A STRUCTURAL EQUATION MODELLING APPROACH TO MEASURE THE EFFECT OF MOBILITY ON QUALITY OF LIFE IN A NORTHERN RURAL CLIMATE

Corresponding author:
Jane M. Kolodinsky
University of Vermont
Dept. of Community Development and Applied Economics
146 University Place
202 Morrill Hall
Burlington, VT 05405 USA
802-656-4616
802-656-1423 (fax)
Jane.kolodinsky@uvm.edu

David Propen
University of Vermont
Dept. of Community Development and Applied Economics
146 University Place
Morrill Hall
Burlington, VT 05405
802-656-2001
dpropen@uvm.edu

Erin Roche
University of Vermont
Center for Rural Studies
146 University Place
206 Morrill Hall
Burlington, VT 05405
802-656-3021
eroche1@uvm.edu

Thomas Patrick DeSisto
University of Vermont
Center for Rural Studies
146 University Place
206 Morrill Hall
Burlington, VT 05405
802-656-3021
Thomas.DeSisto@uvm.edu

William R. Sawyer
University of Vermont
Center for Rural Studies
146 University Place
Burlington, VT 05405
802-656-3021

Matthew E. Putnam
University of Vermont

Dept. Community Development and Applied Economics
146 University Place
Burlington, VT 05405 U.S.A.
802-656-2001
Matthew.Putnam@uvm.edu

5083 words
2 figures
4 tables

ABSTRACT

Northern rural communities are particularly challenging environments in which to provide year-round transportation options and ensure that people can meet their travel (mobility) wants and needs. Climate, lack of amenities, small population sizes and low population densities, as well as vulnerable populations, all present challenges to developing rural transportation systems that will result in more livable communities. Using a 2009 database of residents of Vermont, Maine, and New Hampshire, this study examined how the availability of built and natural amenities, weather and attitudes towards travel help to explain revealed and unserved travel demand and subsequently, how these variables affect livability as measured by quality of life (QOL) in a northern rural climate. Structural equation modeling was used to obtain estimates of QOL. The presence of unserved travel demand significantly decreased QOL. This suggests that addressing unserved travel demand, not trip making, should be the primary objective of future mobility initiatives in northern rural climates.

INTRODUCTION

Mobility is a complex concept which comprises issues including amenity availability, accessibility, and the ability to get to desired destinations. Mobility provides physical, social, and psychological benefits (1) and is a key component of quality of life (QOL) (2).

Northern rural communities are particularly challenging environments in which to provide year-round transportation options that ensure people have access to work, services, and social activities, as well as active, healthy travel options including biking or walking. The climate, seasonality and rural nature of northern New England communities make the provision of public transit, whether local, regional, or inter-regional, particularly challenging and often cost-prohibitive. Important amenities and services, i.e. grocery stores, employment, and places you can walk to, are also considered less available and less accessible in rural areas (3-5), given small population sizes, lower population densities, limited transportation options and fewer financial resources (6, 7). Rural populations also have more poor and elderly residents (7). All of these factors present challenges to developing rural mobility systems.

Understanding impacts of mobility on QOL is an important step in building a sustainable transportation system (8). QOL is an important assessment tool to measure livability. This study, using a 2009 database of residents of Vermont, Maine, and New Hampshire, examines how the availability of built and natural amenities, weather, and attitudes towards travel help to explain revealed and unserved travel demand and subsequently, how all of these variables affect QOL and livability in northern rural climates.

LITERATURE REVIEW

Quality of life (QOL), though difficult to measure and generalize for entire populations, is most often measured through studying self-assessed life satisfaction and individual well-being (9) and is believed to be influenced by mobility, the built environment, attitudes, and social wellbeing .

Mobility has a direct positive relationship with QOL, especially amongst the elderly (10-14). Measures of mobility include trip frequencies and unserved demand for trips (14). Decreased unserved travel demand, or the taking of previously foregone trips has been hypothesized to lead to increased QOL (15). Cutler (16) demonstrated that elderly people without access to a car have been shown to have 2.5 times the rate of unserved travel demand as those with a car. Metz (1) found this loss of mobility, due to the inability to safely drive a car, to be a significant detractor from quality of life. The availability of alternative transportation options and social networks, however, could potentially offset some of the decline in QOL resulting from decreased mobility (17).

Alternative transportation options such as the availability of places you can walk to and the perceived availability of friends' and family's homes within walking distance have been shown to increase walking. Miles and Panton's (18) study found that low-income women's perceived availability

of places they could walk to were associated with increased walking over a 12 month period. Furthermore, the perceived availability of friends' and family's homes to which they could walk to led to increased walking.

Both physical and social infrastructure serve to improve accessibility to essential amenities such as healthcare, education, and emergency services (19). A community's built environment such as transportation infrastructure, bike and pedestrian facilities, and multi-use trails all contribute to mobility and quality of life (20). Cutler (16) found that, amongst people 65 years and older, both the presence of public transportation as well as proximity to it resulted in higher life satisfaction. More recently, Raphael et al. (21) also showed that the presence of public transportation contributes to QOL. The quality of transportation available also impacts QOL (22).

Safety concerns related to community and travel are another important indicator of QOL (23-25). Local and neighborhood safety problems have been shown to affect residents QOL (9, 26). Attitudes regarding the safety of one's neighborhood also had a positive effect on QOL in people aged 65 or older (27). In a survey of a Florida community after the implementation of significant infrastructure improvements, respondents were more likely to feel their community had experienced an increase in QOL once streetlight installations and the creation of safe places to walk and exercise outside were implemented (28). Carp (10) found that having grocery stores in walking distance was positively associated with QOL.

Social benefits are better promoted in built environments that are pedestrian oriented and highly walkable (e.g. those with sidewalks, that promote walking and carrying out of daily activities without the use of a car) than in car-dependent suburban neighborhoods; this is due to increased interactions, trust, and community connections (29). Researchers have shown that social networks and community involvement can have a positive impact on one's health, and subsequently QOL (30). Those who are socially engaged with others and are involved in their communities tend to be healthier, both physically and mentally (29, 31, 32). Indeed, the quality and richness of social relationships with family and friends are widely accepted indicators of QOL (24). Barresi, Ferraro, and Hobey (9, 33)found that interaction with neighbors affected personal wellbeing in older persons.

Attitudes, outlook, personality, and perspective all contribute to mobility and QOL (24, 27). Beliefs and values have also been included in some QOL models (24, 34). As individuals become older, a feeling of losing one's independence sometimes accompanies decreases in mobility. Elderly persons may find themselves depending on others more to make trips resulting in a feeling of loss of autonomy (2), which is a negative contributor to QOL (24). Indeed, the inability to relax and enjoy oneself after a tough trip and the fear of decreasing independence have both had a negative effect on QOL (27). Among the elderly, feelings of fear at bus stops and discomfort while traveling are not unusual (2) and concerns surrounding traffic, the safety of walkable destinations, and the fear of walking-related injuries can all discourage walking (18). Increased mobility, however, can significantly increase feelings of independence (35, 36).

Both seasonality and weather conditions have been shown to have effects on mobility (37, 38). Amongst college students in Australia, regular commuting by bicycle was significantly affected by weather conditions such as rain, wind, temperature, and darkness; seasonally, commuter cycling was lowest in the winter and highest in the summer (39). Another study also demonstrated that cycling flow was almost three times greater in the summer than in the winter (38), perhaps due to temperature, winds, rain, ice, or snow (38, 40, 41). And, in a survey of individuals aged 60 or more in Bonn, Germany, 31.7% responded that they had travel plans that went unfulfilled due to the weather and 32.0% due to a dislike of traveling in the dark (42).

METHODS

The data presented here is taken from the Spring phase of a four season panel survey entitled the Transportation in Your Life Poll. Questions were informed by 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. This survey was funded by the U.S. Department of Transportation (USDOT) and approved by the University of Vermont's Institutional Review Board (IRB).

The initial sample for the survey was a sample frame of 15,000 residents of Vermont, Maine, and New Hampshire provided by the New England Transportation Institute (NETI). The number of surveys completed in the spring was 1,417 (sample) out of 4,625 mail and voice contacts corresponding to a 30.64% response rate. Of those contacted, 2,708 people refused to take the survey or terminated it after only a few questions and 500 people who said they had completed, or would complete, the survey online did not. Respondents had to be over the age of eighteen and willing to participate in all four phases of the survey to be interviewed.

The survey was completed using computer-aided telephone interviewing (CATI) and online polling. Letters were mailed out on Friday, May 22, 2009 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 (43). All computer-aided telephone interviews and online surveys were conducted between Tuesday, May 26, 2009 and Wednesday, June 10, 2009, Monday through Friday from 4:00 p.m. until 9 p.m.

To measure the natural and built environment, respondents rated the perceived availability of eighteen community amenities on a scale from zero (0) to ten (10), with zero being not at all offered and ten being very well offered and 5 being a point in the middle. To measure the attitudes of the respondents on various transportation-related issues, we used a five point Likert Scale ranging from Strongly Agree to Strongly Disagree. Responses were recoded into a binary variable with one (1) representing strongly agree or agree and zero (0) representing everyone else. Similarly, other categorical variables were recoded into binary variables including typical weather (worse than typical=1) and weather affected travel decision (yes=1). Categorical demographics were also recoded as binary variables: gender (male=1), education (at least a bachelor's degree=1), rurality (rural=1), bicycles (at least one per household=1), motor vehicles (at least one per household=1), access to public transportation (yes=1), driver's license (yes=1), and employment (employed=1). We divided household composition into four variables: single adults no kids (SANK), single adults with kids (SAWK), multiple adults no kids (MANK), and multiple adults with kids (MAWK). Of these four we included SANK, SAWK, and MAWK in the regression analyses to compare to the MANK reference group.

Additional exogenous variables included in the regression analyses to satisfy rank and order conditions included four nominal variables, whether a respondent lived in Maine (1) or anywhere else (0), whether a respondent lived in New Hampshire (1) or anywhere else (0), whether a respondent considered today a typical day (1) or not (0), and a single continuous variable, how many years a respondent had lived in northern New England.

Other variables that served as intermediary dependent variables included the nominal variables of whether a respondent had any form of unmet demand, i.e. places they wanted or needed to go but didn't (yes=1), whether a respondent had taken at least one trip (yes=1) as determined by the survey travel log, and the continuous variables, the total number of trips taken by a respondent, and the respondent's self-reported QOL.

All analyses were conducted with the Statistical Program for Social Sciences (SPSS), version 18.0 and LIMDEP Econometrics Software. Within LIMDEP, a series of three models were estimated using structural equation modeling (SEM) techniques. The model can be seen in its totality in Figure 1.

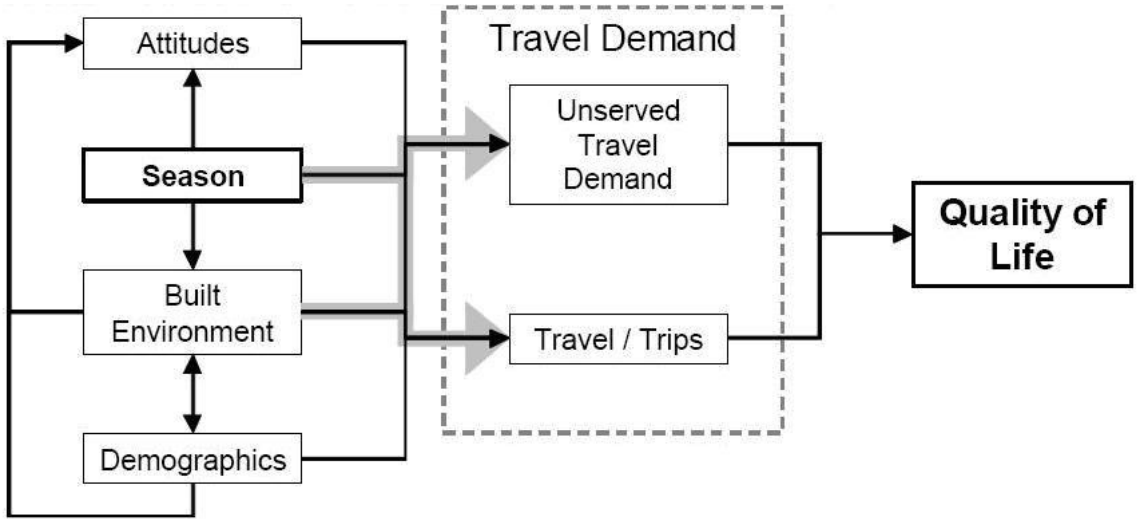

FIGURE 1 Built environment, attitudes, seasonality, travel demand and QOL.

The first model was a binary logistic model with unserved travel demand as the dependent variable. This model was estimated to predict the probability that a respondent had any form of unserved demand, with unserved demand defined as a respondent having anywhere they wanted or needed to go but didn't in the last week (yes=1). Independent variables in the model included the perceived availability of eighteen community amenities, nine attitudinal statements regarding travel, thirteen demographics, and two measures of the weather.

The second model was a two-step, truncated regression model with total number of trips as the dependent variable. This model was suggested by preliminary analysis which indicated that the probability of a respondent making at least 1 trip and the total number of trips a respondent made in a day both depend on the same independent variables used in the previous binary logistic model but in opposite directions (LIMDEP Version 8.0 2007). The initial step, a probit model, served as the indicator of whether the probability of making at least 1 trip was positive or not. The second step was a truncated regression model that indicated the nonlimit observations, or predicted total number of trips made and truncated at greater than zero; here, we included as the dependent variable of total number of trips logged.

Independent variables in the first step of the truncated probit were the same as in the previous binary logistic model. Independent variables in the second step of the truncated regression model included two exogenous variables to identify the model: whether the respondent was a resident of Maine or New Hampshire.

The number of trips a respondent made in a given day was measured through a travel log collected within the survey. Within this travel log, respondents answered such questions as, "where did you start your day," "what time did you first leave," and "what was the purpose of your trip." Once the respondent had answered all the questions regarding a given trip they were asked "Then, did you go home or somewhere else?" If they answered yes (1) then the interviewer would continue to gather data regarding these subsequent trips until the respondent stated that they had ended their day at that location (2). The respondents who took 0 trips were coded as a 0. All respondents who made more than 1 trip were measured by totaling one plus the number of times a respondent went somewhere else, coded as (1), after leaving their starting point for the day yesterday. A single leg was added to account for the respondent's initial trip away from their starting point.

The final model used linear OLS regression techniques with QOL as the dependent variable. QOL was coded on a scale from zero (0) to ten (10), with zero (0) being completely dissatisfied and ten (10) being completely satisfied and 5 being the point in the middle. Included in this regression were the previously included independent variables: community amenities, attitudinal statements regarding travel, demographics, and measures of the weather. To ensure the system of equations was indentified and

satisfied rank and order conditions, the final linear regression analysis of QOL included two exogenous variables that were excluded from the previous equations. The number of previously excluded independent variables (2) was also as large as the number of right hand side endogenous (dependent) variables in the same equation (44). Additional exogenous variables of Maine residence, New Hampshire residence, whether today was a typical day, and the number of years the respondent had lived in northern New England were included in the final model. Lastly, the predicted number of trips a respondent made and predicted probability that a respondent had any form of unserved demand were independent variables in this model.

To test for multicollinearity, an analysis of the variance inflation factors (VIF), was conducted. No collinearity was detected within our model's data; all of the initial variables were included in the final model.

Of the 1,417 respondents, 69.2% lived in a rural area, 45.5% of respondents were male, 47.1% had at least a bachelor's degree, the average age was 53.29 years old, and 52.7% of households had a gross income of over $50,000. As shown in Tables 1 and 2, respondents had a mean QOL rating of 7.80 (1.68). One in five respondents (20%) had some form of unserved travel demand and almost 90% of the respondents made at least 1 trip. Table 1 also presents the perceived availability of eighteen community amenities hypothesized to affect travel demand, mobility and QOL.

TABLE 1 Descriptive Statistics

Variables	Mean (std dev)
Number of trips past 24 hours	2.61 (1.56)
Grocery Store Availability	6.31 (3.26)
Restaurant Availability	5.65 (3.11)
Clothing Store Availability	3.78 (3.15)
Affordable Housing Availability	4.88 (2.52)
Adequate Housing Availability	5.74 (2.44)
Healthcare Provider Availability	6.01 (3.26)
Family Availability	5.66 (3.56)
Friends Availability	7.21 (2.50)
Neighbors Availability	6.96 (2.75)
Education & Training Availability	5.68 (3.07)
Employment Availability	4.33 (2.61)
Recreation Availability	6.76 (2.60)
Feeling of Safety Availability	8.13 (2.05)
Arts & Entertainment Availability	4.85 (2.86)
Place of Worship Availability	7.05 (2.76)
Childcare Availability	5.37 (2.79)
Natural Surroundings Availability	8.55 (1.84)
Place you can walk to Availability	5.95 (3.23)

n=984

TABLE 2 Attitudes Toward Travel and Weather

Travel/weather attitude statement	Percent Agree
Afraid to drive in bad weather in the spring	9.8%
Travel less when gas prices high	62.7%
Able to get places you need to go	93.3%
Feel safe walking after dark	76.5%
Enjoy daily travel	71.7%
Believe should walk/bike more	76.6%
Think about climate change when travel	51.7%
Feel safe making a trip after dark	85.0%
Know people with trouble getting needed places	44.0%

n=984

RESULTS

Table 3 presents the results of the binary logistic model to measure the effects of community amenities, attitudes, demographics, and seasonal weather upon whether or not a respondent had unserved travel demand.

Variables that significantly decreased the probability that a respondent had unserved travel demand included the perceived availability of grocery stores, a feeling of safety, and the availability of at least one motor vehicle. The strongest effect of these variables was the availability of at least one motor vehicle which resulted in a 25.3% decrease in the probability of having unserved travel demand. A perceived availability for grocery stores, and a feeling of safety equal to 10 resulted in an 11% and 19% decrease in the probability of having unserved travel demand, respectively, as shown in the marginal effects column of Table 3.

Variables that significantly increased the probability that a respondent had any form of unserved travel demand included being male (4.3% increase), worse than typical weather (5.9% increase), if weather affected your travel (11.4% increase), and knowing people who had unserved travel demand (6.4% increase).

TABLE 3 Binary Logistic Model to predict Probability of Unmet Travel Demand

Variable	Coefficient	Marginal Effects	b/St.Er.	P(|Z|>z	
Constant|	0.615	0.091	0.777	0.437	
Grocery Store	-0.072	-0.011	-1.837	0.066	*
Restaurant	-0.004	-0.001	-0.104	0.917	
Clothing Store	-0.004	-0.001	-0.086	0.931	
Affordable Housing	0.052	0.008	1.082	0.279	
Adequate Housing	0.000	0.000	-0.006	0.995	
Healthcare Provider	-0.015	-0.002	-0.441	0.659	
Family	-0.003	0.000	-0.104	0.917	
Friends	-0.080	-0.012	-1.587	0.113	
Neighbors	0.008	0.001	0.182	0.856	
Education & Training	0.025	0.004	0.699	0.485	
Employment	-0.071	-0.010	-1.557	0.120	
Recreation	-0.010	-0.001	-0.226	0.821	
Feeling of Safety	-0.127	-0.019	-2.550	0.011	*
Arts & Entertainment	-0.002	0.000	-0.041	0.967	

Place of Worship	0.034	0.005	0.867	0.386	
Childcare	0.065	0.010	1.598	0.110	
Natural Surroundings	0.088	0.013	1.476	0.140	
Place you can walk to	0.006	0.001	0.186	0.853	
Gender	0.291	0.043	1.699	0.089	*
Age	-0.008	-0.001	-0.947	0.344	
Income $50,000+	0.148	0.022	0.724	0.469	
BA or more education	0.041	0.006	0.211	0.833	
Rural	-0.206	-0.031	-0.950	0.342	
At least 1 motor vehicle	-1.262	-0.253	-2.404	0.016	*
At least 1 bicycle	0.012	0.002	0.053	0.958	
Access to public transportation	0.096	0.014	0.483	0.629	
Valid driver's license	-0.259	-0.041	-0.631	0.528	
Employed	0.178	0.026	0.804	0.422	
Multiple adult with children	0.157	0.024	0.684	0.494	
Single adult, no children	0.205	0.032	0.780	0.436	
Single adult, with children	0.331	0.054	0.752	0.452	
Weather typical	0.376	0.059	1.838	0.066	*
Weather affected my travel	0.653	0.114	2.100	0.036	*
Afraid to drive in bad weather in the spring	0.193	0.030	0.674	0.500	
Travel less when gas prices high	0.164	0.024	0.901	0.368	
Able to get places you need to go	-0.467	-0.078	-1.469	0.142	
Feel safe walking after dark	0.110	0.016	0.491	0.624	
Enjoy daily travel	-0.286	-0.044	-1.471	0.141	
Believe should walk/bike more	0.318	0.044	1.473	0.141	
Think about climate change when travel	0.116	0.017	0.646	0.519	
Feel safe making a trip after dark	-0.063	-0.009	-0.232	0.816	
Know people with trouble getting needed places	0.428	0.064	2.398	0.017	*

Note. Model correctly predicted 98.47% of actual 0s (respondents without unmet demand).
n=984

The second model is shown in Table 4. This truncated regression model predicts the number of trips a respondent made in a given day. The perceived availability of grocery stores (0.85 more trips per 10 unit increase in availability) and places you can walk to (0.39 more trips per 10 unit increase in

289 availability) both increased the number of trips a respondent made in a given day, as did having at least a
290 bachelor's degree (0.27 more trips), living in a multiple adult household with children (0.51 more trips as
291 compared to households with multiple adults and no children), and feeling safe making a trip after dark
292 (0.36 more trips). Respondents who agreed that they traveled less when gas prices were high made 0.24
293 more trips than their counterparts (it should be noted that at the time of data collection, gas prices were
294 lower than in the recent past). The perceived availability of restaurants (0.49 fewer trips per 10 unit
295 increase in availability) decreased the number of trips a respondent made in a given day.
296
297

TABLE 4 Truncated Probit Model to predict # of Trips Made

Variable	Coefficient	Standard Error	b/St.Er.	P(|Z|>z)	
Constant	1.145	0.573	1.997	0.046	*
Grocery Store	0.085	0.024	3.486	0.001	***
Restaurant	-0.049	0.027	-1.849	0.064	*
Clothing Store	0.014	0.025	0.558	0.577	
Affordable Housing	0.000	0.030	0.004	0.997	
Adequate Housing	0.005	0.032	0.167	0.867	
Healthcare Provider	0.003	0.022	0.156	0.876	
Family	0.011	0.018	0.622	0.534	
Friends	0.027	0.032	0.849	0.396	
Neighbors	-0.019	0.026	-0.752	0.452	
Education & Training	0.005	0.022	0.233	0.816	
Employment	-0.027	0.028	-0.964	0.335	
Recreation	-0.042	0.027	-1.558	0.119	
Feeling of Safety	0.018	0.034	0.524	0.600	
Arts & Entertainment	-0.035	0.026	-1.352	0.177	
Place of Worship	-0.018	0.024	-0.735	0.462	
Childcare	0.014	0.024	0.567	0.571	
Natural Surroundings	0.059	0.038	1.540	0.124	
Place you can walk to	0.039	0.019	2.068	0.039	*
Gender	-0.077	0.105	-0.732	0.464	
Age	0.007	0.005	1.418	0.156	
Income $50,000+	-0.148	0.124	-1.199	0.230	
BA or more education	0.268	0.118	2.266	0.023	*
Rural	-0.148	0.130	-1.139	0.255	
At least 1 motor vehicle	0.619	0.416	1.487	0.137	
At least 1 bicycle	0.038	0.134	0.284	0.776	
Access to public transportation	-0.175	0.119	-1.474	0.140	
Valid driver's license	-0.427	0.296	-1.440	0.150	
Employed	0.096	0.133	0.722	0.470	
Multiple adult with children	0.514	0.140	3.684	0.000	***
Single adult, no children	0.010	0.164	0.059	0.953	
Single adult, with children	0.131	0.282	0.464	0.643	
Weather typical	-0.092	0.134	-0.682	0.495	
Weather affected my travel	-0.119	0.236	-0.505	0.614	
Afraid to drive in bad weather in the spring	0.034	0.189	0.180	0.857	
Travel less when gas prices high	0.242	0.111	2.176	0.030	*

Able to get places you need to go	-0.288	0.219	-1.316	0.188	
Feel safe walking after dark	-0.085	0.139	-0.613	0.540	
Enjoy daily travel	0.051	0.123	0.410	0.682	
Believe should walk/bike more	0.142	0.128	1.113	0.266	
Think about climate change when travel	0.028	0.109	0.259	0.796	
Feel safe making a trip after dark	0.357	0.175	2.042	0.041	*
Know people with trouble getting needed places	-0.109	0.110	-0.990	0.322	
Sigma	1.421	0.042	34.134	0.000	

n=891 (observations after truncation)

The final model is a linear OLS regression with the dependent variable QOL. Shown in Table 5 below. The model had an Adjusted R Square value of .37. The presence of any form of unserved travel demand, had the greatest impact on QOL with a 1 unit decrease (-.954) out of 11 possible units. Neither the number of trips made nor any of the weather variables had any significant effect on QOL (controlling for unserved travel demand).

QOL was significantly increased by the perceived availability of adequate housing (0.61 units per 10 unit increase in availability), access to neighbors you consider friends (1.09 units per 10 unit increase in availability), and a feeling of safety (1.52 units per 10 unit increase in availability), as well as enjoying your daily travel (0.275 unit increase), having a typical day (0.214 unit increase), and living more years in northern New England (0.002 unit increase). The perceived availability of affordable housing significantly decreased QOL by 0.5 units per 10 unit increase.

TABLE 5 Linear Model: QOL Regression

Variable	Coefficient	Standard Error	b/St.Er.	P(|Z|>z)	
Constant	2.439	3.369	0.724	0.469	
Grocery Store	0.042	0.165	0.256	0.798	
Restaurant	0.000	0.098	0.003	0.997	
Clothing Store	0.001	0.033	0.032	0.974	
Affordable Housing	-0.050	0.025	-1.989	0.047	*
Adequate Housing	0.061	0.028	2.163	0.031	*
Healthcare Provider	-0.015	0.019	-0.795	0.427	
Family	-0.024	0.026	-0.926	0.354	
Friends	0.012	0.057	0.207	0.836	
Neighbors	0.109	0.044	2.495	0.013	*
Education & Training	-0.023	0.021	-1.125	0.261	
Employment	0.089	0.056	1.589	0.112	
Recreation	0.007	0.084	0.083	0.934	
Feeling of Safety	0.152	0.043	3.509	0.001	***
Arts & Entertainment	0.020	0.070	0.282	0.778	
Place of Worship	0.040	0.039	1.018	0.309	
Childcare	-0.022	0.033	-0.663	0.507	
Natural Surroundings	0.153	0.116	1.317	0.188	
Place you can walk to	0.035	0.076	0.465	0.642	
Gender	-0.092	0.171	-0.534	0.593	

Age	0.014	0.014	0.960	0.337	
Income $50,000+	0.000	0.301	-0.001	0.999	
BA or more education	0.210	0.516	0.407	0.684	
Rural	0.304	0.310	0.978	0.328	
At least 1 motor vehicle	-0.450	1.169	-0.385	0.700	
At least 1 bicycle	-0.080	0.135	-0.592	0.554	
Access to public transportation	0.016	0.353	0.046	0.964	
Valid driver's license	-0.105	0.846	-0.124	0.902	
Employed	0.007	0.213	0.032	0.975	
Multiple adult with children	-0.070	1.003	-0.070	0.944	
Single adult, no children	-0.208	0.134	-1.553	0.120	
Single adult, with children	0.010	0.341	0.029	0.977	
Weather typical	-0.011	0.205	-0.055	0.956	
Weather affected my travel	-0.034	0.291	-0.117	0.907	
Afraid to drive in bad weather in the spring	0.030	0.168	0.177	0.859	
Travel less when gas prices high	-0.063	0.474	-0.133	0.894	
Able to get places you need to go	-0.032	0.591	-0.055	0.957	
Feel safe walking after dark	0.093	0.202	0.459	0.646	
Enjoy daily travel	0.275	0.144	1.905	0.057	*
Believe should walk/bike more	-0.286	0.288	-0.991	0.322	
Think about climate change when travel	-0.117	0.109	-1.068	0.285	
Feel safe making a trip after dark	-0.153	0.688	-0.222	0.824	
Know people with trouble getting needed places	-0.266	0.232	-1.149	0.251	
Maine resident	0.005	0.109	0.048	0.962	
New Hampshire resident	-0.090	0.117	-0.776	0.438	
Typical day	0.214	0.099	2.168	0.030	*
Years living in Northern New England	0.002	0.001	1.981	0.048	*
Predicted # of trips	0.308	2.204	0.140	0.889	
Predicted unserved travel demand	-0.954	0.316	-3.019	0.003	**

Note. Adjusted R Square=.3679
n=984

314

Figure 2 below presents structural equation model (SEM) of the entire analysis. The perceived availability of safety was the only variable which affected both unserved travel demand (negatively) and QOL (positively). Figure 2 provides a graphic representation of the variables of the SEM that were significant predictors of their respective dependent variable, as well as the Beta coefficient value (impact) of each of the significant variables. Figure 2 also displays the significant variables coded for the relevant segment of the hypothesized model depicted in Figure 1.

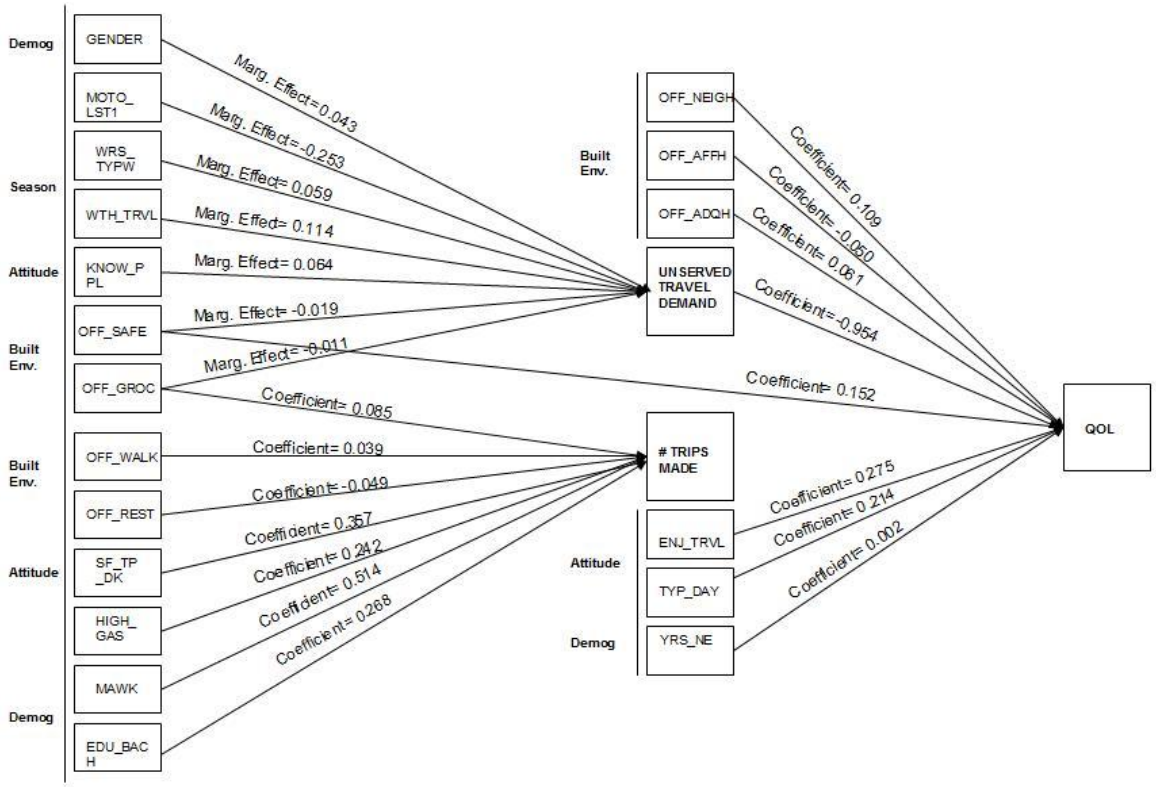

FIGURE 2 Structural Equation Model of Significant Variables Impact on QOL.

CONCLUSION AND DISCUSSION

As this research shows, addressing unmet travel demand is a component of improving livability and QOL in the northern rural climate studied. Although the research concludes that unmet demand is uncommon in the general population, when present it has a significant impact on QOL. In addition, a focus on livability, as a means to improve QOL, including access to food, adequate housing, safe neighborhoods, pleasant commutes and friendly communities is important. Several factors reduce the probability of unmet travel demand, including availability of grocery stores and feeling safe in one's community. Feeling safe in one's community impacts both the probability of having unmet travel demand and QOL. Grocery store availability in one's community, however, impacts QOL only if you can't get to one.

Increased number of trips should not be the primary objective of future mobility initiatives in northern rural climates, as trip-making does not appear to impact QOL. What matters most, with regards to QOL, is the ability to be mobile. While unserved travel demand reduced QOL, several mobility factors increased QOL. Enjoying one's daily travel and having a typical travel day both increased QOL. So, while policy solutions seek to improve QOL by reducing unmet demand, they should also focus on providing pleasant, predictable travel experiences.

Northern New England is not known for its public transportation systems, and providing public transportation in a primarily rural region is challenging. It's not surprising, then, that owning at least one

343 vehicle in the household reduces the probability of unmet demand. Most households own at least one
344 motor vehicle, but for households that do not, policy solutions will be needed to reduce the impact of
345 vehicle ownership on the probability of unmet travel demand.
346 Somewhat surprisingly, after controlling for factors including income, vehicle in household and
347 driver's license, age was not a significant predictor of the probability of unmet travel demand, number of
348 trips made or QOL. To date, many public policy solutions have focused primarily on elders (1, 10, 14, 16,
349 17, 27) and while elders may be more likely to have unmet travel demand, these results show that it is not
350 the result of age per se. This suggests that solutions to address unmet travel demand should be focused
351 both more broadly than just older residents, and more specifically on older residents who lack household
352 travel solutions such as a vehicle or valid driver's license.
353 Policy solutions that focus on the underlying cause of unmet demand, such as programs that
354 provide vehicle access or mitigate the need for travel, may provide more sustainable success in addressing
355 unmet travel demand, and thereby improving QOL (2, 10, 14).
356 The theoretical importance of linking mobility and QOL and building more robust QOL models
357 are numerous (1, 24). This study is unique in that it develops a model both for the factors affecting
358 mobility and for the factors affecting QOL, linking the two in one study. Other studies have shown the
359 cause of mobility-loss (10)or effects on QOL (2) but fail to create a model that links the two. Mattson
360 (14) for example, shows the factors contributing to unserved travel demand but does not demonstrate
361 effects on QOL. Felce and Perry (24) assert the importance of having a QOL model that incorporates a
362 broad range of life domains with both objective and subjective measures. The model presented in this
363 paper captures both objective and subjective measures across many domains. It is further strengthened by
364 allowing for direct and indirect effects on QOL mediated through unserved travel demand and trip
365 making. Other studies use descriptive statistics or techniques that assume clear attribution of items to
366 QOL that the complex nature of QOL does not allow (20). A number of qualitative studies (17, 21, 27)
367 have presented in-depth studies but are limited in their ability to generalize to the larger population.
368 Cutler's study (2)of mobility effects on QOL on older populations lacks the availability of amenities,
369 effects of weather, community and safety and makes owning or access to a car the focus of the study.
370 This study concurs that access to a vehicle increases mobility and thereby indirectly effects QOL but it is
371 mobility not car ownership that is important to QOL. A strength of this study is that it allows for the
372 direct and indirect effects to be teased apart to better inform policy makers.
373 This study highlights the need for future research to address populations facing unserved travel
374 demand. To make effective policy, an in depth look at which population groups are being adversely
375 affected is needed. In addition, this study is limited in its scope as responses are from the Spring when
376 weather is not severe. Future studies should incorporate all four seasons and actual weather observations
377 to better address the effects of weather and seasonality on mobility and quality of life. Policy solution
378 could then be based on the contextual issues surrounding mobility based QOL.
379

ACKKNOWLEDGEMENT

This research was funded by a grant from the U.S. Department of Transportation through the University of Vermont Transportation Research Center.

REFERENCES

1. Metz, D. Mobility of Older People and Their Quality of Life. *Transport Policy*, 7, 2000, pp. 149-152.
2. Cutler, S. Transportation and Changes in Life Satisfaction. *The Gerontologist*, 1975.
3. Dillman, D., and K. Tremblay. The Quality of Life in Rural America. *Annals of the American Academy of Political and Social Science*, 429, 1977, pp. 115-129.
4. Goldsberry, K., and C. Duvall. Visualizing Nutritional Terrain: An Atlas of Produce Accessibility in Lansing, Michican, USA. *American Journal of Preventative Medicine*, 36(4S), 2009.
5. Hart, L., E. Salsberg, D. Phillips, and D. Lishner. Rural Health Care Providers in the United States. *The Journal of Rural Health*, 18(5), 2002., pp. 211-232.
6. Hubsmith, D. Rural Communities: Rural Safe Routes to School. *Diverse Community Roundtable Meeting Notes*, 2007. http://www.saferoutespartnership.org/local/4317/4345. Accessed Aug. 3, 2010.
7. Hart, G., E. Larson, and D. Lishner. Rural Definitions for Health Policy and Research American J*ournal of Public Health*, 95(7), 2005, pp. 1149-55.
8. Steg, L. and R. Gifford. Sustainable Transportation and Quality of Life. *Journal of Transport Geography*, 13(1), 2005, pp. 59-69.
9. Sirgy, J.,M., and T. Cornwell. How Neighborhood Features Affect Qualtiy of Life. *Social Indicators Research*, 59, 2002, pp. 79-114.
10. Carp, F.M. Transportation in an aging society: Improving Mobility and Safety for Older Persons. *Transportation Research Board*, Vol. 2, National Research Council: Washington, D.C., 1988, pp. 1-20.
11. Owsley, C. Clinical and Research Issues on Older Drivers: Future Directions. *Alzheimer disease and associated disorders*, 1997.
12. Marottoli, R.A., C.F. Mendes de Leon, T.A. Glass, C.S. Williams, L.M. Cooney, L.F. Berkman. Consequences of Driving Cessation: Decreased Out-of-Home Activity Levels. *The Journals of Gerontology*, Series B: Psychological Sciences and Social Sciences, 2000.
13. Scott, D.M., K.B. Newbold, J.E.L Spinnery, R.G. Mercado, A. Paez, P.S. Kanaroglou. *Changing Mobility of Elderly Urban Canadians,* 2005.
14. Mattson, J. Aging and Mobility in Rural and Small Urban Areas: A Survey of North Dakota. *Journal of Applied Gerontology*, 2010.
15. Kantor, S. *The Economic Impact of the California High-Speed Rail in the Sacramento/Central Valley Area*. 2008.
16. Cutler, S. The Availability of Personal Transportation, Residential Location, and Life Satisfaction Among the Aged. *Journal of Gerontology*, 27(3), 1972, pp. 383-389.
17. Burkhardt, J. Mobility Changes Their Nature, Effects, and Meaning for Elders Who Reduce or Cease Driving. *Transportation Research Record: Journal of the Transportation Research Board*, No. 1671, Transportation Research Board of the Naional Academies, Washington, D.C., 1999, pp. 11-18.
18. Miles, R., and L. Panton. The Influence of the Percieved Quality of Community Environments on Low-Income Women's Efforts to Walk More. *Journal of Community Health*, 31(5), 2006.
19. Rowley, T., D.W. Sears, G.G. Nelson, J.N. Reid, M.J. Yetley. *Rural development research: a Foundation for Policy.* Greenwood Publishing Group, Inc., Westport, 1996.

20. Shafer, C., B. Lee, and S. Turner. A Tale of Three Greenway Trails: User Perceptions Related to Quality of Life. *Landscape and Urban Planning*, 49, 2000, pp. 163-178.
21. Raphael, D., e.a. Making the Links Between Community Structure and Individual Well-Being: Community Quality of Life in Riverdale, Toronto, Canada. *Health & Place*, 7, 2001, pp. 179-196.
22. Litman, T. *Evaluating Transportation Equity Guidance For Incorporating Distributional Impacts in Transportation Planning*. Victoria Transport Policy Institute, 2010.
23. Lehman, A.F. A Quality of Life Interview for the Chronically Mentally Ill. *Evaluation and Program Planning*, 11(1), 1988, pp. 51-62.
24. Felce, D., and J. Perry. Quality of Life: Its Definition and Measurement. *Research in Developmental Disabilities*, 16(1), 1995, pp. 51-74.
25. Blunden, R., Quality of Life in Persons with Disabilities: Issues in the Development of Services. *Quality of life for handicapped people*, 1988, pp. 37- 55.
26. Lee, B.A. and A.M. Guest. Determinants of Neighborhood Satisfaction: A Metropolitan-Level Analysis. *Sociological Quarterly*, 24(2), 1983, pp. 287-303.
27. Gabriel, Z., and A. Bowling. Quality of Life from the Perspectives of Older People. *Ageing & Society*, 24, 2004, pp. 675-691.
28. Harduar-Morano, L., et al., PACE EH Post Project Assessment of Quality of Life Changes in a Florida Community Related to Infrastructure Improvements. *Journal of Environmental Health*, 70(10), 2008, pp. 40-46.
29. Leyden, K.M. Social Capital and the Built Environment: The Importance of Walkable Neighborhoods. *American Journal of Public Health*, 93(9), 2003, pp. 1546-1551.
30. Putnam, R.D. *Bowling Alone: The Collapse and Revival of American Community.* Simon and Schuster, 2000.
31. House, J., K. Landis, and D. Umberson. Social Relationships and Health. *Science*, 241(4865), 1988, pp. 540-545.
32. Kawachi, I. and L.F. Berkman, Social Ties and Mental Health. *Journal of Urban Health*, 78(3), 2001, pp. 458-467.
33. Barresi, C.M., K.F. Ferraro, and L.L. Hobey. Environmental Satisfaction, Sociability, and Well-Being Among Urban Elderly. *The International Journal of Aging and Human Development*, 18(4), 1983, pp. 277-293.
34. Parmenter, T. An Analysis of the Dimensions of Quality of Life for People with Physical Disabilities. *Quality of life for handicapped people*, 1988, pp. 7-36.
35. Burkhardt, J. *Coordinated Transportation Systems*, AARP , 2000.
36. Burkhardt, J.E., et al., *Improving Public Transit Options for Older Persons*. 2002.
37. Goodwin, L. *Weather Impacts on Arterial Traffic Flow*, 2002, US DOT.
38. Bergstrom, A. and R. Magnusson. Potential of Transferring Car Trips to Bicycle During Winter. *Transportation Research Part A: Policy & Practice*, 37(8), 2003, pp. 649.
39. Nankervis, M., The Effect of Weather and Climate on Bicycle Commuting. *Transportation Research Part A: Policy and Practice*, 33(6), 1999, pp. 417-431.
40. Emmerson, P., T. Ryley, and D. Davies. The Impact of Weather on Cycle Flows. *Traffic engineering & control*, 39(4), 1998, pp. 238-243.
41. Öberg, G., et al., *Single Accidents Among Pedestrians and Cyclists*. VTI, Meddelande, 1996.
42. Kasper, B., and J. Scheiner. Mobility and Mobility Problems of Elderly People in Urban, Suburban and Rural Environment: Preliminary Results from the Research Project FRAME. Presented at the 42nd congress of the European Regional Science Association (ERSA). 2002. German Federal Ministry of Education and Research.
43. Dillman, D.A., J. Smythe, and L. Christian. *Internet, Mail, and Mixed-Mode Surveys: The Tailored Design Method.* John Wiley & Sons, Inc., Hoboken, 2009.
44. Wooldridge, J. *Introductory Econometrics: A Modern Approach*. Thomson South-western, 2003.