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Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2013-004502
Article Type:	Research
Date Submitted by the Author:	19-Nov-2013
Complete List of Authors:	Biehl, Anna; Norwegian Institute of Public Health, Division of Epidemiology Hovengen, Ragnhild; Norwegian Institute of Public Health, Division of Epidemiology Grøholt, Else-Karin; Norwegian Institute of Public Health, Division of Epidemiology Hjelmesæth, Jøran; Vestfold Hospital Trust, The Morbid Obesity Center; Faculty of Medicine, University of Oslo, Department of Endocrinology, Morbid Obesity and Preventive Medicine Strand, Bjorn; Norwegian Institute of Public Health, Division of Epidemiology Meyer, Haakon; Norwegian Institute of Public Health, Division of Epidemiology; Faculty of Medicine, University of Oslo, Department of Community Health
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Paediatrics
Keywords:	EPIDEMIOLOGY, PUBLIC HEALTH, Community child health < PAEDIATRICS

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Keywords: child, overweight, obesity, marital status, Body Mass Index, waist circumference, abdominal obesity, epidemiology, anthropometry

Word count: 2756 words

Abstract

Background

Socio-demographic changes in Norway and other western industrialised countries, including family structure and an increasing proportion of cohabiting and divorced parents, might affect the prevalence of childhood overweight and obesity. We aimed to examine whether parental marital status was associated with general- and abdominal obesity among children. We also sought to explore whether the associations differed by gender.

Methods

Height, weight and waist circumference were measured in 3166 third graders (mean age 8.3years) in the nationally representative Norwegian Child Growth-study of 2010. The main outcome measures were general overweight (including obesity) (BMI≥25kg/m^2) using IOTF cut-offs and abdominal obesity (waist-to-height ratio≥0.5) by gender and parental marital status. Prevalence ratios, adjusted for possible confounders, were calculated by log-binomial regression.

Results

General overweight (including obesity) was 1.54 (95 % confidence interval (CI): 1.21-1.95) times more prevalent among children of divorced parents compared to children of married parents, and the corresponding prevalence ratio for abdominal obesity was 1.89 (95 % CI: 1.35-2.65). Formal tests of the interaction term parental marital status by gender were not statistically significant. However, in gender-specific analyses the association between parental marital status and adiposity measures was only statistically significant in boys (p=0.04 for general overweight (including obesity) and p=0.01 for abdominal obesity). The estimates were robust against adjustment for maternal education, family country background and current area of residence.

Conclusion

General- and abdominal obesity were more prevalent among children of divorced parents. This study provides valuable information by focusing on societal changes in order to identify vulnerable groups.

Strengths and limitations of the study

- This study is representative of the Norwegian population of 8 year-old children.
- Anthropometric data were objectively measured; additionally accompanied by register-based data of parental marital status, maternal education and family country background.
- Data on parental marital status was a “snapshot” of current status with no further information of how long the parents had been married, cohabiting or divorced.
- There were no data on physical activity or diet, which could have contributed to further elucidate the differences.

Introduction

Childhood obesity has major public health implications.(1) The factors accounting for the burden of overweight and obesity are not yet fully understood.(2) Family structure has undergone major changes over the last few decades, the number of divorces has remained at a high level in Norway since 1980.(3) About 25% of children live either the entirety or some part of their childhood with only one of their biological parents or grow up living in two different homes.(4) Marital conflict and dissolution impact upon the well-being of children and may have implications for the future health status of children.(5, 6) Recent studies have reported an association between family structure and childhood overweight and obesity, suggesting that living with either only one parent or divorced parents increases the risk of childhood overweight and obesity.(7-9)

The fact that in recent decades there have been large socio-demographic changes in Norway and in Western countries generally, with an increasing proportion of cohabiting and divorced parents, makes it important to examine the impact these changes have had on childhood overweight and obesity. An additional concern is that over the past few decades waist circumference has exceeded trends in body mass index (BMI) in both child- and adult populations.(10-12) This is important because a more central distribution of fat, measured as waist circumference, is associated with metabolic complications.(13, 14) The current study supplements this literature providing insight into the association between family structure and the prevalence of both general and abdominal obesity.

Using data from a nationally representative study, our primary objective was to examine the association between parental marital status and general overweight and obesity in addition to abdominal obesity among Norwegian third graders (8-9 years old). In addition, we explored whether there were gender differences within these associations, and whether the main associations were independent of maternal education, family country background and area of residence.

Methods

Cross-sectional data from the Norwegian Child Growth Study (NCG) were used.(15) NCG followed the protocol of the WHO Childhood Obesity Surveillance Initiative (COSI),(16) which has previously been described in detail.(17, 18)

Subjects

A nationally representative sample of 3166 third graders (1537 girls and 1629 boys) participated in the 2010 NCG study; mean age 8.3 (SD: 0.3) years. To ensure a national representative sample, a stratified two-stage sampling design was used. The attendance rate was 89 % of all invited children. Data on parental marital status were available for 3137 of the children (99%), whilst additional data on maternal education was available for 2968 of the children (94%).

Data collection

Measurements were performed by trained school nurses at participating schools during October 2010. Each of the scales and stadiometers used in this study were already present at each school, i.e. brand and type model probably differed from one school to another. One SECA measuring tape (SECA GmbH Hamburg, Germany) was distributed to each participating school. All school nurses were trained in anthropometric measures according to standardised procedures, which were explained and illustrated in a booklet specially developed for the NCG. Correction values were collected for each instrument involved in the survey and the measures of each child were corrected.(17, 18)

Anthropometric measurements

Body weight and height were measured with the children wearing light indoor clothing and without shoes, and were recorded to the nearest 0.1 kg and 0.1 cm respectively.(19) Measures were corrected if the child wore items other than light indoor clothing: plus 100 grams for some additional light clothing or plus 500 grams for heavier clothing. BMI was calculated as weight/height^2 (kg/m^2) and children were classified as overweight (including obesity) based on age- and gender specific cut-off values for BMI for children as developed by the International Obesity Task Force (IOTF) (20) and the WHO definitions for children aged 5-19.(21) Waist circumference (WC) was measured to the nearest 0.1 cm with arms hanging relaxed along the body with a measuring tape midway between the lower rib margin and the iliac crest.(19) Waist-to-height ratio (WHtR) was calculated as waist circumference/height (cm/cm). At data entry, height, weight and WC were entered twice, with any punching errors corrected.

Outcome variables

The continuous outcome variables included weight, height, WC, BMI and WHtR. The main outcomes were the categorical variables overweight (including obesity) (BMI≥25 kg/m^2) referred to as *general overweight and obesity* and waist-to-height ratio ≥ 0.5 (WHtR≥0.5) referred to as *abdominal obesity*. *Adiposity* is used occasionally and refers to both general overweight and obesity, and abdominal obesity.

Explanatory variables

Data on parental marital status were obtained from the National Population Registry and compiled by Statistics Norway. Data were linked using the unique 11-digit personal identification code assigned to all Norwegian residents. Parental marital status was categorised into three groups: married; never-married (including cohabiting, single and separated parents); divorced.(22)

Data on highest attained maternal education was obtained from the National Education Database and categorised according to the Norwegian Standard Classification of Education (NUS2000) into three levels: tertiary; secondary; primary (18).

Family country background was classified in three groups: Norwegian/Scandinavian; Non-Western; Western (other than Norwegian/Scandinavian). Area of residence was classified as: urban; semi-urban; rural.(18)

Statistical analyses

Mean and standard deviation for the continuous variables were reported for all children, and gender stratified. Crude prevalence of general overweight and obesity, and abdominal obesity were calculated with 95% confidence intervals (95% CI). Comparisons of difference in anthropometric characteristics between subgroups were performed by F-test for continuous variables and Pearson chi-square test for categorical variables. As a recommended alternative for logistic regression in cross-sectional studies,(23) we used generalised linear models (log-binomial regression) with a logarithmic link function to calculate prevalence ratio (PR) and with an identity link function to calculate prevalence differences. It is especially when the outcome is common (> 10 %) that odds ratio overestimates the PR. The effect of parental marital status on adiposity in boys and girls was tested in the regression models by the inclusion of the interaction terms parental marital status by gender. Statistical analyses were performed using STATA 12 and with survey-prefix command (svy) to take into account the complex two stage sampling procedure. A p-value <0.05 was considered statistically significant.

Ethics

NCG was approved by the Regional Committee for Medical Research Ethics and by the Norwegian Data Inspectorate. Consent forms and detailed information about the study were sent to parents/guardians beforehand. Written informed consent was obtained from a parent/legal guardian via the school nurse prior to the study.

Results

As previously reported, the prevalence of general overweight (including obesity) according to IOTF definitions was 19.0 % and according to WHO definitions the prevalence was 28.6 %, whilst 8.9 % had abdominal obesity. Overall, general overweight (including obesity) was significantly more prevalent among girls compared to boys (p-value for difference=0.03), whereas there was no gender difference for abdominal obesity (p-value=0.82).(18)

In gender collapsed analyses all the mean values of the anthropometric measures were significantly higher for children of divorced parents compared to children of married parents, except for height (table 1). In gender specific analyses, however, these differences were generally larger for boys than girls, and reached statistical significance only among boys; weight (p=0.04) and WC (p=0.03). The same pattern was found in terms of the categorical variables; in gender specific analyses the difference between children of married and divorced parents was only significantly different among boys (table 2).

Children of divorced parents had a 54% higher prevalence (95% CI 21% - 95%) of general overweight (including obesity) and 89% higher prevalence (95% CI 35% - 165%) of abdominal obesity compared to children of married parents (table 2), whereas children of never-married parents had a similar prevalence to children of married parents. Adjustment for maternal education and gender only slightly attenuated the associations, which indicate that maternal education and gender did not explain the association between parental marital status and childhood overweight and obesity. Similarly, the estimates were essentially unchanged after controlling for socio-demographic factors such as family's country background and their area of residence (data not shown). The crude anthropometric measures by parental marital status were essentially equal in the full sample (N=3137) and in the reduced sample with non-missing maternal education (N=2968), indicating that the reduced sample is representative of the full sample.

Gender stratified analyses, adjusting for maternal education, showed that boys with divorced parents had a 63% higher prevalence (95 % CI 11% -139%) of general overweight (including obesity) compared to boys of married parents (table 2), with the absolute difference being 9.9 percentage points. Correspondingly, the prevalence of abdominal obesity was 104% higher (95 % CI 23% - 237%) among boys with divorced parents compared to boys of married parents (table 2), and the absolute difference was 7.4 percentage points. The same pattern was seen among girls, but the associations were less pronounced and not statistically significant. The differences between marital status categories and gender are illustrated in figures 1 and 2, suggesting that boys of divorced parents were particularly prone to abdominal obesity. However, formal tests of the interaction term parental marital status and gender was only borderline significant for WC (p=0.06), and not significant for BMI (p=0.26), WHtR (p=0.13), general overweight (including obesity) (p=0.36) and abdominal obesity (p=0.27).

Table 1: Anthropometric characteristics by parental marital status, presented as mean and standard deviation (SD), for all children and boys and girls separately.

	Married	Never-married		Divorced	
	mean (SD)	mean (SD)		mean (SD)	
ALL CHILDREN	n=2004	n=903		n=230	
			p-value [a]		p-value [b]
Height (cm)	131.8 (6.0)	131.7 (5.6)	0.48	132.5 (6.4)	0.39
Weight (kg)	29.4 (5.7)	29.4 (5.2)	0.76	30.8 (6.5)	0.02
BMI (kg/m2)	16.8 (2.4)	16.9 (2.2)	0.96	17.4 (2.8)	0.03
Waist (cm)	58.3 (6.1)	58.4 (5.7)	0.48	60.3 (7.6)	<0.01
WHtR	0.44 (0.04)	0.44 (0.04)	0.48	0.46 (0.05)	0.02
BOYS	n=1017	n=470		n=121	
			p-value [a]		p-value [b]
Height (cm)	132.4 (5.9)	131.9 (5.6)	0.16	133.8 (6.3)	0.12
Weight (kg)	29.6 (5.8)	29.2 (5.1)	0.17	31.7 (6.8)	0.04
BMI (kg/m2)	16.8 (2.5)	16.7 (2.2)	0.59	17.6 (2.9)	0.12
Waist (cm)	58.8 (6.2)	58.4 (5.5)	0.18	61.4 (8.0)	0.03
WHtR	0.44 (0.04)	0.44 (0.04)	0.49	0.46 (0.05)	0.08
GIRLS	n=987	n=433		n=109	
			p-value [a]		p-value [b]
Height (cm)	131.1 (6.0)	131.4 (5.5)	0.71	131.1 (6.1)	0.75
Weight (kg)	29.1 (5.6)	29.5 (5.3)	0.56	29.9 (6.2)	0.47
BMI (kg/m2)	16.8 (2.3)	17.0 (2.2)	0.51	17.3 (2.6)	0.37
Waist (cm)	57.7 (5.9)	58.5 (5.8)	0.21	59.2 (6.9)	0.19
WHtR	0.44 (0.04)	0.44 (0.04)	0.17	0.45 (0.05)	0.17

[a]) p-value for differences between Married and Never-married, [b]) p-value for differences between Married and Divorced

Table 2: General overweight and obesity (BMI ≥ 25 kg/m^2) according to IOTF and abdominal obesity (waist-to-height ratio ≥0.5), presented as prevalence (%) and prevalence ratio (95 % CI) by marital status, crude and adjusted, for all children and separately for boys and girls.

			CRUDE			ADJUSTED	
		n=	Prevalence (%)	PR	(95 % CI)	PR	(95 % CI)
			GENERAL OVERWEIGHT AND OBESITY				
	All children (N=3137)		19.0				
PARENTAL MARITAL STATUS							
	Married	2004	18.2	1.00	Ref.	1.00	Ref.
	Never-married	903	18.8	1.03	(0.85 -1.25)	1.03 [a]	(0.84 - 1.26)
	Divorced	230	28.0	1.54	(1.21 -1.95)	1.46 [a]	(1.16 - 1.84)
	p-value		<0.01 [c]	0.01 [d]		0.02 [d]	
PARENTAL MARITAL STATUS							
GENDER SPESIFIC							
BOYS	Married	1017	16.2	1.00	Ref.	1.00	Ref.
	Never-married	470	14.6	0.90	(0.66 - 1.22)	0.94 [b]	(0.69 - 1.28)
	Divorced	121	27.5	1.69	(1.18 - 2.44)	1.63 [b]	(1.11 - 2.39)
	p-value		0.02 [c]	0.04 [d]		0.05 [d]	
GIRLS	Married	987	20.3	1.00	Ref.	1.00	Ref.
	Never-married	433	23.1	1.14	(0.87 - 1.50)	1.10 [b]	(0.82 - 1.47)
	Divorced	109	28.5	1.41	(0.97 - 2.04)	1.34 [b]	(0.91 - 1.98)
	p-value		0.16 [c]	0.19 [d]		0.32 [d]	
			ABDOMINAL OBESITY				
	All children (N=3137)		8.9				
PARENTAL MARITAL STATUS							
	Married	2004	8.5	1.00	Ref.	1.00	Ref.
	Never-married	903	8.2	0.97	(0.71 -1.32)	0.97 [a]	(0.69 - 1.36)
	Divorced	230	16.1	1.89	(1.35 -2.65)	1.76 [a]	(1.26 - 2.45)
	p-value		<0.01 [c]	0.01 [d]		0.02 [d]	
PARENTAL MARITAL STATUS							
GENDER SPESIFIC							
BOYS	Married	1017	8.5	1.00	Ref.	1.00	Ref.
	Never-married	470	6.7	0.79	(0.54 - 1.15)	0.85 [b]	(0.58 - 1.24)
	Divorced	121	19.1	2.24	(1.41 - 3.56)	2.04 [b]	(1.23 - 3.37)
	p-value		<0.001 [c]	0.01 [d]		0.03 [d]	
GIRLS	Married	987	8.5	1.00	Ref.	1.00	Ref.
	Never-married	433	9.8	1.16	(0.69 - 1.95)	1.07 [b]	(0.60 - 1.92)
	Divorced	109	12.8	1.51	(0.78 - 2.95)	1.48 [b]	(0.77 - 2.86)
	p-value		0.42 [c]	0.45 [d]		0.47 [d]	

[a]) adjusted for maternal education and gender, [b]) adjusted for maternal education, [c]) Chi-square test and [d]) test for overall p-value for differences between categories

Figure 1: Crude prevalence ratio (PR) of general overweight and obesity by parental marital status separately for boys and girls, where boys with married parents are the reference category, presented with 95% confidence intervals (95% CI).

Figure 2: Crude prevalence ratio (PR) of abdominal obesity by parental marital status separately for boys and girls, where boys with married parents are the reference category, presented with 95% confidence intervals (95% CI).

Discussion

In this nationally representative study we found that general overweight and obesity, and abdominal obesity were more prevalent among children of divorced parents compared with children of married parents. Our findings were robust to adjustments for maternal education, family country background and current area of residence. Although formal tests of the interaction terms parental marital status by gender were not statistically significant, gender stratified analyses showed that the prevalence of general- and abdominal obesity was significantly higher only amongst boys of divorced parents, compared to boys with married parents.

The study has several limitations which ought to be considered when interpreting its findings. First, data on parental marital status were limited to a "snapshot" of current status. For example, we had no information as to how long parents had been divorced. Further, the never-married category was heterogeneous and contained a diversity of family constellations, such as intact cohabiting relationships and dissolved relationships. More detailed information would have been beneficial to the study. Secondly, an obvious limitation is that our cross-sectional design provided no basis for studying causality; whether the development of overweight and obesity was initiated before the divorce or whether the impact on the children's weight status was primarily attributed to marital conflict or the divorce. Thirdly, one cannot exclude the possibility that a higher proportion of overweight children were absent from school on the day measurements were taken and were therefore overrepresented among non-participants, which in turn could imply that children of divorced parents were underrepresented in NCG, as previously stated.(24) If so, the associations shown in this study could be underestimated. But, given that the children were recruited into the NCG by the school health service, selection bias is most likely not a big issue in our study. Finally, the explanatory variables are few in the current study, with no information on e.g. physical activity level or dietary behaviour among the children, meaning that we cannot further explore our findings. On the other hand, high attendance rate was given high priority in NCG. In order to avoid non-participation parents were thus not requested to fill in time-consuming questionnaires. Few explanatory variables could therefore be considered an advantage for the current study. Another obvious strength is that, to the best of our knowledge, this is the first study with objectively measured and systematically collected anthropometric data of a nationally representative sample, and is accompanied by register-based data on parental marital status, parents' level of education, area of residence and country background for each child. Moreover, the NCG study has a high attendance rate (89 %).

Our finding that parental divorce is associated with childhood overweight and obesity is consistent with previous studies.(7-9) Few other studies have studied gender-differences, but one Australian study found an opposite gender-pattern, though the gender specific associations were not statistically significant.(9) A Norwegian study concluded that single parent families were not significantly associated with overweight and obesity among children aged 2-19 years.(25) The divergent findings

most probably reflect a lack of agreement in terms of categorisation.The dichotomisation of marital status does not tell whether a single-parent family is the result of divorce, separation or death, or indeed whether a two-parent family are cohabiting or married. Accordingly, it does not form a solid basis for examining whether changing family structures or "divorce-stress" during childhood may affect weight-status among children. Other studies have also contained methodological limitations and were either based on small samples, self-reported data, and/or marital status was reported at birth.(26-29) Likewise, a review considering risk factors for childhood overweight and obesity found conflicting evidence for maternal marital status.(30) Only three studies were included, all of which measured marital status at birth.

Further, we found that children of never-married parents shared similar adiposity traits with children of married parents. The similarity most likely reflects the heterogeneity of the never-married-category, as mentioned in the limitation section above. This category could still be interesting to investigate further; a four times higher risk of dissolution of relationship has been shown for cohabiting couples as opposed to married couples,(31) and the proportion of cohabitations compared to marriages has increased steadily since 1980.(4)

The excess risk of adiposity among those with divorced parents remained after adjusting for maternal education, despite the fact that maternal education is the strongest single socio-economic predictor of childhood obesity,(32) and divorced parents are more likely to have lower educational level, as reported by a Norwegian study.(33)

One can speculate as to whether the changing structure of daily life has a large affect upon the children of divorced parents (living with only one parent or spending half their time with the mother and/or the father). The loss of various resources, like the absence of one of the parents or the loss of a parental figure, usually the father, can explain the negative implications of divorce.(6, 34, 35) A practical consequence might be less time for domestic tasks such as cooking and reliance on more convenient, ready-to-eat foods. As processed foods tend to be higher in fat and calories and lower in nutritional value(7) the result is an altered, less healthy diet. The household income and support from any non-custodial parent or the welfare state is often lower than in corresponding non-disrupted families.(36) Consequently, fewer economic resources may be available for divorced parents, which might lead to cheaper and less healthy choices. Other mechanisms affecting children's weight status through divorce (or dissolved relationship) could be related to emotional stress. Disruption in the parent-child relationship, continuing conflict between former spouses or other negative events like moving and the need to establishing new networks could induce emotional stress.(34, 35, 37) It has been shown that adolescents with substantial distress symptoms doubled among those with divorced parents.(37) Such emotional stress may impact upon eating behaviour and physical activity level and thus explain the development and maintenance of childhood overweight and obesity.(7, 38, 39)

The higher prevalence of overweight and obesity among children of divorced parents may also be due to selection. Health, socioeconomic resources, psychological characteristics, values and preferences affect the chance of marrying and remaining married, and has previously been found to account for some of the differences between children of divorced and married parents.(34, 40)

In the present study, children of *separated* parents were categorised together with children of *never-married* parents. From a perspective regarding selection as the main explanation, it could be argued that children of separated parents are miscategorised, since these parents will in the future most likely divorce, and are as such akin to divorced parents. Children of separated parents have most likely already been exposed to parental conflicts. However, children of separated parents have probably had less exposure to conflict and emotional stress compared to children of divorced parents. Because overweight and obesity take time to develop, we consider it is relevant to differentiate between the children of divorced and separated parents.

In this nationally representative study of third graders, we found that general overweight and obesity, and abdominal obesity were more prevalent among children of divorced parents compared to children of married parents. The association remained after adjusting for maternal education, family country background and area of residence. Formal tests of interaction terms parental marital status by gender were not statistically significant. However, our data suggest that boys of divorced parents seem to be particularly prone to abdominal obesity. By focusing on actual societal changes, this study adds valuable background information about potentially vulnerable groups at risk of developing adiposity.

Ethics approval: NCG was approved by the Regional Committee for Medical Research Ethics and by the Norwegian Data Inspectorate.

Acknowledgments: This study is a collaboration between the Norwegian Institute of Public Health and the Morbid Obesity Center (Vestfold Hospital Trust in the South-Eastern Norway Regional Health Authority and funded by South-Eastern Norway Regional Health Authority). The funders had no role in the study design, the interpretation of the data or the decision to submit the article for publication. We would like to thank the children, parents and school health nurses who contributed to the study. Thanks are also due to Øystein Kravdal for advice at an early phase of the study, Jørgen Meisfjord for data management and Matthew McGee for proofreading the final manuscript.

Contributors: RH was responsible for conception of the Norwegian Child Growth Study, and AB was involved in the planning and in the data collection. AB and HM were responsible for the conception of this paper. AB and BHS analysed the data and AB drafted the manuscript. All authors interpreted the data, participated in critical revisions of the paper and approved the final submitted version.

Competing interests: None.

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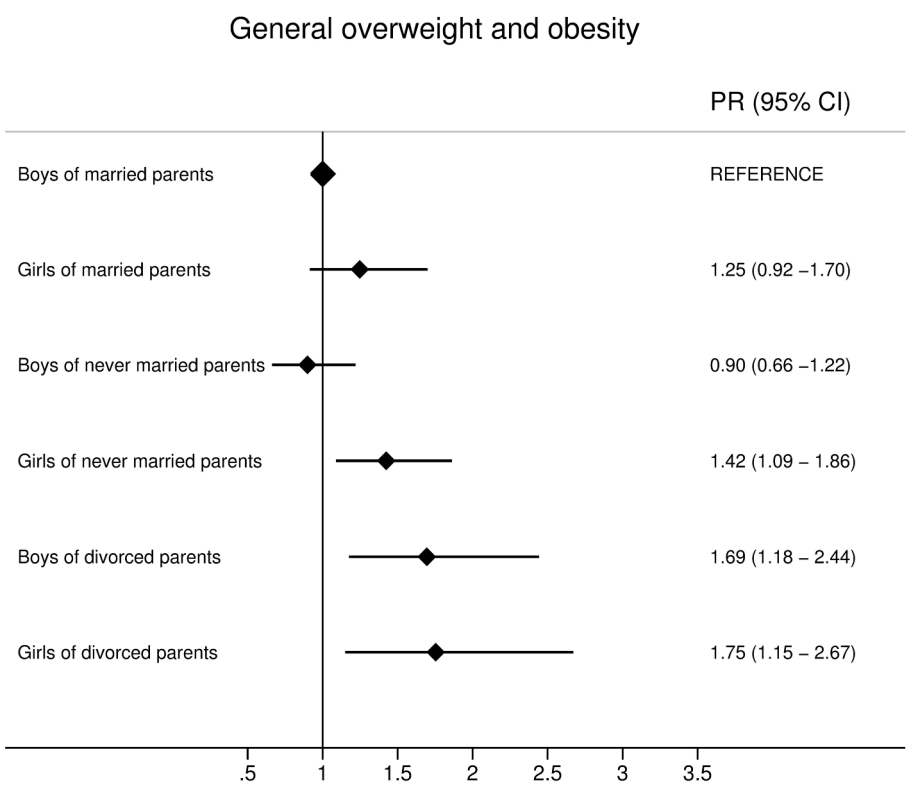

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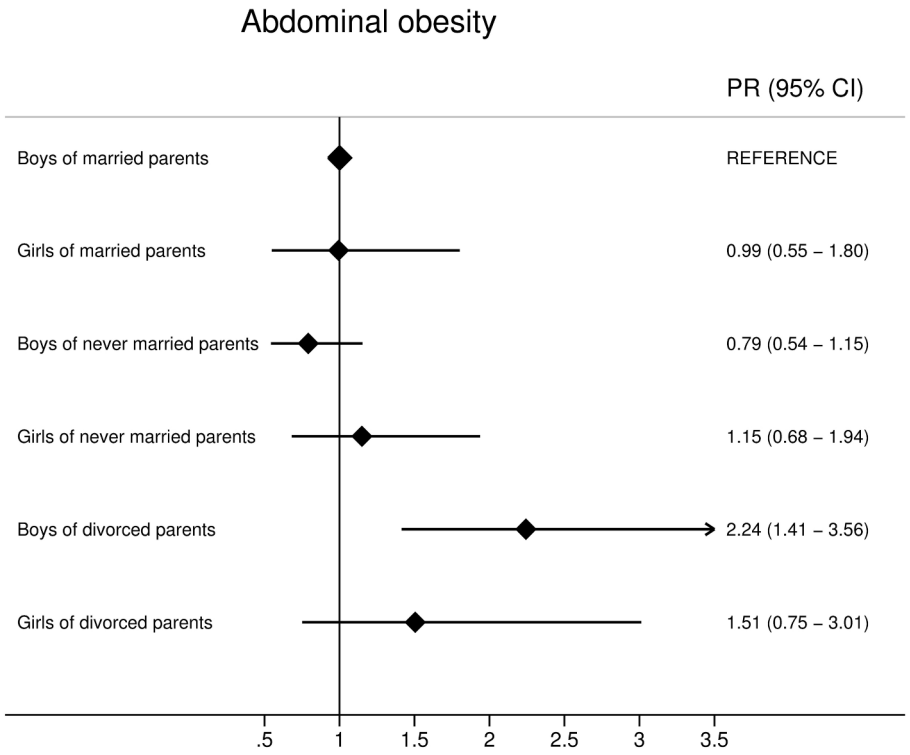

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Parental marital status and childhood overweight and obesity in Norway: A nationally representative cross-sectional study

Journal:	*BMJ Open*
Manuscript ID:	bmjopen-2013-004502.R1
Article Type:	Research
Date Submitted by the Author:	21-Mar-2014
Complete List of Authors:	Biehl, Anna; Norwegian Institute of Public Health, Division of Epidemiology Hovengen, Ragnhild; Norwegian Institute of Public Health, Division of Epidemiology Grøholt, Else-Karin; Norwegian Institute of Public Health, Division of Epidemiology Hjelmesæth, Jøran; Vestfold Hospital Trust, The Morbid Obesity Center; Faculty of Medicine, University of Oslo, Department of Endocrinology, Morbid Obesity and Preventive Medicine Strand, Bjorn; Norwegian Institute of Public Health, Division of Epidemiology Meyer, Haakon; Norwegian Institute of Public Health, Division of Epidemiology; Faculty of Medicine, University of Oslo, Department of Community Health
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Paediatrics
Keywords:	EPIDEMIOLOGY, PUBLIC HEALTH, Community child health < PAEDIATRICS

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Keywords: child, overweight, obesity, marital status, Body Mass Index, waist circumference, abdominal obesity, epidemiology, anthropometry

Word count: 2735 words

Abstract

Objectives

Socio-demographic changes in Norway and other western industrialised countries, including family structure and an increasing proportion of cohabiting and divorced parents, might affect the prevalence of childhood overweight and obesity. We aimed to examine whether parental marital status was associated with general- and abdominal obesity among children. We also sought to explore whether the associations differed by gender.

Design

Cross-sectional.

Setting

127 primary schools across Norway.

Participant

3166 third graders (mean age 8.3years) participating in the nationally representative Norwegian Child Growth-study in 2010.

Measurements

Height, weight and waist circumference were objectively measured. . The main outcome measures were general overweight (including obesity) (BMI≥25kg/m^2) using IOTF cut-offs and abdominal obesity (waist-to-height ratio≥0.5) by gender and parental marital status. Prevalence ratios, adjusted for possible confounders, were calculated by log-binomial regression.

Results

General overweight (including obesity) was 1.54 (95 % confidence interval (CI): 1.21-1.95) times more prevalent among children of divorced parents compared to children of married parents, and the corresponding prevalence ratio for abdominal obesity was 1.89 (95 % CI: 1.35-2.65). Formal tests of the interaction term parental marital status by gender were not statistically significant. However, in gender-specific analyses the association between parental marital status and adiposity measures was only statistically significant in boys (p=0.04 for general overweight (including obesity) and p=0.01 for abdominal obesity). The estimates were robust against adjustment for maternal education, family country background and current area of residence.

Conclusion

General- and abdominal obesity were more prevalent among children of divorced parents. This study provides valuable information by focusing on societal changes in order to identify vulnerable groups.

Strengths and limitations of the study

- This study is representative of the Norwegian population of 8 year-old children.
- Anthropometric data were objectively measured; additionally accompanied by register-based data of parental marital status, maternal education and family country background.
- Data on parental marital status was a "snapshot" of current status with no further information of how long the parents had been married, cohabiting or divorced.
- There were no data on physical activity or diet, which could have contributed to further elucidate the differences.

Introduction

Childhood obesity has major public health implications.(1) The factors accounting for the burden of overweight and obesity are not yet fully understood.(2) Family structure has undergone major changes over the last few decades. The number of divorces increased between 1975 and 2005 and has then remained at a high level in Norway.(3) About 25% of children live either the entirety or some part of their childhood with only one of their biological parents or grow up living in two different homes.(4) Marital conflict and dissolution impact upon the well-being of children and may have implications for the future health status of children.(5, 6) Differences in sedentary behaviour and diet habits between children from single- and dual-parent households have been reported.(7) Recent studies have reported an association between family structure and childhood overweight and obesity, suggesting that living with either only one parent or divorced parents increases the risk of childhood overweight and obesity.(7-10)

The fact that in recent decades there have been large socio-demographic changes in Norway and in Western countries generally, with an increasing proportion of cohabiting and divorced parents, makes it important to examine the impact these changes have had on childhood overweight and obesity. An additional concern is that over the past few decades waist circumference has exceeded trends in body mass index (BMI) in both child- and adult populations.(11-13) This is important because a more central distribution of fat, measured as waist circumference, is associated with metabolic complications.(14, 15)The current study supplements this literature providing insight into the association between family structure and the prevalence of both general and abdominal obesity.

Using data from a nationally representative study, our primary objective was to examine the association between parental marital status and general overweight and obesity in addition to abdominal obesity among Norwegian third graders (8-9 years old). In addition, we explored whether there were gender differences within these associations, and whether the main associations were independent of maternal education, family country background and area of residence.

Methods

Cross-sectional data from the Norwegian Child Growth Study (NCG) were used.(16) NCG followed the protocol of the WHO Childhood Obesity Surveillance Initiative (COSI),(17) which has previously been described in detail.(18, 19)

Subjects

A nationally representative sample of 3166 third graders (1537 girls and 1629 boys) participated in the 2010 NCG study; mean age 8.3 (SD: 0.3) years. To ensure a national representative sample, a stratified two-stage sampling design was used. The attendance rate was 89 % of all invited children. Data on parental marital status were available for 3137 of the children (99%), whilst additional data on maternal education was available for 2968 of the children (94%).

Data collection

Measurements were performed by trained school nurses at participating schools during October 2010. Each of the scales and stadiometers used in this study were already present at each school, i.e. brand and type model probably differed from one school to another. One SECA measuring tape (SECA GmbH Hamburg, Germany) was distributed to each participating school. All school nurses were trained in anthropometric measures according to standardised procedures, which were explained and illustrated in a booklet specially developed for the NCG. Correction values were collected for each instrument involved in the survey and the measures of each child were corrected.(18, 19)

Anthropometric measurements

Body weight and height were measured with the children wearing light indoor clothing and without shoes, and were recorded to the nearest 0.1 kg and 0.1 cm respectively.(20) Measures were corrected if the child wore items other than light indoor clothing: plus 100 grams for some additional light clothing or plus 500 grams for heavier clothing. BMI was calculated as weight/height^2 (kg/m^2) and children were classified as overweight (including obesity) based on age- and gender specific cut-off values for BMI for children as developed by the International Obesity Task Force (IOTF) (21) and the WHO definitions for children aged 5-19.(22) Waist circumference (WC) was measured to the nearest 0.1 cm with arms hanging relaxed along the body with a measuring tape midway between the lower rib margin and the iliac crest.(19) Waist-to-height ratio (WHtR) was calculated as waist circumference/height (cm/cm). At data entry, height, weight and WC were entered twice, with any punching errors corrected.

Outcome variables

The continuous outcome variables included weight, height, WC, BMI and WHtR. The main outcomes were the categorical variables overweight (including obesity) (BMI≥25 kg/m^2) referred to as *general overweight and obesity* and waist-to-height ratio ≥ 0.5 (WHtR≥0.5) referred to as *abdominal obesity*. *Adiposity* is used occasionally and refers to both general overweight and obesity, and abdominal obesity.

Explanatory variables

Data on parental marital status were obtained from the National Population Registry and compiled by Statistics Norway. Data were linked using the unique 11-digit personal identification code assigned to all Norwegian residents. Parental marital status was categorised into three groups: married; never-married (including cohabiting, single and separated parents); divorced.(23)

Data on highest attained maternal education was obtained from the National Education Database and categorised according to the Norwegian Standard Classification of Education (NUS2000) into three levels: tertiary; secondary; primary (19).

Family country background was classified in three groups: Norwegian/Scandinavian; Non-Western; Western (other than Norwegian/Scandinavian). Area of residence was classified as: urban; semi-urban; rural.(19)

Statistical analyses

Mean and standard deviation for the continuous variables were reported for all children, and gender stratified. Crude prevalence of general overweight and obesity, and abdominal obesity were calculated with 95% confidence intervals (95% CI). Comparisons of difference in anthropometric characteristics between subgroups were performed by F-test for continuous variables and Pearson chi-square test for categorical variables. As a recommended alternative for logistic regression in cross-sectional studies,(24) we used generalised linear models (log-binomial regression) with a logarithmic link function to calculate prevalence ratio (PR) and with an identity link function to calculate prevalence differences. It is especially when the outcome is common (> 10 %) that odds ratio overestimates the PR. The effect of parental marital status on adiposity in boys and girls was tested in the regression models by the inclusion of the interaction terms parental marital status by gender. Statistical analyses were performed using STATA 12 and with survey-prefix command (svy) to take into account the complex two stage sampling procedure. A p-value <0.05 was considered statistically significant.

Ethics

NCG was approved by the Regional Committee for Medical Research Ethics and by the Norwegian Data Inspectorate. Consent forms and detailed information about the study were sent to parents/guardians beforehand. Written informed consent was obtained from a parent/legal guardian via the school nurse prior to the study.

Results

As previously reported, the prevalence of general overweight (including obesity) according to IOTF definitions was 19.0 % and according to WHO definitions the prevalence was 28.6 %, whilst 8.9 % had abdominal obesity. Overall, general overweight (including obesity) was significantly more prevalent among girls compared to boys (p-value for difference=0.03), whereas there was no gender difference for abdominal obesity (p-value=0.82).(19)

In gender collapsed analyses all the mean values of the anthropometric measures were significantly higher for children of divorced parents compared to children of married parents, except for height (table 1). In gender specific analyses, however, these differences were generally larger for boys than girls, and reached statistical significance only among boys; weight (p=0.04) and WC (p=0.03). The same pattern was found in terms of the categorical variables; in gender specific analyses the difference

between children of married and divorced parents was only significantly different among boys (table 2).

Children of divorced parents had a 54% higher prevalence (95% CI 21% - 95%) of general overweight (including obesity) and 89% higher prevalence (95% CI 35% - 165%) of abdominal obesity compared to children of married parents (table 2), whereas children of never-married parents had a similar prevalence to children of married parents. Adjustment for maternal education and gender only slightly attenuated the associations, which indicate that maternal education and gender did not explain the association between parental marital status and childhood overweight and obesity. Similarly, the estimates were essentially unchanged after controlling for socio-demographic factors such as family's country background and their area of residence (data not shown). The crude anthropometric measures by parental marital status were essentially equal in the full sample (N=3137) and in the reduced sample with non-missing maternal education (N=2968), indicating that the reduced sample is representative of the full sample.

Gender stratified analyses, adjusting for maternal education, showed that boys with divorced parents had a 63% higher prevalence (95 % CI 11% -139%) of general overweight (including obesity) compared to boys of married parents (table 2), with the absolute difference being 9.9 percentage points. Correspondingly, the prevalence of abdominal obesity was 104% higher (95 % CI 23% - 237%) among boys with divorced parents compared to boys of married parents (table 2), and the absolute difference was 7.4 percentage points. The same pattern was seen among girls, but the associations were less pronounced and not statistically significant. The differences between marital status categories and gender are illustrated in figures 1 and 2, suggesting that boys of divorced parents were particularly prone to abdominal obesity. However, formal tests of the interaction term parental marital status and gender was only borderline significant for WC (p=0.06), and not significant for BMI (p=0.26), WHtR (p=0.13), general overweight (including obesity) (p=0.36) and abdominal obesity (p=0.27).

Table 1: Anthropometric characteristics by parental marital status, presented as mean and standard deviation (SD), for all children and boys and girls separately.

	Married	Never-married		Divorced	
	mean (SD)	mean (SD)		mean (SD)	
ALL CHILDREN	n=2004	n=903		n=230	
			p-value [a]		p-value [b]
Height (cm)	131.8 (6.0)	131.7 (5.6)	0.48	132.5 (6.4)	0.39
Weight (kg)	29.4 (5.7)	29.4 (5.2)	0.76	30.8 (6.5)	0.02
BMI (kg/m2)	16.8 (2.4)	16.9 (2.2)	0.96	17.4 (2.8)	0.03
Waist (cm)	58.3 (6.1)	58.4 (5.7)	0.48	60.3 (7.6)	<0.01
WHtR	0.44 (0.04)	0.44 (0.04)	0.48	0.46 (0.05)	0.02
BOYS	n=1017	n=470		n=121	
			p-value [a]		p-value [b]
Height (cm)	132.4 (5.9)	131.9 (5.6)	0.16	133.8 (6.3)	0.12
Weight (kg)	29.6 (5.8)	29.2 (5.1)	0.17	31.7 (6.8)	0.04
BMI (kg/m2)	16.8 (2.5)	16.7 (2.2)	0.59	17.6 (2.9)	0.12
Waist (cm)	58.8 (6.2)	58.4 (5.5)	0.18	61.4 (8.0)	0.03
WHtR	0.44 (0.04)	0.44 (0.04)	0.49	0.46 (0.05)	0.08
GIRLS	n=987	n=433		n=109	
			p-value [a]		p-value [b]
Height (cm)	131.1 (6.0)	131.4 (5.5)	0.71	131.1 (6.1)	0.75
Weight (kg)	29.1 (5.6)	29.5 (5.3)	0.56	29.9 (6.2)	0.47
BMI (kg/m2)	16.8 (2.3)	17.0 (2.2)	0.51	17.3 (2.6)	0.37
Waist (cm)	57.7 (5.9)	58.5 (5.8)	0.21	59.2 (6.9)	0.19
WHtR	0.44 (0.04)	0.44 (0.04)	0.17	0.45 (0.05)	0.17

[a]) p-value for differences between Married and Never-married, [b]) p-value for differences between Married and Divorced

Table 2: General overweight and obesity (BMI ≥ 25 kg/m^2) according to IOTF and abdominal obesity (waist-to-height ratio ≥0.5), presented as prevalence (%) and prevalence ratio (95 % CI) by marital status, crude and adjusted, for all children and separately for boys and girls.

			CRUDE			ADJUSTED	
		n=	Prevalence (%)	PR	(95 % CI)	PR	(95 % CI)
			GENERAL OVERWEIGHT AND OBESITY				
	All children (N=3137)		19.0				
PARENTAL MARITAL STATUS							
	Married	2004	18.2	1.00	Ref.	1.00	Ref.
	Never-married	903	18.8	1.03	(0.85 -1.25)	1.03 [a]	(0.84 - 1.26)
	Divorced	230	28.0	1.54	(1.21 -1.95)	1.46 [a]	(1.16 - 1.84)
	p-value		<0.01 [c]	0.01 [d]		0.02 [d]	
PARENTAL MARITAL STATUS							
GENDER SPESIFIC							
BOYS	Married	1017	16.2	1.00	Ref.	1.00	Ref.
	Never-married	470	14.6	0.90	(0.66 - 1.22)	0.94 [b]	(0.69 - 1.28)
	Divorced	121	27.5	1.69	(1.18 - 2.44)	1.63 [b]	(1.11 - 2.39)
	p-value		0.02 [c]	0.04 [d]		0.05 [d]	
GIRLS	Married	987	20.3	1.00	Ref.	1.00	Ref.
	Never-married	433	23.1	1.14	(0.87 - 1.50)	1.10 [b]	(0.82 - 1.47)
	Divorced	109	28.5	1.41	(0.97 - 2.04)	1.34 [b]	(0.91 - 1.98)
	p-value		0.16 [c]	0.19 [d]		0.32 [d]	
			ABDOMINAL OBESITY				
	All children (N=3137)		8.9				
PARENTAL MARITAL STATUS							
	Married	2004	8.5	1.00	Ref.	1.00	Ref.
	Never-married	903	8.2	0.97	(0.71 -1.32)	0.97 [a]	(0.69 - 1.36)
	Divorced	230	16.1	1.89	(1.35 -2.65)	1.76 [a]	(1.26 - 2.45)
	p-value		<0.01 [c]	0.01 [d]		0.02 [d]	
PARENTAL MARITAL STATUS							
GENDER SPESIFIC							
BOYS	Married	1017	8.5	1.00	Ref.	1.00	Ref.
	Never-married	470	6.7	0.79	(0.54 - 1.15)	0.85 [b]	(0.58 - 1.24)
	Divorced	121	19.1	2.24	(1.41 - 3.56)	2.04 [b]	(1.23 - 3.37)
	p-value		<0.001 [c]	0.01 [d]		0.03 [d]	
GIRLS	Married	987	8.5	1.00	Ref.	1.00	Ref.
	Never-married	433	9.8	1.16	(0.69 - 1.95)	1.07 [b]	(0.60 - 1.92)
	Divorced	109	12.8	1.51	(0.78 - 2.95)	1.48 [b]	(0.77 - 2.86)
	p-value		0.42 [c]	0.45 [d]		0.47 [d]	

[a]) adjusted for maternal education and gender, [b]) adjusted for maternal education, [c]) Chi-square test and [d]) test for overall p-value for differences between categories

Discussion

In this nationally representative study we found that general overweight and obesity, and abdominal obesity were more prevalent among children of divorced parents compared with children of married parents. Our findings were robust to adjustments for maternal education, family country background and current area of residence. Although formal tests of the interaction terms parental marital status by gender were not statistically significant, gender stratified analyses showed that the prevalence of general- and abdominal obesity was significantly higher only amongst boys of divorced parents, compared to boys with married parents.

The study has several limitations which ought to be considered when interpreting its findings. First, data on parental marital status were limited to a "snapshot" of current status. For example, we had no information as to how long parents had been divorced. Further, the never-married category was heterogeneous and contained a diversity of family constellations, such as intact cohabiting relationships and dissolved relationships. More detailed information would have been beneficial to the study. Secondly, an obvious limitation is that our cross-sectional design provided no basis for studying causality; whether the development of overweight and obesity was initiated before the divorce or whether the impact on the children's weight status was primarily attributed to marital conflict or the divorce. Thirdly, one cannot exclude the possibility that a higher proportion of overweight children were absent from school on the day measurements were taken and were therefore overrepresented among non-participants, which in turn could imply that children of divorced parents were underrepresented in NCG, as previously stated.(25) If so, the associations shown in this study could be underestimated. But, given that the children were recruited into the NCG by the school health service, selection bias is most likely not a big issue in our study. Finally, the explanatory variables are few in the current study, with no information on e.g. physical activity level or dietary behaviour among the children, meaning that we cannot further explore our findings. On the other hand, high attendance rate was given high priority in NCG. In order to avoid non-participation parents were thus not requested to fill in time-consuming questionnaires. Few explanatory variables could therefore be considered an advantage for the current study. Another obvious strength is that, to the best of our knowledge, this is the first study with objectively measured and systematically collected anthropometric data of a nationally representative sample, and is accompanied by register-based data on parental marital status, parents' level of education, area of residence and country background for each child. Moreover, the NCG study has a high attendance rate (89 %).

Our finding that parental divorce is associated with childhood overweight and obesity is consistent with previous studies.(7-10) Few other studies have studied gender-differences, but one Australian study found an opposite gender-pattern, though the gender specific associations were not statistically significant.(7, 10) A Norwegian study concluded that single parent families were not significantly

associated with overweight and obesity among children aged 2-19 years.(26) The divergent findings most probably reflect a lack of agreement in terms of categorisation.The dichotomisation of marital status does not tell whether a single-parent family is the result of divorce, separation or death, or indeed whether a two-parent family are cohabiting or married. Accordingly, it does not form a solid basis for examining whether changing family structures or "divorce-stress" during childhood may affect weight-status among children. Other studies have also contained methodological limitations and were either based on small samples, self-reported data, and/or marital status was reported at birth.(27-30) Likewise, a review considering risk factors for childhood overweight and obesity found conflicting evidence for maternal marital status.(31) Only three studies were included, all of which measured marital status at birth.

Further, we found that children of never-married parents shared similar adiposity traits with children of married parents. The similarity most likely reflects the heterogeneity of the never-married-category, as mentioned in the limitation section above. This category could still be interesting to investigate further; a four times higher risk of dissolution of relationship has been shown for cohabiting couples as opposed to married couples,(32) and the proportion of cohabitations compared to marriages has increased steadily since 1980.(5)

The excess risk of adiposity among those with divorced parents remained after adjusting for maternal education, despite the fact that maternal education is the strongest single socio-economic predictor of childhood obesity,(33) and divorced parents are more likely to have lower educational level, as reported by a Norwegian study.(34)

One can speculate as to whether the changing structure of daily life has a large affect upon the children of divorced parents (living with only one parent or spending half their time with the mother and/or the father). The loss of various resources, like the absence of one of the parents or the loss of a parental figure, usually the father, can explain the negative implications of divorce.(6, 35, 36) A practical consequence might be less time for domestic tasks such as cooking and reliance on more convenient, ready-to-eat foods. As processed foods tend to be higher in fat and calories and lower in nutritional value(8) the result is an altered, less healthy diet. The household income and support from any non-custodial parent or the welfare state is often lower than in corresponding non-disrupted families.(37) Consequently, fewer economic resources may be available for divorced parents, which might lead to cheaper and less healthy choices. Other mechanisms affecting children's weight status through divorce (or dissolved relationship) could be related to emotional stress. Disruption in the parent-child relationship, continuing conflict between former spouses or other negative events like moving and the need to establishing new networks could induce emotional stress.(35, 36, 37) It has been shown that adolescents with substantial distress symptoms doubled among those with divorced parents.(38) Such

emotional stress may impact upon eating behaviour and physical activity level and thus explain the development and maintenance of childhood overweight and obesity.(7, 8, 39)

The higher prevalence of overweight and obesity among children of divorced parents may also be due to selection. Health, socioeconomic resources, psychological characteristics, values and preferences affect the chance of marrying and remaining married, and has previously been found to account for some of the differences between children of divorced and married parents.(35, 40)

In the present study, children of *separated* parents were categorised together with children of *never-married* parents. From a perspective regarding selection as the main explanation, it could be argued that children of separated parents are miscategorised, since these parents will in the future most likely divorce, and are as such akin to divorced parents.

In this nationally representative study of third graders, we found that general overweight and obesity, and abdominal obesity were more prevalent among children of divorced parents compared to children of married parents, even though the divorced category was rather small and the results should be interpret cautiously. The association remained after adjusting for maternal education, family country background and area of residence. Formal tests of interaction terms parental marital status by gender were not statistically significant. However, our data suggest that boys of divorced parents seem to be particularly prone to abdominal obesity. By focusing on actual societal changes, this study adds valuable background information about potentially vulnerable groups at risk of developing adiposity.

Figure legends

Figure 1: Crude prevalence ratio (PR) of general overweight and obesity by parental marital status separately for boys and girls, where boys with married parents are the reference category, presented with 95% confidence intervals (95% CI).

Figure 2: Crude prevalence ratio (PR) of abdominal obesity by parental marital status separately for boys and girls, where boys with married parents are the reference category, presented with 95% confidence intervals (95% CI).

Acknowledgments: This study is a collaboration between the Norwegian Institute of Public Health and the Morbid Obesity Center (Vestfold Hospital Trust in the South-Eastern Norway Regional Health Authority and funded by South-Eastern Norway Regional Health Authority). The funders had no role in the study design, the interpretation of the data or the decision to submit the article for publication. We would like to thank the children, parents and school health nurses who contributed to the study. Thanks are also due to Øystein Kravdal for advice at an early phase of the study, Jørgen Meisfjord for data management and Matthew McGee for proofreading the final manuscript.

Contributors: RH was responsible for conception of the Norwegian Child Growth Study, and AB was involved in the planning and in the data collection. AB and HM were responsible for the conception of this paper. AB and BHS analysed the data and AB drafted the manuscript. All authors interpreted the data, participated in critical revisions of the paper and approved the final submitted version.

Competing interests: None.

Data Sharing Statement: No additional data available.

Ethics approval: NCG was approved by the Regional Committee for Medical Research Ethics and by the Norwegian Data Inspectorate.

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Parental marital status and childhood overweight and obesity in Norway: A nationally representative cross-sectional study.

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Keywords: child, overweight, obesity, marital status, Body Mass Index, waist circumference, abdominal obesity, epidemiology, anthropometry

Word count: ~~2756~~ 2735 words

Abstract

~~Background~~Objectives

Socio-demographic changes in Norway and other western industrialised countries, including family structure and an increasing proportion of cohabiting and divorced parents, might affect the prevalence of childhood overweight and obesity. We aimed to examine whether parental marital status was associated with general- and abdominal obesity among children. We also sought to explore whether the associations differed by gender.

Design

Cross-sectional.

Setting

127 primary schools across Norway.

Participant

3166 third graders (mean age 8.3years) participating in the nationally representative Norwegian Child Growth-study in 2010.

~~Methods~~Measurements

Height, weight and waist circumference were objectively measured. ~~in 3166 third graders (mean age 8.3years) in the nationally representative Norwegian Child Growth-study of 2010~~. The main outcome measures were general overweight (including obesity) (BMI≥25kg/m^2) using IOTF cut-offs and abdominal obesity (waist-to-height ratio≥0.5) by gender and parental marital status. Prevalence ratios, adjusted for possible confounders, were calculated by log-binomial regression.

Results

General overweight (including obesity) was 1.54 (95 % confidence interval (CI): 1.21-1.95) times more prevalent among children of divorced parents compared to children of married parents, and the corresponding prevalence ratio for abdominal obesity was 1.89 (95 % CI: 1.35-2.65). Formal tests of the interaction term parental marital status by gender were not statistically significant. However, in gender-specific analyses the association between parental marital status and adiposity measures was only statistically significant in boys (p=0.04 for general overweight (including obesity) and p=0.01 for abdominal obesity). The estimates were robust against adjustment for maternal education, family country background and current area of residence.

Conclusion

General- and abdominal obesity were more prevalent among children of divorced parents. This study provides valuable information by focusing on societal changes in order to identify vulnerable groups.

Strengths and limitations of the study

- This study is representative of the Norwegian population of 8 year-old children.
- Anthropometric data were objectively measured; additionally accompanied by register-based data of parental marital status, maternal education and family country background.
- Data on parental marital status was a "snapshot" of current status with no further information of how long the parents had been married, cohabiting or divorced.
- There were no data on physical activity or diet, which could have contributed to further elucidate the differences.

Introduction

Childhood obesity has major public health implications.(1) The factors accounting for the burden of overweight and obesity are not yet fully understood.(2) Family structure has undergone major changes over the last few decades. ~~,~~ ~~t~~The number of divorces increased between 1975 and 2005 and has then remained at a high level in Norway ~~since 1980~~.(3) About 25% of children live either the entirety or some part of their childhood with only one of their biological parents or grow up living in two different homes.(4) Marital conflict and dissolution impact upon the well-being of children and may have implications for the future health status of children.(5, 6) Differences in sedentary behaviour and diet habits between children from single- and dual-parent households have been reported.(7) Recent studies have reported an association between family structure and childhood overweight and obesity, suggesting that living with either only one parent or divorced parents increases the risk of childhood overweight and obesity.(7-10) ~~(7-9)~~

The fact that in recent decades there have been large socio-demographic changes in Norway and in Western countries generally, with an increasing proportion of cohabiting and divorced parents, makes it important to examine the impact these changes have had on childhood overweight and obesity. An additional concern is that over the past few decades waist circumference has exceeded trends in body mass index (BMI) in both child- and adult populations.(~~10-12~~11-13) This is important because a more central distribution of fat, measured as waist circumference, is associated with metabolic complications.(1~~4~~3, 1~~4~~5)The current study supplements this literature providing insight into the association between family structure and the prevalence of both general and abdominal obesity.

Using data from a nationally representative study, our primary objective was to examine the association between parental marital status and general overweight and obesity in addition to abdominal obesity among Norwegian third graders (8-9 years old). In addition, we explored whether there were gender differences within these associations, and whether the main associations were independent of maternal education, family country background and area of residence.

Methods

Cross-sectional data from the Norwegian Child Growth Study (NCG) were used.(15~~6~~) NCG followed the protocol of the WHO Childhood Obesity Surveillance Initiative (COSI),(16~~7~~) which has previously been described in detail.(17~~8~~, 18~~9~~)

Subjects

A nationally representative sample of 3166 third graders (1537 girls and 1629 boys) participated in the 2010 NCG study; mean age 8.3 (SD: 0.3) years. To ensure a national representative sample, a stratified two-stage sampling design was used. The attendance rate was 89 % of all invited children. Data on parental marital status were available for 3137 of the children (99%), whilst additional data on maternal education was available for 2968 of the children (94%).

Data collection

Measurements were performed by trained school nurses at participating schools during October 2010. Each of the scales and stadiometers used in this study were already present at each school, i.e. brand and type model probably differed from one school to another. One SECA measuring tape (SECA GmbH Hamburg, Germany) was distributed to each participating school. All school nurses were trained in anthropometric measures according to standardised procedures, which were explained and illustrated in a booklet specially developed for the NCG. Correction values were collected for each instrument involved in the survey and the measures of each child were corrected.(17~~8~~, 18~~9~~)

Anthropometric measurements

Body weight and height were measured with the children wearing light indoor clothing and without shoes, and were recorded to the nearest 0.1 kg and 0.1 cm respectively.(~~19~~20) Measures were corrected if the child wore items other than light indoor clothing: plus 100 grams for some additional light clothing or plus 500 grams for heavier clothing. BMI was calculated as weight/height^2 (kg/m^2) and children were classified as overweight (including obesity) based on age- and gender specific cut-off values for BMI for children as developed by the International Obesity Task Force (IOTF) (20~~0~~1) and the WHO definitions for children aged 5-19.(21~~2~~) Waist circumference (WC) was measured to the nearest 0.1 cm with arms hanging relaxed along the body with a measuring tape midway between the lower rib margin and the iliac crest.(19) Waist-to-height ratio (WHtR) was calculated as waist circumference/height (cm/cm). At data entry, height, weight and WC were entered twice, with any punching errors corrected.

Outcome variables

The continuous outcome variables included weight, height, WC, BMI and WHtR. The main outcomes were the categorical variables overweight (including obesity) (BMI≥25 kg/m^2) referred to as *general overweight and obesity* and waist-to-height ratio ≥ 0.5 (WHtR≥0.5) referred to as *abdominal obesity*.

Adiposity is used occasionally and refers to both general overweight and obesity, and abdominal obesity.

Explanatory variables

Data on parental marital status were obtained from the National Population Registry and compiled by Statistics Norway. Data were linked using the unique 11-digit personal identification code assigned to all Norwegian residents. Parental marital status was categorised into three groups: married; never-married (including cohabiting, single and separated parents); divorced.(2~~2~~3)

Data on highest attained maternal education was obtained from the National Education Database and categorised according to the Norwegian Standard Classification of Education (NUS2000) into three levels: tertiary; secondary; primary (1~~8~~9).

Family country background was classified in three groups: Norwegian/Scandinavian; Non-Western; Western (other than Norwegian/Scandinavian). Area of residence was classified as: urban; semi-urban; rural.(1~~9~~8)

Statistical analyses

Mean and standard deviation for the continuous variables were reported for all children, and gender stratified. Crude prevalence of general overweight and obesity, and abdominal obesity were calculated with 95% confidence intervals (95% CI). Comparisons of difference in anthropometric characteristics between subgroups were performed by F-test for continuous variables and Pearson chi-square test for categorical variables. As a recommended alternative for logistic regression in cross-sectional studies,(2~~3~~4) we used generalised linear models (log-binomial regression) with a logarithmic link function to calculate prevalence ratio (PR) and with an identity link function to calculate prevalence differences. It is especially when the outcome is common (> 10 %) that odds ratio overestimates the PR. The effect of parental marital status on adiposity in boys and girls was tested in the regression models by the inclusion of the interaction terms parental marital status by gender. Statistical analyses were performed using STATA 12 and with survey-prefix command (svy) to take into account the complex two stage sampling procedure. A p-value <0.05 was considered statistically significant.

Ethics

NCG was approved by the Regional Committee for Medical Research Ethics and by the Norwegian Data Inspectorate. Consent forms and detailed information about the study were sent to parents/guardians beforehand. Written informed consent was obtained from a parent/legal guardian via the school nurse prior to the study.

Results

As previously reported, the prevalence of general overweight (including obesity) according to IOTF definitions was 19.0 % and according to WHO definitions the prevalence was 28.6 %, whilst 8.9 % had abdominal obesity. Overall, general overweight (including obesity) was significantly more prevalent among girls compared to boys (p-value for difference=0.03), whereas there was no gender difference for abdominal obesity (p-value=0.82).(19)

In gender collapsed analyses all the mean values of the anthropometric measures were significantly higher for children of divorced parents compared to children of married parents, except for height (table 1). In gender specific analyses, however, these differences were generally larger for boys than girls, and reached statistical significance only among boys; weight (p=0.04) and WC (p=0.03). The same pattern was found in terms of the categorical variables; in gender specific analyses the difference between children of married and divorced parents was only significantly different among boys (table 2).

Children of divorced parents had a 54% higher prevalence (95% CI 21% - 95%) of general overweight (including obesity) and 89% higher prevalence (95% CI 35% - 165%) of abdominal obesity compared to children of married parents (table 2), whereas children of never-married parents had a similar prevalence to children of married parents. Adjustment for maternal education and gender only slightly attenuated the associations, which indicate that maternal education and gender did not explain the association between parental marital status and childhood overweight and obesity. Similarly, the estimates were essentially unchanged after controlling for socio-demographic factors such as family's country background and their area of residence (data not shown). The crude anthropometric measures by parental marital status were essentially equal in the full sample (N=3137) and in the reduced sample with non-missing maternal education (N=2968), indicating that the reduced sample is representative of the full sample.

Gender stratified analyses, adjusting for maternal education, showed that boys with divorced parents had a 63% higher prevalence (95 % CI 11% -139%) of general overweight (including obesity) compared to boys of married parents (table 2), with the absolute difference being 9.9 percentage points. Correspondingly, the prevalence of abdominal obesity was 104% higher (95 % CI 23% - 237%) among boys with divorced parents compared to boys of married parents (table 2), and the absolute difference was 7.4 percentage points. The same pattern was seen among girls, but the associations were less pronounced and not statistically significant. The differences between marital status categories and gender are illustrated in figures 1 and 2, suggesting that boys of divorced parents were particularly prone to abdominal obesity. However, formal tests of the interaction term parental marital status and gender was only borderline significant for WC (p=0.06), and not significant for BMI

(p=0.26), WHtR (p=0.13), general overweight (including obesity) (p=0.36) and abdominal obesity (p=0.27).

Table 1: Anthropometric characteristics by parental marital status, presented as mean and standard deviation (SD), for all children and boys and girls separately.

	Married	Never-married		Divorced	
	mean (SD)	mean (SD)		mean (SD)	
ALL CHILDREN	n=2004	n=903		n=230	
			p-value [a]		p-value [b]
Height (cm)	131.8 (6.0)	131.7 (5.6)	0.48	132.5 (6.4)	0.39
Weight (kg)	29.4 (5.7)	29.4 (5.2)	0.76	30.8 (6.5)	0.02
BMI (kg/m2)	16.8 (2.4)	16.9 (2.2)	0.96	17.4 (2.8)	0.03
Waist (cm)	58.3 (6.1)	58.4 (5.7)	0.48	60.3 (7.6)	<0.01
WHtR	0.44 (0.04)	0.44 (0.04)	0.48	0.46 (0.05)	0.02
BOYS	n=1017	n=470		n=121	
			p-value [a]		p-value [b]
Height (cm)	132.4 (5.9)	131.9 (5.6)	0.16	133.8 (6.3)	0.12
Weight (kg)	29.6 (5.8)	29.2 (5.1)	0.17	31.7 (6.8)	0.04
BMI (kg/m2)	16.8 (2.5)	16.7 (2.2)	0.59	17.6 (2.9)	0.12
Waist (cm)	58.8 (6.2)	58.4 (5.5)	0.18	61.4 (8.0)	0.03
WHtR	0.44 (0.04)	0.44 (0.04)	0.49	0.46 (0.05)	0.08
GIRLS	n=987	n=433		n=109	
			p-value [a]		p-value [b]
Height (cm)	131.1 (6.0)	131.4 (5.5)	0.71	131.1 (6.1)	0.75
Weight (kg)	29.1 (5.6)	29.5 (5.3)	0.56	29.9 (6.2)	0.47
BMI (kg/m2)	16.8 (2.3)	17.0 (2.2)	0.51	17.3 (2.6)	0.37
Waist (cm)	57.7 (5.9)	58.5 (5.8)	0.21	59.2 (6.9)	0.19
WHtR	0.44 (0.04)	0.44 (0.04)	0.17	0.45 (0.05)	0.17

[a]) p-value for differences between Married and Never-married, [b]) p-value for differences between Married and Divorced

Table 2: General overweight and obesity (BMI ≥ 25 kg/m^2) according to IOTF and abdominal obesity (waist-to-height ratio ≥0.5), presented as prevalence (%) and prevalence ratio (95 % CI) by marital status, crude and adjusted, for all children and separately for boys and girls.

			CRUDE			ADJUSTED	
		n=	Prevalence (%)	PR	(95 % CI)	PR	(95 % CI)
			GENERAL OVERWEIGHT AND OBESITY				
	All children (N=3137)		19.0				
PARENTAL MARITAL STATUS							
	Married	2004	18.2	1.00	Ref.	1.00	Ref.
	Never-married	903	18.8	1.03	(0.85 -1.25)	1.03 [a]	(0.84 - 1.26)
	Divorced	230	28.0	1.54	(1.21 -1.95)	1.46 [a]	(1.16 - 1.84)
	p-value		<0.01 [c]	0.01 [d]		0.02 [d]	
PARENTAL MARITAL STATUS							
GENDER SPESIFIC							
BOYS	Married	1017	16.2	1.00	Ref.	1.00	Ref.
	Never-married	470	14.6	0.90	(0.66 - 1.22)	0.94 [b]	(0.69 - 1.28)
	Divorced	121	27.5	1.69	(1.18 - 2.44)	1.63 [b]	(1.11 - 2.39)
	p-value		0.02 [c]	0.04 [d]		0.05 [d]	
GIRLS	Married	987	20.3	1.00	Ref.	1.00	Ref.
	Never-married	433	23.1	1.14	(0.87 - 1.50)	1.10 [b]	(0.82 - 1.47)
	Divorced	109	28.5	1.41	(0.97 - 2.04)	1.34 [b]	(0.91 - 1.98)
	p-value		0.16 [c]	0.19 [d]		0.32 [d]	
			ABDOMINAL OBESITY				
	All children (N=3137)		8.9				
PARENTAL MARITAL STATUS							
	Married	2004	8.5	1.00	Ref.	1.00	Ref.
	Never-married	903	8.2	0.97	(0.71 -1.32)	0.97 [a]	(0.69 - 1.36)
	Divorced	230	16.1	1.89	(1.35 -2.65)	1.76 [a]	(1.26 - 2.45)
	p-value		<0.01 [c]	0.01 [d]		0.02 [d]	
PARENTAL MARITAL STATUS							
GENDER SPESIFIC							
BOYS	Married	1017	8.5	1.00	Ref.	1.00	Ref.
	Never-married	470	6.7	0.79	(0.54 - 1.15)	0.85 [b]	(0.58 - 1.24)
	Divorced	121	19.1	2.24	(1.41 - 3.56)	2.04 [b]	(1.23 - 3.37)
	p-value		<0.001 [c]	0.01 [d]		0.03 [d]	
GIRLS	Married	987	8.5	1.00	Ref.	1.00	Ref.
	Never-married	433	9.8	1.16	(0.69 - 1.95)	1.07 [b]	(0.60 - 1.92)
	Divorced	109	12.8	1.51	(0.78 - 2.95)	1.48 [b]	(0.77 - 2.86)
	p-value		0.42 [c]	0.45 [d]		0.47 [d]	

[a]) adjusted for maternal education and gender, [b]) adjusted for maternal education, [c]) Chi-square test and [d]) test for overall p-value for differences between categories

Figure 1: Crude prevalence ratio (PR) of general overweight and obesity by parental marital status separately for boys and girls, where boys with married parents are the reference category, presented with 95% confidence intervals (95% CI).

Figure 2: Crude prevalence ratio (PR) of abdominal obesity by parental marital status separately for boys and girls, where boys with married parents are the reference category, presented with 95% confidence intervals (95% CI).

Discussion

In this nationally representative study we found that general overweight and obesity, and abdominal obesity were more prevalent among children of divorced parents compared with children of married parents. Our findings were robust to adjustments for maternal education, family country background and current area of residence. Although formal tests of the interaction terms parental marital status by gender were not statistically significant, gender stratified analyses showed that the prevalence of general- and abdominal obesity was significantly higher only amongst boys of divorced parents, compared to boys with married parents.

The study has several limitations which ought to be considered when interpreting its findings. First, data on parental marital status were limited to a "snapshot" of current status. For example, we had no information as to how long parents had been divorced. Further, the never-married category was heterogeneous and contained a diversity of family constellations, such as intact cohabiting relationships and dissolved relationships. More detailed information would have been beneficial to the study. Secondly, an obvious limitation is that our cross-sectional design provided no basis for studying causality; whether the development of overweight and obesity was initiated before the divorce or whether the impact on the children's weight status was primarily attributed to marital conflict or the divorce. Thirdly, one cannot exclude the possibility that a higher proportion of overweight children were absent from school on the day measurements were taken and were therefore overrepresented among non-participants, which in turn could imply that children of divorced parents were underrepresented in NCG, as previously stated.(2~~5~~4) If so, the associations shown in this study could be underestimated. But, given that the children were recruited into the NCG by the school health service, selection bias is most likely not a big issue in our study. Finally, the explanatory variables are few in the current study, with no information on e.g. physical activity level or dietary behaviour among the children, meaning that we cannot further explore our findings. On the other hand, high attendance rate was given high priority in NCG. In order to avoid non-participation parents were thus not requested to fill in time-consuming questionnaires. Few explanatory variables could therefore be considered an advantage for the current study. Another obvious strength is that, to the best of our knowledge, this is the first study with objectively measured and systematically collected anthropometric data of a nationally representative sample, and is accompanied by register-based data on parental marital status, parents' level of education, area of residence and country background for each child. Moreover, the NCG study has a high attendance rate (89 %).

Our finding that parental divorce is associated with childhood overweight and obesity is consistent with previous studies.(7-~~9~~10) Few other studies have studied gender-differences, but one Australian study found an opposite gender-pattern, though the gender specific associations were not statistically significant.(~~9~~7, 10) A Norwegian study concluded that single parent families were not significantly associated with overweight and obesity among children aged 2-19 years.(26~~5~~) The divergent findings

most probably reflect a lack of agreement in terms of categorisation.The dichotomisation of marital status does not tell whether a single-parent family is the result of divorce, separation or death, or indeed whether a two-parent family are cohabiting or married. Accordingly, it does not form a solid basis for examining whether changing family structures or "divorce-stress" during childhood may affect weight-status among children. Other studies have also contained methodological limitations and were either based on small samples, self-reported data, and/or marital status was reported at birth.(26-30) Likewise, a review considering risk factors for childhood overweight and obesity found conflicting evidence for maternal marital status.(31) Only three studies were included, all of which measured marital status at birth.

Further, we found that children of never-married parents shared similar adiposity traits with children of married parents. The similarity most likely reflects the heterogeneity of the never-married-category, as mentioned in the limitation section above. This category could still be interesting to investigate further; a four times higher risk of dissolution of relationship has been shown for cohabiting couples as opposed to married couples,(32) and the proportion of cohabitations compared to marriages has increased steadily since 1980.(5)

The excess risk of adiposity among those with divorced parents remained after adjusting for maternal education, despite the fact that maternal education is the strongest single socio-economic predictor of childhood obesity,(33) and divorced parents are more likely to have lower educational level, as reported by a Norwegian study.(34)

One can speculate as to whether the changing structure of daily life has a large affect upon the children of divorced parents (living with only one parent or spending half their time with the mother and/or the father). The loss of various resources, like the absence of one of the parents or the loss of a parental figure, usually the father, can explain the negative implications of divorce.(6, 34, 35) A practical consequence might be less time for domestic tasks such as cooking and reliance on more convenient, ready-to-eat foods. As processed foods tend to be higher in fat and calories and lower in nutritional value(8) the result is an altered, less healthy diet. The household income and support from any non-custodial parent or the welfare state is often lower than in corresponding non-disrupted families.(36) Consequently, fewer economic resources may be available for divorced parents, which might lead to cheaper and less healthy choices. Other mechanisms affecting children's weight status through divorce (or dissolved relationship) could be related to emotional stress. Disruption in the parent-child relationship, continuing conflict between former spouses or other negative events like moving and the need to establishing new networks could induce emotional stress.(35, 36, 37) It has been shown that adolescents with substantial distress symptoms doubled among those with divorced parents.(38) Such emotional stress may impact upon eating behaviour and physical activity level and thus explain the development and maintenance of childhood overweight and obesity.(7, 8, 39)

The higher prevalence of overweight and obesity among children of divorced parents may also be due to selection. Health, socioeconomic resources, psychological characteristics, values and preferences affect the chance of marrying and remaining married, and has previously been found to account for some of the differences between children of divorced and married parents (354, 40)

In the present study, children of *separated* parents were categorised together with children of *never-married* parents. From a perspective regarding selection as the main explanation, it could be argued that children of separated parents are miscategorised, since these parents will in the future most likely divorce, and are as such akin to divorced parents. ~~Children of separated parents have most likely already been exposed to parental conflicts. However, children of separated parents have probably had less exposure to conflict and emotional stress compared to children of divorced parents. Because overweight and obesity take time to develop, we consider it is relevant to differentiate between the children of divorced and separated parents.~~

In this nationally representative study of third graders, we found that general overweight and obesity, and abdominal obesity were more prevalent among children of divorced parents compared to children of married parents, even though the divorced category was rather small and the results should be interpret cautiously. The association remained after adjusting for maternal education, family country background and area of residence. Formal tests of interaction terms parental marital status by gender were not statistically significant. However, our data suggest that boys of divorced parents seem to be particularly prone to abdominal obesity. By focusing on actual societal changes, this study adds valuable background information about potentially vulnerable groups at risk of developing adiposity.

Ethics approval: NCG was approved by the Regional Committee for Medical Research Ethics and by the Norwegian Data Inspectorate.

Acknowledgments: This study is a collaboration between the Norwegian Institute of Public Health and the Morbid Obesity Center (Vestfold Hospital Trust in the South-Eastern Norway Regional Health Authority and funded by South-Eastern Norway Regional Health Authority). The funders had no role in the study design, the interpretation of the data or the decision to submit the article for publication. We would like to thank the children, parents and school health nurses who contributed to the study. Thanks are also due to Øystein Kravdal for advice at an early phase of the study, Jørgen Meisfjord for data management and Matthew McGee for proofreading the final manuscript.

Contributors: RH was responsible for conception of the Norwegian Child Growth Study, and AB was involved in the planning and in the data collection. AB and HM were responsible for the conception of this paper. AB and BHS analysed the data and AB drafted the manuscript. All authors interpreted the data, participated in critical revisions of the paper and approved the final submitted version.

Competing interests: None.

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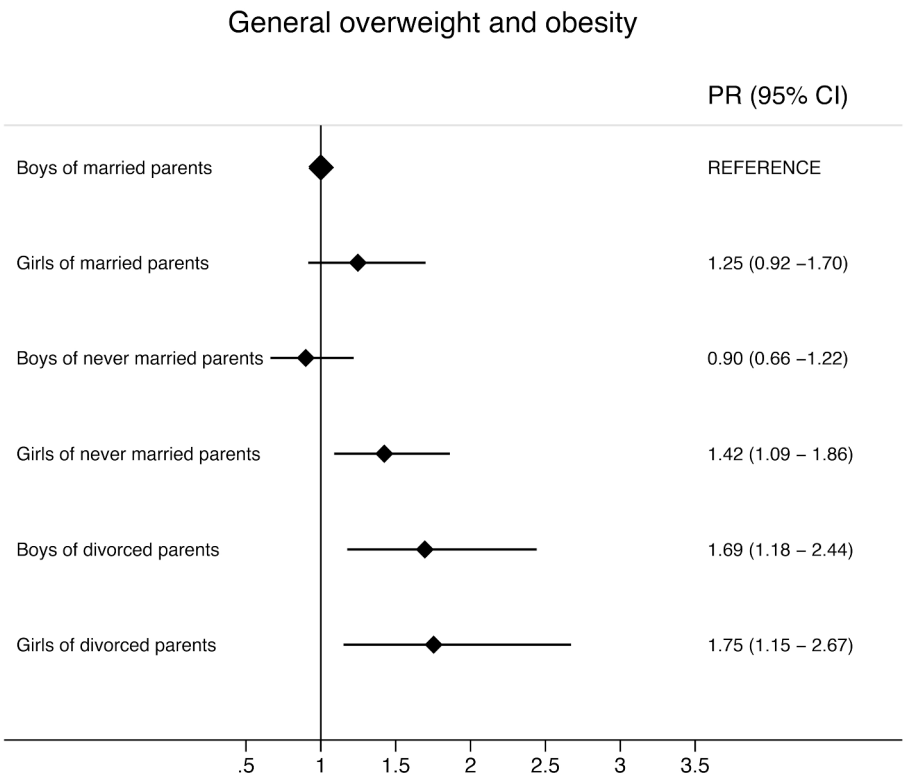

Crude prevalence ratio (PR) of general overweight and obesity by parental marital status separately for boys and girls, where boys with married parents are the reference category, presented with 95% confidence intervals (95% CI).
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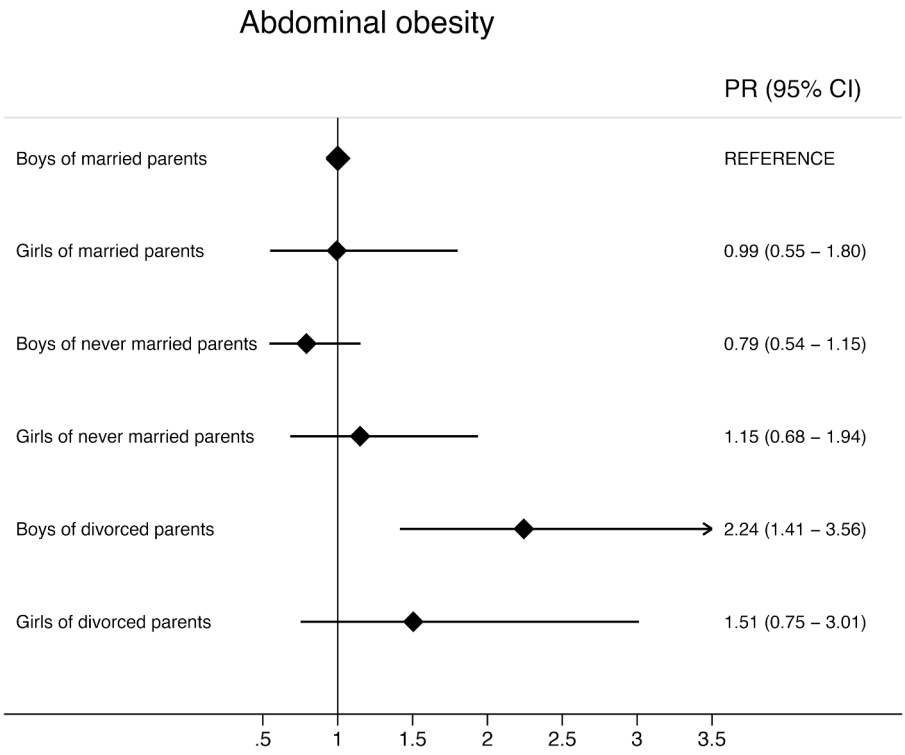

Crude prevalence ratio (PR) of abdominal obesity by parental marital status separately for boys and girls, where boys with married parents are the reference category, presented with 95% confidence intervals (95% CI).
279x229mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.