What is the current status of childhood obesity in Saudi Arabia?
Evidence from 20,000 cases in the Eastern Province: A cross-sectional study

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Abstract
The prevalence rate of those overweight, as well as obesity among children in Saudi Arabia, keeps rising. The aim of the study was to estimate childhood obesity in the Eastern Province, Saudi Arabia.

Over the period 2016 to 2017, a cross-sectional campaign was carried out in the Eastern Province of Saudi Arabia. Data were collected from over 20,000 boys' and girls' schools. The campaign collected data on birthday/age, weight, height, sex, district in which the school is located, level of education, and blood pressure level.

The findings from the present study indicated a prevalence of 25.7% for overweight and obesity among school-age students. More importantly, ≈35% of the study's students have either elevated blood pressure or hypertension. The significant predictors of childhood obesity were education level, age, glucose level, and blood pressure.

The children in higher school levels originally from the Eastern Province had a high prevalence of overweight and obesity. Recommendations are made on the need of regular screening program among school-age children, as well as to continue raising awareness about childhood obesity.

Abbreviations: BMI = body mass index, IQR = interquartile range.

Keywords: blood pressure, children, obesity, Saudi Arabia

1. Introduction
Childhood obesity is one of the most common health problems in the world due to its rising trend.[1] According to the World Health Organization, >1.9 billion people were overweight in both developing and developed countries in 2016 with >340 million children and adolescents (5–19 years) being overweight or obese.[2]

The global number of overweight or obese newborns and young children is expected to reach 70 million by 2025.[3] Overweight and obesity have been found to be significantly correlated with an increased risk of several health disorders, such as cardiovascular disease, psychological disturbance, metabolic syndrome, type 2 diabetes, fatty liver disease, and premature death.[4] Childhood obesity is of particular concern as it has increased globally, and it could have adverse health impact in adulthood.[5]

Over the past 3 decades, several studies have been conducted on childhood obesity in different regions in Saudi Arabia. In a study carried out by El Mouzan et al (2010), the aim was to estimate the national prevalence of obesity and of being overweight in children in Saudi. This study found that Saudi Arabia's level was intermediate, between those of developing and developed countries.[6] In another study carried out in 2015 to 2016 based on data from 3613 school-aged children from different regions of Saudi Arabia, the estimated prevalence of obesity and of being overweight was 21.5%.[7] The same study stated that obesity began to rise from age 10 and continued to increase and develop in significance and complexity until the age of 19 years.[7]

Overall, Saudi Arabia currently ranks among the countries with the highest prevalence of childhood obesity.[8] Moreover, obesity-related health consequences among children in Saudi Arabia keep rising and, according to a national study, are...
significantly linked to cardiometabolic risk factors, which in turn impact the possibilities of being associated with other social and psychological outcomes.[9]

To achieve the Saudi Vision by 2030, the Ministry of Health aims to fulfill multiple strategic objectives that promote health status and support efforts toward an efficient disease-free society, including strategic objective number 13, which is targeted to lower obesity among Saudis.[10] The first step to controlling the obesity among children is to accurately evaluate its prevalence and to tailor evidence-based effective intervention programs. Moreover, as far as we know, there is no recent report describing the existing childhood obesity prevalence in the Eastern Province, Saudi Arabia. According to the General Authority for Statistics, the Eastern Province has the highest average monthly income per household in Saudi Arabia.[11] As various reports have documented that obesity is frequently associated with income growth, it is of interest to learn about the current rate of childhood obesity in the province.[12,13] Thus, the aim of the present study was to provide a recent estimate of childhood body weight and determine the trend in childhood obesity in the Eastern Province, Saudi Arabia.

### 2. Methods and materials

From 2016 to 2017, a cross-sectional campaign was carried out in schools in the Eastern Province of Saudi Arabia. The campaign was carried out by the Saudi Diabetes and Endocrine Association in collaboration with the Ministry of Education, Eastern Province Branch.

Inclusion criteria were as follows: Saudi, with subjects aged 6 to 19 years of any sex. Participants with any acute or chronic health condition or amputated body parts were excluded from the study, since these conditions could affect their body mass index (BMI).

The campaign collected data on birthday/age, weight, height, sex, district in which the school is located, level of education, exercise, and comorbidities. Blood pressure was measured (after 5 minutes of rest) using an automatic BP monitor using Dinamap.[14] Weight and height were measured using a portable stadiometer (Seca 704; Seca, Hamburg, Germany). Participants were requested to “remove their shoes and wear light clothing before taking their measurements.” The height of the students was documented to the nearest 0.1 cm, and the weight was calculated after 5 minutes of rest using an automatic monitor (Omron M6 Comfort IT), and the mean of the blood pressure recordings was considered for the data analysis.[14]

Data were also collected on the names and telephone numbers of the students. The data on weight and height were used to calculate BMI. Children were classified based on BMI as underweight (BMI < 18.5), normal (18.5 ≤ BMI ≤ 24.9), overweight (25.0 ≤ BMI ≤ 29.9), obese (BMI ≥ 30),[15] and the mean of the blood pressure recordings was considered for the data analysis.[14]

The frequency of exercise, as it was written in free text.

| Variable                  | Categories                      | Number | Percentage |
|---------------------------|---------------------------------|--------|------------|
| Sex                       | Male                            | 11537  | 57.50      |
|                           | Female                          | 8536   | 42.50      |
| Total                     |                                 | 20073  | 100.00     |
| School level              | Primary                         | 6895   | 34.30      |
|                           | Intermediate                    | 6734   | 33.50      |
|                           | Secondary                       | 6444   | 32.10      |
| Total                     |                                 | 20073  | 100.00     |
| District                  | Al-Thuabah                       | 4019   | 20.00      |
|                           | Madinat Al Umal                 | 3129   | 15.60      |
|                           | Al Jisr                          | 2996   | 14.90      |
|                           | Iskan                           | 2206   | 11.00      |
|                           | Al Aqabiyah                      | 1933   | 9.60       |
|                           | Al Khobar Al Shamali             | 1465   | 7.30       |
|                           | Rakaa                           | 748    | 3.70       |
|                           | AIR-BASE                        | 590    | 2.90       |
|                           | Al Tahliyah                      | 574    | 2.90       |
|                           | Olaya                           | 399    | 2.00       |
|                           | Khobar Al Janubiyah              | 336    | 1.70       |
|                           | Al Hizam Al Thahabi              | 283    | 1.40       |
|                           | Tahliyah                        | 158    | 0.80       |
|                           | Al Hada                         | 130    | 0.60       |
|                           | Not stated                       | 1107   | 5.50       |
| Total                     |                                 | 20073  | 100.00     |
| BMI class                 | Underweight (BMI < 18.5)        | 6862   | 34.20      |
|                           | Normal (18.5 ≤ BMI ≤ 24.9)      | 8039   | 40.00      |
|                           | Overweight (25.0 ≤ BMI ≤ 29.9)  | 2974   | 14.80      |
|                           | Obese-1 (30.0 ≤ BMI ≤ 34.9)     | 1334   | 6.60       |
|                           | Obese-2 (35.0 ≤ BMI ≤ 39.9)     | 529    | 2.60       |
|                           | Obese-3 (BMI ≥ 40.0)            | 335    | 1.70       |
| Total                     |                                 | 20073  | 100.00     |
| Blood pressure class      | Normal <120/<80 mm Hg            | 7083   | 35.30      |
|                           | Elevated <120–129/<80 mm Hg     | 1996   | 9.90       |
|                           | Hypertension stage I            | 3037   | 15.10      |
|                           | 130–139/80–89 mm Hg             | 1962   | 9.80       |
|                           | Hypertension stage II           | 5996   | 29.90      |
| Total                     |                                 | 20073  | 100.00     |

The following variables were dropped from the analysis:

The birthday variable, as age could not be easily calculated from it for several reasons, including lack of uniformity in reporting the birthdays.

The frequency of exercise, as it was written in free text.
Comorbidities, as they were written in free text after the data cleaning, and the final file consisted of little over 20,000 cases.

Informed signed written parental consent and child assent were obtained from all participants. The study was approved by the Ethics Committee of the Imam Abdulrahman Bin Faisal University, Institutional Review Board (IRB-2021-01-296).

2.1. Statistical analysis

Data were analyzed using the MedCalc, PAST, and SSP softwares. Normality distribution was assessed using the Shapiro–Wilk test. The distribution of the continuous variables was presented using the median and interquartile range (IQR). Categorical variables were summarized using percentages. Associations between categorical variables were assessed using the χ² test. Multiple regression was used to assess the predictors of BMI. For all the analyses, the significance level was set at 5% (α = 0.05).

3. Results

The frequency distribution of the categorical variables in the study population is shown in Table 1. Data were collected from over 20,000 boys’ and girls’ schools from different districts of the Eastern Province. The school population is made up of 57.5% boys. They are roughly equally distributed between primary (34.3%), intermediate (33.5%), and secondary (32.1%) levels. In total, the students covered in the campaign come from 14 districts. Of these districts, a little over half (50.5%) come from the 4 districts of Al-Thuqbah, Madinat Al Umal (central business district), Al Jisr, and Iskan (Khobar housing). These are all in the south and are of relatively lower income compared to higher income districts in the North of Khobar. The frequency distribution of the BMI classes shows a skewed distribution with 34.2% being underweight and 40% being of normal weight. About a quarter of the students (25.7%) are obese or overweight. For blood pressure, data are not stated for close to a third of the students. The frequency distribution of the blood pressure classes in Table 1 shows that 35.3% of the students are of normal blood pressure. Students with either elevated blood pressure or hypertension amount to 34.8%.

| BMI class | Male | Female | χ²(df) | P value |
|-----------|------|--------|--------|---------|
| Underweight (BMI < 18.5) | 4258 | 2604 | 114.657 (5) | <.0001 |
| Normal (18.5 ≤ BMI ≤ 24.9) | 4319 | 3720 | | |
| Overweight (25.0 ≤ BMI ≤ 29.9) | 1682 | 1292 | | |
| Obese-1 (30.0 ≤ BMI ≤ 34.9) | 800 | 534 | | |
| Obese-2 (35.0 ≤ BMI ≤ 39.9) | 306 | 223 | | |
| Obese-3 (BMI ≥ 40.0) | 172 | 163 | | |
| Total | 11,537 | 8536 | | |

BMI = body mass index, df = degree of freedom.

Figure 1. Comparison of the distribution of BMI classes among males and females, school health campaign. BMI = body mass index.
The characteristics of the numeric variables in the study are shown in Table 2. For this young student population, the median age is 14 (IQR: 12–16) years, median weight is 49.6 (IQR: 36.5–63.5) kg, median height is 1.54 (IQR: 1.4–1.63) m, and the median BMI is 20.54 (IQR: 17.46–25.2) kg/m². The association between sex and BMI classes is shown in Table 3. The table shows that for both males and females, the prevalence rates decrease with increase in the BMI level above the normal range (overweight and obese levels). The association is significant as $P < .0001$. This distribution of males and females within each BMI class is shown in Figure 1, and proportions are shown in Table 4. The table shows that for underweight, there is a statistically significant difference between the proportions of males and females, with the proportion of males being higher. For normal weight, there is also statistical difference between the proportions of males and females but with the proportion of females being higher. For both overweight and obese categories, there is no statistical difference between the proportions of males and females.

Table 5 and the accompanying Figure 2 show the comparison of the distribution of BMI classes across education levels. The table shows that there is a significant association between BMI and school level ($P < .001$). For all the school levels, the proportion of obese or overweight is much lower than the proportion of normal or underweight. Also, for the overweight and obese categories, the proportions decrease for all levels of education.

The result of the multivariate regression analyses is shown in Table 6. The overall model fit was significant; $F(5, 20,067) = 654$, $P < .001$. However, the predictive power of the model is relatively low as the adjusted $R^2$ is about 14%. After controlling for the other variables in the model, sex drops in significance. The remaining significant variables were education level, age, glucose level, and blood pressure.

### 4. Discussion

This large, representative school-based study found that the percentage of overweight or obese among high school children in the Eastern Province of Saudi Arabia was 25.7%. This finding is consistent with another study conducted in other regions; Saudi Arabia showed that the prevalence of obesity was higher in high schools.\(^{[16,17]}\) To date, several studies on childhood obesity among school students were conducted in the Kingdom of Saudi Arabia; however, these studies were small, cross-sectional studies. Al-Shammari et al (2001) performed a cross-sectional study on a population-based sample of Riyadh city in the Central Province that was not randomly chosen. In total, there were 4775 participants, of whom 1848 were children and 2927 were adults. Among the children, about 10.5% were overweight, and 8.7% were considered obese.\(^{[18]}\) In the same region, a new study reported a higher prevalence rate of obesity (15.7%) among school-age students.\(^{[19]}\) A study in Jazan (Southern Province) reported that the prevalence of obesity and overweight was 12.4% and 10.1%, respectively.\(^{[20]}\) In contrast, according to a study carried out by Qamar Farshori et al\(^{[21]}\) in 2015, it was found that 48% of male children were either overweight or obese, and for female children, 13% of them were obese and 20% were overweight.

The present study found no significant gender differences regarding BMI classes. However, some local studies reported inconsistent results regarding the obesity and gender difference prevalence among the Saudi population. Results from other local studies in this regard, however, were conflicting.\(^{[17,22]}\) According to a previous review, results suggested that the gender differences in obesity rates are generally small and inconsistent.\(^{[10,23]}\)

Our study also investigated some obesity-related risk factors and found that the risk factors for obesity in this study population were age, education level, age, glucose level, and blood pressure. The high prevalence of elevated blood pressure or hypertension among the study’s students is in agreement with a similar study conducted in the same region of Saudi Arabia.\(^{[24]}\) The relation between elevated blood pressure and obesity is well documented. Previous studies showed that there is approximately 3-fold increased risk in obese children for developing hypertension rather than nonobese children.\(^{[25,26]}\) Indeed, previous research from the Eastern Province of Saudi Arabia demonstrated that behavioral aspects could explain the probable cause of the increase in BMI and blood pressure in early life. These factors included physical inactivity, eating habits, especially high salt intake,\(^{[27]}\) fructose aerated beverages and energy drink consumption,\(^{[28]}\) physical inactivity,\(^{[29]}\) and obesity.\(^{[30]}\) In addition, increased TV viewing, use of smart tools, and sleep duration at a young age have been linked to an increased risk of being obese.\(^{[31,32]}\)

There is evidence that the prevalence of obesity in school age is increasing dramatically in the Kingdom of Saudi Arabia, possibly as a result of a sedentary lifestyle and urbanization, and the problem appears to be becoming worse as the children become older.\(^{[33]}\) Urbanization is considered a major risk factor for obesity in developing countries in economic transition.\(^{[34]}\) The cities of Saudi Arabia are now modernized, with separate zoning and large transportation networks for commercial areas and residential areas. This type of city design requires the use of the automobile for most trips and totally discourages walking, which reflects negatively on public health.\(^{[35]}\) Moreover, the

### Table 4

| BMI classes    | Male (n = 11,537) | Female (n = 8536) | $z$ | $P$ value |
|---------------|------------------|------------------|----|-----------|
| Underweight   | 36.9%            | 30.5%            | 9.453 | <.001     |
| (BMI < 18.5)  |                  |                  |     |           |
| Normal (18.5 ≤ BMI ≤ 24.9) | 37.4% | 43.6% | 8.783 | <.001     |
| Overweight (25.0 ≤ BMI ≤ 29.9) | 14.6% | 15.1% | 1.075 | .283      |
| Obese (BMI ≥ 30) | 11.1% | 10.8% | 0.672 | .502      |

**BMI = body mass index.**

### Table 5

| BMI classes    | Primary | Intermediate | Secondary | $\chi^2$ (df) | $P$ value |
|---------------|---------|--------------|-----------|---------------|-----------|
| Underweight   | 3910    | 1729         | 1223      | 2737.76 (10)  | <.0001    |
| (BMI < 18.5)  |         |              |           |               |           |
| Normal (18.5 ≤ BMI ≤ 24.9) | 2216 | 2882 | 2941 | 1186 |           |
| Overweight (25.0 ≤ BMI ≤ 29.9) | 554 | 1234 | 637 | 637 |           |
| Obese-1 (30.0 ≤ BMI ≤ 34.9) | 144 | 553 | 288 | 288 |           |
| Obese-2 (35.0 ≤ BMI ≤ 39.9) | 43 | 198 | 169 | 169 |           |
| Obese-3 (BMI ≥ 40.0) | 28 | 138 | 6444 | 6444 |           |

**BMI = body mass index, df = degree of freedom.**
access to technology (e.g., smart phone, video games, and computers) is likely to contribute to a more sedentary lifestyle with significant association with obesity among Saudi children.\textsuperscript{[34]}

5. Conclusion

Our evidence clearly shows that childhood obesity is still a growing problem in Saudi Arabia and that children are at risk of becoming overweight and obese with age. In conclusion, levels of overweight children and obesity among high school children were found to be 25.7\% in the Eastern Province of Saudi Arabia. The high prevalence of overweight and obesity, as well as high levels of BP, suggested implementing appropriate lifestyle interventions program to readjust this problem among childhood. This requires the development of a school health information system in which there is routine collection of health-related variables, such as BMI, blood pressure, and glucose level. Future

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Table 6

Multiple regression with BMI as outcome variable, school health campaign.

| Dependent variable | BMI, 2 |
|--------------------|--------|
| N                  | 20,073 |
| Multiple $R$       | 0.37433|
| Multiple $R^2$     | 0.14012|
| Multiple $R^2$adj  | 0.13991|
| ANOVA              |        |
| $F$                | 654.01 |
| df1, df2           | 5, 20,067|
| $P$                |        |

| Coefficients       | Standard error | $t$ | $P$ value |
|--------------------|----------------|-----|-----------|
| Constant           | 11.794         | 0.32296 | 36.519 | <.001 |
| Sex                | 0.144          | 0.085 | 1.694 | .090 |
| School level       | 2.006          | 0.072 | 28.029 | .000 |
| Age                | 0.199          | 0.023 | 8.721 | .000 |
| Glucose level      | 0.012          | 0.002 | 7.809 | .000 |
| Blood pressure     | 1.159          | 0.044 | 26.584 | .000 |

$BMI =$ body mass index, $df =$ degree of freedom, $R =$ regression, $R^2adj =$ adjusted $R^2$. 

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Figure 2. Comparison of the distribution of BMI classes across education levels, school health campaign. BMI = body mass index.
studies should include associated factors such as social background, exercise, culture, nutrition, and genes.

5.1. Strength and limitation

This is a multicenter school-based screen that used a representative and large sample of over 20,000 students. The study had a very high participation rate. Limitation of the study includes the fact that blood pressure readings were taken from a single reading in 1 visit.

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