Original Article

# Association of infant weight at one year of age with the mode of delivery: A case-control study in Primary Health Care Centers, Dubai, United Arab Emirates

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## Abstract

**Objective:** To demonstrate the association between body mass index (BMI) centile at age one year with the mode of delivery and selected maternal and infant variables in Dubai, United Arab Emirates. **Methods:** A retrospective case-control study where data were collected from the medical records of infants attending Primary Health Centers in 2019. Based on the World Health Organization 2006 growth standard, cases of overweight and obesity ($n = 149$) were defined as infants with BMI ≥85$^{th}$ centile, whereas controls ($n = 434$) were infants with a normal BMI between 3$^{rd}$ and <85$^{th}$ centile. Univariate analysis was performed first to compare the distribution of mode of delivery and other covariates between cases and controls. Adjusted odds ratios (adjOR) and 95% confidence interval (95%CI) were calculated by logistic regression. **Results:** The adjOR for infant overweight and obesity at one year of age was 1.53 (95% CI: 1.01, 2.39, $P = 0.047$) for a cesarean mode of delivery as compared to vaginal delivery. The analysis also showed that the adjOR for infant overweight and obesity was 2.67 (95% CI: 1.22, 5.85, $P = 0.014$) for having no siblings and 2.20 (95%CI: 1.07, 4.51, $P = 0.032$) for ≤4 siblings. In contrast, infant overweight and obesity was associated with a lower odds of breastfeeding (adjOR = 0.60; 95%CI: 0.38, 0.92; $P = 0.020$) and mixed milk feeding (adjOR = 0.36; 95%CI: 0.20, 0.66; $P = 0.001$). **Conclusion:** In this study, infant overweight and obesity was associated with a greater likelihood of cesarean mode of delivery and having ≤4 siblings. The absence of breastfeeding was also associated with infant overweight and obesity.

**Keywords:** Breastfeeding, cesarean delivery, infant overweight and obesity, mode of delivery, number of siblings

## Introduction

Childhood overweight and obesity is a global epidemic that has tripled in the last 3 decades, predominantly in developed countries. Globally in 2019, nearly 38 million children under age ≤ 5 years were overweight or to have obesity.[1] The increased prevalence of young aged overweight and obesity in the United Arab Emirates (UAE) has been similar to the global prevalence, which increased from 16.6% in children aged 6–16 years to 32.8% in children aged 2–12 years between the years 2000 and 2015.[2,3] However, prevalence data in the UAE for children at either one year of age or below 5 years are scarce.

Child obesity may lead to many noncommunicable diseases including adult obesity.[1] Therefore, it is important to identify modifiable risk factors in early childhood in order to develop interventions to prevent child and later life obesity.[4] Several

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**Received:** 17-08-2022 **Revised:** 06-09-2022
**Accepted:** 27-09-2022 **Published:** 15-02-2023

Access this article online

Quick Response Code:

Website: www.jfmpc.com

DOI: 10.4103/jfmpc.jfmpc_1631_22



**How to cite this article:** Yousuf A, Williams S, Al Mazrouei KS. Association of infant weight at one year of age with the mode of delivery: A case-control study in Primary Health Care Centers, Dubai, United Arab Emirates. J Family Med Prim Care 2023;12:145-51.

systematic reviews have summarized potential risk factors for excess weight among young children. These include higher maternal prepregnancy body mass index (BMI), maternal diabetes, excess gestational weight gain, high birth weight of more than 4 kg, and rapid infant growth.[4] Lack of breastfeeding and starting complementary food before four months of age are other potential risk factors for pediatric excess weight.[5,6] Review of the Eastern Mediterranean regional studies has found higher parental education, shorter duration of breastfeeding, increased high-calorie food consumption, infrequent breakfast consumption, physical inactivity, increased screen time, and higher social status as potential risk factors for obesity in young children.[5] Available studies from UAE concluded that high paternal BMI, increasing child's age, male gender, and lack of dairy consumption are significantly associated with obesity in children.[3,7]

Globally, the frequency of cesarean section (CS) has increased significantly from 6.7% in 1990 to 19.1% in 2014.[8] In 2016, the frequency of CS in the UAE was found to be 33%.[9] This is markedly different from the World Health Organization (WHO) recommendation that the frequency of CS should not exceed more than 10–15% in any part of the world because of maternal and fetal complications resulting from CS.[10] CS may be planned or elective in conditions such as advanced maternal age, history of previous CS, twin pregnancy, or due to maternal request without any other medical indication where the mother considers CS, a safer option to avoid pain and genital disfigurement associated with vaginal delivery (VD).[10,11] CS may also be unplanned or emergency in the case of maternal pelvic deformity, eclampsia, obstructed labor, or fetal malposition.[10]

Due to the parallel rise in obesity and CS frequency, the relationship between these variables has been evaluated in a number of studies. A meta-analysis revealed a 34% increased risk for obesity among children delivered by CS versus VD.[12] However, the findings were limited by the potential for residual confounding and publication bias. Another bias-adjusted meta-analysis found no convincing evidence of a relationship between CS and offspring weight.[13]

To our knowledge, no studies have examined this association in the UAE. Furthermore, only a limited number of studies have investigated potential risk factors for pediatric overweight and obesity in the UAE.[5,7] Therefore, the main purpose of this study was to determine the association between infant overweight and obesity at age one year with a mode of delivery and other potential maternal and child-related risk factors in the setting of Primary Health Centers (PHCs) in Dubai, UAE. Determining this association will help the primary care physician educate pregnant women about the impact on their child's weight after having CS and the need to take extra care to prevent obesity among their offspring. The rationale for choosing the age one year was to better assess the impact of delivery mode and other variables without having to control for environmental and behavioral factors that become increasingly dominant with age.[5]

# Materials and Methods

## Study design

Retrospective, case-control study.

## Study setting

Child Health clinics in 12 PHCs of Dubai Health Authority (DHA), Dubai. These clinics offer immunization and growth assessment for the young population.

## Sample size and sampling

The sample size was calculated based on a previous study which reported that 33% of infants were delivered with CS in 2016 in Dubai.[9] Using OpenEpi stat-calc version 3.01, a power of at least 90%, a two-sided confidence level (CI) of 95%, and odds ratio (OR) of 2.0, the calculated sample size was 482 consisting of 121 cases and 361 controls. Three controls were recruited for every case because the frequency of normal weight in the cesarean group was 3 times higher than the group with overweight and obesity.[14] To overcome the effect of missing data, the sample size was increased by 20%, so the final sample calculated was 149 cases and 434 controls. Data were obtained by simple random sampling from a daily list of children first three controls were selected, followed by a case, till the whole sample size was reached.

## Study duration

Data were obtained from 1st July 2019 till 30th September 2019.

## Data collection

Ethical approval was taken from Dubai Scientific Research Ethics Committee (DSREC-SR-10/2019_01). As mothers or infants were not contacted for data collection, informed consent was not required as agreed by the DSREC. All data were anonymized and remained confidential. Thereafter, data were obtained from the electronic medical record (EMR) of the infants visiting for vaccination at all PHCs, where nurses routinely document weight and height, measured by standard measuring scales. BMI centile was recorded according to the WHO (2006) growth charts.[1] EMRs were first reviewed for inclusion and exclusion criteria. Inclusion criteria were infants born between 37 and 42 weeks gestation in Latifa Hospital, DHA, without any congenital anomaly. Twin pregnancies and infants with BMI less than the third centile were excluded. Mother's data were obtained from the EMR obstetrician records linked with the child's medical record. Included files were accessed for data variables.

## Study variable

### *Dependent variable (outcome)*

Based on the age and sex-specific 2006 WHO Child Growth Standards from birth to 2 years, cases were defined as infants at one year of age (12 months till 23 months old) with a BMI ≥85th centile (combined overweight and obesity). Controls were infants at one year of age (12 months till 23 months old) with a BMI between 3rd and less than 85th centile.[1]

### *Independent variables (Exposure)*

Mode of delivery was either: (1) VD (2) elective CS that was performed before labor began or (3) emergency CS which was performed after labor began.

### *Covariates*

Maternal covariates: Age at delivery (<25 years, 25–30 years or >30 years); nationality (Emiratis or Expatriates), BMI before 20 weeks of gestation (<25.0 kg/m$^2$, 25.0–29.9 kg/m$^2$, or >30.0 kg/m$^2$); BMI in the third trimester (<30.0 kg/m$^2$, 30.0–39.9 kg/m$^2$, or >40.0 kg/m$^2$); diabetes and hypertension (gestational/pregestational or none).

Infant covariates: Gender (male or female); birth weight (<2500 g, 2500–4000 g, or >4000 g); number of siblings (none, 1–4, >4); any breastfeeding (ever or never); milk-feeding practice at age one year (breast-milk only; formula-milk only; mixed-milk); start of weaning age (<6 months or >6 months).

## Data analysis

Data were analyzed using Statistical Package for the Social Sciences version 23. Descriptive statistics were determined by computing frequencies and percentages. Univariate analysis used either Chi-square or binary univariate logistic regression to determine the unadjusted association between each variable and infant weight status by computing OR and 95%CI. Variables with a $P < 0.05$ in univariate analysis were considered for inclusion in multivariable models. The final model was tested for goodness of fit by the Hosmer–Lemeshow statistic. Adjusted OR and 95% CIs were used to interpret the final model.

# Results

Percentages of 149 cases and 434 controls for different health centers drawn from all 12 PHCs which was not statistically significant [$\chi^2$ (11df) = 10.315; $P = 0.502$].

Missing data were 15.8% for maternal BMI before 20 weeks of gestation (cases 25 and controls 67), 2.9% for maternal BMI in the third trimester (cases 3 and controls 14), and 5.3% for start of infant's weaning age (cases 5 and controls 26). Little's MCAR (missing completely at random) test showed that the data were missing completely at random [$\chi^2$ (9df) = 8.872, $P = 0.449$].

Median BMI centiles for cases and controls were 94.81 and 55.01, respectively. The maternal mean (SD) age was 30.33 (5.35) years. Further descriptive statistics are summarized in Table 1, arranged by infant BMI centile with demographic, maternal, and infant-related factors. Results of univariate analysis are also provided in Table 1. Infant weight was not statistically significantly associated with maternal age or maternal BMI before 20 weeks of gestation. However, infant weight status was statistically significantly associated with maternal BMI in the third trimester; specifically, infant overweight and obesity was associated with 2.29 greater odds of maternal BMI >40 kg/m$^2$ compared to a maternal BMI <30 kg/m$^2$ ($p < 0.05$).

Among infant-related variables, infant weight status was not associated with nationality, gender, birth weight, or starting weaning age. In this study, 29.2% of infants were delivered with CS, of which 14.4% were elective and 14.8% were emergency. In infants with a BMI ≥85$^{th}$ centile, the odds of CS delivery was increased in comparison with VD. When elective and emergency CS were compared separately with VD, the increased odds were not statistically significant [Table 1]. Infants with a BMI ≥85$^{th}$ centile were more likely to have either no siblings or 1–4 siblings than those having more than four siblings. Compared to infants of normal weight, infants with overweight and obesity were less likely to have breast-milk alone, or mixed-milk, compared to formula-milk only.

In multivariate logistic regression analysis [Table 2], after adjustment for all variables, infant BMI ≥85$^{th}$ centile at age one year was statistically significantly directly associated with CS compared to VD ($p < 0.05$) and having none or 1–4 siblings compared to having more than four siblings ($p < 0.05$). BMI ≥85$^{th}$ centile was also found to be significantly inversely related to breast-milk only and mixed-milk feeding as compared to formula-milk only ($p < 0.05$).

# Discussion

After controlling for several confounding variables, this case-control study found that the odds of overweight and obesity at age one year were significantly higher among infants who were delivered by CS as compared to VD. Lesser siblings (≤4) and lack of breast milk were also found to be independently associated with increased BMI (≥85$^{th}$ centile) in infants age one year. To our knowledge, this is the first study in the UAE to examine the effect of the mode of delivery on infant overweight and obesity.

## Infant weight and mode of delivery

The observed association between infant's weight and CS in this study is consistent with the findings of two previous meta-analyses. Both meta-analyses indicated that children 2–18 years old delivered by CS had a moderately increased risk of obesity of 34–59% when compared with children delivered by VD.[12,15] Another recent cross-sectional survey in China also reported a positive association between CS and increased weight for ages 5–13 years.[16]

In contrast, the results of a recent large cohort study found that infants born by CS had a significantly higher BMI only at aged 6 months.[17] Another bias-adjusted meta-analysis did not support the association between CS and increased weight in children and young adults and concluded that the association is largely explained by residual confounding and publication bias.[13] This may be because as the child grows, other environmental and lifestyle factors play a dominant role in determining BMI, overcoming the early effects associated with the mode of delivery.

An explanation for this relationship between CS and increased infant weight could be drawn from the altered microflora

**Table 1: Univariate analysis showing an association between overweight and obesity (BMI ≥85th centile for age and sex) at age one year and demographic, maternal and infant-related variables in 583 infants in Dubai, United Arab Emirates**

| Variables | Cases 149 (25.6%) *n* (%) | Controls 434 (74.4%) *n* (%) | Odds ratio | 95% confidence interval | *P* |
|---|---|---|---|---|---|
| Demographics | | | | | |
| National | | | | | |
| Emiratis | 99 (66.4) | 262 (60.4) | 1.30 | 0.88, 1.92 | 0.204 |
| Expatriate | 50 (33.6) | 172 (39.6) | REF | | |
| Gender | | | | | |
| Male | 79 (53.0) | 225 (51.8) | 1.05 | 0.72, 1.52 | 0.849 |
| Female | 70 (47.0) | 209 (48.2) | REF | | |
| Maternal variables | | | | | |
| Mother's age at delivery (years) | | | | | |
| 30 or more | 73 (49.0) | 213 (49.1) | 0.75 | 0.44, 1.26 | 0.271 |
| 25-30 | 48 (32.2) | 160 (36.9) | 0.65 | 0.38, 1.14 | 0.131 |
| <25 | 28 (18.8) | 61 (14.1) | REF | | |
| Mother's BMI before 20 weeks of gestation† | | | | | |
| >30 kg/m² | 41 (27.5) | 93 (21.2) | 1.45 | 0.87, 2.41 | 0.150 |
| 25-29.9 kg/m² | 42 (28.2) | 139 (32.1) | 1.00 | 0.61, 1.63 | 0.984 |
| <25 kg/m²** | 41 (27.5) | 135 (31.2) | REF | | |
| Mother's BMI in third trimester!† | | | | | |
| >40 kg/m² | 16 (10.7) | 24 (5.5) | 2.29 | 1.41, 4.61 | 0.020* |
| 30-39.9 kg/m² | 73 (49.0) | 200 (46.1) | 1.26 | 0.84, 1.87 | 0.264 |
| <30 kg/m²** | 57 (38.3) | 196 (45.2) | REF | | |
| Maternal history of diabetes or gestational diabetes | | | | | |
| Present | 34 (22.8) | 93 (21.4) | 1.08 | 0.69, 1.69 | 0.731 |
| Absent** | 115 (77.2) | 341 (78.6) | REF | | |
| Maternal history of hypertension/preeclampsia | | | | | |
| Present | 8 (5.4) | 30 (6.9) | 0.76 | 0.34, 1.71 | 0.570 |
| Absent** | 141 (94.6) | 404 (93.1) | REF | | |
| Infant-related variables | | | | | |
| Mode of delivery | | | | | |
| Caesarean delivery | 54 (36.2) | 116 (26.7) | 1.56 | 1.05, 2.32 | 0.036* |
| Vaginal delivery** | 95 (63.8) | 318 (73.3) | REF | | |
| Subcategorized caesarean mode of delivery | | | | | |
| Elective caesarean | 27 (18.1) | 57 (13.1) | 1.59 | 0.95, 2.65 | 0.078 |
| Emergency caesarean | 27 (18.1) | 59 (13.6) | 1.53 | 0.92, 2.55 | 0.101 |
| Vaginal mode** | 95 (63.8) | 318 (73.3) | REF | | |
| Birth weight (g) | | | | | |
| <2500 | 5 (3.4) | 15 (3.5) | 1.33 | 0.26, 6.74 | 0.728 |
| 2500-4000 | 141 (94.6) | 407 (93.8) | 1.39 | 0.39, 4.98 | 0.617 |
| 4000** | 3 (2.0) | 12 (2.8) | REF | | |
| Breastfeeding | | | | | |
| Never | 8 (5.4) | 11 (2.5) | 2.18 | 0.86, 5.53 | 0.109 |
| Ever** | 141 (94.6) | 423 (97.5) | REF | | |
| Milk feeding practices at one-year age | | | | | |
| Breast-milk only | 42 (28.2) | 150 (34.6) | 0.58 | 0.38, 0.88 | 0.011* |
| Mixed-milk | 16 (10.7) | 96 (22.1) | 0.34 | 0.19, 0.69 | 0.000* |
| Formula-milk only** | 91 (61.1) | 188 (43.3) | REF | | |
| Start of weaning age† | | | | | |
| Before 6 months | 1 (0.7) | 8 (1.8) | 0.35 | 0.04, 2.82 | 0.480 |
| At or after 6 months** | 143 (96.0) | 400 (92.2) | REF | | |
| Number of siblings | | | | | |
| None | 39 (26.2) | 93 (21.4) | 2.56 | 1.19, 5.50 | 0.016* |
| 1-4 | 100 (67.1) | 280 (64.5) | 2.18 | 1.08, 4.42 | 0.031* |
| More than 4** | 10 (6.7) | 61 (14.1) | REF | | |

†Variables with missing data; *Significant $P<0.05$; **REF reference category. BMI, body mass index

**Table 2: Final multiple logistic regression model showing an association between overweight and obesity (BMI ≥85th centile for age and sex) at age one year with the mode of delivery, feeding practice, maternal BMI and number of siblings in 583 infants in Dubai, United Arab Emirates**

| | [a]Adjusted odds ratio | 95% confidence interval | *P* |
|---|---|---|---|
| Mode of delivery | | | |
| Caesarean mode | 1.53 | 1.01, 2.34 | 0.047* |
| Vaginal mode** | REF | | |
| Milk feeding practices at 1-year age | | | |
| Breast-milk only | 0.60 | 0.38, 0.92 | 0.020* |
| Mixed-milk | 0.36 | 0.20, 0.66 | 0.001* |
| Formula-milk only** | REF | | |
| Mother's BMI in third trimester | | | |
| <30 kg/m$^2$ | 0.50 | 0.24, 1.05 | 0.066 |
| 30-39.9 kg/m$^2$ | 0.61 | 0.30, 1.23 | 0.166 |
| >40 kg/m$^2$** | REF | | |
| Number of siblings | | | |
| None | 2.68 | 1.22, 5.85 | 0.014* |
| 4 or less | 2.20 | 1.07, 4.51 | 0.032* |
| >4** | REF | | |

[a]Adjusted for maternal age at delivery, maternal BMI before 20 weeks of gestation, maternal diabetes, maternal hypertension, infant gender, birthweight, any breastfeeding, start of weaning age. *Significant *P*<0.05; ** REF reference category. BMI, body mass index

in a CS-delivered child. Studies have reported that CS may deprive a newborn from maternal vaginal and fecal anaerobes colonization.[18] Moreover, it has been found that infants born by CS have lower numbers of intestinal bifidobacteria and bacteroides and more clostridium as compared to VD infants.[18] Researchers proposed that this altered fetal microbial environment in CS-delivered infants has a tendency to yield more energy from dietary nutrients, thereby placing a child at higher risk of overweight and obesity.[18]

According to these explanations, only infants delivered by elective CS, when there might be no rupture of vaginal membranes and hence no fetal exposure to maternal vaginal flora, should be at risk of future overweight and obesity. One cohort study[19] found that elective CS was significantly associated with an increased odds of overweight and obesity (OR 2.02; 95%CI: 1.05, 3.89; $P = 0.04$) as compared to emergency CS and VD. Our study partially contradicts the findings from this cohort study as the association with CS was not dependent on whether it was elective or emergency. Another cohort study instead supported the association between emergency CS and infant overweight and obesity.[14] These different results could be related to the possibility that the presence of membrane rupture during CS is not considered by many studies, including our own. Therefore, simply differentiating CS mode into emergency and elective may not be enough to evaluate the type of CS for this relationship.[14]

## Infant weight and milk-feeding practices

This study has observed that breast-milk only, or mixed-milk fed infants at age one year, were inversely related to infant overweight and obesity as compared to infants who were solely fed on formula milk. This finding is consistent with many previous reports.[5,20] Horta *et al.*[20] concluded that breastfeeding reduced the odds of overweight and obesity for populations aged from 1 to 20 years by approximately 25%, supporting the findings of our study.

Moreover, the present study has also observed that infants who were 'ever' breastfed during their first year, as compared to those who were never breastfed, did not have greater odds of higher BMI. This shows that a longer duration of breastfeeding is important to provide a protective role against increased child weight, a finding that is in agreement with a study by Musaiger.[5] A possible reason for this association could be the energy and macronutrient composition of breast milk versus formula milk, which could differently affect immune regulation, metabolic responses, and adipogenesis in offspring.[21]

## Infant weight and number of siblings

Another interesting finding in this study is that infants who had a BMI ≥ 85th centile at age one year were twice as likely to have none or fewer than four siblings. These findings are in agreement with many other studies.[22,23] A reasonable explanation for this finding could be the increased availability of food per capita in smaller households, where the parents can afford to devote more time per child.[23]

## Infant weight and maternal BMI

Although this study demonstrated a positive association between infant overweight and obesity at age one year and higher maternal BMI of ≥40 kg/m$^2$ during the third trimester in univariate analysis, the statistical significance was not sustained after covariate adjustment in the multivariate analysis. This finding contradicts a cohort study of 17-year-aged adolescents that found the association of CS with overweight and obesity was evident only among those born to mothers with the highest prepregnancy BMI (adjusted OR: 1.70; 95%CI: 1.18, 2.43).[24] This means that the mother's lifestyle and eating habits may influence child-eating behavior and may not be directly caused by CS. However, this cohort study did not consider the effect of breastfeeding and did not include behavioral variables such as physical activity and diet in the analysis, which are the recognized risk factors for overweight and obesity later in childhood. The present study may have found similar results with persisting statistical significance of this factor if the maternal BMI was categorized differently.

## Infant weight and other insignificant covariates

This study did not find any association between the early introduction of weaning before age 6 months with infant weight at age one year. These results opposed the findings of a meta-analysis by Wang *et al.*[6] that favor weaning at 6 months or more for the prevention of child overweight and obesity. This could be because we did not look into the type of weaning food, or because a smaller number of infants who started weaning before 6 months of age were present in this study, making it

difficult to identify associations between early weaning and infant's excess weight.

This study did not find any association of gender with infant overweight and obesity. Moreover, other covariates that are established risk factors for CS, such as maternal age at delivery, maternal BMI before 20 weeks of gestation, maternal history of diabetes or hypertension and birthweight, in our study were not found to be associated with increased infant weight at age one year. Thus, these factors simply act as confounders for the association between CS delivery and infant overweight and obesity.[13]

## Strengths and limitations

This study has several strengths. First, the data were collected from different PHCs working under one organization with standardized and uniform measuring tools and practices. This avoids any individual BMI assessment variability related to equipment by trained staff.

Second, recall bias is a major concern in a case-control study. However, in this study, recall bias may be of less concern because data were extracted from EMR.

The limitations of this study should not be overlooked. Although in this study multiple confounders were included, other confounders such as type of weaning products, maternal education, and working status of a mother may exist and result in residual confounding.

The major limitation of this study is the lack of information regarding the indications for CS. Moreover, this study did not consider the presence of membrane rupture during CS, which could have supported the proposed mechanism for the association between infant weight and mode of delivery.

Another limitation is the study design itself. Being a case-control study, it is not possible to confer a causal effect of CS on child excess weight.

# Conclusion

This study concludes that infants at age one year with overweight and obesity have greater odds of CS delivery compared to infants with a normal weight in Dubai, the UAE. Furthermore, the absence of breastfeeding, and having a fewer number of siblings, were both found to be associated with infant overweight and obesity after adjustment for selected confounders. This observational study suggests the need for strategies to effectively control the rate of CS and adopt prudent actions to control infant weight post-CS delivery. It is important to increase maternal knowledge to practice appropriate infant feeding practices.

Future prospective studies could provide a better understanding of the longitudinal relationship between CS and childhood obesity, where information on the rupture of the membrane could also be explored to determine the effect of individual types of CS on a child's weight.

## Statement of ethics

The research was conducted ethically in accordance with the World Medical Association Declaration of Helsinki and was approved by Dubai Scientific Research Ethics Committee (DSREC-SR-10/2019_01). The patients' deidentified data used in this research was carried retrospectively from DHA EMR. Patients treated in DHA care facilities provided written informed consent for their deidentified data to be used for research, and the study was done accordingly. All data were anonymized and remained confidential.

## Acknowledgements

All authors acknowledge with deep gratitude the support of Dr. Hanan Mohammed Al Hammadi and Dr. Fatma Mohammad Sultan AlOlama at Dubai Health Authority for facilitating this project and providing access to Child Health data.

All authors also acknowledge Dr. Marwan Abdelrahim Abdelghafer Zidan, a statistician at Dubai Health Authority for his valuable assistance in statistical analysis.

The work was completed in partial fulfilment of an online MSc in Obesity and Weight Management undertaken through Learna Ltd (https://www.learna.ac.uk/) affiliated with University of South Wales.

The undersigned stipulates that the material submitted to Journal is new, original and has not been submitted to another publication for concurrent consideration. Only an abstract is published by the same authors in 'Obesity Reviews', volume 21, a supplementary issue, page number 308–309 in August 2020 as a part of a poster presentation in the 'European and International Congress on Obesity 2020'. It is also presented as a poster at 5th Emirates Family Medicine Society Congress, which took place from March 10 to 17 2022.

## Financial support and sponsorship

Nil.

## Conflicts of interest

There are no conflicts of interest.

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