7-1-2013

It is not how far you go, it is whether you can get there: Modeling the effects of mobility on quality of life in rural New England

Jane M. Kolodinsky
University of Vermont

Thomas Patrick DeSisto
University of Vermont

David Propen
University of Vermont

Matthew E. Putnam
University of Vermont

Erin Roche
University of Vermont

See next page for additional authors

Recommended Citation

Kolodinsky JM, DeSisto TP, Propen D, Putnam ME, Roche E, Sawyer WR. It is not how far you go, it is whether you can get there: modeling the effects of mobility on quality of life in rural New England. Journal of Transport Geography. 2013 Jul 1;31:113-22.

Authors
Jane M. Kolodinsky, Thomas Patrick DeSisto, David Propen, Matthew E. Putnam, Erin Roche, and William R. Sawyer

Journal of Transport Geography 31 (2013) 113–122

Contents lists available at SciVerse ScienceDirect

Journal of Transport Geography

journal homepage: www.elsevier.com/locate/jtrangeo

It is not how far you go, it is whether you can get there: modeling the effects of mobility on quality of life in rural New England

Jane M. Kolodinsky [a,b,*], Thomas Patrick DeSisto [b,1], David Propen [a,2], Matthew E. Putnam [a,3], Erin Roche [b,4], William R. Sawyer [b,5]

[a] University of Vermont, Dept. of Community Development and Applied Economics, 146 University Place, 202 Morrill Hall, Burlington, VT 05405, United States
[b] University of Vermont, Center for Rural Studies, 146 University Place, 206 Morrill Hall, Burlington, VT 05405, United States

ARTICLE INFO

Keywords:
Mobility
Quality of life (QOL)
Structural equation modeling (SEM)
Rural transportation

ABSTRACT

Many northern rural areas in the United States present particular challenges to providing year-round transportation options for residents. Climate and the distribution of population and amenities present challenges to developing rural mobility systems that may result in a higher quality of life. Using structural equation modeling and a 2009 survey of residents of Vermont, Maine, and New Hampshire, this study estimated how the availability of built amenities, natural amenities, weather and attitudes toward travel explain actual and unserved travel demand and subsequently quality of life. The presence of unserved travel demand significantly decreased quality of life, while the predicted number of trips taken had no impact. With regard to quality of life in northern rural climates, future mobility initiatives would have more impact by addressing trips not taken as measured by unserved travel demand, instead of number of trips or vehicle miles traveled.

1. Introduction

Mobility is a concept that encompasses amenity availability, accessibility, and the ability to get to desired destinations (Miller et al., 2013; Steg and Gifford, 2005). Mobility provides physical, social, and psychological benefits (Metz, 2000) and is a component of quality of life (QOL) (Cutler, 1975; Mollenkopf et al., 2005).

Northern rural areas in the United States are particularly challenging environments in which to provide year-round transportation options that ensure people have access to work, services, social activities, and active, healthy travel options such as biking or walking. Rurality characterizes the human geography of Northern New England, a three-state region located at the northeastern extreme of the United States. A majority of the population resides outside US Census-designated urban areas (Bureau of the Census, 2000), defined by high-density population clusters (Bureau of the Census, 2011) (Fig. 1). The rural built environment and climate of Northern New England communities make the provision of public transit, whether local, regional, or inter-regional, particularly challenging and often cost-prohibitive. Given more poor and elderly residents, small population sizes, lower population densities, limited transportation options and fewer financial resources, important amenities and services (i.e. grocery stores, employment, and places you can walk to) are less available and less accessible in rural areas (Dillman and Tremblay, 1977; Goldsberry and Duvall, 2009; Hart et al., 2002; Hart et al., 2005; Hubsmith, 2007; Velaga et al., 2012). Mobility research has focused primarily on urban areas rather than rural communities (Velaga et al., 2012). Understanding the impacts of mobility on QOL is an important step in building a sustainable mobility system (Mollenkopf et al., 2005; Steg and Gifford, 2005).

Linking mobility and QOL, and building more robust QOL models, is of significant theoretical importance (Felce and Perry, 1995; Metz, 2000). Mobility studies have shown the cause of mobility-loss (Carp, 1988) or effects on QOL (Cutler, 1975), but fail to create a model that links the two. Mattson (2010) shows the factors contributing to unserved travel demand but does not demonstrate ef-

* Corresponding author at: University of Vermont, Dept. of Community Development and Applied Economics, 146 University Place, 202 Morrill Hall, Burlington, VT 05405, United States. Tel.: +1 802 656 4616; fax: +1 802 656 1423.

E-mail addresses: Jane.kolodinsky@uvm.edu (J.M. Kolodinsky), Thomas.DeSisto@uvm.edu (T.P. DeSisto), David.propen@gmail.com (D. Propen), Matthew.Putnam@uvm.edu (M.E. Putnam), eroche1@uvm.edu (E. Roche), c.sawyer@stalbansvt.com (W.R. Sawyer).

[1] Tel.: +1 802 656 3021.
[2] Address: University of Vermont, Dept. of Community Development and Applied Economics, 800 Washington St., #3, Evanston, IL 60202, United States. Tel.: +1 203 214 4022.
[3] Tel.: +1 802 656 2001.
[4] Tel.: +1 802 656 3021.
[5] Address: University of Vermont, Center for Rural Studies, 100 N. Main St., St. Albans, VT 05478, United States. Tel.: +1 802 524 1500.

0966-6923 © 2013 The Authors. Published by Elsevier Ltd. Open access under CC BY-NC-ND license.
http://dx.doi.org/10.1016/j.jtrangeo.2013.05.011

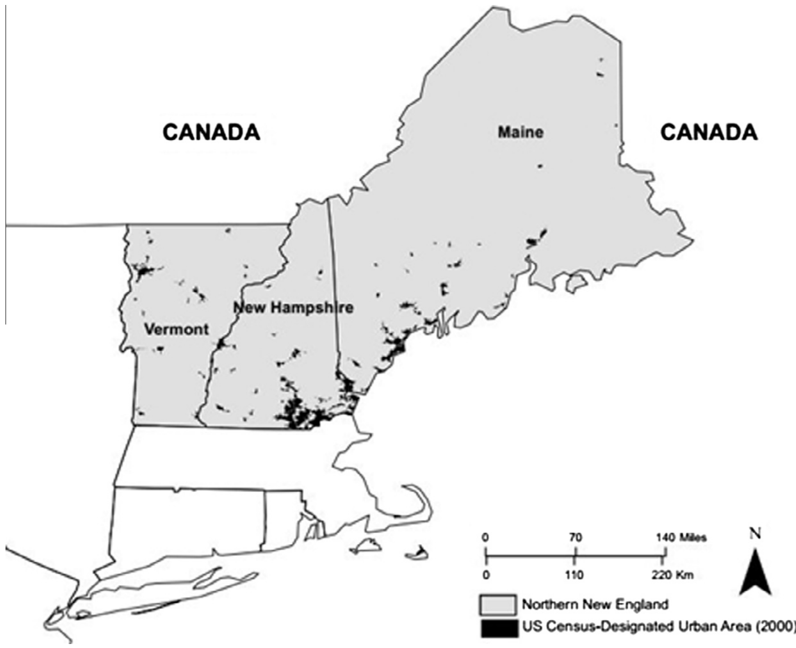

Fig. 1. Northern New England and its urban landscape.

fects on QOL. Felce and Perry (1995) and Mollenkopf et al. (2005) assert the importance of having a QOL model that incorporates a broad range of life domains with both objective and subjective measures.

QOL, though difficult to measure and generalize for entire populations, is most often measured through studying self-assessed life satisfaction and individual well-being (Sirgy et al., 2008; Theodori, 2001) and is believed to be influenced by mobility, the built environment, attitudes, and social wellbeing (Blunden, 1988; Felce and Perry, 1995; Mollenkopf et al., 2005). A summary of QOL drivers and the respective literature is shown in Table 1. This literature has focused on factors that have a positive impact on QOL; however, there are mediating factors that decrease mobility.

This study develops a model both of the factors affecting mobility and of the factors affecting QOL, linking the two in one study. The model presented in this paper captures both objective and subjective measures across multiple domains (e.g., built environment, natural environment). It uses a 2009 survey of residents of Vermont, Maine, and New Hampshire to examine how the availability of built and natural amenities, weather, and attitudes towards travel help to explain actual and unserved travel demand and subsequently QOL in northern rural climates. The specification includes the possibility that variables may have a positive, negative, or no association with QOL.

2. Methods

2.1. Sample and survey design

The data presented here were from the first phase of a four-season panel survey, which focused on the effects of seasonality on mobility and QOL. 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. This study was approved by the University of Vermont's Institutional Review Board (IRB). The survey was conducted using computer-aided telephone interviewing (CATI) and an online data-collection tool. 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 (Dillman et al., 2009). Multiple collection techniques were used to capture a broader segment of the population. 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. No difference was detected between the QOL of the two survey methodologies ($p > 0.10$).

In the first phase of the study, 1,417 surveys were completed out of 4,625 mail and voice contacts, a 31% response rate. The New England Transportation Institute (NETI) provided the list of residents of Vermont, Maine, and New Hampshire, which had been randomly sampled. Of those contacted, 2708 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 were required to be over the age of eighteen years and willing to participate in all four phases of the survey.

As shown in Table 2, 71.4% lived in a rural area, 45.5% of respondents were male, 47.1% had at least a bachelor's degree, the median age was 51 years – greater than the national average but expected given the exclusion of children from the survey – and 52.7% of households had a gross income of over $50,000. Table 3 presents respondents' general attitudes towards travel. One in five respondents (19.5%) reported some form of unserved travel demand, yet over 90% agreed they were able to get where they needed to go. Table 4 presents the perceived availability of eighteen community amenities hypothesized to affect travel demand, mobility and QOL. Neugarten et al. (1961) indicated that the subjective evaluation of quality of life is a valid indicator of overall happiness. Participants were asked to rate their quality of life on a scale of 0–10, with 0 being completely dissatisfied. The mean rating of quality of life was 7.83 among residents, signifying an overall happiness with living conditions despite the inaccessibility of certain amenities such as clothing stores (3.78) and employment (4.33). Note that the survey was administered during the 2008–2009 U.S. economic recession.

Table 1
Review of QOL drivers.

Driver	Review
Effects of mobility on quality of life	Mobility has a direct positive relationship with QOL, especially amongst the elderly (Carp, 1988; Marottoli et al., 2000; Mattson, 2010; Mollenkopf et al., 2005; Owsley, 1997; Scott et al., 2005). Measures of mobility include trip frequencies and unserved demand for trips (Mattson, 2010). Decreased unserved travel demand, or the taking of previously foregone trips, has been hypothesized to lead to increased QOL (Kantor, 2008). Cutler (1972) demonstrated that elderly people without access to a car have 2.5 times the rate of unserved travel demand as those with a car. Metz (2000) found this loss of mobility 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 (Burkhardt, 1999)
Infrastructure effects on quality of life	Both physical and social infrastructure serve to improve accessibility to essential amenities such as healthcare, education, and emergency services (Rowley et al., 1996). 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 (Shafer et al., 2000). Cutler (1972) 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. (2001) also showed that public transportation contributes to QOL and Litman (2010) found that the quality of transportation available effects QOL.
Perceptions of safety effects on quality of life	Safety concerns related to community and travel are another important indicator of QOL (Blunden, 1988; Felce and Perry, 1995; Lehman, 1988; Mollenkopf et al., 2005). Local and neighborhood safety problems have been shown to affect residents QOL (Lee and Guest, 1983; Sirgy and Cornwall, 2002). In a survey of a Florida community, after implementation of street light installations and the creation of safe places to walk and exercise outside, respondents were more likely to feel their community had experienced an increase in QOL (Harduar-Morano et al., 2008)
Social networking effects on quality of life	Social benefits are better promoted in built environments that are pedestrian oriented and highly walkable than in car-dependent suburban neighborhoods (Leyden, 2003). Researchers have shown that social networks and community involvement can have a positive impact on one's QOL (Mollenkopf et al., 2005; Putnam, 2001). Those who are socially engaged with others and are involved in their communities tend to be healthier, both physically and mentally (House et al., 1988; Kawachi and Berkman, 2001; Leyden, 2003). The quality and richness of social relationships with family and friends are widely accepted indicators of QOL (Felce and Perry, 1995). The homophilous characteristics among members of a social network suggest that individuals associate with those with similar socioeconomic and behavioral traits (McPherson et al., 2001), including quality of life
Effects of age on quality of life	As individuals become older, a feeling of losing one's independence sometimes accompanies decreases in mobility (Cutler, 1975), which is a negative contributor to QOL (Felce and Perry, 1995). Increased mobility can significantly increase feelings of independence (Burkhardt, 2000, 2003). Among the elderly, feelings of fear at bus stops and discomfort while traveling are not unusual (Cutler, 1975) and concerns surrounding traffic, the safety of walkable destinations, and the fear of walking-related injuries can all discourage walking (Miles and Panton, 2006)
Effects of weather on quality of life	Weather conditions have been shown to have effects on mobility (Bergström and Magnusson, 2003; Goodwin, 2002). Regular commuting by bicycle was significantly affected by weather conditions such as rain, wind, temperature, and darkness (Bergström and Magnusson, 2003; Emmerson et al., 1998; Nankervis, 1999; Öberg et al., 1996). 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 (Kasper and Scheiner, 2002).

Table 2
Sample demographics compared to region.

	TIYL	American Community Survey		
		VT	ME	NH
Median age (years)	51.0	41.5	41.9	40.3
Mean household size	2.57	2.48	2.34	2.46
% Male respondents	45.5	49.1	48.7	49.2
% Sample income >$50,000	52.7	52.3	46.9	61.7
% Sample with at least a bachelor's degree	47.1	33.8	27.1	33.1
% Sample rural residency	71.4	61.1	61.3	39.7
% Sample with driver's license	97.4	NA	NA	NA
n = 984				

n = 984.
Note: 2008 Median Age in VT, ME, and NH includes over 20% of the population under 18 yrs of age. From American Community Survey SO201 and DP03, 2008 (Bureau of the Census, 2009).

Table 3
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
Unserved travel wants or needs	19.5
Know people with trouble getting needed places	44.0
Household owns 1 or more motor vehicles	97.2

n = 984.

2.2. Measuring responses

To measure the natural and built environment, respondents rated the perceived availability of eighteen community amenities on a scale from zero to ten (with zero being not at all offered, ten being very well offered, and five being a point in the middle), the mean (standard deviation) ratings are shown in Table 4. To measure the attitudes of the respondents on various transportation-related issues shown in Table 3, a five-point Likert Scale was used, ranging from Strongly Agree to Strongly Disagree. Responses were recorded into a binary variable with one representing strongly agree or agree and zero otherwise. Weather was measured on a three-point semantic differential scale and recoded as worse than typical weather or not. Household composition was divided into four variables: single adults without children (SANK), single

Table 4
Amenity and QOL ratings on 0–10 scale.

Variables	Mean (std. dev.)
Quality of life	7.83 (1.67)
Number of trips past 24 h	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 and 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 and 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)

$n = 984$.

adults with children (SAWK), multiple adults without children (MANK), and multiple adults with children (MAWK). Finally, to record trip-making behavior, respondents answered a 24-h recall travel log running from 4am the day before the survey to 4am the day of the survey.

Within this travel log, respondents answered a series of travel questions, such as, "where did you start your day," "what time did you first leave," and "what was the purpose of your trip?" Once respondents 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 respondents stated that they had ended their day at that location (2). The respondents who took zero 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 previous day. A single leg was added to account for the respondents' initial trip away from their starting point.

Additional exogenous variables included in the regression analyses included four nominal variables:

(1) Whether a respondent lived in Maine (1) or anywhere else (0).
(2) Whether a respondent lived in New Hampshire (1) or anywhere else (0)
(3) Whether a respondent considered today a typical day (1) or not (0).
(4) How many years a respondent had lived in northern New England.

Other variables served as intermediary dependent variables and included the nominal variables of whether a respondent had any form of unmet travel demand, (places they wanted or needed to go but did not; yes = 1), whether a respondent had taken at least one trip (yes = 1), the total number of trips taken by a respondent, and the respondent's self-reported QOL measured on a scale of 0–10, with 10 being the highest quality of life.

2.3. SEM

Due to the complex nature of modeling QOL and its influencing variables (Mollenkopf et al., 2005), a structural equation modeling (SEM) approach was used. A series of three models were estimated; Fig. 2 shows the hypotheses 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.

SEM 1 used a standard 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 respondents having anywhere they wanted or needed to go but did not go 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 characteristics, and two measures of the weather. The general model is written (Greene, 2007):

$$\ln(\pi i 1 - \pi i) = \eta i = X' i \beta \quad (1)$$

SEM 2 used 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 may both depend on the same independent variables used in the previous binary logistic model but in opposite directions (Greene, 2007; Fin and Schmidt, 1984; Cragg, 1971). This is a combination of the probit model and the truncated regression model. The initial step, a probit model, served as the indicator of whether the probability of making at least one trip was positive or not. The second step was a truncated regression model that indicated the non-limit observations, or predicted total number of trips made and truncated at greater than zero; here, we included as the dependent variable the total number of trips recorded in the travel log. Independent variables were the same as in the previous binary logistic model. The truncated regression model is written:

$$\mathrm{Prob}(y^* > 0) = \Phi(\gamma' z), \quad (2)$$

$$\mathrm{Prob}(y^* \leq 0) = 1 - \Phi(\gamma' z),$$

if $y^* > 0$, a truncated regression in $\beta' x$ applies (Greene, 2007).

SEM 3 used linear OLS regression techniques with QOL as the dependent variable. QOL was coded on a scale from zero to ten, with zero being completely dissatisfied, ten being completely satisfied, and five being the point in the middle. Included in this regression were the previously included independent variables: community amenities, attitudinal statements regarding travel, characteristics, and measures of the weather. 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. 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.[6] All analyses were conducted with the Statistical Program for Social Sciences (SPSS), version 18.0 and LIMDEP Econometrics Software, version 8.0.

3. Results

Fig. 3 presents a summary of the significant variables of all three models. It provides a graphic representation of the variables in 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. Fig. 3 also displays the significant vari-

[6] To test for multicollinearity, an analysis of the variance inflation factors (VIFs) was conducted. No collinearity was detected within the model; all of the initial variables were included in the final model.

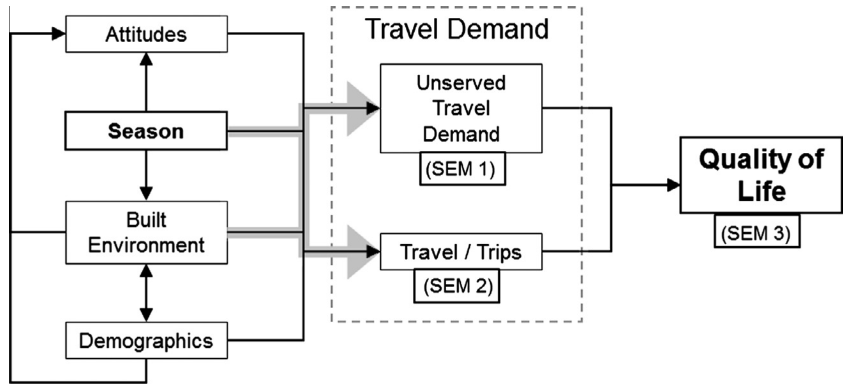

Fig. 2. Built environment, attitudes, seasonality, travel demand, and QOL.

ables coded for the relevant segment of the hypothesized model depicted in Fig. 2.

Tables 5–7 present the estimated results of SEM 1, SEM 2, and SEM 3. Table 5 presents the estimated results of the binary logistic model (Model 1) that predicted the effects of community amenities, attitudes, characteristics, 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 in the community, a feeling of safety in the community, and the availability of at least one motor vehicle in the household. 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 of 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 5.

As shown in Table 5, 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), and if weather affected travel (11.4% increase). Knowing people who had unserved travel demand also significantly increased the probability of unserved travel demand (6.4% increase), suggesting social networking with homophilous association (McPherson et al., 2001). These significant variables and their marginal effects upon the likelihood of unserved travel demand are also shown in Fig. 3.

The second model (SEM 2) predicting the number of trips a respondent made in a given day is shown in Table 6. The perceived availability of grocery stores (0.85 more trips at full availability) and places you can walk to (0.39 more trips at full availability) both increased the number of trips a respondent made in a given day. As did having at least a bachelor's degree (0.27 more trips), living in a multiple adult household with children (0.51 more trips as compared to households with multiple adults and no children),

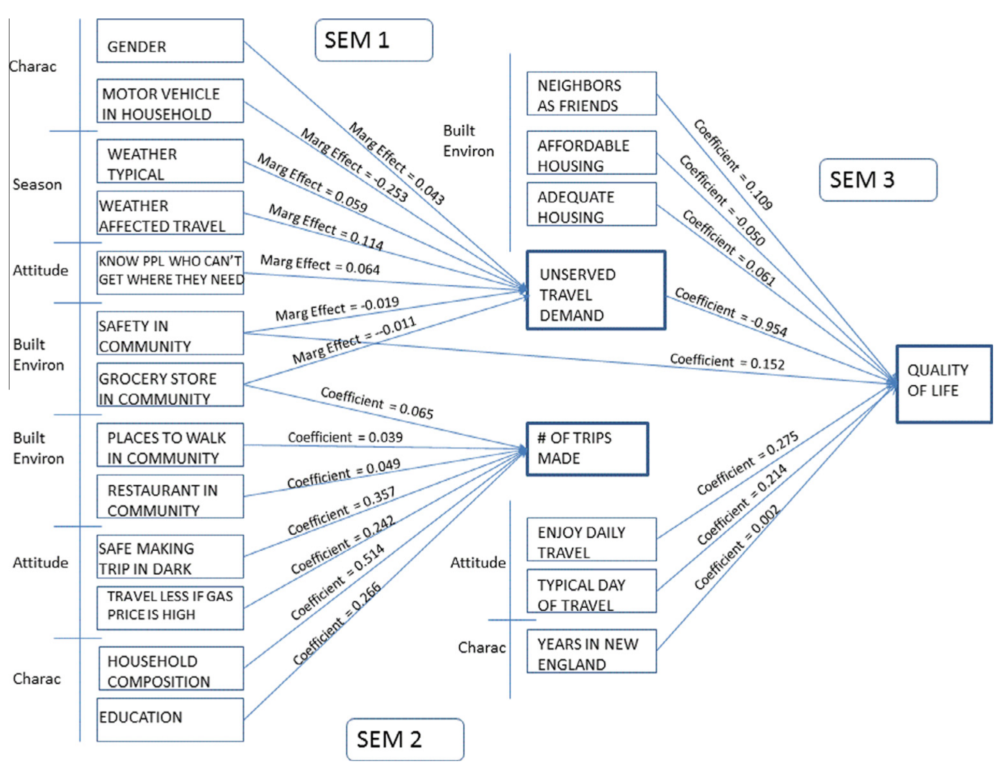

Fig. 3. Structural equation model of significant variables impact on QOL.

Table 5
Binary logistic model to predict probability of unmet travel demand.

	Coefficient	Marginal effects	b/St.Er.	P[|Z|>z
Available amenities				
Constant|	0.615	0.091	0.777	0.437
Built environment				
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
Natural surroundings	0.088	0.013	1.476	0.140
Place of worship	0.034	0.005	0.867	0.386
Services				
childcare	0.065	0.010	1.598	0.110
Arts and entertainment	−0.002	0.000	−0.041	0.967
Education and training	0.025	0.004	0.699	0.485
Employment	−0.071	−0.010	−1.557	0.120
Healthcare provider	−0.015	−0.002	−0.441	0.659
Recreation	−0.010	−0.001	−0.226	0.821
Feeling of safety	−0.127	−0.019	−2.550	0.011**
Social				
Neighbors	0.008	0.001	0.182	0.856
Friends	−0.080	−0.012	−1.587	0.113
Family	−0.003	0.000	−0.104	0.917
Place you can walk to	0.006	0.001	0.186	0.853
Characteristics				
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**
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
Know people with trouble getting needed places	0.428	0.064	2.398	0.017**
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
Season				
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
Attitudes				
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

Note: Model correctly predicted 98.47% of actual 0s (respondents without unmet demand).
$n = 984$.
* $p < 0.10$.
** $p < 0.05$.

and feeling safe making a trip after dark (0.36 more trips). Respondents who agreed that they traveled less when gas prices were high made 0.24 more trips than their counterparts (it should be noted that at the time of data collection, gas prices were lower than in the recent past). The perceived availability of restaurants (0.49 fewer trips per 10-unit increase in availability) decreased the number of trips a respondent made in a given day.

The final model (SEM 3) was a linear OLS regression with the dependent variable QOL, shown in Table 7. The model had an adjusted R Square value of 36.8%. The presence of any form of unserved travel demand decreased QOL by almost 1 unit (−0.954) 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 at full availability), access to neighbors considered friends (1.09 units at full availability), and a feeling of safety (1.52 units at full availability). Also, increasing QOL came from enjoying 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 feeling of safety was the only variable that affected both unserved travel demand (negatively) and QOL (positively). The perceived availability of affordable housing significantly decreased QOL by 0.5 units per 10-unit increase.

Table 6
Truncated probit model to predict # of trips made.

	Coefficient	Standard error	b/St.Er.	P[|Z|>z]
Available amenities				
Constant	1.145	0.573	1.997	0.046**
Built environment				
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
Natural surroundings	0.059	0.038	1.540	0.124
Place of worship	−0.018	0.024	−0.735	0.462
Services				
Childcare	0.014	0.024	0.567	0.571
Arts and entertainment	−0.035	0.026	−1.352	0.177
Education and training	0.005	0.022	0.233	0.816
Employment	−0.027	0.028	−0.964	0.335
Healthcare provider	0.003	0.022	0.156	0.876
Recreation	−0.042	0.027	−1.558	0.119
Feeling of safety	0.018	0.034	0.524	0.600
Social				
Neighbors	−0.019	0.026	−0.752	0.452
Friends	0.027	0.032	0.849	0.396
Family	0.011	0.018	0.622	0.534
Place you can walk to	0.039	0.019	2.068	0.039**
Characteristics				
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
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
At least 1 bicycle	0.038	0.134	0.284	0.776
Know people with trouble getting needed places	−0.109	0.110	−0.990	0.322
Access to public transportation	−0.175	0.119	−1.474	0.140
Valid driver's license	−0.427	0.296	−1.440	0.150
Able to get places you need to go	−0.288	0.219	−1.316	0.188
Season				
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
Attitudes				
Travel less when gas prices high	0.242	0.111	2.176	0.030**
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**
Sigma	1.421	0.042	34.134	0.000

$n = 891$ (observations after truncation).
* $p < 0.10$.
** $p < 0.05$.
*** $p<.01$.

4. Conclusion and discussion

As this research shows, addressing unmet travel demand should be a component of improving QOL in the northern rural climate. While the research concludes that unmet demand is uncommon in the general population, when present it has a large impact on those residents' rating of QOL. Several factors reduce the probability of unmet travel demand, including individual perceptions of grocery store availability and feeling safe in one's community. Safety impacts both the probability of having unmet travel demand and QOL. Clarifying Carp's (1988) finding that having grocery stores in walking distance was positively associated with QOL, this research shows that it only impacts QOL if you cannot travel to one.

Increased trip making should not be the primary objective of future mobility initiatives in northern rural climates, as trip making does not appear to impact QOL. More important 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, keeping in mind that what makes for a higher QOL may vary by community (Kolodinsky et al., 2012; Miller et al., 2013). This may be especially true when considering policies for urban versus rural communities (Steg and Gifford, 2005; Cebollada, 2009).

Table 7
Linear model: QOL regression.

	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]
Built environment				
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 and 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 and 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
Characteristics				
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
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
Maine resident	0.005	0.109	0.048	0.962
New Hampshire resident	−0.090	0.117	−0.776	0.438
Years living in Northern New England	0.002	0.001	1.981	0.048*
Know people with trouble getting needed places	−0.266	0.232	−1.149	0.251
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
Able to get places you need to go	−0.032	0.591	−0.055	0.957
Season				
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
Attitudes				
Travel less when gas prices high	−0.063	0.474	−0.133	0.894
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
Typical day	0.214	0.099	2.168	0.030**
Travel demand				
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.
* $p < 0.10$.
** $p < 0.05$.
*** $p < .0.01$.

Providing public transportation in a primarily rural region is challenging, and Northern New England is no exception. Dufresne et al. (2009) find public transportation accessibility is limited in scale and schedule throughout rural Vermont, while the low-density built environment of many municipalities makes it difficult to link potential users with their destinations. It is not surprising, then, that owning at least one vehicle in the household reduces the probability of unmet demand. Most households in northern New England own at least one motor vehicle but, for households that do not, policy solutions are necessary to reduce the impact of a lack of vehicle ownership on the probability of unmet travel demand. This study concurs that access to a vehicle increases mobility and thereby indirectly affects QOL. However, the models show that mobility rather than car ownership is more important to QOL. Moreover, access to public transport did not affect mobility. Having sufficient mobility to access job opportunities can impact QOL by improving social connections in the community (Cebollada, 2009; Bocarejo, 2012).

Somewhat surprisingly, after controlling for factors including income, vehicles in the household, and driver's license, age was not a significant predictor of the probability of unmet travel demand, number of trips made, or QOL. To date, many public policy solutions have focused primarily on elders (Burkhardt, 1999; Carp, 1988; Cutler, 1972; Gabriel and Bowling, 2004; Mattson, 2010; Metz, 2000; Mollenkopf et al., 2005) and, while elders may be more likely to have unmet travel demand, these results show that it is not necessarily the result of age alone. This suggests that solutions to address unmet travel demand may be focused both more broadly than just older residents, and more specifically on older residents who lack household travel solutions such as a vehicle or valid driver's license. In addition, individuals with unmet travel demand were more likely to know other people with unmet travel demand, suggesting that these people may not have the social infrastructure to overcome their mobility shortages. Finding and targeting these populations may be important for decreasing the prevalence of unserved travel demand. Based on the results of the SEM models, a focus on solutions that help people get where they need to go, not necessarily to make more trips, will do more to address QOL, especially among those who experience unserved travel demand.

A strength of this research is that it allows for direct and indirect effects on QOL mediated through unserved travel demand and trip making. Identifying both the direct and indirect effects allows policy makers to be better informed. Policy solutions that focus more on the underlying cause of unmet demand, such as programs that provide vehicle access or mitigate the need for travel altogether, may provide more sustainable success in addressing unmet travel demand, and thereby improving QOL (Carp, 1988; Cutler, 1975; Mattson, 2010). Policy solutions may take multiple avenues; policymakers could stimulate or support more local grocery stores or they may address the lack of transportation to existing regional grocery stores, for example.

This study highlights the need for future research to address populations facing unserved travel demand. To make effective policy, an in-depth examination of which population groups are being adversely affected is needed. In addition, this study is conservative in its scope as responses are from the spring when weather is less severe. Future studies should incorporate all the seasons and actual weather observations to address the subjective and objective effects of weather and seasonality on mobility and quality of life.

Acknowledgements

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

References

Bergström, A., Magnusson, R., 2003. Potential of transferring car trips to bicycle during winter. Transportation Research Part A: Policy and Practice 37, 649–666.
Blunden, R., 1988. Quality of life in persons with disabilities: issues in the development of services. In: Brown, R.I. (Ed.), Quality of Life for Handicapped People. Croom Helm, London, pp. 37–55.
Bocarejo S., J.P., 2012. Transport accessibility and social inequities: a tool for identification of mobility needs and evaluation of transport investments. Journal of Transport Geography, 24, 142–154.
Bureau of the Census. 2000. Census of Population and Housing, Population and Housing Unit Counts PHC-3. <www.census.gov/prod/cen2000/index.html>.
Bureau of the Census. 2009. American Community Survey. DP03: Selected Economic Characteristics and Population Profile, 2008. http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml.
Bureau of the Census. 2011. Urban Area Criteria for the 2010 Census. Federal Register 76, 164, 53030–53043. <www.census.gov/goe/reference/ua/urban-rural2010.html>.
Burkhardt, J., 1999. Mobility changes their nature, effects, and meaning for elders who reduce or cease driving. Transportation Research Record 1671, 11–18.
Burkhardt, J., 2000. Coordinated Transportation Systems. AARP, Washington, DC.
Burkhardt, J., 2003. Improving public transit options for older persons. In: Paper Presented at the International Conference on Aging, Disability, and Independence, Arlington, VA: 4–6 December.
Carp, F.M., 1988. Significance of mobility for the well-being of the elderly. In: Transportation in an Aging Society: Improving Mobility and Safety for Older Persons, vol. 2. Washington, DC, Transportation Research Council Special, Report SR218B, pp. 1–20.
Cebollada, A., 2009. Mobility and labour market exclusion in the Barcelona Metropolitan Region. Journal of Transport Geography 17, 226–233.
Cragg, J., 1971. Some statistical models for limited dependent variables with application to the demand for durable goods. Econometrica 39, 829–844.
Cutler, S., 1972. The availability of personal transportation, residential location, and life satisfaction among the aged. The Journal of Gerontology 27, 383–389.
Cutler, S., 1975. Transportation and changes in life satisfaction. The Gerontologist 15, 155–159.
Dillman, D., Tremblay, K., 1977. The quality of life in rural america. Annals of the American Academy of Political and Social Science 429, 115–129.
Dillman, D.A., Smythe, J., Christian, L., 2009. Internet, Mail, and Mixed-Mode Surveys: The Tailored Design Method, third ed. John Wiley & Sons, Inc., Hoboken, NY.
Dufresne, K., Raines, C.R., Souffrant, C., Wohlgemuth, T.K., 2009. Public Transportation in Vermont: An Assessment of Applicable Methods of Improvement and Funding for Vermont Transportation. Rockefeller Center at Dartmouth College, Hanover, NH.
Emmerson, P., Ryley, T., Davies, D., 1998. The impact of weather on cycle flows. Traffic Engineering & Control 39, 238–243.
Felce, D., Perry, J., 1995. Quality of life: its definition and measurement. Research in Developmental Disabilities 16, 51–74.
Fin, T., Schmidt, P., 1984. A test of the Tobit specification against an alternative suggested by Cragg. Review of Economics and Statistics 66, 174–177.
Gabriel, Z., Bowling, A., 2004. Quality of life from the perspectives of older people. Ageing & Society 24, 675–691.
Goldsberry, K., Duvall, C., 2009. Visualizing nutritional terrain: an atlas of produce accessibility in Lansing, Michigan, USA. American Journal of Preventative Medicine 36, 485–499.
Goodwin, L., 2002. Weather Impacts on Arterial Traffic Flow. US Department of Transportation, Washington, DC.
Greene, W., 2007. LIMDEP Version 9.0 Economic Modeling Guide. Plainview, NY, Economic Software, Inc.
Harduar-Morano, L., Price, J.R., Parker, D., Blackmore, C., 2008. PACE EH post project assessment of quality of life changes in a florida community related to infrastructure improvements. Journal of Environmental Health 70 (10), 40–46.
Hart, G., Larson, E., Lishner, D., 2005. Rural definitions for health policy and research. American Journal of Public Health 95, 1149–1155.
Hart, L., Salsberg, E., Phillips, D., Lishner, D., 2002. Rural health care providers in the United States. The Journal of Rural Health 18, 211–232.
House, J., Landis, K., Umberson, D., 1988. Social relationships and health. Science 241, 540–545.
Hubsmith, D., 2007. Rural Communities: Rural Safe Routes to School. Diverse Community Roundtable Meeting Notes. <www.saferoutespartnership.org/resourcecenter/enews/>.
Kantor, S., 2008. The Economic Impact of the California High-Speed Rail in the Sacramento/Central Valley Area. Merced, CA: University of California (Merced).
Kasper, B., Scheiner, J., 2002. Leisure mobility and mobility problems of elderly people in urban, suburban and rural environment: preliminary results from the research project FRAME. In: Paper presented at the 42nd Congress of the European Regional Science Association. Dortmund: German Federal Ministry of Education and Research, 27–31 August.
Kawachi, I., Berkman, L.F., 2001. Social ties and mental health. Journal of Urban Health 78, 458–467.
Kolodinsky, J., Roche, E., DeSisto, T., Sawyer, W., Propen, D., 2012. Understanding quality of life in a northern, rural climate. Community Development, 1–12 doi: 10.01080/15575830.2012.720580.
Lee, B.A., Guest, A.M., 1983. Determinants of neighborhood satisfaction: a metropolitan-level analysis. Sociological Quarterly 24, 287–303.
Lehman, A.F., 1988. A quality of life interview for the chronically mentally ill. Evaluation and Program Planning 11, 51–62.
Leyden, K.M., 2003. Social capital and the built environment: the importance of walkable neighborhoods. American Journal of Public Health 93, 1546–1551.
Litman, T., 2010. Evaluating Transportation Equity: Guidance For Incorporating Distributional Impacts in Transportation Planning. Victoria Transport Policy Institute, Victoria, BC.
Marottoli, R.A., Mendes de Leon, C.F., Glass, T.A., Williams, C.S., Cooney Jr., L.M., Berkman, L.F., 2000. Consequences of driving cessation: decreased out-of-home activity levels. The Journal of Gerontology: Series B: Psychological Sciences and Social Sciences 55, S334–S340.
Mattson, J., 2010. Aging and mobility in rural and small urban areas: a survey of north Dakota. Journal of Applied Gerontology 30, 700–718.
McPherson, M., Smith-Lovin, L., Cook, J.M., 2001. Birds of a feather: homophily in social networks. Annual Review of Sociology 27, 415–444.
Metz, D., 2000. Mobility of older people and their quality of life. Transport Policy 7, 149–152.
Miles, R., Panton, L., 2006. The influence of the percieved quality of community environments on low-income women's efforts to walk more. Journal of Community Health 31, 379–392.
Miller, H.J., Witlox, F., Tribby, C.P., 2013. Developing context-sensitive livability indicators for transportation planning: a measurement framework. Journal of Transport Geography 26, 51–64.
Mollenkopf, H., Marcellini, F., Ruoppila, I., Széman, Z., Tacken, M. (Eds.), 2005. Enhancing Mobility in Later Life. IOS Press, Amsterdam.
Nankervis, M., 1999. The effect of weather and climate on bicycle commuting. Transportation Research Part A: Policy and Practice 33, 417–431.

Neugarten, B.L., Havinghurst, R.J., Tobin, S.S., 1961. The measurement of life satisfaction. The Journal of Gerontology 16, 134–143.
Öberg, G., Nilsson, G., Velin, H., Wretling, P., Berntman, M., Brundell-Freij, K., Hydén, C., Ståhl, A., 1996. Single Accidents Among Pedestrians and Cyclists. Linkoeping, Sweden: VTI Meddelandea 799A.
Owsley, C., 1997. Clinical and research issues on older drivers: future directions. Alzheimer Disease and Associated Disorders 11, 3–7.
Putnam, R.D., 2001. Bowling Alone: The Collapse and Revival of American Community. Simon and Schuster, New York.
Raphael, D., Renwick, R., Brown, I., Steinmetz, B., Sehdev, H., Phillips, S., 2001. Making the links between community structure and individual well-being: community quality of life in Riverdale, Toronto, Canada. Health & Place 7, 179–196.
Rowley, T., Sears, D., Nelson, G., Reid, N., Yetley, M., 1996. Rural Development Research: a Foundation for Policy. Greenwood Publishing Group, Westport, CT.
Scott, D., Newbold, K., Spinney, J., Mercado, R., Páez, A., Kanaroglou, P., 2005. Changing Mobility of Elderly Urban Canadians, 1992–1998. McMaster University Centre for Spatial Analysis Working Paper Series, Hamilton. <http://www.science.mcmaster.ca/cspa/papers/CSpA%20WP%20007.pdf>.
Shafer, C., Lee, B., Turner, S., 2000. A tale of three greenway trails: user perceptions related to quality of life. Landscape and Urban Planning 49, 163–178.
Sirgy, M., Cornwall, T., 2002. How neighborhood features affect quality of life. Social Indicators Research 59, 79–114.
Sirgy, M., Gao, T., Young, R., 2008. How does residents' satisfaction with community services Influence quality of life (QOL) outcomes? Applied Research in Quality of Life 3, 81–105.
Steg, L., Gifford, R., 2005. Sustainable transportation and quality of life. Journal of Transport Geography 13, 59–69.
Theodori, G.L., 2001. Examining the effects of community satisfaction and attachment on individual well-being. Rural Sociology 66, 618–628.
Velaga, N.R., Beecroft, M., Nelson, J.D., Corsar, D., Edwards, P., 2012. Transport poverty meets the digital divide: accessibility and connectivity in rural communities. Journal of Transport Geography 21, 102–112.