Predictors of maternal misclassifications of their offspring's weight status: a longitudinal study

A A Mamun1, B M McDermott2, M J O'Callaghan3, J M Najman1 and G M Williams1

1. Longitudinal Studies Unit, School of Population Health, University of Queensland, Brisbane, Queensland, Australia
2. Kids in Mind Research: The Mater Centre for Service Research in Mental Health, Department of Psychiatry, University of Queensland, Brisbane, Queensland, Australia
3. Child Development and Rehabilitation Services, Mater Children’s Hospital, University of Queensland, Brisbane, Queensland, Australia

Correspondence: Dr AA Mamun, Longitudinal Studies Unit, School of Population Health, University of Queensland, Public Health Building, Herston Road, Herston, Brisbane, Queensland 4006, Australia. E-mail: mamun@sph.uq.edu.au

ABSTRACT

Background: Very little is known about the factors influencing parental misclassifications of a child’s weight status. The aim of this study is to examine the predictors of maternal misclassifications of their adolescent offspring’s weight status.

Methods: A mother–child linked analysis was carried out using 14-year follow-up data from a population-based prospective birth cohort of 2650 children (52% males) who were participants in the Mater-University Study of Pregnancy in Brisbane (Australia) in 1981. Offspring’s observed height and weight and maternal perception of offspring weight were reported when they were 14 years old and predictors were prospectively recorded either at first clinical visit of mothers or at 5 or 14 years follow-up. Maternal misclassifications were defined combining observed body mass index (BMI) categories and maternal perceptions of their offspring’s weight status.

Results: We found that maternal misclassification of child’s weight status was common and included misclassifications both to higher and lower weight categories. Forty percent of mothers of overweight children misclassified their child as normal or underweight, more so in males than females. Fifteen percent of mothers of normal weight children misclassified their child as underweight, again more so in males than females. The main independent predictors of maternal misclassifications of child weight status were gender, child dissatisfaction with appearance, shape, size and weight, dieting to lose weight, general health status, maternal BMI and family meals. Gender, child dissatisfaction, dieting and maternal overweight were especially associated with misclassifications of overweight children.

Conclusions: This study identified a number of maternal, child and family factors associated with maternal misclassifications of child weight status. Although relevant for clinical practice, further study is needed, however, to evaluate the benefits and harms of promoting increasing parental and child awareness of the child’s weight status at a population level.

Keywords: maternal misclassifications, predictors, underweight, overweight, right weight
INTRODUCTION

Obesity in childhood increases the risk of obesity in adulthood, and this increase is even more marked if one or both parents are overweight.\textsuperscript{1, 2} It has also been argued that prevention of obesity should start from childhood and intervention programs are more successful with parental involvement.\textsuperscript{3} Thus, parental recognition of their children who are overweight or obese is important so that prevention and treatment strategies may be implemented early in life.

While there is increased media attention on, and public awareness of, childhood obesity in developed countries, evidence suggests that many parents of overweight or obese children are unaware that their child has a weight problem. Several recent studies have found that parents underestimate the weight status of their overweight or obese child\textsuperscript{4, 5, 6, 7, 8, 9, 10, 11, 12} in both population and clinical research settings. Parents weight status estimation is worse for younger rather than older children\textsuperscript{9} and possibly for mothers with poorer educational attainment,\textsuperscript{4} but is more accurate for daughters rather than for sons.\textsuperscript{9} Mothers of heavier children were more likely to underestimate their child's weight. There was also a trend for underestimation seen more often in mothers who themselves were heavier.\textsuperscript{9, 13, 14}

While these studies have consistently reported that parents do not adequately acknowledge their child's weight status, very little is known about the factors influencing parental misclassifications of a child's weight status. Research is particularly needed to better understand the factors predicting parental misclassifications of their child's overweight or obesity status. Without such information, it will be difficult to plan and implement effective interventions.

The aims of this study are to examine the extent to which mothers misclassify their child's weight status and to identify the factors that influence this misclassification, especially misclassification of adolescents who were overweight, using a cohort of Australian adolescents who have been followed up since their birth in a public hospital in Brisbane in the 1980s. In addition to factors associated with self-reported weight, adolescent dieting and self image,\textsuperscript{15, 16} we postulated that relevant social and family factors, lifestyle, and physical and mental health status of the child and mothers in early life or at 14 years would be associated with maternal misclassifications of their offspring's weight status.

METHODS

Participants

The participants were from the Mater-University Study of Pregnancy and its outcomes (MUSP), which is a prospective study of 7223 women, and their offspring, who received antenatal care at a major public hospital in Brisbane between 1981 and 1984 and delivered a live singleton child who was not adopted before leaving hospital.\textsuperscript{17} The mothers and children have been followed up prospectively with maternal questionnaires being administered when their children were 3–5 days, 6 months, 5 years and 14 years. In addition, at the 5- and 14-year follow-up, detailed physical, cognitive and developmental examinations of the children were undertaken, and at 14 years the children completed health, welfare and lifestyle questionnaires. MUSP initial data collection and all subsequent follow-ups were approved by the relevant ethics authorities, and participants gave signed informed consent for their participation and that of their children. Full details of the study participants and measurements have been previously reported.\textsuperscript{17, 18} In this paper, examination of the predictors of maternal misclassifications of child weight status analyses is restricted to the 2650 offspring for whom we have measured height and weight and maternal perceptions of child weight status at 14 years follow-up. Children who could not participate were more likely to be from families...
with low income at birth, to have mothers who smoked throughout their pregnancy, and mothers and fathers with lower educational attainment.18,19

MEASURES

Measurements of outcomes

The main outcome of interest of this study was maternal misclassifications of their offspring's overweight status. Maternal perceptions of offspring's weight status were compared with offspring's measured body mass index (BMI) categories to identify the misclassification of maternal perceptions of their child's weight status. At 14 years follow-up, mothers were asked to complete the statement 'Do you think your child is...' by giving one of five possible responses: 'very underweight,' 'slightly underweight,' 'about the right weight,' 'slightly overweight' or 'very overweight.' The five categories are collapsed into three categories because of small numbers of the two extreme categories. The analysis began by regrouping maternal perceptions of child weight status and identifying whether children are misclassified. The mothers who answered very underweight or slightly underweight were classified as believing that their child was underweight, and those who responded very overweight or slightly overweight were classified as believing their child was overweight. Mothers answering at about the right weight were classified as believing their child was neither underweight nor overweight.

Adolescent's BMI at the 14-year follow-up was calculated from the measured weight and height. In all assessments, the average of two measures of the participant's weight, with the participant wearing light clothing, with a scale accurate to 0.2 kg was used. A portable stadiometer was used to measure height. Overweight and obesity were defined according to standard definitions derived from international surveys by Cole et al.20 BMI values less than 10 percentiles were considered as underweight. Because of small numbers in the obese group, for a meaningful analysis the overweight and obese categories are combined into one category called overweight. Thus, the final analysis contained the following misclassification categories: (1) not misclassified (measured BMI normal and mothers reported the right weight; measured BMI overweight and mother reported child was overweight; or measured BMI underweight and mother reported child was underweight); (2) misclassified as overweight (measured BMI underweight but mother reported normal weight; measured BMI normal but mother reported overweight) and (3) misclassified as underweight (measured BMI normal but mother reported underweight; observed BMI overweight but mother reported normal or underweight).

Measurements of predictors and confounders

The main factors we considered in this study, in addition to child dissatisfaction about their personal appearance, body shape, body size and weight, child dieting to lose weight and gender, were as follows: (1) social and family—income, maternal age and education, race, marital change and communication; (2) health—physical and mental health of the child and mother, maternal BMI and (3) lifestyle—maternal smoking, family eating patterns, adolescent TV and sports participation. Given the lack of similar papers, selection of potential factors was based on identification of studies examining self-reporting bias for height, weight and BMI, adolescent dieting and perception of body image, as well as early life, maternal and family factors are thought to potentially influence maternal judgment.
At the first clinical visit

Maternal age (three categories 13–19, 20–29 and 30 or more), paternal educational attainment (did not complete secondary school, completed secondary school, completed further/higher education) and parental racial origin (White, Asian and Aboriginal-Islander) were obtained from questionnaires at the first clinical visit and obstetric records in the study. Maternal height and pre-pregnancy weight were obtained at the study initiation from obstetric records or maternal questionnaires. A high degree of correlation was obtained between maternal estimate of her pre-pregnancy weight and her measured weight on the first antenatal visit (Pearson’s correlation coefficient=0.95). We defined three BMI categories for the mother based on the World Health Organization guidelines (1998).

First clinical visit to 14 years follow-up

Maternal depression was prospectively assessed at each follow-up from pregnancy to 14 years, using Bedford and Fould’s Delusions Symptoms States Inventory. At each follow-up, the experience of four or more symptoms was used to define those who were depressed. Combining all follow-ups, a composite indicator of maternal depression over 14 years of follow-up was generated with two categories: (1) not depressed at any follow-ups or (2) at least one episode of depression. A composite indicator of maternal tobacco consumption based on prospectively collected maternal smoking status (non-smokers or smoked at least one cigarette per day at each follow-up) was categorized as never smoked (reported non-smoker at each follow-up), smokers (consistently reported to have smoked at least one cigarette at each follow-up) and otherwise ex-smokers.

Five and 14 years follow-up

Child behavioral problems were prospectively assessed from maternal reports of child behavior using Achenbach’s child behavior check list at ages 5 and 14 years. We refer to those with scores above 1 s.d. of the mean score as having behavioral problems. On the basis of this cutoff, the child behavior check list was categorized into four mutually exclusive groups: (a) no behavioral problems (<1 s.d. on the child behavior check list) at ages 5 and 14 years; (b) early remitter (>1 s.d. percentile on the child behavior check list) at age 5 but normal at 14 years; (c) adolescent onset—normal at age 5 but had problems at 14 years and (d) persistent problems at ages 5 and 14 years. Change in gross-family income from ages 5 to 14 years: poor if income $A$15 548 per year at 5 years follow-up and income $A$20 799 per year at 14 years follow-up; rich if income >$26 000 per year at 5 years follow-up and >$31 149 per year at 14 years follow-up, otherwise middle income.

14 years follow-up

At 14 years follow-up, mothers were asked how often their child was dissatisfied about their personal appearance, body shape, body size and weight, each having the response options ‘often,’ ‘sometimes,’ ‘rarely’ and ‘never.’ Combining the four items, a composite indicator (standardized coefficient=0.92) was generated, with the lower quintile of scores being used to indicate children most dissatisfied (that is, low score indicates most dissatisfaction) with their appearance, shape, size and weight. Adolescent’s were asked ‘How often do you go on a diet to lose weight’? with four options ‘most of the time,’ ‘a few times a year,’ ‘rarely’ or ‘never.’ For the purpose of analysis, the first two categories are combined into one category to increase the frequencies in this group. Maternal and child self-reported general health status was categorized as excellent, good and fair/poor. Change in marital status (no change, 1–2 changes, and 3 or more changes during last 7 years) was used to assess the family stability. The Parent–Adolescent Communication Scale was used to assess mother–child communication at adolescence. Maternal report of the amount of time
the child spent watching television (<1 h per day, 1–<3 h per day, 3–<5 h per day and 5 or more hours per day), time spent on sports or exercise (4–7 days per week; 0–3 days per week), as well as the family attitude to having meals together (at least once a day, few times/once/less than once a week) were considered as predictors.

**Statistical analyses**

We used $X^2$-test to examine the associations of maternal misclassifications with maternal, child and family characteristics as previously described. Those factors that appeared statistically significant ($P<0.05$) in bivariate analysis were included in the multivariable analysis. Multivariable associations were evaluated using multinomial logistic regression.\(^\text{25}\) Finally, those factors that remain statistically significant in the multivariable models were included in the final analyses (Table 2). Statistical evidence for a difference in effect between males and females was assessed by computing a likelihood ratio test of the interaction with sex. We found the association of maternal misclassification with child weight status was different between the sexes ($P<0.001$). As the size of this difference was not substantial, results are presented for males and females combined to increase the statistical precision of the estimate.

Non-participants were more likely to be from families with low income at birth, to have mothers who smoked throughout their pregnancy and to have mothers and fathers with lower educational attainment.\(^\text{18,10}\) To determine whether loss to follow-up at 14 years affected the validity of our findings, we undertook a weighted analysis using inverse probability (of having missing outcome data) weights.\(^\text{26}\) All analyses were undertaken using Stata version 8.0 (Stata Inc., TX, USA).

**RESULTS**

Of 2650 mothers, 13.81% (16.19% males and 11.19% females) perceived their offspring were underweight, 18.49% (17.05% males and 20.08% females) perceived their children as overweight and the rest were described as about the right weight.

Comparisons of the mother's perception of their child's weight status with the measured BMI of child are shown for adolescent boys and girls in Table 1. Overall, 60% of mothers correctly classified their children who were overweight and 37% of mothers of an overweight child misclassified that child as at about the right weight. Of 328 overweight boys, the mother perceived 55.18% about the right weight and only 40.24% overweight. Similarly, of 334 overweight girls, the mother perceived 32.93% about the right weight and 73.17% overweight. Mothers were generally more likely to consider their normal-weight child to be underweight than overweight. Mothers classified half of the underweight children as underweight and the other half about the right weight.
Table 1 - Maternal perception of the weight status of their offspring at age 14 years by measured weight status at that age.

<table>
<thead>
<tr>
<th>Maternal report of child weight status</th>
<th>Measured body mass index categories</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Underweight (n = 143)</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Underweight</td>
<td>56.64</td>
</tr>
<tr>
<td>About the right weight</td>
<td>43.36</td>
</tr>
<tr>
<td>Overweight</td>
<td>0</td>
</tr>
</tbody>
</table>

In the bivariate analyses, maternal misclassification was significantly associated with gender, child dissatisfaction, child dieting to lose weight, child general health status in last year, child behavioral problems, maternal BMI, problems in family communication and family meals. All these factors except problems in family communication and presence of child behavioral problems remained as significant predictors in the final multivariable model (Table 2). Maternal education, race, change in marital status, change in income, maternal mental health, smoking status, fast-food, and TV watching were not associated with misclassifications.

Table 2 - Odds ratios and 95% confidence intervals for predictors of maternal misclassification of the weight status of their 14-year-old offspring (N=2402).

<table>
<thead>
<tr>
<th>N</th>
<th>Correct estimation (p-value)</th>
<th>Overestimation</th>
<th>Underestimation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unadj. OR</td>
<td>Adj. OR</td>
<td>Unadj. OR</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1255</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Female</td>
<td>1144</td>
<td>0.95 (0.56, 1.60)</td>
<td>1.16 (0.69, 2.08)</td>
</tr>
<tr>
<td>Child dissatisfaction</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Least dissatisfaction</td>
<td>1.76</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Most dissatisfaction</td>
<td>0.97</td>
<td>0.24 (0.12, 0.50)</td>
<td>0.37 (0.18, 0.80)</td>
</tr>
<tr>
<td>Maternal education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td>560</td>
<td>0.71 (0.41, 1.24)</td>
<td>0.25 (0.12, 0.53)</td>
</tr>
<tr>
<td>Marital status</td>
<td>372</td>
<td>0.08 (0.02, 0.33)</td>
<td>0.11 (0.03, 0.46)</td>
</tr>
<tr>
<td>Income</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Child health status last year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>1122</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Fairly good</td>
<td>1095</td>
<td>0.97 (0.69, 1.34)</td>
<td>1.00 (0.72, 1.44)</td>
</tr>
<tr>
<td>Poorly</td>
<td>56</td>
<td>0.71 (0.33, 1.52)</td>
<td>1.00 (0.24, 2.32)</td>
</tr>
<tr>
<td>Material BMI</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underweight</td>
<td>204</td>
<td>2.13 (1.52, 2.43)</td>
<td>2.02 (1.25, 3.31)</td>
</tr>
<tr>
<td>Normal</td>
<td>149</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Overweight</td>
<td>594</td>
<td>0.48 (0.23, 0.90)</td>
<td>0.53 (0.24, 1.11)</td>
</tr>
<tr>
<td>Family income together</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than once a week</td>
<td>1641</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>More than once a week</td>
<td>554</td>
<td>0.68 (0.41, 1.15)</td>
<td>0.74 (0.43, 1.36)</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; OR, odds ratio. UL, underweight; OB, overweight; BMI, body mass index; N, sample size; p-value, p-value; CI, confidence interval; *Unadjusted ORs; Adjusted ORs, adjusted by all other factors listed in this table.

In the final multivariable model, mothers were better at recognizing both normal weight and overweight in girls compared to boys. Child dissatisfaction of their body and dieting were associated with maternal misclassification. If an adolescent was dieting and underweight, mothers were less likely to misclassify the child as normal. However, for children with normal or increased BMI who dieted, the mother was more likely to misclassify them as overweight. For children with ill health and normal BMI, there was increased non-directional maternal misclassification. Overweight or

Published source available from Nature Publishing Group [www.nature.com/ijo]
obese mothers were less likely to identify overweight or obesity in their adolescents. Those mothers with a positive attitude to having family meals together were more likely to misclassify their child's weight from normal to underweight compared to their counterparts.

When we repeated the analyses using weights for factors that predicted non-response, the results did not differ from those presented here.

DISCUSSION

In this study of Australian adolescents, we found that maternal misclassification of child's weight status was common and included misclassifications to both higher and lower weight categories. Forty percent of mothers of overweight children misclassified their child as normal or underweight, more so in males than females. Fifteen percent of mothers of normal weight children misclassified their child as underweight, again more so in males than females. Half of the mothers of underweight children misclassified their child as about the right weight. When modeling multiple variables, the independent predictors of maternal misclassifications of child weight status were gender, child dissatisfaction with appearance, shape, size and weight, dieting to lose weight, general health status, maternal BMI and family meals. Gender, child dissatisfaction, dieting and maternal overweight were especially associated with misclassifications of overweight children. Child behavioral problems, early life, social factors, maternal mental health and life style and family factors considered in this analysis were not associated with maternal misclassifications of their child's weight.

Maternal underestimation of their overweight children found in this study is consistent with other studies. Misclassification of overweight children was specifically associated with child male gender, dissatisfaction, dieting and higher maternal BMI. The findings that essentially 40% of mothers failed to correctly classify their overweight child as 'overweight' can be explained in at least three possible ways. First, mothers may be reluctant to acknowledge that their child has a socially undesirable and stigmatizing condition, and hence either consciously or unconsciously do not want to admit that their child is overweight. Misclassification, however, was not associated with depression or social background in mothers, but occurred more commonly in mothers who themselves were overweight. Second, if the child no longer looks markedly larger than many of his or her peers, parents may not recognize their child as overweight or they lack understanding of what 'overweight' means. Our prediction model of maternal misclassifications of child weight status showed that the more children are concerned about their physical appearance, shape, size and weight, and the more they dieted to lose weight, the more their mothers underestimated overweight in the children. On the basis of this finding, a third possibility could be that mothers' misclassification and perception are influenced by evidence of the child dieting and expressing concern about their physical appearance, shape and size. We cannot, however, distinguish the possibility that the adolescent's behavior reflects maternal and family factors not examined in this study.

Study limitations

The participants who did not attend were more likely to be from poorer backgrounds and mothers were more likely to have had low education and to be non-white. Our results would be biased if the associations we have assessed were non-existent or in the opposite direction in non-participants, which is unlikely. To further assess whether those lost to follow-up produced bias in our results, we attached inverse probability weighting to subjects included in the analyses to restore the representation of those lost to follow-up. We followed the method suggested by Hogan and colleagues and used robust standard error estimates in this model. We found no difference
between the weighted and unweighted results, which suggests that attrition is unlikely to have substantially biased our findings. We have compared our estimates of overweight or obese at age 14 to the Australian National Nutritional Survey (NNS) 1995 for similar age categories, and the results are compatible. At age 14, the prevalence of overweight or obesity was 25% in the Mater-University Study of Pregnancy and 23% in NNS. These small differences are likely to be explained by regional variations and this comparison does not suggest a major problem with selection due to loss of follow-up.

**Implications of the findings**

We found that mothers frequently misclassify their child’s weight status. A limited number of maternal and child factors, predominantly at 14 years rather than early childhood, were associated with maternal misclassifications of their child’s weight. Although misclassification was common and included misclassifications to both higher and lower weight categories, overweight children go largely unrecognized. The main predictors of maternal misclassifications for children with increased BMI were male gender, child dieting, shape, size and weight, and maternal overweight or obesity.

Recognition of excess weight and knowledge of its health consequences are essential first steps in tackling obesity. Our data confirm that the laypersons’ perception of average weight now conflicts with the clinical definition of underweight, normal weight and overweight. This indicates a campaign of changing lifestyle to prevent further overweight, and obesity may receive insufficient motivation at an individual level. The change motivation literature suggests a low likelihood of change in individuals, in this case parents, in the precontemplation stage of change. Contemplation to change followed by more active phases requires acknowledgement that a problem exists.

There is strong support that primary prevention of childhood overweight and obesity, including promoting healthy nutrition and patterns of activity, is likely to be successful with parental involvement. However, such support is less likely to occur if parents, particularly mothers, do not recognize or perceive their overweight children as overweight. The finding that early life experiences were not related to misclassification should be helpful to clinicians as it suggests understanding adolescent and family perceptions of overweight and obesity will best be achieved by a focus on current adolescent and family circumstances.

The recent report of the US Preventive Services Task Force concluded that there was insufficient evidence on the benefits and harms of interventions to recommend for or against a population-screening program for overweight in children and adolescents. Potential harms identified and relevant to this study include labeling, poor self-image and disordered eating. Therefore, there is a need to evaluate the benefits and harms of increasing parental and child awareness of the child’s health, dieting, physical appearance, shape and size. Until these are resolved, we are missing critical partners in our efforts to halt an impending health crisis in relation to overweight and obesity.

**References**


**Published source available from Nature Publishing Group** [www.nature.com/ijo](http://www.nature.com/ijo)


Acknowledgements

We are grateful to all participants in the study. Greg Shuttlewood, University of Queensland, helped with data management for the study. The core study was funded by the National Health and Medical Research Council (NHMRC) of Australia. This work was funded by the NHMRC (Grant number 252834) and carried out at the University of Queensland and The Mater Hospital. The views expressed in the paper are those of the authors and not necessarily those of any funding body.