PREVALENCE AND POSSIBLE COMPLICATIONS OF PEDIATRIC OBESITY IN ROMANIA: A REVIEW OF RECENT LITERATURE

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ABSTRACT

Introduction. Excess weight has been recognized as a global health issue for many years. It is an established risk factor for several chronic conditions, notably cardiovascular disease and diabetes, and is increasingly present in the pediatric population. The purpose of this paper is to review the existent local data regarding pediatric excess weight (including obesity) and its impact.

Method. A review of existent literature from the year 2000 and onwards was performed. Only material referring to a Romanian cohort (or subgroup) was included.

Results. Of the initial 455 identified records, 62 full text papers in English and Romanian were considered relevant to the topic and analyzed. A mean prevalence of excess weight of 31.6% (WHO), 18.35% (CDC) and 21.37% (IOTF) with obesity rates of 11.4% (WHO), 7.2% (CDC) and 7.69% (IOTF) was calculated. Several factors that could promote excess weight have been identified in Romanian cohorts and are presented. Possible complications are in line with previous published data and mainly involve the cardiovascular system and metabolic effects. Psychological obesity-associated issues have also been reported.

Discussion. To our knowledge, there has not been a local study to assess the prevalence of pediatric excess weight at a country level. The available prevalence data is in line with both previous reports of Romanian data and international figures. There does not appear to be an increase in rates over time in the last few years. Systematic country-level attempts to tackle the excess weight problem are few, however smaller range community-based intervention programs have been reported, with modest results.

Conclusions. A worrying proportion of children are overweight or obese in Romania and this may lead to a variety of physical and psychological issues for the child. Conditions such as arterial hypertension and dyslipidemia, typically encountered in adults, are being noted with increased frequency in the pediatric population and their full impact on quality of life and life expectancy is difficult to grasp. Sustained, community-based interventions could possibly achieve a slow reduction in the rates of pediatric excess weight.

Keywords: pediatric obesity, child obesity, obesity prevalence, excess weight, Romanian cohort, obesity complications

INTRODUCTION

Overweight and obesity are roughly defined as “abnormal or excessive fat accumulation that presents a risk to health” [1]. This has been recognized as a global health issue for many years, with a prevalence that doubled or even tripled in certain countries from the WHO European region since the 1980s [2]. It is an established risk factor for several chronic conditions, notably cardiovascular disease and diabetes.

Excess weight affects the population as a whole, regardless of age or gender. The issue has been growing in significance in the pediatric population as well, with rates of obesity as high as 18.5% of children aged 2-19 years in the United States (13.9% among 2- to 5-year-old children, 18.4% among 6- to 11-year-old children, and 20.6% among 12- to 19-year-old children) according to the CDC (Centers for Disease Control and Prevention) [3]. According to the Global Health Observatory (GHO) data in 2016, around 18% of children and adolescents aged 5-19 years were overweight or obese worldwide [4].

Moving from the global picture to a local one, the importance of excess weight in Romania has not gone
unnoticed, with various reports, campaigns and proposed plans of action having been published [2,5-7].

The purpose of this paper is to review the existent local data regarding pediatric excess weight (including obesity) and its impact.

To note, a person’s weight can be assessed in several ways, including abdominal circumference and body fat percentage (which in turn may also be determined using various methods). Although body fat percentage is considered to be the more accurate way of determining adiposity [8], the body mass index (BMI), which does not quantify body fat directly, has been established as a simple and effective clinical screening tool [9-11]. Its ease of use has made it the preferred method of assessment in most clinical trials. The BMI is a person’s weight in kilograms divided by the square of height in meters. While standard normal values are accepted for adults, for the pediatric population the BMI is both age and gender-specific and underweight, overweight and obesity are defined either using percentiles (CDC [12], Table 1), standard deviations (WHO [13], Table 2) or international cut off points for body mass index (International Obesity Task Force, IOTF [14,15]; for cut-offs please refer to relevant articles cited here).

### TABLE 1. BMI-for-age weight status categories and the corresponding percentiles according to the CDC

| Weight Status Category | Percentile Range          |
|------------------------|---------------------------|
| Underweight            | Less than the 5th percentile |
| Normal or Healthy Weight | 5th percentile to less than the 85th percentile |
| Overweight             | 85th to less than the 95th percentile |
| Obese                  | Equal to or greater than the 95th percentile |

### TABLE 2. WHO Growth Standards for children. SD – standard deviation(s)

| Weight Status Category | Children under 5 years of age | Children aged between 5 and 19 years |
|------------------------|-------------------------------|-----------------------------------|
| Overweight             | >+2SD                         | >+1SD (equivalent to BMI 25 kg/m² at 19 years) |
| Obesity                | >+3SD                         | >+2SD (equivalent to BMI 30 kg/m² at 19 years) |
| Thinness               | <+2SD                         | <+2SD                             |

### METHOD

A review of existent literature from the year 2000 and onwards was performed. Articles written in English were searched for in PubMed. In addition, a Google Scholar search was performed for relevant Romanian literature not included in the PubMed Search. Only material referring to a Romanian cohort (or subgroup) was included. This search strategy yielded 453 articles, 65 of which were selected as relevant to the topic. Of these, full text was not available for 3 articles, leaving 62 papers for review. Given the paucity of data, some of the remaining articles were still mentioned as reference, provided the abstract was believed to contain significant information. A further 11 papers were later excluded for various reasons (supplementary Figure 1).

### RESULTS

19 papers were found to include data regarding prevalence. Papers that reported percentages of excess weight children derived from the total number of hospitalized children over a certain period were excluded, as it was felt they may not accurately reflect the situation in the general setting. Of the remaining...
| Reference | Period of assessment | Area (county) | Cohort (no) | Age group (years) | Data collection | Urban population (%) | Male gender in cohort (%) | Excess weight (%) | Overweight (%) | Obesity (%) | Prevalence EW boys | Prevalence EW girls | Prevalence OW boys | Prevalence OW girls | Prevalence Ob boys | Prevalence Ob girls |
|-----------|----------------------|--------------|-------------|-------------------|-----------------|---------------------|------------------------|---------------------|-----------------|-------------|---------------------|---------------------|-------------------|-------------------|-------------------|-------------------|
| 17        | NS                   | SV           | 223         | 14-18             | M               | 33.33%              | x                      | 25.11%              | 9.41%           | 2%           | 12.50%                | 8.38%                | 8.92%             | 6.58%             | 3.57%             | 1.79%             |
| 18        | 2004                 | NS           | 1826        | 2-4               | M               | NS                  | NS                    | NS                  | NS              | NS           | NS                   | NS                  | NS                | NS                | NS                | NS                |
| 19        | 2006-2008            | B, IF        | 4866        | 3-17              | M               | 44.94%              | 49.5%                  | 16.46%              | 10.1%           | 6.40%        | 10%                   | 6.40%                | 5.7%              | 4.2%              | 2.1%              | 4.8%              |
| 20        | 2007                 | DB           | 3761        | 6-18              | M               | NS                  | 45.49%                | 11.4%              | 8%               | 3.47%        | 13.68%                | 9.60%                | 9.64%             | 6.78%             | 4.03%             | 2.82%             |
| 21        | 2008                 | CJ           | 7904        | 6-19              | M               | NS                  | NS                    | 21.13%              | 12.84%          | 8.29%        | x                       | x                  | x                 | x                 | x                 | x                 |
| 22        | 2008-2012            | IS, NT       | 3444        | 6-10              | M               | 100%                | 49.70%                | 23.7% (IOTF)        | 16.60%          | 7.10%        | 24.60%                | 22.70%                | 16.80%            | 16.30%            | 7.80%            | 6.30%            |
| 23        | 2009-2010            | NS           | 3780        | 11-15             | Q               | NS                  | 49.47%                | 14% (IOTF)          | x               | 19% (IOTF) | x                       | x                  | x                 | x                 | x                 | x                 |
| 24        | 2010                 | NS           | 1003        | 6-11              | Q               | NS                  | NS                    | 31.40%              | 21.10%          | 10.30%      | 19% (IOTF)            | 9% (IOTF)             | x                 | x                 | x                 | x                 |
| 25,26     | 2010-2011            | TM           | 3626        | 7-18              | M               | 72.3%               | 43.13%                | 25.80%              | 25.34%          | 14% (CDC) | 11.80%                | 30.80%                | 22% (CDC)         | 15.20%            | 13% (CDC)         | 15.60%            |
| 27        | 2010-2011            | GL           | 3103        | 7-18              | M               | 100%                | NS                    | 18.9% (CDC)         | 10.53%          | 8.44%        | 8.44% (CDC)            | x                  | x                 | x                 | x                 | x                 |
| 28        | 2011                 | B            | 866         | 6-18              | M               | 100%                | 46.76%                | 26.4%              | 11.4%           | 36.2%      | 11.4% (WHO)            | 14% (WHO)             | 27.6%             | 19.1%             | 17.5%             | 14.3%             |
| 29        | 2011-2012            | NS           | 1646        | 14-17             | Q               | NS                  | NS                    | 9.20% (IOTF)        | x               | x                       | x                  | x                 | x                 | x                 | x                 |

Legend: NS, not specified; M, measured. Q, questionnaire. * Excess weight = overweight plus obese
papers, we were unable to locate critical information in 2 instances, and another paper was a review and did not provide original data. The latest available round of the WHO Childhood Obesity Surveillance Initiative (COSI) initiative [16] was also not included in the analysis, as this only targeted specific age groups (7, 8 and 9-year-old children in Romania) and we were unable to locate general prevalence data in the report. The remaining data concerning the prevalence of excess weight in Romania as reported in various studies is summarized in Table 3, in chronological order. 36,048 children were included. The derived mean values by various methods are recorded in Table 4. Some of the percentages and numbers, although not included in the original papers, could be derived from the data presented in the articles; most though could not be calculated accurately, as the percentages reported had most likely been rounded up. Given the fact that we did not have access to the actual data presented in the published literature, the bolded (calculated) values should be interpreted with caution, as they may be inexact.

As showed in Table 3, data collection included direct measurement of height and weight in most cases, with only 3 papers relying on questionnaires. There is considerable variability in the standard used to define excess weight, although, recognizing the various available classifications [12–14], some papers reported data using more than one standard.

Several factors have been shown to have a somewhat protective effect. These include breastfeeding in the first 6 months of life (exclusive or not) [33], parental educational level and the child’s school performance (children with better grades are more likely to have normal weight) [29].

Excess weight has been proven to worsen or even cause many conditions and is a well-recognized risk factor for cardiovascular disease. An overview can be found in a recent review [44]. Some of the possible complications of excess weight that have been identified in Romanian pediatric cohorts are summarized in Table 6.

### DISCUSSION

To our knowledge, there has not been a single, local study to assess the prevalence of excess weight at a country level. The only recent available data with adequate, country-wide sampling comes from the WHO COSI initiative, which reports prevalence data according to specific age groups and gender and will be discussed briefly below. The few local studies that are available give some insight into the situation in only 9 counties out of 41. To this, data from studies performed abroad that included a Romanian cohort was included, but the exact geographical area of data collection is unclear in most cases [18,23,24,29]. Based on the information reviewed here, the prevalence of excess weight is in line with previous published data, namely 23.77% of children aged 2-19 have excess weight, 16.6% being overweight and 8.7% being obese (mean values based on WHO, CDC and IOTF derived prevalences, Table 4). The overall numbers are also similar to prevalence data found in a review by Chiriţă-Emandi et al. [61] (28.3% / 23% / 23.2% (WHO / IOTF / CDC)), which included studies performed during 2006-2015 as well as some unpublished data.

To note, the numbers reported here were driven up by the results obtained using the WHO classification provided in a single study by Barbu et al. [28]. The overall data obtained by means of both the CDC and

|          | EW (%) | OW (%) | Ob (%) | Prevalence EW boys | Prevalence EW girls | Prevalence OW boys | Prevalence OW girls | Prevalence Ob boys | Prevalence Ob girls |
|----------|--------|--------|--------|--------------------|---------------------|--------------------|--------------------|--------------------|--------------------|
| WHO      | 31.6%  | 20.2%  | 11.4%  | 26.5%              | 17%                 | 13.8%              | 11.45%             | 8.2%               | 5.55%              |
| CDC      | 18.35% | 11.09% | 7.2%   | 21.74%             | 15.24%              | 12.81%             | 9.89%              | 8.92%              | 5.35%              |
| IOTF     | 21.37% | 18.56% | 7.69%  | 23.01%             | 17.16%              | 16.58%             | 13.92%             | 7.42%              | 5.34%              |
| Mean     | 23.77% | 16.61% | 8.76%  | 23.75%             | 16.46%              | 14.39%             | 11.75%             | 8.18%              | 5.41%              |

#### TABLE 4. Calculated mean prevalence according to the WHO, CDC and IOTF standards, based on prevalence data recorded in Table 3. EW, excess weight. OW, overweight. Ob, obese
### TABLE 5. Factors that may promote excess weight or obesity in the Romanian population. Legend: BMI, body-mass index; MUAC, middle upper arm circumference; TST, tricipital skin-fold thickness; SNP, single nucleotide polymorphism; CNVs, copy number variants; VOUS, variants of unknown significance; UPD, uniparental disomy; T2DM, type 2 diabetes mellitus

| Group             | Factor                                                                                                                                  | Details                                                                                                                                                                                                 | Reference |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| Genetic           | CC allele carriers of the Interleukin-6 (IL-6) 572 gene                                                                             | BMI, MUAC, TST and serum albumin levels correlated with CC allele carriers of IL-6 572 gene in children with obesity                                                                                       | [34]      |
|                   | FTO rs 9939609 SNP                                                                                                                     | AA genotype carriers have a 2.02 times higher risk for obesity compared with AT+TT genotype carriers                                                                                                       | [35]      |
|                   | Leptin Gene Polymorphisms 223 A/G and 1019 G/A                                                                                         | Obesity is more frequent in children with LEPR 223 AG+GG and LEPR 1019 GA+AA genotypes                                                                                                                 | [36]      |
|                   | Pathogenic copy number variants (CNVs) in patients with obesity and developmental/intellectual disability                               | 33% of study group presented CNVs with a higher degree of pathogenicity (pathogenic CNVs in 66.7%, VOUS in 16.7% and UPD in 16.7% of patients)                                                                  | [37]      |
| Maternal factors  | Maternal smoking during pregnancy                                                                                                     | An association between maternal smoking and overweight was seen in all participant countries except Romania                                                                                               | [38]      |
|                   | Hyperglycemia of the mother in maternal T2DM                                                                                           | The child’s risk of developing T2DM and obesity is higher than the genetically transmitted susceptibility                                                                                               | [39]      |
|                   | Maternal obesity and gestational weight gain                                                                                            |                                                                                                                                                                                                       | [40]      |
| Characteristics at birth | Birthweight                                                                                                                                         | Both high [32,33] and low birthweight [31] could be involved                                                                                                                                                  | [31-33]   |
|                   | Prematurity                                                                                                                              | Preterm babies have higher odds of being obese                                                                                                                                                    | [31,33]   |
| Lifestyle         | Decreased sleep time                                                                                                                    |                                                                                                                                                                                                       | [41]      |
|                   | Diet                                                                                                                                    | Imbalanced diet and excess calorie intake                                                                                                                                                               | [32,42]   |
|                   | Internet and electronic media use                                                                                                      | Use of electronic media > 2 h per day (if physically inactive) [23], heavier internet use (> 2 h per day), heavier social networking sites use and internal addictive behaviors [29] | [23,29]   |
| Others            | Disorders in hypothalamic-pituitary-adrenal (HPA) axis caused by chronic stress                                                        | Repeated stimulation of the reward pathways through highly palatable food leads to overeating because of neurobiological adaptations                                                                        | [43]      |

### TABLE 6. Possible complications of excess weight identified in Romanian cohorts. LV, left ventricle. Legend: HCM, hypertrophic cardiomyopathy; IL, interleukin; ICS, inhaled corticosteroids; NAFLD, non-alcoholic fatty liver disease; T2DM, type 2 diabetes mellitus; SIBO, small intestinal bacterial overgrowth

| Group                  | Factor                                      | Details                                                                                                                                                                                                 | Reference |
|------------------------|---------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| Cardiovascular         | Arterial hypertension                        | 12-24% of overweight or obese children were found to have arterial hypertension in various cohorts                                                                                                     | [19,26,45,46] |
|                       | LV hypertrophy / HCM                         | Study performed on 188 children (all of whom were overweight or obese). Rates of 32% (LV hypertrophy) and 12% (HCM) were reported                                                                        | [46]      |
|                       | Dyslipidemia                                 | Increased total cholesterol, LDL, triglycerides, low HDL or combinations                                                                                                                              | [45,47,48] |
|                       | Elevated plasma homocysteine level           | Observed in hypertensive subjects in particular.                                                                                                                                                      | [49]      |
| Endocrine and metabolic| Metabolic syndrome                           | Rates of 21-55% of study groups                                                                                                                                                                        | [27,50]   |
|                       | Hyperinsulinism                              | 47.76% of study group, all of whom were obese                                                                                                                                                         | [48]      |
|                       | Insulin resistance                           |                                                                                                                                                                                                       | [48]      |
|                       | Impaired basal glycemia                      |                                                                                                                                                                                                       | [45]      |
|                       | Elevated inflammatory adipokines            | Increased leptin, IL-6 and IL-8 and decreased adiponectin                                                                                                                                              | [51]      |
|                       | Changes in thyroid parameters                | Elevated TSH, FT3/FT4 levels and increased prevalence of thyroid nodules                                                                                                                            | [52]      |
| Respiratory           | Asthma                                      | Obesity correlates with more severe or even difficult asthma (persistent asthma symptoms and/or frequent moderate/severe asthma exacerbations despite regular intake of ICSs (beclomethasone or equivalent) > 800 μg/day for at least 3 months in one study) | [53,54]   |
| Digestive             | Non-alcoholic fatty liver disease (NAFLD)    | Metabolic syndrome or family history of T2DM seems to increase the risk for NAFLD                                                                                                                      | [55,56]   |
|                       | Chronic functional constipation              |                                                                                                                                                                                                       | [57]      |
|                       | Small intestinal bacterial overgrowth (SIBO) | SIBO was found in 37.6% of overweight group. Obese children with SIBO have an increased risk for developing NAFLD.                                                                                     | [58]      |
| Other                 | Psychological issues                         |                                                                                                                                                                                                       | [45,59]   |
|                       | Lower limb deficiency                       | Genu varum or genu valgum. The prevalence of genu varum was also significantly higher in underweight children                                                                                           | [60]      |
the IOTF are much closer together and prevalence rates are lower using these standards (mean of 19.86%, 14.82% and 7.44% respectively).

This data is in stark contrast with a 2017 report from the Ministry of Health [7] that brought together data reported by medical facilities from 39 counties for 2016-2017, which quotes a prevalence of obesity of only 1.65% of children aged 0-19. This difference could reflect the inclusion of the 0-2 age group, but also the fact that in some cases obesity may not be officially recorded (and thus reported) as a chronic condition. The 2018 report of the National Institute of Public Health [6] however, also based on data from 2016-2017, highlights the importance of the problem by stating that obesity ranked as the second most frequent chronic condition in children, outnumbered only by refractive errors.

The studies reviewed here provided no clue as to the prevalence of severe obesity, but some data derived from previous COSI data is available [62], reporting a prevalence of 2.2% (WHO criteria) and 1.2% (IOTF criteria) respectively, with significantly higher numbers in boys.

The data that has been pooled together here mostly reflects the urban area (75% of children). A single study [63] provided data regarding the difference between the prevalence of excess weight in the rural versus urban areas, finding a slight excess in the rural environment (27.9% as opposed to 24.9%). This trend was also noted in the National Institute of Health report [6]. To note, this was not confirmed in the review performed by Chiriţă-Emandi et al. [61].

The gender distribution is much more even, with an average of 44% of subjects in these papers being of male gender. According to the latest COSI round data (2015-2016) [64], there is a prevalence of excess weight, overweight and obesity of 31%, 16% and 15% in boys and a slightly lower one of 26%, 17% and 9% in girls.

Unfortunately, the extremely heterogeneous data did not permit analysis of age group distribution.

Concerning the time trend of excess weight, it appears that there has been no increase in prevalence in recent years [18,61]. Prevalence data reported from the third and fourth COSI rounds are similar for Romania [64,65]. According to the 2018 National Institute of Public Health report [6], the local incidence of obesity has also been relatively stable.

Regarding the possible complications of excess weight, various potential problems have been reported, with increased probability of arterial hypertension, dyslipidemia and several metabolic disturbances (including diabetes) being the most consistent across studies. One study [46] has reported a surprisingly high percentage of children with LV hypertrophy and even hypertrophic cardiomyopathy. We considered these findings with caution, as the authors did not mention the diagnostic criteria used.

Additional data is needed for other topics, such as the potential correlation with asthma severity, as not all studies were able to demonstrated this [66]. In addition to physical health implications, several psychological issues have been noted. The search strategy employed here did not reveal abundant information on the matter and it is possible this has not been consistently studied in a Romanian population. One study mentions lower use of contraception in obese adolescent girls [67]. More data is needed with respect to this topic, as excess weight bears a close relationship with psychological issues in adults and clearly cannot be overlooked in the pediatric patient.

There have been relatively few systematic attempts to tackle the excess weight problem. General recommendations about obtaining and maintaining a healthy weight can be found on numerous websites and in various articles. Some have tried to focus on the family doctor’s (general practitioner’s) role, emphasizing that prevention is key [68]. We have identified one small study in which the authors have tried to demonstrate the beneficial effect of a structured, personalized, physical exercise program, however comparative results were only reported in two subjects [69].

On a wider scale, the EPHE project [70] which ran from 2013 to 2015 in 7 countries including Romania, focused on community-based interventions (including games, workshops and educational materials on healthy diet, psychical activity and sleep). In Romania the authors demonstrated a statistically significant decrease in fruit juice consumption after the intervention, however this was not maintained on follow-up. Another initiative, the More and Less Europe study [71] aimed at preschoolers, proposes a slightly different approach, including a parent support program with group sessions, followed by a 6-month period of support by means of a mobile application. Recruitment has started in 2019 and results are pending.

**CONCLUSIONS**

A worrying proportion of children are overweight or obese in Romania (roughly 18 to 31%, according to the definition used) and although the prevalence does not seem to be increasing, the problem cannot be ignored, as it may lead to a variety of physical and psychological issues for the child. Conditions such as arterial hypertension and dyslipidemia, typically encountered in adults, are being noted with increased
frequency in the pediatric population (being triggered or at least worsened by excess weight) and their full impact on quality of life and life expectancy is difficult to grasp.

Excess weight is, unfortunately, favored by the modern lifestyle; it is thus extremely difficult to devise an efficient action plan to address it. Modest benefit has been shown with community-based intervention, however the effects were short lived.

It is clear that no option will provide an immediate effect and that any measure will take time to show actual benefit, as it needs to target the entire population. The continued implication of the authorities is crucial. Perhaps sustained interventions in schools and continued support for parents and caregivers, combined with increased awareness of the importance of offering information and advice during routine medical visits, will be able to achieve this.

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