ORIGINAL ARTICLE

Coexistence of social inequalities in undernutrition and obesity in preschool children: population based cross sectional study

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Arch Dis Child 2003;**88**:671–675

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Accepted 17 December 2002

Aims: To test for the coexistence of social inequalities in undernutrition and obesity in preschool children.

Methods: Retrospective, cross sectional, study of routinely collected data from 74 500 children aged 39–42 months in 1998/99. Main outcome measures were weight, height, sex, and age routinely recorded by health visitors. Body mass index (BMI) standardised for age and sex, relative to UK 1990 reference data, was used to define undernutrition (BMI <2nd centile) and obesity (BMI >95th centile; BMI >98th centile). Social deprivation was assessed as Carstairs deprivation category (1 = most affluent to 7 = most deprived).

Results: Both undernutrition (3.3%) and obesity (8.5% above 95th centile; 4.3% above 98th centile) significantly exceeded expected frequencies from UK 1990 reference data. Undernutrition and obesity were significantly more common in the more deprived families. Odds ratios in deprivation category 7 relative to category 1 were 1.51 (95% CI 1.22 to 1.87) for undernutrition (BMI <2nd centile) and 1.30 (95% CI 1.05 to 1.60) for obesity (BMI >98th centile). The cumulative prevalence of under and overnutrition (malnutrition) in the most deprived group was 9.5% compared to 6.9% in the least deprived group.

Conclusions: Undernutrition and obesity are significantly more common than expected in young children and strongly associated with social deprivation. Both undernutrition and obesity have adverse short and long term health effects. Public health strategies need to tackle malnutrition (both undernutrition and obesity) in children and take into consideration the association with social deprivation.

The coexistence of undernutrition and overnutrition with social deprivation has recently emerged from epidemiological studies in developing countries. This phenomenon has been shown to exist in children[1] and in adolescents[2 3] within population groups, and also within households (as mother child pairs).[4] This pattern of health in children is strongly associated with the persistence and adoption of poor quality diets and physical inactivity.[1]

In the UK, improving nutritional status and reducing health inequalities are at the centre of government health policy.[5] However, there are at present no data on the population prevalence of undernutrition, and only limited evidence on social inequalities in undernutrition (low body mass index (BMI)) or overnutrition (obesity, high BMI) in children. There is some evidence of a social class gradient in obesity in English children of school age,[6] and geographical differences in the UK.[7] The UK experienced an epidemic of childhood obesity during the 1990s,[7 8] and even preschool children were affected.[9 10] Childhood obesity is associated with a number of co-morbidities in childhood,[11] and with increased risk of adult disease, particularly cardiovascular disease and type II diabetes.[12–16] Obese children tend to have lower self esteem than their non-obese peers, and tend to be more isolated.[17] In addition, there is evidence from the USA and the UK that obesity in female adolescents and young adults is associated with lifetime socioeconomic disadvantage.[18 19] Tackling childhood obesity is therefore relevant to improving and sustaining child health, preventing cardiovascular disease, and addressing health inequalities, all of which are national health priorities.[5 20]

Although there is detailed prevalence information on low birth weight infants, there is currently no information on the population prevalence of undernutrition in children or its persistence during childhood. There is good evidence of adverse short and long term effects of severe undernutrition in developing countries,[21 22] but effects in developed countries are less clear, and in any setting are modified by the severity and duration of the insult, its timing, and other environmental factors.[22] However, recent evidence suggests there are potentially long term health risks associated with undernutrition occurring in early life.[23 24] Children who are undernourished at birth usually experience a period of catch up growth within the first two years. Social conditions during childhood may be an important determinant of achieving catch up growth and the persistence of undernutrition into later years.[25] Thus, while social class gradients in intrauterine growth are well known,[21 26] whether social deprivation has a more persistent effect on nutritional status during childhood is unclear. Evidence on social inequalities in childhood under and overnutrition is therefore lacking. The "coexistence" of undernutrition and overnutrition has been experienced recently by many of the world's developing countries,[1] the manifestations of which may be most pronounced in the most deprived groups.[27] However, no data on "coexistence" exist for the developed world at present. In addition it is unclear, and important to know from a public health perspective in the UK, whether the recent epidemic of overnutrition is replacing undernutrition or adding to it.

The primary aim of the present study therefore was to test for the coexistence of under and overnutrition with socioeconomic deprivation in preschool children in the UK. If coexistence is significant, effective public health strategies which promote healthy lifestyles and improve diet quality will need to address both under and overnutrition.

Table 1 Prevalence of undernutrition and severe obesity in Scottish children aged 3–4 years

Deprivation category (n)	% (n) undernutrition (BMI <2nd centile)	% (n) obese (BMI >95th centile)	% (n) severe obesity (BMI >98th centile)
1 (4500)	3.2 (144)	7.8 (350)	3.7 (166)
2 (8320)	3.0 (253)	7.8 (647)	3.6 (297)
3 (13173)	3.0 (398)	8.4 (1102)	4.1 (546)
4 (15620)	3.0 (462)	9.1 (1422)	4.6 (721)
5 (10269)	3.3 (341)	8.7 (893)	4.7 (487)
6 (8106)	4.0 (324)	8.6 (694)	4.4 (358)
7 (4496)	4.8 (214)	8.8 (397)	4.7 (213)
Total (64484)	3.3 (2136)	8.5 (5505)	4.3 (2788)

1 = least deprived group, 7 = most deprived group.

METHODS

Sample

As part of Scottish National Preschool Child Health Surveillance System (NCHS-P), anthropometric data on children (height or length, weight, head circumference) are routinely collected at a number of stages during childhood, allowing longitudinal follow up of children's growth and nutritional status. These population based data are collected from measurements of weight and height made routinely by health visitors at particular ages, and collated by the Information and Statistics Division (ISD) of the Common Services Agency, Edinburgh. All families of children of this age are expected to attend these routine checks, and >98% of families attend. The Scottish Child Health Surveillance Project Board set clinical guidelines for health professionals taking height and weight measurements at routine visits.[28 29] We examined the health records of 74 500 children who had a routine 39–42 month health review in 1998/99. The single year birth cohort in Scotland was 52 987 in 1999. The variables extracted for this cohort were age (at measurement), height, weight, deprivation category, and birth weight. Birth weight is recorded at time of birth on the birth notification certificate and entered into the information system. The deprivation category is based on postcode sector, which is recorded at the time of review. At this time, health data were accessible for approximately 80% of the preschool population of Scotland.

Definitions of undernutrition and obesity

Weight and height were used to calculate BMI (weight in kg/height in m^2). In children, BMI changes with age and differs between boys and girls, so must be interpreted by comparison with appropriate reference data. We made this comparison for both undernutrition and overnutrition using the UK 1990 BMI reference data and expressed BMI as centiles and standard deviation (SD) scores.

We defined undernutrition as BMI <2nd centile (SD scores <−2.06), following clinical guidelines on UK BMI reference charts (Harlow Printing South Shields, England; Child Growth Foundation London, England). This definition represents an assessment for a group or population: sensitivity and specificity in screening for undernutrition in individual children using this definition are unclear. By definition, 2% of the reference population would be expected to have a BMI <2nd centile. Most infants and young children with failure to thrive have a low BMI which is nutritional in origin.[30]

Obesity was defined as BMI >95th centile, and severe obesity >98th centile (Clinical BMI charts, Harlow Printing/Child Growth Foundation). These definitions have high specificity and moderately high sensitivity[31] in identifying the fattest children within the population, and so are informative for individual children as well as populations. The definition of obesity was that which is widely used and recommended,[32] and is not arbitrary. Children with BMI >95th centile are those most likely to experience co-morbidity, obesity defined in this way is likely to persist, and is associated with presence and clustering of cardiovascular risk factors.[12 14–16 33]

Assessment of social deprivation

Deprivation was defined using the Carstairs Deprivation Category.[34] This is a measure of deprivation based on area of residence (calculated at Scottish postcode sector level) and derived from UK 1991 census variables for overcrowding in housing, male unemployment, low social class, and car ownership. These items were combined to create an aggregate score on a scale of 1 (most affluent) to 7 (most deprived).[34] This method of assessing deprivation is widely used in Scotland and strongly related to a number of health outcomes.[35] The children in this study were born in 1994/95, three to four years after the 1991 census used to establish exposure (deprivation) categories. The outcome data (undernutrition and obesity) were collected in 1998/99, and therefore we are assuming the social environment to which the children in this sample were exposed was as represented by 1991 census data.

BMI values for 2nd and 98th centiles in three populations

We compared the BMI values for the 2nd and 98th centiles for the sample of Scottish children aged 40 months to the UK 1990 reference (table 3). As a further comparison, the BMI values (2nd and 98th centile) of a contemporary sample of English children aged 37 months in a large prospective cohort study, the Avon Longitudinal Study of Parents and Children (ALSPAC) were calculated, using data from the Children in Focus Study. We have described this sample and the methodology elsewhere.[9] The ALSPAC cohort reached age 37 months in 1995/96, but was slightly more affluent than the rest of the UK.[36]

Statistical analysis

The outcome measures were overnutrition (BMI >95th and 98th centiles) and undernutrition (BMI <2nd centile). Logistic regression analysis was used to establish the unadjusted odds ratios (OR) and 95% confidence intervals (CI) for deprivation categories. These analyses were repeated adjusting for birth weight. Birth weight was categorised as follows: <2500 g, 2500–2999 g, 3000–3999 g, 4000–4499 g, and 4500 g or more. Statistical analyses were carried out using SPSS for Windows, version 10.1.

RESULTS

Sample

Children were excluded from analysis if they had missing data on gender, age, deprivation category, weight, or height (n = 9358, 12.5%) at the routine check, or if implausible BMI

Table 2 Crude odds ratio (OR) and odds ratio adjusted for birth weight (AOR) for undernutrition and obesity at age 3–4 in each deprivation category compared to deprivation category 1 (least deprived group)

Deprivation category (n)	BMI <2nd centile		BMI <2nd centile		BMI >98th centile		BMI >98th centile	
	OR	95% CI	AOR	95% CI	OR	95% CI	AOR	95% CI
1 (4500)	1.00		1.00		1.00		1.00	
2 (8320)	0.95	0.77 to 1.17	0.93	0.74 to 1.15	0.97	0.80 to 1.17	0.96	0.79 to 1.17
3 (13173)	0.94	0.78 to 1.14	0.91	0.74 to 1.11	1.13	0.95 to 1.35	1.11	0.93 to 1.34
4 (15620)	0.92	0.76 to 1.12	0.88	0.72 to 1.07	1.26	1.06 to 1.50	1.26	1.08 to 1.53
5 (10269)	1.04	0.85 to 1.27	0.96	0.78 to 1.18	1.30	1.09 to 1.56	1.32	1.10 to 1.59
6 (8106)	1.26	1.03 to 1.54	1.16	0.95 to 1.43	1.21	1.00 to 1.46	1.28	1.06 to 1.55
7 (4496)	1.51	1.22 to 1.87	1.29	1.03 to 1.62	1.30	1.05 to 1.60	1.43	1.16 to 1.77
Total 64484								

Table 3 BMI values (kg/m^2) for the 2nd centile and 98th centile for BMI in British children from three populations

	UK 1990 reference (age 40 mth)		Scottish children (age 40 mth)		ALSPAC (English) children (age 37 mth)	
	2nd centile	98th centile	2nd centile	98th centile	2nd centile	98th centile
Males	13.8	19.0	13.5	19.8	14.3	19.6
Females	13.5	19.1	13.0	20.0	14.0	19.9

values were recorded (BMI SDS >+4 or <–4) (n = 658, 0.8%). The final sample was 64 484, 87% of the original sample (n = 74 500).

Undernutrition and obesity

The prevalence of undernutrition (girls 3.3%, boys 3.2%), obesity (girls 8.0%, boys 9.0%), and severe obesity (girls 4.1%, boys 4.4%) was significantly higher than expected from the UK 1990 reference values of 2%, 5%, and 2% respectively (χ^2 goodness of fit, $p < 0.001$ in all cases). Table 1 shows prevalence by deprivation category. Undernutrition and obesity were significantly associated with deprivation category, with a significantly higher prevalence of both undernutrition and severe obesity (BMI >98th centile) in the more deprived children. Within each deprivation category the prevalence of children with BMI >98th centile exceeded those <2nd centile, with the exception of the deprivation category 7 (most deprived) where prevalences were similar (4.8% *v* 4.7%; table 1). The cumulative prevalence of undernutrition and obesity in the most deprived groups 6 and 7 was 8.4% and 9.5% respectively compared to the least deprived group 1 (6.9%).

Table 2 shows the unadjusted and adjusted (for birth weight) odds ratios and 95% confidence intervals for undernutrition and obesity by deprivation category. Scottish children aged 3–4 years in the most deprived category (7) had a 30% higher risk of undernutrition compared to those in the least deprived category (1) after adjusting for birth weight (AOR 1.29, 95% CI 1.03 to 1.62). The same group (category 7) had a 43% higher risk of obesity compared to the least deprived after adjusting for birth weight (OR 1.43, 95% CI 1.1.6 to 1.77). Undernutrition was most evident in the deprived categories (6 and 7), while the risk of obesity was higher in the middle categories (4 and 5) in addition to the most deprived (7).

BMI: 2nd and 98th centiles in three populations

Table 3 shows the absolute BMI values (kg/m^2) for the 2nd and 98th centiles for the sample of Scottish children, the UK 1990 reference data, and the ALSPAC study. The BMI value for the 2nd centile in the Scottish children was approximately 0.5 kg/m^2 lower than the equivalent for the UK 1990 reference, and 1.0 kg/m^2 lower than that of the ALSPAC sample of English children. The BMI value for the 98th centile in the Scottish children was 1.0 kg/m^2 higher than the equivalent for the UK 1990 reference and similar to the ALSPAC sample of English children. These data show a kurtotic distribution of BMI in the Scottish population, consistent with a higher prevalence of Scottish children in both extremes of the BMI distribution.

DISCUSSION

Main findings and implications

The present study has shown, for the first time, the coexistence of undernutrition and obesity associated with social deprivation in contemporary children from the developed world. Recent evidence has shown the phenomenon of coexistence of undernutrition and obesity in developing countries and within families.[2–4] In the present study, Scottish children aged 3–4 years in the most deprived families had a 30% higher risk of obesity and 50% higher risk of undernutrition when compared to children in the least deprived group, and these remained significant after adjusting for birth weight. The data presented in this study show a higher prevalence of undernutrition at age 3–4 years in the most deprived groups. For obesity at age 3–4 years there was a higher prevalence in both middle deprivation categories (4 and 5) and in the most deprived groups (6 and 7). Within each deprivation category the prevalence of children >98th centile exceeded those <2nd centile with the exception of the most deprived group. Thus obesity was more common in middle and low socioecomomic groups, while undernutrition was more confined to the most deprived groups. The cumulative prevalence of undernutrition and obesity in the most deprived group was higher in the least deprived (9.5% *v* 6.9%).

Undernutrition

With the strength of association between socioeconomic status and birth weight,[26] it was important to analyse the data with an adjustment for birth weight. A low birth weight and lack of catch up growth may have explained some of the risk of undernutrition at age 3–4. The odds ratio for undernutrition in deprivation category 7 (OR 1.29, 95% CI 1.03 to 1.62) shows that the association between social deprivation and undernutrition at age 3–4 remained significant after adjusting for birth weight. This relation may be a reflection of growth patterns of children living in poorer circumstances,[24 25] with inadequate

nutrition and a higher risk of household food insecurity. The phenomenon of household food insufficiency and the potential adverse effects on nutritional status and child development have recently been described in school age children from the USA.[37] With the high nutritional requirements for growth, younger children are more vulnerable to undernutrition and its consequences.[22 24] Undernutrition persisting through childhood may have significant effects on cognitive development, school achievement, and later health.[22 37] However, the specific long term health and developmental risks to children in more affluent developed countries are less well defined and warrant further study.[23 30 38]

Obesity

Obesity, even in young children, confers increased risk of short and longer term morbidity,[11 33] and is particularly strongly associated with presence and clustering of cardiovascular risk factors and type 2 diabetes.[12–15] Moreover, the immediate psychosocial consequences for obese children may increase the risk.[11 17 19] An association between Townsend score (an index of social deprivation) and obesity in children of school age has previously been described for English children.[6] The present study showed that risk of obesity is much higher than expected and associated with social deprivation at an early age. The indices of nutritional status used in the present study reflect energy balance (energy intake − sum of energy outputs), and are largely determined by energy intake and levels of physical activity. The epidemic of childhood obesity which occurred in the UK during the 1990s resulted largely from increasing physical inactivity coupled with consumption of energy dense diets. However, the specific factors which explain the associations between obesity, undernutrition, and social deprivation in childhood need further study. There are marked differences in nutritional quality (energy and micronutrient density) of the diet in Scottish children from different deprivation categories,[39] and this may be partly responsible for the greater risk of malnutrition in young children in the most deprived families.

BMI distribution and public health implications

The observation that both undernutrition and obesity are associated with social deprivation may have implications for preventive strategies. The traditional paradigm has been that shifts in the entire distribution of BMI (down) are desirable, and that population based approaches (in obesity prevention, for example) are necessary, rather than approaches which target high risk groups.[40 41] However, if the pattern of malnutrition in deprived children resembles a U shaped curve with both undernutrition and obesity prevalent, success in shifting the population distribution (of BMI, for example) downwards could potentially have adverse implications for those children at the lower end of the distribution. Our analysis suggests differences in BMI distribution between the three samples we compared (Scotland; UK reference; ALSPAC) with the Scottish sample having a lower BMI value at the 2nd centile and higher BMI value at the 98th centile. In contrast the BMI values for the 2nd and 98th centile in the ALSPAC sample of English children were higher than the UK 1990 reference data. This suggests differences in these population groups, which may be greater than might have been expected based on methodological differences between datasets.

Strengths and weaknesses of the present study

The present study was epidemiological, cross sectional, and limited to identifying associations, and so cannot definitively confirm causality between social deprivation and malnutrition. The strength of using population data lies in the sample size, power, and wide coverage/representation of the population. The value of using routinely collected data is increasingly being recognised.[6 10] However, there are a number of limitations with using routinely collected data not under a strict research protocol. There are issues of missing data and data quality which are usually greater than studies with strict protocol design. From the sample of 74 500 children in the present study, those missing data for one or more of the variables deprivation category, height, weight, or gender equated to 9358 (12.5%), and there were very few with invalid BMI data (658, 0.8%). There was a small bias of more missing data from the most deprived groups (8.2% in category 7 *v* 6.2% in category 1), but this is likely to result in the differences between deprivation groups being underestimated rather than overestimated.

Our definitions of obesity were well founded, in that above approximately the 91st centile for BMI on the UK 1990 reference, any definition of obesity based on BMI centile cut off has moderately high sensitivity (low to moderate false negative rate), but high specificity (low false positive rate).[31] In addition, obesity defined as BMI >95th centile has a strong tendency to persist, and is associated with a number of measures of clinical/biological significance (such as psychological health; social, educational, and economic outcomes; and presence, clustering, and maintenance of cardiovascular risk factors).[11] At present there is no gold standard for the definition of undernutrition in child population groups, and the sensitivity and specificity of any available definition is unknown. The definition used here (BMI <2nd centile) is suitable for comparison between groups or populations, but it cannot definitively identify individual children as undernourished. The WHO expert committee recommends using the observed standard deviation of height/weight or BMI SDS distribution to assess the quality and spread of height and weight survey data.[42] With accurate age and anthropometric measurements in a population, the SDS of the observed BMI SDS distribution should be relatively constant and close to 1.0 for the reference distribution (ranging within 0.2 units). In this study the standard deviation of the BMI SDS distribution equated to 1.14; close to 1, but indicating a flatter, bell shaped distribution. An important limitation of the study was not being able to adjust for other potential risk factors for under and overnutrition in children, notably maternal BMI, smoking, and catch up growth.

There is currently no gold standard for assessing social deprivation, although a combination of area based and individual measures (for example, maternal education, income) provides a more accurate assesment.[43 44] The present study was limited to the use of the area based Carstairs Deprivation Category, a widely used measure strongly linked to morbidity and mortality in Scotland.[35] There was a time difference between the assessment of deprivation category (from 1991 census), the birth of the children (1994/95), and outcome measures (taken 1998/99), but such a difference is small and inevitable in longitudinal studies of this kind.

Conclusions

We have shown that undernutrition and obesity coexist in preschool children in Scotland and are strongly associated with social deprivation. Further research is needed to identify other risk factors involved in the development and persistence of malnutrition in the children, and to clarify the long term effects. Effective public health strategies for improving child health will encompass environmental, behavioural, and biological determinants of childhood undernutrition and obesity,[1 40] some of which may be interrelated, and focus on improving nutritional status of the child population.

ACKNOWLEDGEMENTS

The study was funded by the Scottish Executive Health Department. We acknowledge the support of the ALSPAC Study Team, and their contribution to collecting data from the ALSPAC cohort.

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Funding: Scottish Executive Chief Scientists Office

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