Household structure and risks of obesity in middle childhood

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RUNNING HEAD: Household structure and children's obesity risks

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Abstract

Studies from the social and the health sciences have depicted the household as the main locus of access to and distribution of care, resources, monitoring and modeling for children's wellbeing. However, obesity may present a curious case for the study of how investments in children may not necessarily lead to better outcomes. Instead of investments leading to better health for children, when investments take the form of certain types or quantities of food, electronic devices, or permissiveness, they may lead to higher levels of obesity. We examine the role of household structure in children's weight gain and obesity during elementary and middle school, conceptualizing household in terms of the number of adults, biological relatedness, and sibling resource competition of its members and using the Early Childhood Longitudinal Study Kindergarten Class of 1998-99 (ECLS-K), the largest national dataset with measures of child anthropometrics and household structure at seven waves of data collection over 9 years. Children living with two biological parents, generally considered to be the best arrangement for child wellbeing, may not have lower obesity risks and in fact may be at greater risk of obesity than children living with a step-parent. Moreover, children living with other adults, including grandmothers, may experience greater obesity risks and greater weight gain, whereas children sharing the home with other children tend to have lower obesity risks. These findings are consistent with a scenario in which, for health problems associated with contemporary lifestyles, greater per capita household resources for children are associated with poorer outcomes.

Introduction

The prevalence of obesity among American children is at an all-time high, with 18.0% of 6 to 11 year-olds having high body mass index (BMI) for their age in 2009-10, triple the levels in the 1970 (Ogden et al. 2010; Ogden et al. 2012). Childhood obesity is associated with poorer physical and mental health (Must and Anderson 2003; Pearce, Boergers and Prinstein 2002) and social exclusion (Friedlander et al. 2003; Pearce et al. 2002; Strauss 2000). Expert recommendations identify the household as an important locus to prevent and reverse obesity in children (Barlow and the Expert Committee 2007; Fiese and Jones 2012; Gerards et al. 2012; Lindsay AC 2006).

Social scientists have identified specific components of household structure, including marriage, relatedness and competition, which may influence children's wellbeing because they determine net resources, resource sharing, behavioral modeling, and childcare. The application of these dimensions of household relations to an outcome such as obesity offers two interesting opportunities. First, while the home environment is considered crucial for promoting healthier weight among obese children (Adkins et al. 2004; American Dietetic Association 2006; Bautista-Castano, Doreste and Serra-Majem 2004; Flodmark et al. 1993; Golan, Fainaru and Weizman 1998; Gruber and Haldeman 2009; Lindsay AC 2006; Muller, Danielzik and Pust 2005), and recommendations for preventing obesity in children emphasize home-focused strategies (Barlow and and the Expert 2007), little is known about who in the household matters and about what different household types entail for children's weight status. There is a focus on parents, but without consideration for the bio-social relationship of the parent and child; in addition, only 62% of American children live with both biological parents (Kreider and Fields 2005). Nor has there been sufficient research on the importance of household structure beyond parents for children's obesity risks, though 79% of children live with other children and 15% live with a grandparent, aunt, or uncle (Kreider and Fields

2005). Thus, there remains a need to conceptualize and to clarify empirically the dimensions of household structure that matter for children's risks of obesity.

Second, the extensive research in the social sciences that has examined the importance of household structure for child health has focused on a different type of outcome, such as vaccination, education, and survival – for these, more investments are generally beneficial (Dawson 1991; Duflo 2003; Entwisle and Alexander 1996; Flewelling and Bauman 1990; Ginther and Pollak 2004; Keith and Finlay 1988). Yet there are some health outcomes, such as obesity, for which more investments – more food, more goods, more permissiveness – may actually lead to *poorer* outcomes. Thus, another contribution of this research is to establish how household structure relates to a "contemporary" health risk like obesity. For this research, we use nine years of data from the Early Childhood Longitudinal Study Kindergarten Class of 1998-99 (ECLS-K), the largest national longitudinal study measuring child anthropometrics and household structure from kindergarten through eighth grade.

Conceptual framework

For all aspects of child wellbeing through middle childhood, the household is the most important context (Birch and Davison 2001). The links between relatives' body weight has a genetic component (Agras et al. 2004; Frankish 2001; Karnik and Kanekar 2012; Whitaker et al. 1997), but behavioral and social factors also are likely to be important, and genetic predispositions work in concert with environmental conditions (Birch and Davison 2001; Dattilo et al. 2012).

Previous studies have shown that household structure affects several components of child wellbeing, including education (McLanahan and Sandefur 1994), health behaviors (Flewelling and Bauman 1990), and mental and physical health (Aseltine 1996; Byrne et al. 2011; Dawson 1991). Household structure also may shape the home environment, which includes food availability and

eating patterns, levels of activity and inactivity, and rules and support, all of which can affect children's risks for obesity (Arkes 2012; McConley et al. 2011). The presence or absence of close relatives has been shown to matter for multiple components of child wellbeing (Byrne et al. 2011; Case, Lin and McLanahan 1999; Freeman et al. 2012; Sear, Mace and McGregor 2000). For example, the household is an important force in determining, directly and indirectly, children's dietary behaviors (Birch and Davison 2001; Dishman, Sallis and Orenstein 1985; Gordon-Larsen, McMurray and Popkin 2000; Patrick and Nicklas 2005; Salmon et al. 2005; Timperio et al. 2008).

A focus of previous studies of household structure and children's wellbeing has been on the negative consequences of living with a single mother (Adam and Chase-Lansdale 2002; Aseltine 1996; Byrne et al. 2011; Chen and Escarce 2010; Dawson 1991; Deleire and Kalil 2002; Entwisle and Alexander 1996; Flewelling and Bauman 1990). This discussion has been couched largely in terms of economic resources and parental modeling (Ginther and Pollak 2004; McLanahan and Sandefur 1994). In addition to having more limited financial resources, single parents are also limited in time resulting in fewer homemade, high quality meals {McLanahan, 1994 #49}. Thus, children living with a single mother are living in poorer circumstances, and so have less access to economic resources (Manderbacka, Merilainen and Hemminki 1992; McLanahan and Sandefur 1994). In addition, these children are living without paternal role models and supervision, which can be particularly deleterious, especially for boys(Gabel 2004). Some researchers also have found that marriage may solidify both parents' investments in children (Case et al. 1999; Hofferth and Anderson 2003).

The relatedness between the child and the parent also is noteworthy (Case et al. 1999; Case and Paxson 2001; Hofferth and Anderson 2003): economic resources and supervision are important, but these are often not distributed to children as equally by other adults as by parents (Bishai et al. 2003; Case and Paxson 2001). It may be that families with two biological parents have the most

resources (McLanahan and Sandefur 1994), but that parents who select into step-parenthood may have limited abilities to parent, perhaps due to individual qualities and motivations or due to the desire of the bioloigical parent (Ginther and Pollak 2004), or that there is direct competition for resources between step-parent and biological children (Daly and Wilson 1998). It also may be that social norms entail lower expectations for involvement from people who are not biological or married parents (Hofferth and Anderson 2003). Finally, different outcomes may result from purposefully differential investment, either to promote the success of closest kin to carry on the genetic line, as suggested by evolutionary theory (Emlen 1995) or to ensure an informal, long-term safety net against risks (Schoeni 1997) through the success and loyalty of children most likely to be supportive. Evolutionary theory predicts altruistic behavior towards related children by adult relatives and older siblings (Hamilton 1964). Differing investments also may be used to construct strategic family safety nets by providing for the children most likely to be supportive (Schoeni 1997) or to solidify a long-term relationship between the child's parents.

The propositions about the importance of resources and supervision for child wellbeing extend to other aspects of household structure. Having additional adults in the home, such as grandparents, provides additional supervision, perhaps even sufficient to replace an absent father (REF). Moreover, if the other adults can provide income or wealth, also their presence also increases the financial resources available to the child (Beise 2005; Duflo 2003; Entwisle and Alexander 1996; Geronimous 1997; Leonetti et al. 2005; Mace, R. and McGregor 2000; Sear et al. 2000). That said, the presence of other children can be deleterious, as it distributes household income across more dependents and entails lower per capita supervision of each child (Downey 1995, 2001; Gennetian 2005; Rosenzweig and Wolpin 1988).

However, many of these arguments are based in a world of scarcity – where a single mother may not have the resources to provide sufficient food, clothing, or school fees to promote her

child's wellbeing and where additional supervision and role models can encourage or enforce good study habits, school attendance, or healthy romantic relationships (Ginther and Pollak 2004; Mace et al. 2000; McLanahan and Sandefur 1994; Sear and Mace 2008). But what resources are needed to prevent health problems associated with high consumption and inactivity, such as obesity? The implications for investment in nutrition and healthy weight in a resource-rich setting are less clear than the implications of other investments. Here, providing maximum nutrition and shielding from physical exertion may actually be detrimental. So, the lower spending on food in step- and adoptive families may be beneficial for children in the U.S., even if it is not optimal in less food-rich circumstances (Case, Lin, and McLanahan 1999). That is, non-biological parents may be less permissive, buy less junk food in spite of children's pleas, enforce walking commutes, provide fewer indoor and screen-based games. If this is the case, their children may achieve less excess weight gain.

Household structure and child health

Parents

The presence and relationship type of parents in the home have been linked to many aspects of child wellbeing, as outlined below. We organize the discussion by considering the *number of co-residing parents, their relatedness to the child,* and their *relationship with each other*.

Number of co-residing parents: Only about 60% of American children live with both biological parents (Kreider and Fields 2005), and this percentage ranges from a low of 32% among African American children to a high of 78% among Asian American children (Kreider and Fields 2005). Over half of children born in the 1990s will have spent some time in single-parent or step-parent arrangements (Deleire and Kalil 2002). Children living in single-parent families experience more negative outcomes in terms of education (McLanahan and Sandefur 1994), health behaviors (Flewelling and Bauman 1990), and mental and physical health (Aseltine 1996; Dawson 1991). In

terms of obesity, children living with a single mother were more likely to be obese in elementary school than children living with two parents (Byrne et al. 2011; Chen and Escarce 2010).

Relatedness of co-residing parents to the child: Step-parents tend to invest less in children than biological parents: In the US, households that include stepchildren of the mother spend less on food than households that do not (Case et al. 1999). Spending varies with the strength of relationship ties between mother and child, with less spent on adoptive than biological children, less on step than on adoptive children, and less on foster than on stepchildren. In South Africa, when a child's biological mother is the head or spouse of the household head, the household spends more on food, in particular milk, fruit and vegetables (Case, Lin and McLanahan 2000). American children living with stepmothers are less likely to have routine doctor and dentist visits, to have a health care provider, to wear seatbelts, and to live in a non-smoking home (Case et al. 1999). By many measures, children living with a father and step-mother are no better off than those living only with a father (Case and Paxson 2001; Daly and Wilson 1998; Gennetian 2005). In a comparison of half-siblings where one of the siblings is the biological child of both parents and the other is the biological child of only one parent, step-children had inferior outcomes in terms of education, health investments and social wellbeing compared to biological children living in the same home (Case et al. 1999; Gennetian 2005; Halpern-Meekin and Tach 2008; Hofferth and Anderson 2003; Zvoch 1999). This literature suggests that step-children receive limited resources, which in the case of obesity may result in lower levels of obesity compared to single parents.

Parents' relationship: In the US and elsewhere, the children of married parents are healthier on a myriad of indicators, including health at birth (Manderbacka et al. 1992; Miller 1991; Reichman and Pagnini 1997) and survival (Beise 2005; Leonetti et al. 2005). In the US, teenagers in non-marital families have poorer educational outcomes and poorer health behaviors (Deleire and Kalil 2002). In terms of some investments, marriage may be a more important determinant of parental investments

than is biological relatedness of the parent to the child, at least in part because it proxies for the quality and commitment of the parents' relationships (Hofferth and Anderson 2003). In terms of nutrition, families spend less on food when the man is raising the child of his non-marital partner (Case et al. 1999).

Co-residing grandparents and other adults

A large minority (15%) of American children live in a home with non-parent adult relatives, most often grandparents (Kamo 2000; Kreider and Fields 2005). Racial and ethnic minority children more often live with other relatives in addition to or in place of parents: 22-24% of households consist of extended families among African Americans, Hispanics, and Asians, compared with 9% of non-Hispanic Whites (Kamo 2000). Co-residence with additional adults is usually positively associated with child health. Studies from around the world have shown that children who have a surviving nearby or co-resident grandmother are healthier in terms of several indicators, including survival (Beise 2005; Leonetti et al. 2005; Mace et al. 2000; Sear et al. 2002; Voland and Beise 2002) and growth (Duflo 2003). In a review, 9 of 13 studies examining the importance of grandmothers for child survival found positive effects, as did 2 of 12 among studies of grandfathers (Sear and Mace 2008). In the US, grandmother's co-residence was associated with better cognition, behavior, and health at age 3 (Pope et al. 1993). Teenagers living with a single mother and a grandparent have educational outcomes and health behaviors equal to or better than teenagers living with two parents (Deleire and Kalil 2002). Children living with a single mother and grandparents had better school outcomes than those living with only a single mother (Entwisle and Alexander 1996; Thomas 2006), though the evidence is not always consistent (McLanahan and Sandefur 1994). The role of non-parental adults is complicated because it is often entangled with parents' living arrangements (Landry-Meyer 1999); still, related adults, especially grandparents, can often mitigate the negative

outcomes that would otherwise be experienced by children living in non-intact families (Geronimous 1997).

In terms of nutrition and obesity risks, other co-residing adults, and especially grandmothers, may be important, because they often are in charge of childcare, supervision, and the preparation of meals. On the one hand, they may provide more supervision, care, and home-cooked meals, promoting better nutrition and more activity. That said, grandparents, perhaps because the emergence of obesity as a major health concern is recent, may not appreciate the possible negative consequences of child obesity. Grandparents in China tended to encourage children to eat more, used food as an emotional tool, and favored heavy size in children (Jingxiong et al. 2007). Children living with grandparents also had poorer weight-related behavior (Wu et al. 2003). Mothers have reported pressure to feed children more from grandmothers who are concerned about children being too thin (Bruss, Morris and Dannison 2003).

Co-residing children

Nearly 80% of American children live with siblings or other children (Kreider and Fields 2005). The relationship between number of children in the household and their health is ambiguous. Multiple children in the home entail more competition for resources but create more opportunities for active play. A review found that, in 5 of 6 studies from around the world, having older siblings improved survival up to age 15 (Sear and Mace 2008). In terms of nutrition and weight, there is wide variation in the BMI scores of siblings (Price and Swigert 2012), but children with siblings may be less likely to be obese (Chen and Escarce 2010). Studies suggest that overweight children who have active siblings are more likely to experience a decrease in BMI than children with inactive siblings or who do not have siblings (Timperio et al. 2008).

Previous research has highlighted the ways in which household structure is associated with child wellbeing, but remains agnostic as to the implications of these patterns for components of wellbeing

such as obesity, which may be less clearly associated with increased investments. We address this gap in terms of the following research questions:

1. Do children living in households with a) two rather than one parent and with b) parents who are and are not biologically related to them experience different risks of becoming obese during elementary school?

2. Do children living in households with a) more adults and with b) a grandmother have different risks of becoming obese during elementary school than children who do not?

3. Do children living in households with more children have different risks of becoming obese during elementary school than only children?

Additional characteristics associated with weight status

Several characteristics of the child, the household, and the community in which they live have been shown to be associated with weight status. These include gender (Ogden et al. 2012)(Hofferth and Curtin 2005), race/ethnicity {Strauss, 2001 #152}(Hofferth and Curtin 2005) and age of the child (Ogden et al. 2012)(Hofferth and Curtin 2005); the child's weight at birth, an indicator of genetic and prenatal weight predispositions (Ong and Loos 2006); and characteristics of the school attended, for example whether it is public or private (Li and Hooker 2010). Higher rates of obesity have been observed in the U.S. among poorer individuals in recent decades (Singh, Siahpush and Kogan 2010b)(Ogden et al. 2012), and poverty may prevent families from providing nutritious food for children (Hofferth and Curtin 2005; Phipps et al. 2006; Singh et al. 2010b).

Parents' education has been found to be inversely correlated with child obesity (Chen and Escarce 2010; Hofferth and Curtin 2005; Singh et al. 2010b). The reasons for this are thought to be two-fold. First, higher education levels are associated with better quality and better paid jobs, which results in greater material (such as financial) and immaterial (such as time) resources (Singh et al.

2010b). Second, higher education levels are associated with greater knowledge of causes of and means to prevent childhood obesity, which may lead to better health behaviors including a prioritization of nutrition quality over quantity (Hofferth and Curtin 2005). Maternal employment has been found to correlate with higher levels of child obesity, particularly among higher socioeconomic status households (Anderson, Butcher and Levine 2003; Fertig, Glomm and Tchernis 2009; Hofferth and Curtin 2005): the number of hours mothers work reduces their availability to plan healthy meals and to engage and encourage physical activity of children (Anderson et al. 2003; Fertig et al. 2009).

Language spoken at home and nativity are also important correlates of household structure and possibly of obesity (Himmelgreen et al. 2004; Lauderdale and Rathouz 2000). Those who are foreign born are less likely to be obese than native born residents of the United States (Lauderdale and Rathouz 2000). However, this pattern diminishes with length of time in country. Evidence suggests that immigrants who have better English skills tend to have higher levels of obesity, and immigrants who have been in the United States for a longer period of time also have higher levels of obesity (Himmelgreen et al. 2004).

Weight status has been found to vary between US regions, with children being more likely to be obese in the Southeastern region of the United States and least likely to be obese in the Mountain and Western states (Singh, Kogan and van Dyck 2010a; Wang and Beydoun 2007). Childhood obesity rates differ between urban, suburban and rural (Datar, Sturm and Magnabosco 2004; Wang and Beydoun 2007), but these differences tend to be small, and to vary by age (younger rural children are less likely to be obese, but older urban children are less likely to be obese) (Wang and Beydoun 2007).

Data

The Early Childhood Longitudinal Study, Kindergarten Class of 1998-99 (ECLS-K) is a study of children's early school experiences, developed by the National Center for Education Statistics and following a large cohort from kindergarten to 8th grade. Multistage probability sampling was used to select a nationally representative sample of kindergartners. At each wave, the survey includes interviews with parents, teachers and principals, student records abstracts and one-on-one direct child assessments (Tourangeau et al. 2006). Measures include direct anthropometric, cognitive and academic assessments, and detailed information on the home and school environments. At the 5th and 8th grade waves, information was collected about food and drink availability, consumption and purchases at school from children and school administrators.

The base year sample, with 21,260 kindergartners in 1,277 schools, was collected in the fall of 1998, followed by waves in the Spring of 1999, 2000, 2002, 2004, and 2007 and a 30% sub-sample in the fall of 1999. The longitudinal sample is representative of individuals who were in kindergarten in 1998-99 or in 1st grade in 1999-2000. Children were retained in the sample if they fell behind or advanced ahead in grades. Most sample attrition from the original kindergarten sample resulted from random selection for non-sampling due to survey costs. That is, children who moved to different schools before fifth grade were randomly selected not be followed up (Tourangeau et al., 2006).

The ECLS-K recorded height and weight, each measured twice per wave by trained assessors: height in inches to the nearest 0.25 inch using a Shorr Board and weight in pounds using a digital scale (U.S. Department of Education - National Center for Education Statistics 2004). This procedure is a major advantage over datasets that collect self-reported or parent-reported anthropometric data, which have been shown to be systematically biased (Bogaert et al. 2003; Datar et al. 2004).

Methods

Variables

Obesity in children is difficult to identify because increases in weight and changes in body proportions are part of growth and maturation. While growth charts and BMI measures are not ideal measures of childhood adiposity, they are acceptable indicators (American Dietetic Association 2006) and are feasible to collect in large-scale studies (Must, Dallal and Dietz 1991). Because BMI varies by age and sex in childhood, z-scores or percentiles are generally used (Johnson-Taylor and Everhart 2006). For this study, BMI z-scores were constructed from children's weight, height, sex, and age using the age and sex-specific 2000 CDC Growth Reference. Children were categorized according to the International Obesity Taskforce cutoff points for normal weight, overweight, and obese.

For each survey wave, the outcome measures used were obesity and change in BMI between waves. While z-scores are the most appropriate approach cross-sectionally, BMI is a better measure for assessing change in an individual child because the variability of z-scores over time is lower for the heaviest children (Cole et al. 2005). At these ages, most children experience increases in weight and height as they grow, but increases in weight relative to height compared with other children of the same age and sex is generally an indicator of unhealthy body changes in children (Hammer et al. 1991).

Indicators of *household structure*, as outlined above, were defined at each survey wave as: co-residence arrangement of parents (both biological parents; mother only; mother and step-father; father only; father and step-mother; both adoptive parents and guardians); marital status of parents; additional adults in the home (more than 2 adults in the home; grandmother co-resides); and number of children in the home.

Characteristics of the child and the household that are expected based on previous studies to be associated with weight status were used as control variables. Child characteristics were gender,

race/ethnicity, and age. Household characteristics were an SES scale for socio-economic status created by ECLS-K based on all data about parents' occupational prestige and income (Tourangeau et al. 2006); an indicator of whether the household is below the national poverty line; parents' education; maternal employment and whether English was the primary language spoken at home. Community characteristics were whether the child attended a public or a private school, US region (five categories) and whether the school was in an urban, sub-urban or rural area.

Analysis

We used lagged survey-adjusted linear and logistic regressions to estimate the association between household structure and, respectively, 1) change in children's BMI by the subsequent wave and 2) children's obesity risks at the following data wave for waves four, five, six, and seven, when the children are in first, third, fifth, and eighth grade respectively:

$$BMI_{it+1} - BMI_{it} = \beta_0 + F_{jt}'\theta + D_{it}'\gamma + S_{jt}\lambda + \varepsilon_{it}$$

$$\ln\left(\frac{Obese_{t+1}}{1-Obese_{t+1}}\right) = \beta_0 + F_{jt}'\theta + D_{it}'\gamma + S_{jt}\lambda$$

where the indicators of household structure are included in the vector, F_{jt} and controls for family socio-economic status and child demographics are included in W_{jt} and D_{it}, respectively.

Examining subsequent changes in children's BMI estimates the effect of characteristics and circumstances at the first wave on weight status at the later wave, with the outcome variables being the linear difference in BMI between the 2 points in time. Examining change in BMI accounts for the cumulative nature of weight gain, with caloric surpluses accumulating over time into weight gain (Bogaert et al. 2003; Ong and Loos 2006). We also included in some specifications BMI z-score at the previous wave as a right-hand side variable. Finally, we exploited the panel nature of our dataset by estimating individual random effects and fixed effects models. In fixed effects models, we control for all time-invariant child characteristics that differentiate levels of obesity and changes

in BMI across children, looking only at the changes between waves. Any characteristics that did not change across observations were automatically dropped in the de-meaning process. Thus, we decompose our error term for the first specification such that $\varepsilon_{it} = v_i + e_{it}$ where v_i is either a single, normally distributed parameter that is assumed to be orthogonal to the other covariates in the random effects specification, or a vector of individual-specific parameters that absorbs the individual trend in BMI. The parameter e_{it} captures the remaining error component.

Results

As shown in Table 1, between Kindergarten and eighth grade, the percentage of children who was obese increased from 7 to 15. The percentage of children living with two biological parents fell from 66 in Kindergarten to 60 in eighth grade. There were only very small changes in the percentage of children who lived with a single mother or adoptive parents, but large increases in the percentage living with a step-parent, only a father, and with guardians. About 70% of primary caregivers were currently married throughout. Children lived with on average 2 adults throughout elementary and middle school. A decreasing proportion (10% to 8%) lived with a grandmother. Children lived on average with 1.5 other children in the home.

-Insert table 1-

Number, relatedness, and relationship of parents

Table 2 shows lagged models, with change in weight between two waves predicted by characteristics at the previous wave. Between Kindergarten and first grade, children living with one biological parent and one step-parent gained less weight - with significant differences between children living with a mother and a stepfather and those living with two biological parents. Children living with a single parent did not gain significantly more weight than did children living with two biological parents – the only ones who may have gained more were those living in adoptive or

guardian families.

Between first and third grade, children living with a biological parent and a step-parent gained less weight - with significant differences between children living with a father and a stepmother and those living with two biological parents. Children living with a single parent did not gain significantly more weight than children living with two biological children.

Between third and fifth grade, there is a hint that children living with just one biological parent or one biological and one step-parent gained less weight, but there are no significant differences in weight gain between children by household structure.

The pattern described above only changed between fifth and eighth grade, during which time it is the children living with a single mother who gained significantly more weight than children living with both parents.

While number of parents and relatedness of parents to the child were associated with changes in children's weight, the marital relationship of the parents was not significantly associated with children's weight change at any age.

-Insert table 2-

Table 3 shows lagged logistic models with obesity being predicted by characteristics measured in the prior wave. In first grade, children who had been in all other household types in Kindergarten were less likely to be obese than children who had been living with both biological parents, with significant differences between children living in single parent or step-parent families and those living with two biological parents.

In third grade, children who had been living with a biological parent and a step-parent in first grade, especially a step mother, were less likely to be obese. The only significant difference is in the other direction, however, with children living with a single father being more likely to be obese than children living with both biological parents.

In fifth grade, children living with one biological and one step-parent in third grade were less likely to be obese than children living with both biological parents, and the difference between children living with a father and stepmother and those living with both biological parents was large and significant. These differences became even larger when controlling for BMI in third grade (results available upon request).

In eighth grade, children living in all other arrangements in fifth grade may have been less likely to be obese than children living with both biological parents, but no difference reached statistical significance.

Again, the marital relationship of the parents was not significantly associated with children's obesity risks at most ages. Only in first grade, children whose parents had been married when they were in Kindergarten were significantly more likely to be obese.

-Insert table 3-

Other adults in the household

Children living with more than two adults in the household gained more weight between Kindergarten and first grade but experienced no significant differences subsequently (Table 2). However, children living with more than two adults had higher obesity risks throughout elementary school (Table 3).

After accounting for the number of adults in the household, children living with a grandmother may experience greater weight increases during elementary and middle school, but the differences were not statistically significant. Children living with a grandmother were more likely to be obese at the next data wave, but these differences were only strongly significant in middle school.

Other children in the household

The relationship between number of children in the home and weight increases during elementary and middle school changed as children grew (Table 2). In first and third grade, children

gained significantly less weight for each additional child in the household in Kindergarten and first grade respectively. In fifth grade, there were no significant associations between amount of weight gained and number of children in the home two years earlier. In eighth grade, children gained more weight since fifth grade for each additional child with whom they resided. In terms of obesity risks (Table 3), children were significantly less likely to be obese in first, third and fifth grade for each additional co-residing child at the time that the index child was in Kindergarten, first, and third grade, respectively, but the relationship was no longer significant in eighth grade.

Discussion

Previous studies have shown that household structure is associated with children's wellbeing, including health at birth, survival, growth, and education. Specifically, children who live with adults in addition to parents, who are more closely related to coresiding adults, and whose parents are in married or lasting relationships tend to have better outcomes, primarily because of greater investments in resources such as food, vaccination, and school fees. However, some child outcomes, such as obesity, may not be associated in the same way with household structural proxies for investments. The relationships between household structure and children's weight gain and risk of obesity has not been explored sufficiently, but may be increasingly important especially in settings where absolute scarcity is not an immediate challenge for many households.

We found that children living in households with two rather than one parent did not consistently experience greater weight increases and obesity during elementary and middle school than did children living with both parents (Research question 1a). Children living only with a father experienced greater obesity risks between first and third grade only, and children living only with a mother did not experience greater obesity risks at any ages compared with children living with both biological parents. A previous study using the same dataset reported that children living with single

mothers were more likely to be obese than children living with two parents (Chen and Escarce 2010). We were able to replicate these findings, but found that this relationship was masking significant differences between children living with two biological parents and those living with parents who were not their biological parents. Indeed, the sharpest dichotomy may be among children whose biological parents are separated – specifically between those whose parents remained single compared with those whose parents moved in with a new partner.

Relatedness of the parents to the children was associated with children's subsequent obesity risks across ages and household types (Research question 1b). Most notably, children living with a biological parent and a step-parent were more likely to be obese, especially those living with a biological father and a step-mother. Previous studies have found that children living with a step-mother receive fewer resources and less care. Our findings corroborate these reports, but paradoxically indicate that living with a step-parent is not necessarily associated with worse outcomes in the case of obesity. One concern would be whether the absence of obesity is actually a negative outcome, in that it could actually indicate underweight. We do not find this to be the case, as children living in step-families were not more often underweight than children living with both biological parents.

There was very limited evidence that parents' marital status, beyond living arrangements, was associated with children's obesity risks, and the few significant relationships indicated that the children of married parents had higher obesity risks, consistent with our emerging hypothesis that household structure proxies for the availability of more resources may not prevent obesity.

We found some evidence that children living with more adults (Research question 2a), and especially those living with a grandmother (Research question 2b) gained more weight and had higher risks of obesity than other children. This pattern corroborates those in previous studies, showing that grandparents may promote unhealthy eating patterns and obesity in children(Bruss et

al. 2003; Jingxiong et al. 2007; Wu et al. 2003), and is also consistent with our emerging hypothesis that more resources and permissiveness may be associated with greater obesity risks.

There was robust evidence that co-residence with other children was associated with lower obesity risks and lower weight increases (Research question 3), especially for pre-adolescent children. This pattern is consistent with the proposition that more per capita resources are not preventative of poorer outcomes in terms of obesity. Perhaps parents with multiple children must provide more structured lifestyles for financial or organizational reasons (Downey 2001), and these lifestyle differences are protective against excessive weight gain (Chen and Escarce 2010; Price and Swigert 2012). It may also be that children living together have more options for active play than do only children (Salmon et al. 2005; Timperio et al. 2008).

Having accounted for economic resources and multiple other characteristics, it seems plausible that more parental care rather than less is associated with unhealthy weight. Children living with step-parents have been shown in other studies, including from the U.S., to have lower access to resources, including resources pertinent to health(Case et al. 1999; Case and Paxson 2001; Daly and Wilson 1998; Gennetian 2005; Zvoch 1999). In this study, we have shown that they also gain less weight during elementary school and are also LESS likely to be obese. Further, children living with more adults, and especially with a grandmother, were MORE likely to be obese. The additional adults providing either additional economic resources or care and supervision for children do not improve outcomes in the domain of body weight. Similarly, having more children in the home, expected to decrease per capita economic resources, care, and supervision, are nonetheless associated with less weight gain and obesity. Finally, consistent with studies suggesting that single parents tend to be more lenient with their children and less willing to deny them anything (Furstenberg and Cherlin 1991; Gabel 2004; McLanahan and Sandefur 1994; McLanahan and Schwartz 2002), we find that children living with a single parent, especially a mother, are more likely

to be obese. These patterns all suggest that, with respect to obesity, permissive parenting leads to greater harm regardless of parental intent.

This study did not take into account specifics of the parental relationship, such as the quality or longevity of the relationship, which are likely to be pertinent to child wellbeing. We did not distinguish specific types of relationships such as same-sex relationships beyond the number of parents, biological relationship to the child, and marital status.

The practical implications of these findings raise questions about what good parenting entails in a world of abundance. Across cultures, the way for parents to show love for their children and promote their health and wellbeing has been through food and material goods. These traditions perpetuated in the contemporary world entail that more food and more sedentary toys may continue to show love but may also increase the risk of chronic disease. There has been some suggestion that new ways to show love should be adopted, for example rewarding good behaviors with stickers rather than cookies (Puhl and Schwartz 2003).

Another practical consideration is the possibility of improving the involvement of families in child wellbeing across family types. Having found that obesity risks differ between households with two biological parent, single parent, step-parent households, and multigenerational households, future studies should explore how parenting behaviors across these household types to understand which household interactions and activities are associated with better weight trajectories.

Table 1: Descriptive statistics of body weight and household structure at each data wave

	Kindergarten		1st grade		3rd grade		5th grade		8th grade	
	Mean or %	SE	Mean or %	SE	Mean or %	SE	Mean or %	SE	Mean or %	SE
Change in BMI by next data wave	0.47	2.36	1.76	3.47	1.97	4.52	2.45	6.41	2.45	6.42
Child is obese	7.30	0.28	8.96	0.43	12.51	0.57	14.99	0.65	15.30	0.70
Number and relatedness of parents										
Both biological parents	66.34	0.91	65.74	1.17	64.57	1.22	62.33	1.27	59.56	1.29
Biological mother and step-father	8.46	0.37	8.80	0.50	9.61	0.79	10.15	0.58	11.42	0.66
Biological father and step-mother	0.55	0.08	0.67	0.11	0.73	0.15	0.99	0.19	1.58	0.28
Biological mother only	20.73	0.84	20.41	0.99	19.74	1.10	21.13	1.21	21.86	1.18
Biological father only	1.40	0.13	1.69	0.19	2.21	0.36	2.21	0.33	2.25	0.29
Adopted	0.86	0.11	0.72	0.12	0.78	0.19	0.80	0.19	0.84	0.19
Guardians	1.66	0.17	1.97	0.22	2.36	0.38	2.38	0.35	2.49	0.44
Primary caregiver currently married	30.88	1.02	29.90	1.13	28.21	1.25	29.57	1.35	30.04	1.28
Number of adults in household	2.02	0.01	2.02	0.01	2.05	0.01	2.03	0.02	2.07	0.02
Grandmother resides in household	10.04	0.48	10.11	0.54	10.10	0.79	8.63	0.66	8.21	0.66
Number of co-residing children	2.50	0.02	2.51	0.03	2.50	0.03	2.48	0.03	2.38	0.03

Table 2: Household structure and change in BMI by next data wave

VARIABLES	BMI change Kindergarten to 1st grade	BMI change 1st to 3rd grade	BMI change 3rd to 5th grade	BMI change 5th to 8th grade
Number and relatedness of parents (Ref=Both biological parents)				
Biological mother and step-father	-0.21**	-0.06	-0.00	0.29
	(0.069)	(0.111)	(0.133)	(0.194)
Biological father and step-mother	-0.32	-0.39+	-0.31	-0.24
	(0.242)	(0.230)	(0.227)	(0.248)
Biological mother only	-0.10	0.08	-0.02	0.51*
	(0.087)	(0.118)	(0.193)	(0.252)
Biological father only	-0.04	0.01	-0.22	-0.10
	(0.143)	(0.206)	(0.263)	(0.417)
Adopted	0.09	-0.15	0.04	0.17
	(0.153)	(0.232)	(0.322)	(0.406)
Guardians	0.04	-0.07	-0.45	0.16
	(0.137)	(0.215)	(0.402)	(0.337)
Primary caregiver is currently married	0.03	-0.06	0.11	-0.34
	(0.081)	(0.107)	(0.170)	(0.220)
More than 2 adults in the household	0.12+	-0.00	0.17	-0.09
	(0.072)	(0.075)	(0.108)	(0.144)
Grandmother resides in household	0.03	0.09	0.24	-0.08
	(0.066)	(0.105)	(0.145)	(0.215)
Number of co-residing children	-0.06**	-0.09**	-0.04	0.13*
	(0.017)	(0.023)	(0.025)	(0.054)
Constant	0.39*	1.44**	1.83**	1.45**
	(0.169)	(0.215)	(0.342)	(0.409)
Observations	13,265	10,575	9,057	7,295
R-squared	0.011	0.026	0.030	0.028

Standard errors in parentheses

** p<0.01, * p<0.05, + p<0.1

Multivariate models controlling for child demographic characteristics (gender, race, weight at birth), household socio-economic characteristics (SES quintile, mother's full time employment, whether a language other than English is spoken at home, and whether the child attends a public school).

Table 3: Household structure and obesity at the next data wave

VARIABLES	Obese in 1st grade	Obese in 3rd grade	Obese in 5th grade	Obese in 8th grade
Number and relatedness of parents (Ref=Both biological parents)				
Biological mother and step-father	-0.42*	-0.04	-0.23	-0.23
	(0.167)	(0.151)	(0.200)	(0.164)
Biological father and step-mother	-1.33*	-0.42	-1.50**	-0.15
	(0.547)	(0.520)	(0.580)	(0.567)
Biological mother only	-0.39*	0.06	-0.02	-0.07
	(0.173)	(0.140)	(0.233)	(0.253)
Biological father only	-0.61*	0.63**	0.09	-0.37
	(0.300)	(0.238)	(0.341)	(0.432)
Adopted	-0.11	-0.27	-0.57	-0.19
	(0.324)	(0.404)	(0.349)	(0.463)
Guardians	-0.31	0.08	-0.57	-0.31
	(0.227)	(0.327)	(0.426)	(0.326)
Primary caregiver is currently married	0.45**	-0.10	-0.12	0.12
	(0.170)	(0.126)	(0.214)	(0.229)
More than 2 adults in the household	0.14	0.16	0.12	0.08
	(0.114)	(0.106)	(0.130)	(0.133)
Grandmother resides in household	0.25+	0.07	0.14	0.36*
	(0.130)	(0.112)	(0.159)	(0.177)
Number of co-residing children	-0.17**	-0.19**	-0.11+	-0.06
	(0.036)	(0.031)	(0.058)	(0.052)
Constant	-4.24**	-3.29**	-2.95**	-3.69**
	(0.345)	(0.332)	(0.425)	(0.416)
Observations	13,421	11,427	9,407	7,728

Standard errors in parentheses

** p<0.01, * p<0.05, + p<0.1

Multivariate models controlling for child demographic characteristics (gender, race, weight at birth), household socio-economic characteristics (SES quintile, mother's full time employment, whether a language other than English is spoken at home, and whether the child attends a public school).

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