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# Association between consumption of ultra processed foods and obesity among Jordanian children and adolescents

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**The consumption of ultra-processed food (UPF) is associated with obesity. This study aims to evaluate the contribution of UPF to total calorie intake and investigate the correlation between UPF consumption and obesity. The NOVA categorization was used to identify UPF in a single 24-hour dietary recall for participants. UPF consumption has been quantified as a percentage of total energy intake. Weight, height, and waist circumference were measured, and the Body Mass Index-for-Age Z-Score (BAZ) and waist-to-height ratio (WHtR) were computed. The prevalence of overweight and obesity was 23.9% and 13.3%, respectively. Approximately 25.5% of the participants had abnormal WHtR. The average energy intake was 1925 kcal/day, of which 40% was derived from UPF. The subgroups with the highest caloric contributions among UPF were savory snacks and sweets (13.5%), industrial grain products (8.4%), fast foods (7.8%), and sweetened beverages (4.2%). UPF consumption showed a weak but significant correlation with waist circumference ($r = 0.119$, $P = 0.005$). The remarkable finding is that 47 (7.6%) of the participants did not have any UPF. UPF's substantial contribution to daily caloric intake reflects an inadequate diet in children and adolescents. Public policies that discourage UPF use and encourage a nutritious diet are desperately needed.**

**Keywords** Adolescents, Children, Energy contribution, Obesity, NOVA, Ultra-processed food

The prevalence of overweight and obesity has reached an alarming level globally, affecting people of all age groups[1]. This worrisome level is linked to the massive development of food processing, resulting in new processed foods, which increased the need for a classification based on the degree of food processing. The term ultra-processed food (UPF) refers to unhealthy diets; these foods, derived from food ingredients and additives, have undergone extensive industrial processes and have received increased attention in the last decade[2]. The higher intake of food choices is deficient in fiber and protein but high in sodium, fats, sugars, and energy[3].

Monteiro et al. initially proposed the classification of foods according to the degree and intent of industrial processing in 2010[4], referred to as the NOVA classification. This system categorizes foods into four primary groups: unprocessed or minimally processed foods (group 1), processed culinary ingredients (group 2), processed foods (group 3), and UPF (group 4).

NOVA is being increasingly used in studies on nutritional status. The consumption of UPF garnered more attention than the other three groups in the NOVA classification. The impact of excessive consumption of UPF has been assessed through various factors, such as the amount of added sugar consumed[5], adult and child obesity[6,7], and the nutritional quality of diets[8].

Some studies suggested that the consumption of UPF plays a role in the development of chronic diseases, such as dyslipidemia[9], hypertension[10], and cancer risk, such as breast cancer[11].

Recent studies conducted on children have indicated a correlation between the consumption of UPF and a higher likelihood of being overweight or obese[12]. In Argentina, it is reported that adolescents who consume UPF have significantly high body mass index (BMI) and also have higher odds of being obese and having excess weight[8]. In Spain, a cross-sectional study on children ages 3–6 years reported that higher consumption of UPF was positively associated with body mass index, waist circumference, and fat mass index[13]. Furthermore, a systematic review reported that 14 out of 17 observational studies showed that an increase in UPF was associated

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with a higher prevalence of overweight/obesity among children and adolescents[14]. In Northern Portugal, UPF consumption at four years old was found to be associated with BMI at ten years old[15].

On the other hand, many studies reported no association between high UPF consumption and increased BMI, waist circumference, and fat percentage. In Iran, It was found that there was no association between intake of UPF and the risk of being overweight and obese among children[16]. Also, Oliveira et al. (2020) found no significant association between UPF consumption and BMI, WC, and waist-to-height ratio (WHtR)[17].

UPF accounts for over 50% of the total daily energy intake from 1950 to 5042 calories in certain high-income countries, such as the United States and Canada[18,19]. However, the energy contribution from UPF varies among countries. In Brazil, it is indicated that around 50.0% of energy consumption (4176 kcal) originated from UPF[20], whereas Indonesia accounted for 15.5% of a daily intake of 1591 kcal[21]. In Belgium, the contribution of UPF was 33.3% among children and 29.2% among adolescents[22], while in Switzerland, UPF consumption averaged 1.6 servings every day, constituting 20% of total food intake[23].

Nevertheless, more research must be done in the Eastern Mediterranean Region to examine how much UPF contributes to total energy intake. Nonetheless, a recent study conducted in Lebanon assessed the consumption of UPF by school-age children and adolescents, which accounted for 49.9% of total energy intake[24]. Thus, the knowledge gap is the diversity of data and the lack of data on UPFs consumption in the Eastern Mediterranean region. For the Jordanian population, the precise proportion of daily energy intake that comes from UPF has yet to be established. To fill this knowledge gap.The study aimed to determine the calorie intake of UPF and evaluate its correlation with obesity.

## Results

### Demographic and anthropometric characteristics of the participants

This study included 617 children and adolescents aged 8 to 19. The percentage of female participants exceeded that of male participants, 54.4% and 45.6%, respectively. The prevalence of overweight and obesity among these participants was 23.9% and 13.3%, respectively, whereas one-quarter of the participants had abdominal obesity (abnormal WHtR), as shown in Table 1.

### Distribution of BMI for age Z-scores

Figure 1 shows that the participants' BMI z-scores were right-shifted compared to the WHO normal distribution curve for both males and females. The mean BMI z-scores for females was 0.501 ± 1.22, while for males, it was 0.625 ± 1.46, and the mean for the entire study population was **0**.568 ± 1.35.

### The caloric contribution of food to the daily total energy intake of UPF

The average energy intake was 1925 kcal/day and UPF consumption contributed 40.0% of the total calories consumed. In the category of UPF, the subgroups contributing the most calories were savory snacks and sweets (13.5%), industrial grain products (8.4%), fast foods (7.8%), and sweetened beverages (4.2%) (Table 2). The minimal contribution of UPFs to total calorie intake was 0.27%, whereas the maximum contribution reached 100%. Notably, 47 (7.6%) participants had no UPFs, of which three-quarters were aged 13–19 years, 50% had a normal weight, and 60% had a normal WHtR.

| | **n(%) = 617** |
|---|---|
| **Age** | |
| 8–12 years | 243 (39.4) |
| 13–19 years | 374 (60.6) |
| **Sex** | |
| Males | 287 (46.5) |
| Females | 330 (53.5) |
| **Supplement use** | |
| Yes | 60 (9.7) |
| No | 557 (90.3) |
| **Weight Status** | |
| Thinness | 21 (3.4) |
| Normal | 366 (59.4) |
| Overweight | 147 (23.9) |
| Obese | 82 (13.3) |
| **WHtR** | |
| Normal | 458 (74.5) |
| Abnormal | 157 (25.5) |

**Table 1.** Demographic and anthropometric characteristics of the participants. Waist to height ratio (WHtR).

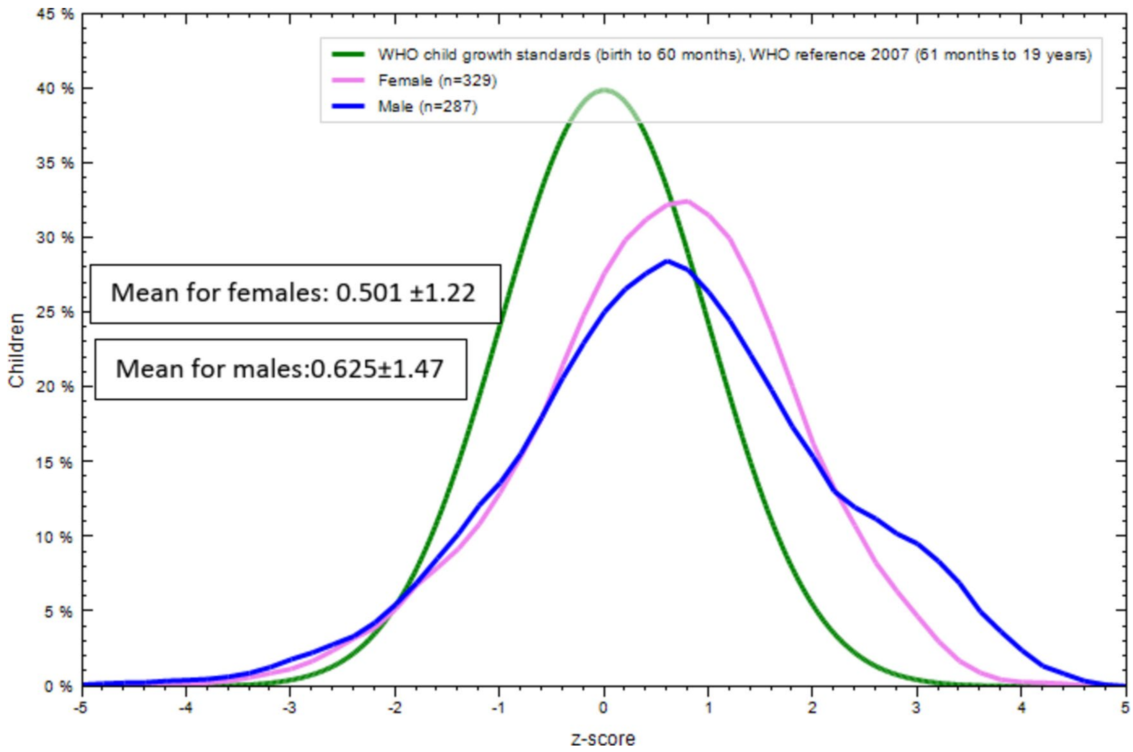


**Fig. 1**. Distribution of BMI for age Z-scores of the studied participants by sex compared with WHO standard distribution for both sexes.

| UPF subgroups | Absolute ingestion (kcal/day) | Absolute intake (% total kcal) |
|---|---|---|
| Industrial grain products (G1) | 159.9 ± 238.5 | 8.4 ± 11.9 |
| Processed dairy foods (G2) | 37.1 ± 84.9 | 2.1 ± 5.0 |
| Ready-to-eat/heat meals (G3) | 66.3 ± 135.4 | 3.5 ± 7.5 |
| Savory snacks and sweets (G4) | 255.3 ± 282.5 | 13.5 ± 12.7 |
| Fast foods (G5) | 167.9 ± 356.8 | 7.8 ± 15.6 |
| Sweetened beverages (G6) | 77.5 ± 95.5 | 4.2 ± 5.2 |
| Others (G7) | 21.1 ± 49.9 | 1.0 ± 2.2 |
| Total | 774.2 ± 590.6 | 40.0 ± 23.3 |

**Table 2**. The caloric contribution of UPFs to the absolute average caloric intake of 569 participants (mean ± SD).

## The percentage of UPF subgroups within the overall UPF food intake

Figure 2 shows the percentage of UPF subgroups within the overall UPF food intake. Around one-third of the UPF energy comes from savory snacks and sweets. Industrial grain products and fast foods contribute around 40% of the UPF energy. The other subgroup, which included sauces and ketchup, contributed the least.

## Obesity indicators according to quartiles of the contribution of ultra-processed

The study found no significant correlation between UPF and BMI or WHtR. ANOVA was conducted on the mean BMI z-score across the four quartiles, revealing no significant differences. The prevalence of overweight was determined as the percentage of children and adolescents with a BMI-z-score exceeding + 1 (as defined by the World Health Organization) relative to the total population in each quartile. In contrast, those with a BMI-z-score above + 2 were classified as obese. For abdominal obesity, a Waist-to-Height Ratio (WHtR) of ≥ 0.5 is indicative of abdominal obesity. However, the first quartile had a higher prevalence of overweight and abdominal obesity, whereas the last quartile had the highest prevalence of obesity (Table 3). A separate Pearson's correlation coefficient examination revealed that UPFs consumption exhibited a weak yet significant link with waist circumference ($r = 0.119$, $P = 0.005$).

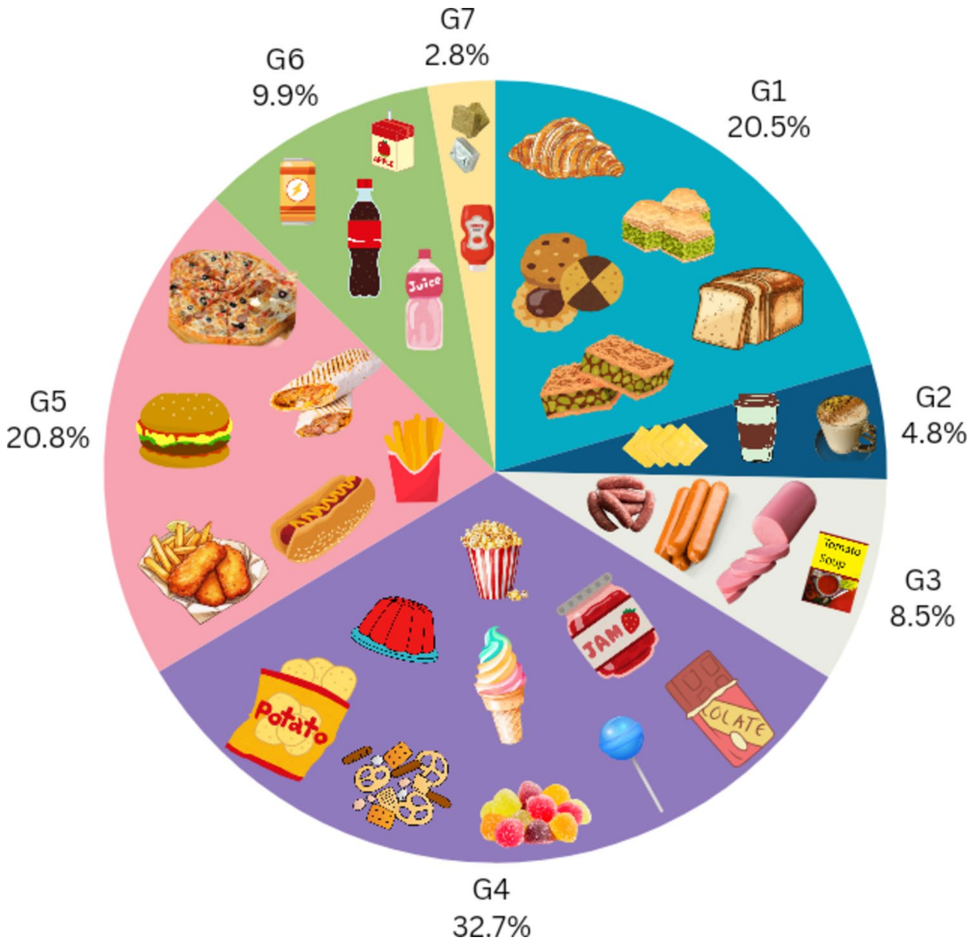


**Fig. 2**. The percentage of UPF subgroups within overall UPF food intake. **G1**: Industrial grain products, **G2**: Processed dairy foods, **G3**: Ready-to-eat/heat meals, **G4**: Savory snacks and sweets, **G5**: Fast foods, **G6**: Sweetened beverages, **and G7**: Others.

| Quartiles of UPF intake (% total energy) | BMI z-score [a] Mean ± SD | Overweight [b] (%) | Obesity [b] (%) | Abdominal obesity [b] (WHtR) (%) |
|---|---|---|---|---|
| 1st quartile (0.27 – 21.4%) | 0.66 ± 1.3 | 29.8 | 26.3 | 26.8 |
| 2nd quartile (21.5 – 38.1%) | 0.48 ± 1.3 | 29.0 | 15.8 | 21.0 |
| 3rd quartile (38.2- 56.0%) | 0.54 ± 1.4 | 22.1 | 27.6 | 25.4 |
| 4th quartile (> 56.0%) | 0.54 ± 1.5 | 19.1 | 30.3 | 26.8 |

**Table 3**. Mean BMI and prevalence of overweight, obesity, and abnormal WHtR based on quartiles of UPFs contribution to daily calorie intake. Note: ANOVA[a], $p > 0.05$; Linear trend test [b], $p > 0.05$. BMI: Body Mass Index; SD: Standard Deviation.

## Discussion

The evidence linking UPFs to adult health outcomes is extensive, as evidenced by many studies. However, research in children and adolescents is more limited. Studies on the consumption of UPFs among adults, children, and adolescents in the Eastern Mediterranean countries and their relationship to health outcomes are even more restricted. This study is the first to evaluate UFP's calorie intake and its potential link to obesity in 617 Jordanian children and adolescents.

In our study, the proportion of UPFs consumed by children and adolescents aged 8–19 years consistently differed significantly from data collected in several countries, with figures of 50% or more, as observed in the UK[25], the USA[26], and Brazil[20].

According to our research, UPFs account for nearly 40% of the caloric intake of Jordanian children and adolescents. This aligns with data indicating that UPF accounts for approximately less than 50% of total energy intake, as observed in Belgium[22], Lebanon[24], Italy[27], and Portugal[28]. The variations in the proportion of UPFs to total energy consumption between studies may be ascribed to the cheap cost, high affordability, and broad availability of processed foods.

Savory snacks, sweets, industrial grain products, and fast foods contributed the most calories among ultra-processed foods, which comprise the predominant UPF energy consumption subgroups. These findings are consistent with research conducted in many countries, including Brazil[20]. On the contrary, the primary contributors to UPF consumption included processed meat, cakes, pies, pastries, sweet biscuits, and soft drinks, such as those in Belgium[22] and Italy[27]. In this study, children and adolescents can get UPFs by purchasing food at the school canteen, bringing food from home, and using online food delivery services.

The consumption of UPF is acknowledged as a risk factor for the increase in obesity, as demonstrated by body fat measurements, abdominal obesity (WC or WHtR), and BMI. Many types of conducted studies, such as systematic reviews, prospective studies, and cross-sectional studies, examined the association between UPF consumption and overweight/obesity and abdominal obesity in children and adolescents[29].

The different studies reveal inconsistent findings concerning the association between UPF consumption and BMI increase. Some studies indicate a positive correlation between the consumption of UPF and BMI in children and adolescents, as observed in Brazil and the United States[7,12]. The current study found no association between UPF consumption and BMI z-scores; these observations agree with findings from Indonesia[21] and Brazil[17]., respectively, similar to that investigated in this study. In children and adolescents, the association between UPF consumption and overweight or obesity is less conclusive than in adults[29]. Recent research exhibits contradictory findings concerning the association between energy from UPF and obesity in children and adolescents, likely attributable to discrepancies in dietary assessment methods, including 24-hour recalls or food frequency questionnaires, study design and sample size variations, and the variation in included age.

However, some studies examined the association between UPF consumption and WC. Costa et al.[30] reported that early consumption of UPF increased abdominal obesity in children. The current study found a significant positive correlation between UPF consumption and WC, which aligns with the systematic review results[14]. One possible explanation is that UPFs have a high energy density, which delays satiety. Also, when the body receives more energy, it will be stored as fat, which may result in central obesity. Factors contributing to central obesity are modern lifestyles, such as low physical activity and diet quality.

Despite that, this study's findings revealed no association between UPF consumption and overweight and obesity among Jordanian children and adolescents. A recently published analysis of the same population indicated that fiber, vegetable, and fruit consumption did not meet dietary recommendations, while sugar intake was high[31].

In general, it is suggested that the consumption of UPF be limited to prevent non-communicable diseases. The consumption of UPF is generally linked to increased amounts of fats, calories, sugars, and salt, along with a reduced intake of micronutrients and fiber. Exposure to UPFs was linked to an increased risk of negative health outcomes, particularly overweight and obesity, cardiometabolic disorders, certain malignancies, a prevalent mental condition, and mortality rates[32,33]. It may not be fully elucidated by its nutrient contents and energy density but also by its chemical and physical properties. Firstly, changes in the food matrix after extensive processing, sometimes called dietary reconstitution, might impact satiety, nutrient absorption, and digestion. Secondly, food processing, particularly heat treatments, additives, and packaging, may induce carcinogenicity and genotoxicity. Thirdly, intense industrial food processing may generate potentially hazardous substances associated with increased risks of chronic inflammation[34,35].

The consumption of UPFs by children is alarming. Children are recognized as the principal consumers of these products. Media marketing that promotes increased intake of UPFs specifically targets children due to their considerable susceptibility. Public actions must be enacted, including affixing warning signs on the packaging's front, banning the sale or promotion of these products at educational institutions, and setting a target percentage to decrease the consumption of UPFs.

Since few studies on this subject in Jordan involve children and adults, future longitudinal research must examine UPF consumption in a larger cohort supplemented by multiple-day, 24-hour dietary recall questionnaires. Examining the correlation between this consumption and the rise in chronic non-communicable diseases might be beneficial.

## Strengths and limitations of the study

This study has several strengths. It is the first study investigating the link between UPF consumption and obesity in Jordanian children and adolescents. Moreover, conducting this study in the Middle Eastern region, where only one prior study exists, can enhance understanding of UPF consumption and its health implications.

However, some possible limitations exist, including (1) The data are based on 24-hour dietary recall, (2) the study's cross-sectional design cannot establish a causal relationship between the intake of UPF and obesity, (3) Presence of uncontrolled confounding factors, such as physical activity and smoking, particularly among adolescents.

## Conclusion

The findings showed that UPF contributes significantly to children's and adolescents' diets. The substantial contribution of UPF to daily caloric intake reflects an inadequate diet in children and adolescents. Nonetheless, this has not been demonstrated as a factor linked to overweight or obesity. Public policies that discourage UPF use and encourage a nutritious diet are desperately needed. Moreover, longitudinal studies are crucial to clarify the impact of UPF consumption on health across all population ages, not solely children and adolescents.

## Methods
### Study design
This study is a component of the bigger project, the Jordan Population-based Food Consumption Survey (JPFCS), conducted on households from October 2021 to March 2022. A cross sectional study encompassed individuals aged 9 to 85, and the studied sample comprised 617 participants aged 8 to 19, with a mean age of 13.7[36].

The study was conducted according to the guidelines of the Declaration of Helsinki. The Hashemite University's Institutional Board Review (IRB) committee examined and approved the survey protocol (No. 7/13/2020/2021). The interviewer obtained parental consent from all children and adolescents through a written agreement. Additionally, one of the participants' parents granted informed consent for children and adolescents and was present during the data collection process. Informed consent was obtained from all subjects and/or their parents.

### Anthropometric measurements
Following established guidelines, a trained nutritionist measured height, weight, and waist circumference. Participants' height was measured to the nearest centimeter using a portable wall stadiometer while standing upright, wearing light clothing, and without shoes.

The body weight was measured precisely to the nearest tenth of a kilogram using a digital scale (Microlife WS 50, Widnau, Switzerland) under consistent conditions. The waist circumference was assessed using an anthropometric tape at the point where the narrowest part is located between the lower costal border and the iliac crest.

The researchers entered weight and height into the WHO Anthro-Plus program (v1.0.4, WHO, Geneva, Switzerland). It evaluates detailed information regarding children's growth between 5 and 19 years old. The Body Mass Index-for-Age Z-Score (BAZ) was computed. Values greater than > + 1SD indicate overweight, while values greater than > + 2 SD indicate obesity based on the WHO reference curves from 2007. Values within + 1SD and − 2 SD were considered normal, while values below <-2 SD were considered thin[37].

The waist-to-height ratio (WHtR) was determined by dividing the waist circumference of the participant by their height. A waist-to-height ratio (WHtR) cutoff of ≥ 0.5 is widely recognized as an internationally accepted criterion for identifying obesity in children (aged ≥ 6 years) and adults[38].

### Dietary intake
The dietary intake was evaluated using a single weekday face-to-face 24-hour food recall completed by professional interviewers accompanied by one parent. The recall listed all food and drinks ingested by the participants 24 h before the questionnaire delivery.

. The foods and drinks that were consumed were quantified using the Photographic Jordanian Food Atlas[39]. The calculation of dietary energy and nutrient intake was conducted by utilizing the food composition database employing the Food Processor ®, Nutrition Analysis Software (version 11:0; ESHA Research), as well as the Composition of Local Jordanian Food Dishes[40] and Food Composition Data from Lebanon, which includes market foods, Arabic sweets, and traditional dishes[41]. All reported food and drinks were classified using the NOVA method[4]. It was employed to classify foods and beverages based on their degree of processing. This study exclusively examined group 4 (UPF). This group included hydrogenated fat mayonnaise, margarine, potato chips, pizza, burgers, sausages, biscuits, cakes, candies, chocolates, ice cream, cocoa milk, crackers, and Middle Eastern sweets (Baklava, Burma, and Hareeseh). It was categorized into seven subgroups, as shown in Supplemental Material 1.

The proportion of energy derived from UPF relative to total dietary energy was calculated after collecting detailed nutritional information and separating the food list and ingredients from the 24-hour recall.

### Statistical analysis
Analyses were performed using (Statistical Package for Social Sciences (SPSS) software (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp). The Shapiro-Wilk test was used to test whether the underlying distribution was normal, continuous variables were described using means and standard deviations (SD), and categorical variables were described using percentages. One-way ANOVA, Kruskal-Wallis, was used, and Pearson's coefficient correlation was performed. Statistically significant values were considered at $p < 0.05$.

## Data availability
The data supporting the findings of this study are available upon request from the corresponding author.

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## Author contributions
H. Al: Conceptualization, Visualization, Writing –original draft. H. A. wrote Methodology, Data curation, investigation, Resources. A. Al: Supervision, Writing –review & editing. All authors reviewed the manuscript.

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## Declarations

## Competing interests
The authors declare no competing interests.

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