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Food Availability as a Determinant of Weight Gain Among Renal Transplant Recipients

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Abstract

Excessive weight gain is common after renal transplantation, but it is unknown whether environmental factors, such as food availability, contribute to this important clinical problem. We evaluated the effects of food availability (fast food restaurants, convenience stores, and grocery stores within 1, 2, and 3 mile buffers of transplant recipients′ residences) on body mass index (BMI) change during the first year post-transplant. Participants (*n = 299*) resided in Memphis, Tennessee. BMI increased by 1.42 units ($p<.001$) corresponding to an average weight gain of 9.25 lbs (5.43%) during the first year post-transplant. The number of grocery stores within 1 mile of recipient's residence was associated with an increase in BMI ($p<.05$), but fast food restaurants and convenience stores were not significantly associated with BMI change.

Keywords

food availability; obesity; BMI; renal transplant; post-transplant weight gain

Excessive weight gain is common among renal transplant recipients (Cashion et al., 2007; Jezior et al., 2007). Most weight gain occurs during the first 12 months post-transplant (Clunk, Lin, & Curtis, 2001; Thoma, Grover, & Shoker, 2006) and averages between 5 and 10kg (Clunk et al., 2001; Elster et al., 2008), with 30–57% of recipients gaining more than 10% of pre-transplant body weight (Johnson et al., 1993). Weight gain in renal transplant

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recipients has effects on morbidity and mortality similar to the general population (e.g., el-Agroudy, Wafa, Gheith, Shehab el-Dein, & Ghoneim, 2004; Johnson et al., 1993) and is also associated with graft loss and mortality (el-Agroudy et al., 2004).

Several sociodemographic, clinical, and behavioral risk factors for excessive weight gain and obesity after renal transplantation have been identified. Sociodemographic predictors include being African American (Baum et al., 2002; Cashion et al., 2007), female (Cashion et al., 2007; Jezior et al., 2007), younger (Clunk et al., 2001; Johnson et al., 1993), and of lower socioeconomic status (Clunk et al., 2001).

In terms of clinical risk factors, the hyperphagic effects of immunosuppressant therapies were previously thought to be a major contributor to excessive weight gain in this population, but accumulating evidence suggests that this may not be the case, as steroid-free protocols alone do not reduce the risk of obesity (Elster et al., 2008; van den Ham, Kooman, Christiaans, Nieman, & van Hooff, 2003). For recipients on corticosteroids, weight gain may be reduced by early withdrawal of treatment when compared to chronic use, and this effect is greatest in certain patient sub-groups, including women, whites, and those with high pre-transplant BMI (Rogers et al., 2005). Among non-corti-costeroid immunosuppressant therapies, mammalian target of rapamycin is associated with less post-transplant weight gain than calcineurin inhibitors (Diekmann et al., 2013). Better renal transplant function, in terms of glomerular filtration rate (Thoma et al., 2006) and absence of rejection episodes (Clunk et al., 2001), is associated with greater weight gain 1 year post-transplant, suggesting that improved appetite after transplantation contributes to excessive weight gain (Thoma et al., 2006). Overall, these findings indicate substantial heterogeneity in clinical risk factors for post-transplant weight gain.

Among behavioral risk factors, physical inactivity and excessive energy intake are strongly associated with weight gain in the renal transplant population (Macdonald, Kirkman, & Jibani, 2009). Fear of injuring the new organ and health problems both related and unrelated to the transplant have been reported as barriers to physical activity, while medication issues and removal of dietary restrictions are barriers to healthy eating (Stanfill, Bloodworth, & Cashion, 2012). Although shedding light on the possible causes of weight gain post-transplant, these individual-level factors are not adequate to fully explain post-transplant weight gain.

Consistent with the socio-ecological model, in which there is a complex interplay between individual, relationship, community, and societal determinants of health, there is growing evidence that environmental factors, including food access, contribute to obesity in the general US population (Giskes, van Lenthe, Avendano-Pabon, & Brug, 2011; Rahman, Cushing, & Jackson, 2011). Easier access to unhealthy food outlets, such as convenience stores and fast food restaurants, is associated with increased obesity risk in the general population (Giskes et al., 2011; Rahman et al., 2011). In contrast, access to grocery stores, which generally provide healthier foods than other food outlets, has been shown to be negatively associated with obesity in some studies (Giskes et al., 2011; Rahman et al., 2011) but positively correlated in another (Wang, Kim, Gonzalez, MacLeod, & Winkleby, 2007). Thus, neighborhood food availability appears to influence body weight, but there is conflicting evidence regarding the influence on weight of specific food outlet types, such as convenience stores, fast food restaurants, and grocery stores. Renal transplant recipients typically experience more weight gain than in the general population (Cashion et al., 2007; Jezior et al., 2007), and the role of food availability in weight gain in this clinical population has not been explored.

In the current study, we explored how food availability affected BMI change during the first year after renal transplant, in a largely low-income cohort at a Memphis, TN transplant center. We hypothesized that greater availability of fast food restaurants and convenience stores and larger ratios of fast food restaurants and convenience stores to total food sources would be associated with BMI increase. Further, we hypothesized that lower availability of grocery stores and a lower ratio of grocery stores to total food sources would be associated with BMI increase.

Methods

Design

This was an exploratory study of the association of neighborhood food access to post-transplant weight gain. A retrospective cohort design was used, utilizing data from renal transplant recipients at Methodist University Transplant Institute (MUTI) in Memphis, TN. Clinical data from the recipients' medical records and publicly available environmental data referenced to the recipients' residential addresses were used.

Because this study did not involve recipient contact or exposure to substantial risk, it was granted exempt status by the Institutional Review Boards (IRB) at The University of Tennessee Health Science Center, which operates a combined IRB with MUTI, and The University of Memphis.

Subjects

Subjects were MUTI renal transplant recipients who received renal grafts between January 1, 2004 and July 31, 2010, resided in the county where MUTI is located (Shelby County, TN), and did not die or lose their grafts during the first year after transplant. While data on immunosuppressant therapy for individuals in the sample were not obtained, the majority of renal transplant recipients at MUTI were given 20mg of prednisone at the time of transplant, which was tapered to 5mg by 12 months. MUTI immunosuppressant protocol also included mycophenolate mofetil and tacrolimus.

January 1, 2004 was selected as the beginning of the transplant date range, because that is when clinical measures began to be recorded electronically at MUTI, which allowed for verification of outliers and retrieval of missing data. The end date for accrual of July 31, 2010 enabled follow-up of all in the sample to the 1-year post-transplant endpoint.

The original target group included 484 individuals who met the study criteria. In the analytic process, we eliminated 172 patients who resided outside of Shelby County, which included many outlying rural areas, because the extreme distances to food sources in these areas produced non-tenable solutions to the mixed models. Due to small sample sizes, recipients who self-reported being Hispanic (*n*=5), Asian (*n*=7), or Native Hawaiian/Pacific Islander (*n*=1) were excluded from analyses, leaving a sample of 299 recipients.

The sample size (*n*=299) is relatively small compared to previous studies of food access and weight in the general population (Bodor, Rice, Farley, Swalm, & Rose, 2010; Inagami, Cohen, Brown, & Asch, 2009). Despite likely limitations in statistical power, the analysis was deemed worthwhile because, as the first exploration of the association of food access with weight gain in this clinical population, the results could guide larger studies. Furthermore, because weight gain in transplant recipients is generally higher than in the general population, we believed that effects in our sample would be larger and more detectable.

Measures

Clinical and sociodemographic data—Race, gender, date of transplant, age at time of transplant, diabetes status at time of transplant, residential address (house number, street, city, state, and zip code), height, weight at time of transplant, and weight 12 months after transplant were obtained from a data specialist at MUTI, using the Organ Procurement and Transplantation Network Database. As a proxy for household income level, we used zip-code-level median household income data from the 2010 United States Census (US Census Bureau, 2011).

Outcome variable—The primary outcome variable was change in body mass index (BMI; weight in kg divided by height in m^2) from baseline (time of transplant) to 1 year after transplant, also obtained from the Organ Procurement and Transplantation Network Database. Weight and height were routinely documented at all MUTI visits, including at admission for the transplant procedure, and at a 1-year post-transplant follow-up visit.

Exposure variables—Exposure variables included the number of fast food restaurants, convenience stores, and grocery stores within 1-, 2-, and 3-mile buffers of recipient households and the ratio of each food source (fast food restaurants, convenience stories, or grocery stores) to total food sources (sum of the three sources) within each buffer zone.

Names and addresses of food sources for the year 2007, the mid-point of the 2004–2010 data collection time interval, were obtained from InfoGroup, Inc. (Infogroup, 2012) for the zip codes in which recipients resided when recipients received their transplants. Residential addresses were geocoded and spatially mapped on a coordinate plane using geographic information system (GIS) technology, ArcMap, version 10 (ESRI, 2010). Each food source was then geocoded and added to the map of residential addresses, using the same coordinate plane. This resulted in a map of all residential addresses and food sources in relation to each other.

ArcMap was used to calculate the numbers and types of food sources (fast food restaurants, convenience stores, and grocery stores) in 1-, 2-, and 3-mile buffers of each recipient's residential address. A ratio of each food source type to total food sources then was calculated. For example, if 12 of the 28 total food sources in a 1-mile radius of a recipient's residence were fast food restaurants, then the total for fast food in this buffer zone was 12, and the fast food ratio in this buffer zone would be 12/28 or 43%.

Data Analysis

Ordinary least squares regression analyses were used to assess quantity and ratio of food sources within 1-, 2-, and 3-mile buffers of recipient residential addresses as predictors of post-transplant BMI change. Because failing to account for clustering of BMI within buffer zones could yield overly optimistic significance of predictors, we first investigated the possibility of clusters of post-transplant BMI in small areas within Shelby County, Tennessee. Regression models accounting for BMI within buffer zones had no better fit than a regression model with no clustering of BMI (p=.99), so smaller BMI clusters within zones were not included in the analysis. Age, gender, race, and pre-transplant diabetes status were included as covariates in each regression model. Examination of variance inflation factors showed that multicollinearity was not an issue in any of the models. All analyses were performed using SAS/STAT, version 9.1 (SAS Institute, 2004).

Results

Sample Characteristics

As shown in Table 1, about one-third of the 299 transplant recipients were women, and about two-thirds were African American. Mean age at time of transplant was 49. BMI averaged 28 before transplant and 30 at 12 months after transplant. The average increase in BMI from pre- to post- transplant was 1.42, and average weight gain was 9.25 lbs, both of which were statistically significant increases (p<.001).

Food Sources

The average number of food sources (fast food restaurants, convenience stores, grocery stores) within 1-, 2-, and 3-mile buffer zones around transplant recipients' residences is shown in Table 2. As expected, the number of food sources increased as the buffer zone size increased. Standard deviations and ranges generally were large relative to the means, indicating considerable variability in availability of food sources.

Association of Food Availability With BMI Change

The availability of fast food restaurants, defined as the number of establishments located within 1-, 2-, and 3-mile buffer zones around the recipients' residences, was not significantly related to BMI change from before to after renal transplant (Table 3). Likewise, the availability of convenience stores was not significantly related to BMI change (Table 4). Contrary to our hypothesis, a larger number of grocery stores within a 1-mile buffer (but not within a 2- or 3-mile buffer) was associated with an increase in BMI (Table 5).

Ratios of each food source type (fast food restaurants, convenience stores, grocery stores) to the total number of food sources in 1-, 2-, or 3-mile buffer zones were not significantly associated with BMI change in any models (data not shown). We also assessed whether age, race, and gender moderated the effects of food availability on BMI change by including interaction terms of these demographic characteristics with the food source variable in regression models. No significant interactions were observed.

Discussion

To our knowledge, this is the first study to evaluate potential environmental determinants of post-renal transplant weight gain. Based on previous studies in the general population, we hypothesized that larger BMI change would be associated with a larger number of fast food restaurants and convenience stores and a lower number of grocery stores near the transplant recipient's home. We detected only one food environment relationship with weight gain, and this was in the opposite direction of what we hypothesized. The number of grocery stores located within 1 mile of the recipient's residence was associated with an increase in BMI, adjusted for age, gender, race, and pre-transplant diabetes status.

This finding contrasts with that of several studies conducted in the general population of US adults (Giskes et al., 2011; Rahman et al., 2011) but is consistent with findings from the Stanford Heart Disease Prevention Program, in which proximity to both small grocery stores and chain grocery stores was associated with higher BMI among more than 7,500 women in agricultural neighborhoods in California (Wang et al., 2007). Our findings, derived from a large urban environment in the mid-South, are consistent with these findings from rural California. Our results may reflect that having easier access to grocery stores in the immediate vicinity of one's home, in conjunction with the usual improvements in appetite and physical functioning that occur after renal transplantation (Landreneau, Lee, & Landreneau, 2010; Thoma et al., 2006), promote weight gain.

We anticipated more consistent results for the three food source types, based on results in the general population (Giskes et al., 2011; Rahman et al., 2011). However, our sample size (n = 299) was much smaller than those in previous studies (Bodor et al., 2010; Inagami et al., 2009). For the eight non-significant associations we assessed, power to detect an effect ranged from only 5% to 29%, and thus we would have required a much larger sample size to detect statistically significant effects, even given the greater magnitude and reduced variability of weight gain among renal transplant recipients than in the general population (Kuczmarski, 1992).

Other limitations also should be noted. Recipients were drawn from a single transplant center, and all resided in the same county, thus reducing sample variability. Also, due to limited funding, we obtained food source data for only one year, corresponding to the mid-point (2007) of the date range in which recipients received their transplants (2004-2010), which likely added error to the analyses. Selection bias also may have occurred, in that transplant recipients who were excluded from the analyses due to graft failure and/or death may have experienced greater weight gain or have been disproportionately likely to live in "food-poor" environments, which could bias effects towards the null. Last, it should be noted that weight gain in these renal transplant recipients averaged 9.25 pounds, which is lower than the average weight gains of 5-10 kg (11-22 pounds) in previous samples (Clunk et al., 2001; Elster et al., 2008), suggesting that mechanisms of weight gain may have differed in our sample than in other renal transplant patients.

Despite these limitations, this study has several strengths, including use of a retrospective cohort design, a sample of predominantly low-SES transplant recipients who were at risk of both excessive weight gain and living in food-deprived environments, and availability of complete clinical and corresponding food source availability data. The results suggest that environmental factors such as food availability might be less salient predictors of post-renal transplant weight gain than other behavioral, clinical, and genetic risk factors. Further study is needed with larger, more geographically diverse samples to more thoroughly explore potential determinants of this important clinical issue.

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Table 1

Characteristics and BMI and Weight Change of Renal Transplant Recipients Before and After Transplant (*N*=299)

	n	%
Female	114	38
Black	223	75
Pre-transplant diabetes[a]	85	29
	M	*SD*
Age at time of transplant	48.77	12.09
Median household income ($)	41,040.00	17,226.00
BMI		
Baseline	28.33	5.13
1 year	29.75	5.74
Change	1.42	3.23
Weight (lbs)		
Baseline	186.53	38.02
1 year	195.71	41.06
Change	9.25	20.93

Note. SD =standard deviation.

[a] *n*=297.

Table 2

Number and Type of Food Sources Within Buffer Zones Around Renal Transplant Recipients' Residential Addresses (*N*=299)

	Fast Food Restaurants		Convenience Stores		Grocery Stores	
	M	***SD***	***M***	***SD***	***M***	***SD***
1-Mile buffer	4.16	5.15	5.90	5.26	1.88	2.68
2-Mile buffer	15.62	11.24	22.20	15.11	7.86	8.03
3-Mile buffer	30.52	18.38	45.87	28.98	15.72	14.51

Note. SD =standard deviation.

Table 3

Multiple Linear Regression Analysis of Fast Food Restaurant Availability within 1, 2, and 3 Miles of Residential Addresses as a Predictor of Change in BMI During the First Year After Renal Transplant (*N*=297)

	1-Mile Buffer		2-Mile Buffer		3-Mile Buffer	
	β	*SE*	β	*SE*	β	*SE*
Fast food restaurants	.05	.04	.03	.02	−.05	.01
Age	−.07	.02	−.07	.02	−.08	.02
Race[a]	−.12*	.43	−.12*	.44	−.14*	.44
Gender[b]	−.10	.39	−.10	.39	−.10	.39
Pre-transplant diabetes[c]	−.01	.44	−.01	.44	.00	.44
Intercept	.05**	.38	.03**	.44	−.05**	.47
R^2	.04		.03		.04	

Notes. SE, Standard error. Age is age at time of transplant.

[a] 0 = white and 1 = Black.

[b] 0 = male and 1 = female.

[c] 0 = no and 1 = yes.

* $p<.05$.

** $p<.001$.

Table 4

Multiple Linear Regression Analysis of Convenience Store Availability within 1, 2, and 3 Miles of Residential Addresses as a Predictor of Change in BMI During the First Year After Renal Transplant (*N* =297)

	1-Mile Buffer		2-Mile Buffer		3-Mile Buffer	
	β	*SE*	β	*SE*	β	*SE*
Convenience stores	.02	.04	.09	.01	.05	.01
Age	−.07	.02	−.07	.02	−.07	.02
Race[a]	−.12	.46	−.10	.45	−.11	.45
Gender[b]	−.10	.39	−.10	.38	−.10	.39
Pre-transplant diabetes[c]	−.01	.44	−.01	.44	−.01	.44
Intercept	.02***	.44	.09**	.47	.05***	.48
R^2	.03		.04*		.04	

Notes. SE, Standard error. Age is age at time of transplant.

[a] 0 = white and 1 = Black.

[b] 0 = male and 1 = female.

[c] 0 = no and 1 = yes.

* $p< .05$.

** $p< .01$.

*** $p< .001$.

Table 5

Multiple Linear Regression Analysis of Grocery Store Availability within 1, 2, and 3 Miles of Residential Addresses as a Predictor of Change in BMI During the First Year After Renal Transplant (*N*=297)

	1-Mile Buffer		2-Mile Buffer		3-Mile Buffer	
	β	*SE*	β	*SE*	β	*SE*
Grocery stores	.13*	.07	.10	.02	.08	.01
Age	−.08	.02	−.08	.02	−.08	.02
Race[a]	−.09	.44	−.10	.44	−.11	.44
Gender[b]	−.09	.38	−.10	.38	−.10	.38
Pre-transplant diabetes[c]	−.01	.43	−.01	.43	−.01	.44
Intercept	.13***	.38	.10***	.40	.08***	.41
R^2	.05*		.04*		.04*	

Notes. SE, Standard error. Age is age at time of transplant.

[a] 0 = white 1 = Black.

[b] 0 = male and 1 = female.

[c] 0 = no and 1 = yes.

* $p<.05$.

** $p<.001$.