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ABSTRACT

Peer Effects on Obesity in a Sample of European Children*

This study analyzes peer effects on childhood obesity using data from the first two waves of the IDEFICS study, which applies several anthropometric and other measures of fatness to approximately 14,000 children aged two to nine participating in both waves in 16 regions of eight European countries. Peers are defined as same-sex children in the same school and age group. The results show that peer effects do exist in this European sample but that they differ among both regions and different fatness measures. Peer effects are larger in Spain, Italy, and Cyprus – the more collectivist regions in our sample – while waist circumference generally gives rise to larger peer effects than BMI. We also provide evidence that parental misperceptions of their own children's weight goes hand in hand with fatter peer groups, supporting the notion that in making such assessments, parents compare their children's weight with that of friends and schoolmates.

JEL Classification: I12, J13, J22

Keywords: peer effects, children, obesity, Europe

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1 Introduction

Child obesity is a major public health concern in Europe. According to self-reported data on height and weight gathered by the 2005–2006 Health Behaviour in School-aged Children (HBSC) survey from 11-year-olds in 26 EU countries, up to 30% of boys and 25% of girls could be considered overweight or obese (EC, 2010). In some European countries, the prevalence of overweight among children of primary school age is alarming: 35.9% of eight- to nine-year-olds in Italy, 31.5% of seven- to nine-year-olds in Portugal, and 30.6% of six- to ten-year-olds in the Czech Republic are considered overweight or obese. Even in European countries like Sweden that have the lowest levels of child obesity, the prevalence is still high, with approximately every fifth child aged eight years being overweight or obese (WHO, 2009). In addition, although the empirical evidence is limited, there are strong indications that child obesity levels are rising (WHO, 2009). Most worrying is that despite efforts by international organizations and national governments to promote awareness of the problem and develop preventive measures, the prevalence continues to increase (WHO, 2009).

Many factors may play an important role in explaining child obesity, including parental influence, food prices, access to fast food, environment, opportunities for physical activities, school nutrition policies, and advertising. Yet such "root causes" cannot always explain excess variance within regions or racial groups. One additional explanation for the persistent increase in obesity levels – and one that has received considerable attention in recent years – is the effect of peer groups. In addition to the ample documentation that social norms affect a range of health behaviors, including smoking (e.g., Mercken et al., 2012) and alcohol consumption (e.g. Balsa et al., 2011), there is increasing evidence that social norms and peer groups significantly affect obesity weight control behavior among both adolescents and adults (e.g., Christakis and Fowler, 2007; Hammond, 2010; Wal, 2012). For example, Christakis and Fowler's (2007) seminal longitudinal analysis of the Framingham Heart Study shows that an individual's chances of becoming obese increase by 57% if he or she has a friend who becomes obese in a given interval. Numerous subsequent studies also support the notion that social norms and networks affect individual obesity (Cohen-Cole and Fletcher, 2008; Renna et al., 2008; Trogdon et al., 2008; Christakis and Fowler, 2007; Halliday and Kwak, 2009; Valente et al., 2009; Larson et al., 2013; Yang and Huang, 2013; Blanchflower et al., 2009; Leatherdale and Papadakis, 2011; Mora and Gil, 2013; Loh and Li, 2013).

Nevertheless, although several extant studies examine peer effects on obesity among adults and adolescents, we are aware of only one published study that explores peer effects on childhood obesity (Asirvatham et al., 2014).[1] Yet knowing whether such effects exist among children is particularly important not only because children who are overweight before puberty will be overweight in early adulthood but healthy eating behaviors and diets take shape early in life and persist into adulthood (Schwartz et al., 2011). Hence, in the presence of peer effects among children, the oft-cited "social multiplier effect" (Christakis and Fowler, 2007) associated with policies aimed at combatting obesity may be quite effective and highly beneficial.[2] Finally, a large body of psychological research provides "ample evidence that peers can contribute to the amplification of problem behavior and distress from early childhood through late adolescence" (Dishion and Tipsord, 2011, p. 203).

The focus of our study, therefore, is to assess peer effects among children in a selection of European countries. To do so, we draw on the unique IDEFICS study ("Identification and prevention of Dietary and lifestyle induced health EFfects In Children and infantS") dataset, which covers approximately 14,000 children aged two to nine years participating in both the baseline and the follow-up survey in 16 regions of eight European countries. Our analysis makes the following contributions to the literature on peer effects and obesity: first, because a lack of appropriate data has seemingly prevented previous analyzes of peer effects on obesity in early and middle childhood (Cunningham et al., 2012),[3] our study serves as a primer in this regard. Second, our analysis is one of very few that explores peer effects on obesity in Europe (one exception being Mora and Gil, 2013). Third, our dataset allows us to analyze several measures of fatness, some arguably better suited to measuring body fat than the Body Mass Index (BMI) (Burkhauser and Cawley, 2008; Gallagher et al., 1996; McCarthy et al., 2006; Romero-Corral et al., 2006; Wellens et al., 1996; Yusuf et al., 2005). Finally, by including data on weight perceptions, our study is able to determine an association between peers and social norms, thereby shedding light on the mechanisms through which peer influences may occur.

[1] In Asirvatham et al. (2014) the effect of older peers on younger ones is analyzed. Their 2013 unpublished study (Asirvatham et al., 2013) is more akin to ours as it analyzed the effects of same-aged peers. Another recent but as yet unpublished paper on peer effects on childhood obesity is Nie et al. (2014).

[2] In Trogdon and Allaire (2014) an agent-based model of weight choice and peer selection is developed that simulates the effect of peer selection on social multipliers for weight loss interventions.

[3] As Cunningham et al. (2012) explain in their literature review: "We did not restrict inclusion criteria based on age, but, because few datasets are designed to permit research on friendship influence, many studies relied on one of the few datasets that does so, the National Longitudinal Study of Adolescent Health […], and so focused on adolescence and early adulthood. Few studies have focused on adults […] and none on early or middle childhood" (p. 1181).

The remainder of the paper proceeds as follows: section 2 reviews the relevant research on the topic, section 3 describes our data and methodology, section 4 discusses the study results, and section 5 concludes the paper.

2 Previous research

The various articles on peer effects and obesity published since Christakis and Fowler's (2007) seminal paper are reviewed in Yakusheva et al. (2014), Cunningham et al. (2012), and Nie et al. (2014), all of whom provide substantial evidence that peer effects exist among adolescents and adults. For the purpose of our study, three findings are particularly important:

First, although this literature uses several different peer concepts, the most common is the average BMI of friends (e.g., Christakis and Fowler, 2007; de la Haye et al., 2011; Mora and Gil, 2013; Renna et al., 2008; Yakusheva et al., 2011). Nevertheless, some studies use a broader measure, such as the average BMI of a community or school grade (e.g., Trogdon et al., 2008; Asirvatham et al., 2014; Nie et al., 2014). Trogdon et al. (2008), however, argue that these broad versus narrow peer measures define conceptually different reference groups: "broader measures of social networks could operate through the establishment of BMI norms and a reference BMI for body image concerns […], while more proximal measures of peer effects could operate through influences on diet and physical activity behaviour" (p. 1390). Both peer concepts have been used in past research, and both have given rise to peer effects.

Second, virtually no research exists that analyzes peer effects on obesity among children. In fact, we are aware of only two recent studies: Nie et al. (2014), using China Health and Nutrition Survey data for a sample of 3- to 18-year-olds, demonstrate that peer effects among children aged 3–10 are mostly stronger than those among adolescents. Similarly, Asirvatham et al. (2013), using data from Arkansas schools, identify peer effects among school children up to grade ten but show that estimates for peers within one grade are much larger than those for peers in other grades within the school.

Third, extant research on the peer effects in adolescence is strongly dominated by studies based on U.S. data – and predominantly data from the National Longitudinal Study of Adolescent Health (NLSAH) (e.g., Cohen-Cole and Fletcher, 2008; Renna et al., 2008; Trogdon et al., 2008; Christakis and Fowler, 2007; Halliday and Kwak, 2009; Yang and Huang, 2013). The only non-U.S. studies we know of are de la Haye et al. (2011) for Australia, Leatherdale and Papadakis (2011) for Canada, Mora and Gil (2013) for Spain, Loh and Li (2013) for rural China, and Nie et al. (2014) for China, very little of which reports any results for Europe. Yet extending conclusions from U.S. studies to child obesity-related issues in Europe is problematic not only because of the very different institutional setups (Gwozdz et al., 2013) but also because peer effects may differ among cultures and races (Mora and Gil, 2013; Asirvatham et al., 2013). For example, the Mora and Gil (2013) study, which uses BMI data from secondary school students in Spain for peer groups based on nominated classmate friends, finds that the peer effects are stronger than similar effects observed in the U.S.

Finally, all the studies which we are familiar with use BMI, and most rely on self-reported measures (most notably, from the NLSAH). Not only is there some controversy over BMI's reliability as a measure of body fat (especially among children and adolescents) (see Barlow et al., 2007; Burkhauser and Cawley, 2008; Gallagher et al., 1996; McCarthy et al., 2006; Romero-Corral et al., 2006; Wellens et al., 1996; Yusuf et al., 2005),[4] but epidemiologists tend to have strong reservations about using *self-reported* data on weight and height because of potential reporting bias (Huybrechts et al., 2006; Shields et al., 2011). Our study therefore uses different measures of fatness to assess peer effects among a sample of European children.

3 Data and Methods

The IDEFICS study data

Our dataset is drawn from the IDEFICS study ("Identification and prevention of Dietary and lifestyle induced health EFfects In Children and infantS") (see also Ahrens et al., 2011 and Gwozdz et al., 2013 for a more detailed description), a multi-center population-based study on childhood obesity carried out in two selected regions[5] in each of eight European countries: Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain, and Sweden. The child participants were recruited in school and kindergarten settings. One of the study's strengths is that all the children underwent a highly standardized and thorough physical examination (conducted by study nurses, dieticians and medical doctors) to determine body fat, meaning

[4] It should nonetheless be noted that the use of BMI for children is widespread and has been endorsed by an expert committee convened by the American Medical Association (AMA) in collaboration with the U.S. Department of Health and Human Services Health Resources and Services Administration (HRSA) and the CDC (Barlow et al., 2007).

[5] The participating regions, which are comparable in their infrastructural, socio-demographic, and socio-economic characteristics, are as follows: Belgium: Geraardsbergen and Aalter; Cyprus: Strovolos and Paphos; Estonia: Tartu and Tallinn; Germany: Delmenhorst and Wilhelmshaven; Hungary: Pecs and Zalaegerszeg; Italy: Atripalda/Monteforte I/Volturara I and Avellino/Forino/Pratola Serra; Spain: Zaragoza 1. District and Huesca; Sweden: Partille and Alingsas/Mölndal. For a description of the regions, see Bammann et al. (2012).

that the dataset contains several objective measurements of body fatness. The IDEFICS study also includes detailed information on the children's lifestyle, diets, consumer behavior, parental attitudes, and socio-demographic circumstances. For our study, we analyze such data for a sample of 14,601 children aged two to nine years who participated in both survey waves (2007/08 and 2009/10). These children are from 390 kindergartens and schools, with an average of 41.6 children per setting.

Fatness measures

Our analysis is based on four fatness measures: (i) measured BMI *z*-values calculated with International Obesity Task Force (IOTF) growth charts, (ii) measured waist circumference *z*-values calculated with IOTF growth charts, (iii) body fat (in kilograms) estimated by a composite measure developed using field-derived data on hip circumference, triceps skinfold, and resistance (measured with BIA), and (iv) percentage of body fat (PBF) calculated by body fat (kg) divided by total weight (kg). Our choice of methods was largely determined by the results of an IDEFICS validation study (Bammann et al., 2013), which revealed high performance values for both the waist circumference and composite measures. Although BMI performed less well, it is the most common measure in the peer-effects literature and so is included for practical reasons (for more information on the composite measure, as well as the advantages and disadvantages of the different measures, see Gwozdz et al., 2013).

Peer group definitions

We use two broad peer group definitions, both based on average fatness measured by BMI *z*-scores, waist circumference *z*-scores, and body fat. The first definition applies these measures to all children of the same sex in the same school within an age range of one year (excluding the target child) and the second applies it to all children of the same sex in the same school (excluding the target child). These peer groups primarily capture the effect of BMI norms within the setting across the psychosocial mechanisms suggested by Christakis and Fowler (2007), which "rely less on behavioral imitation or modelling and more on changes in individuals' general perceptions of the social norms regarding the acceptability of obesity" (Salvy et al., 2012, p. 374). A priori one could assume that the peer effect of children within the same age group is stronger than for the entire setting. Differences in the effects of these two groups could also be an indication that peer effects indeed exist and are not an artifact of omitted contextual variables (e.g., the nutritional quality of the school meals). It should also be noted that such broad measures are more exogenous than those defined using friends (Trogdon et al., 2008), especially with regards to selection and reflection issues. Nevertheless, selection could occur in the form of parents choosing the family residence based on the quality of local schools, which in turn could influence obesity. We are able to partly address this issue by using a fixed-effects specification.

Definitions of weight (mis)perception

Although research on how peers affect weight perceptions is scarce, especially for children, Blanchflower et al. (2009), using cross-sectional data from the Eurobarometer, do provide evidence that perceptions of overweight depend on peers' BMI among adults (measured as the average BMI in a specific age/gender/country group cell). Assessing the effect of peers on young children's weight perceptions, however, is more difficult because it requires the children's own reports of their weight perceptions, information that is neither readily available nor easy to collect. The IDEFICS survey instead asks for parental perceptions of their children's weight, perceptions that may matter not only because parents play a major role in determining their children's diets and physical activities but because their perceptions may be influenced by the weight of the children's peers (Jones et al., 2012). Specifically, the IDEFICS survey asks parents the following question: *"Do you think your child is: (1) Much too underweight? (2) Slightly too underweight? (3) Proper weight? (4) Slightly too overweight? (5) Much too overweight?"*. To derive our measures, we match parental responses to this item with the four-category Cole and Lobstein (2012) classification of a child's BMI: (1) thin, (2) normal, (3) overweight, or (4) obese. With this information, we create three dummy variables depicting parental (mis)perceptions: perceiving their children as thinner than they are, accurately assessing their children's weight, or perceiving their children as heavier than they are.

Covariates

C*hild characteristics:* These characteristics include a child's age, sex, birth weight, premature birth and breastfeeding, as well as three variables capturing health problems during the first four weeks after birth (respiratory problems, infections, and jaundice), four variables indicating the number of younger, older, or same-aged sibling or no siblings, and one variable indicating birth in a foreign country. Birth weight is captured by actual birth weight in grams. The additional dummy variables are non-exclusive breastfeeding and the three health problems (respiratory problems, infections, and jaundice). We also include dummy variables capturing the child's country of residency.

Family and parental characteristics: These characteristics include parents' age, foreign country of origin, household size, age of mother at birth, weight gained during pregnancy and smoking during pregnancy (dummy), parental employment (represented by three dummy variables: full-time, part-time, and in school/university, with non-working parents as the reference group), and parental BMI.

Socio-economic variables: These variables include parents' educational level (ISCED 1–6) and household income (net income after taxes and deductions), which is classified into nine categories. To derive comparable income categories by country, we build country-specific categories based on the median equivalent income adjusted for the number of household members. The lowest category is defined by each country's poverty line for a single parent with one child. The middle category is the median country-specific income for a household consisting of two adults and one child (see Bammann et al., 2012, for a more detailed description of these categories).

Statistical analysis

In a first step, we estimate a pooled ordinary least squares (OLS) model of the following form:

$$W_{ij} = \alpha_0 + \alpha_1 W_{-ij} + \alpha_2 X_{ij} + \varepsilon_i$$

where W_{ij} is the fatness measure of child *i* in school *j*, and W_{-ij} is the average measure of fatness in the peer group, excluding individual *i*. X_{ij} captures the individual, family, parental, and socio-economic control variables; ε_i is the error term; and α_1 is the endogenous peer effect. Outcomes are clustered at the setting level. OLS estimates based on this model, however, cannot correctly identify the endogenous peer effect because of the reflection problem (Manski, 1993), which stems from the fact that W_{-ij}, being computed as the mean fatness of individual i's reference group, is endogenous. This latter is also a source of a simultaneity problem in that the second variable influences the individual's BMI while in turn being influenced by it. Although our broad measure of peer group is more exogenous than measures defined based on friends (Trogdon et al., 2008), this reflection issue may still remain.

We mitigate this bias by also estimating a fixed-effects model along the lines of Arcidiacono and Nicholson (2005) and Halliday and Kwak (2009), expressed formally as:

$$W_{ijt} = \alpha_0 + \alpha_1 W_{-ijt} + \alpha_2 X_{ijt} + \mu_i + \varepsilon_{it}$$

where W_{ijt} is the fatness measure of child *i* in school *j* at time *t*, X_{ijt} depicts the time-variant control variables, μ_i is the time-invariant fixed-effects, and ε_{it} is the error term. Although this approach does not necessarily remedy the endogeneity problem, the alternative of using instrumental variables (such as background information on peers) is also not without drawbacks. In particular, as pointed out by Halliday and Kwak (2009), it comes at the expense of increased measurement error and weak instruments.[6] This inability to totally solve the potential endogeneity problem means that we can draw no conclusions about causality and our estimates must be interpreted as upper bounds (Halliday and Kwak, 2009). In a final step, we analyze parental misperceptions of their children's weight by estimating a pooled logit model using the same specifications as in the pooled OLS case.

4 Results

Analysis of the entire sample

The peer-effect estimates for the entire sample are given in table 1 and the descriptive statistics, in appendix table A1. The first two columns of table 1 report the results for the pooled OLS estimates, and the last two columns, the results for the fixed-effects model. The rows show the results for the four dependent variables; namely, BMI *z*-score, waist circumference *z*-score, fat mass in kilograms, and PBF, respectively. For each dependent variable, coefficients are given for both peer definitions.

As the table shows, the peer effects are positive and significant, and the coefficients for the broader definition of peers (i.e., at the setting level) are much smaller than those for the

[6] However, in order to identify a causal relationship between peer effects and individual BMI, we also perform a two-stage Generalized Method of Moment (GMM) procedure. Following Renna et al. (2008), Trogdon et al. (2008) and Loh and Li (2013), we adopt average peers' parental BMI as instruments and our results indicate that average peer effects are positive (e.g., coefficient of 0.368 when using BMI *z*-scores) and significant. We also notice a larger effect of peers when using the broader peer definition (setting) compared to the narrow peer definition (+/- 1 year). We do, however, observe heteroskedasticity (Breusch-Pagan test=121.10, p-value=0.00). The results are available upon request. We do not want to, however, overinterpret these results, because, as pointed out by Cawley and Ruhm (2011), the validity of these instruments is questionable: "friendships could also be selected on the basis of obesity status, with obese youths are relatively likely to have obese parents. This strategy may also suffer from a second-order case of the reflection problem – friend's parents' weight may be affected by friend's weight which in turn may be affected by the respondent's weight" (Cawley and Ruhm, 2011, p. 49).

narrower definition (i.e., children within +/- 1 year). In the case of PBF we even observe a very small negative effect. With regard to the magnitude of the estimated effects, the BMI estimate in the fixed-effects model gives rise to a coefficient of 0.379 (0.142) when using the narrow (broad) peer definition. The corresponding values for waist circumference are 0.540 and 0.100 for the narrow and broad peer definitions, respectively. Thus, when using waist circumference and a narrow definition, a 1-standard deviation increase in the peer group's average BMI (e.g. a movement from mean BMI to the 85th percentile in the underlying growth chart population; or a movement from mean BMI to overweight) goes hand in hand with a 0.54 standard deviation increase in individual BMI (e.g. a movement from mean BMI to about the 70th percentile in the underlying growth chart population). The results based on fat mass and PBF are easier to interpret: a 1kg increase in peer fat mass goes hand in hand with a 235g (89g) increase in individual fat mass when the narrow (broad) peer definition is used (based on the fixed-effects model). A one percentage point increase in PBF corresponds to a 0.163% point increase in individual PBF in the fixed-effects model and when using the narrow definition. In general, the peer effects are smaller in the fixed-effects specification. Interestingly, the waist circumference estimates of the peer effect tend to be significantly larger than those for the BMI estimates, particularly under the narrower peer definition. This finding indicates that using other obesity measures than BMI can give rise to substantially different results. Burkhauser and Cawley (2008) show that, among adults, correlation of obesity with employment is sensitive to the definition of obesity, and that BMI is often less significant that more accurate measures of body fat. The authors attribute this insignificance to the inability of BMI to distinguish between total body fat and fat-free mass. Thus, the more significant and stronger measures obtained with waist circumference (compared to BMI) could be due to the fact that, in the IDEFICS study, waist circumference is a more valid measure of body fatness (Bammann et al., 2013), and therefore better able to distinguish between total body fat and fat-free mass.

Our results are generally in line with Asirvatham et al.'s (2013) study of Arkansan children. Their results show that a twofold increase in the obese proportion among peers in the same grade gives rise to an approximately 0.4 standard deviation increase in individual BMI. However, contrary to Asirvatham et al. (2013), we find no pronounced gender differences among our sample of European children (see appendix table A2). In Peng et al.'s (2014) study for China, peer-effect estimates using BMI z-scores among children aged three to nine are, depending on the specification, between 0.2 and 0.1.

Table 1: Peer effects for the entire sample – pooled OLS and fixed effects

	Pooled OLS		Fixed effects	
	Peer: +/- 1 year	Peer: setting	Peer: +/- 1 year	Peer: setting
BMI z-score				
Peer BMI	0.267***	0.214***	0.379***	0.142***
	(0.044)	(0.056)	(0.037)	(0.020)
95% CI	[0.181,0.353]	[0.104,0.324]	[0.306,0.452]	[0.104,0.181]
Obs.	14,566	16,549	14,566	16,549
F-value	105.31	107.26	12.55	11.71
(p-value)	0.000	0.000	0.000	0.000
adj./overall R-sqr	0.227	0.223	0.048	0.030
Waist circumference *z*-score				
Peer waist	0.403***	0.171***	0.540***	0.100***
	(0.036)	(0.048)	(0.032)	(0.024)
95% CI	[0.332,0.475]	[0.076,0.266]	[0.476,0.603]	[0.053,0.147]
Obs.	13,986	15,795	13,986	15,795
F-value	172.85	119.09	37.14	25.34
(p-value)	0.000	0.000	0.000	0.000
adj./overall R-sqr	0.250	0.239	0.051	0.026
Fat mass (in kg)				
Peer fat	0.698***	0.269***	0.235***	0.089***
	(0.032)	(0.080)	(0.025)	(0.011)
95% CI	[0.635, 0.761]	[0.111, 0.427]	[0.185, 0.284]	[0.068, 0.109]
Obs.	13,001	14,601	13,001	14,601
F-value	236.58	150.52	11.99	13.08
(p-value)	0.000	0.000	0.000	0.000
adj./overall R-sqr	0.390	0.336	0.131	0.051
Percentage body fat (PBF)				
Peer PBF	0.645***	-0.158*	0.163***	-0.032***
	(0.034)	(0.063)	(0.025)	(0.011)
95% CI	[0.579,0.711]	[-0.283,-0.034]	[0.114,0.212]	[-0.055,-0.009]
Obs.	12,549	14,713	12,549	14,713
F-value	133.55	67.71	170.69	221.65
(p-value)	0.000	0.000	0.000	0.000
adj./overall R-sqr	0.285	0.252	0.043	0.0645

Note: Dependent variables are four obesity measures (BMI *z*-scores, waist circumference *z*-scores and fat mass in kg by Bammann et al., 2013, percentage body fat) for children aged 2-9. Pooled OLS regressions include child, family, parental, and socio-economic controls. Fixed-effects model only includes the time-variant controls. Standard error in parentheses. Clustering at the setting level. * p < .05, ** p < .01, *** p < .001

Individualism versus collectivism

One of the unique features of the IDEFICS dataset is that it covers several European regions, making cross-cultural comparisons feasible. Because peer effects may differ among cultures (Mora and Gil, 2013), it is useful to characterize them according to type, with one possibility being individualist versus collectivist. According to Prinstein and Dodge (2008), peer effects may be larger in collectivistic societies: “As a function of culture descriptive constructs such as collectivism and individualism, children are likely to feel different pressures to conform or to be part of the social group. It is possible that the effects of peer influence would be stronger for persons who are sensitive to the collectivistic orientation that may exist in their society. Persons who believe that their culture is characterized by individualism may be more likely to be immune to the effects of peers” (p. 137). According to Hofstede (2001) and Hofstede et al. (2010), Cyprus, Italy,[7] and Spain are primarily collectivist countries, while Belgium, Estonia, Germany, Hungary, and Sweden are predominantly individualist. To shed light on the collectivist versus individualist hypothesis, we run individual country fixed-effects regressions using the narrow peer definition (see table 2). Our results suggest that collectivist societies may indeed be more susceptible to peer effects, an observation best supported by the analysis based on waist circumference: peer effects in the Spanish, Italian, and Cypriot samples are considerably larger than in the samples for most other countries (with the exception of Estonia). The analysis based on BMI and PBF, however, provides only limited support for the hypothesis, and the analysis based on body fat provides none. Overall, however, we note that the estimated peer effects vary substantially both among countries and among the three measures of fatness. Moreover, despite the reasonably large sample sizes, a number of estimates are not statistically significant.[8]

[7] According to the Hofstede classification, Italy as a whole is predominantly individualist; however, Southern Italy (where our data were collected) is mostly collectivist.

[8] This insignificance persists when we use the pooled OLS model instead of the fixed-effects model.

Table 2: Peer effects by country – fixed effects

	Collectivistic			Individualistic				
	ITA	ESP	CYP	BEL	SWE	GER	HUN	EST
				BMI z-score				
Peer BMI	0.440***	-0.033	0.402***	-0.082	0.225	0.192	0.277*	0.609***
	(0.101)	(0.131)	(0.111)	(0.121)	(0.133)	(0.101)	(0.125)	(0.080)
95% CI	[0.242, 0.637]	[-0.289, 0.224]	[0.184, 0.620]	[-0.321, 0.157]	[-0.037, 0.487]	[-0.007, 0.391]	[0.031, 0.523]	[0.453, 0.766]
Obs.	2,501	1,717	1,219	1,671	2,194	1,270	2,007	1,987
F-value	6.38	5.23	4.04	1.99	1.08	1.74	1.58	3.53
(p-value)	0.000	0.000	0.000	0.000	0.120	0.000	0.000	0.000
overall R-sqr	0.137	0.138	0.183	0.093	0.024	0.108	0.073	0.095
				Waist circumference z-score				
Peer waist	0.662***	0.624***	0.545***	0.278*	0.264**	0.281*	0.267**	0.622***
	(0.080)	(0.095)	(0.139)	(0.113)	(0.099)	(0.110)	(0.095)	(0.079)
95% CI	[0.505, 0.818]	[0.437, 0.811]	[0.271, 0.819]	[0.056, 0.500]	[0.071, 0.458]	[0.064, 0.498]	[0.080, 0.455]	[0.467, 0.776]
Obs.	2,438	1,670	1,183	1,553	2,012	1,252	1,997	1,881
F-value	12.42	7.62	1.94	5.03	4.79	10.00	4.76	8.04
(p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
overall R-sqr	0.243	0.195	0.101	0.219	0.110	0.421	0.192	0.212
				Fat mass (in kg)				
Peer fat	0.079	0.029	0.530***	0.159*	0.149*	0.207**	0.147*	0.332***
	(0.059)	(0.117)	(0.095)	(0.070)	(0.070)	(0.071)	(0.068)	(0.071)
95% CI	[-0.036, 0.195]	[-0.201, 0.258]	[0.343, 0.716]	[0.022, 0.296]	[0.011, 0.286]	[0.066, 0.348]	[0.013, 0.281]	[0.192, 0.473]
Obs.	2,336	1,679	1,056	1,417	1,875	1,204	1,768	1,666
F-value	1.44	0.91	5.26	2.64	3.99	4.43	1.28	6.15
(p-value)	0.000	0.906	0.000	0.000	0.000	0.000	0.003	0.000
Overall R-sqr	0.037	0.028	0.245	0.133	0.107	0.246	0.062	0.173
				Percentage body fat (PBF)				
Peer PBF	0.230***	-0.175	0.552***	0.185	0.222*	0.143	0.196*	-0.009
	(0.053)	(0.091)	(0.094)	(0.101)	(0.099)	(0.107)	(0.076)	(0.078)
95% CI	[0.126, 0.334]	[-0.353, 0.004]	[0.366, 0.737]	[-0.014, 0.384]	[0.028, 0.416]	[-0.067, 0.353]	[0.046, 0.346]	[-0.162, 0.144]
Obs.	2,100	1,660	1,082	1,675	1,425	1,608	1,219	1,780
F-value	52.18	21.01	28.90	39.06	22.15	18.10	42.68	15.80
(p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Overall R-sqr	.057	.041	.039	.076	.023	.087	0.001	0.028

Note: Dependent variables are four obesity measures (BMI *z*-scores, waist circumference *z*-scores and fat mass in kg by Bammann et al., 2013, percentage body fat) for children aged 2-9. Fixed-effects model only includes the time-variant controls. The regions are: Belgium: Geraardsbergen and Aalter; Cyprus: Strovolos and Paphos; Estonia: Tartu and Tallinn; Germany: Delmenhorst and Wilhelmshaven; Hungary: Pecs and Zalaegerszeg; Italy: Atripalda/Monteforte I/Volturara I and Avellino/Forino/Pratola Serra; Spain: Zaragoza 1. District and Huesca; Sweden: Partille and Alingsas/Mölndal. Standard error in parentheses. * p < .05, ** p < .01, *** p < .001

Effect of peers on parental perceptions

As in several other studies (see Parry et al., 2008, for a meta-analysis), our results also confirm a clear disconnect in parental perceptions of their child's weight status. According to the descriptive statistics for all children in both waves (see table 3), only 14% of the parental perceptions correctly identified obesity in their child, while over half misperceived overweight.

Table 3: Parental (mis)perceptions of child weight

BMI categories		Parental perceptions					
		Much too underweight	Slightly underweight	Proper weight	Slightly overweight	Much too overweight	Total
Thin	N	208	1,278	1,239	9	1	2,735
	% row	7.61	46.73	45.30	0.33	0.04	100.00
	% col	56.99	30.52	6.93	0.28	0.34	10.52
Normal weight	N	140	2,777	14,358	479	6	17,76
	% row	0.79	15.64	80.84	2.70	0.03	100.00
	% col	38.36	66.31	80.30	14.66	2.02	68.31
Overweight	N	3	76	2,055	1,501	36	3,671
	% row	0.08	2.07	55.98	40.89	0.98	100.00
	% col	0.82	1.81	11.49	45.93	12.12	14.12
Obese	N	14	57	229	1,279	254	1,833
	% row	0.76	3.11	12.49	69.78	13.86	100.00
	% col	3.84	1.36	1.28	39.14	85.52	7.05
Total	N	365	4,188	17,881	3,268	297	25,999
	% row	1.40	16.11	68.78	12.57	1.14	100.00
	% col	100.00	100.00	100.00	100.00	100.00	100.00

Note: Data are from the pooled sample of children. BMI categories are defined according to Cole (2012). The yellow shaded areas depict observations where parents perceive their children as thinner than they actually are. Green shaded areas depict observations where parents perceive their children as fatter than they actually are.

These misperceptions are clearly tied to peer weight. According to the logit estimates of the relation between average peer fatness and parental perceptions of their child's weight (table 4), a larger probability of parents perceiving their child as thinner than he or she really is (with odds ratios ranging from 1.046 to 1.280) goes hand in hand with higher levels of peer fatness. This result, however, applies only to the narrow peer definition and is particularly pronounced in parents' perceptions of their boys (see appendix table A3). When using BMI as our measure of fatness, we also observe a significant negative association between peer's BMI and the probability of parents perceiving their children as fatter than they are. That is, the lower the peer's BMI, the more likely that parents will consider their child fatter than he or she actually is.

Table 4: Peer effects and parental misperceptions – logit model

	Weight perception: thinner		Weight perception: fatter	
	Peer: +/- 1 year	Peer: setting	Peer: +/- 1 year	Peer: setting
BMI z-score				
Peer BMI	1.280***	1.027	0.587***	0.630**
	(0.088)	(0.076)	(0.078)	(0.106)
95% CI	[1.119,1.464]	[0.889,1.187]	[0.452,0.761]	[0.453,0.875]
N	14,566	16,549	14,566	16,549
Ll	-7,474	-8,493	-3,408	-3,989
df_m	34	34	34	34
Aic	15,017	17,057	6,888	8,048
Bic	15,283	17,327	7,153	8,318
Waist circumference *z*-score				
Peer waist	1.221***	1.024	0.935	0.989
	(0.068)	(0.069)	(0.105)	(0.154)
95% CI	[1.094,1.362]	[0.897,1.170]	[0.751,1.165]	[0.729,1.341]
N	14,566	16,549	14,566	16,549
Ll	-7,474	-8,493	-3,424	-4,000
df_m	34	34	34	34
Aic	15,019	17,057	6,919	8,071
Bic	15,285	17,327	7,184	8,341
Fat mass (in kg)				
Peer fat	1.046**	1.024	0.952	0.937
	(0.016)	(0.022)	(0.031)	(0.037)
95% CI	[1.015,1.078]	[0.981,1.068]	[0.894,1.014]	[0.866,1.013]
N	14,367	16,339	14,367	16,339
ll	-7,365	-8,371	-3,353	-3,940

df_m	34	34	34	34
aic	14,800	16,811	6,776	7,951
bic	15,065	17,081	7,041	8,220
Percentage body fat (PBF)				
Peer PBF	1.039***	1.024	0.970*	1.001
	(0.007)	(0.022)	(0.013)	(0.011)
95% CI	[1.025,1.053]	[0.981,1.068]	[0.945,0.995]	[0.979,1.023]
N	13,922	16,339	13,922	16,473
Ll	-7,134	-8,447	-3,268	-3,978
df_m	34	34	34	34
Aic	14,337	16.9611	6,604	8,024
Bic	14,594	17,223	6,860	8,286

Note: Dependent variable in the first two (last two) columns has a value equal to “1” if the parent perceives the child to be thinner (heavier) than it actually is; zero otherwise. Odd ratios are presented in the table. The analysis is conducted for children aged 2-9. Regressions include child, family, parental, and socio-economic controls. Standard error in parentheses. Clustering at the setting level. * $p < .05$, ** $p < .01$, *** $p < .001$

These results support the notion that peer fatness affects parental perceptions; that is, in forming their perceptions of their own child’s weight, parents make comparisons with their children’s friends and classmates, a phenomenon also observed in the qualitative study by Jones et al. (2012).

5 Conclusions

This paper uses data on more than 14,000 children aged two to nine in 16 regions of eight European countries from the first two waves of the IDEFICS survey in order to analyze the effects that peers may have on child obesity. Scant empirical evidence of peer effects in Europe exists, and we are only aware of one study (Mora and Gil, 2013) that addresses peer effect on adolescents in Spain. Furthermore, we are only aware of two non-European studies that analyze the effects that peers may have on *child* obesity (namely Peng et al., 2014 and Asirvatham, 2013). This is surprising as there is ample research in many disciplines that show effects of peers on several child behaviors and outcomes including school achievement (Burke and Sass, 2013), eating behavior and physical activity (Salvy et al., 2012). The main reason for this dearth of research on children is the lack of adequate data. The IDEFICS study is one of the few large-scale surveys that collects reliable information on child obesity. Our results in fact show that, even after we control for a rich set of covariates and unobserved heterogeneity, a child’s fatness is related to the average fatness of the same-sex similarly aged children in the same school. Although we cannot rule out an upward bias from the reflection issue despite our use of broad peer definitions and fixed-effects estimations to mitigate this problem, our findings still provide clear support for the existence of peer effects in the European sample.

Another unique feature of the IDEFICS dataset is that it provides strong objective measures of child fatness, including waist circumference, imputed body fat, and percentage body fat. The inclusion of these additional measures provides clear evidence that different measures give rise to different results, with waist circumference generally producing larger peer effect estimates than BMI. The fact that the IDEFICS study covers several regions in eight European countries also allows a useful cross-cultural comparison of peer effects, which shows substantial variation among the regions, with generally larger effects in the Spanish, Italian, and Cypriot regions than in the German, Swedish, Belgian, and Hungarian areas. One tentative explanation for this observation – and one in line with the hypotheses put forward by Mora and Gil (2013) and Prinstein and Dodge (2008) – is that peer pressure may be larger in more collectivist societies.

Little is known about the mechanisms of peer effects among children. Do they, for example, work through "peer pressure", leading children to imitate peers' eating and physical activity behavior, or do peers simply influence changes in individuals' general perceptions of the social norms for obesity's acceptability (Salvy et al., 2012)? In this paper, we throw some light on this aspect by examining the association between peer fatness and parental perceptions of their own children's weight. We show that increases in peer fatness go hand in hand with a higher probability of parents misperceiving their children as being thinner than they actually are. Although our analysis cannot claim to show a causal link between these misperceptions and peer fatness, it supports existing evidence that parents tend to assess their offspring's weight based on comparisons with their children's friends and classmates.

Identifying and understanding peer effects on child obesity is extremely important, not only because of ample evidence that childhood obesity persists into adulthood (Guo and Chumlea, 1999) but because healthy lifestyles (including eating habits and adequate physical activity) are formed at young ages and continue into adolescence and adulthood. In addition, knowing how and to what extent peers influence lifestyle choices in different cultural setting raises many interesting questions for further investigation.

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Appendix

Table A1: Descriptive statistics (pooled sample)

Variable	Obs.	Mean	Std. Dev.
Weight status			
BMI z-score	27,341	0.310	1.362
Waist circumference z-score	25,964	0.383	1.379
Fat mass (kg)	23,650	4.051	3.571
Percentage body fat (%)	23,650	13.986	9.006
Weight perception			
Thinner (dummy)	27,345	0.242	0.429
Fatter (dummy)	27,345	0.104	0.305
Peer weight status			
Peer BMI (+/- 1 year)	23,927	0.335	0.563
Peer BMI (Setting)	27,344	0.310	0.380
Peer waist circumference (+/- 1 year)	23,927	0.383	0.641
Peer waist circumference (Setting)	27,344	0.380	0.419
Peer fat mass (+/- 1 year)	23,521	4.034	2.102
Peer fat mass (Setting)	27,037	4.010	1.250
Peer percentage body fat (+/- 1 year)	22,694	13.738	4.637
Peer percentage body fat (setting)	27,033	11,925	4.962
Child characteristics			
Age child (years)	27,345	6.401	2.077
Sex child (dummy)	27,344	0.497	0.500
Audiovisual media time (hours/week)	25,115	12.694	7.517
Siblings: older (#)	27,344	0.615	0.835
Siblings: same age (#)	27,344	0.037	0.205
Siblings: younger (#)	27,344	0.437	0.639
Siblings: none (dummy)	27,344	0.111	0.314
Country of birth child	26,736	0.017	0.129
Birth factors			
Birth weight	25,513	3334,229	569,450
Premature birth (dummy)	26,127	0.271	0.444
Breastfed (dummy)	25,151	0.524	0.499
Respiratory problems	27,344	0.029	0.166
Infection	27,344	0.024	0.154
Jaundice	27,344	0.121	0.326
Mother age at birth	24,492	29.314	5.033
Weight gain during pregnancy	23,963	14.240	6.038
Pregnancy: smoking	27,344	0.129	0.335
Parental characteristics			
Age mother	25,973	36.143	5.432
Age father	23,931	39.049	5.995
BMI mother	25,207	23.904	4.292
BMI father	22,528	26.470	3.662
Country of birth mother	26,712	0.074	0.262
Country of birth father	26,650	0.069	0.253
ISCED (max in household)	25,910	3.900	1.200

Household monthly net income	23,492	5.478	2.458
Country			
Italy	27,344	0.140	0.347
Estonia	27,344	0.121	0.326
Cyprus	27,344	0.145	0.352
Belgium	27,344	0.121	0.327
Sweden	27,344	0.122	0.327
Germany	27,344	0.110	0.313
Hungary	27,344	0.141	0.348
Spain	27,344	0.100	0.300

Table A2: Peer effects by gender – pooled OLS and fixed effects

Model (2) controls	Pooled OLS				Fixed Effects			
	Peers: +- 1year		Peers: setting		Peers: +- 1year		Peers: setting	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
BMI z-score								
Peer BMI	0.177**	0.338***	0.171**	0.250***	0.389***	0.382***	0.133***	0.152***
SE	(0.064)	(0.057)	(0.063)	(0.069)	(0.055)	(0.052)	(0.028)	(0.028)
CI95	[0.051,0.304]	[0.226,0.449]	[0.048,0.294]	[0.115,0.385]	[0.281,0.496]	[0.279,0.485]	[0.078,0.189]	[0.098,0.206]
Obs.	7139	7427	8159	8390	7139	7427	8159	8390
F-value	72.28	76.28	66.82	62.70	6.99	7.57	5.85	7.44
(p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
adj. R-sqr	0.213	0.244	0.212	0.235	0.059	0.061	0.044	0.053
Waist circumference z-score								
Peer waist	0.387***	0.409***	0.213***	0.114*	0.552***	0.547***	0.132***	0.066*
SE	(0.049)	(0.046)	(0.056)	(0.058)	(0.046)	(0.046)	(0.035)	(0.033)
CI95	[0.290,0.484]	[0.318,0.500]	[0.102,0.323]	[0.001,0.228]	[0.461,0.642]	[0.458,0.636]	[0.063,0.202]	[0.001,0.130]
Obs.	6876	7110	7797	7998	6876	7110	7797	7998
F-value	85.50	118.21	67.51	81.93	19.20	24.13	12.88	17.16
(p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
adj. R-sqr	0.226	0.272	0.220	0.255	0.156	0.183	0.097	0.124
Fat mass (in kg)								
Peer fat	0.677***	0.710***	0.218**	0.313***	0.226***	0.240***	0.080***	0.096***
SE	(0.036)	(0.038)	(0.080)	(0.085)	(0.038)	(0.035)	(0.015)	(0.015)
CI95	[0.607,0.748]	[0.636,0.784]	[0.060,0.376]	[0.145,0.480]	[0.151,0.300]	[0.171,0.310]	[0.051,0.108]	[0.066,0.126]
Obs.	6367	6634	7191	7410	6367	6634	7191	7410
F-value	136.92	166.27	101.73	86.98	4.81	9.27	5.37	10.18
(p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
adj. R-sqr	0.388	0.369	0.340	0.311	0.049	0.083	0.044	0.080

Note: Dependent variables are four obesity measures (BMI *z*-scores, waist circumference *z*-scores and fat mass in kg by Bammann et al., 2013, percentage body fat) for children aged 2-9. Pooled OLS regressions include child, family, parental, and socio-economic controls. Fixed-effects model only includes the time-variant controls. Standard error in parentheses. Clustering at the setting level. * p < .05, ** p < .01, *** p < .001

Table A3: Peer effects and parental misperceptions by gender – logit model

	Weight perception: thinner				Weight perception: fatter			
	Peers: +- 1year		Peers: setting		Peers: +- 1year		Peers: setting	
	girls	boys	girls	boys	girls	boys	girls	boys
				BMI z-score				
Peer BMI	1.190	1.351***	1.038	1.021	0.684**	0.485***	0.764	0.518**
	(0.127)	(0.122)	(0.087)	(0.106)	(0.098)	(0.096)	(0.148)	(0.104)
95% CI	[0.966, 1.467]	[1.132, 1.613]	[0.881, 1.222]	[0.833, 1.252]	[0.518, 0.905]	[0.329, 0.717]	[0.522, 1.118]	[0.350, 0.767]
N	7,139	7,427	8,159	8,390	7,139	7,427	8,159	8,390
Ll	-3,528	-3,922	-4,057	-4,410	-1,790	-1,592	-2,106	-1.856
df_m	33	33	33	33	33	33	33	33
Aic	7,124	7,913	8,181	8,889	3,648	3,253	4,279	3,780
Bic	7,358	8,148	8,420	9,128	3,882	3,488	4,517	4,019
				Waist circumference z-score				
Peer waist	1.111	1.322***	1.044	0.993	1.167	0.722	1.292	0.707
	(0.093)	(0.112)	(0.079)	(0.102)	(0.156)	(0.126)	(0.197)	(0.175)
95% CI	[0.943, 1.308]	[1.120, 1.560]	[0.900, 1.210]	[0.812, 1.215]	[0.898, 1.515]	[0.513, 1.017]	[0.959, 1.741]	[0.436, 1.148]
N	7,139	7,427	8,159	8,390	7,139	7,427	8,159	8,390
Ll	-3,529	-3,923	-4,057	-4,410	-1,793	-1,604	-2,105	-1,865
df_m	33	33	33	33	33	33	33	33
Aic	7,126	7,914	8,181	8,889	3,654	3,276	4,279	3,798
Bic	7,359	8,149	8,420	9,128	3,888	3,511	4,517	4,037
				Fat mass (in kg)				
Peer fat	1.031	1.065**	1.015	1.039	0.977	0.897*	0.968	0.883*
	(0.025)	(0.023)	(0.026)	(0.033)	(0.039)	(0.043)	(0.043)	(0.052)
95% CI	[0.983, 1.082]	[1.020, 1.112]	[0.965, 1.067]	[0.976, 1.107]	[0.903, 1.057]	[0.817, 0.985]	[0.887, 1.057]	[0.787, 0.991]
N	7,034	7,333	8,066	8,273	7,034	7,333	8,066	8,273
Ll	-3,468	-3,873	-4,002	-4,342	-1,764	-1,565	-2,084	-1,829
df_m	33	33	33	33	33	33	33	33
Aic	7,005	7,814	8,072	8,752	3,596	3,197	4,236	3,725
Bic	7,238	8,048	8,310	8,990	3,829	3,432	4,474	3,964
				Percentage body fat (PBF)				
Peer PBF	1.030**	1.047***	1.003	1.000	0.987	0.942**	1.015	0.973
	(0.011)	(0.011)	(0.005)	(0.009)	(0.016)	(0.020)	(0.013)	(0.017)
95% CI	[1.008,	[1.026,	[0.992,	[0.983,	[0.956,	[0.904,	[0.989,	[0.973,

	1.052]	1.069]	1.013]	1.017]	1.019]	0.981]	1.040]	1.007]
N	6,848	7,074	8,124	8,349	6,848	7,074	8,124	8,349
Ll	-3,372	-3,740	-4,030	-4,390	-1,718	-1,527	-2,112	-1,839
df_m	33	33	33	33	33	33	33	33
Aic	6,810	7,546	8,126	8,846	3,502	3,120	4,289	3,744
Bic	7,036	7,772	8,357	9,078	3,727	3,347	4,520	3,976

Note: Dependent variable in the first four (last four) columns has a value equal to “1” if the parent perceives the child to be thinner (heavier) than it actually is; zero otherwise. Odd ratios are presented in the table. The analysis conducted for children aged 2-9. Regressions include child, family,parental, and socio-economic controls. Standard error in parentheses. Clustering at the setting level. * $p < .05$, ** $p < .01$, *** $p < .001$