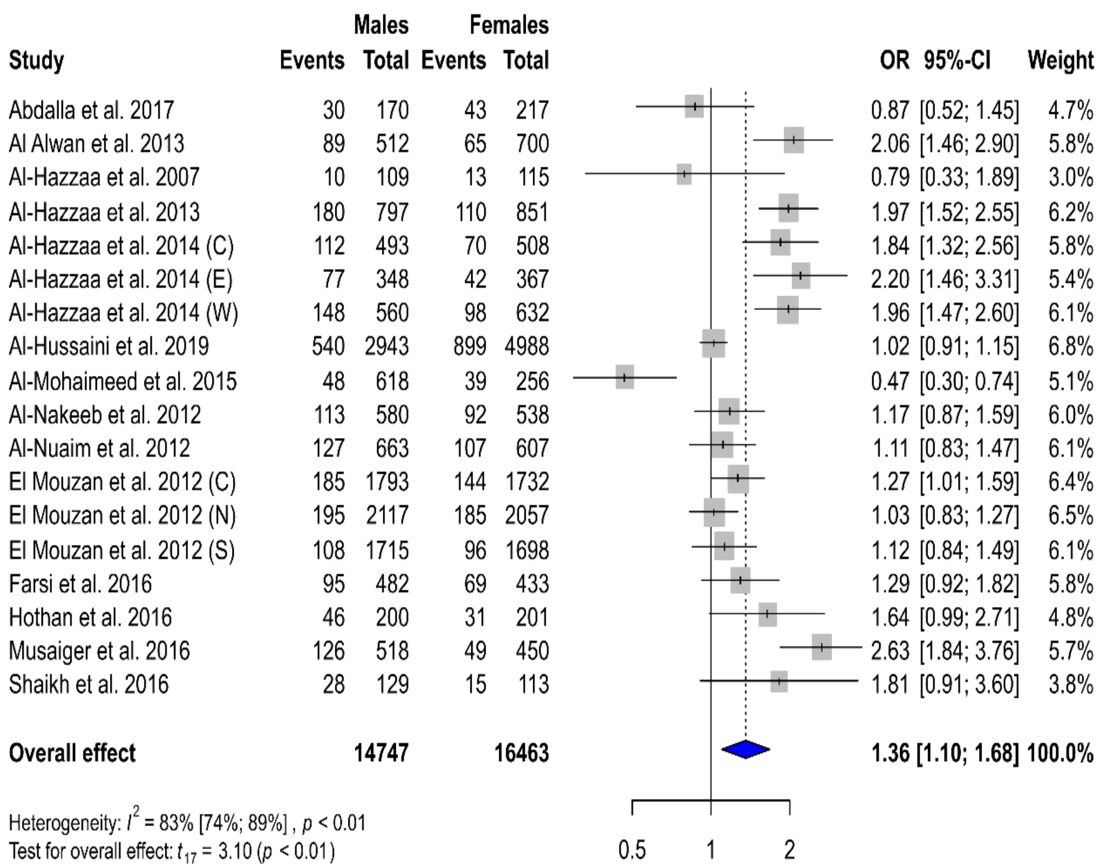

Figure 4:- A forest plot showing the difference in obesity prevalence among male and female children/adolescents.

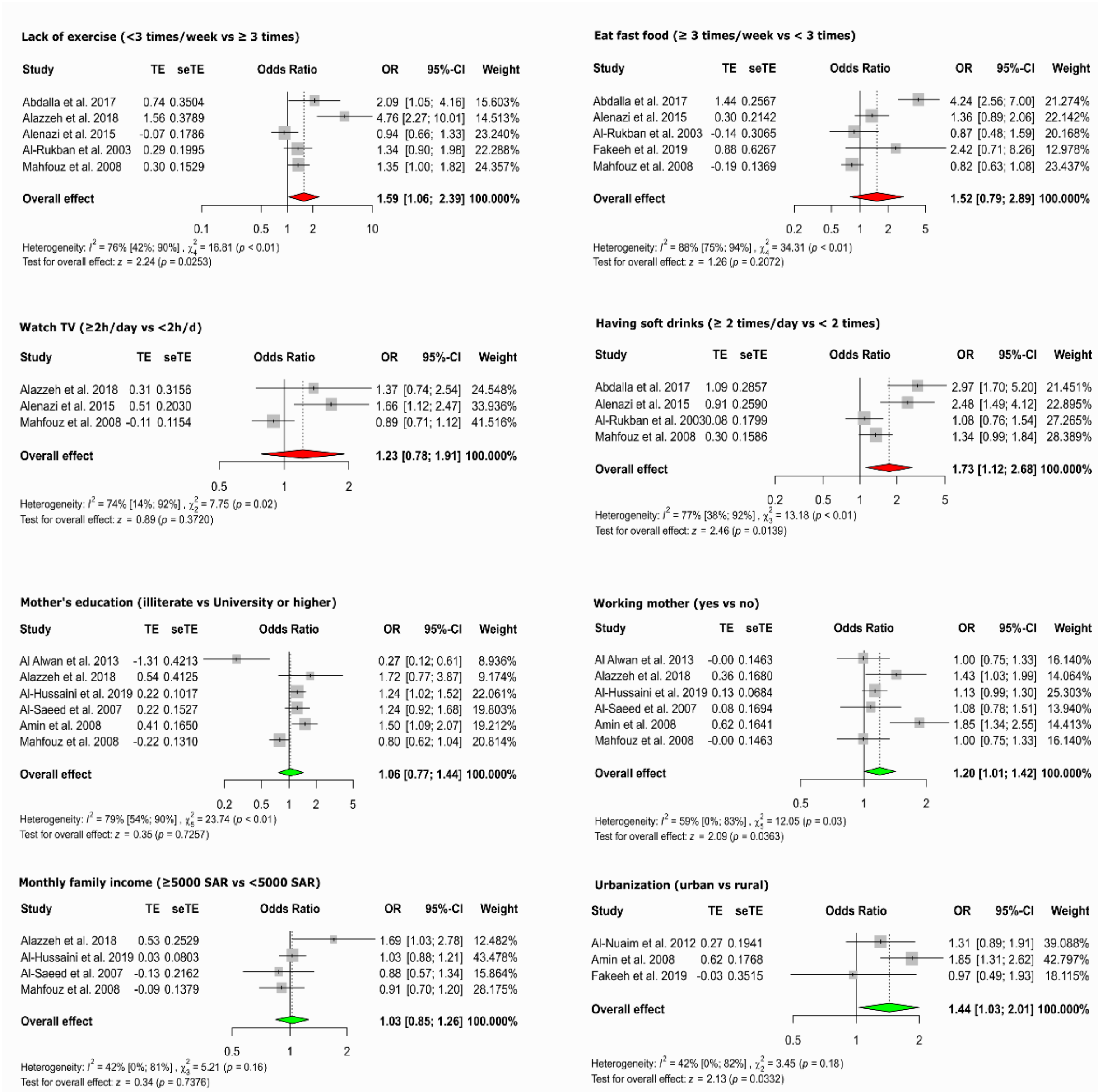

Figure 5:- Forest plots showing the sociodemographic risk factors of obesity among children/adolescents.

Table 1:- Characteristics of the included studies.

Author and year	Year of data collection	City (province)	Setting	Diagnostic criteria	Sample size (male, female)	Quality score
Al-Rukban et al. 2003	2001 and 2002	Riyadh (C)	Intermediate and secondary schools	CDC 2000	885 (885, 0)	6
Al-Hazzaa et al. 2007	2006	Jeddah (W)	Preschools	NA	244 (109, 115)	6
Al-Saeed et al. 2007	2003	Al-Khobar (E)	Primary and preparatory	CDC 2000	2239 (0, 2239)	7
Amin et al. 2008	2006	Al-Ahsa (E)	Primary	CDC 2000	1139 (1139, 0)	5
Mahfouz et al.	2005	Abha (S)	Intermediate and	CDC	2696 (2696,	7

2008			secondary schools	2000	0)	
Abahussain et al. 2011	2007	Al-Khobar (E)	Secondary schools	CDC 2000	336 (0, 336)	7
Shatoor et al. 2011	2010	AhadRufeida (S)	Secondary schools	IOTF	1249 (1249, 0)	
Al-Nakeeb et al. 2012	2011	Al-Ahsa (E)	NA	IOTF	1118 (580, 538)	
Al-Nuaim et al. 2012	2011	Al-Ahsa (E)	Secondary schools	IOTF	1270 (663, 607)	
El Mouzan - C et al. 2012 (C)	2004 and 2005	Riyadh and Qassim (C)	House-to-house visits (based on the population census)	CDC 2000	3525 (1793, 1732)	7
El Mouzan - N et al. 2012 (N)		Hail, Jouf and Northern Borders (N)		CDC 2000	4174 (2117, 2057)	
El Mouzan - S et al. 2012 (S)		Gizan and Aseer (S)		CDC 2000	3413 (1715, 1698)	
Al Alwan et al. 2013	2006	Riyadh (C)	Schools	WHO 2007	1212 (512, 700)	6
Al-Hazzaa et al. 2013	2011	Riyadh and Al-Khobar (C and E)	Secondary schools	IOTF	1648 (797, 851)	6
Al-Hazzaa - C et al. 2014 (C)	2009 and 2010	Riyadh (C)	Secondary schools	IOTF	1001 (493, 508)	6
Al-Hazzaa - E et al. 2014 (E)		Al-Khobar (E)	Secondary schools		715 (348, 367)	
Al-Hazzaa - W et al. 2014 (W)		Jeddah (W)	Secondary schools		1192 (560, 632)	
Alenazi et al. 2015	2012	Arar (N)	Schools	CDC 2000	523 (523, 0)	8
Al-Mohaimeed et al. 2015	2012	Qassim (C)	Schools	WHO 2007	874 (618, 256)	7
Farsi et al. 2016	2015	Jeddah (W)	Elementary schools	CDC 2000	915 (482, 433)	7
Hothan et al. 2016	2015	Jeddah (W)	Intermediate schools	CDC 2000	401 (200, 201)	7
Musaiger et al. 2016	2013 and 2014	Dammam (E)	Secondary schools	IOTF	968 (518, 450)	7
Shaikh et al. 2016	2013 and 2014	Qassim (C)	Intermediate and secondary schools	WHO 2007	242 (129, 113)	6
Abdalla et al. 2017	2015	Majmaah (C)	Primary schools	WHO 2007	387 (170, 217)	5
Bajamal et al. 2017	2016	Jeddah (W)	Intermediate and secondary schools	IOTF	383 (0, 383)	6
Alazzeh et al. 2018	2016	Hail (N)	Intermediate and secondary schools	WHO 2007	1495 (1495, 0)	6
Fatima et al. 2018	2017	Arar (N)	Schools	IOTF	314 (0, 314)	7
Al-Hussaini et al. 2019	2015	Riyadh (C)	Primary and intermediate	WHO 2007	7931 (2943, 4988)	6
Bandy et al. 2019	2018	Sakaka (N)	Intermediate and secondary schools	CDC 2000	400 (400, 0)	6
Fakeeh et al. 2019	2017	Baish (W)	Primary schools	WHO 2007	298 (298, 0)	7

C: central; CDC: Centers for Disease Control and Prevention; E: eastern; IOTF: International Obesity Task Force; N: northern; S: southern; W: western; WHO: World Health Organization

Table 2:- The analysis of subgroups based the study region, diagnostic criteria, and year of data collection

Variables	**No. of studies**	**Prevalence (95%CI)**	**Heterogeneity**		**Test for between-group differences**	
			I^2	**Q**	**DF**	**p**
Diagnostic criteria						
CDC 2000	12	13.62 (9.57-19.01)	98.7	764.29	3	0.316
WHO 2007	7	16.1 (12.58-20.38)	95.7	146.57		
NA	1	10.66 (7.36-15.19)	NA	NA		
IOTF	10	14.08 (11.4-17.26)	94.5	79.3		
Year of data collection						
2000-2005	4	10.34 (6.23-16.69)	98.3	177.4	3	0.333
2006-2010	8	13.12 (11.36-15.11)	81	44.3		
2011-2015	13	16.00 (12.68-19.98)	97.9	566.14		
2016-2020	5	14.58 (7.63-26.06)	97.6	141.38		
Region						
Eastern	7	14.62 (12.23-17.38)	90	72.24	5	0.0005
Central	8	15.07 (12.26-18.39)	95.4	193.21		
Northern	5	18.61 (9.52-33.18)	99.1	470.71		
Western	6	13.25 (10.37-16.79)	86	34.64		
Central and Eastern	1	17.60 (15.83-19.51)	NA	NA		
Southern	3	7.10 (4.62-10.75)	95.8	65.61		

CI: confidence interval; DF: degree of freedom; NA: non-applicable

Table 3:- The results of the meta-regression model of the moderating effect of study region on the effect size.
Variables Coefficient 95% CI p.

Variables	**Coefficient**	**95% CI**	**p**
Central	Reference		
Central and Eastern	0.183	-0.752 to 1.117	0.702
Eastern	-0.041	-0.502 to 0.421	0.863
Northern	0.282	-0.229 to 0.793	0.281
Southern	-0.844	-1.445 to -0.244	0.006
Western	-0.164	-0.654 to 0.326	0.513
Constant	**-1.728**	**-2.043 to -1.412**	**< 0.0001**