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Movers and Stayers: How Residential Selection Contributes to the Association between Female Body Mass Index and Neighbourhood Characteristics

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Abstract

Background/Objectives—To examine how a woman's current Body Mass Index (BMI) is associated with non-random residential migration that is based on the average BMI of her origin and destination neighbourhoods.

Subjects/Methods—Among women having at least two children, all birth certificates from Salt Lake County from 1989-2010 (n=34,010) were used to obtain pre-pregnancy weights prior to the first and second births, residential location and socio-demographic information. Census data were used for measures of walkability of neighbourhoods.

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Results—After adjustments for age, education, race/ethnicity, and marital status, obese women living in the leanest neighbourhoods are found to be three times more likely (OR= 3.03, 95% CI 2.06-4.47) to move to the heaviest neighbourhoods relative to women with healthy weight (BMI between 18-25). Conversely, obese women in the heaviest neighbourhoods are 60% less likely (OR=0.39, 95% CI: 0.22-0.69) to move to the leanest neighbourhoods relative to healthy weight women. Indicators of relatively greater walkability (older housing, greater proportion of residents who walk to work) and higher median family income characterize leaner neighbourhoods.

Conclusions—The findings are consistent with the hypothesis that non-random selection into and out of neighbourhoods accounts for some of the association between BMI and neighbourhood characteristics.

Introduction

With 68% of US adults overweight or obese (1) and about 112,000 excess annual deaths attributable to obesity (2), the search for community designs that might help prevent obesity has intensified. An early set of cross-sectional studies and reviews revealed relationships between more walkable community designs, as typically measured by the “3Ds”: population Density, Diversity of destinations, and pedestrian friendly Designs (3), and lower levels of Body Mass Index (BMIs) and/or lower obesity risk (4-10).

Cross-sectional studies are subject to potential non-random selection biases such that individuals with healthy weights may choose neighbourhoods support their healthy weights. Residents may prefer neighbourhoods with nutritious food and/or wider physical activity options, or other features that correlate with nutritious food and activity, and thus move to areas that support their healthy lifestyles (11-15). This threat to internal validity weakens our ability to make causal inferences in observational studies examining the association between unhealthy weight and neighbourhood characteristics.

From a theoretical perspective, residential choice is a consequence of complex economic (e.g., cost of housing, time costs of employment travel), social (e.g., proximity to family/friends, schooling options for children), and neighborhood environment considerations (16, 17). Some of these have causal influences while others reflect selection mechanisms. Consequently, longitudinal designs and statistical techniques to distinguish causal from selection effects are increasingly common, especially for researchers examining community design and physical activity (8, 18-27).

In this study, we adopt a novel approach for assessing the role that residential selection may play in the relationship between built environment and obesity risk. We argue that an individual's BMI at a point in time represents in part the collective influence of direct causal effects of the current neighbourhood environment, and the individual's preference for a certain type of neighbourhood that is related directly or indirectly to weight. The neighborhood may offer a certain food environment and physical activity setting that may have causal effects on obesity risk. However, some residents may also vary in their selection of neighborhoods based on their food and physical activity opportunities.

Among studies using experimental longitudinal designs, results suggest that neighbourhood designs are associated with BMI, even after addressing selection effects. A community experiment, the Moving to Opportunity (MTO) study, showed that persons randomized to move from a neighbourhood with elevated poverty to one with a lower prevalence of poverty had lower levels of extreme obesity and diabetes in relation to a control group (28). A few studies using statistical methods to assess selection in cross-sectional studies have concluded that both selection and environmental influences are likely (14, 29). In a Utah study, of women, Zick and collaborators in used instrumental variables to account for the likelihood that neighbourhoods may affect weight but women may also choose their neighbourhoods based on weight and activity considerations (30). They show that the impact of neighbourhoods on BMI changed (surprisingly, it became somewhat stronger) when potential selection effects were taken into account.

Few mover-stayer models studies exist that examine BMI. Of these studies, one examines only non-movers (31) while others considered the effects of moving or staying on BMI without direct assessment of non-random selection (32, 33). An exception is Grafova and colleagues (5) who examined weight changes for 15,000 older individuals from the Health and Retirement Survey. They concluded that relationships between neighbourhoods and BMI were unlikely due to selection bias because weight did not matter in predicting where they would move, at least for the individuals age 50+ represented in this survey.

We introduce a variant of the mover-stayer approach (34, 35) that exploits longitudinal information on both individual BMI status and neighbourhood BMI levels to assess the degree to which differential neighbourhood selection by BMI occurs. Our objective is to examine associations between individual BMIs and neighbourhood BMIs for both origin and destination neighbourhoods in order to determine if non-random selection into and out of neighborhoods exists. The use of neighbourhood-level BMI provides an opportunity to assess whether movers' individual BMIs are typical of the BMIs from their origin neighbourhoods or BMIs of their destination neighbourhoods. If moving is due to differential selection into neighbourhoods, then prospective movers may be more like their destination neighbourhood before their move than their origin neighbourhood. This means that individuals moving from low BMI neighbourhoods to high BMI neighbourhoods may have elevated BMIs prior to their move and are distinct from their origin neighbors who remain in that origin area. If neighbourhoods have strictly causal effects on BMI, then we argue that BMIs of movers should not be associated with their future neighbourhood BMI.

Materials and Methods

Data

This study relies on a unique population-based data source, the Utah Population Database (UPDB). The vast UPDB genealogical records are linked to statewide vital records including birth certificates that contain data on female height and weight, notably pre-pregnancy height and weight over multiple births. The UPDB also holds all driver licenses that contain data on height/weight for all licensed drivers. These data are used to compute the BMI levels of neighbourhoods for all female and male residents age 18-64 with driver licenses. UPDB is also linked to U.S. Census information on neighbourhood characteristics using

Geographic Information Systems databases. The study protocol was approved by the University of Utah Institutional Review Board and the Resource for Genetic and Epidemiologic Research, which approved our request for waiver of consent because the study is based on deidentified data.

Utah Birth Certificates

For all women bearing children in 1989 or later, the UPDB contains data from birth certificates on their residential addresses and pre-pregnancy weights for each birth along with key socio-demographic characteristics. From 1989-2010, we identified 177,536 mothers who gave birth to at least one child in Salt Lake County. Of these, 40,096 mothers had their first and second child in this same county, which provided the sample frame for our study. We excluded records where birth certificates had reduced data quality, or where mothers had twins or a birth interval less than seven months. The final exclusions included women who (a) had incomplete residential addresses which precluded assigning them to a census block group (N=1,591), (b) were under age 18 at the time of their first birth (N=1,887), or (c) had missing data on any of the included birth certificate covariates (N=60). These women were ineligible for any of these reasons. The final sample size after these exclusions was 34,010 women. Salt Lake County, the most urban location in the state, is also well characterized in terms of spatial attributes of their neighbourhoods.

Birth certificates offer distinct advantages. First, Utah's fertility rate is higher than the nation's average, resulting in a substantial sample size. The birth certificates include data on each woman's pre-pregnancy height and weight, from which individual-level BMIs are calculated. Second, birth certificates provide individual-level variables measured at the time the birth certificate is issued for the first birth. These variables include age (years), highest level of education (less than high school, high school [reference category], some college, college or higher), marital status (married [reference category], not married) and race (white [reference category], African American, Native American, Pacific Islander, Asian, Other), and ethnicity (Hispanic, non-Hispanic [reference category]). Third, birth certificates record residential location information at each birth. Since parents' decisions about residential location are affected in part by neighbourhood, work, life-style and schooling considerations (36), the choices parents make on behalf of their children may affect location decisions that then affect maternal BMI. Fourth, if these data provide a method for assessing the association between BMI and neighbourhood characteristics, other states may adopt this data linkage strategy (37).

Neighbourhood Data

Area measures in this study include several U.S. Census 2000 variables that capture neighbourhood characteristics measured at the Census block-group level based on the residence at the time that the birth certificate was issued. The block group is a relatively small area (i.e., typically about 1,500 residents, ranging from 300 to 3000) (38) that approximates a local neighbourhood. We use 550 of the 567 census block groups in Salt Lake County, Utah, eliminating 17 block groups because they are at the periphery of the county (e.g., including largely uninhabitable areas) with very few residents.

Addresses were geocoded and assigned to a census block group using the ArcGIS geocoder function and street address (or PO Box) and zip code. This is done in partnership with the DIGIT (Digitally Integrated Geographic Information Technologies) Lab at the University of Utah. The centroids of addresses are coded to the Universal Transverse Mercator (UTM) coordinates, which is to the square meter, that are then used to locate the addresses in the appropriate census block group. If an address lacks a zip code, then it is not geo-coded. When a zip code exists, it must be examined to ensure that it is located in the correct city or town; if the match is not correct, then no geo-code is assigned. A handful of PO boxes are included and are generally in the vicinity of the residence but nonetheless creates trivial random misclassification bias in the geocodes (i.e., of the 177,536 total births in Salt Lake County, only 313 had a PO box).

Data on neighbourhood environments in Salt Lake County include measures of the 3Ds measured in the 2000 U.S. Census. The Census-based proxy for land-use diversity is the proportion of workers who walk to work, and a proxy for both diversity and pedestrian-friendly design is the median age of housing in the neighbourhood. Both measures relate to BMI (15, 39, 40). Although only 2.9% of workers in the U.S. report that they usually walk to work (41) and only 2% do so in this Salt Lake County sample (42), the measure should indicate which neighborhoods have a sufficient mix of residential and employment land uses to make walking feasible and attractive. Some studies show that neighbourhoods where more adults walk to work are associated with a larger range and wider variety of destinations in that neighbourhood. (43)

Older neighborhoods also support walkability, as such neighborhoods were more often designed with pedestrians in mind, while newer neighborhoods are often designed to facilitate car travel and to separate needed destinations from residential areas (44). Older streets often have better and tree-shaded sidewalks; more attractive residential, work, and commercial destinations; and narrower streets that encourage drivers to slow down and make street crossing easier for pedestrians (45).

The last 3D measure is the population density of the block group, a factor found to correlate with the BMI of residents (46, 47). Data on neighbourhood socio-demographic characteristics include measures of median family income and the median age of the residents in the block group drawn from the 2000 US Census (39).

Neighbourhood BMI & Mover/Stayer Definitions

We adopt the following strategy to compare movers and stayers from different neighbourhoods. First, we rank all block groups in Salt Lake County in terms of their mean adult (18-64) BMI based on driver license division (DLD) data where we select one measure per license that was closest to the year 2000, the same year from which we derive census data (39). These data are optimal for characterizing block group BMI since they include all women (not just mothers) and men aged 18-64 who hold Utah driver licenses. We rank block groups from leanest to heaviest and divide them into quartiles. Between the two births, movers are those who move to another neighborhood BMI quartile. Accordingly, stayers are those who remain within their BMI quartile at the time of both births. A person who moves but remains in the same quartile is classified as a stayer.

Statistical Analysis Strategy—Ordered logistic regression models are estimated to test the research hypotheses. Robust standard errors are used that correct for correlated observations at the census block-group level using PROC SURVEY LOGISTIC SAS 9.4 in all multivariate analyses. All block groups in Salt Lake County are placed into (ordinal) quartiles based on average BMI derived from driver license data that are referenced as Q1 (lowest/leanest), Q2, Q3 and Q4 (highest/most overweight), both at the time of the first as well as the second birth. The sample is then stratified by neighbourhood BMI quartile for the first birth. The quartiles are based on the following categorizations: Q1 is based on average block groups with a BMI less than 24.8, Q2 is between 24.8 and 25.4, Q3 between 25.5 and 26.0, and Q4 is based on BMI over 26.

The dependent variable is an ordered outcome that describes the BMI neighbourhood quartile of the mother at the time of the second birth. For ordered logistic regressions, values of the dependent variables are ordered so that higher values of the categories refer to greater differences in neighbourhood BMI relative to the origin neighborhood. In general, we used ordered logistic regressions to estimate how a woman's BMI is associated with her odds of moving to a neighbourhood with a different neighbourhood BMI. For the analyses of the leanest neighbourhood sub-sample, Q1, we hypothesize that the coefficients for overweight and obese will be *positive* (i.e., Odds Ratios (OR) >1), which indicates that increasing individual-level BMI is associated with moves to places with higher neighbourhood BMIs. For analyses of the heaviest neighbourhood sub-sample, Q4, we predict that the coefficients for overweight and obese will be *negative* (i.e., OR <1) demonstrating that increasing BMI is associated with remaining in heavier neighbourhoods and being less likely to move to places that have lower average neighbourhood BMIs.

For each BMI quartile-specific subsample assessed at the time of the first birth, the key independent variable is the individual's BMI, treated as a set of dummy variables: healthy weight (18 BMI < 25, the reference category), overweight (25 BMI < 30), or obese (BMI ≥ 30).

In an ancillary analysis, we estimate the effects of the mother's BMI on a simpler binary outcome that measures whether the individual stayed in the same quartile by time 2 or moved to the most extreme quartile. Accordingly, for these models, the binary dependent variable in these cases are (1) stayed in Q1 or moved to Q4 for mothers starting in Q1 or (2) stayed in Q4 or moved to Q1 for mothers starting in Q4. Both are estimated using dichotomous logistic regression. Regression coefficients associated with BMI categories and their significance are the statistics used to assess selection.

Regressions are estimated first by controlling only for age at first birth and then by including potential confounders: education, race/ethnicity, and marital status (variables listed in Table 1). When the outcome is the ordered BMI quartiles of the neighbourhoods at the time of the second birth, ordinal logistic regression is used. For the ordered logistic models, the majority of the women remain in the same quartile by the second birth. To refine these estimates, we also estimate ordered logistic regressions but only for those who moved outside their initial neighbourhood BMI quartile, thus isolating the estimates to that subset of the sample that migrates.

All significance tests and confidence intervals are based on 2-tailed tests with a Type I error of 0.05. ORs and 95% confidence intervals (CI) are shown in the Figure.

Code Availability—All analysis is performed using SAS 9.4. Programs used to perform these analyses are available from the author.

Results

Table 1 provides descriptive statistics for the full sample as well as by neighbourhood BMI quartiles. The average pre-pregnancy BMI for the sample is 23.7, with the lowest average BMI, 22.7, in the leanest quartile (Q1) and the highest average BMI, 24.3, in the heaviest quartile (Q4). Table 2 shows the transitions between BMI-designated neighbourhoods across the two time points. The top and bottom BMI quartiles differ by an average of 1.6 BMI points. To put this in perspective, a 5'6" women weighing 136.5 pounds has a BMI of 22.7. If she instead weighed 146 pounds, her BMI would be 24.3. This average gain of approximately 10 pounds, at this height, for the entire population represents substantial additional weight and additional risks for diseases such as diabetes (48-50), all for a population that is quite young (mean age 24.7 years). These BMI differences by quartile co-exist with other trends in socio-demographic characteristics shown in Table 1.

Figure 1 is a summary of the odds ratio (OR) estimates from the ordered logistic regressions depicted in a forest plot. *All estimates rely on the same contrast: the effects of being obese/overweight relative to having a healthy BMI.* For all results, the odds ratios reflect moves to a different (heavier or leaner) BMI destination neighborhood relative to the origin neighborhood. In panel A, the models show that women living in lean neighborhoods (Q1) who are overweight or obese have significantly greater odds of moving to heavier neighborhoods. The results are quite similar when age only or the full set of demographic controls are included. This same pattern persists in panel B that includes only those who started in Q1 but moved to Q2, Q3, or Q4.

Panels C and D include estimates for woman who begin in the heaviest neighbourhood, Q4, who are overweight or obese. The odds ratios are below one indicating that overweight and obese women are significantly less likely to move to leaner neighborhoods. Once again, when focusing only on the subset of movers out of Q4, this general association continues with both overweight and obese woman being less likely to move.

When we restrict the analysis to the Q1 subsample and consider only those who stay in Q1 or move to the extreme BMI quartile Q4 (panel E), we show that for the fully adjusted models, obese women are three times more likely to move to Q4 than healthy weight women (OR= 3.03, 95% CI 2.06-4.47). Conversely, as shown in panel F for the fully adjusted models, obese women starting in the heaviest neighbourhoods are 60 percent less likely (OR=0.39, 95% CI: 0.22-0.69) to move to the leanest neighbourhoods in relation to healthy weight women. These results are consistent with non-random migration between neighborhoods.

What are the socio-demographic and 3D attributes of the neighborhoods to which these women move? The first row of Table 3 shows that relative to staying in the lowest weight

Q1, movers to the highest weight Q4 will be living in neighbourhoods that have lower family incomes and younger residents. These neighborhoods are also less walkable as indicated by having fewer workers who walk to work and housing that is newer. Unexpectedly, population density of the Q4 neighbourhoods is greater. As shown in the second row of Table 3, the general pattern is true in reverse for women moving from Q4 to Q1: higher income, older age and indications that the neighbourhoods in Q1 are more walkable characterize their neighbourhoods.

Finally, we find evidence that an individual's sociodemographic characteristics are associated with the likelihood of moving in ways that are consistent with prior research on the correlates of residential location (51-53). At the individual level, older age, non-Hispanic white race/ethnicity, college education, and being married are all associated with staying in lean neighbourhoods or moving to them (not shown).

Discussion

Identifying the role of selection into and out of neighbourhoods is important for increasing our understanding of the association between neighbourhood characteristics and the individual body weight. Many investigations consider this association without attention to the effects patterned selection into neighborhoods. Our analyses suggest that these selection effects are present in both directions (i.e., lean to heavy, heavy to lean neighbourhoods) and that studies that ignore them may be overstating the causal impact of the built environment. Estimating the causal influence of neighbourhood characteristics on BMI is not the focus of this paper; our objective was to determine if systematic sorting into and out of neighborhoods exists, as assessed using BMI.

Our conclusion is that individuals are sorting into neighborhoods that follow BMI patterns where leaner *individuals* are staying in or moving to leaner *neighborhoods*; similar patterns exist for heavier individuals staying in or moving to heavier neighborhoods. We acknowledge that at the individual level, people are likely to make residential choices based on factors that are associated with BMI (as seen in Table 1) rather than BMI *per se*. Our goal, however, was to consider whether the association between neighborhood characteristics and individual-level BMI was due in part to selection of individuals with certain BMI levels into neighborhoods that would induce an association between neighborhoods and individual-level BMI. This selection mechanism is at odds with a strictly causal argument linking features of a neighborhood to individual-level BMI. Our analyses show that non-random sorting exists using BMI as our barometer and that the migration patterns observed are clearly linked to the socioeconomic qualities of neighborhoods. The difference in BMI levels between the lowest and highest quartiles translates into 10 pounds on average, an amount that is related to current and future health risks, especially for young individuals in their twenties.

Although we advocate the use of birth certificate data for the study of neighbourhood and BMI association, these data are not without some limitations. First, and most obvious, the sample is restricted to mothers of reproductive age. We do not have the same depth of information on men or nulliparous/primiparous women. Our requirement that we observe

two births is important to acknowledge. Relative to primiparous women, those bearing a second child tend to be slightly younger at first birth (23.8 vs. 24.7), somewhat more non-Hispanic white (80.5% vs. 77.8%), and more likely to be married (75.1% vs. 68.6%), all of which are statistically significant differences ($p < .05$) for this very large sample. Second, bearing children may create a weight gain profile that may obfuscate the association between neighbourhood characteristics and maternal BMI. Future work on weight gain during pregnancy itself is of interest since there may be patterning in unhealthy weight gain by neighbourhood. Finally, the data on pre-pregnancy weight are based on self-reported height and weight, a potential source of error that should serve to create a conservative bias.

Despite the above limitations, our results suggest that birth certificate data may provide a rich resource for researchers in other locales. Many studies depend upon the Behavioral Risk Factor Surveillance System (BRFSS) or other national surveys (51, 52). Although these surveys are useful, they do not provide extensive sample sizes in any one neighbourhood and across a range of places. We utilize birth certificate databases (using pre-pregnancy weights) and driver licenses because they provide extensive coverage of neighbourhoods (i.e., very large numbers per neighbourhood) and consistently assessed height and weight information. If birth certificate databases prove useful in the present study, as we anticipate given our analyses, this strategy could encourage researchers from other states to consider using similar databases. Some states have used administrative records for population surveillance of BMI (37). Extensive local databases on obesity may prove most relevant to policy makers and other local and state officials who will need to be partners for neighbourhood-based obesity prevention efforts.

Our findings suggest an ambitious research agenda moving forward. First, it will be important to replicate this study using data from women as well as men of various ages and living in various geographic locations to assess the external validity of our findings. Second, additional models can be estimated that distinguish the choice to move from the choice of destinations. Our analyses suggest that over time, if the selection processes persist, we should observe growing neighborhood segregation based on BMI and its associated economic and walkability attributes. If sorting compounds with time across geographic locales, the resulting segregation could lead to obesity “hot spots” where the need for intervention would be the greatest and the ability to change physical activity and/or diet may be the most challenging (53). Unabated concentration of people into such intense BMI locales is not likely so it is important to understand what forces would mitigate such a trend.

We suggest that some of the association between neighbourhoods and BMI are already in place prior to moves that sort individuals into neighbourhoods. These findings suggest that new urbanist communities seeking to create neighbourhoods that promote physical activity may see residents with healthier weights, in part, because they disproportionately attract healthy-weight individuals. This outcome also suggests that some movers to these new developments will be leaving neighbourhoods where the ‘staying’ residents remain exposed to obesogenic forces. The challenge is to understand the migration flows in future housing and transportation policies that address all neighbourhoods without benefitting one sub-population at the expense of others. Future research on neighbourhoods and obesity should

address how residential selection may influence results; our methodology may prove useful for other researchers.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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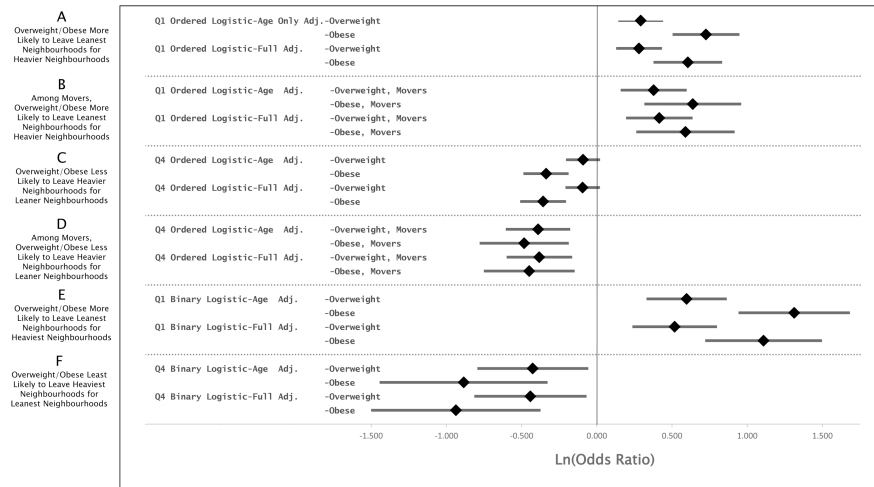


Figure 1. Forest Plot of Log Odds Ratios for the Risk of Moving from the Leanest (Q1) to the Heavier Quartiles Neighbourhoods and from the Heaviest (Q4) to Leaner Quartile Neighbourhoods. Estimates are based on Ordered (Panels A-D) and Binary (Panels E-F) Logistic Regressions. Panel A shows that overweight and obese women are *more* likely to move to increasingly heavier quartiles out of Q1 in relation the healthy weight women. Panel B shows the same pattern as Panel A based only on those who move out of Q1 and into Q2, Q3, or Q4. Panel C shows that overweight and obese women are *less* likely to move to increasingly leaner quartiles out of Q4 in relation to healthy weight women. Panel D shows the same pattern as Panel C based only on those who move out of Q4 and into Q3, Q2, or Q1. Panel E shows that overweight and obese women are *more* likely to move to the heaviest quartile (Q4) out of Q1 in relation the healthy weight women. Panel F shows that overweight and obese women are *less* likely to move to the leanest quartile (Q1) out of Q4 in relation the healthy weight women.

Table 1
Descriptive Statistics for the Full Sample and Stratified by Neighborhood Quartiles At Time of First Birth

Variable	All (N=34,010)			Q1 (N=6,669)			Q2 (N=8,070)			Q3 (N=10,022)			Q4 (N=9,249)		
	Mean or Prop.	Std Dev	Range	Mean or Prop.	Std Dev	Range	Mean or Prop.	Std Dev	Range	Mean or Prop.	Std Dev	Range	Mean or Prop.	Std Dev	Range
BMI First Pregnancy	23.7	4.6	18.0-59.8	22.7	3.8	18.0-49.9	23.4	4.4	18.0-51.7	24.0	4.8	18.0-59.8	24.3	5.0	18.0-54.7
Age First Pregnancy	24.7	4.5	18.0-43.0	26.6	4.8	18.0-43.0	25.2	4.5	18.0-42.0	24.2	4.1	18.0-42.0	23.3	4.1	18.0-42.0
Race															
Non-Hispanic White	0.80	0.40	0 - 1	0.91	0.29	0 - 1	0.86	0.34	0 - 1	0.80	0.40	0 - 1	0.67	0.47	0 - 1
African American	0.01	0.08	0 - 1	0.01	0.07	0 - 1	0.01	0.08	0 - 1	0.00	0.07	0 - 1	0.01	0.09	0 - 1
Hispanic	0.14	0.35	0 - 1	0.05	0.21	0 - 1	0.08	0.28	0 - 1	0.14	0.35	0 - 1	0.25	0.43	0 - 1
American Indian	0.01	0.08	0 - 1	0.00	0.06	0 - 1	0.01	0.07	0 - 1	0.01	0.09	0 - 1	0.01	0.10	0 - 1
Asian-Pacific Islander	0.04	0.19	0 - 1	0.02	0.14	0 - 1	0.02	0.15	0 - 1	0.04	0.19	0 - 1	0.06	0.23	0 - 1
Other	0.01	0.11	0 - 1	0.02	0.13	0 - 1	0.02	0.12	0 - 1	0.01	0.10	0 - 1	0.01	0.10	0 - 1
Education															
Less than High School	0.09	0.28	0 - 1	0.02	0.13	0 - 1	0.05	0.22	0 - 1	0.09	0.28	0 - 1	0.17	0.38	0 - 1
High School	0.30	0.46	0 - 1	0.14	0.34	0 - 1	0.26	0.44	0 - 1	0.34	0.47	0 - 1	0.42	0.49	0 - 1
Some College	0.32	0.46	0 - 1	0.29	0.45	0 - 1	0.34	0.47	0 - 1	0.34	0.48	0 - 1	0.29	0.45	0 - 1
College Graduate	0.30	0.46	0 - 1	0.56	0.50	0 - 1	0.35	0.48	0 - 1	0.23	0.42	0 - 1	0.12	0.33	0 - 1
Marital Status (Married=1)	0.78	0.42	0 - 1	0.90	0.31	0 - 1	0.81	0.39	0 - 1	0.78	0.41	0 - 1	0.66	0.47	0 - 1
Destination Block Group (BG) Demographics															
Median Household Income (\$1000): BG	53.8	16.3	16.5-143.0	61.9	21.6	16.5-143.0	56.6	15.6	16.5-137.5	52.4	13.4	16.5-137.5	47.0	11.4	16.5-136.6
Median Age: BG	28.6	5.0	19.7-61.4	31.6	5.5	19.7-61.4	29.5	5.1	19.7-61.4	27.3	4.5	19.7-61.4	27.1	3.7	19.7-61.4
3Ds Density, Diversity and Design Indicators															
Density: population per square mile, BG	5439	2919	136-22219	5472	3055	136-22219	5285	2514	136-22219	5115	2968	154-22219	5902	3033	154-22219
Diversity: proportion workers walk to work, BG	0.02	0.03	0.00-0.26	0.03	0.05	0.00-0.26	0.02	0.03	0.00-0.26	0.02	0.03	0.00-0.26	0.01	0.02	0.00-0.26
Diversity/Design: housing age (in years), BG	24.1	15.8	0.0-60.0	32.3	17.7	0.0-60.0	23.4	15.6	0.0-60.0	19.4	14.3	0.0-60.0	23.8	13.6	0.0-60.0

Table 2
Number of Movers/Stayers by First and Second Births and By Neighborhood BMI Quartile*

Pre-Pregnancy BMI Quartile Group Before 1st Birth	Pre-Pregnancy BMI Quartile Group before 2nd Birth, Sample Size (N, Row %)					Total
	Q1 (lowest/leanest quartile BMI) BMI<24.8	Q2 24.8<BMI<25.5	Q3 25.5<BMI<26.0	Q4 (highest/heaviest quartile BMI) BMI>26.0		
Q1	4,512(67.7%)	995(14.9%)	714(10.7%)	448(6.7%)	6669 (100%)	
Q2	799(9.9%)	4,886(60.5%)	1,417(17.6%)	968(12.0%)	8070 (100%)	
Q3	441(4.4%)	1,144(11.4%)	6,731(67.2%)	1,706(17.0%)	10,022 (100%)	
Q4	220(2.4%)	634(6.9%)	1,701(18.4%)	6,694(72.4%)	9,249 (100%)	
Total	5,972	7,659	10,563	9,249	34,010	

* Neighborhood (census block group) BMI quartiles are derived from height and weight for all male and female licensed drivers in Salt lake County ages 18-64

Table 3
Block Group Characteristics for Women Moving between the Leanest (Q1) and the Heaviest (Q4) Quartiles at the Time of their First and Second Births

	Neighborhood Characteristics At Time 2					
	For Those Who Stayed Leanest (Q1)→Leanest (Q1)			For Those Who Moved Leanest (Q1)→Heaviest (Q4)		
	Mean	Std Dev	Q4 Measures	Mean	Std Dev	Q4 Measures
Start in Leanest Neighborhood (Q1) at Time 1						
Median Family Income in Thousands (\$) (BG)	66.396	23.143		45.346	9.353	
Median Age (BG)	32.92	5.212		27.061	3.295	
Proportion Workers Walk to Work (BG)	0.032	0.056		0.015	0.024	
Average age of Housing Relative to 1999 (BG)	36.019	17.416		25.964	13.39	
Population density per sq_miles (BG)	5449.789	3221.124		5899.769	2859.451	
	For Those Who Moved Heaviest (Q4)→Leanest (Q1)			For Those Who Stayed Heaviest (Q4)→Heaviest (Q4)		
Start in Heaviest Neighborhood (Q4) at Time 1						
Median Family Income in Thousands (\$) (BG)	59.137	23.177		45.303	9.258	
Median Age (BG)	31.751	5.014		26.937	3.304	
Proportion Workers Walk to Work (BG)	0.045	0.067		0.013	0.019	
Average age of Housing Relative to 1999 (BG)	31.145	17.363		25.591	12.836	
Population density per sq_miles (BG)	6418.785	4159.936		6090.608	2961.705	

BG = US Census Block Group