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Maternal Employment, Childcare and Childhood Overweight during Infancy

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MATERNAL EMPLOYMENT, CHILDCARE AND CHILDHOOD OVERWEIGHT DURING INFANCY

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ABSTRACT

This paper examines the relationship between maternal employment, childcare during infancy and the overweight status of pre-school children. Using data from the Infant Cohort of the Growing-Up in Ireland Survey, propensity score matching addresses the issue of potential selection bias, quantile regression allows the impact of both maternal employment and childcare to be examined throughout the weight distribution and multiple imputation is used to address the problem of missing data due to item non-response. The results suggest that both full-time and part-time maternal employment when a child is 9 months old increase the likelihood of being overweight at 3 years old, but only for children of mothers with higher levels of education. Informal childcare at 9 months also has harmful effects on child weight, but again only for children of more educated mothers. Quantile regression finds that the children most impacted by maternal employment are those at the upper percentiles of the weight distribution. When selection on observables is used to assess bias arising from selection on unobservables, maternal employment estimates are determined to be a lower bound, while informal childcare results could be attributed to selection bias. Overall findings are consistent with research from North America and the United Kingdom, and are in contrast to recent findings from the rest of Europe, suggesting the possible role of institutional factors.

1. INTRODUCTION

The World Health Organisation (WHO) states that "childhood obesity is one of the most serious health challenges of the 21st century". Worldwide, 170 million children under the age of 18 (WHO, 2012) and more than 40 million children under the age of 5 are estimated to be overweight (OECD, 2013). US research has shown that 59 percent of boys and 45 percent of girls who are overweight at 3 years of age will be overweight at 35 years, and this risk increases with both the weight and age of the child (Guo et al., 2002). Raised body mass index (BMI) is a major risk factor for cardiovascular diseases, diabetes, musculoskeletal disorders in particular osteoarthritis, and many cancers (OECD, 2013). In addition, many childhood health conditions are more prevalent in obese children, such as bone and joint problems, sleep apnea, and social and psychological problems such as stigmatisation and poor self-esteem (Daniels et al., 2005; Freedman et al., 2005). Factors believed to contribute to childhood obesity include the consumption of sugary drinks, advertising of unhealthy foods targeted at young children, inconsistent childcare standards on nutrition and activity levels, lack of community outdoor play areas, affordability of healthy foods, increased portion sizes, television and computer usages, and lack of breastfeeding support. Evidence suggests that many of these factors may be influenced by maternal employment and non-parental childcare (Cawley & Liu, 2007; Bauer et al., 2012; Fertig et al., 2006).

Over a period consistent with the rise in childhood obesity, female labour force participation among women aged 25-54 has risen sharply in most OECD countries, with average participation rates increasing from 54 percent in 1980 to 71 percent in 2010 (OECD Statistics on Employment). An increase in the provision of childcare services has been both a response to and a driver of this increased participation (Thévenon, 2013). Consequently, many

parents share their child-rearing responsibilities with caregivers working in formal centre-based settings, or informal childminders including non-parental care provided by friends, family, neighbours, nannies and au pairs in a home-setting. Therefore, an investigation of the potential impact of maternal employment in early childhood on child health would be incomplete without an examination of whether childcare choices play a role in the childhood obesity problem. Most of the research in this field emanates from the USA, however, with country specific factors such as maternity leave entitlements, supports for working parents, and the extent and quality of childcare services likely to exert an influence on the health of young children, research from countries other than the US will make a valuable contribution to the examination of childhood obesity.

Ireland, like most of the developed world, has seen a dramatic rise in both adult and childhood obesity levels over the past 30 years. Approximately 26 percent of Irish children are overweight (Layte & McCrory, 2011), with levels of childhood overweight doubling since 1990 (IUNA, 2005). Over the same period, the number of mothers participating in the workforce has also increased. In 1983, 40 percent of Irish women worked outside the home, with this figure rising to 67 percent in 2007 (Russell et al., 2009). A rise in the cost of living, in particular the cost of housing, over this period has resulted in many new mothers maintaining full-time employment due to financial commitments. However, with the notable exception of improved maternity leave entitlements, there is little institutional support in Ireland for parents combining parenthood with employment (Barry & Sherlock, 2008). Government expenditure on pre-school care and education stands at 0.4% of GDP, well below the UNICEF target of 1% (UNICEF, 2008). Most centre-based childcare is provided by the private sector, is expensive, and of inconsistent quality (Barry & Sherlock, 2008).

Regulation is focused on basic health and safety and, while guidelines on areas such as nutrition do exist, they are typically not enforced or monitored (Johnston Molly et al., 2014).

Using data on Irish pre-school children, this study examines the relationship between maternal employment and childcare usage when a child is 9 months old and the likelihood that a child is overweight at 3 years of age. The results are consistent with the general findings of the literature from North America and the UK. Full-time and part-time maternal employment when a child is 9 months old increases both age 3 BMI and the risk of being overweight, however the effect is driven by the children from more advantaged backgrounds, with advantage measured in terms of maternal education. Informal childcare also increases the probability of being overweight and, once again, this elevated risk is prevalent only for children from advantaged backgrounds.

2. THEORETICAL MOTIVATION AND LITERATURE

2.1 Theoretical Framework

Two theoretical frameworks can serve to underpin the analysis of maternal employment, childcare and childhood obesity. Grossman (1972), in deriving his concept of health capital, states that health is produced from medical inputs and other factors, such as time, diet and exercise. Individuals decide how to allocate their resources to the production of their own health capital and that of their child in order to maximise their utility. In the context of childhood obesity, managing a child's health takes both time and financial resources. A healthy diet requires the purchase of nutritious foods, time spent on meal preparation, and effort on behalf of a parent to resist low quality convenience food and high sugar treats.

Parental time and money is also required to ensure a child participates in activities that promote health.

Importantly, the Grossman model suggests that greater education should make an individual more efficient at producing health. Cutler & Lleras-Muney (2006) state that, while greater education can lead to better health through increased income levels and occupational choices with low levels of health risk, education can also affect behaviour and decision-making. For example, education may affect health through lower future discount rates, such that the more educated may place a higher value on the future (Becker & Mulligan, 1997). Therefore, maternal education should play a positive role in the health production of a child.

A further theory proposed by Becker and Lewis (1973) states that there is a trade-off between the quality and quantity of children. If children are viewed as a normal good in theoretical terms, then an increase in income would lead to an increase in the demand for children. However, Becker and Lewis show that greater resources usually lead to a greater investment in children, increasing the marginal cost of children. Greater income may lead to fewer children and a higher standard of living for the family, with access to better health services, education, higher quality food, and positive activities.

Applying these theories to the current study, maternal employment may result in increased family income and higher standards of living, however, maternal time constraints may have adverse consequences for the health capital of a child, particularly if replacement childcare is inferior to the care provided by a mother. In addition, time spent with children may be highly valued by a mother in employment, such that the opportunity cost of time spent on activities such as grocery shopping and meal preparation relative to time with her children is

high (Cawley and Liu, 2007). Better educated individuals tend to have higher income jobs (Cutler & Lleras-Muney, 2006) and may derive greater satisfaction from such roles. Therefore, the opportunity cost for a well-educated mother of leaving the workforce or reducing her work hours may be greater than the utility value of caring for her children. While more educated mothers may be more efficient at producing health capital for their child, the absence of the mother from the home while working may offset the return from these efforts.

2.2 Literature

Research investigating the influence of maternal employment on the health and development of young children gained momentum about 10 years ago. A separate strand of research analysing the impact of childcare on child outcomes has also evolved in response to the increased use of non-parental childcare. However, few studies address the interdependent influence of maternal employment and childcare usage on child weight.

Investigating the relationship between maternal employment and overweight children in the US, Anderson et al. (2003), the most cited study in this field, and Ruhm (2008) find that the greater the intensity of the mother's work schedule over the child's life, the higher the probability that the child will be overweight, a result which is driven by more affluent, educated white mothers. Ruhm (2008) also finds that disadvantaged children benefit from part-time maternal employment across a number of developmental domains, yet some of this advantage is eroded by more intensive maternal employment. Using Danish data, and with findings that contrast with these studies, Greve (2011) finds no significant association between maternal employment and child weight status, and attributes these findings to factors specific to family life in Denmark, in particular the availability of universal high

quality affordable childcare . Gwozdz et al. (2013) is the only study to use bioelectrical impedance and anthropometric measures to assess weight, and examines data gathered on children between the ages of 2 and 9 from eight European countries (Belgium, Cyprus, Estonia, Germany, Hungary, Italy, Spain and Sweden). The authors find that, for all countries, current maternal employment is not associated with childhood overweight. Therefore, recent European findings appear to diverge from those emanating from North America.

US research suggests a number of mechanisms through which maternal employment may lead to a greater risk of overweight or obesity in children. Women employed full-time spend less time cooking or eating meals with their children (Cawley and Liu, 2007), while children of employed mothers have a lower probability of eating breakfast (Fertig et al., 2006), and consume more sweetened drinks and fast food (Bauer et al., 2012). However, Gwozdz et al. (2013), using European data, find that children of mothers in employment generally have a higher quality diet, lower energy intake and higher activity levels. Focusing more on activity levels, Ziol-Guest et al. (2013), using US data, conclude that the number of hours highly-educated mothers work over a child's lifetime increases the risk of overweight at ages 13 or 14, with television viewing time acting as a mediator. Conversely, using Danish data, Bonke and Greve (2012) find no relationship between maternal working hours and unhealthy activities such as excessive television viewing.

One of few studies to investigate the interdependency between maternal employment and childcare in early childhood, Hubbard (2008) finds that any maternal employment decreases the probability of obesity but, for mothers working full-time, childcare increases the probability of obesity. Using the same data, applying fixed effects and distinguishing

between types of childcare arrangements, Herbst et al. (2010) find that non-parental childcare arrangements are not strongly associated with children's weight. A number of other US studies find that informal childcare in the early years has a detrimental effect on the risk of overweight during childhood (Benjamin et al., 2009; Maher et al.; 2007), while formal childcare has no adverse effect (Lumeng et al., 2005). Studies from the UK (Pearce et al., 2010) and Hong Kong (Lin et al., 2011) arrive at similar conclusions.

Unobservable differences and self-selection issues which may bias the relationship between maternal employment, childcare and child weight, are dealt with in a number of ways in this literature and conclusions on the potential effect of unobserved selection issues vary. Anderson et al. (2003), using probit, sibling difference and instrumental variable models, conclude that there is no evidence that the impact of maternal employment on child weight is biased by unobserved heterogeneity. However, on obtaining a significant estimate on an indicator of maternal employment for a period after the measurement of the child's weight, Ruhm (2008), also using sibling fixed effects, concludes that there is some evidence of reverse causation. When Scholder (2008) applied a similar approach using both random and fixed effects, she found no evidence of unobserved heterogeneity. Assessing the likely influence of selection issues on the impact of childcare, Herbst et al. (2010), using a fixed effects estimator, suggest that the raw differences observed in child weight by different forms of childcare are due to differences in observed and unobserved characteristics of children and their families.

The findings of research on the influence of maternal employment and childcare on the weight of children appears to vary internationally, and is likely a result of cultural, institutional and policy differences between Continental European countries and North

America and the UK. Differences in State support for families, such that childcare is both affordable and good quality, and policies that allow parents to spend more time with their children, may be at the root of such differences (Gwozdz et al., 2013; Hawkins et al., 2008). However, while the application of different econometric techniques to the assessment of the impact of maternal employment yield largely consistent results, the influence of childcare does vary when more advance econometric techniques are used.

3. DATA AND METHODOLOGY

3.1 Growing Up In Ireland

This study uses data from the Infant Cohort of the Growing Up in Ireland study. The 11,134 participant children were selected randomly from the 41,185 children born between 1 December 2007 and 30 June 2008 as per the Child Benefit Register. The first wave of interviews took place when the infants were aged 9 months (sample size of 11,134) and interviews for the second round took place when the child was 3 years of age (sample size of 9,793). Response rates for Wave 1 and Wave 2 are 64 percent and 91 percent respectively. This study uses data on participants who responded in both waves. Population weights are used, where appropriate, to account for between wave attrition.

3.2 Overweight & Body Mass Index (BMI)

Body Mass Index (BMI) is the most widely used measure of weight status and is calculated using both the actual weight and height measurements taken by the interviewers for each child in the GUI study. This is then cross-referenced against gender specific growth charts (Cole et al., 2000) to determine the weight status of the child at age 3. A 3 year old boy with

a BMI greater than or equal to 17.89 is defined as overweight (obese >= 19.57), while the overweight threshold for a girl is 17.56 (19.36 for obese). In the sample, more girls are overweight than boys, 24.5 percent versus 23.4 percent. Similarly, 6 percent of girls are obese, compared to 5 percent of boys.

3.3 Maternal Employment & Childcare Choice

This study investigates the impact of maternal employment first, then examines the role of childcare type, and finally uses a categorical variable combining both maternal employment and childcare type. Utilising self-reported work status when the child is 9 months old, maternal work status[1] is categorised as home-duties (39%), part-time employment (21%), full-time employment (27%), and mothers on leave but planning to return to work (13%). The majority (94%) of children in childcare at 9 months have a mother who is working. Yet, 31 per cent of children with working mothers are cared for at home by a parent. As there is no measure of childcare quality in the data, childcare type is used, where the reference category is children cared for at home by a parent or in childcare for 8 hours or less per week (65%). The second category includes "Informal" care and comprises of children cared for by a childminder, relative or friend in either the child's or carer's home (24%); with the final category referring to children cared for in a centre-based setting, which is labelled "Formal" care (11%). A third variable[2] is derived from classifying both part-time and full-

[1] Maternal Employment: Home-duties (3,693), which includes those unemployed (292) and on long term illness (59); part-time (1,946), including those on state training schemes (42); full-time (2,582), including full-time students (142); and with the fourth category relating to mothers on leave but planning to return to work (1,252).

[2] Maternal Employment split by Childcare type: The reference category, mother not in the workforce (3,692: 39%), consists of children cared for at home, though a small number of children in either informal (79) or formal childcare (67) are also included, as further categorisation of these small samples would not lead to statistically meaningful results. There are 7 further categorisations: part-time work and care at home by a parent (782: 8%); part-time work and informal childcare (889: 9%); part-time work and formal childcare (275; 3%); full-time work and care at home by a parent (614; 6%); full-time work and informal childcare (1,292; 14%); full-time work and formal childcare (676; 7%); and children of mothers at home but planning to return to the workforce (1,252; 13%).

time maternal employment at 9 months into 3 categories of childcare - care at home by a parent, informal childcare and formal childcare.

3.4 Choice of Covariates

Control variables are selected based on their theoretical relevance, availability in the dataset, and the findings of prominent studies in the field. As detailed on Table 1, control variables include child characteristics, birth characteristics, early nutrition, family characteristics, and maternal characteristics. Family characteristics include the number of siblings, family income, an indicator of mother's partner residing in the home, and rural location. Maternal characteristics include covariates which have a significant impact on the weight status of the child including the weight status of the mother, though the relative influence of environmental and genetic factors is unclear and much debated (Gibson, L. et al., 2007; Danielzik, S., 2004), maternal smoking, her age, ethnicity, and whether or not she lived in a household at the age of 16 that experienced financial difficulties.

3.5. Methodology

Before the application of estimation techniques, an analysis of missing data due to item non-response confirmed that the characteristics of the complete-case sample and the missing data sample differ. In addition, as the extent of missing data from item non-response is significant, reliance on complete case data may result in biased estimates and a substantial loss of valuable information. Therefore, multiple imputation (MI) is used throughout, increasing the sample size by 1,286 observations.

Probit and Ordinary Least Squares (OLS) regression analysis are used to examine the impact of maternal employment and type of childcare on child weight. As these results may be

influenced by endogeneity, propensity scare matching (PSM) is used to reduce any potential bias. PSM has the advantage of being intuitively easy to understand, while also making no assumption on the functional form of the relationship between the outcome and covariates (Dehejia and Wahba, 1999). Those who receive a treatment i.e. maternal employment/childcare, are matched with those that do not receive a treatment but have a similar probability of being treated based on observable characteristics. Note that this approach does not address selection on unobservable characteristics, therefore causal estimates may not be produced using PSM. This claim can only be made if selection is on observables only or, in the case where unobservable characteristics influence the selection into childcare type or maternal employment, the balancing on observables also balances on these unobservables.

Variables that are not affected by participation in the treatment (Caliendo and Kopeinig, 2005) are used in the estimation of the propensity score. These variables are then evaluated to assess the quality of the matching process before MI, with a maximum difference between the two groups of 5% deemed acceptable. Once the propensity score is calculated, radius matching with a caliper (distance) of 0.01 is used to match the treated with the control group. With the exception of nearest neighbour without replacement, results are robust to the choice of matching estimator and caliper. Each treated observation is matched with all counterfactuals within the caliper, with each counterfactual observation within the calliper weighted equally. An untreated observation may be matched with more than one treated observation and, while all treated observations within the area of common support are matched, this may not be the case for all observations in the control group. Appendix 3

details the selection of matching estimator and the results of tests of the level of bias after each estimation.

Many studies have found that the impact of maternal employment and non-parental childcare varies by socio-economic status (Anderson et al., 2003; Ruhm, 2008; Pearce et al., 2010), therefore the results are divided into sub-groups based on two covariates that represent socio-economic status – low and high (top 2 quintiles) equivalised household income, and low and high (minimum of post-secondary school qualification) maternal education.

Finally, quantile regression techniques are applied to determine whether the results differ throughout the weight distribution. The standard model for linear quantile regression is used and results are estimated using the estimator suggested by Koenker and Bassett (1978).

4. RESULTS

4.1 Descriptive Statistics

Descriptive statistics by maternal work status at 9 months are presented in Table 1. While the proportion of overweight children of full-time working mothers is marginally higher than children with mothers at home, working part-time or on-leave, selection bias may mask the true effect of maternal employment on child weight.

[INSERT TABLE 1 HERE]

Full-time working mothers have the highest level of educational attainment, are more likely to be of Irish ethnicity, have a lower incidence of depression, and have the highest rate of breastfeeding, although both mothers on-leave and on home-duties breastfeed for longer. More working mothers are in the highest 2 income quintiles, which may be expected as income is endogenous to working. Full-time working mothers have both fewer children and more children classified as normal weight at birth. Mothers on home-duties have the highest rate of smoking, single parenthood, and overweight. They also report the highest levels of chronic illness and are most likely to have lived in a family that had difficulty making ends meet when they were aged 16. Therefore, there are a number of key observed differences between these groups that must be controlled for.

4.2 Regression Analysis

Table 2 reports the results from probit regressions estimating the probability of a child being overweight, and OLS regressions estimating the impact on BMI. The results of each estimation are broadly consistent. Model 1 shows that full-time maternal employment at 9 months is associated with an increase in BMI, and an increase in the likelihood of a child being overweight at 3 years of age. Model 2 shows that no form of childcare is significantly associated with an increase in BMI or overweight. Model 3 examines the combination of maternal employment and childcare, and finds that only full-time maternal employment combined with informal childcare results in a higher BMI and an elevated risk of a child being overweight. The probit estimate suggests that part-time employment combined with formal childcare may reduce the likelihood of overweight in early childhood.

[INSERT TABLE 2 HERE]

4.3 Propensity Score Matching

Examining the impact of maternal employment and childcare respectively on BMI, Table 3 displays the results of both PSM and OLS. Seven specifications of treatment and control are used, 3 referring to maternal employment, and 4 referring to childcare choice.

[INSERT TABLE 3 HERE]

The results report the treatment effect on the treated when compared with the counterfactual control group, and the PSM results are broadly consistent with OLS findings. Full-time maternal employment is associated with a higher BMI when compared to both mothers at home (PSM: 0.16, OLS: 0.12) and part-time maternal employment (PSM: 0.08. OLS: 0.9), though the latter findings are significant using PSM only. Informal childcare increases BMI by 0.08 (OLS: 0.8) compared with parental care,[3] though this result is significant at the 10% level only. Hill et al. (2005) apply PSM matching to examine the effect of first year maternal employment on the cognitive outcomes of children at age 3 and also find that results obtained using PSM are consistent with regression results.

4.4 Analysis by Socio-Economic Status

When the sample is divided into low and high SES groupings using two different classifications, maternal education and equivalised family income, the OLS results, as detailed on table 4, show clear heterogeneity in the effects of both maternal employment and childcare[4]. Maternal employment is associated with an elevated BMI for children from higher income and higher maternal education households only. Indeed, part-time

[3] Mother at home refers to a mother not in the workforce, while parental childcare refers to a child cared for solely by a parent, regardless of the maternal employment status.
[4] All OLS results are consistent with estimates using Propensity Score Matching.

employment may lead to a reduced BMI for children from lower SES groups if the children are in formal childcare.

[INSERT TABLE 4 HERE]

Children in informal childcare with a highly educated working mother appear to be particularly vulnerable to an elevated BMI regardless of whether the mother works full-time or part-time. However, formal childcare leads to as elevated BMI only when coupled with full-time maternal employment.

4.5 Quantile Regression

The quantile regression results reported in Table 5 provide evidence of heterogeneity in response to maternal employment, such that the weight of children at different points at the BMI distribution respond differently to maternal employment. When the sample is divided by maternal education, again, there is no evidence of a relationship between employment and BMI for children with mothers with low levels of education (not shown). However, for children of mothers with higher levels of education the effect both increases in magnitude and significance as we move to the higher percentiles, with the effect of both part-time and full-time maternal employment largest for those children at the 90^{th} weight percentile. This suggests that maternal employment adds significantly to the risk of a child being obese if they are already overweight. As the cut-off for overweight for boys of 17.89 is only 1.68 below the obese threshold of 19.57 (for girls overweight is over 17.56 and obese 19.36, a gap of 1.8), an effect of between 0.22 and 0.33 is material. When the sample is divided by income (results not shown), there is no significant relationship between

employment and BMI for children within the low income category. However, the BMI of children with a BMI at the 50th percentile or below increases with full-time maternal employment. This may suggest that greater income has a beneficial effect on child weight by increasing the BMI for those considered underweight.

Informal childcare has a significant and increasing effect on the BMI of children of mothers with higher levels of education for those at the higher percentiles. However, formal childcare has no statistically significant effect at any point in the distribution for children from either SES group.

[INSERT TABLE 5 HERE]

4.6 Selection on Unobservables

Altonji et al. (2005) propose a theory that uses the degree of selection on observables as a measure of the degree of selection on unobservables, and provide a method to quantitatively assess the degree of omitted variable bias. A measurement of the amount of selection on observables is used in the calculation of a ratio that determines how large the selection on unobservables would need to be in order to attribute the entire effect of either maternal employment or childcare to selection bias[5].

Applying this methodology to the current study, a negative bias for full-time maternal employment of 0.73 is estimated. This implies that maternal employment is negatively related to ε_i as a result of the negative correlation between maternal employment and the observable determinants of BMI. The coefficient on full-time maternal employment should

[5] For a detailed description refer to Appendix 2

therefore be viewed as a lower bound, such that maternal employment is likely to increase BMI by at least the effect estimated in these results. Ruhm (2008) similarly concludes that, once a particularly comprehensive number of controls for non-random selection into maternal employment have been included, remaining omitted variable bias may lead to underestimates of the adverse effects of maternal employment.

When this methodology is applied to informal childcare, a positive bias figure of 0.27 is estimated. The implied ratio of 0.22 suggests that unmeasured characteristics of both those selecting informal childcare and the quality of this care need only be 22 percent as strong as the observable characteristics in order to fully explain the effect of informal childcare. The possible role of selection bias is greatest for families with higher levels of maternal education. This is consistent with some of the debate in the literature on the level of bias in estimates of the impact of childcare on child health outcomes (Duncan and Gibson, 2000; NICHD and Duncan, 2003), a conclusion supported by Herbst et al, (2010).

5. DISCUSSION

These results suggest that pre-school children of well-educated employed mothers have an increased risk of childhood overweight and obesity. Educated mothers are likely to have positive health behaviours and understand the nutritional and health needs of their children (Grossman, 1972). They may be more vigilant about appropriate food choices and activity levels than mothers without the advantage of education. However, maternal employment has a major impact on the pattern of family life and the strain of combining both employment and parenting may result in this vigilance proving difficult to maintain. Many

childminders may not be as attentive to the child's health, such that replacement childcare may be of a lower quality than maternal care by a well-educated mother (Pearce et al., 2010; Nazarov & Rendall, 2011).

The findings of this study must be understood within the institutional context of employment and childcare in Ireland. Whether the harmful effect of maternal employment by more educated mothers is due to a mother being away from her child or the lack of supports for these families, cannot be determined. However, these findings are consistent with those from countries with limited institutional support for working parents, such as the US and the UK. The contrast with findings from Denmark (Greve, 2011) is noteworthy. Maternal employment may have no impact on the weight status of a child when adequate structures are in place to support working mothers and their children. The provision of affordable childcare services of a consistently high quality has the potential to play a substantial role in mitigating the rise in childhood obesity. Healthy activity and diet behaviours that commence in the pre-school years have the potential to reduce childhood obesity levels and, if continued into adulthood, result in long term health benefits and an improved quality of life (Larson et al., 2011).

This paper is subject to some limitations due to data availability. Like most studies in this field, childcare quality is unmeasured and information on the work status of mothers is limited. The availability of the outcome measure at wave two is a further constraint, such that panel data techniques cannot be used.

Despite these limitations, this study makes a valuable contribution to the international literature for a number of key reasons. Firstly, viewing maternal employment and childcare both separately and jointly allows the effect of these interdependent variables to be

assessed. Secondly, the use of multiple imputation ensures results are representative of the population as a whole. Thirdly, the use of propensity score matching allows potential selection bias to be minimised, although this methodology may not capture the effect of such bias if selection is on unobservable characteristics. The application of the methodology to assess selection bias derived by Altonji et al. suggests that the results for maternal employment should be viewed as a lower bound estimate, while those for informal childcare may be due to self-selection. As further waves of GUI data become available, this concern may be explored. Fourthly, quantile regression directs the conclusions of this study to the children most affected by maternal employment i.e. the children most at risk of obesity. Finally, as the Growing Up in Ireland survey captures actual height and weight measurements, the accuracy of the outcome variables is unquestionable.

This research concludes that maternal employment and childcare choices have implications for the health of young children. The obesity problem is multifaceted and this research contributes to a greater understanding of the key drivers, with the potential to inform policy decisions designed to tackle this serious issue.

TABLE 1 - DESCRIPTIVE STATISTICS & SPLIT BY MOTHER'S EMPLOYMENT STATUS AT 9 MONTHS

	ALL	HOME	PART-TIME	FULL-TIME	ON LEAVE
% OF MOTHERS	100%	39%	21%	27%	13%
Child's Weight at 3 years					
BMI	16.84	16.84	16.83	16.87	16.79
Overwgt	24%	24%	24%	25%	23%
Obese	5%	6%	5%	5%	5%
Childcare at 9 months					
Cared for at Home by Parent	65%	97%	40%	24%	92%
Informal Childcare	24%	2%	46%	50%	5%
Formal Childcare	11%	1%	14%	26%	3%
Maternal Workstatus at 3 years					
At home	42%	77%	20%	13%	31%
Part-time	29%	15%	59%	23%	34%
Full-time	23%	6%	15%	54%	24%
On leave	6%	2%	7%	11%	11%
Childcare at 3 years					
Cared for at Home by Parent	51%	74%	44%	30%	42%
Informal Childcare	22%	8%	30%	36%	25%
Formal Childcare	26%	19%	26%	34%	32%
Worked before Birth	78%	52%	99%	97%	88%
Study Child Female	49%	50%	49%	49%	49%
EARLY NUTRITION					
Breastfed					
Never	41%	46%	42%	35%	37%
Less than 120 days	33%	28%	32%	40%	33%
120 - 180 days	7%	5%	8%	8%	7%
180days +	19%	20%	17%	18%	23%
Age weaned					
Younger than 4 months	15%	15%	16%	15%	12%
4 - 6 months	55%	55%	56%	56%	55%
6 months or more	30%	30%	28%	29%	33%
FAMILY CHARACTERISTICS					
Top 2 Income Quintiles	40%	19%	44%	66%	57%
No of siblings	1.32	1.55	1.29	1.05	1.30
Only Child	40%	31%	38%	53%	41%
Partner	89%	83%	91%	94%	94%
Marital Status	69%	64%	69%	72%	79%
Urban	44%	45%	39%	43%	47%
BIRTH CHARACTERISTICS					
Low Birth Wgt	5%	6%	4%	4%	7%
High Birth Wgt	20%	20%	20%	18%	21%
Caesarean Section	26%	24%	26%	27%	28%
Child in poor health at birth	3%	4%	2%	3%	3%
MATERNAL CHARACTERISTICS					
Maternal Education					
Up to Leaving Certificate	43%	59%	41%	28%	29%
Up to Degree	38%	30%	41%	44%	44%
Postgraduate	19%	11%	18%	28%	27%
Smoker	23%	28%	23%	20%	18%
Smoked During Pregnancy	16%	22%	15%	12%	11%
Materal Depression	12%	14%	11%	9%	12%
Ethnicity	18%	25%	14%	15%	12%
Mother Overweight	46%	50%	44%	44%	44%
Folic Acid	92%	89%	93%	94%	94%
Mother's Age (when child 9 months)	31.8	31.2	32.1	31.8	33.4
Mother's Age at first pregnancy	27.2	25.6	27.4	28.2	29.3
Quality of Attachment Score	42.6	42.8	42.6	42.2	42.7
Chronic Illness (Mother)	11%	15%	9%	8%	12%
Maternal poverty (Aged 16)	20%	23%	19%	18%	16%

**NOTE: THIS SPLIT IS BASED ON COMPLETE DATA AND DOES NOT INCLUDE IMPUTED DATA*

TABLE 2 - PROBIT & OLS RESULTS

N = 9,431	Probit	OLS
	Overwgt	BMI
Model 1 - Baseline: Mother at Home	**MATERNAL EMPLOYMENT AT 9 MONTHS**	
Part-time Employment	0.004	0.002
	(0.048)	(0.050)
Full-time Employment	0.088*	0.108**
	(0.047)	(0.052)
On Leave	0.090	0.049
	(0.057)	(0.065)
Model 2 - Baseline: Child Cared for at Home by Parent	**CHILDCARE AT 9 MONTHS**	
Informal Childcare	0.051	0.068
	(0.042)	(0.045)
Formal Childcare	0.012	0.048
	(0.058)	(0.056)
Model 3 - Baseline: Mother at Home	**MATERNAL EMPLOYMENT & CHILDCARE AT 9 MONTHS**	
Part-time Employment & Parental Care	0.047	0.036
	(0.066)	(0.071)
Part-time Employment & Informal Childcare	0.021	0.006
	(0.063)	(0.066)
Part-time Employment & Formal Childcare	-0.211**	-0.106
	(0.107)	(0.095)
Full-time Employment & Parental Care	0.024	(0.001)
	(0.072)	(0.088)
Full-time Employment & Informal Childcare	0.100*	0.155**
	(0.057)	(0.058)
Full-time Employment & Formal Childcare	0.117	0.116
	(0.071)	(0.072)
On Leave & Child in Childcare	0.089	0.049
	(0.057)	(0.065)

*Robust standard errors in parentheses & significance:*** p<0.01, ** p<0.05, * p<0.1*

Full covariates are included in all models: gender & early nutrition; birth characteristics; family characteristics & maternal characterisitics

**Probit marginal effects not available for MI data*

TABLE 3 - PROPENSITY SCORE MATCHING RESULTS

Outcome: BMI

Treatment	Control	Sample (N)	OLS	PSM
Full-time maternal employment	Mother at home	6,244	0.122***	0.164***
			[0.047]	[0.051]
Part-time maternal employment	Mother at home	5,608	0.035	0.051
			[0.046]	[0.045]
Full-time maternal employment	Part-time maternal employment	4,520	0.077	0.089*
			[0.047]	[0.051]
Non-parental childcare (any form)	Parental Child Care	9,431	0.056	0.048
			[0.036]	[0.036]
Informal Childcare	Formal Childcare	3,330	0.053	0.051
			[0.057]	[0.060]
Informal Childcare	Parental Child Care	8,395	0.074*	0.072*
			[0.04]	[0.04]
Formal Childcare	Parental Child Care	7,137	0.016	0.005
			[0.053]	[0.052]

*Robust standard errors in parentheses & significance:*** p<0.01, ** p<0.05, * p<0.1.*

Full covariates used: gender & early nutrition; birth characteristics; family characteristics & maternal characterisitics.

Sample size varies for each of the specifications as only observations for the particular binary treatment are included.

All PSM estimations include the full set of covariate controls used in the regression equations.

TABLE 4 - SES SUB-GROUPS - OLS

Outcome: BMI	TOTAL	MATERNAL EDUCATION		EQUIVALISED HOUSEHOLD INCOME	
		LOW	HIGH	LOW	HIGH
N	9431	4042	5389	5453 - 5464	3967 - 3978
Maternal Employment & Childcare at 9 months					
Part-time Employment & Parental Care	0.036	-0.088	0.207**	0.002	0.148
	(0.071)	(0.102)	(0.090)	(0.083)	(0.134)
Part-time Employment & Informal Childcare	0.006	-0.141	0.156*	0.086	-0.061
	(0.066)	(0.101)	(0.081)	(0.091)	(0.099)
Part-time Employment & Formal Childcare	-0.106	-0.290*	0.037	-0.232	-0.015
	(0.095)	(0.170)	(0.114)	(0.154)	(0.126)
Full-time Employment & Parental Care	(0.001)	-0.174	0.146	-0.069	0.092
	(0.088)	(0.159)	(0.102)	(0.136)	(0.114)
Full-time Employment & Informal Childcare	0.155**	0.126	.194***	0.043	0.230**
	(0.062)	(0.108)	(0.073)	(0.099)	(0.086)
Full-time Employment & Formal Childcare	0.116	0.112	0.177**	0.223	0.113
	(0.072)	(0.151)	(0.082)	(0.149)	(0.092)
On Leave & Child in Childcare	0.049	0.035	0.097	0.059	0.076
	(0.065)	(0.116)	(0.075)	(0.100)	(0.087)

*Robust standard errors in parentheses & significance:*** p<0.01, ** p<0.05, * p<0.1*

Full covariates used: gender & early nutrition; birth characteristics; family characteristics & maternal characterisitics

N varies for samples split by Equivalised Income as this variable is imputed

TABLE 5 - QUANTILE REGRESSION

		BMI AT 3 YEARS QUANTILES				
N	**TOTAL**	**0.1**	**0.25**	**0.5**	**0.75**	**0.9**
			FULL-TIME MATERNAL EMPLOYMENT V. AT HOME			
PANEL A			**ALL**			
6244	0.120**	0.076	0.082	0.109**	0.129*	0.165
	(0.047)	(0.058)	(0.053)	(0.051)	(0.067)	(0.106)
PANEL B			**HIGH MATERNAL EDUCATION**			
3,357	0.192***	0.133*	0.082	0.137**	0.225***	0.315***
	(0.057)	(0.078)	(0.069)	(0.065)	(0.085)	(0.123)
PANEL D			**HIGH INCOME**			
2384 - 2411	0.166**	0.223**	0.203**	0.165**	0.126	0.204
	(0.069)	(0.097)	(0.087)	(0.083)	(0.098)	(0.157)
			PART-TIME MATERNAL EMPLOYMENT V. AT HOME			
PANEL C			**ALL**			
5,628	0.038	(0.021)	0.019	0.088*	0.109	0.020
	(0.045)	(0.056)	(0.054)	(0.048)	(0.067)	(0.105)
PANEL D			**HIGH MATERNAL EDUCATION**			
2639	0.173***	0.100	0.084	0.127**	0.301***	0.315***
	(0.059)	(0.075)	(0.075)	(0.063)	(0.080)	(0.121)
			INFORMAL CHILDCARE V. AT HOME			
PANEL E			**ALL**			
8,395	0.074*	0.057	0.059	0.088**	0.079	0.113
	(0.040)	(0.053)	(0.045)	(0.042)	(0.058)	(0.082)
PANEL F			**HIGH MATERNAL EDUCATION**			
4,572	0.120**	0.096	0.074	0.110**	0.154**	0.206**
	(0.050)	(0.060)	(0.057)	(0.053)	(0.072)	(0.103)
			FORMAL CHILDCARE V. AT HOME			
PANEL G			**ALL**			
7,137	0.015	0.034	0.031	0.051	0.035	-0.102
	(0.055)	(0.075)	(0.061)	(0.058)	(0.078)	(0.118)
PANEL H			**HIGH MATERNAL EDUCATION**			
3,902	0.051	0.086	0.032	0.078	0.061	-0.033
	(0.061)	(0.080)	(0.071)	(0.066)	(0.088)	(0.127)

*Robust standard errors in parentheses & significance:*** p<0.01, ** p<0.05, * p<0.1*

Full covariates used: gender & early nutrition; birth characteristics; family characteristics & maternal characterisitics

Results for Low Maternal Education not shown due to lack of significance

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APPENDIX 1 - REGRESSION RESULTS WITH ALL COVARIATES

	OLS BMI			Probit Overweight			LPM (OLS) Overweight		
Maternal Workststatus at 9 months									
Part-time Employment	0.002			0.004			0.000		
	[0.050]			[0.048]			[0.015]		
Full-time Employment	0.108**			0.088*			0.025*		
	[0.052]			[0.047]			[0.014]		
On Leave	0.048			0.090			0.026		
	[0.065]			[0.057]			[0.018]		
Childcare at 9 months									
Informal Childcare		0.068			0.051			0.014	
		[0.045]			[0.042]			[0.013]	
Formal Childcare		0.048			0.012			0.003	
		[0.056]			[0.058]			[0.017]	
Maternal Workstatus & Childcare at 9 months									
Part-time Employment & Parental Care			0.036			0.047			0.014
			[0.071]			[0.066]			[0.020]
Part-time Employment & Informal Childcare			0.006			0.021			0.004
			[0.066]			[0.063]			[0.020]
Part-time Employment & Formal Childcare			-0.106			-0.211**			-0.055**
			[0.095]			[0.107]			[0.027]
Full-time Employment & Parental Care			-0.001			0.024			0.007
			[0.088]			[0.072]			[0.022]
Full-time Employment & Informal Childcare			0.155**			0.100*			0.029*
			[0.062]			[0.057]			[0.018]
Full-time Employment & Formal Childcare			0.116			0.117			0.033
			[0.072]			[0.072]			[0.022]
On Leave & Child in Childcare			0.049			0.089			0.026
			[0.065]			[0.057]			[0.018]
Female	-0.241***	-0.241***	-0.241***	0.108***	0.107***	0.107***	0.032***	0.032***	0.032***
	[0.038]	[0.038]	[0.038]	[0.034]	[0.034]	[0.034]	[0.010]	[0.010]	[0.010]
Breastfed									
Less than 120 days	-0.019	-0.016	-0.018	-0.032	-0.029	-0.032	-0.010	-0.009	-0.010
	[0.047]	[0.047]	[0.047]	[0.041]	[0.041]	[0.041]	[0.013]	[0.013]	[0.013]
120 - 180 days	0.055	0.053	0.058	0.036	0.034	0.035	0.011	0.011	0.012
	[0.086]	[0.086]	[0.086]	[0.074]	[0.073]	[0.074]	[0.022]	[0.022]	[0.022]
180 days +	-0.016	-0.015	-0.014	0.000	0.000	0.000	0.000	0.000	0.000
	[0.059]	[0.059]	[0.059]	[0.055]	[0.055]	[0.055]	[0.016]	[0.016]	[0.016]
Age Weaned									
4 - 6 months	-0.047	-0.046	-0.048	0.013	0.014	0.012	0.004	0.004	0.003
	[0.057]	[0.057]	[0.057]	[0.049]	[0.049]	[0.049]	[0.016]	[0.016]	[0.016]
6 months or more	-0.151**	-0.149**	-0.150**	-0.080	-0.077	-0.079	-0.024	-0.024	-0.024
	[0.063]	[0.063]	[0.063]	[0.056]	[0.056]	[0.056]	[0.017]	[0.017]	[0.017]
Top 2 Income Quintiles	-0.051	-0.041	-0.054	-0.038	-0.026	-0.037	-0.011	-0.007	-0.010
	[0.044]	[0.044]	[0.044]	[0.042]	[0.042]	[0.042]	[0.013]	[0.013]	[0.013]
Number of siblings	0.032	0.029	0.031	0.027	0.024	0.026	0.008	0.007	0.008
	[0.034]	[0.034]	[0.034]	[0.031]	[0.031]	[0.031]	[0.010]	[0.010]	[0.010]
Only Child	0.049	0.052	0.046	0.063	0.065	0.061	0.020	0.021	0.020
	[0.061]	[0.061]	[0.061]	[0.056]	[0.056]	[0.056]	[0.017]	[0.017]	[0.017]
Partner	-0.095	-0.085	-0.095	-0.126**	-0.119*	-0.127**	-0.04*	-0.04*	-0.04*
	[0.076]	[0.076]	[0.076]	[0.063]	[0.063]	[0.063]	[0.021]	[0.021]	[0.021]
Urban	-0.079**	-0.076*	-0.077**	-0.075**	-0.071**	-0.074**	-0.022**	-0.021*	-0.022**
	[0.039]	[0.039]	[0.039]	[0.036]	[0.036]	[0.036]	[0.011]	[0.011]	[0.011]
Ethnicity of Mother	-0.122**	-0.119*	-0.117*	-0.064	-0.065	-0.062	-0.018	-0.018	-0.017
	[0.061]	[0.061]	[0.061]	[0.052]	[0.052]	[0.052]	[0.015]	[0.015]	[0.015]
Low Birth Weight	-0.522***	-0.521***	-0.521***	-0.229**	-0.228**	-0.228**	-0.0641***	-0.0634***	-0.0638***
	[0.092]	[0.092]	[0.092]	[0.090]	[0.090]	[0.090]	[0.024]	[0.024]	[0.024]
High Birth Weight	0.498***	0.497***	0.495***	0.325***	0.323***	0.324***	0.105***	0.105***	0.105***
	[0.054]	[0.054]	[0.054]	[0.044]	[0.044]	[0.044]	[0.015]	[0.015]	[0.015]
Caesarean Section	0.119***	0.120***	0.120***	0.078**	0.079**	0.079**	0.024**	0.024**	0.025**
	[0.045]	[0.045]	[0.045]	[0.039]	[0.039]	[0.039]	[0.012]	[0.012]	[0.012]
Child in poor health at birth	-0.002	0.001	-0.007	0.073	0.075	0.071	0.022	0.022	0.021
	[0.142]	[0.142]	[0.142]	[0.099]	[0.099]	[0.099]	[0.031]	[0.031]	[0.031]

continued	**OLS BMI**			**Probit Overweight**			**LPM (OLS) Overweight**		
Maternal Education									
Leaving Cert to Degree level	0.019	0.025	0.022	0.015	0.021	0.017	0.004	0.006	0.005
	[0.045]	[0.045]	[0.045]	[0.042]	[0.042]	[0.042]	[0.013]	[0.013]	[0.013]
Postgraduate	-0.011	0.000	-0.009	0.001	0.014	0.002	0.001	0.005	0.002
	[0.057]	[0.056]	[0.056]	[0.054]	[0.054]	[0.054]	[0.016]	[0.016]	[0.016]
Smoker	0.122**	0.123**	0.121**	0.102*	0.104**	0.102*	0.032*	0.032*	0.032*
	[0.061]	[0.061]	[0.061]	[0.053]	[0.053]	[0.053]	[0.017]	[0.017]	[0.017]
Mother Overweight	0.345***	0.348***	0.347***	0.283***	0.286***	0.285***	0.087***	0.088***	0.087***
	[0.042]	[0.042]	[0.042]	[0.037]	[0.037]	[0.037]	[0.011]	[0.011]	[0.011]
Folic Acid taken during pregnance	0.035	0.033	0.034	0.046	0.044	0.043	0.014	0.014	0.014
	[0.076]	[0.076]	[0.076]	[0.065]	[0.065]	[0.065]	[0.020]	[0.020]	[0.020]
Mother's age when child 9 months	-0.004	-0.004	-0.004	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
	[0.007]	[0.007]	[0.007]	[0.006]	[0.006]	[0.006]	[0.002]	[0.002]	[0.002]
Quality of Attachment Score	0.011	0.011	0.011	0.007	0.007	0.007	0.002	0.002	0.002
	[0.008]	[0.008]	[0.008]	[0.007]	[0.007]	[0.007]	[0.002]	[0.002]	[0.002]
Chronic illness (Mother)	-0.092	-0.093	-0.092	-0.039	-0.040	-0.039	-0.019	-0.012	-0.012
	[0.060]	[0.060]	[0.060]	[0.055]	[0.055]	[0.055]	[0.017]	[0.017]	[0.017]
Smoked during Pregnancy	0.181**	0.179**	0.181**	0.104*	0.102*	0.104*	0.033*	0.033	0.033*
	[0.071]	[0.071]	[0.071]	[0.061]	[0.061]	[0.061]	[0.020]	[0.020]	[0.020]
Mother's Age at first pregnancy	-0.001	-0.001	-0.001	-0.004	-0.004	-0.004	-0.001	-0.001	-0.001
	[0.006]	[0.006]	[0.006]	[0.005]	[0.005]	[0.005]	[0.002]	[0.002]	[0.002]
Maternal Depression	0.007	0.007	0.007	-0.033	-0.032	-0.032	-0.011	-0.011	-0.011
	[0.059]	[0.059]	[0.059]	[0.054]	[0.054]	[0.054]	[0.017]	[0.017]	[0.017]
Maternal Poverty (Aged 16)	0.060	0.061	0.061	0.113***	0.113***	0.114***	0.036***	0.036***	0.036***
	[0.050]	[0.050]	[0.050]	[0.04]	[0.04]	[0.04]	[0.014]	[0.014]	[0.014]
Constant	16.46***	16.47***	16.45***	-1.071***	-1.069***	-1.082***	0.133	0.134	0.129
	[0.377]	[0.377]	[0.378]	[0.338]	[0.336]	[0.338]	[0.103]	[0.103]	[0.103]
Observations	**9,431**	**9,431**	**9,431**	**9,431**	**9,431**	**9,431**	**9,431**	**9,431**	**9,431**
Robust standard errors in brackets	*** p<0.01, ** p<0.05, * p<0.1								

APPENDIX 2 – SELECTION BIAS

The Problem

In order to identify a causal effect of maternal employment and/or childcare on the weight status of a child, the coefficient on the regressor variable must not contain, either partly or entirely, the effect of relevant characteristics not identified and controlled for in the estimation. While sufficient controls should identify the effect of observables, it may prove more challenging to identify the existence of unobserved characteristics that impact the relationship between the explanatory variable and the outcome and, if appropriate, adjust the explanatory variable to exclude the influence of unobserved characteristics. In the absence of an appropriate instrumental variable for either maternal employment or non-parental childcare, an estimation method developed by Altonji et al., (2005) is used to assess selectivity bias.

Potential Solution - Altonji Methodology

Selection Bias

Adapting the approach taken in Altonji, Elder and Taber (2005) and taking maternal employment as our endogenous variable, the outcome (Y), representing the probability of the study child being overweight, is determined by:

$Y^* = \alpha ME + W'\tau$ Equation (1)

$= \alpha ME + X\tau_x + e$ Equation (2)

ME is a binary variable that represents 1 if the mother works and α is the causal effect of maternal employment on the weight status of the child. W represents a vector of observed and unobserved variables that determine Y*, and τ is the causal effect of this vector of variables on the outcome. X is a vector of observable characteristics of W, and τ_x is the causal effect of this sub-vector of W. The error component, e, is an index of the unobservable variables. As we cannot control for these

unobservables, to the extent that they are correlated with both ME, the explanatory variable, and the outcome, Y*, the estimation results may be biased.

Theoretical Foundation

Altonji et al. (2005) propose a theory that uses the degree of selection on observables as a measure of the extent of selection on unobservables, and provide a method to quantitatively assess the degree of omitted variable bias. A measurement of the amount of selection on observables is used in the calculation of a ratio that determines how large the selection on unobservables would need to be in order to attribute the entire effect of either maternal employment or childcare to selection bias.

This methodology relies on 3 key assumptions, which are required to derive Condition 1:

1. The variables in X, the observed variables, are chosen at random from the full set or variables W that determine Y;
2. The number of variables in both X and W are large, such that no one element dominates the distribution of ME or Y;
3. The regression of ME* on Y*- αME is equal to the regression of the part of ME* that is orthogonal to X on the corresponding part of Y* - αME. ME* is the latent variable that determines ME such that ME=1(ME*>0), where the indicator function 1(.) is 1 when ME*>0 and zero otherwise. ME* is therefore exogenous. The authors propose that this assumption is weaker than the standard OLS assumption of Cov (X, e).

These assumptions allow the authors to set selection on the unobservables equal to selection on observables. What this means is that the part of Y* that is related to the observables and the part related to the unobservables have the same relationship with ME*. This is known as Condition 1.

Condition 2 says that the part of Y* that relates to the unobservables has no relationship with ME*. While this is a standard assumption in econometrics, it's unlikely to hold in practice, as many of the factors that influence Y* are correlated with maternal employment or X.

The authors, in the context of discussing the effect of attending a Catholic School (CH) on educational attainment and test scores, comment that the "random selection on observables" assumption required as part of Condition 1 should not be taken literally. They suggest there are compelling reasons why the relationship between the unobservables and CH (or, in this case ME) is likely to be weaker than the relationship between the observables and CH. Applying their thoughts to this study, the reasons why this might be so are:

1. The selection of the covariates is not random, such that they have been selected in order to reduce bias. For example, maternal education and ethnicity are both related to ME and child overweight.
2. **e** is also likely to contain a random element of child overweight, perhaps traits of the child or mother that are not related to the decision of a mother to work.
3. Shocks that occur after 9 months are not included within the regressors. These shocks may influence the weight of the child but not the decision to return to work when the child is 9 months.

The final condition, Condition 3, involves the authors identifying a set of bounds for α. The upper bound occurs with the assumption that Cov (ME*, e)/Var (e) = 0 and a lower bound that assumes

$$\frac{\mathrm{Cov}\,(\mathrm{ME}*,\mathrm{e})}{Var\,(\mathrm{e})} = \frac{\mathrm{Cov}(\mathrm{ME}*,\mathrm{X}\dagger)}{Var\,(\,\mathrm{X}\dagger)} \qquad \text{Equation (3)}$$

By arguing that for the decision of a mother to work, selection on unobservables is likely to be less strong than selection on observables. By estimating joint models of maternal employment and the outcome, child overweight, subject to selection on unobservables and observables being equal, we

achieve this lower bound estimate. Both OLS and Probit assume no selection on unobservables, and therefore provide an upper bound estimate.

Should the sign of the estimated effect of the unobservables on the outcome be negative, this would alter this logic, such that the bounds as outlined above would be reversed, with Cov (ME*, ε)/Var (ε) = 0 providing a lower bound estimate. This logic means that the unobservable factors that influence a mother's decision to work may have a favourable impact on the child risk of being overweight. Such factors may include a diligent well organised mother or an even tempered child.

Application of Altonji et al. Methodology

The first step of this estimation involves finding an estimate of τ under the null hypothesis of no maternal employment effect:

$Y_i = \alpha + X_i'\tau + \varepsilon_i$ Equation (4)

This equation provides estimates of $\mathrm{Cov}(\mathrm{ME}*, \mathrm{X}\tau)$, $Var\,(\mathrm{X}\tau)$ and $Var\,(\varepsilon_i)$, as indentified in Equation (3) above. Using these 3 estimates, an estimate of the implied bias, $\mathrm{Cov}\,(\mathrm{ME}*, \varepsilon)$, can be computed. An measure of the strength of this implied bias is determined from its ratio to the estimate of β, representing how strong selection on unobservables would have to be relative to selection on observables in order to attribute the entire estimated effect of maternal employment to selection bias (Elder & Jepsen, 2014).

The Results

Column 1 of Table A2.1 details the OLS estimates of the binary treatment on the total sample, and the sample split by maternal education. Column 3 details the level of selection bias if selection on observables is set equal to selection on unobservables, with Column 4 lists the implied ratio.

Assessing first the issue of selection bias for full-time maternal employment for the entire sample, while the small implied ratio suggests that the absolute effect of the unobservables would only need

to be 12% as strong as the unobservables to explain the OLS estimate, the fact that the bias and therefore the implied ratio are negative suggests that the OLS estimate should be viewed as a lower bound. Therefore, the existence of selection bias is likely to understate the true effect of full-time maternal employment. When the sample is split by maternal education, only the OLS estimate for children with mothers with high levels of education is significant. While the estimated bias for this result is 0.06, suggesting that selection bias could overstate the OLS estimate, selection on unobservables would have to be 2.39 (239%) times as strong as selection on observables for this to hold, which would seem unlikely.

The OLS estimate of the effect of part-time employment by educated mothers on the BMI of the child is actually larger that the effect for full-time employment. However, the implied ratio of 0.26 suggests that this result could very easily be explained by selection bias. In fact, if condition 1 holds, the estimate could be -0.47 i.e. reducing the BMI. However, selection bias does not appear to explain the estimate for the low education sub-sample, as the implied ratio of -3.25 is very large. Should this hold, the negative result would move from -0.13 to -0.17.

Assessing the role of selection bias on the childcare OLS results, it does appear that selection bias could easily explain the results for the use of Informal childcare by families with higher levels of maternal education. The 0.12 effect of BMI for those children in informal childcare with well-educated mothers could be explained by unobservables if they are just 10% as strong as the observables. This could be a reflection on the wide variety of types of carers within this category and the lack of information on care quality.

TABLE A2.1

Estimates of bias of the effects of Maternal Employment and Childcare based on the Altonji et al. Methodology (OLS)

OUTCOME: BMI of child at 3 years of age Treatment	Sample	OLS Estimate	Significance	Estimated Bias	Implied Ratio
		(1)	(2)	(3)	(4)
Full-time Employment v Home	All	0.09	10%	-0.73	-0.12
Full-time Employment v Home	High Maternal Education only	0.15	5%	0.06	2.39
Full-time Employment v Home	Low Maternal Education only	0.02	No	0.13	0.14
Part-time Employment v Home	All	0.01	No	-0.16	-0.03
Part-time Employment v Home	High Maternal Education only	0.17	5%	0.64	0.26
Part-time Employment v Home	Low Maternal Education only	-0.13	10%	0.04	-3.25
Childcare v Home	All	0.05	No	-0.09	-0.58
Childcare v Home	High Maternal Education only	0.10	5%	0.60	0.17
Childcare v Home	Low Maternal Education only	-0.03	No	0.19	-0.17
Informal childcare v Home	All	0.06	No	0.27	0.22
Informal childcare v Home	High Maternal Education only	0.12	5%	1.27	0.10
Informal childcare v Home	Low Maternal Education only	-0.05	No	0.91	-0.05
Formal childcare v Home	All	0.04	No	-0.89	-0.05
Formal childcare v Home	High Maternal Education only	0.07	No	-0.74	-0.10
Formal childcare v Home	Low Maternal Education only	-0.01	No	-0.09	0.09

Note 1: Beta: coefficient on binary treatment with full controls, child's BMI as outcome measure, population weights applied and no imputation

Interpretation of Results

The application of this methodology to the results in the paper suggests that the effect of full-time maternal employment on the weight of a child may be understated, such that unobservable factors, be they characteristics of the mother or the child, offset some of the effect of maternal employment. However, unmeasured characteristics of both those selecting informal childcare and the quality of this care could fully explain the effect of informal childcare. This is consistent with some of the debate in the literature on the level of bias in estimates of the efficacy of childcare on child health outcomes (Duncan and Gibson, 2000; NICHD and Duncan, 2003).

APPENDIX 3 - PROPENSITY SCORE MATCHING

Choice of Matching Estimator, Selection of Variables for PSM estimation & Bias Reduction

Propensity score matching was used on three configurations of maternal employment and four configurations of childcare, as detailed by Table 3. However, in order to ensure the most appropriate matching estimator is applied, a number of estimators were tested, using full-time maternal employment as the treatment and Mother at Home as the counterfactual.

Variables that are not affected by participation in the treatment (Caliendo and Kopeinig, 2005) are used in the estimation of the propensity score. These variables are then evaluated to assess the quality of the matching process before MI, with a maximum difference between the two groups of 5% deemed acceptable (see one exception noted below).

Propensity scores were estimated using a probit model and three types of matching methods were assessed. The radius-caliper method matches each treatment child to all children in the control group with an estimated propensity score within a particular caliper (distance). As this method matches treatment observations with controls within the specified caliper, is allows for usage of extra units when good matches are available, thus oversampling and avoiding the risk of bad matches. A possible problem with this method is that it's difficult to determine a priori what tolerance level is reasonable (Smith & Todd, 2005). For this reason 3 difference calipers were applied (0.01, 0.001, 0.1) and results from each were broadly consistent, though the bias reduction was smallest for the largest caliper.

The second method applied was nearest neighbour (NN) matching, with the treatment child matched with the child in the control group with the nearest estimated propensity score.

This method was initially applied with no replacement, which produced the most limited reduction in bias, such that the method was deemed inappropriate. This method of matching is sensitive to the order in which matching occurs and while it may reduce variance, it does tend to lead to a higher bias. 3 formulations of nearest neighbour matching were then applied with replacement, firstly matching with replacement to the single nearest neighbour, then to the nearest 5 and 10 control observations using a uniform weight. All 3 versions of NN matching with replacement produced satisfactory reductions in bias levels.

The final matching estimator, the kernel density estimator, matches each student to a weighted average of all observations in the comparison group, with each observation in the comparison group weighted inversely proportional to the difference between the observations estimated propensity score and the propensity score of the treatment child. While this methodology results in a lower variance as more information is used (Caliendo & Kopeinig, 2005), this can be at the expense of bad matches. 6 versions of the estimator are applied, the first simply applying the kernel distribution and the second the normal distribution, both giving satisfactory results. However, as the match should be within the area of common support, the remaining third version imposes this condition, as does the fourth, while also imposing a normal distribution, again giving similar results. Finally, 2 bandwidths are applied in the fifth and sixth version of 0.01 and 0.001 respectively, with results identical to the fourth estimation, such that there is no sensitivity to the imposition of the limit of a bandwidth.

Based on its comparability to most estimators and its success in reducing bias, radius-caliper matching with a calliper of 0.01 was selected to perform all matching. Equivalised family income is excluded from the estimation of the propensity score as this is believed to be

endogenous to maternal employment and choice of childcare. Consistent across most estimators, breastfeeding bias remained high and was therefore excluded from the estimation. While the bias on the ethnicity of the mother reduces to 6%, above the usual threshold of 5%, this variable is not excluded from the estimation as it's deem important and is only marginally above the suggested threshold.

TABLE A3.1 PROPENSITY SCORE MATCHING - ASSESSMENT OF QUALITY OF ESTIMATORS

	UNMATCHED % BIAS	MATCHED % BIAS													
		RADIUS - CALIPER			NEAREST NEIGHBOUR				KERNEL					
Variable		0.01	0.1	0.001	No replacement	1, with replacement	5, with replacement	10, with replacement	Kernel	Normal	Common Support	Normal Common Support	Common Support BW 0.01	Common Support BW 0.001
Female	-0.7	2.6	1.7	3	0.2	2.6	2.6	2.2	2.7	2.6	2.6	3.3	3.3	3.3
Breastfed	5.5	-14.1	-14.6	-12.7	1.1	-14.4	-13.1	-13.6	-15	-14.4	-15.3	-14.9	-14.9	-14.9
Weaned (age)	-1.9	-0.7	-2.6	-0.1	-0.6	-3.2	-1.4	-0.8	-1.5	-3.2	-1.4	-2.2	-2.2	-2.2
siblings at 9mths	-63.1	-0.7	-4.2	-0.8	-29.1	1	-0.6	-1.1	-1.6	1	-1.6	1	1	1
Only child	47.9	-0.9	3.9	-0.4	30.1	-4.4	-1	-0.6	0.2	-4.4	0.2	-4.5	-4.5	-4.5
Partner	36.1	0.5	1.6	0.3	17.4	-0.3	0.7	0.4	0.6	-0.3	0.6	-0.3	-0.3	-0.3
Urban	-4.1	-2.9	-3	0.7	-0.8	4.3	-1	-2.9	-2.8	4.3	-2.9	3.6	3.6	3.6
Ethnicity (Mother)	-25	-6	-8.2	-5.7	-18	-5.3	-4.6	-5.3	-6.4	-5.3	-6.4	-5.3	-5.3	-5.3
Low Birth Wgt	-7	0.1	-0.3	0.6	-4.1	-0.9	-0.9	0	0.1	-0.9	0.1	-0.9	-0.9	-0.9
High Birth Wgt	-2.5	-2	-1.9	-2.9	-1.2	-3.2	-2.3	-1.7	-1.5	-3.2	-1.7	-3.5	-3.5	-3.5
Ceasarean Section	7.5	-3.4	-2.3	-2.9	3.8	-0.4	-4.2	-3	-2.4	-0.4	-2.8	-0.9	-0.9	-0.9
Child health at birth	-4.7	-0.8	-1.5	-5.8	-3.1	-5.2	-2.6	-2	-0.9	-5.2	-1.2	-5.4	-5.4	-5.4
Maternal Education	70.2	-3.5	1.7	-3.1	47.8	-1.6	-3.7	-3.6	-2	-1.6	-2.2	-1.6	-1.6	-1.6
Mother a Smoker	-21.4	2.3	1.2	1.4	-11.9	-0.4	1.9	2.2	1.9	-0.4	1.8	-0.6	-0.6	-0.6
Mother Overweight	-13.4	-2.5	-2.5	-4.1	-7.1	-2.6	-2.2	-2.9	-2.5	-2.6	-2.6	-2.9	-2.9	-2.9
Folic acid taken in pregnancy	16.9	3	3.8	4.4	7.2	4.6	2.9	3.2	3.1	4.6	3.1	4.7	4.7	4.7
Mother age	9.9	-1.5	-1.3	-0.9	9.6	0.8	-0.4	-1.7	-1.5	0.8	-1.6	1.1	1.1	1.1
Quality of Attachment score	-23	3.7	1.1	4.9	-15.2	5.3	2.8	2.8	2.1	5.3	2.6	5.5	5.5	5.5
Mother Chronic Illness	-21.9	0.4	-0.9	-0.5	-9.2	-0.5	-0.5	-0.1	0.2	-0.5	0.2	-0.5	-0.5	-0.5
Mother Smoked while pregnany	-29.2	0.9	-0.1	2.4	-15.4	-0.7	0.8	1.6	1	-0.7	1	-0.7	-0.7	-0.7
Mother's age when first pregnant	48.4	0.1	2.2	-0.7	27.8	0	1.1	0	0.9	0	0.7	0.3	0.3	0.3
Mother ever depressed	-17	-1.5	-2.1	-0.1	-8	-0.8	-2.3	-1.7	-1.3	-0.8	-1.2	-0.8	-0.8	-0.8
Maternal Poverty at Age 16	-11	0.4	0	-1	-2.5	-3.2	-0.8	1.1	0.7	-3.2	0.4	-2.3	-2.3	-2.3

NOTES:

1. All covariates taken from Wave 1 data - when child was 9 months old

2. Breastfed excluded from estimation as bias too high

3. Equivalised income deemed endogenous so excluded

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