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Arch Dis Child. 2020 Mar;105(3):292-297

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Keywords: Child obesity; Waist circumference; Body mass index; Healthcare; Drug prescriptions

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Word count: 2565

ABSTRACT

Objectives: To evaluate the association between excess weight and the demand of health services in preschool children compared to healthy weight.

Methods: The data come from the ELOIN cohort (1884 4-year old children, residing in the Madrid region, Spain) who provided information through telephone questionnaire, physical examination, and electronic medical records. We defined overweight, general and abdominal obesity based on body mass index, waist circumference, and waist-to-height ratio. Using mixed models of multivariable negative binomial regression we calculated the incidence rate ratio (IRR) regarding primary care doctor visits, drug prescriptions, and hospital admissions by weight status at the end of the 2-year follow-up.

Results: Childhood general obesity was associated with a higher demand for primary care services related to psychological problems (IRR=1.53; 95%CI:1.02-2.28), and childhood abdominal obesity, according to waist-to-height ratio, was related to more frequent problems of the musculoskeletal system (IRR=1.27; 95%CI:1.00-1.62). Drugs were prescribed more frequently to children falling under all three definitions of excess weight, compared to healthy weight children. No differences in the number of hospital admissions were observed.

Conclusions: The demand of health services related to early childhood obesity was small. Nevertheless, obesity was associated with a slightly greater demand for drug prescriptions and for primary care doctor visits related to psychological and musculoskeletal problems.

INTRODUCTION

In recent decades, the prevalence of obesity in children and adolescents has increased progressively worldwide, although since 2000 such rise seems to have leveled off in many developed countries(1). By 2016, it corresponded to a disease burden of 33.6 and 27.3 DALYs (Disability-Adjusted Life Years) for 100,000 children aged 5-9 years and 10-14 years, respectively(2).

Substantial evidence shows that excess weight in childhood and adolescence leads to adverse outcomes in adult life by increasing morbidity and the risk of premature mortality(3). Unfortunately, there is also evidence that some health professionals(4) and parents(5) underestimate the impact of childhood obesity, hampering the prevention and control of this health problem from an early age. This is due, in part, because childhood obesity, unlike its adult counterpart, does not substantially burden the health system regarding time and economic resources(6)(7).

There is scarce work evaluating the association between carrying some extra weight as a preschooler and the use of health services. For instance, based on parental self-reported comorbidity data, authors highlight the low burden of disease despite the high prevalence of excess weight(8). Others report an association between weight and health problems only among children with severe obesity(9). Still, Au (2012) concludes that children with excess weight generate higher pharmaceutical and medical costs at an early age than their healthy weight schoolmates(10).

Based on literature reviews examining the effects of childhood obesity on the use of health services, authors report that the value of available evidence is limited by the heterogeneity in study designs, age groups, obesity definitions, and outcome variables evaluated(11). Thus, it is necessary to develop more evidence on the clinical effects of

childhood obesity, evaluating the demand and use of the health system prospectively by analyzing longitudinal quality data.

The main objective of this study was to determine the prospective association between excess weight (overweight, general and abdominal obesity) and the use of specific health system services (visits to primary care (PC) physicians, drug prescriptions in PC, and hospital admissions) among preschoolers. Our analyses are based on a representative sample of 4 year-old children and their health care utilization during the 2 years of follow-up.

MATERIALS AND METHODS

Design and study population characteristics

The Longitudinal Study of Childhood Obesity (ELOIN for its Spanish acronym), is a population-based cohort recruited in the Madrid region, an area of 6.5 million inhabitants in Spain. The objectives of the parent study are to: estimate weight changes between the ages of 4 and 14, describe the main risk factors associated with overweight and obesity, and evaluate the impact of excess weight on health status. The methodology and characteristics of the study sample have been previously reported(12,13). A total of 2627 children were included in the original cohort with parents acting as their proxy. Foreign parents and those with low educational level were less likely to fill out the baseline survey than others. For this study, our sample consisted of 1884 children examined and interviewed first at age 4 (baseline measurement) and then two years later, at age 6. Data were collected in three consecutive steps: first, a standardized physical examination performed at the health center by one of the 31 participating pediatricians; second, a structured parental survey

by computer-assisted telephone interview; and third, a review of electronic medical records to collect data on health service use during the 2-year follow-up.

Anthropometric measurements

During the physical examination weight, height, and waist circumference were measured in a standardized manner by participating pediatricians. Weight was measured with a digital scale (SECA® model 220, precision 0.1 kg), height was measured by telescopic height rod (SECA® model 220, precision 1 mm), and waist circumference was measured with approved inextensible metric tape just above the iliac crests with the tape held horizontally and without tissue compression. Each variable was measured twice and the average of the two values was for used for the analyses.

We calculated the child´s body mass index (BMI) (kg/m2), standardizing its values according to the available WHO-2006 reference tables by age and sex. Based on the z-scores we classified children as overweight if their z-BMI> +1 standard deviation (SD) and z-BMI ≤ +2 SD) and as obese if their z-BMI score > +2 SD(14). The mean waist circumference readings were standardized based on age and sex reference tables for European-American children and adolescents proposed by Fernández JR, et al(15) interpolated monthly. Abdominal obesity was defined as any value ≥90^{th} percentile according to the recommendations of the International Diabetes Federation (IDF)(16). The waist-to-height ratio (waist circumference in cm/height in cm), was also used to defined abdominal obesity when the value ≥90th percentile(17).

Primary Care Electronic Clinical History

Data on visits to doctor offices, drug prescription, and recorded episodes of medical care (codified following the CIAP-2 classification) were collected from the Primary Care Electronic Clinical history. We analyzed the information corresponding to the

most commonly reported events, that is, those related to the respiratory, musculoskeletal, and nervous systems as well as data on psychological problems. The records of hospital discharges were obtained through the Minimum Basic Data Set (MBDS), a single file of hospital admissions/discharges from all public and private hospitals.

Covariables

The sociodemographic covariates included in the models were sex, child´s age in months, mother´s educational achievement (5 categories), duration of breastfeeding (4 categories), family purchasing power (low (0-5 points), medium (6-7 points) and high (8-9 points)) defined based on the Family Affluence Scale (18) and parent´s perception of the child´s health status at baseline classified as either optimal (very good or good) or suboptimal health (regular, poor, or very poor).

Statistical Analyses

The initial sample consisted of 1884 participants. We excluded 27 children classified as underweight and/or with no waist circumference data at baseline. After taking into account missing values for some other covariates, the final sample was 1857 for analyses regarding BMI-based excess weight or 1851 participants for analyses related to abdominal obesity.

First, we performed descriptive analyses and simple statistical hypothesis testing at the bivariate level (Student's t-test or analysis of variance depending on the number of groups to contrast). The null hypothesis assumed no difference in the average (and variance) number of PC visits, of drug prescriptions, and of hospital admissions for each variable and corresponding categories. Second, since over-dispersion was detected, we designed multilevel models of negative binomial regression, including the identification

of the pediatrician as a random factor, to evaluate the number of PC visits, drugs prescriptions, and hospital admissions during the 2-year follow-up period. The quotient of incidence rates (IRR) and their respective 95% confidence intervals and p values were calculated. All models were adjusted for the covariates described above. We tested for interactions between our excess weight variables and sex as well as family purchasing power.

The level of statistical significance was set at a p-value of <0.05. All the analyses were performed using Stata v.14. (StataCorp. 2015. *Stata Statistical Software: Release 14*. College Station, TX: StataCorp LP).

Ethical Implications

The study protocol was approved by the Ethics Committee of the Ramón y Cajal

Hospital in Madrid, approval number 242 and register number 44/10. All participants´ parents signed an informed consent form.

RESULTS

The characteristics of the sample are described in Table 1. From age 4 to age 6 our participants had an accumulated average of 11.7 visits to a PC physician, 1.25 drug prescriptions from PC physicians, and 0.22 hospitalizations. We observed some statistically significant differences; first, a greater number of drug prescriptions and hospital admissions among boys than girls and, second, a lower frequency of PC doctor visits among children of college-educated mothers and high socioeconomic status than other children. As one might expect, children with a suboptimal health status made greater use of health services.

Table 2 shows the association between excess weight and PC doctors´ visits, drug prescriptions, and hospital admissions. Children affected by general or abdominal obesity at age 4 visited a PC doctor a statistically similar number of times as normo-weight children (IRR = 1.08 and 1.06, respectively). However, children falling under any of the 3 excess weight categories were prescribed a greater number of drugs than their normo-weight counterparts (IRR= 1.62; 95%CI: 1.11-2.38) for general obesity, 1.37 (95%CI: 0.99-1.90) for abdominal obesity according to waist circumference (not statistically significant), and 1.34 (95%CI: 1.02-1.76) for abdominal obesity according to the waist-to-height ratio. Finally, we observed no differences by baseline weight status in the incidence of hospital admissions during the follow-up period.

The average number of PC visits by body system during the 2-year follow-up was: 4 visits for respiratory system problems, 0.5 for musculoskeletal system problems, 0.2 for nervous system problems, and 0.5 for psychological problems (data not shown). Table 3 describes the relationship between weight status and PC visits grouped by different body systems. Results showed an increase in the cumulative incidence rate for musculoskeletal system problems (IRR=1.27; 95%CI: 1.00-1.62) associated with abdominal obesity based on waist-to-height ratio but not with the other two obesity indicators. We also observed a positive relationship between childhood BMI-based general obesity and PC visits due to psychological problems (IRR=1.53; 95%CI: 1.02-2.28). However, the association with other obesity indicators failed to reach statistical significance. We did not find associations with respiratory or nervous systems problems.

None of the interactions explored reached statistical significance.

DISCUSSION

Our study shows that early childhood obesity (both general and abdominal) is associated with a higher demand for drug prescriptions during a 2-year follow-up period. Although we failed to detect a higher overall demand for PC services associated with obesity, additional doctor´s visits were probably related to psychological and musculoskeletal problems. No differences were observed regarding the number of hospital admissions.

Childhood obesity may adversely affect practically every system in the organism(19) to the point that large literature reviews link childhood and adolescent obesity to reduced self-rated health and quality of life(20,21). However, there is a discrepancy between said reports and the low burden of disease detected by parents(5). Additionally, there is evidence that some health professionals underestimate the impact of childhood obesity(4), hampering any excess weight prevention and control efforts at early ages.

Previous studies show an increase in demand for health services among children and adolescents affected by obesity. The magnitude of such increases tend to be small-to-moderate and mostly reflect demand for services other than hospital admissions(7,22–26). Estabrooks and colleagues observed an 11% increase in the risk of PC visits during a 1-yr follow-up and of 6% during a 3-yr follow-up of a sample of 3- to 17-year olds(22). Although we detected an 8% increase in visits, but if failed to reach statistical significance. Janicke and co-authors(26) observed a slightly higher increase (19%) in children between 7 and 15 years of age; whereas Hampl et al.(27), failed to detect any significant increase in PC visits in the 5- to 18-year old population.

Obesity, based on waist circumference/height, was associated with a greater demand for PC services involving musculoskeletal system issues. Childhood obesity´s impact on a young musculoskeletal system works through the dysfunction of the joints. This in turn,

generates foot, ankle, and knee problems, as well as muscle pain and increased risk of fractures(28), though the evidence regarding the risk of fractures and accidents remains scarce(29). The only longitudinal study of 2-year old preschool children revealed an increase in hospitalizations due to musculoskeletal problems during the three-year follow-up among children affected by obesity(24). The evidence regarding a link between obesity and risk of accidents remains inconclusive. Whereas Lynch et al.(23) reported that obesity seemed to increase such risk, Ferro and colleagues(30) concluded that obesity played a protective role. Such role, however, probably reflects the inverse relationship between obesity and physical activity levels among children.

The finding that BMI-based obesity was also associated with greater demand for PC services related to psychological problems supports previous findings identifying poor mental health as one of the most widespread side-effects of childhood obesity(4). However, few studies evaluate obesity´s impact on psychological-related health services use. Estabrook and colleagues(22) and Turer and colleagues(25) observed an increase in visits due to mental health problems in children aged 3-17 and 10-17 years, respectively, with excess weight. Wooldford et al.(31) found an increased hospital burden due to affective disorders among the 2- to 18 year-old patient population with a secondary hospital diagnosis of obesity.

The greater number of drugs prescribed to children affected by obesity in our study also supports previous findings such as Solmi et al.´s (32) on prescription use in a cohort of 5 year-olds followed for 7 years. In another study(10) conducted on Australian 4- to 5-year old children, excess weight was associated with higher pharmaceutical expenditure. However, Hayes et al.(24) analyzed health records data from 2- to 5-year olds and failed to detect differences in medication use by weight category, although the small sample size may be the culprit.

Again, published evidence regarding the relationship between obesity and increased risk of hospital admissions is inconclusive. Three studies found no association(9,10,23), whereas two others reported a direct relationship between risk of admissions and excess weight in children(6,24). One of these works(6) linked BMI trajectories to health services use and concluded that children who gained weight quickly, i.e., reaching high BMI values quickly and maintaining that excess weight for up to 10 years, were more likely to be hospitalized during the study period.

Finally, we explored whether changes in weight status during the 2 year follow-up may have influenced our results. We repeated the analysis only with children classified under the same weight category at age 4 and again at age 6 (data not shown). The association between obesity and greater number of prescriptions or psychological problems with obesity remained unchanged. However, the association between musculoskeletal problems and excess weight was no longer significant.

Limitations and strengths of the study

When interpreting our study´s results, some limitations should be kept in mind. First, foreign parents or those with low educational achievement were less likely to fill out the baseline survey. This moderate selection bias may limit the generalization of results to the entire population of 4-year olds in the Madrid region. Second, the short follow-up time (two years), the small sample size, and the limited number of events reduced the statistical power of some estimates.

Third, there are no validation studies of the clinical data included in the electronic medical record for the region´s children, although errors are probably random, i.e.,

affecting obese and non-obese children equally. Finally, incompatibility between data systems precluded extending the analysis to demand for emergency room services.

Our study has important strengths. First, its longitudinal design, and adjustment for key likely confounders, offer great potential for the detection and establishment of causal associations. Second, it contributes to the very scarce body of work examining the use of health services by preschool children. Third, the anthropometric measures were performed in an objective and standardized manner. Further, general and abdominal obesity were differentiated for the first time when examining their relation to the use of health services. Finally, the models were adjusted for the main sociodemographic covariates, as well as for duration of breastfeeding and the child´s health status as perceived by the parents.

In sum, the demand for health services related to obesity was small in pre-school age. Nevertheless, general and abdominal obesity were associated with a slightly greater burden on health systems due to an increase risk of PC visits related to musculoskeletal and psychological problems, as well as to a higher number of drug prescriptions in primary care.

Conflicts of interest statement: The authors declared no conflict of interest.

Funding: this research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors

Contributorship statement: Maira Alejandra Ortiz-Pinto and Iñaki Galán, conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript.

Maira Alejandra Ortiz-Pinto and Iñaki Galán, designed the data collection instruments, collected data, carried out the initial analyses, and Maira Alejandra Ortiz-Pinto,

Honorato Ortiz-Marrón, Maria Esteban-Vasallo and Iñaki Galán, reviewed and revised the manuscript.

Honorato Ortiz-Marrón, Maria Esteban-Vasallo, Agueda Quadrado Mercadal, Dayami

Casanova Pardo, Marta González Alcón, y María Ordobás-Gavin, collected data, and critically reviewed the manuscript for important intellectual content.

All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Acknowledgements

The authors thank all participating families, the pediatricians from the Network of Sentinel Doctors of the Community of Madrid and the two companies interviewing the families: Demométrica SL and Sondaxe SL.

What is already known on this topic?

- There is a perception that overweight and obesity have few clinical consequences in early life.

What does this study add?

- Childhood obesity was associated with a slightly greater demand for psychological and musculoskeletal problems in primary care.

- Childhood obesity was associated with more drug prescriptions.

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Table 1. Sample characteristics according to type of health care use: Primary care visits, drug prescriptions, and hospital admissions for between baseline (age 4) and follow-up (age 6).

	Study participants		Primary Care Visits		Drug Prescriptions		Hospital Admissions	
	N	%	Mean (SD)	p-value[f]	Mean (SD)	p-value	Mean (SD)	p-value[f]
Total	1863	100	11.7 (7.6)		1.2 (2.3)		0.22 (0.7)	
Sex				0.581		0.003		<0.001
Boys	946	50.8	11.6 (7.3)		1.4 (2.4)		0.29 (0.8)	
Girls	917	49.2	11.8 (8.0)		1.1 (2.1)		0.15 (0.5)	
Mother´s Education[a]				<0.001		0.498		0.164
Primary or below	62	3.3	11.7 (6.8)		0.9 (1.6)		0.32 (0.5)	
Secondary-first level	355	19.1	12.8 (8.3)		1.4 (2.7)		0.22 (0.5)	
Secondary-second level	624	33.6	12.4 (7.5)		1.3 (2.3)		0.26 (0.7)	
Some College (2-years)	263	14.2	11.3 (7.4)		1.2 (2.2)		0.16 (0.8)	
College degree (4-years)	553	29.8	10.5 (7.3)		1.2 (2.1)		0.18 (0.7)	
Family-level Purchasing Power[a,b]				0.005		0.272		0.217
Low	861	46.2	12.2 (8.0)		1.3 (2.4)		0.24 (0.7)	
Medium	705	37.9	11.6 (7.4)		1.2 (2.2)		0.22 (0.8)	
High	296	15.9	10.5 (6.9)		1.1 (2.2)		0.15 (0.4)	
Breastfeeding (months)				0.836		0.295		0.936
None	187	10.0	11.9 (7.3)		1.0 (1.8)		0.24 (0.9)	
1 to 2 months	289	15.5	11.5 (7.0)		1.1 (1.9)		0.22 (0.6)	
3 to 5 months	739	39.7	11.9 (7.8)		1.3 (2.4)		0.20 (0.7)	
≥6 months	282	15.1	11.3 (7.7)		1.2 (2.4)		0.22 (0.7)	
No Response	366	19.6	11.8 (7.8)		1.4 (2.6)		0.24 (0.6)	
Health Status[a]				<0.001		<0.001		<0.001
Optimal	1704	91.5	11.4 (7.5)		1.2 (2.1)		0.20 (0.6)	
Suboptimal	158	8.5	14.7 (8.8)		1.9 (3.5)		0.44 (1.2)	
Weight Status at age 4 according to z-BMI[c]				0.459		0.707		0.421
No excess weight	1453	78.0	11.7 (7.6)		1.3 (2.3)		0.21 (0.7)	
Overweight	315	16.9	11.5 (7.4)		1.2 (2.2)		0.26 (0.8)	
Obesity	95	5.1	12.6 (8.7)		1.3 (2.3)		0.16 (0.5)	
Weight Status at age 4 according to waist circumference[a,d]				0.184		0.611		0.711
No abdominal obesity	1732	93.3	11.7 (7.6)		1.2 (2.3)		0.22 (0.7)	
Abdominal obesity	125	6.7	12.6 (8.1)		1.4 (2.0)		0.20 (0.5)	
Weight Status at age 4 according to waist-to-height ratio[a,e]				0.118		0.189		0.412
No abdominal obesity	1670	89.9	11.6 (7.6)		1.2 (2.3)		0.22 (0.7)	
Abdominal obesity	187	10.1	12.6 (8.2)		1.5 (2.5)		0.18 (0.5)	

SD: Standard Deviation; BMI: Body Mass Index.
[a] Variables with missing values.
[b] Family level purchasing power estimated using the Family Affluence Scale.
[c] Overweight: +1 SD of the Body Mass Index (z-scores) (z-BMI); Obesity: +2 SD of z-BMI, based on the OMS-2006 reference tables.
[d] Abdominal obesity: ≥90 percentile according to reference tables by Fernández et al(15).
[e] Abdominal obesity: ≥90 percentile del waist-to-height ratio (both in cm).
[f] Student's t-test (2 groups) or analysis of variance (more than 2 groups).

Table 2. Weight status and abdominal obesity at age 4 according to type of health care use: Primary care visits, drug prescriptions, and hospital admissions, during the 2-year follow-up.

	Primary Care Visits		Drug Prescriptions		Hospital Admissions	
	IRR[d]	**95% CI[e]**	**IRR[d]**	**95% CI[e]**	**IRR[d]**	**95% CI[e]**
Weight Status at age 4 according to z-BMI[a] (N=1857)						
No excess weight	1(ref)		1(ref)		1(ref)	
Overweight	0.98	0.91 to 1.06	1.02	0.82 to 1.28	1.24	0.87 to 1.77
Obesity	1.08	0.94 to 1.23	1.62	1.11 to 2.38	0.80	0.41 to 1.57
Weight Status at age 4 according to waist circumference[b] (N=1851)						
No abdominal obesity	1(ref)		1(ref)		1(ref)	
Abdominal obesity	1.06	0.95 to 1.19	1.37	0.99 to 1.90	0.94	0.53 to 1.64
Weight Status at age 4 (baseline) according to waist-to-height ratio[c] (N=1851)						
No abdominal obesity	1(ref)		1(ref)		1(ref)	
Abdominal obesity	1.06	0.97 to 1.17	1.34	1.02 to 1.76	0.88	0.54 to 1.44

CI: Confidence Interval.

[a] Overweight: +1 SD of the Body Mass Index (z-scores) (z-BMI); Obesity: +2 SD of z-BMI, based on the OMS-2006 reference tables.

[b] Abdominal obesity: ≥90 percentile according to reference tables by Fernández et al(15).

[c] Abdominal obesity: ≥90 percentile del waist-to-height ratio (both in cm).

[d] IRR: Incidence Rate Ratio estimated using mix models of negative binomial regression adjusted for sex, age, maternal educational level, familial purchasing power, time breastfeeding, and perceived health status at age 4.

Table 3. Association between weight status and abdominal obesity at age 4 and primary care visits during the 2-year follow-up. Primary care visits are classified according to the four systems most health problems relate to.

	Respiratory system problems		Musculoskeletal system problems		Nervous system problems		Psychological problems	
	IRR[d]	**95% CI**	**IRR[d]**	**95% CI**	**IRR[d]**	**95% CI**	**IRR[d]**	**95% CI**
Weight Status at age 4 according to z-BMI[a] (N=1857)								
No excess weight	1(ref)		1(ref)		1(ref)		1(ref)	
Overweight	0.95	0.86 to 1.06	1.10	0.90 to 1.35	1.11	0.85 to 1.45	0.83	0.61 to 1.11
Obesity	1.04	0.87 to 1.26	1.28	0.91 to 1.78	1.02	0.65 to 1.60	1.53	1.02 to 2.28
Weight Status at age 4 according to waist circumference[b] (N=1851)								
No abdominal obesity	1(ref)		1(ref)		1(ref)		1(ref)	
Abdominal obesity	1.05	0.91 to 1.23	1.09	0.81 to 1.46	0.95	0.63 to 1.44	1.11	0.74 to 1.67
Weight Status at age 4 (baseline) according to waist-to-height ratio[c] (N=1851)								
No abdominal obesity	1(ref)		1(ref)		1(ref)		1(ref)	
Abdominal obesity	0.99	0.87 to 1.14	1.27	1.00 to 1.62	1.10	0.79 to 1.53	1.09	0.77 to 1.54

CI: Confidence Interval.

[a] Overweight: +1 SD of the Body Mass Index (z-scores) (z-BMI); Obesity: +2 SD of z-BMI, based on the OMS-2006 reference tables.

[b] Abdominal obesity: ≥90 percentile according to reference tables by Fernández et al(15).

[c] Abdominal obesity: ≥90 percentile del waist-to-height ratio (both in cm).

[d] IRR: Incidence Rate Ratio estimated using mix models of negative binomial regression adjusted for sex, age, maternal educational level, familial purchasing power, time breastfeeding, and perceived health status at age 4.