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Estimating the Effect of Mobility and Food Choice on Obesity

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ii. Disclaimer

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the UVM Transportation Research Center. This report does not constitute a standard, specification, or regulation.

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1. Introduction

Ogden et al. (2014) report that more than two-thirds of the US adult population is overweight and one-third are obese. Obesity has emerged as one of the most pressing public health issues in the United States. The trend toward weight gain carries long-term ramifications for the nation's physical and economic health *(1)*. Perhaps more importantly, the chronic conditions associated with obesity stand to impact the quality of life of a large proportion of the population, including certain socioeconomic groups and geographic regions.

Vermont presents a unique case in the national dialogue on rural obesity. On the one hand, it is one of the most rural areas in the nation by population, with diffuse land use patterns that leave large swaths of the state without comprehensive grocery stores and viable opportunities for active transportation, placing individuals at risk for obesity *(2–5)*. On the other hand, it is one of the healthiest states with an estimated 23.7% obese and 60.3% overweight and obese in 2012 *(6)*. This is despite higher levels of automobile use and lower levels of devoted physical activity relative to other states *(6, 7)*.

1.1. The Sources of Energy Imbalance

Obesity is a caloric energy imbalance; either too much energy intake, not enough energy expenditure, or both *(8)*. Environmental and socio-economic factors contribute to both higher caloric intake and a sedentary lifestyle. However, individual perceptions of the same environment may vary greatly. The following tables explore the literature. Table 1-1 explores the correlates guiding caloric intake.

Table 1-1. Review of Food Choice Correlates

	Review
Effects of demographics on food choice	Socioeconomic characteristics impact food choice. Poorer, less-educated individuals are more likely to consume low cost foods that are calorically dense *(9, 10)*. Woman are more likely to consume fruits and vegetables and less likely to consume fast food than men, controlling for other factors *(10–12)*. Seniors and women are more likely to eat according to health concerns *(13)*. Ethnicity impacts food choice, due in part to cultural norms *(14, 15)*. Mothers have a higher caloric intake than women without children *(16)*.
Effects of built environment on food choice	The variety of foods available at rural food markets is less than urban areas, particularly fresh fruits and vegetables *(17, 18)*. Low-income neighborhoods have worse access to supermarkets, but higher access to fast food restaurants than the general population *(19, 20)*.
Effects of personal preference on food choice	Personal diet preferences significantly impact both food choice and obesity *(21, 22)*. The health concerns of mothers prompts them to purchase healthy food for their families *(23, 24)*.

Physical activity facilitates individual energy balance. Table 1-2 explores the correlates guiding caloric expenditure, including the trade-off between active and motorized mobility.

Table 1-2. Review of Active and Motorized Mobility Correlates

Correlate	Active Mobility
Effects of demographics on mobility	Higher-income, more educated, younger, white men engage in more physical activity than the general population *(25–29)*. Lee and Moudon *(30)* note that age and gender significantly impact the frequency of walking trips to utilitarian amenities. Residents of lower-income neighborhoods engage in less physical activity than the general population, even after controlling for demographic and health characteristics *(31)*. Owning an automobile positively impacts vehicle mobility *(32)*. The 2009 National Household Travel Survey indicates that employed individuals spend more time travelling by car than non-working individuals.
Effects of built environment on mobility	The presence of sidewalks increases walkability and active mobility behavior *(33–35)*. Scenic natural surroundings encourage active mobility *(30)*. Poor weather negatively impacts the frequency of vigorous physical activity *(28)*. Mixed-use zoning increases active mobility *(36, 37)*. Motorized transportation is not as necessary to reach utilitarian amenities *(25)*, and individuals can more easily access recreational amenities, further augmenting the opportunity to exercise *(35)*. Lee and Moudon *(30)* suggest proximity to utilitarian amenities has a stronger effect on walking than proximity to recreational amenities. Rural regions have less robust, resilient transportation systems. Cars are often required because of sparsely-distributed residential and commercial amenities *(38–40)*. Inclement weather may reduce the functionality of the motorized mobility network as well as opportunities for active mobility *(41, 42)*.
Effects of social networks on mobility	Social connectedness and personal motivation positively impact active mobility *(29)*. Having a physically-active social network encourages physical activity *(28)*. Mothers and fathers engage in lower level of physical activity than adults without children *(16)*. Knowing someone who regularly provided transportation increases carless individual's frequency of trips in rural areas *(32)*.

1.2. Measuring Obesity

Obesity in the United States is a complex, multi-dimensional problem that requires a variety of possible solutions ranging from changes in individual behaviors related to food and physical activity, changes in the food and built environment, and changes in public policy *(43)*. The literature reveals a wide variety of studies ranging from the fields of medicine and nutrition to economics and public policy. Methods vary across studies, as do measurements of relevant variables.

However, the literature lacks models where food choice, mobility, and obesity are simultaneously incorporated in the context of a rural environment. We contribute to the literature by employing a social-ecological model *(44, 45)* to estimate obesity on a regional scale. The model simultaneously assesses individual relationships with food choice, active mobility, and motorized mobility amid the characteristics of their built environment.

2. Research Methodology

2.1. Acquiring Behavioral and Demographic Data

The panel survey data presented here were collected during the winter phase of a four-season panel survey, which focused on the effects of seasonality on mobility and QOL. The "winter" survey included an additional data module with focused questions on eating behaviors. The survey instrument was informed by the findings from focus groups conducted in the Fall of 2008 and guided by the Transportation Research Center and Center for Rural Studies at the University of Vermont. Respondents were required to be over the age of eighteen years and willing to participate in all four phases of the survey. This study was approved by the University of Vermont's Institutional Review Board (IRB).

Survey data were collected using computer-aided telephone interviewing (CATI) and an online data collection tool. Letters were mailed out in late January 2010 to potential respondents. These letters contained a short description of the survey, and alerted potential respondents to the availability and web address of the online survey *(46)*. Multiple collection techniques were used to capture a broader segment of the population. All computer-aided telephone interviews and online surveys for the winter data were conducted between Monday, February 1, 2010 and Friday, April 2, 2010, between the hours of 4:00 p.m. and 9:00 p.m. No difference in BMI was detected between the two survey methodologies ($p>0.10$).

As shown in Table 2-1, 81.1% lived in a rural area, 39.0% of respondents were male, 69.1% had at least a bachelor's degree, the median age was 51-years-old–greater than the Vermont average but expected given the exclusion of minors from the survey–and 66.4% of households had a gross income of over $50,000.

Table 2-1. Sample Demographics Compared to Vermont's Population

	TIYL	ACS
Median Age (years) [1]	51.0	41.5
Mean household size	2.57	2.48
% Male Respondents	39.0	49.1
% Sample Income >$50,000	66.4	52.3
% Sample with at least a bachelor's degree	69.1	33.8
% Sample rural residency [2]	81.1	61.1
% Sample with driver's license	98.3	NA
% Sample with 1 or more vehicles	97.2	NA
n=356		

[1] The ACS median age includes over 20% of the population under 18 years of age. From American Community Survey SO201 and DP03, 2008.

[2] TIYL rural residency is self-assessed and may differ from U.S. Census definition.

2.2. Acquiring Geospatial Data

The geospatial characteristics of the food choice and mobility environments were constructed using 2010 Nielsen Claritas Business Data and the Vermont Center for Geographic Information (VCGI). Business addresses were geocoded in ArcGIS 10 and clipped within 10 miles of the state borders. The study area was confined to one state–Vermont–after encountering inconsistent geospatial data for active mobility amenities, i.e., hiking trails, among the region's GIS data clearinghouses. Survey participants' home addresses were also geocoded into the built environment with a 100% match rate (n=356).

Network analysis was employed to determine the food choice and mobility environment of each survey participant. A network dataset with distance in miles as the travel cost was created from the North American Streets dataset (ESRI). ArcGIS Network Analyst was then used to create a 5-mile service area polygon for each participant's address. The frequency of food choice and mobility amenities within each polygon was attached to the participant's panel data under the variables names in Table 2-2.

Table 2-2. Sources of Geospatial Variables

Variable	Definition	Source	Classification
CONV5	Freq. of convenience stores within 5 miles of home	Nielsen	"NAI_LAB" = 'Convenience Stores' OR "SIC_LAB" = 'Service Stations-gasoline & oil' OR "SIC_LAB" = 'Truck stops & plazas' AND Duplicate locations removed
FFOOD5	Freq. of fast food restaurants within 5 miles of home	Nielsen	"NAI_LAB" = 'Full-service restaurants' AND "CO_NAME" = 'Kfc', 'Mc Donald's', 'Quiznos', 'Subway', 'Taco Bell', 'Wendy's', 'Burger King', 'Blimpie Subs & Salads', 'Arby's', 'Dunkin' Donuts'
SKI5	Freq. of downhill ski resorts within 5 miles of home	Nielsen	"SIC_LAB" = 'Skiing Centers & Resorts'
HIKING5	Freq. of hiking trails within 5 miles of home	VCGI	"Tourism Trails_TRAILS" data set

2.3. SEM Analysis

Due to the complex nature of modeling food choice, mobility, and their influencing variables, a structural equation modeling (SEM) approach was used *(47)*. A series of three models were estimated; Figure 1 outlines the hypothesized directions of effects of relevant variables. tested. SEM allows both measured and estimated factors to be included in the model and the identification of direct and indirect effects of factors. SEM was selected because it allows the dependent variable of one model to become the independent variable in the next model.

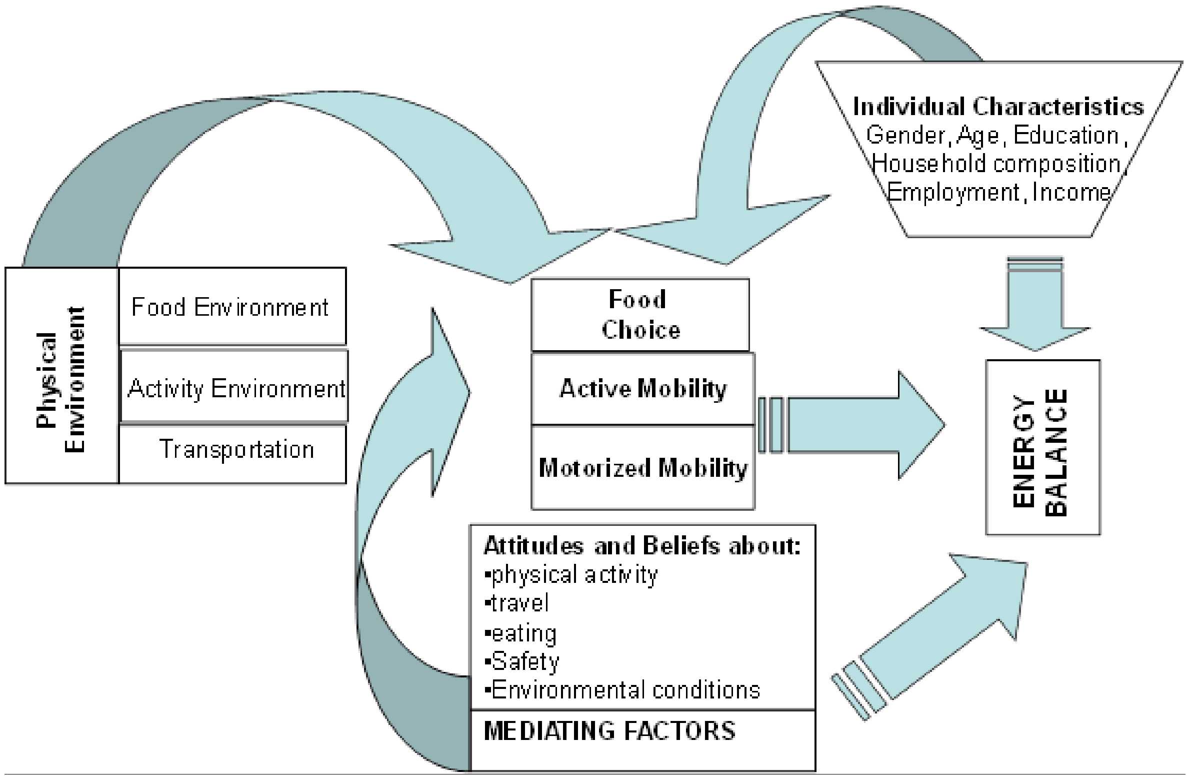

Figure 1. Thematic guide to the structural equation model

SEM 1 used a series of tobit equations with the proportion of meals eaten away from home, minutes of exercise yesterday, and total travel time yesterday as dependent variables. This model was estimated to predict food choice, active mobility, and motorized mobility behaviors. Independent variables in the model included proximity to food choice and active mobility amenities, attitudinal statements regarding travel, a measure of the weather, and demographic characteristics. The general model is written *(48)*:

$$\ln(\pi i1 - \pi i) = \eta i = X'i\beta$$

SEM 2 used a regression model with the food choice, active mobility, and motorized mobility estimates as dependent variables. This model evaluated the correlates of each dependent variable subject to the simultaneous results of the other dependent variables. Independent variables for each equation therefore include the dependent variables of the other two equations as well as socioeconomic variables and instrumental variables relevant to the respective dependent variable. The truncated regression model is written:

$\text{Prob}(y^* > 0) = \Phi(\gamma' z)$,
$\text{Prob}(y^* \leq 0) = 1 - \Phi(\gamma' z)$,
if $y^* > 0$, a truncated regression in $\beta' x$ applies *(48)*

The equations were bootstrapped to improve estimates of standard errors, and the simultaneous estimates were saved and used in the structural equation to estimate overweight and obesity

SEM 3 used linear OLS regression techniques with being overweight or obese (BMI > 25) and being obese (BMI > 30) as the binary dependent variables. Included in this regression were the demographic variables of previous equations. Consciously choosing a healthy diet, working out to lose weight, and the desire to walk or bike more were instrumental variables in the final equations. All analyses were conducted with the Statistical Program for Social Sciences (SPSS), version 21.0 and NLOGIT Econometrics Software, version 5.0. The descriptive statistics of all variables in the final equation are shown in Table 2-3.

Table 2-3. Descriptive Statistics of Model Variables (SEM 3)

	Description	Mean	SD	Min	Max
CONV_5	Freq. convenience stores (5 mi)	5.820	6.793	0	45
FFOOD_5	Freq. fast food restaurants (5 mi)	2.400	3.911	0	25
HIKING_5	Freq. hiking locations (5 mi)	2.160	2.055	0	14
SKI_5	Freq. downhill ski resorts (5 mi)	0.150	0.410	0	4
NUM_VEH	Number of vehicles in household	2.230	1.200	0	11
NUM_BIK	Number of bikes in household	2.160	1.970	0	10
SAFE	Do you feel safe walking at night? (yes, 1)	0.910	0.287	0	1
T_ENJ	Enjoy your daily travel? (yes, 1)	0.680	0.468	0	1
ONDIET	On a diet to lose weight? (yes, 1)	0.470	0.500	0	1
PHYS_ENJ	Enjoy physical activity? (yes, 1)	0.770	0.423	0	1
WTHR	Weather worse than usual yesterday? (yes, 1)	0.140	0.349	0	1
INCOME	Household income less than $35,000 (yes, 1)	0.170	0.377	0	1
AGE	Age	52.54	14.429	19	95
RURAL	Rural household (yes, 1)	0.810	0.392	0	1
OCCUP	Employed (yes, 1)	0.630	0.484	0	1
GENDER	Male? (yes, 1)	0.390	0.489	0	1
CHILDREN	Number of children	0.580	0.997	0	5
PTUSE	Did you use public transport yesterday? (yes, 1)	0.050	0.217	0	1
PHYSTHIN	Are you exercising to lose weight? (yes, 1)	0.430	0.495	0	1
WBM [1]	Do you think you should walk or bike more?	3.860	0.909	1	5
HDIET	Do you consciously choose a healthy diet? (yes, 1)	0.950	0.214	0	1
PMOH [2]	Proportion of meals eaten away from home	0.197	0.199	0	1

[1] Likert Scale, with 5 = strongly agree
[2] Derived from meals at home, full-service restaurants, fast food restaurants, and takeout.

3. Results

The intermediate equations (SEM 2) indicate the overarching themes behind energy balance – food choice, active mobility, and motorized mobility – interact with one another within a larger system. The themes were quantified using estimates derived from SEM 1 as FC, AM and MM, respectively (results not shown).

The built environment and personal characteristics impact food choice. Proximity to convenience stores increases eating meals away from home while proximity to fast food, lower income, and number of children in household decrease eating meals away from home.

Active mobility and motorized mobility complement one another. Travel time, number of bikes in household, and age increase physical activity while being employed decreases physical activity. Minutes of exercise and being employed increase travel time while enjoying daily travel and age decrease travel time. The motorized mobility results coincide with the demands of commuting on younger, employed individuals.

The final equations (SEM 3) indicate differing influences on being overweight than being obese (Table 3-1).

Table 3-1. Correlates of Energy Balance (SEM 3 Results)

	BMI>25 (overweight)				BMI> 30 (obese)			
	Coeff.	SE	P-val	Sig.	Coeff.	SE	P-val	Sig.
CONSTANT	-1.100	3.557	0.757		1.552	2.902	0.593	
FC	-0.001	0.004	0.772		.0467	0.013	0.000	***
AM	-0.030	0.011	0.006	***	0.005	0.003	0.178	
MM	-0.011	0.022	0.602		-.0933	0.021	0.000	***
HDIET	0.270	0.646	0.676		0.361	0.864	0.676	
PHYSTHIN	0.590	0.288	0.042	**	-0.655	0.609	0.282	
WBM	0.653	0.338	0.053	*	0.606	0.523	0.247	
RURAL	0.408	0.452	0.367		-1.126	0.474	0.018	**
AGE	0.075	0.117	0.522		0.115	0.108	0.289	
AGESQ	-0.001	0.001	0.608		-0.002	0.001	0.102	
INCOME	-1.529	0.404	0.000	***	1.725	0.455	0.000	***
GENDER	-0.292	0.276	0.290		0.441	0.505	0.382	
CHILDREN	-0.291	0.183	0.112		-1.537	0.340	0.000	***
OCCUP	0.016	0.485	0.973		-0.181	0.608	0.766	

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Active mobility and low household income decrease being overweight. Overweight individuals are more likely to report exercising to lose weight and to believe they should engage in more physical activity.

Higher percentage of meals prepared away from home and low income are associated with being obese. More time spent in motorized mobility, rural residency, and having children in the household are associated with a decreased likelihood of being obese.

4. Conclusions

Energy balance is wrapped in a web of personal and environmental circumstances. However, the correlates of energy balance differ based on the severity of the imbalance. Increased active mobility is associated with a decreased likelihood of being overweight, while increases in the percentage of food purchased and/or eaten away from home and increases in time spent in motorized mobility are associated with increased probabilities of being classified as obese. The association of low income on overweight versus being obese suggests opposing food choice and mobility behaviors among individuals faced with resource constraints, e.g. buying calorically-dense low-cost foods or eating out more often when working long hours.

The interconnectedness among the correlates of obesity adds additional insight to measuring energy balance. Active and motorized mobility complement one another, suggesting that driving is necessary to reach locations for physical activity in a rural winter environment. Food choice does not appear to be related to active nor motorized mobility, but proximity to food choice amenities significantly impacts the choice of where to eat (at home versus away from home).

The next step toward unravelling the energy balance equation is the impact of seasonality. The Transportation in Your Life Survey includes longitudinal panel data across four seasons, and this model may be expanded to incorporate multiple seasons of data and their impact on food choice, active mobility, and motorized mobility in a rural, northern climate.

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