Published in final edited form as:

Pediatr Obes. 2020 February ; 15(2): e12576. doi:10.1111/ijpo.12576.

Residential Mobility in Early Childhood and Obesity at Kindergarten-age among Children from the United States

Kathryn L. Krupsky, MPH^{a,*}, Rebecca R. Andridge, PhD^b, Sarah E. Anderson, PhD^a

^aDivision of Epidemiology, The Ohio State University College of Public Health, Columbus, Ohio, USA

^bDivision of Biostatistics, The Ohio State University College of Public Health, Columbus, Ohio, USA.

Abstract

Background: Children who frequently move have poorer behavioral, emotional, and overall health. For similar reasons, the experience of changing home may contextualize children's risk for obesity. Few studies have assessed the relationship between residential mobility and obesity; even fewer explore this relationship with assessment of obesity before school age.

Methods: We analyzed data from the Early Childhood Longitudinal Study-Birth Cohort. Obesity at kindergarten-age was determined from measured height and weight. Early childhood residential mobility was categorized as not moving, or having moved once, twice, or 3 or more times. Analyses are weighted to be representative of children from the U.S. and variance estimates account for the complex survey design.

Results: The prevalence of obesity at kindergarten-age was 17.5% and most children (71%) moved in early childhood. Compared to children who did not move, the adjusted odds ratios for obesity at kindergarten-age were 0.72 (95% CI: 0.57–0.92); 0.70 (95% CI: 0.55–0.89); and 0.64 (95% CI: 0.50–0.84) for children who experienced 1, 2, or 3+ moves.

Conclusions: Our study suggests obesity and mobility in early-life are associated, but not in the way we might expect. Residential mobility may fit into a broader picture of instability and, on its own, may not elevate a child's risk for obesity.

Keywords

ECLS-B; obesity; early-childhood; residential mobility; instability

*Corresponding author contact information: 1841 Neil Avenue, Columbus, OH 43210; 734-612-0893(p). krupsky.1@osu.edu.
Author Contributions

KLK designed and conceptualized this research, led the analysis and interpretation of data, and drafted the manuscript. RRA participated in the conceptualization of the data analysis and critically reviewed the manuscript. SEA supervised the design and conception, supervised the analysis and interpretation of data, and critically revised the manuscript.

Conflicts of Interest

The authors have no conflicts of interest to declare.

Background

Obesity persists as a serious public health issue.¹ United States (U.S.) estimates from 2016 suggest nearly one in five youth have obesity.² Treatment for obesity remains challenging and is often unsuccessful despite best efforts to develop and implement obesity interventions.³ Therefore, prevention is essential and may be informed by understanding early-life correlates of obesity. Ecological developmental models suggest child health is most influenced by household environments, particularly before children enter school.^{4,5} Organized and stable households are thought to promote child health and development by minimizing stress and cultivating positive parent-child interactions.⁶ Early-life experiences, such as frequent residential moves, may hinder the development of home environments conducive to child well-being.^{7,8}

It is common for young children to experience a change in residence. In the U.S., approximately 11% of youths age 18 years and younger moved at least once between 2017 and 2018.⁹ Families with children move for a variety of reasons. For some families, moving may be associated with socioeconomic advancement, such as a new job, or selection into a better neighborhood¹⁰ to access higher quality school systems.¹¹ For others, moves are associated with negative life events, such as divorce or family separation¹² or even abuse.¹³ Rates of residential moves are typically highest among children one to four years of age and decline during adolescence.⁹ In addition to high mobility, early childhood is also a key developmental period where disruption from residential moves may be problematic for young children.¹⁴ Instability in a child's physical environment requires adjustments for families, such as becoming acquainted with community resources or changes in daily schedules, and may be stressful if moving reduces caregivers' ability to buffer stress for children.¹⁵ Associations between residential moves and social-emotional, as well as behavioral outcomes have been reported in several studies. Specific outcomes include, increased problematic behavior, diminished school readiness, and psychological and emotional health issues.¹⁶ A smaller body of literature, focused on linking residential mobility to physical health, suggests more frequent residential moves may be associated with poorer parent-reported child health¹⁷ and poorer self-reported overall health in adulthood.¹⁸ Assessing the relationship between residential moves and more specific physical health indicators, such as obesity, may inform how early-life residential instability shapes child health.

Moving alters neighborhood context as well as social structures—both influential factors tied to weight status.¹⁹ Changing neighborhoods shapes the amenities and services available to residents, some of which may directly influence one's ability to engage in healthful behaviors, such as physical activity²⁰ and consumption of fruits and vegetables.²¹ Social networks evolve when individuals change locations and peer support and modeling are key predictors in successful weight maintenance.²² The effect of individual residential change on weight status, separate from neighborhood context and social resources, may be important. Associations between residential mobility and weight status have most often been assessed among adolescents and adults, and among these studies, the relationship is unclear. Two prospective studies, one among Scottish adolescents followed into middle adulthood and the other among a nationally representative sample of children (ages 5–18) from the U.S. and

their parents, found no relationship between residential moves and obesity.^{23,24} Another study of children from southwest England found limited evidence for increased BMI among children 4 to 8 years of age, and stronger evidence for increased BMI at 17 years of age when children moved three or more times in their first four years of life.²⁵ Finally, two analyses from a large, nationally representative sample of adolescents from the U.S. found that greater residential mobility was associated with a lower likelihood of obesity in adulthood.^{26,27} Together, these studies of overweight and obesity provide inconsistent evidence regarding the nature of the relationship between changing residence and weight status. Furthermore, null or protective effects associated with moving contrast with studies of other physical, behavior, and emotional health outcomes in which residential moves were associated with poorer outcomes among children and adults.^{16–18} We believe this discrepancy merits further investigation of the relationship between increased residential mobility and obesity, with special focus on early childhood.

The influence of residential mobility on obesity may differ for young children compared to adolescents or adults. Ecological models of predictors of child weight status highlight the importance of community, demographic, and societal characteristics.²⁸ However, social contexts are largely attenuated by family characteristics and parenting styles. Young children are most influenced by proximal settings, comprised of family and home environments^{5,6} and unlike adolescents or adults, young children lack the ability to independently interact with neighborhood settings. Therefore, changes to neighborhood amenities and social characteristics through residential moves may not directly influence young children. Instead, the influence of residential mobility may depend on the extent to which children's routines and relationship are affected. Toddlers with low security of attachment to their primary caregiver have demonstrated susceptibility to greater body mass index (BMI, kg/m²) at preschool-age.²⁹ Moving is stressful and disruption attributed to frequent residential changes may hinder a parent's ability to engage in positive parenting behaviors³⁰ and potentially undermine a child's ability to maintain a healthy weight.

In the current study, we investigate the relationship between early-life residential mobility and obesity in a large, nationally representative cohort of children from the U.S. who were born in 2001 and followed through kindergarten-age. Additionally, we assess the extent to which associations between residential mobility and risk for obesity depend on indicators of socioeconomic adversity. We hypothesize that children who experience frequent residential changes will be at greater risk for obesity at kindergarten-age, when compared to children who never move.

Methods

Study Population

We analyzed data from the Early Childhood Longitudinal Study—Birth Cohort (ECLS-B). The ECLS-B is a prospective cohort of a representative sample of children from the U.S. born in 2001. The sampling design for ECLS-B has been previously described,³¹ but is briefly summarized here. Using a clustered list-frame design and state birth certificate records, a probability sample of 14,000 children born in 2001 was identified. Children were excluded from the study if they were born to mothers younger than 15 years of age, died

during infancy, or were adopted. Children who were Chinese or American Indian/Native Alaskan, children born at low birth weight, and twins were over-sampled. Survey weights were constructed to account for overall selection probabilities as well as non-response. A final study cohort of 10,700 children was formed when children were approximately 9-months old (wave 1). A second and third wave of assessments were completed at 24-months (n = 9850) and at preschool-age (approximately 4.5 years of age) (n = 8750). A fourth assessment wave was completed when children were approximately 5.5 years of age, (median age = 64.5 months; interquartile range = 6 months). At wave 4, a random selection of 85% of participating children was assessed (n = 6950) due to budgetary constraints. Data collection occurred during visits to the children's homes. During these home visits, direct measurements were completed with the child and computer-assisted personal interviews were conducted with the child's primary caregiver (with very few exceptions, the biological mother).

The ECLS-B was directed by the National Center for Education Statistics (NCES) and approved for data collection by the NCES ethics review board. Parental written informed consent was obtained at study enrollment. Under a restricted-use data agreement, analyses were conducted at the Ohio State University. Per this agreement, unweighted sample sizes are rounded to the nearest 50.

Residential Mobility

We characterized early childhood residential mobility as the number of residential moves children experienced across the four waves of ECLS-B. This variable was constructed using information from parent interviews. At the second, third, and fourth waves, the primary caregiver was asked, "*have you moved since our last interview?*" and if so, "*how many times have you moved since our last interview?*" The first ECLS-B visit occurred when children were 9-months old, and caregivers were not directly asked about changes of residence that the infant may have experienced before wave 1. However, at wave 2, caregivers were asked, "*how long have you lived in this neighborhood?*" and we used this information to estimate residential moves between birth and wave 1. To do this, we compared the child's age at wave 2 to the reported time lived in their current neighborhood; we assigned one move if the family reported having lived in the neighborhood for less time than the child was old and had not moved between waves 1 and 2. We then summed the number of residential moves reported across the waves of the study. While this sum may slightly underestimate the total number of moves experienced by a child, it allows us to categorize children's experience with residential mobility from birth to approximately 5.5 years of age. Furthermore, similar methods for characterizing residential mobility in early-life using the ECLS-B have been utilized elsewhere.^{10,32} We coded residential mobility multiple ways to determine the most appropriate scale. First, the sum was top coded at 10, as only 4% of the sample reported moving 10 or more times. We assessed the functional form of the association between childhood obesity at kindergarten-age and residential mobility using LOWESS smoothed scatter plots³³ and determined residential mobility was linear in the logit. However, we did not feel modeling a constant one-unit change in residential mobility was a clinically meaningful interpretation of the relationship. Therefore, we decided to categorize a child's experience as not moving, or having moved once, twice, or three or more times. We also ran

analyses with residential mobility top coded at four or more moves, which produced nearly identical results (data not shown).

Childhood Obesity

Our outcome was obesity as assessed at wave 4 and defined relative to the CDC BMI-for-age growth charts.³⁴ NCES data collection teams followed a standardized protocol to measure children's height, using a portable stadiometer, and weight, using a digital scale. Children wore only light clothing and no shoes during measurements.³⁵ BMI was calculated and obesity was defined as a sex-specific BMI-for-age $\geq 95^{\text{th}}$ percentile.³⁶

Covariates

We selected covariates a priori, based on previously established relationships with childhood obesity^{37,38} and/or residential mobility.¹⁰ During the wave 1 assessment, primary caregivers confirmed the child's date of birth and sex as reported on the child's birth certificate. Child ethnicity and race were reported by the primary caregiver using established categories from the U.S. census.³⁹ Race/ethnicity categories were defined as non-Hispanic white, non-Hispanic black, Hispanic, and non-Hispanic other race (including multiple races) as previously described.³⁸ Information on household composition, age of the primary caregiver, maternal education, and household income-to-poverty ratio were all collected during the wave 1 interview. For maternal education, we used the primary caregiver's response to the highest grade or year of school they completed. We recoded this variable categorically as less than high school, high school diploma or GED, some college, or a college graduate or more. Household income was self-reported (rounded to the nearest thousand dollars) from the previous year. If respondents were unsure of the exact amount they could select from ranges of annual household incomes. Household income-to-poverty ratio at wave 1 was calculated using estimated household income and the number of household members reported living in the home, relative to 2001 poverty levels in the U.S.⁴⁰ At wave 4, the child's age (in months) was calculated using the child's date of birth and the date of the assessment. Finally, maternal BMI at wave 1 was calculated from measured weight and self-reported height. For cases when maternal weight was not available at wave 1, but measured at subsequent visits, we used the first available weight to calculate BMI. Maternal obesity was defined as a BMI ≥ 30 .

Analytic approach

Children were included in our analyses if their height and weight were measured at wave 4 and if they had non-missing data on residential mobility. All analyses utilized ECLS-B sampling weights that account for non-response and potential under-coverage of the target population.⁴¹ Estimates are generalizable to children born in the U.S. in 2001. We accounted for the complex survey design in our variance estimates using jackknife replicate weights.^{42,43} All analyses were completed using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina).⁴⁴

Bivariate analyses assessed associations between covariates, residential mobility in early childhood, and obesity at kindergarten-age. Logistic regression was used to estimate the odds of obesity at kindergarten-age in relation to residential mobility in early childhood.

Residential mobility was modeled as a categorical variable and the reference category was not having moved. Unadjusted and covariate-adjusted odds ratios (ORs) are presented with 95% confidence intervals (CIs). A minimally sufficient adjustment set of covariates was determined using a directed acyclic graph (DAG) approach to identify confounding.⁴⁵ Finally, to test for possible effect modification, we constructed interaction terms to determine if the association between residential mobility and obesity differed by potential indicators of social and economic adversity (income-to-poverty ratio, maternal education, and single-parent status). One at a time, we assessed the statistical significance of an interaction term using the Wald-statistic. Interaction terms with *P* values <0.05 suggested heterogeneity of the association and warranted stratification.

Results

Of the 6950 children included at wave 4, our analytic sample consisted of 6750 children. Of the children excluded from our analysis, 200 were missing height or weight measurements. We assessed patterns of missing data for residential mobility responses according to assessment waves and found <50 children were missing responses from one wave and even fewer were missing responses from two waves. We tested for differences between children included in our analytic sample and those excluded. Children who were excluded from the analytic sample were more likely to be boys, to live with a single parent, and were on average 1.6 months older than children in the analytic sample (Table 1).

The prevalence of not having moved by kindergarten-age was 29.4% (95% CI: 27.0–30.9). Thus, most children moved at least once during early childhood [29.0% (95% CI: 27.5–30.5) moved once, 18.0% (95% CI: 16.7–19.2) moved twice, and 23.6% (95% CI: 22.2–25.0) moved three or more times] (Table 2). Boys and girls had similar mobility patterns across early childhood. Children born as singletons moved more frequently than non-singletons. Children who moved more frequently were slightly older. The distribution of mobility significantly differed according to a child's race/ethnicity; the proportion of children who were white, non-Hispanic was highest among those who did not move and steadily decreased as mobility increased, while the proportion of children who were black, non-Hispanic was lowest among those who did not move and steadily increased as mobility increased. Children who were Hispanic had similar mobility patterns to children who were black, non-Hispanic. Greater maternal age and greater maternal education were associated with less mobility over early childhood. Maternal obesity was not associated with residential mobility. Greater economic resources were associated with fewer residential moves. Finally, one-third of children who moved three or more times over early childhood were from single-parent households (Table 2).

The overall prevalence of obesity among children at wave 4 was 17.5% (Table 2). The distribution of child sex only marginally differed according to obesity status. Children who had obesity had greater representation of singleton births and less representation of children who were white, non-Hispanic. Child age and maternal age were not associated with obesity at kindergarten-age. Among children with obesity, mothers were less educated and had greater prevalence of obesity. Finally, poverty and single-parent households were more common among children who had obesity (Table 2).

Residential Mobility and Obesity

The prevalence of obesity at kindergarten-age was highest among children who had not experienced a residential move [20.0% (95% CI: 17.2–22.7)] (Table 3). The prevalence of obesity at kindergarten-age was 16.2% (95% CI: 14.1–18.2), 16.8% (95% CI: 14.2–19.4), and 16.8% (95% CI: 14.3–19.4) for children who experienced 1, 2, or 3+ moves respectively. Based on the unadjusted model, the odds of obesity at kindergarten-age among children who moved once were 0.77 (95% CI: 0.61–0.98) times those of children who did not move at all. The unadjusted association comparing children who moved twice or three or more times to those who did not move were the same (OR: 0.81; 95% CI: 0.64–1.0). Our minimally sufficient adjustment set of covariates included singleton birth status, race/ethnicity, maternal education, income-to-poverty ratio, and single parent status. Adjusting for these factors strengthened the association between residential mobility and obesity. Compared to children who never moved, the odds of obesity were 0.72 (95% CI: 0.57–0.93) for children who moved once, 0.70 (95% CI: 0.55–0.89) for children who moved twice, and 0.64 (95% CI: 0.50–0.84) for children who moved three or more times. Individual interaction terms between residential mobility and income-to-poverty ratio, maternal education, and single-parent status were added to the adjusted model one at a time. The *P*-values from the Wald tests associated with each interaction term were all 0.10. Therefore, we concluded there was no evidence for effect modification (results not shown). We also conducted a sensitivity analysis to ensure that our results were not influenced by inclusion of children in the reference group who were underweight. Very few (*n* = 200) children were underweight (BMI-for-age <5th percentile) at wave 4, and our results did not change when these children were (data not shown).

Discussion

Residential moves can be momentous events in a child's life, with potential to disrupt household routines conducive to a child's healthy development.¹⁵ Our study builds upon a body of literature on the effect of frequent residential moves on children's behavioral,¹⁶ educational,³² and overall health.^{17,18} Although frequent residential moves have been associated with poorer outcomes in these domains, the association between residential mobility and obesity may not follow this pattern. We assessed the relationship between residential mobility in early childhood and obesity in early childhood (approximately 5.5 years of age) using the ECLS-B. This large cohort study followed a representative sample of U.S. children born in 2001 from infancy to early childhood. We found a significant association between residential mobility and the prevalence of obesity at kindergarten-age that persisted after controlling for factors capable of providing alternative explanations. However, the relationship was not in the direction we hypothesized. Furthermore, this association was not modified by indicators of social or economic adversity. To our knowledge, this is the first study of residential moves and obesity focused exclusively on the early childhood.

Few studies have been published on the relationship between residential mobility and obesity. Among these studies, adolescents and adults were the primary populations reported on. One prospective study, beginning in 1987 and ending in 2008, followed Scottish

adolescents into middle adulthood and measured the relationships between residential moves from birth to 18 years of age and indicators of health, including BMI and waist-to-hip ratio. After accounting for a wide range of sociodemographic characteristics, there was no evidence of a relationship between moving and BMI or waist-to-hip ratio.²³ The most important attenuating factor in relationship between childhood mobility and health was school moves, suggesting social environments may play an important role when predicting whether a child will develop obesity. However, our analysis of the ECLS-B represents a period of childhood preceding formal education. Therefore, we would not expect changing schools to account for the relationship we observed. Another study, with the primary goal of describing how several aspects of the built environment influence the weight status of school-age children and adolescents, also accounted for residential mobility. Using the Child Development Supplement of the Panel Study of Income Dynamics (PSID), a nationally representative sample of youth aged 5–18 years of age from the U.S., assessed between October 2002 and May 2003, Grafova found evidence that residential moves influenced neighborhood characteristics, but found no association between residential moves and obesity.²⁴ While the population in the Child Development Supplement of the PSID includes children closer to the age of children in ECLS-B, the average age in the sample assessed by Grafova²⁴ was 11.8 years (SD: 3.72), representing a population that may have more autonomy over interactions with neighborhood environments.

An analysis of the Avon Longitudinal Study of Parents and Children, a cohort of children born between 1991 and 1992 from southwest England, used residential moves in the first four years of life to predict BMI changes between the ages 4 and 17 years. After accounting for a wide range of explanatory variables, there was weak evidence for increased BMI among children between ages 4–8 years who moved three or more times, when compared to not moving at all. A more substantial effect, suggesting increase BMI with more frequent residential moves, was detected among children between the ages 15–17 years.²⁵ The association between increased BMI and greater residential mobility supports our original hypothesis that frequent residential changes will increase the risk for childhood obesity. However, the results from our current analyses not only contradict our original hypothesis, but also contradict the association detected by Morris et al.²⁵ The explanation for these inconsistent findings are not known, but could be attributed to differences in the time periods and populations studied or differing modeling strategies. Unlike our study, Morris et al.²⁵ modeled the percent change in BMI z-score attributable to frequent residential moves. While their results suggest greater BMI among children who frequently move, they do not describe the burden of obesity or whether a child was more likely to have obesity in early life when compared to children who never moved. Our analyses clearly illustrate the proportion of children who had obesity at the wave four assessment in ECLS-B and the relative odds of children having obesity at kindergarten-age, according to residential mobility.

We note consistency of two prior studies with the unexpected association we found in our analyses where more frequent moves were linked to lower obesity prevalence. However, given differences in the age of participants and other methods we caution against direct comparisons. In two analyses^{26,27} of the National Longitudinal Study of Adolescent to Adult Health (Add Health), a large nationally representative sample of adolescents from the U.S. in grades 7–12 enrolled during the 1994–95 school year and followed prospectively

into adulthood,⁴⁶ Jones found small effects suggesting more frequent residential moves were associated with lower BMI over time. However, effects were partially explained by individual characteristics, health behaviors, and indicated slight differences between individuals living in urban versus non-urban areas.²⁷ In the second analysis of Add Health, the relationship between residential mobility and obesity was further investigated by incorporating more specific characteristics of the physical environment. After adjusting for time-varying individual and spatial measures, such as physical activity, resource availability, and crime rates, the association between mobility and BMI was no longer statistically significant.²⁶ While these results offer some support for the direction of the effect detected in our analyses, they assess the relationship between residential mobility and obesity among adolescents transitioning into adulthood. Associations for young children may be different because compared to adolescents, young children's interactions with their neighborhood environments are more likely to be mediated by caregivers.

Explanations for the counterintuitive relationship we observed between residential moves and obesity in early childhood remain unclear. Moving may correspond with positive life changes, such as job advancement or increased economic means, that are conducive to healthier lifestyles and greater access to health-promoting amenities.²⁷ It is common for households with children to move to more advantaged neighborhoods,¹⁰ suggesting that when economically feasible, households selecting into more prosperous environments may purposefully choose characteristics ideal for child rearing; these characteristics may promote behaviors which support healthy growth and reduced risk for obesity. However, in our analysis of ECLS-B, we found that children who moved the most in early life were more likely to be from households with the lowest socioeconomic means and the prevalence of obesity was higher among children at or below the poverty threshold. Interestingly, controlling for these variables in our analyses increased the magnitude of the association we observed. Furthermore, when we tested for possible effect modification, we found no evidence of differences in the relationship between residential mobility and obesity by income-to-poverty ratio or other indicators of socioeconomic status, such as maternal education or having a single-parent.

Residential mobility may fit into a broader picture of instability and chaos in early-life. Chaotic environments are high in noise and crowding, low in routines, and lack organization.⁴⁷ Children from households with greater instability and chaos are more susceptible to negative health outcomes, such as internalizing and externalizing behaviors, developmental delays, and poor overall physical health.⁴⁸ Conversely, children living in households with greater levels of structure and routine experience health benefits, such as better sleep and shorter duration of illness.⁴⁸ For similar reasons, chaotic household conditions may undercut a child's ability to maintain a healthy weight. The Family Ecological Model (FEM),²⁸ an adaptation to ecological systems theory, stresses the complexity of dynamic relationships between families and the environments in which they are embedded. Such relationships pose great influence on a family's ability to make lifestyle choices that prevent childhood obesity.⁴ The FEM previously emphasized parenting behaviors and practices, relationships between household members, and the food environment.²⁸ However, in a recent qualitative study to expand the FEM for childhood obesity prevention, experiences such as frequent residential moves were highlighted as contributors to chronic stress which distract parents from

engaging in positive parenting behaviors.⁴⁹ Therefore, for younger children, explaining the relationship between residential mobility and childhood obesity may require research approaches incorporating more comprehensive pictures of stability and organization in early childhood and minimize a child's experience with stress.

Limitations

Our analyses have several limitations. First, ECLS-B is an observational study and no causal conclusions can be drawn from our analyses. We controlled for many plausible confounders, yet bias from potential uncontrolled confounding or measurement error cannot be ruled out. Although children's heights and weights were directly measured, BMI is not a direct measure of adiposity.³⁶ Children from the ECLS-B were born in 2001, the wave four assessments took place in 2006, and our analyses took place between 2018 and 2019. Potential period-specific effects make it unknown whether the findings from our analyses would apply to children today. Finally, the frequency of residential moves is an important factor when considering child health. However, our analysis was unable to distinguish the effects of frequency of household moves from reasons for changing residence or the time spent at each residence. While our analysis showed little difference between the prevalence of obesity for children who moved once versus twice or more frequently, more nuanced characteristics of residential mobility may play important roles in predicting child weight status.

Conclusions

Obesity is a complex issue and prevention efforts should acknowledge place and time in which early-life experiences occur. Residential mobility is common among children from the U.S. and identifying the potential downstream effects associated with residential moves offers opportunities for households with children to create healthy environments and plan for healthy futures. Our study suggests obesity and mobility in early-life are associated, but perhaps not in the way we might expect. Especially for young children, the experience of moving may not fully capture characteristics of home environments and family processes that meaningfully contribute to the development, or prevention, of childhood obesity.

Acknowledgements

These analyses were supported by The Ohio State University College of Public Health and the National Institutes of Health (R01DK108969). The funders had no role in the design or conduct of the study; collection, management, analysis, and interpretation of data; and preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication. The ECLS-B data were collected by the National Center for Educational Statistics (NCES), within the Institute of Education Sciences of the U.S. Department of Education. A license agreement is in place with The Ohio State University for analysis of restricted-use data from ECLS-B. We thank the families who participated in ECLS-B, and the staff involved in the collection and management of the data.

References

1. Robert Wood Johnson Foundation. The State of Obesity. Obesity Rates and Trends 2018; <https://stateofobesity.org/data/>. Accessed 27 December, 2018.
2. Hales CM, Carroll MD, Fryar CD, Ogden CL. Prevalence of Obesity Among Adults and Youth: United States, 2015–2016. Centers for Disease Control and Prevention;2017.

3. Peirson L, Fitzpatrick-Lewis D, Morrison K, Warren R, Ali MU, Raina P. Treatment of overweight and obesity in children and youth: a systematic review and meta-analysis. *CMAJ Open*. 2015;3(1):E35.
4. Bronfenbrenner U Ecology of the family as a context for human development: Research perspectives. *Developmental Psychology*. 1986;22(6):723.
5. Bates CR, Buscemi J, Nicholson LM, Cory M, Jagpal A, Bohnert AM. Links between the organization of the family home environment and child obesity: a systematic review. *Obesity Reviews*. 2018;19(5):716–727. [PubMed: 29520946]
6. Ackerman BP, Brown ED. Physical and psychosocial turmoil in the home and cognitive development. Washington, D.C.: American Psychological Association; 2010.
7. Anderson S, Leventhal T, Dupéré V. Residential mobility and the family context: A developmental approach. *Journal of Applied Developmental Psychology*. 2014;35(2):70–78.
8. Compas BE. Stress and life events during childhood and adolescence. *Clinical Psychology Review*. 1987;7(3):275–302.
9. United States Census Bureau. Table 1. General mobility, by race and hispanic origin and region, and by sex, age, relationship to householder, educational attainment, marital status, nativity, tenure, and poverty status: 2017 to 2018. In. *Current Population Study, 2018 Annual Social and Economic Supplement*. 2018.
10. Lawrence E, Root ED, Mollborn S. Residential mobility in early childhood: Household and neighborhood characteristics of movers and non-movers. *Demographic Research*. 2015;33:939. [PubMed: 26819568]
11. Borman GD, Dowling M. Schools and Inequality: A Multilevel analysis of coleman's equality of educational opportunity data. *Teachers College Record*. 2010;112(5).
12. South SJ, Crowder KD, Trent K. Children's residential mobility and neighborhood environment following parental divorce and remarriage. *Social Forces*. 1998;77(2):667–693.
13. Dong M, Anda RF, Felitti VJ, et al. Childhood residential mobility and multiple health risks during adolescence and adulthood: the hidden role of adverse childhood experiences. *Archives of Pediatrics & Adolescent Medicine*. 2005;159(12):1104–1110. [PubMed: 16330731]
14. Shonkoff JP. Building a new biodevelopmental framework to guide the future of early childhood policy. *Child Development*. 2010;81(1).
15. Stokols D, Shumaker SA. The psychological context of residential mobility and well-being. *Journal of Social Issues*. 1982;38(3):149–171.
16. Jelleyman T, Spencer N. Residential mobility in childhood and health outcomes: A systematic review. *Journal of Epidemiology & Community Health*. 2008;62(7).
17. Busacker A, Kasehagen L. Association of residential mobility with child health: An analysis of the 2007 National Survey of Children's Health. *Maternal and Child Health Journal*. 2012;16(1):78–87.
18. Bures RM. Childhood residential stability and health at midlife. *American Journal of Public Health*. 2003;93(7):1144–1148. [PubMed: 12835200]
19. Leonard T, Ayers C, Das S, Neeland IJ, Powell-Wiley T. Do neighborhoods matter differently for movers and non-movers? Analysis of weight gain in the longitudinal Dallas Heart Study. *Health and Place*. 2017;44:52–60. [PubMed: 28167268]
20. Franzini L, Taylor W, Elliott MN, et al. Neighborhood characteristics favorable to outdoor physical activity: Disparities by socioeconomic and racial/ethnic composition. *Health and Place*. 2010;16(2):267–274. [PubMed: 19896408]
21. Litt JS, Soobader MJ, Turbin MS, Hale JW, Buchenau M, Marshall JA. The influence of social involvement, neighborhood aesthetics, and community garden participation on fruit and vegetable consumption. *American Journal of Public Health*. 2011;101(8):1466–1473. [PubMed: 21680931]
22. Kulik N, Ennett ST, Ward DS, Bowling JM, Fisher EB, Tate DF. Brief report: A randomized controlled trial examining peer support and behavioral weight loss treatment. *Journal of Adolescence*. 2015;44:117–123. [PubMed: 26265590]
23. Brown D, Benzeval M, Gayle V, Macintyre S, O'Reilly D, Leyland AH. Childhood residential mobility and health in late adolescence and adulthood: findings from the West of Scotland Twenty-07 Study. *Journal of Epidemiology & Community Health*. 2012;66(10):942–950. [PubMed: 22315239]

24. Grafova IB. Overweight children: Assessing the contribution of the built environment. *Preventive Medicine*. 2008;47(3):304–308. [PubMed: 18539318]
25. Morris TT, Northstone K, Howe LD. Examining the association between early life social adversity and BMI changes in childhood: a life course trajectory analysis. *Pediatric Obesity*. 2016;11(4):306–312. [PubMed: 26305573]
26. Jones A Residential instability and obesity over time: The role of the social and built environment. *Health and Place*. 2015;32:74–82. [PubMed: 25655942]
27. Jones A Residential mobility and trajectories of adiposity among adolescents in urban and non-urban neighborhoods. *Journal Urban Health Journal of Urban Health : Bulletin of the New York Academy of Medicine*. 2015;92(2):265–278. [PubMed: 25801487]
28. Davison KK, Birch LL. Childhood overweight: A contextual model and recommendations for future research. *Obesity Reviews*. 2001;2(3):159–171. [PubMed: 12120101]
29. Anderson SE, Whitaker RC. Attachment security and obesity in US preschool-aged children. *Archives of Pediatrics & Adolescent Medicine*. 2011;165(3):235–242. [PubMed: 21383273]
30. Anderson S, Leventhal T, Newman S, Dupéré V. Residential mobility among children: A framework for child and family policy. *Cityscape*. 2014;16(1):5–36.
31. Bethel J, Green JL, Kalton G, Nord C. Early Childhood Longitudinal Study, Birth Cohort (ECLS-B), Sampling. Volume 2 of the ECLS-B Methodology Report for the 9-Month Data Collection, 2001–02 (NCES 2005–147). Washington, DC: Institute of Educational Sciences; 2005.
32. Mollborn S, Lawrence E, Root ED. Residential Mobility Across Early Childhood and Children's Kindergarten Readiness. *Demography*. 2018;1–26. [PubMed: 29192386]
33. Hosmer DW Jr, Lemeshow S, Sturdivant RX. *Applied Logistic Regression*. Vol 398: John Wiley & Sons; 2013.
34. Kuczmarski R, Ogden C, Guo S, et al. 2000 CDC growth charts for the United States: methods and development In: National Center for Health Statistics, ed. *Vital Health Statistics*. Vol 112002:246.
35. Najarian M, Snow K, Lennon J, Kinsey S, Mulligan G. Early Childhood Longitudinal Study, Birth Cohort (ECLS-B). In: *Preschool–Kindergarten*; 2007.
36. The Centers for Disease Controls and Prevention. Overweight & Obesity. Defining Childhood Obesity: BMI for children and teens 2018 <https://www.cdc.gov/obesity/childhood/defining.html>. Accessed 24 April, 2019.
37. Gibson LY, Allen KL, Byrne SM, et al. Childhood overweight and obesity: maternal and family factors. *Journal of Child and Family Studies*. 2016;25(11):3236–3246.
38. Anderson SE, Whitaker RC. Prevalence of obesity among US preschool children in different racial and ethnic groups. *Archives of Pediatrics & Adolescent Medicine*. 2009;163(4):344–348. [PubMed: 19349563]
39. Office of Management and Budget. Standards for maintaining, collecting, and presenting federal data on race and ethnicity. *Federal Register*. 1997;62:58781–58790.
40. United States Census Bureau. Historical poverty tables: People and families - 1956 to 2017. In: *Current Population Study, Annual Social and Economic Supplement*. 2017.
41. Snow K, Derecho A, Wheelless S, et al. Early Childhood Longitudinal Study, Birth Cohort (ECLS-B), kindergarten 2006 and 2007 data file user's manual (2010–010). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, US Department of Education 2009.
42. Wheelless S, Ault K, Copello E, Black S, Johnson R. Early Childhood Longitudinal Study, Birth Cohort (ECLS-B), Sampling. Volume 2 of the ECLS-B Methodology Report for the Kindergarten 2006 Data Collection (NCES 2010–007). Washington, DC: U.S. Department of Education; 2009.
43. Wolter K Introduction to variance estimation. Springer Science & Business Media; 2007.
44. SAS. *STAT User's Guide*, Version 9.4. Cary, NC, USA: SAS Institute 2014.
45. Shrier I, Platt RW. Reducing bias through directed acyclic graphs. *BMC Medical Research Methodology*. 2008;8(1):70. [PubMed: 18973665]
46. Harris KM, Halpern CT, Whitsel E, et al. The national longitudinal study of adolescent to adult health: Research design. 2009.

47. Matheny AP Jr, Wachs TD, Ludwig JL, Phillips K. Bringing order out of chaos: Psychometric characteristics of the confusion, hubbub, and order scale. *Journal of Applied Developmental Psychology*. 1995;16(3):429–444.
48. Fiese BH, Rhodes HG, Beardslee WR. Rapid changes in American family life: consequences for child health and pediatric practice. *Pediatrics*. 2013:peds. 2013–0349.
49. Davison KK, Jurkowski JM, Lawson HA. Reframing family-centred obesity prevention using the Family Ecological Model. *Public Health Nutrition*. 2013;16(10):1861–1869. [PubMed: 23089267]

Table 1.

Characteristics of children included in the analytic sample compared to those not in the analytic sample

	Analytic Sample % (95% CI) ^a	Not in Analytic Sample % (95% CI)	P value ^b
N	6750	200	
Child Sex			
<i>Male</i>	50.9 (50.5–51.3)	62.4 (52.4–72.3)	0.03
<i>Female</i>	49.1 (48.7–49.5)	37.6 (27.7–47.6)	
Singleton Birth			
<i>Yes</i>	96.8 (96.7–96.8)	97.3 (96.2–98.4)	0.65
<i>No</i>	3.2 (3.2–3.2)	2.7 (1.6–3.8)	
Child Race/Ethnicity			
<i>White, non-Hispanic</i>	53.4 (52.4–54.9)	53.2 (43.3–63.1)	0.33
<i>Black, non-Hispanic</i>	15.5 (14.7–16.2)	14.8 (8.4–21.2)	
<i>Hispanic, any race</i>	24.3 (23.2–25.3)	26.1 (17.9–34.4)	
<i>Other, non-Hispanic</i>	6.6 (6.0–7.2)	5.9 (2.9–8.9)	
Child Age in Months (Wave 4) ^c	64.7 (0.06)	66.3 (0.25)	<0.001 ^d
Maternal Age at Birth			
<i>Less than 20 years</i>	7.4 (6.9–8.0)	10.0 (5.0–15.0)	0.52
<i>20–24 years</i>	23.9 (22.6–24.6)	26.0 (15.6–36.4)	
<i>25–29 years</i>	26.1 (25.1–26.8)	27.9 (18.4–37.4)	
<i>30–34 years</i>	25.3 (24.1–26.1)	17.9 (11.4–24.4)	
<i>35 years or older</i>	17.9 (17.1–18.6)	18.2 (10.4–26.0)	
Maternal Education			
<i>Less than high school</i>	19.0 (18.1–20.0)	21.3 (13.4–29.1)	0.30
<i>High school or GED</i>	28.3 (27.0–29.5)	32.7 (23.4–41.9)	
<i>Some college</i>	28.1 (27.0–29.3)	29.1 (20.9–37.3)	
<i>College graduate or more</i>	24.6 (23.9–25.2)	16.9 (10.0–23.9)	
Maternal Obesity			
<i>Not Obese (<30 BMI)</i>	72.1 (70.4–73.8)	74.8 (65.7–84.0)	0.57
<i>Obese (BMI ≥30)</i>	27.9 (26.2–29.6)	25.2 (16.0–34.3)	
Income-to-poverty Ratio			
<i>< 0.50</i>	10.4 (9.2–11.7)	13.9 (7.8–20.1)	0.10
<i>0.50–0.99</i>	13.2 (12.0–14.4)	13.9 (6.8–21.0)	
<i>1.00–1.84</i>	24.6 (23.0–26.2)	24.3 (15.9–32.7)	
<i>1.85–3.00</i>	27.1 (25.5–28.7)	34.0 (23.0–45.0)	
<i>>3.00</i>	24.7 (23.1–26.3)	13.9 (8.3–19.5)	
Single Parent			
<i>No</i>	79.7 (78.7–80.7)	70.7 (62.6–78.8)	0.01
<i>Yes</i>	20.3 (19.3–21.3)	29.3 (21.2–37.4)	

Children were included in our sample if they had complete height and weight measurements at wave 4 and had a non-missing value for residential moves.

^a All percentages were weighted and the 95% CI accounts for the complex survey design.

^b Rao-Scott (design-corrected) likelihood ratio χ^2 .

^c Continuous variables presented as weighted means and standard errors.

^d t-test (design corrected).

Table 2.

Participant characteristics in relation to residential mobility and obesity

	Moving Status					Obesity Status		
	No Moves % (95% CI) ^c	Moved Once % (95% CI)	Moved Twice % (95% CI)	Moved 3+ Times % (95% CI)	<i>P</i> value ^d	Not Obese % (95% CI)	Obese % (95% CI)	<i>P</i> value ^d
Sample size ^a	2050	1950	1150	1550		5700	1050	
Proportion of Sample	29.4 (27.9–30.9)	29.0 (27.5–30.5)	18.0 (16.7–19.2)	23.6 (22.2–25.0)		82.5 (81.2–83.7)	17.5 (16.3–18.8)	
Child Sex								
Male	49.8 (47.3–52.3)	50.0 (47.2–52.9)	53.0 (49.5–56.4)	51.7 (48.7–54.7)	0.54	50.1 (49.2–51.0)	54.5 (50.8–58.3)	0.052
Female	50.2 (47.7–52.7)	50.0 (47.1–53.8)	47.0 (43.6–50.5)	48.3 (45.3–51.3)		49.9 (49.0–50.8)	45.5 (41.7–49.2)	
Singleton Birth								
Yes	96.2 (95.7–96.6)	96.6 (96.1–97.0)	97.3 (96.8–97.7)	97.5 (97.1–97.9)	0.001	96.6 (96.4–96.7)	97.9 (97.5–98.4)	<0.001
No	3.8 (3.4–4.3)	3.4 (3.0–3.9)	2.7 (2.3–3.2)	2.5 (2.1–2.9)		3.4 (3.3–3.6)	2.1 (1.6–2.5)	
Child Race/Ethnicity								
White, non-Hispanic	61.6 (59.0–64.2)	55.7 (52.7–58.8)	49.3 (45.9–52.7)	44.5 (41.0–49.0)	<0.001	56.2 (54.4–58.0)	41.7 (38.2–45.3)	<0.001
Black, non-Hispanic	11.0 (9.4–12.7)	14.8 (13.0–16.5)	18.6 (16.0–21.3)	19.4 (17.3–21.4)		14.9 (13.9–15.9)	17.9 (15.1–20.7)	
Hispanic, any race	21.6 (19.5–23.8)	22.2 (20.0–24.6)	25.4 (22.1–28.7)	29.2 (25.7–32.7)		22.4 (20.9–23.9)	32.9 (29.3–36.6)	
Other, non-Hispanic	5.7 (4.8–6.6)	7.2 (5.9–8.6)	6.7 (5.3–8.1)	6.9 (5.5–8.2)		6.4 (5.8–7.1)	7.4 (5.7–9.2)	
Child Age in Months ^{b, e}	64.2 (63.9–64.4)	64.5 (64.2–64.7)	65.1 (64.8–65.4)	65.4 (65.2–65.6)	<0.001	64.7 (64.5–64.8)	64.7 (64.4–65.0)	0.95
Maternal Age at Birth								
Less than 20 years	2.3 (1.4–3.2)	4.6 (3.6–5.6)	8.8 (6.8–10.7)	16.4 (14.1–18.6)	<0.001	7.2 (6.5–8.0)	8.5 (6.2–10.7)	0.61
20–24 years	9.9 (8.1–11.8)	18.9 (16.7–21.1)	33.4 (29.6–37.2)	39.2 (36.2–42.2)		23.6 (22.4–25.8)	23.8 (20.3–27.2)	
25–29 years	23.7 (21.3–26.1)	29.0 (26.2–31.7)	26.5 (23.0–30.0)	24.7 (22.2–27.2)		25.7 (24.5–26.8)	27.5 (24.0–30.9)	
30–34 years	33.5 (30.6–36.3)	29.5 (26.9–32.0)	20.0 (16.7–23.3)	13.1 (10.9–15.3)		25.6 (24.3–26.9)	22.7 (19.0–26.4)	
35 years or older	30.7 (28.4–32.9)	18.0 (15.9–20.2)	11.3 (9.0–13.6)	6.6 (4.9–8.3)		17.9 (16.8–18.9)	17.6 (14.3–20.9)	
Maternal Education								
Less than high school	13.6 (11.5–15.7)	15.4 (13.2–17.5)	15.9 (12.7–19.0)	21.5 (18.3–24.7)	<0.001	18.3 (17.2–19.5)	22.2 (19.2–25.2)	<0.001
High school or GED	24.2 (21.3–27.1)	27.3 (24.7–30.0)	29.1 (25.5–32.6)	34.2 (31.3–37.1)		27.1 (25.7–28.6)	33.7 (29.8–37.7)	
Some college	29.2 (26.1–32.2)	32.3 (29.7–35.0)	27.2 (24.1–30.3)	31.2 (27.8–34.5)		28.3 (26.9–29.7)	27.5 (23.7–31.2)	
College graduate or more	34.0 (31.4–36.6)	27.8 (25.3–30.3)	24.2 (21.2–27.2)	11.3 (9.1–13.5)		26.3 (25.4–27.1)	16.7 (14.2–19.1)	

	Moving Status				Obesity Status			
	No Moves % (95% CI) ^c	Moved Once % (95% CI)	Moved Twice % (95% CI)	Moved 3+ Times % (95% CI)	P value ^d	Not Obese % (95% CI)	Obese % (95% CI)	P value ^d
Maternal Obesity								
Not Obese (<30 BMI)	73.2 (70.4–76.0)	73.0 (69.9–76.1)	71.6 (67.1–76.2)	70.0 (66.5–76.5)	0.51	76.0 (74.3–77.8)	53.3 (49.1–57.3)	<0.001
Obese (≥ 30 BMI)	26.8 (24.0–29.6)	27.0 (23.9–30.1)	28.4 (23.8–32.9)	30.0 (26.5–33.5)		24.0 (22.2–25.7)	46.7 (42.7–50.6)	
Income-to-poverty Ratio								
< 0.50	6.6 (5.1–8.2)	8.4 (6.7–10.1)	12.3 (9.7–15.0)	16.2 (13.1–19.2)	<0.001	10.1 (8.8–11.3)	12.1 (9.6–14.5)	<0.001
0.50–0.99	9.1 (7.4–10.8)	10.9 (9.1–12.8)	15.5 (12.6–18.4)	19.2 (16.5–21.9)		12.4 (11.1–13.7)	16.9 (13.9–19.9)	
1.00–1.84	19.8 (17.7–21.9)	23.6 (20.7–26.4)	26.6 (23.3–30.0)	30.2 (26.8–33.5)		23.7 (21.8–25.5)	28.8 (25.2–32.4)	
1.85–3.00	30.7 (27.7–33.8)	26.7 (23.8–29.6)	26.3 (23.6–29.0)	23.8 (20.1–27.5)		28.0 (26.2–29.8)	22.8 (25.2–32.4)	
> 3.00	33.7 (30.7–36.7)	30.4 (27.8–33.05)	19.2 (16.3–22.1)	10.7 (8.2–13.2)		25.8 (24.0–27.7)	19.4 (16.2–22.6)	
Single Parent								
No	87.9 (85.9–89.9)	83.5 (81.6–85.30)	74.9 (71.3–78.5)	68.6 (65.7–71.5)	<0.001	80.6 (79.5–81.8)	75.4 (72.5–78.3)	0.0011
Yes	12.1 (10.1–14.1)	16.5 (14.7–18.4)	25.1 (21.5–28.7)	31.4 (28.5–34.3)		19.3 (18.2–20.5)	24.6 (21.7–27.5)	

Analytic sample restricted to observations with complete data on height and weight at the wave 4 assessment.

^aSample sizes are unweighted and rounded to the nearest 50 to conform to reporting guidelines. Because of rounding, percentages may not total 100 and sample sizes may not total 6750.

^bAge in months at the wave 4 assessment as a continuous variable presented as weighted mean and standard error.

^cAll percentages were weighted. The 95% CI accounts for the complex survey design.

^dRao-Scott (design-corrected) likelihood ratio χ^2 .

^et-test (design corrected).

^fObesity defined as sex-specific, BMI-for-age 95th percentile according to the CDC 2000 growth standard.

Table 3. Obesity (BMI-for-age 95th percentile) among kindergarten-age children by residential mobility status

Early childhood residential mobility	Prevalence of Obesity % (95% CI) ^a	Unadjusted OR (95% CI)	Adjusted ^b OR (95% CI)
<i>Did not move</i>	20.0 (17.2–22.7)	1.00 (referent)	1.00 (referent)
<i>Moved once</i>	16.2 (14.1–18.2)	0.77 (0.61–0.98)	0.72 (0.57–0.92)
<i>Moved twice</i>	16.8 (14.2–19.4)	0.81 (0.64–1.0)	0.70 (0.55–0.89)
<i>Moved 3+ times</i>	16.8 (14.3–19.4)	0.81 (0.64–1.0)	0.64 (0.50–0.84)

^a All estimates were weighted and 95% CI accounts for complex survey design.

^b Adjusted for covariates both independently associated with the exposure and the outcome: singleton birth status, race/ethnicity, maternal education, income-to-poverty ratio, and single parent status. Adjusting for all other variables examine (i.e. child sex, age, maternal age at birth, and maternal obesity) did not change the results.