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The shifting patterns of childhood obesity: Insights from national school screening data

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ABSTRACT

Background: Recent reports indicated an increasing prevalence of obesity among children and adolescents in Saudi Arabia, making it an impending national epidemic. However, obesity prevalence data in children and adolescents in Saudi Arabia are largely inconsistent.
Objectives: This study analyzed and compared the prevalence of obesity among a national sample of children and adolescents across sexes, school grades, regions, and city types in Saudi Arabia using the Growth Charts for Saudi Children and Adolescents.
Methods: Weight, height, and body mass index (BMI) data from 1 134 317 children in first, fourth, seventh, and tenth school grades who participated in the national school screening program were analyzed cross-sectionally. BMI values were classified using the Growth Charts for Saudi Children and Adolescents.
Results: Nearly 10.4% of students were overweight, 10.7 % were obese, and 4.50% were severely obese. Male students had a higher prevalence of overweight and obesity than their female counterparts. The prevalence of overweight and obesity was the highest among students in intermediate school, the Central region, and administrative capitals.
Conclusion: Managing childhood obesity is challenging due to its multifaceted nature Therefore, utilizing clinical and community-based participatory approaches is essential to develop nationwide obesity prevention and management program that is effective and sustainable. This program must utilize dynamic BMI surveillance systems using ethnically representative growth references, conduct national pediatric obesity research with careful consideration for demographic and regional differences, lead targeted pediatric obesity awareness campaigns, provide obesity management interventions in a pediatric multi-disciplinary clinic, and evaluate the program outcomes periodically.

1. Introduction

Over the last four decades, the prevalence of overweight and obesity among children and adolescents aged 5–19 has increased dramatically from 4 % in 1975 to 18 % in 2016 in more than seventeen countries, including middle-and low-income countries (Gregg & Shaw, 2017; WHO, 2021; Ng et al., 2014). Despite the recent slowing in obesity rates among adults in developed countries, rates of childhood obesity continue to increase (Afshin et al., 2017). Previous reports indicated that the prevalence of obesity among children and adolescents in Saudi Arabia is between developed and developing countries (El Mouzan et al., 2010a). However, a recent systematic review indicated that the

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prevalence of obesity among children and adolescents in Saudi Arabia continues to increase, which makes pediatric obesity an impending national epidemic (Habbab & Zulfiqar, 2020). Recent population-based and school-based studies indicated that the prevalence of overweight and obesity in children and adolescents in Saudi Arabia ranges between 11 % and 14.4 % and 7.1 % to 9.4 %, respectively (AlEnizi et al., 2023; Alshaikh et al., 2020; Ibrahim et al., 2021; World Obesity, 2023).

Pediatric obesity is a product of the interaction between child characteristics (e.g., biology, genetics, feeding practices, and physical activity level) and environmental factors (e.g., geographical location, culture, community, and the society) (Lobstein et al., 2004; Smith et al., 2019). Previous reports indicated that unhealthy dietary habits and decreased physical activity were the significant risk factors for childhood obesity in Saudi Arabia (Albaker et al., 2022; Ibrahim et al., 2022). Obesity is now recognized internationally as a chronic disease (Sawyer et al., 2012; Sajer & Gupta, 2017), which contributes to adulthood obesity and is associated with physical, mental, and economic debilitations (Brown et al., 2019; Lobstein et al., 2004). As such, obesity prevention has become an international public health priority (WHO, 2021; United Nations, 2016). Saudi Arabia has witnessed a significant improvement in its health indicators for both curative and public health services, with hundreds of centers established (Ministry of Health [MOH], 2023; General Authority of Statistics, 2018). However, pediatric obesity management and prevention efforts remain largely disintegrated and untargeted, and the burden of pediatric obesity continues to be inadequately addressed (Alhazzaa et al., 2022).

Previous studies used different Body Mass Index (BMI) referencing tools such as the WHO BMI references (WHO, 2009), the International Obesity Task Force (IOFT) references (Cole et al., 2000), the Center for Disease Control and Prevention (CDC) growth charts (CDC, 2000), or country-specific growth charts (El Mouzan et al., 2016; MOH, 2023), which resulted in inconsistent obesity prevalence data. As such, comparing obesity prevalence data across studies and analyzing BMI trends to guide public health interventions remains a significant challenge. National data using standardized and ethnically representative pediatric growth charts are needed to guide obesity prevention and management public health interventions and resource allocation. As such, this study aimed to assess and compare the prevalence of overweight and obesity among a national sample of school-age children across genders, school grades, regions, and city types using the Growth Charts for Saudi Children and Adolescents (El Mouzan et al., 2016; MOH, 2023).

2. Material and methods

2.1. Design and sample

This study was based on a secondary data analysis of a cross-sectional national sample including 1 134 317 children and adolescents living in Saudi Arabia and were part of the national school screening program established by the Saudi MOH. The national school screening program consists of a medical examination of school students to early detect health problems, refer them to the concerned authorities, provide health awareness programs, and build school health database (MOH, 2016). Data were collected from 1st, 4th, 7th, and 10th grade students.

2.2. Measures

The data collection for the national school screening program was established in September 2018, and the total number of students screened was 2,687,308. The data obtained for this study was limited to January 2020 and April 2022. Demographic data for age, sex, school grade, geographical regions, and type of cities were collected. The city type in Saudi Arabia was coded based on The Law of Provinces (Bureau of Experts, 1992). The Law of Provinces classifies the governorates of Saudi Arabia into three categories according to the availability of services, population, geographical considerations, and means of transportation. These categories are administrative capitals (i.e., large urban cities), governorate A (i.e., large governorates), governorate B (i.e., small governorates), and rural areas. The geographical region in Saudi Arabia was coded as Central (which includes Riyadh and Qassim), Western (which includes Jeddah, Makkah, Madinah, Taif, and Al Qunfothah), Southern (which includes Jazan, Beshah, Asseir, Albahah, and Najran), Northern (which includes Tabuk, Algurayat, Aljoof, the Northern boarders, and Hail), and Eastern (which includes Hafr Albatin, Alahsaa, and the Eastern region). School grade was coded as primary school (grades 1 and 4), intermediate school (grade 7), and secondary school (grade 10).

Anthropometric data for weight, height, and body mass index (BMI) were collected. Height was measured in centimeters (cm) using a stadiometer, and weight was measured in kilograms (kg) using a calibrated scale by nurses from the Saudi MOH. BMI was calculated as weight in kilograms divided by height in meters squared (kg/m2), with percentiles calculated using the Growth Charts for Saudi Children and Adolescents (El Mouzan et al., 2016; MOH, 2007). BMI data were plotted on Saudi's sex-specific percentile charts and categorized into four groups: underweight (less than the 5th percentile), normal weight (5th percentile to less than 85th percentile), overweight (85th to less than 95th percentile), obese (95th percentile or greater), and severe obesity (120% of the 95th percentile or greater) (Aldaajani et al., 2021; El Mouzan et al., 2016; Hampl et al., 2023).

2.3. Analytic strategy

The statistical analysis in this study was conducted using Statistical Package for Social Sciences (SPSS) software version 26.5. Data from 1 133,430 Saudi school-age children who participated in the school screening program and provided complete data were utilized in this analysis. The data were cleaned, and duplicate cases and cases with biologically implausible values for weight and height were excluded using the Saudi pediatric growth charts and age percentiles for weight, height, and BMI (El Mouzan et al., 2016). A total of 1 124 116 Saudi school-age children were included in the analysis. Descriptive statistics were used to describe the sample in relation to the study variables. Chi-Square was used to compare between groups across categories of the study variables. Pearson Product-Moment Correlation (r) was used to test the relationships among study variables. Multiple linear regression was used to test whether the demographic variables predicted BMI. Categorical variables such as city type, region, school grade, and sex were dummy-coded. Only variables that met the multiple linear regression assumptions (Williams et al., 2019) were included in the regression analysis. Statistical significance was set at a 95 % Confidence Interval, with a two-tailed P value of < 0.005 for all test parameters.

2.4. Ethical consideration

Approval to conduct this study was obtained from the Institutional Review Board and the approval to utilize the national school screening data was obtained from the Data Office in the Saudi MOH. The dataset has been de-identified.

3. Results

Data from 1 134 317 Saudi school-age children were utilized in this analysis. A total of 1 124 116 Saudi school-age children were included in the analysis after data cleaning. Our sample consisted of 47.6 % male and 52.4 % female students. The mean for age was 11.85 ($\pm$3.57), with 45.4 % of students in primary school, 28.5 % in secondary school, and 26.1 % in intermediate school. About 41 % of students lived in administrative capitals, 36.8 % were in governorates A, 13.9 % were in rural areas, and 8.3 % were in Governorates B. Around 28.8 % of students

were in the western region, 26.5 % were in the central, 17.8 % in the southern, 15.6 % in the eastern, and 11.3 % in the northern regions of Saudi Arabia (Table 1).

Among students in the primary school, 47.6 % were males, 52.4 % were females, 42.6% of were in Governorates A, 37.6 % were in administrative capitals, 11.1 % were in rural areas, and 8.7 % were in Governorates B. About one third of students were in the western region, 23.4 % were in the central, 17.2 % were in the eastern, 15.8 % were in the southern, and 11.5 % were in the northern regions.

Among students in the intermediate school, 48.2 % were males and 51.8 % were females. Around 43 % of students were in administrative capitals, 33.1 % were in governorates A, 14.8 % were in rural areas, and 9 % were in governorates B. About one third of students were in the central region, 24.8 % in the western region, 20.2 % in the southern, 14.2 % were in the eastern, and 11.9 % were in the northern regions.

Among students in secondary school, 47.3 % were males, and 52.7 % were females. Around 44.7 % of students were in administrative capitals, 30.3 % were in governorates A, 17.8 % were in rural areas, and 7.2 % were in governorates B. About one third of students were in the central region, 26.5 % in the western region, 19.1 % in the southern, 14.6 % were in the eastern, and 10.4 % were in the northern regions (Table 2).

The mean of BMI was the highest among male students, secondary school students, students living in rural areas, and among students living in the central region. The mean BMI among children who were underweight was 12.9 with a standard deviation (SD) of 1.5, the mean BMI for children who were normal weight was 17.4 with a SD of 3.1, the mean of BMI among children who were overweight was 23.14 with a SD of 3.6, and the mean of BMI among children who were obese was 27.58 with a SD of 4.8. (Table 3).

Age (r = [0.532], p = [0.001]), being in intermediate school (r = [0.155], p = [0.001]), and being in secondary school (r = [0.402], p = [0.001]) were significantly correlated with BMI (Table 4).

The overall prevalence of overweight and obesity was 10.4 % and 10.7 %, higher among male students (10.8 % and 12.5 %) than their female counterparts (10.1 % and 9.1 %), respectively. Using chi-square statistic, the difference between BMI categories across males and females was significant, X^2 (3, N = 1, 124, 116) = 4467.753, p =.001. The highest prevalence of overweight was among students in intermediate school (12.6 %), and the lowest was in primary school (8.8 %). In addition, the highest prevalence of obesity was among students in intermediate school (12.3 %), and the lowest was in secondary school (9.8 %). The difference between BMI categories across school grades was significant, X^2 (6, N = 1, 124, 116) = 4754.923, p =.001. The highest prevalence of overweight and obesity was in administrative capitals (12 % and 12.4 %), and the lowest was in governorates B (8.5 % and 8.2 %),

Table 1
Demographic sample characteristics (n = 1, 124, 116):

Variable	Frequency	Percentage
Sex		
Male	534,979	47.6 %
Female	589,137	52.4 %
School Grade		
Primary	510,478	45.4 %
Intermediate	293,415	26.1 %
Secondary	320,223	28.5 %
City Type		
Administrative capital	460,616	41.0 %
Governorate A	413,697	36.8 %
Governorate B	93,308	8.3 %
Rural	156,495	13.9 %
Region		
Central	297,505	26.5 %
East	175,707	15.6 %
North	126,699	11.3 %
South	200,255	17.8 %
West	323,950	28.8 %

Table 2
Demographic characteristics school age students in each school grade (n = 1, 124, 116).

Demographic Variables		School grades		
		Primary	Intermediate	Secondary
Age M (SD)		8.51 (1.7)	12.99 (0.8)	15.8 (1.08)
Sex	Male	242,112 (47.6%)	140,772 (48.2%)	151,430 (47.3%)
	Female	268,266 (52.4%)	151,544 (51.8%)	168,760 (52.7%)
City Type	Administrative Capital	191,145 (37.6%)	126,254 (43.2%)	143,133 (44.7%)
	Governorates A	216,299 (42.6%)	96,625 (33.1%)	97,172 (30.3%)
	Governorates B	44,108 (8.7%)	26,205 (9%)	22,990 (7.2%)
	Rural	56,359 (11.1%)	43,232 (14.8%)	56,895 (17.8%)
Region	Central	119,047 (23.4%)	84,182 (28.8%)	94,228 (29.4%)
	East	87,332 (17.2%)	41,615 (14.2%)	46,746 (14.6%)
	North	58,523 (11.5%)	34,882 (11.9%)	33,262 (10.4%)
	South	80,147 (15.8%)	59,064 (20.2%)	61,031 (19.1%)
	West	162,862 (32.1%)	72,573 (24.8%)	84,923 (26.5%)

Note. *M = Mean, SD = Standard Deviation.*

Table 3
Mean and standard deviation of body mass index across categories of sex, school grade, city types, regions, and body mass index (n = 1, 124, 116).

Variables	Body Mass Index Mean (Standard Deviation)
Sex	
Male	18.99 (5.03)
Female	18.96 (4.7)
School grade	
Primary	16.27 (3.3)
Intermediate	20.24 (4.4)
Secondary	22.08 (5.05)
City type	
Admin Capitals	19 (4.7)
Governorate A	18.46 (4.6)
Governorate B	18.49 (4.7)
Rural	19.44 (5.08)
Region	
Central	19.82 (5.1)
East	19.15 (5.03)
North	18.7 (4.6)
South	18.6 (4.5)
West	18.4 (4.8)
Body mass index categories	
Underweight	12.9 (1.5)
Normal weight	17.4 (3.1)
Overweight	23.14 (3.6)
Obese	27.58 (4.8)

Table 4
Pearson R correlation analysis among body mass index and demographic variables (n = 1, 124, 116):

Variable	Body Mass Index Pearson r Correlation
Age	0.532***
Female	-0.006
Male	-0.006
Administrative capitals	0.082
Governorates A	-0.073
Governorates B	-0.031
Rural	0.009
Primary school	-0.006
Intermediate school	0.155**
Secondary school	0.402**
North	-0.019
South	-0.035
West	-0.073
East	0.017
Central	0.104**

Note. *Significance of Pearson r parameter, *p ≤. 05, **p ≤. 01, ***p ≤. 001 (two-tailed).*

respectively. The difference between BMI categories across city types was significant, X^2 (9, N = 1, 124, 116) = 6004.022, p =.001. The highest prevalence of overweight was in the Central (13 %) and in the Eastern region (12.4 %), and the lowest was in the Southern region (7.20 %). The highest prevalence of obesity was in the Central (13.6 %) and in the Eastern region (13.7 %), and the lowest was in the Southern region (6.9 %). The difference between BMI categories across regions was significant, X^2 (12, N = 1, 124, 116) = 17908.203, p =.001 (Table 5).

Of students who were classified as obese, 42 % of them were severely obese, making up 4.5 % of the total sample in our analysis. Of male students classified as obese, 43.50 % were severely obese, making 5.30 % of male students in our sample and 2.5 % of the total sample in our analysis. Of female students categorized as obese, 40.32 % were severely obese, making 3.60 % of all female students in our sample and 1.90 %. The prevalence of severe obesity was the highest in students in secondary (9.70 %), followed by intermediate (5.30 %) and primary school (4.70 %).

The overall regression model was statistically significant (R *Square* = [0.303], F (11, 1124109) = [744366.490], p = [0.001]). However, only three variables significantly predicted BMI. Age significantly predicted BMI (β = [0.372], p = [0.001]), being in intermediate school grade significantly predicted higher BMI (β = [0.140], p = [0.001]), and being in secondary school grade predicted higher BMI (β = [0.173], p = [0.001]) (Table 6).

Table 5
Body mass index categories distribution according to sex, region, city type, and school grade (n = 1, 124, 116).

Demographic Variables	Underweight	Body Mass Index Categories		
		Normal weight	Overweight	Obese
Overall	33,559 (3 %)	853,385 (75.9 %)	117,013 (10.4 %)	120,159 (10.7 %)
Sex				
Male	12,802 (2.4 %)	397,916 (74.4 %)	57,649 (10.8 %)	66,612 (12.5 %)
Female	20757(3.5 %)	455,469 (77.3 %)	59,364 (10.1 %)	53,547 (9.1 %)
Chi-Square 4467.753***			df 3	
School Grade				
Primary	16,001 (3.1 %)	396,978 (77.6 %)	44,753 (8.8 %)	52,751 (10.3 %)
Intermediate	7535 (2.6 %)	212,824 (72.5 %)	36,902 (12.6 %)	36,154 (12.3 %)
Secondary	10,023 (3.1 %)	243,588 (76.1 %)	35,358 (11 %)	31,254 (9.8 %)
Chi-Square 4754.923***			df 6	
City type				
Administrative Capital	13,177 (2.9 %)	334,775 (72.7 %)	55,425 (12 %)	57,239 (12.4 %)
Governorate A	12,512 (3 %)	319,331 (77.2 %)	40,068 (9.7 %)	41,786 (10.1 %)
Governorate B	3002 (3.2 %)	74,695 (80.1 %)	7958 (8.5 %)	7653 (8.2 %)
Rural	4868 (3.1 %)	124,584 (79.6 %)	13,562 (8.7 %)	13,481 (8.6 %)
Chi-Square 6004.022***			df 9	
Region				
Central	6246 (2.1 %)	212,211 (71.3 %)	38,587 (13 %)	40,461 (13.6 %)
East	4071 (2.3 %)	125,906 (71.7 %)	21,773 (12.4 %)	23,998 (13.7 %)
North	3196 (2.5 %)	101,969 (80.5 %)	10,916 (8.6 %)	10,618 (8.4 %)
South	7046 (3.5 %)	164,985 (82.4 %)	14,400 (7.2 %)	13,824 (6.9 %)
West	13,000 (4 %)	248,314 (76.7 %)	31,378 (9.7 %)	31,258 (9.6 %)
Chi-Square 17908.203***			df 12	

Note. *p ≤. 05, **p ≤. 01, ***p ≤. 001 (two-tailed), df = degrees of freedom.

4. Discussion

Our analysis indicated that the overall prevalence of overweight among a national sample of school-age children and adolescents in Saudi Arabia was 10.4 %. Our findings indicated a slightly lower prevalence of overweight than previous national reports (Alshaikh et al., 2020; AlEnizi et al., 2023; El Mouzan et al., 2012; Ibrahim et al., 2021). In their population-based study involving 351,195 children, AlEnizi et al. (2023) found that the prevalence of overweight was 11.2 %. Among a national sample of school-age children, Ibrahim et al. (2021) reported that the prevalence of overweight was 11 %. In a cross-sectional study involving 3613 school-age children in the western, central, and eastern regions, Alshaikh et al. (2020) found that the prevalence of overweight was 14.4 %.

Our analysis indicated that the prevalence of obesity among a national sample of school-age children and adolescents was 10.7 %. Our findings indicated a slightly higher prevalence of obesity compared to previous national reports. El Mouzan et al. (2012), Alshaikh et al. (2020), Ibrahim et al. (2021), and ElEnizi et al. (2023) found that the prevalence of obesity among national samples of school-age children was 8.3 %, 7.1 %, 7.6, and 9.4 %, respectively.

Our analysis indicated that the overall prevalence of severe obesity in our sample was 4.40 %. While national data on the prevalence of severe obesity are limited compared with previous reports (El Mouzan et al., 2010a), our findings indicate that the prevalence of severe obesity is higher than previous reports. Using the WHO BMI reference on a national sample of 19 371 Saudi school-age children, El Mouzan et al., (2010a) found that the prevalence of severe obesity was 2 %.

While our findings were reassuring regarding overweight, they highlighted an increasing pattern of obesity and severe obesity among children and adolescents in Saudi Arabia.

The vast economic growth and urbanization in Saudi Arabia during the last two decades have led to significant changes in lifestyle and dietary habits such as eating for pleasure, consumption of high-calorie foods, and the easy access and availability of junk food (Alhussaini

Table 6
Regression: demographic study variables predicting body mass index (n = 1, 124, 116).

Variable	B	St error	Beta	t
Constant	11.438	0.027		427.378
Age	0.543***	0.003	0.374***	7.469
Male	-0.058	0.008	0.006	−33.311
Administrative capitals	-0.058	0.008	0.006	−28.422
Governorates A	-0.320	0.010	-0.031	−46.177
Governorates B	-0.430	0.015	-0.024	99.975
Rural	0.586	0.013	-0.041	84.258
Primary school	0.586	0.013	-0.041	16.188
Intermediate school	1.564***	0.016	0.140***	−10.627
Secondary school	1.882***	0.022	0.173***	75.207
North	0.231	0.014	0.015	80.808
South	-0.131	0.012	-0.010	192.791
East	0.926	0.012	0.069	427.378
West	0.926	0.012	0.069	7.469
Central	0.895	0.011	0.081	−33.311

Note. Significance of Pearson r parameter, *p ≤. 05, **p ≤. 01, ***p ≤. 001 (two-tailed).B = unstandardized regression coefficient, Beta = standardized regression coefficient, st. error = standard errors.

et al., 2019; Alhazzaa & Almarzooqi, 2018; Afshin et al., 2017; Alswat et al., 2016; Fakeeh et al., 2019). In addition, the dependence on cars for transportation and the extended screen time due to the heavy consumption of social media, video gaming, and movie platforms contributed to a sedentary lifestyle among children and adolescents (Alhazza et al., 2022; Aljassim & Jradi, 2021).

Comparing our results with those of other countries, Saudi Arabia remains in an intermediate position for both overweight and obesity (Habbab & Zulfiqar, 2020). For example, in the US, obesity prevalence was 20.7 % among 6-to 11-year-olds and 22.2 % among 12 to 19-year-olds (Stierman et al., 2021). In China, among a sample of 1 196 004 school-age children, the prevalence of overweight and obesity was 11.8 % and 8.1 %, respectively (Cheng et al., 2019). While data from some Western countries have shown a plateauing of obesity levels in children (Olds et al., 2011), our findings indicate that childhood obesity continues to rise in Saudi Arabia.

Our analysis indicated that BMI was correlated with age and that being in intermediate school grade and in secondary school grade significantly predicted higher BMI. Our findings were consistent with previous reports indicating a positive correlation between age and BMI in children (Albaker et al., 2022; Alshaik et al., 2020; El Mouzan et al., 2012; Fakeeh et al., 2019). Previous studies indicated that obesity was the highest among students in secondary school (El Mouzan et al., 2010b). Moreover, we found that the prevalence of overweight and obesity was the highest among children in intermediate school. Our findings were consistent with recent national and international reports highlighting the changing pattern of pediatric obesity as it has increased among the 12–15 age groups (Alhussaini et al., 2023; Center for Disease Control and Prevention [CDC], 2023; Ibrahim et al., 2021; Ibrahim et al., 2022).

We found that overweight and obesity were higher among male students compared to their female counterparts, which was consistent with recent local, national, and international reports (Alhazza et al., 2022; Alenizi et al., 2023; Faris & Alkhodary, 2017; Farrag et al., 2017; Ibrahim et al., 2021; Habbab & Zulfiqar, 2020), While there is no clear pattern of sex differences in the prevalence of obesity in children (Albaker et al., 2022; Alshaikh et al., 2020; El Mouzan et al., 2012), old references indicate a higher prevalence of obesity among female adolescents compared to males (Al Nuaim et al., 2012; El Mouzan et al., 2012). Our finding suggests a changing pattern of obesity among children and adolescents in Saudi Arabia. We attribute the lower prevalence of obesity in female students compared to males due to the increased concerns with body weight among female adolescents (Alhussaini et al., 2019; Farsi & Alkhodary, 2017). In addition, this can be attributed to the recent expansion of access and availability of opportunities and facilities for female adolescents to engage in physical activities (United Nations Saudi Arabia, 2018). As such, the reduction in the prevalence of obesity among female students reflects the progress toward the Saudi Arabia 2030 Agenda of the Sustainable Development Goals (WHO, 2017).

The prevalence of overweight and obesity in the central, northern, southern, and western regions in our study was generally lower than those reported in previous studies (Alhussaini et al., 2019; Alsweed et al., 2023; Fakeeh et al., 2019; Farsi & Alkhodary, 2017). However, the prevalence of obesity in the eastern region in our study was higher than those reported in previous studies (Albakert et al., 2022). Overall, the highest prevalence of overweight was in the central region, which was consistent with Alskaikh et al. (2020), AlEnizi et al. (2023), and El Mouzan et al. (2012). Consistent with previous studies, the highest prevalence of obesity was in the Eastern region, attributed to physical inactivity and a diet high in carbohydrates and fats (Albaker et al., 2022; Ibrahim et al., 2021). Consistent with AlEnizi et al. (2023) and El Mouzan et al. (2012), we found that the lowest prevalence of overweight and obesity was in the southern region. In addition, a higher prevalence of obesity was found among children living in urbanized cities compared to those living in rural areas, which was consistent with previous reports (Alshaikh et al., 2020; Alenizi et al., 2023; Fakeeh et al., 2019). Regional variation in the prevalence of obesity can result from individual, biological, social, demographic, geographical, and economic differences in population characteristics. Such variation can create different risk factors for obesity related to ethnic background, genetic makeup, level of education, dietary habits, lifestyle, access to health care, level and access to physical activity, and community awareness (Fakeh et al., 2019; Alazzeh et al., 2018; El Mouzan et al., 2012).

Obesity among children and adolescents in Saudi Arabia is becoming a national public health concern (Habbab & Zulfiqar, 2020). Managing childhood obesity is challenging due to its multifaceted nature (Smith et al., 2020). Several public health interventions to prevent childhood obesity have been implemented by national and local institutions (Aldojaani et al., 2019). However, the impact of those interventions on reducing pediatric obesity remains limited (Alhazzaa & Almarzooqi, 2018; Hales et al., 2018). Therefore, integrating efforts of the Ministry of Health, the Ministry of Education, and the community stakeholders via clinical and community-based participatory approaches is essential to develop an effective and sustainable nationwide pediatric obesity prevention and management program (Hoffman et al., 2018). This program needs to be designed based on the Ecological System Theory (Davison & Birch, 2001), which approaches pediatric obesity by identifying risk factors moderated by the interaction between child characteristics, the proximal and the distal contexts such as the family, the school, the community, the region, and the society (Smith et al., 2020). This program must utilize dynamic BMI surveillance systems using standardized and ethnically representative growth references, conduct pediatric obesity research, organize regular obesity prevention and management awareness campaigns, provide pediatric obesity prevention and management interventions via a multi-disciplinary clinic, and evaluate the program outcomes periodically. The national school screening program by the MOH can be the building block for such a program (MOH, 2016; Aldojaani et al., 2019). Due to the nature of their training, school, public, and pediatric health nurses are best fitted to lead such a program (Fruh et al., 2019; Whitehead et al., 2021). Several studies have documented the effectiveness of nurse-led obesity prevention programs in reducing BMI among children (Alkon et al., 2014; De Vries et al., 2015). In addition, annual screening for pediatric obesity in primary care centers and schools should be mandated. Therefore, primary care providers and school nurses must be adequately trained and enabled to identify, discuss, refer, and follow up children and adolescents with overweight and obesity (Ling et al., 2016).

Our analysis was based on a large national sample representing all regions of Saudi Arabia. In addition, we used ethnically representative

growth charts to classify BMI values (El Mouzan et al., 2016). Moreover, we were able to report the magnitude of obesity by identifying students with severe obesity. However, our analysis has a few limitations that need to be addressed. Due to the nature of a secondary data analysis, we could not examine the magnitude of factors contributing to obesity. Therefore, future pediatric obesity research needs to be based on community health models that capture all factors that contribute to obesity including familial and cultural dietary practices, availability and affordability of junk versus healthy food in schools and the community, screen time, community resources for physical activities, and related public health policies. Additionally, our data were cross-sectional, which limited our ability to track BMI status. Future research will benefit from longitudinal approaches as it enable researchers to monitor BMI values and identify risk factors for pediatric obesity. Moreover, our data were collected from 2018 until 2022, and grouping them into pre-, during, and post-COVID-19 pandemic may have provided us with additional insights into the effect of the pandemic and its accompanying social-distancing measures on the weight status of children and adolescents. Moreover, comparing our findings with previous studies was challenging due to the differences between the used pediatric BMI references. Previous reports affirmed discrepancies, overestimating, and underestimating pediatric obesity in Saudi Arabia when using internationally developed BMI references (Alhazzaa et al., 2022; El Mouzan et al., 2016). As such, future obesity research must utilize standardized and ethnically representative growth references (Alhazzaa et al., 2022; Alhussaini et al., 2019).

5. Conclusions

The overall prevalence of overweight and obesity in children and adolescents in Saudi Arabia is increasing and discriminately affecting male teens. Therefore, a national obesity prevention and management program is essential to tackle childhood obesity via preventative and curative approaches guided by standardized, ethnically representative, and dynamic national pediatric obesity surveillance systems, national pediatric obesity research, targeted pediatric obesity awareness campaigns, and a multi-disciplinary obesity management clinic.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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