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Evaluating Heterogeneity in Household Travel Response to Carbon Pricing: A Study Focusing on Small and Rural Communities

Authors

Rowangould, Gregory
Ahmadnia, Narges
Nelson, Clare
et al.

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Evaluating Heterogeneity in Household Travel Response to Carbon Pricing: A Study Focusing on Small and Rural Communities

December 2024

A Research Report from the National Center for Sustainable Transportation

Gregory Rowangould, University of Vermont

Narges Ahmadnia, University of Vermont

Clare Nelson, University of Vermont

Erica Quallen, University of Vermont

Julia Clarke, University of Vermont

National Center for Sustainable Transportation
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16. Abstract

Smaller and rural communities are often automobile dependent, a fact that has raised considerable concerns about the equity and effectiveness of market-based climate strategies including carbon taxes and carbon cap and trade schemes in rural states like Vermont. A lack of research and data describing how people in smaller and rural communities respond to changes in transportation costs is a critical gap to informing the design of market-based greenhouse gas mitigation policies and evaluating their potential outcomes. This report describes several related studies that focus on understanding the opportunities and constraints that people face in changing how they travel in small and rural communities in Vermont and also evaluates the equity implications of gas tax alternatives. The research is informed by data collected by the researcher team from interviews, surveys and unique administrative datasets. Findings show that urban, suburban, and rural households all made significant travel adjustments in response to higher gas prices. Urban households were more likely to substitute their mode of transportation or move and rural households were more likely to adopt an electric vehicle (EV); however, most people in all community types were able to reduce the amount they travel by making fewer or shorter trips. Greater accessibility and more transit options were noted as barriers to change in all communities studied. Significant concerns about the feasibility of EVs were common and also shared across all communities. Overall, these findings suggest that market-based climate policies could be effective, even in smaller and rural communities. The authors also find that many people misunderstand how the gas tax is collected and what it funds, resulting in widely held beliefs that a milage base fee alternative would be unfair, particularly to rural households. Using motor vehicle registration and inspection records, the researchers demonstrate that a milage based user fee would be somewhat less regressive than the current gas tax and also less costly than the gas tax to rural households on average in Vermont. They also find that providing simple, factual, information about the gas tax and alternatives can significantly shift public support for gas tax alternatives in Northern New England.

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Disclaimer

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Evaluating Heterogeneity in Household Travel Response to Carbon Pricing: A Study Focusing on Small and Rural Communities

A National Center for Sustainable Transportation Research Report

December 2024

Gregory Rowangould, Department of Civil and Environmental Engineering, University of Vermont

Narges Ahmadnia, PhD Student**,** Civil and Environmental Engineering, University of Vermont

Clare Nelson, MS Student, Civil and Environmental Engineering, University of Vermont

Erica Quallen, MS Student, Civil and Environmental Engineering, University of Vermont

Julia Clarke, BS Student, Civil Engineering, University of Vermont

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EXECUTIVE SUMMARY

Most of the research conducted on travel behavior and sustainable transportation has concentrated heavily on cities and urban environments, born from a legacy of focus on congestion and air quality concerns. Addressing climate concerns, however, requires reducing greenhouse gas emissions from travel occurring everywhere, including the wide range of small cities, towns, suburbs and rural communities where many people in the United States live and work. Smaller and rural communities are often automobile dependent, a fact that has raised considerable concerns about the equity and effectiveness of market-based climate strategies including carbon taxes and carbon cap and trade schemes in states with large rural populations like Vermont. A lack of research and data describing how people in smaller and rural communities respond to changes in transportation costs is a critical gap to informing the design of market-based greenhouse gas mitigation policies and evaluating their potential outcomes.

This research project focused on two aspects of transportation pricing in small to rural communities.

The first part of this research project focused on how people responded to an actual changes in prices and how they perceive they would change their travel if prices remain high. We began by asking people in Vermont who lived in a range of small urban to dispersed rural areas how they traveled, perceived barriers to driving less, and about how they responded to the sudden increase in gasoline and diesel prices during the spring of 2022.

We collected data through 173 structured in-person interviews during the spring and summer of 2021 with people living in 43 different municipalities in Vermont, asking questions about travel patterns, responses to hypothetical changes in fuel prices, attitudes towards electric vehicles (EVs), and the identification of obstacles and opportunities related to curtailing GHG emissions from their transportation and their community's. When the price of gasoline surged from $3.5 per gallon to a peak of $5.02 per gallon between March 2022 and May 2022, we also distributed an electronic survey to 40,000 random e-mail addresses of people living in Vermont and asked them to describe how they had responded. We also asked them to describe how else they would respond if prices were to remain high and about barriers they faced in avoiding higher prices.

Key findings from this part of the project included:

Urban, suburban, and rural households all made significant travel adjustments in response to higher gas prices. Urban households were more likely to substitute their mode of transportation or move and rural households were more likely to adopt an EV; however, most people in all community types were able to reduce the amount they travel by making fewer or shorter trips.

People's attitudes and beliefs significantly influence the decisions they make when faced with price increases. Individuals who exhibit higher levels of environmental concern or political activism tend to have a greater likelihood of making changes in response to price increases. Conversely, having a higher preference for car travel enjoyment are less likely to make changes in their travel behavior.

Greater accessibility and more transit options were noted as barriers to change, even in rural areas where accessibility and transit are generally not expected. Improvement in transit, safer biking and walking, closer shopping locations were likely to reduce the amount of respondent's driving within each community type. Particularly in rural areas, the challenge of distant access to essential services underscores the potential of promoting denser, mixed-use village centers.

There is still a lot of concern about EVs, and the differences are not very different across community types. Costs, charging station availability, range, charging speed, 4-wheel drive and truck and SUV models were all important factors to adopt an electric vehicle, with range being the largest concern among urban and rural households. Moreover, a significant portion of individuals remained uninformed about the rebate and incentive initiatives extended by the state. Among those who had knowledge of these programs, a notable number expressed skepticism regarding their adequacy in offsetting vehicle costs.

The second part of the project responded to an emergent question about milage based user fees in Vermont at the time we were completing the research described above. Mileage fees, or road user charges, are being explored as an alternative to motor fuel taxes (colloquially, "gas taxes") in the United States. The search for alternatives is motivated by rising fuel efficiency standards and fleet electrification, which have diminished the revenue generating capacity of state and federal gas taxes. While mileage fees are a more stable and fuel agnostic transportation funding source, they face criticism due to concerns surrounding individual location and privacy protection as well as widely held perceptions that they would raise costs for low income and rural households.

In response to these questions, we surveyed households in Vermont, New Hampshire, and Maine to evaluate current levels of support for mileage fees and the extent to which providing information about the policy options and their costs modifies support for a policy shift. We also used vehicle registration and odometer data to evaluate how replacing the gas tax with a mileage fee shifted the distribution of tax burden across Vermont community types and households.

Key findings from this part of the project included:

Basic knowledge about the gas tax is lacking. Survey respondents were largely misinformed about how the gas tax charged users (e.g., it is an excise tax or price per quantity), when it was last increased, and what the revenue from the gas tax funds. Misconceptions about the gas tax may contribute to opposition to policy alternatives.

Support for mileage fees increases when common mileage fee misconceptions are addressed. By modeling the relationship between respondent mileage fee support and personal attitudes and demographics, we find that initial perceptions of mileage fees are strongly associated with perceived mileage fee cost, privacy, and fairness concerns. After two educational treatments designed to address common misconceptions about what gas tax revenues are used for, mileage fee collection options, and equity, and the cost difference that each respondent could expect based on driving and vehicle data they provided, support for the policy increased by 11%. Overall, we find that respondents were 2.5 times as likely to support a mileage fee by the end of the educational treatments. This result suggests that relatively simple learning experiences using non-biased and tailored cost information can cause substantial changes in policy support.

While mileage fees are commonly perceived as more inequitable, the data says otherwise. Our analysis of Vermont vehicle registration records and odometer data shows that on average rural households currently pay more gas tax than urban households and would continue to do so with a milage fee—but the cost difference would shrink. On average, rural and low-income communities see reductions in their tax burden compared to their urban and high-income counterparts. Households in rural and low-income areas save money with a milage fee because they tend to own vehicle with lower fuel economy.

Replacing the gas tax with a revenue-neutral mileage fee results in small annual cost differences for households. Our data show that most households will experience shifts in tax burden between -$5 and $50, with an average of $23 increase. Commercial vehicles tend to have lower fuel economies and therefore save more money when switching away from a fuel tax. To lessen the tax burden on personal vehicle owners, mileage fees could be separated for commercial and residential vehicles.

Chapter 1: Introduction

The need to better understand rural travel behavior has never been greater or more urgent. Transportation is the largest source of greenhouse gas (GHG) emissions in the US, and transportation GHGs are particularly significant in small and rural (S&R) communities where 30% of U.S. auto-travel occurs, according to highway statistics collected by the US Department of Transportation and the average person travels 40% farther that their urban counterparts according to data tabulated in the Transportation Energy Data Book (*1*). A significant body of travel behavior research seeks to predict how infrastructure investments, technology and policies can reduce GHG emissions from transportation, however the vast majority of this research has been conducted in urban areas. As a result, very little is known about how people and households in S&R communities make travel decisions and how they respond to changes in transportation infrastructure, technology, and policies. Strategies that have been found to reduce GHGs in urban areas are likely to be ineffective in S&R communities due to differences in transportation options, the built environment, socioeconomics, values and norms, attitudes, and beliefs.

This research aims to begin addressing the need for a deeper understanding of travel behavior in S&R communities by conducting exploratory qualitative research in a wide range of small and rural communities in Vermont to identify travel barriers, taking advantage of a sudden increase in gasoline prices during the spring of 2022 to survey Vermont residents about how they actually responded to higher prices, developing a unique learning experiment to understand the influence of education on support for gas tax alternatives in small and rural communities and using a novel vehicle registration and odometer dataset to evaluate the redistribution of tax burdens with a transition to a milage fee program in Vermont and understand what rural travel looks like under different definitions of the urban to rural continuum.

This research is described in a series of papers that make up the remaining chapters of this report.

Chapter 2: Consistently Inconsistent: An Assessment of Definitions of Rural and Travel Behavior Outcomes in Vermont

Erica Quallen and Gregory Rowangould

Introduction

As of 2018, 45% of the world's population lived in non-urban areas, yet the word "rural" does not appear once in the 2019 revision of the United Nations' World Population Prospects (*2*). Urban systems are seen as centers of economic growth, significant sources of resource and energy consumption, and environmental pollution, so these are more frequently studied, but there is an increasing interest in assessing development progress and transportation systems in rural areas (*3*). Understanding transportation systems in rural communities is paramount to developing effective, efficient, and equitable policies which are tailored to meet the needs of each targeted community. In the United States, state and federal agencies attempt to do this by classifying cities and towns as accurately as possible along the urban-rural continuum, but numerous definitions appear across various areas of study. Being defined as urban or rural can decide if a region is eligible for certain funding opportunities and policy applications including those coming from the United States Department of Agriculture (USDA) Rural Development Program which funds transportation projects across the country but require a local designation of rural. There are also many US Department of Transportation (USDOT) rural funding programs that require this same designation, including the Rural Transit Assistance Program and others under the Rural Opportunities to Use Transportation for Economic Success Initiative. When definitions of urban and rural are assumed to give the whole picture of distinctions between these types of communities, it can lead to the misdirection of federal programs and funds (*4*). Without a clear understanding of which communities are rural and what that means in terms of explaining the heterogeneity of travel behavior in these areas, transportation planners and policymakers are left to follow department-specific standards when choosing which of the various classification schemes to use. This leaves communities to be impacted in ways which were decided by the policy maker and their department or jurisdiction rather than from an objective analysis of the behavior and needs of the area. Without filling this gap of how rural definitions represent travel behavior, this pattern of simplistic definitions determining the allocation of funds will persist. In this study, we use a dataset of Vermont registration and inspection records to assess vehicle miles traveled (VMT) under different definition schemes to understand the variance of distributions across these definitions and discuss policy implications of inaccurate representations of travel behavior, particularly in rural areas.

Travel behavior can be defined in a multitude of ways including mode choice, number of trips, vehicle miles traveled, or safety. Most of the research on these behavioral components occur in urban areas or simply dichotomize urban and rural areas. In these studies, it is generally agreed upon that individuals living in rural areas have higher rates of vehicle ownership, increased trip distances, walk less for transportation, and generally have less accessibility to services than their urban counterparts (*5*–*7*). These conclusions may not show the whole picture due to their lack of nuance provided in their definitions of what constitutes urban versus rural areas. Can it really be said with certainty that all rural communities exhibit this pattern of more and longer distance travel than urban communities? Policymakers and planners must rely on existing representations of urban and rural travel behavior, whether it is an accurate picture of behavior or not. To know if these claims are true, more in-depth analysis needs to be completed which captures additional information about how these rural communities are made up in terms of transportation systems, public transit access, land use, and other characteristics related to these areas. Only when planners and policymakers have a more informed view of the communities, they serve can impactful policy be designed and implemented to improve transportation in rural areas.

Defining "Rural"

Rural areas are often understood as neither urban nor metropolitan, but with 83% of the United States' geographic area classified as "rural", such communities require a wider body of scholarship and their own robust definition that accounts for the diversity present. Rural communities are inconsistently, and often vaguely defined due to varying definition techniques and a lack of available data (*3*, *8*). When various definitions exist for a single term such as "rural" or "urban", levels of urbanization and demographic characteristics can be analyzed in ways that suit the researcher or the needs of the policy, rather than by what is objectively observed. Identifying areas with low population is a typical approach to designating rural areas, although the population threshold is unclear, with the United States Department of Transportation Federal Highway Administration (USDOT FHWA) using proximity to areas with 5,000 people or areas outside of metropolitan areas of 50,000 people (*9*) and many other organizations using different thresholds or entirely different categorizations. Using the USDOT's values, the entire state of Vermont and the majority of New Hampshire and Maine fall generally under the heading of rural.

Urban and rural are usually taken to be distinct types of communities, with high density and mixed-use land use patterns defining urban areas and sprawling farmland and villages defining rural areas. This fails to take into account the integration of these areas and the interplay between their forms and functions. Particularly at the county level, researchers, planners, and policymakers can fall into a "county trap" and does not consider the presence of rural people and places in urban counties and vice versa (*4*). By doing this, planners in particular, look at the counties for which they are responsible and see only the urban areas, neglecting the planning needs of rural communities (*10*).

Federal level definitions the Office of Management and Budget (OMB), National Center for Health Statistics (NCHS), and National Center for Education Statistics (NCES), and five coming from the USDA Economic Research Service (ERS). The definitions coming from the USDA ERS are typically used for social science research, policy development, and program administration (*11*). The adoption of these USDA ERS definitions as decision making tools has come after they were developed originally for research purposes. The NCHS and NCES definitions, however, were designed with more practical applications in mind. The NCHS definition is primarily used for analysis of associations between community types and public health outcomes, while the NCES definition is used to define which schools are eligible for rural specific educational and professional development programs and funding. When looking globally, a 2018 pilot test was conducted to develop an international definition and in 2020, the “Degree of Urbanization” standard was endorsed by the UN Statistical Commission as the recommended method for comparing urban and rural definitions across international boundaries (*12*, *13*). The newly recommended Degree of Urbanization standard involves three classes which extend to: (1) cities, dense and semi-dense towns, suburban or per-urban areas, villages, dispersed rural areas, and mostly uninhabited areas; and (2) a commuting zone around each city to create a functional urban or metropolitan area.

While some definitions take into account specific attributes of an area, simplistic definitions of urban and rural are commonly used because they can rely on easily accessible data but often, these basic data contain differing levels of correlation between variables, and can perpetuate myths regarding stereotyped communities (*3*, *8*, *14*). For example, rural communities have typically been associated with agricultural land and employment, but there has been a gradual shift away from an agricultural focus in favor of movement towards a more diversified economy (*8*). Other potential, more data intensive, measures may be used in place of the typical categorical definitions involving population. One study conducted in the US suggests using “(1) population of the largest place in the county; (2) root sum of squared populations of the three largest places; and (3) root sum of squared population of all places” (*14*). By using new or combined means of identifying rural areas, a clearer picture of the types of communities may emerge.

Some studies look to bring more detail into the continua developed by defining multiple urban and suburban types, but classify the rest generally as rural, if rural is even a category (*15*, *16*). Voulgaris et al. established seven neighborhood types across the country, only one of which was rural, described as “new development rural”, thereby leaving out rural areas that have an older history or lack much development. The variables in this study were wider ranging than the USDOT or US Census definitions, including job access within a 45-minute drive, housing density, network density (including roadways, sidewalks, intersections, etc.), and employment share of office and retail jobs. Applying these variables to 30,000 census blocks across the US, 20% were identified as “new development rural” and the rest were categorized as some type of urban or suburban (*15*). The 2010 census, as previously mentioned, identified 83% of the country’s geographic area and approximately 20% of the population as rural. There is clearly more than one way of defining what is constituted as a rural community.

Wineman et al. found different levels of urbanization in Tanzania when using administrative categorizations, population data, nighttime lights, or economic characteristics to classify areas (*8*). They illustrate this well by showing that the share of urban populations varies between 12 and 38% depending on which rural identification technique is used. In the same study, household income from the same source varies between 37% and 42%. When income or levels of urbanization are misrepresented, resources and funding may not be allocated in an equitable manner. Proper designations could also affect the quality of data, as current inconsistent or excessively broad data create issues when comparing rural vs. urban areas (*17*). This requires that locations be accurately designated to ensure proper planning and resource allocation. Hart and their colleagues identify the need for the definition of rural to measure something “explicit and meaningful, be replicable, be derived from available, high-quality data, be quantifiable and objective, and have on-the-ground validity” (*18*). Taking this approach in Vermont may lead to data skewed by the few metropolitan areas which may still be considered rural using many of the current criteria as they have low populations, despite being urban compared to the rest of the state.

Research on the connection between travel behavior, land use, and rurality exists in numerous forms including the development of typologies which consider these factors in determining urbanicity and rurality as previously mentioned (*15*, *16*). These studies seek to characterize the built environment and assess the relationship between this and travel behavior for various land use schemes and therefore, creating definitional schemes that more accurately represent transportation networks and their use. Other studies focus on existing definitions and how they have a direct impact on statistical analysis that will subsequently influence policy (*12*). This study by the European Commission shows the disjointed nature of global definitions of urbanicity and proposes a unified framework that will capture more of the continuum that exists within and across communities. The current classification scheme is used to capture local, national, and international statistics which are used for research and policy development in nearly all fields of study, including the study of transportation infrastructure and mobility. These definitions extend beyond statistics, performance measures, and policies and into the realm of sustainability, livability, and equity. Transportation data, categorized by their urbanicity and rurality, are used to assess access to goods and services needed for members of society to be included socially and physically (*19*). The ability to accurately assess mobility needs and opportunities based on rurality can allow for effective and efficient planning and policies which will facilitate stronger communities, but this cannot happen if we do not understand how these communities travel.

With the rising interest in better understanding rural communities, we seek to add to the body of literature on rural communities and their travel behavior. This paper presents numerous classification schemes for identifying varying levels of urbanicity and rurality and then compares six of them using vehicle miles traveled (VMT) per person and per vehicle. These definitions are applied at different geographic scales and the subsequent discrepancies and potential implications are discussed at the conclusion of the paper. Using this analysis, we seek to explore if there are varying outcomes when applying the same dataset to different definitions. If there are differences, what are the implications of this when looking to understand travel behavior in communities across Vermont and the US? To do this, we will apply a dataset from the Vermont Department of Motor Vehicles (DMV) registration records and statewide inspection records which include yearly odometer readings. VMT per person and per vehicle was calculated and aggregated to the scales used by six of the definitions to identify any discrepancies and discuss how this may impact policy decisions regarding travel behavior. Through this process, more light can be shed on the true travel behavior observed in various community types, not simply relying on overarching assumptions (often based only on population or population density) about how rural individuals interact with the transportation system. By aggregating data to define community types, there is a loss of observed variance which may lead to conclusions which cannot be trusted and relied upon. The impact of this is unclear in terms of allocated funding and proposed policies in rural communities.

Table 1 describes 18 different definitional schemes for urban and rural areas from international organizations, federal agencies, and academic sources. These definitions range from highly simplistic (i.e., urban, suburban, and rural) to very detailed (i.e., 12 levels of urbanicity and rurality). It is not clear if one of these styles is better than the other; all may have their proper time for use and this paper does not propose a preferred approach. Some of these definitions, such as the US Census, National Household Travel Survey (NHTS), FHWA, or Rural Urban Commute Area (RUCA) definitions are used for the purpose of transportation research, planning, and funding allocation. They all use slightly different metrics and have differing level of detail in terms of their spectrum of urbanicity. Of these four definitions, only one of them (RUCA) uses travel behavior as an indicator of urban or rural travel behavior. By applying only population thresholds, as the other three definitions do, the heterogeneity of travel behavior across communities is likely not captured. The purpose of this research is an examination of the current literature and an analysis of these definitions when applied to the same travel behavior dataset. By studying the wide-ranging definitions of rurality, we are looking to examine if any or all of these definitions align with the current understanding of travel behavior.

Table 1. Rural Definitions from Federal and Research Sources

Source	Definition	Geographic Unit	Usage
United Nations (*12*)	*Cities* – Local unites that have at least 50% of their population in urban centers *Dense Towns* – have a larger share of their population in dense urban clusters than in semi-dense urban clusters (i.e., it is dense) and a larger share in dense plus semi-dense urban clusters than in suburban or peri-urban cells (i.e., it is a town). *Semi-Dense Towns* – have a larger population share in semi-dense urban clusters than in dense urban clusters (i.e., it is semi-dense) and a larger share in dense plus semi-dense urban clusters than in suburban or peri-urban cells (i.e., it is a town) *Suburban/Peri-Urban* – have a larger population share in suburban or peri-urban cells than in dense plus semi-dense urban clusters *Villages* – Have the largest share of their rural grid cell population living in a rural cluster *Dispersed Rural* – have the largest share of their rural grid cell population living in low density rural grid cells *Mostly Uninhabited* – have the largest share of their rural grid cell population living in very low-density rural grid cells.	1 km^2 grid cell	International unified definition for analysis of national metrics
US Census (*20*)	*Urban Area* – Area with population of 50,000 or more *Urban Cluster* – Area with population between 2,500 and 50,000 *Rural* – Any area not in an urban area or cluster	Combination of census blocks and tracts	Federal funding allocations; grant award eligibility

Source	**Definition**	**Geographic Unit**	**Usage**
Federal Highway Administration (*9*)	*Urban* – Counties or regions with population of 50,000 or more *Urban Boundary Rural* – Counties or regions bordering metropolitan centers and are highly developed *Developed Rural* – Fundamentally dispersed counties or regions with one or more population center(s) of 5,000 or more *Basic Rural* – Dispersed counties or regions with few or no major population centers of 5,000 or more	County	Highway functional classification; transportation planning; outdoor advertising regulations
National Household Travel Survey (NHTS)	*Urban* – Downtown areas of major cities *Suburban* – Areas surrounding urban areas *Second City* – Satellite cities surround major metropolitan areas *Town/Rural* – Exurban towns with slightly denser populations than rural areas	Block group	Transportation research
Office of Management and Budget (OMB) (*21*)	*Metropolitan* – Area containing urban core with population of 50,000 or more *Micropolitan* – Area containing an urban core with population between 10,000 and 50,000 *Neither* – An area which is neither metropolitan nor micropolitan	Core-based statistical area	Research and statistics

Source	Definition	Geographic Unit	Usage
National Center for Health Statistics (*22*)	*Metropolitan* – Large central counties in OMB metropolitan statistical area (MSA) of 1 million population that 1) contain the entire population of the largest principal city of the MSA, or 2) are completely contained within the largest principal city of the MSA, or 3) contain at least 250,000 residents of any principal city in the MSA. *Large Fringe Metropolitan* – Counties in MSA of 1 million or more population that do not qualify as large central *Medium Metropolitan* – Counties in MSA of 250,000-999,999 population. *Small Metropolitan* – Counties are counties in MSAs of less than 250,000 population. *Nonmetropolitan* – Micropolitan counties in OMB micropolitan statistical area; Noncore counties not in micropolitan statistical area	County	Public Health research

Source	Definition	Geographic Unit	Usage
US Department of Agriculture – Economic Research Service (*23*) US Health Resources and Service Administration	*Rural-Urban Commute Area (RUCA) 1* – Metropolitan area core: primarily flow within urbanized area (UA) *RUCA 2* – Metropolitan area high commuting: primary flow with 30% or more to UA *RUCA 3* – Metropolitan area low commuting: primary flow 10-30% to UA *RUCA 4* – Micropolitan area core: primary flow within a large urban cluster (UC) *RUCA 5* – Micropolitan area high commuting: primary flow with 30% or more to a large UC *RUCA 6* – Micropolitan low commuting: primary flow 10-30% to a large UC *RUCA 7* – Small town core: primary flow within a small UC *RUCA 8* – Small town high commuting: primary flow 30% or more to small UC *RUCA 9* – Small town low commuting: primary flow 10-30% to a small UC *RUCA 10* – Rural areas: primary flow to a tract outside UA or UC	Census tract	
USDA – Economic Research Service (*24*)	*Frontier and Remote (FAR) Level 1* – Zip code area remote (15 minutes or more) from urban areas of more than 50,000 people *FAR Level 2* – Zip code area remote from urban areas of 25,000 or more people *FAR Level 3* – Zip Code area remote from urban areas of 10,000 or more people *FAR Level 4* – Zip code area remote from urban areas of 2,500 or more people	Zip Code Area	Research

Source	Definition	Geographic Unit	Usage
USDA – Economic Research Service (*25*)	*Rural-Urban Continuum Codes (RUCC) 1* – Counties in metro areas of 1 million people or more *RUCC 2* – Counties in metro areas of 250,000 – 1 million people *RUCC 3* – Counties in metro areas fewer than 250,000 people *RUCC 4* – Urban population of 20,000 or more, adjacent to metro area *RUCC 5* – Urban population of 20,000 or more, not adjacent to metro area *RUCC 6* – Urban population of 2,500 – 19,999, adjacent to metro area *RUCC 7* – Urban population of 2,500 – 19,999, not adjacent to metro area	County	Research
USDA – Economic Research Service (*25*)	*RUCC 8* – Completely rural or less than 2,500 urban population, adjacent to a metro area *RUCC 9* – Completely rural or less than 2,500 urban population, not adjacent to metro area	County	Research
USDA– Economic Research Service (*26*)	*Natural Amenities Scale Levels 1-7* – Based on scoring of six measures of climate, topography, and water area that reflect environmental qualities most people prefer with 1 being low amenities and 7 being high amenities	County	Research
USDA – Economic Research Service (*27*)	*Urban Influence Code (UIC)* 1 – In large metro area of 1+ million residents *UIC* 2 – In small metro area of less than 1 million residents *UIC 3* – Micropolitan area adjacent to large metro area *UIC* 4 – Noncore adjacent to large metro area *UIC* 5 – Micropolitan area adjacent to small metro area *UIC* 6 – Noncore adjacent to small metro area and contains a town of at least 2,500 residents	County	Research

Source	**Definition**	**Geographic Unit**	**Usage**
USDA – Economic Research Service (*27*)	*UIC* 7 – Noncore adjacent to small metro area and does not contain a town of at least 2,500 residents *UIC* 8 – Micropolitan area not adjacent to a metro area *UIC* 9 – Noncore adjacent to micro area and contains a town of at least 2,500 residents *UIC* 10 – Noncore adjacent to micro area and does not contain a town of at least 2,500 residents *UIC* 11 – Noncore not adjacent to metro or micro area and contains a town of at least 2,500 residents *UIC 12* – Noncore not adjacent to metro or micro area and does not contain a town of at least 2,500 residents	County	Research
National Center for Education Statistics (*28*)	*City* – Categorized Small, Midsize, or Large; Territories inside an UA and inside a principal city (PC) *Suburb* – Categorized Small, Midsize, or Large; Territories outside PC and inside UA *Town* – Categorized Remote, Distant, or Fringe; Territories inside UC *Rural* – Categorized Remote, Distant, or Fringe; Census-defined rural-territory outside UA and UC	Location of school	School Funding, Grant and loan award eligibility

Source	Definition	Geographic Unit	Usage
Gray (*19*)	*A1* – Rural areas close to a major conurbation (Up to 80% of households within 13 minutes of hourly bus service; 65-75% of journeys made by car) *A2* – Rural locality surrounding a freestanding city (Up to 80% of households within 13 minutes of hourly bus service; 65-75% of journeys made by car) *B1* – Retail and service provision of a smaller market town (Up to 60% of households within 13 minutes of hourly bus service; 65-75% of journeys made by car) *B2* – Market town(s) servicing a dispersed rural population (Up to 50% of households within 13 minutes of hourly bus service; 70-75% of journeys made by car) *B3* – Market town(s) servicing a rural population dispersed in a linear fashion along main routes (Up to 50% of households within 13 minutes of hourly bus service; 70-75% of journeys made by car) *C1* – A remote "honey-pot" or "tourist" location (Less than 35% of households within 13 minutes of hourly bus service; 70-80% of journeys made by car) *C2* – An isolated village or villages (Less than 25% of households within 13 minutes of hourly bus service; 75-85% of journeys made by car)		Rural Transport Research
Gray (*19*)	*C3* – Extremely isolated settlement or households well removed from main roads and/or buses 0% of households within 13 minutes of hourly bus service; 80-90% of journeys made by car)		Rural Transport Research

Source	Definition	Geographic Unit	Usage
Ralph et al. (*16*) Voulgaris et al. (*15*)	*Rural* – Least dense, few jobs nearby, little or no public transit service (19% of US population; 20% of census tracts) *New Development* – New areas with low-density single-family homes and very few jobs (27% of US population; 22% of census tracts) *Patchwork* – Mostly mixed-use areas with relatively low-density housing and suburban retail and office developments (18% of US population, 18% of census tracts) *Established Suburbs* – Older suburban developments with higher density, greater access to jobs, and better transit service (13% of US population, 15% of census tracts) *Urban Residential* – Urban version of Established Suburbs with higher density, better transit service, and higher share of rental housing (14% of US population, 14% of census tracts) *Old Urban* – Highest density neighborhoods with good transit service and high number of jobs within a 45-minute drive (4% of US population, 5% of census tracts)	Cluster and latent based statistical area; census tract	Transportation Research
Ralph et al. (*16*) Voulgaris et al. (*15*)	*Mixed-Use* – Primarily job centers with some housing (5% of US population, 6% of census tracts)	Cluster and latent based statistical area; census tract	Transportation Research

Source	Definition	Geographic Unit	Usage
Hamilton et al. (*29*)	*Amenity-Rich Rural* – Growing population of higher income individuals and retirees drawn by natural landscape *Declining Resource-Dependent Rural* – Declining population which previously depended on a single economy which supported a blue-collar middle class *Chronically Poor Rural* – Historically low-income with limited services, jobs, and infrastructure *Amenity/Decline Rural* – A transitional area characterized by both Amenity-Rich and Declining Resource-Dependent attributes	Community, Town, or City	Public Policy Research
Miller (*10*)	*Productive* – Location dependent definition of productive based on land-use, population, and/or potential use, and reliant on productive uses *Destination* – Location defined by seasonally-occupied housing, high property values, and known tourist destinations *Edge* – "Rounded up" areas often classified as urban, locations with spillover urban development, and low-density areas with infill or a return to agriculture	Census block or Community	Planning Research
National Cooperative Highway Research Program (Report 582) (*30*)	*Exurban* – Communities on the fringe of must urban areas with dependence on jobs outside of the community *Destination* – Communities featuring natural amenities which rely on a service-based economy *Production* – Communities found in remote areas which depend on a single industry such as agriculture, manufacturing, or mining	Community, Town, or City	Local and regional transportation and land-use planning

Source	Definition	Geographic Unit	Usage
Oregon Office of Rural Policy Classification (*31*)	*Urban* – Community of 50,000 or more and the surrounding area within 10 miles of these communities *Urban Rural* – Geographic area that is at least 10 miles by road from an urban community *Rural* – Geographic area that is at least 30 miles by road from and urban community *Isolated Rural* – A rural area that is at least 100 miles by road from a community of 3,000 or more *Frontier Rural* – A rural area that is at least 75 miles by road from a community of less than 2,000	Community or Census block group	Planning and Policy

Policy Applications

The designation as rural is required by policies across the country to be eligible for funding assistance for various types of transportation projects, including those related to public transportation, infrastructure, and vehicle electrification support. As the future of sustainable transportation grows closer, there have been policy recommendations for funding the electrification of vehicles throughout the US's rural communities. The USDOT's 2022 Electric Mobility Infrastructure Guide defines rural using census data and notes that 20% of Americans and 70% of America's road miles are in these rural-defined areas (*32*). This document was developed in response to a supposed need for electrifying areas where individuals drive the most. The USDOT cites the NHTS LATCH survey data which says rural-dwelling people drive more than their urban counterparts. The *Charging Forward* document identifies 48 different funding programs specifically tailored to communities designated rural by the census or other departments' definitions. Since definitions vary from one agency to another, a community may be eligible for one of these programs but not another. This leaves room for confusion amongst local planners and town officials who are seeking funding for a project in their area. In addition to potential misunderstanding of eligibility, none of these definitions, aside from the RUCA codes, account for travel behavior, despite being used for funding vehicle electrification projects which is an issue deeply tied to current behavior. One example where a rural designation that does not account for behavior would be misleading is the case of compact development in a low population area. If the assumption is that rural areas are sparsely populated and have high VMT, there may be a case made for electrification causing lifecycle cost reductions. However, if VMT is lower because of this compact development, the cost savings may be overpromised, and the efficiency of a funding program is less than optimal.

Also at the national level, there has been a piece of legislature brought to Congress which is known as the Rural Transportation Equity Act of 2021 (S.2137) (*33*). This Act proposes establishing an Office of Rural Investment within the US DOT and appropriating $7,000,000 per fiscal year to this office from 2022 to 2026. This shows an interest in deepening the understanding rural transportation and how it relates to equity and behavior. The key goals and objectives of this Act and the Office of Rural Investment are to address and prioritize the "unique needs and attributes of rural transportation", encourage better coordination between federal programs, policies, and activities, expand federal investment in rural transportation, promote innovative solutions for rural transportation challenges, and improve access to resources for outreach, education, and technical assistance in the relevant communities. This Act does not specify which communities would be included in the work carried out by the proposed office, but it can be assumed that they will be designated as rural by the Census or FHWA, as they are the mostly closely aligned departments. These definitions rely on population as the defining feature of a community as to their labelling as rural or not.

Plans and policies moving towards electrification exist locally in Vermont as well, where the VMT analysis in this study takes place. Pursuant to the State's 2020 Global Warming Solutions Act (Act 153), a Climate Action Plan has been developed and outlines objectives and strategies for reducing emissions from transportation in this overwhelmingly rural state. The Climate

Action Plan was developed by the Vermont Climate Council which includes a subcommittee on Rural Resilience and Adaptation. The plan includes two objectives related to this subcommittee:

(1) Minimize negative impacts on marginalized and rural communities and individuals with low and moderate incomes;

(2) Support economic sectors and regions of the state that face the greatest barriers to emissions reductions, especially rural and economically distressed regions and industries (*34*)

This plan cites a study which was performed in collaboration with the Union of Concerned Scientists (UCS) which, like the example previously mentioned, that claims rural-dwelling individuals could save more money than urban-dwelling individuals could by switching to an electric vehicle (*35*). The study uses census definitions which were aggregated to the county level, whereby hiding variability across communities even further than the census tract scale already does. The policy recommendations made using this process for classifying urban and rural areas then may not reflect the needs across the wide range of communities that fall into either category. For example, if rural areas are seen as driving a much higher amount per year, they may be seen as having an even larger price burden for transportation, which may or may not be the case.

An additional statewide policy, this occurring in Massachusetts, is the 2018 Rural Policy Plan (*36*). This plan identifies three communities of interest which fall under their general heading of "rural" (in this case, meaning a population density of less than 500 people per square mile): (1) bedroom communities, (2) areas of economic distress, and (3) concentrations of second homes. At the outset of the plan's section on transportation infrastructure challenges it is noted that rural communities are identified as struggling to pay for design and engineering to get projects included in the state's Transportation Improvement Program (TIP) or to apply for other grants. The related goal for addressing this is to "develop and fund sustainable, efficient, and convenient transportation options in rural areas to provide optimal mobility and accessibility to goods, services, and employment". The plan proceeds with recommendations for meeting this goal through public transportation, passenger rail, and increased active transportation. These recommendations have been laid out without any identified travel behavior statistics. If rural travel were to be better understood and applied to the definition used in this plan, these types of recommendations could be more well-informed and be better suited to match the existing behavior. This highlights a need for a more nuanced definition that can represent travel behavior when making planning and policy decisions, rather than relying on population alone.

Methods

To assess travel behavior metrics under different definitions of urban and rural, six measurable or publicly available definitions were applied to Vermont and then VMT per vehicle and person were calculated for each definition. The selected definitions were the US Census, RUCA, RUCC, UIC, NAM and NHTS LATCH classification schemes, details of which can be found in Table 1. The Census, RUCA, and NHTS LATCH classifications are available at the census tract level and were compared to each other. The RUCC, UIC, and NAM classifications are provided at the county level and compared against each other. This method was used to identify any discrepancies in outcomes when the same data were applied to different definitions. The NHTS LATCH and RUCA definitions were selected as they are directly related to travel behavior and are developed (NHTS LATCH) and used by transportation sectors for evaluating data. The US Census, RUCC, and UIC definitions were included as they are commonly used metrics for both research and practical applications across numerous sectors, including transportation, and are frequently referenced in policy documents. Finally, the NAM definition was selected as Vermont is known for its natural amenities throughout the State and may be an indicator of VMT if those in areas with fewer amenities frequently travel longer distances to reach the natural amenities. The opposite may also be true if the more remote and naturally amenable areas have less services and residences are therefore required to travel to other areas to meet their needs. The following sections outline in more detail the methods for calculating VMT from Vermont's inspection data and the subsequent assignment of these metrics to each definition.

Vehicle Miles Traveled Calculation

The units of comparison for urban-rural definitions in this study are average yearly VMT per person, average vehicles per household, and average yearly VMT for the geographic unit (either census tract or county). VMT values were calculated using vehicle inspection and registration datasets acquired from the Vermont Department of Motor Vehicles (DMV) in June 2019. These datasets contain the Vehicle Identification Number (VIN), date of inspection, odometer reading at time of inspection, registration address, vehicle fuel type, vehicle make and model, and other attributes of the vehicle. In the inspection dataset, each entry equates to one vehicle inspection. Many inspection records shared the same date which occurs when someone fails their inspection and goes for additional inspections on the same day. To avoid using these types of occurrences, VINs were searched to identify those that had at least two entries with unique inspection dates. These were used for VMT per day and per year calculations. Using the two different dates, the number of days between each inspection was calculated. The difference in the two odometer readings from each inspection was divided the by the number of days between inspection to get the VMT per day for the vehicle. This was then multiplied by 365 to calculate VMT per year for each vehicle.

Registration records were acquired in June 2019 and cleaned to keep only records that were up to date and any registrations that would expire after August 2019 (allowing for a two-month grace period for renewal) were removed. This left 608,127 unique registration records. Registration records were merged with inspection records based on VIN, keeping all registration records, and removing any unused inspection records. For any duplicate VINs, the record with the most recent inspection date was kept for use. This resulted in a total of 511,334 records. After the initial VMT calculation, many records had unreasonably low or high yearly VMT values after calculation which were likely a result of errors when odometer readings were manually entered into the system. To remove these values, only the central 95th percentile of data was used for analysis. Taking this percentile of the data removed any negative VMT values or unreasonably large outliers and resulted in a spread of yearly vehicle VMT of 72 to 35,387 miles. An additional cleanup step of removing out of state vehicles which are registered in

Vermont, only records associated with a valid Vermont zip code were kept for analysis. After taking only the Vermont records within the central 95th percentile, there were 462,047 records.

VMT Aggregation

From these records, which included the previously calculated registration address, VMT per day per vehicle, and VMT per year per vehicle, mean yearly VMT per vehicle was aggregated at the census tract and county levels, using the mean value for each tract or county. Average household vehicle availability by household size and average household size were acquired from the five-year averages of the 2019 American Community Survey (ACS) at the census tract level. To obtain an average number of vehicles available to households for every census tract, the mean was taken of an expanded frequency table of all numbers of vehicles available for each tract. The census tract level data were used at this geographic scale and were also aggregated to the county level. After calculating average vehicles per household and yearly VMT per vehicle, yearly VMT per person could be calculated using the formula presented below.

$$VMT_{person} = \frac{VMT_{veh} * V_{HH}}{P} \quad (1)$$

Where:

VMT_{veh} = vehicle miles traveled per vehicle (from inspection records);

V_{HH} = average rate of vehicle per household of the census tract or county;

P = average rate of persons per household of the census tract or county

The raw and aggregated VMT values are presented in Figure 1. These graphics show the loss of variation that occurs during the aggregation process, with the overall spread of values decreasing.

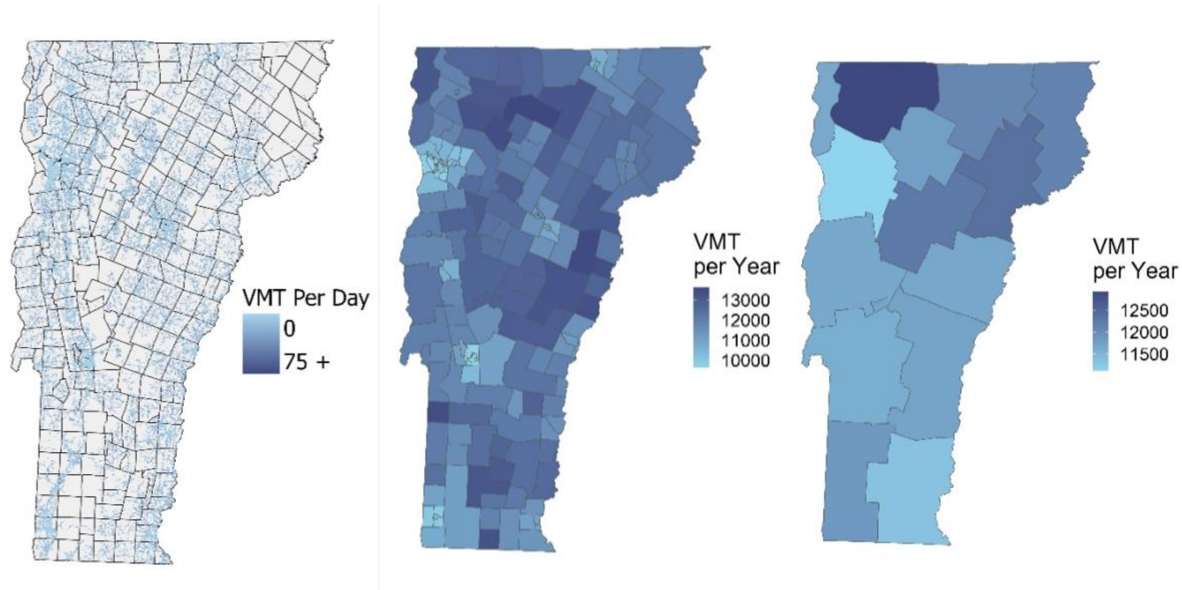


Figure 1. (From left to right) Statewide VMT Per Day, Census Tract Average VMT per Year, County Average VMT per Year

After aggregating VMT to census tract and county levels, the six classification schemes could then be applied to these data. Classification of each tract and county was collected from publicly available databases from the Census, NHTS, and USDA ERS. These databases were merged with the tract and county VMT data and could then be further assessed. The range, variance, mean, and median VMT were calculated for each classification across the six definitions.

Results

Results are presented in the following two sections based on the two geographic scales at which the VMT comparisons were conducted. The first is a census tract level comparison which assesses the US Census, RUCA, and NHTS LATCH definitions. The second comparison is presented at the county level to assess the RUCC, NAM, and UIC classification schemes. The two comparisons resulted in varying outcomes and did not present a consistent pattern of VMT related to level of rurality or urbanicity. The number of vehicles available to each household does not vary widely across classifications, whereas VMT per person varied by nearly 1,000 miles depending on the definitional scheme applied.

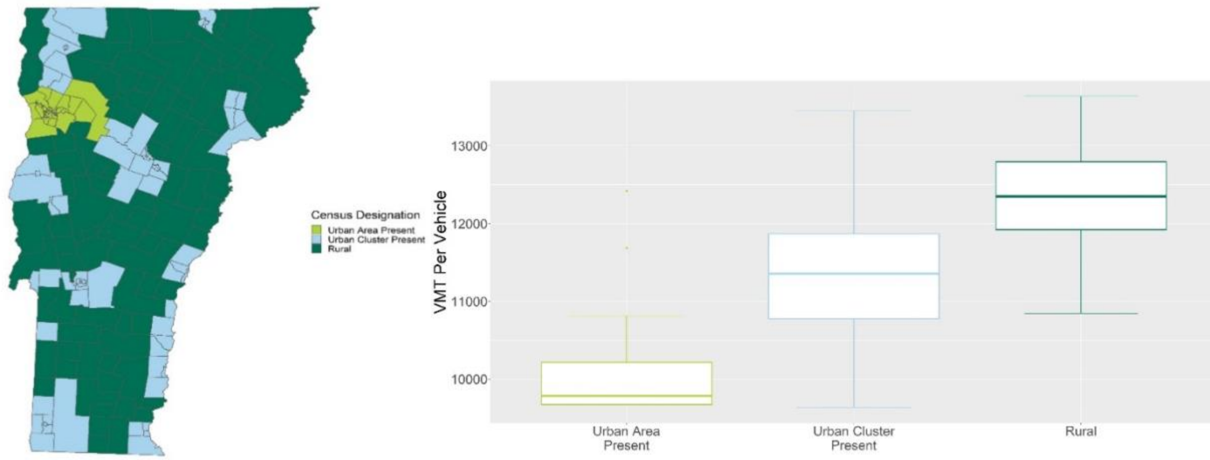
Census Tract Level Comparison

The VMT comparison conducted was at the census tract level included the US Census, RUCA, and NHTS LATCH definitions. When looking at the US Census and NHTS LATCH classification schemes, there is a general pattern of increasing VMT and vehicle availability as level of rurality increases, however this not the case when the RUCA codes are applied. The Census and LATCH definitions include only urban, suburban, and rural classifications based on population, whereas the RUCA classification is dependent on the primary commute flow into urban areas or clusters.

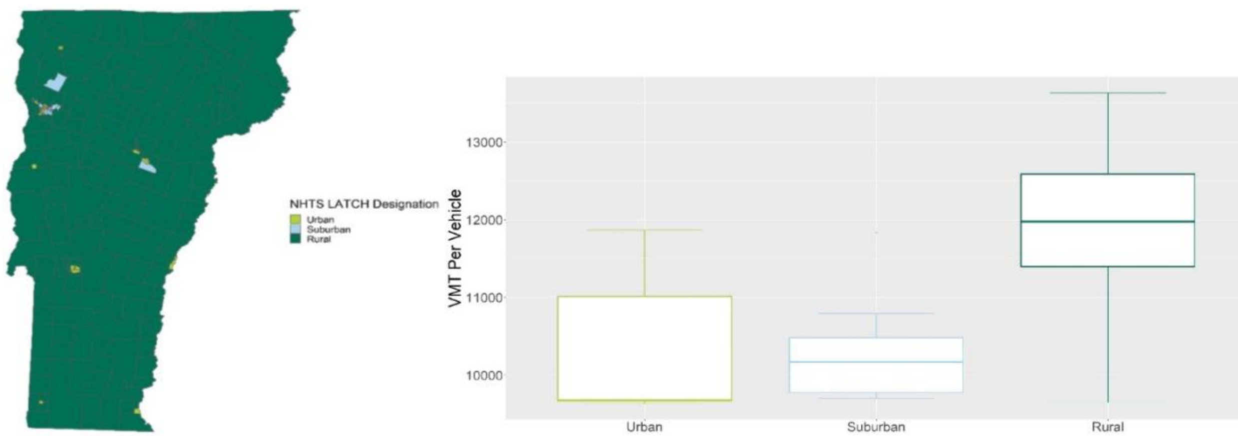
Under the RUCA definitions, the highest VMT per person is associated with the metropolitan area low commuting classification where 10 to 30% of commuter travel to an urbanized area, which in the case of Vermont, is Burlington. These areas also have the highest rate of vehicle availability per household at 2.62 vehicles per household. When using the RUCA codes, yearly VMT per person varies from 10,715 to 14,092. However, using the definition provided by the census, the variation drops by nearly 1,000 miles to a spread of 11,184 to 13,666. The standard deviations of the distributions show that the variance is minimized under the RUCA definitions whereas this is not the case for the other two definitions. When variance is minimized within groups, this points to more precision in the categorization and more accurately reflects the true behavior being exhibited in each community types. The standard deviations for the rural category for the Census, NHTS, and RUCA schemes are 609.1, 916.4, and 558.7, respectively.

When addressing the stereotype that rural areas travel more than their urban counterparts, this is shown to be true under the Census and NHTS LATCH definitions. However, using the RUCA definitions, the “Metro Low Commuting” and “Small Town Low Commuting” categories exhibit a higher median VMT than the “Rural” category.

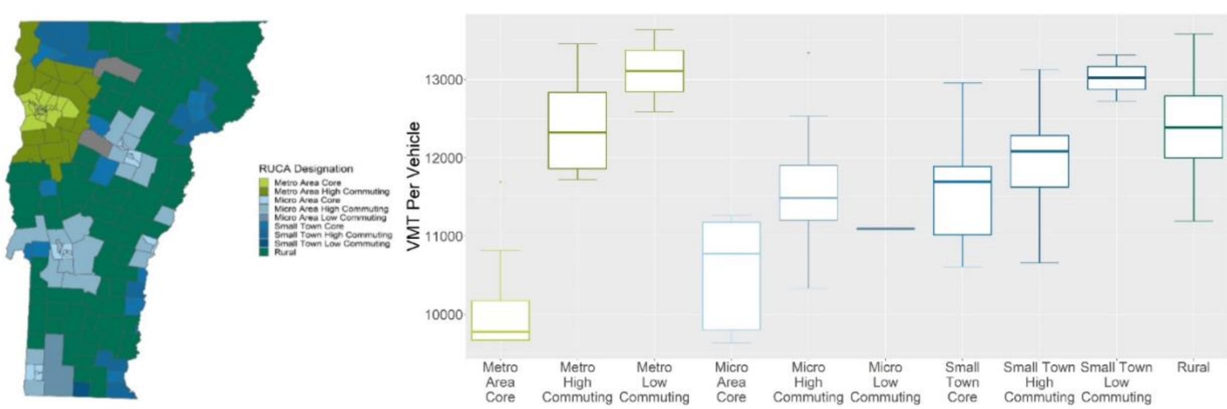
The maps shown in Figure 2 show the classification of each tract according to the three definitions. The boxplots then show the interquartile ranges and median VMT for each of the definitions.



(a)



(b)



(c)

Figure 2. (a) Census, (b) NHTS LATCH, (c) RUCA Census Tract Designations (Left) and VMT Boxplots (Right)

To test if the distributions of VMT within each rural designation, a Kolmogorov-Smirnov (K-S) test was conducted. The K-S test looks to see if the values within each designation could be drawn from the same distribution. If the p-value calculated is statistically significant, it can be concluded that the distributions are significantly different. The Census, NHTS, and RUCA distributions of VMT for the rural-designated tracts were compared and it was found that the RUCA rural VMT values are significantly different from both the Census and NHTS rural tracts' VMT values (p = 0.007 and 0.003). The cumulative distributive functions from which the K-S test is based are provided in Figure 3.

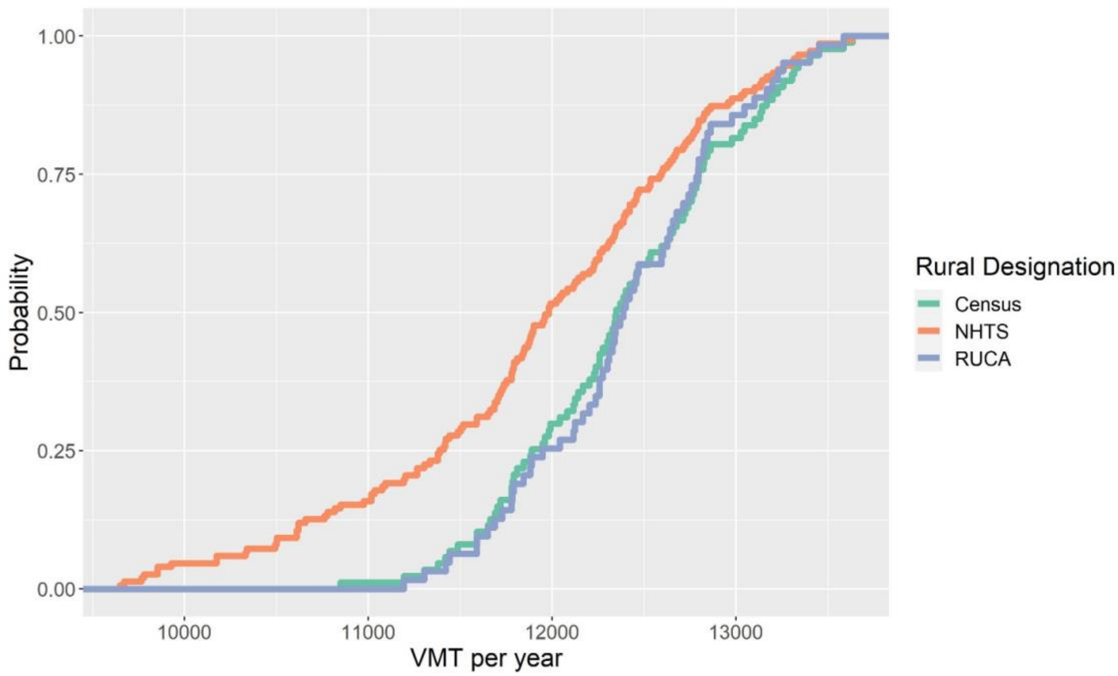
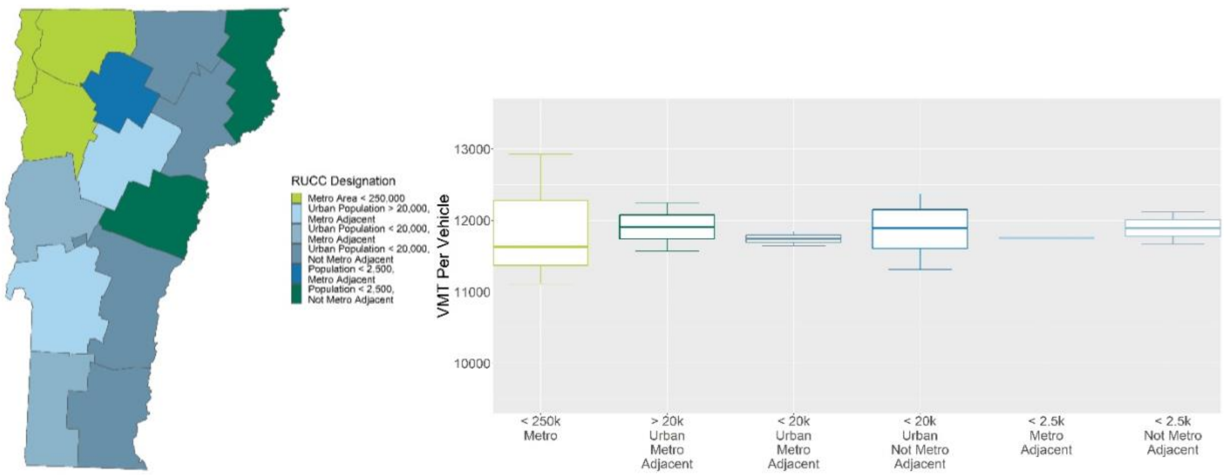


Figure 3. Cumulative Density Functions of Tract Level VMT Distributions for Rural Designations

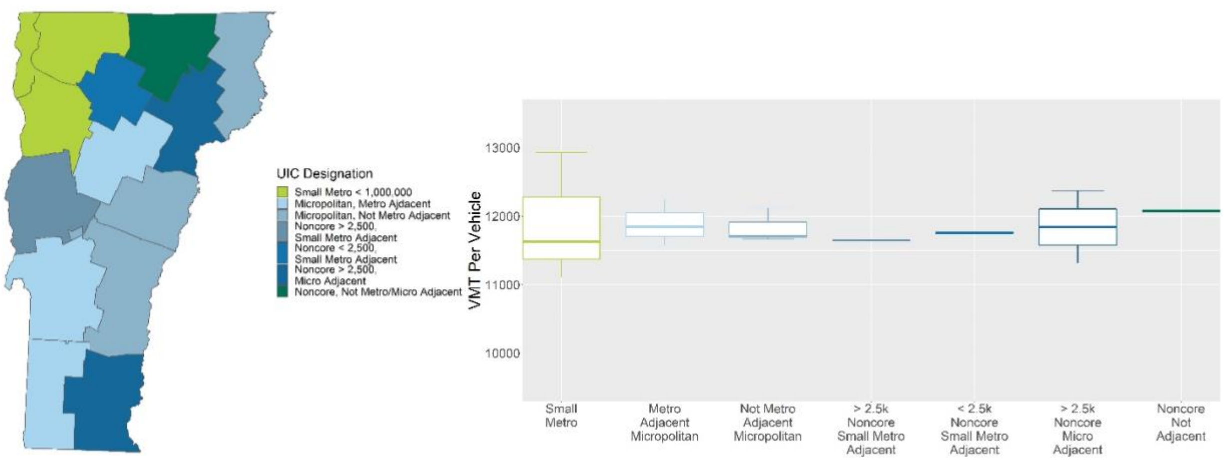
County Level Comparison

The second VMT comparison conducted was between the RUCC, NAM, and UIC classification schemes, all of which occur at the county level. At the county level, there was much less variation in VMT values compared to the census tract level. This is not surprising as this is a higher level of analysis with coarser aggregation. The RUCC and UIC definitions result in similar variation with RUCC having a spread of 810 miles and UIC varying by 1,153. None of the county level classification schemes display a pattern of increasing or decreasing VMT as the level of rurality increases. As aggregation occurs at a larger geographic scale, the mean will grow closer to that of the state and be less sensitive to the variations which occur at a block, block group, or census tract level.

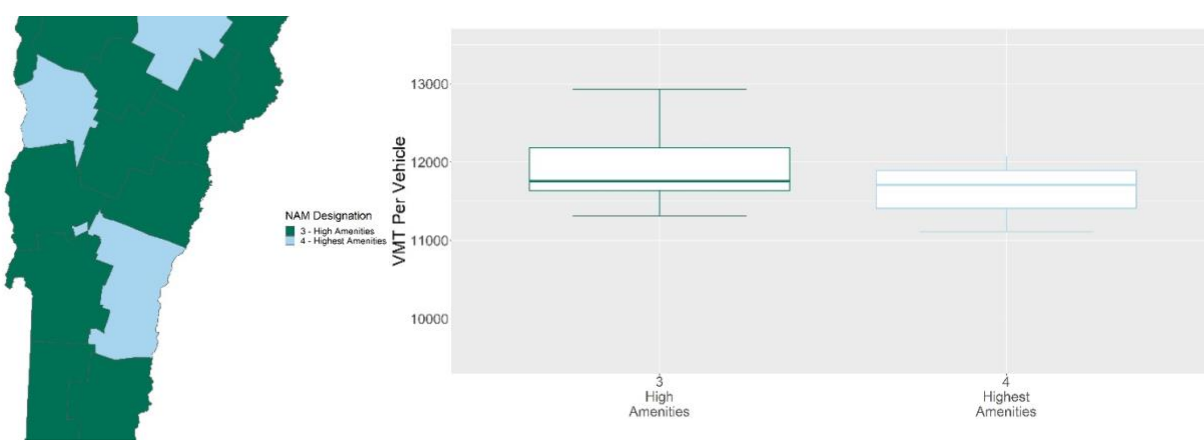
The maps shown in Figure 4 show the classification of each tract according to the three definitions. The boxplots then show the interquartile ranges and median VMT for each of the definitions.



(a)



(b)



(c)

Figure 4. (a) RUCC, (b) UIC, (c) NAM County Designations (Left) and VMT Boxplots (Right)

To test if the distributions of VMT within each rural designation at the county, a Kolmogorov-Smirnov (K-S) test was conducted. The RUCC, UIC, and NAM distributions of VMT for the rural-designated tracts were compared and it was found that none of the distributions were significantly different. The cumulative distributive functions from which the K-S test is based are provided in Figure 5.

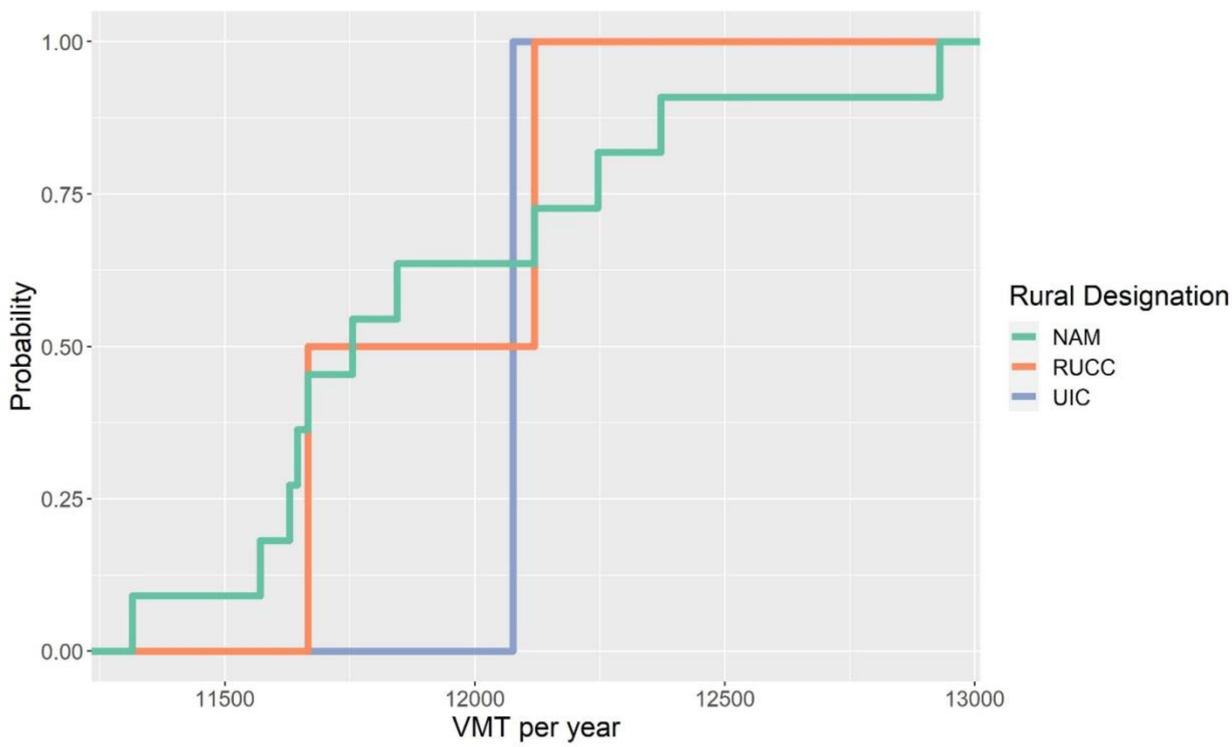


Figure 5. Cumulative Density Functions of County Level VMT Distributions for Rural Designations

Discussion

When looking at various definitions of urban and rural areas, the question must be asked, why are there so many varying definitions and what purpose do they each serve? A unified definition which is used for funding allocations and policy research and implementation many be helpful but with the previously noted heterogeneity of rural areas, applying these definitions may even be harmful. By assuming that all rural areas, whether defined by population, land use, or any other characteristic, a level of homogeneity is assumed which could be detrimental when developing policies aimed at these communities.

Many definitions are applied at high geographic scales such as the census tract or county level and this allows for even less accuracy in capturing the true identity of a community. The research presented here shows that as geographic scale increase, the level of variation decreases and therefore, does not adequately represent many smaller communities. Those definitions that use a large geographic scale likely result in skewed data and inaccurately portray attributes such as average yearly vehicle miles traveled (VMT), income, or any other social or demographic statistic. This then raises the question of how different definitions may provide opportunities for policymakers or researchers to draw varying conclusions about an area. If the goal of a study is to show that urban and rural areas present similar behaviors, a county level classification scheme may be used to prove this, and if variation between communities is the goal, using census tracts or a smaller scale can be used.

Following this research, questions remain on whether these classification schemes along the urban-rural continuum should exist, and if they do, how can they most accurately convey the diverse communities across the country. The first suggestion is to apply these definitions at a finer scale, such as census block or block group level. This will minimize homogeneity within groups and maximize heterogeneity across groups. The second suggestion is to take into account many characteristics of a community including demographic, social, land use, and travel behavior variables. When these two components are combined, the more subtle differences in areas may be noticed. These subtle differences may be the difference between choosing to implement one policy or another. For example, an area may seem like public transportation will never be a viable option when looking at the county level, but a smaller scale analysis may reveal that bolstering public transportation would be worthwhile endeavor.

For example, within Vermont, when looking at the block group level, the 2019 ACS shows a 13.7% mode share of commuting by public transportation in downtown Burlington. When zoomed out to the county level, this drops to 2.8%. Clearly the travel behavior varies across the county and what may be considered urban at the block or block group level does not appear that way at the county level. This renders the RUCC and UIC classification schemes essentially useless when analyzing travel behavior in downtown Burlington. Vermont is not unique in this phenomenon and this likely occurs across the country in many small cities that are densely populated and heavily mixed use but surrounded by sparsely populated areas with limited access. As definitions of rurality and urbanicity currently exist, there is no accurate way of classifying these cities and towns which exhibit behavior drastically different than those with which they share a census tract or county.

This study examined metrics only examined VMT per vehicle under six definitions and further study is encouraged to understand outcomes related to additional transportation metrics to continue stitching together a more comprehensive picture of the impacts of having so many definitional schemes for rurality. Policy decisions and funding allocations are at stake under these definitions and the need to understand this impact is paramount to the success of these policies and the efficient use of state and federal funds. As shown, numerous funding mechanisms apply to rural communities and require an official designation under one classification scheme or another. If these definitions do not truly capture the behavior of these areas, it cannot be said with any certainty that meaningful change will be realized.

We hope to grow the body of literature on defining rural and how this impacts the study of travel behavior as the need for better data is constantly expanding. While we race against the pressures of problems such as climate change, travel behavior is under scrutiny, as transportation is such a large contributor of emissions. This makes it even more imperative that we understand the problem so that we can learn how to tackle the problems at hand with proper policy mechanisms. When inconsistencies are present at the definitional level of a field of study, all outcomes using these definitions are sure to exhibit some of that inconsistency as well. By shedding light on part of the issue in classifying rural areas, we aim to work towards a unified approach so that proper research decisions, policymaking, and funding allocations can be used in the most effective and efficient ways possible.

Chapter 3: Comparing Travel Behavior and Opportunities to Increase Transportation Sustainability in Small Cities, Towns and Rural Communities

Erica Quallen, Julia Clarke, Clare Nelson, and Gregory Rowangould

The content in this chapter has also been published in the Transportation Research Record:

Quallen, E., Clarke, J., Nelson, C., & Rowangould, G. (2023). Comparing Travel Behavior and Opportunities to Increase Transportation Sustainability in Small Cities, Towns, and Rural Communities. *Transportation Research Record*, *2677*(3), 1439-1452. https://doi.org/10.1177/03611981221124590

Introduction

The need to better understand rural travel behavior has never been greater or more urgent. Transportation is the largest source of greenhouse gas (GHG) emissions in the US, and transportation GHGs are particularly significant in small and rural (S&R) communities where 30% of U.S. auto-travel occurs, according to highway statistics collected by the US Department of Transportation and the average person travels 40% farther that their urban counterparts according to data tabulated in the Transportation Energy Data Book (*37*). A significant body of travel behavior research seeks to predict how infrastructure investments, technology and policies can reduce GHG emissions from transportation, however the vast majority of this research has been conducted in urban areas. As a result, very little is known about how people and households in S&R communities make travel decisions and how they respond to changes in transportation infrastructure, technology, and policies. Strategies that have been found to reduce GHGs in urban areas are likely to be ineffective in S&R communities due to differences in transportation options, the built environment, socioeconomics, values and norms, attitudes, and beliefs. This research aims to begin addressing the need for a deeper understanding of travel behavior in S&R communities by conducting exploratory qualitative research in a wide range of small and rural communities in Vermont. Our objective is to develop an initial understanding of potential barriers to travel behavior change in S&R communities that would support more sustainable transportation.

We focus on Vermont because of our location and knowledge of the state, its history of aggressive GHG emission reduction targets, and the lack of mitigation achieved so far. Vermont is unique in the amount of political support for widespread GHG mitigation but general lack of progress in reducing emissions. Vermont first adopted GHG mitigation targets in 2005 (10 V.S.A. § 578), requiring reductions of 50% below 1990 levels by 2028 and 75% below 1990 levels by 2050. In 2016, the state's comprehensive energy plan established additional goals to meet 25% of energy demand with renewable resources by 2025, 40% by 2035 and 90% by 2050 (*38*). Then, in 2020 the state adopted a new set of legally binding GHG mitigation targets (Act 153) requiring reductions of 26% below 2005 levels by 2025, 40% below 1990 levels by 2030 and 80% below 1990 levels by 2050. Despite these goals and a wide range of related policy and planning initiatives undertaken to achieve them, Vermont's GHG emissions have been increasing since 2011 (*39*). Transportation is the largest source of Vermont's GHG emissions, accounting for nearly 40% of the state's emissions (*40*). Many states in the northeastern United States face similar challenges in reducing transportation sector emissions and some have considered signing on to the Transportation and Climate Initiative (TCI). TCI aims to create a collaboration among northeastern and mid-Atlantic states to cut GHG emissions from transportation through a regional carbon cap and invest program. TCI would place a cap on GHG emissions from on-road gasoline and diesel and invest the proceeds from the auction of emission allowances to incentive households to reduce their driving or to purchase lower emitting vehicles.

An important concern for Vermont where 61% of the population resides in a rural area according to the 2010 US Census, and other states with large rural populations, is that market-based climate policies like TCI may disproportionately impact the welfare of low income and rural households because they may be more automobile dependent, less able to afford alternatives, and transportation costs may be a higher share of their household expenditures (*40*–*46*). While the proceeds from GHG emission allowance auctions can be used to increase the effectiveness of policies like TCI and offset inequities (*39*, *47*), data to understand welfare impacts and investments decisions is lacking for rural communities (*42*, *48*). Similar gaps exist with respect to the effectiveness of programs and policies to encourage the use of electric vehicles (EV), such as rebate programs. While research on EV incentive programs generally find that they are associated with higher EV adoption rates, there is little evidence on their effectiveness in rural communities as prior research evaluates national and state-level data (*49*). Even in states with high EV adoption rates, adoption and incentive effectiveness may be lower in rural areas where range anxiety could be greater given longer trip distances, people may have preferences for different types of vehicles (e.g., trucks and four-wheel drive vehicles), and where incomes are often lower.

While travel behavior research and the knowledge it has produced is extensive, this field of scholarship has its roots in trying to solve urban transportation problems with little attention given to rural areas. The lack of rural transportation GHG mitigation research is perhaps best summarized in the concluding remarks of a TRB 2nd Strategic Highway Research Program (SHRP 2) study on GHG mitigation decision making that states "By far, and not surprisingly, most of the research on GHG emissions reduction strategies has focused on metropolitan areas or at the national and state levels." and that "…very little attention has been given to nonurban areas." (*50*). Most of what we currently know about travel behavior, including theories of travel demand, mode and destination choice, vehicle and housing location choice, price elasticities, and technology adoption has come from research collecting data in urban areas to address urban transportation problems such as traffic congestion and regional air quality concerns, and more recently urban GHG mitigation strategies. However, climate change and GHG mitigation policies will also affect, and require robust participation from, small and rural communities. New data and knowledge are required to understand the interactions between individual and household attributes, contextual factors and travel behavior in S&R communities and ultimately identify effective, efficient and equitable transportation GHG mitigation strategies.

Evidence that travel behavior in S&R communities differs from behavior in more urbanized areas is starting to emerge from research on gasoline price responsiveness (elasticity). Hundreds of fuel price elasticity studies have been conducted (*51*), but only a few have attempted to also understand price responses in S&R communities (*52*–*54*). Perhaps counterintuitively, some of these studies suggest that rural households may be more responsive to changing fuel prices than their urban counterparts, challenging the findings of earlier studies that use more aggregate data (*53*, *55*). While more spatially refined gasoline price elasticities would be useful for estimating the impacts of market-based GHG mitigation policies on S&R communities they are essentially a black box—they reveal how much a traveler changes their consumption of transportation-related goods, but they do not reveal how and why they do so. Insights about how and why travelers change their behavior is necessary to understand the role contextual factors such as transportation infrastructure and the attributes of households and individuals play in supporting or limiting travel behavior change.

Our research begins to address the lack of travel behavior research in S&R communities by conducting exploratory qualitative research through interviews in a wide range of S&R community types. Gathering data on the travel behavior and attitudes of a diverse cohort of people in rural places can be challenging. We address this challenge by going out to these communities and interviewing people in public places in a wide range of settings. Our recruitment approach of intercepting research subjects in public places and conducting our interviews on the spot, eliminates some of the bias inherent in telephone or internet surveys relating to access to internet or a smartphone, income, and/or age (*56*). The data we collect through these interviews are evaluated to identify factors, including attitudes and beliefs, that may create barriers to more sustainable travel behavior and choices and how they vary across different types of communities. The remainder of this paper discusses our interview and qualitative research methods in more detail, discusses what we learned about travel behavior and potential barriers to change in different types of Vermont communities and concludes with how the findings from this phase of our work can inform policy decisions and further research needs.

Methods

We collected information on travel behavior, fuel price response, attitudes towards EVs, and opportunities and barriers to reduce GHG emissions from transportation from 173 in-person interviews conducted during the spring and summer of 2021 with individuals from 43 Vermont municipalities. Interviews were transcribed and coded to identify differences in the responses of individuals from different types of communities.

On-the-Street Interviews

To reach a diverse group of people in a variety of small and rural places, we choose to interview people in person in a range of frequently used public places. The semi-structured interviews included 20 questions with additional follow up questions depending on the respondents' answers (e.g., asking if they use public transportation after the respondent states that they have access). Topics of questioning included general travel questions about primary mode in a typical week, overall challenges and likes about travel in their community, travel changes related to the Covid-19 pandemic, responses to fuel price changes, predictions for fuel prices, opportunities and challenges to meeting statewide GHG emission reduction goals, and one question comparing their personal travel to others in their community. The full range of questions we asked, and their themes are shown in Table 2. The audio of the interviews was recorded, and a transcript was generated to be coded qualitatively. At the conclusion of the interview, an optional demographic questionnaire capturing town of residence, age, household size, number of household vehicles, gender, income, employment status, race, and ethnicity.

Table 2. Interview Questions by Theme

Theme	Interview Questions
Opening Questions	1. Do you live in an urban, suburban, or rural area? 2. How long have you lived in Vermont?
Covid-19 Effects on Travel	1. How has your travel changed since Covid-19? 2. During the initial stages of the pandemic quarantines, were you walking or biking more or less than usual? 3. Do you walk or bike more or less since the pandemic conditions have improved?
Responses to Fuel Prices	1. Has the increasing cost of gas has changed how you travel? 2. Has the increasing cost of gasoline changed the type of vehicle you now own or would consider purchasing in the future? 3. Do you think gas prices will stay about the same, increase, or decrease in the next 5 – 10 years? 4. If gas prices were expected to increase by 50% in the next year, how do you think this would impact how you travel?
Actual and Perceived Barriers to Change	1. What do you think could be done to reduce greenhouse gas emissions from transportation in your community so the State can meet its goals? 2. What are some of the largest challenges you see to reducing the amount of gas that people in your community use for transportation? 3. Are you aware of the rebates and incentive programs offered by the state and federal governments? 4. Do you feel that electric vehicles would work for you? 5. Do you think these incentives are helping people purchase electric vehicles?

Theme	Interview Questions
Alternative Modes of Transportation	1. Do you have access to public transportation where you live and/or work? A. If yes, do you use it? a. If no, why? b. If yes, how do you use it? 2. Would you ever consider moving somewhere else to reduce or change the way you travel?
Range of Travel Behavior	1. What are your largest challenges you face while travelling? A. Are there things that you like, or you think work well for people traveling in your community? B. What suggestions or ideas do you have for improving how people travel in your community? 2. In a typical week, what mode of transportation do you usually use? 3. How do you feel your travel varies from people in your community? For example, do you feel like you travel more, less, or about the same? What about the different modes of transportation you use?

Over the course of the study, interviews were conducted in 16 towns at 26 locations. The towns and cities selected represented a range of population densities and distance to more metropolitan areas. Locations included public parks, beaches, recreation facilities, downtowns and village centers, boat launches, farmers markets, state parks, and general stores or supermarkets. These places were selected as they attract a wide variety of people and are open to the general public. Researchers conducted interviews between 10am and 1pm and again between 3pm and 7pm on both weekdays and weekends. In a given city or town, between 2 and 20 people were interviewed during a single session with each interview lasting approximately five minutes.

Interview participants were selected at random with a few considerations. To qualify as a research participant, the individual must be at least 18 years old and be a resident of Vermont. In sparsely populated parks and beaches, all individuals who were not actively preoccupied (i.e., on the phone, taking care of a child, etc.) were approached for an interview. In more populated public spaces, the area was subdivided and each person within a randomly selected subdivision was approached. When interviews were conducted outside of stores or on a downtown sidewalk, every third person to pass by was asked to participate in the study. We had a 74.6% acceptance rate for inclusion in the study with 173 completed interviews out of 232 attempted interviews.

Interview Analysis

The 173 audio recordings of the interviews were transcribed using computer software which was then manually verified by listening to the recordings and updating transcripts as needed.

19 of these recordings were inaudible due to windy conditions, leaving 151 usable interviews. After removing out of state interviews, 139 interviews remained for analysis. Transcriptions were then coded for attributes of the interviewee, their community, or their travel behavior using NVivo by three members of the research team. The coding scheme used by the coders was developed iteratively after initial attempts at coding a small portion of the interviews. The codes included 21 topics with numerous subcodes to be used in analysis. A brief description of the coding topics is provided in Table 3.

Table 3. Coding Scheme Description

Topic	Number of Subcodes	Description
Introductory Questions		
Primary Mode	4	Primary mode of transportation in a typical week
Length of Vermont Residence	5	Length of time the participant has lived in Vermont
Pandemic Travel Behavior		
Overall Travel After Pandemic	4	Overall amount of travel after pandemic conditions improved
Overall Travel During Pandemic	4	Overall amount of travel during pandemic
Walk-Bike Purpose During Quarantine	2	Recreational or essential travel by walking and/or biking during early pandemic quarantine
Travel Improvement Suggestions	15	Suggestions for improving local or regional travel
Walk-Bike-Vehicle Change During Pandemic	16	No change, increase, or decrease of walking, biking, public transportation, and/or vehicular travel during early pandemic quarantine
Responses to Fuel Prices		
Fuel Price Impact	11	Impact of fuel price increases since 2009
Future Fuel Price Impact	10	Anticipated impact from fuel prices if they were to increase by 50% in the next 1 – 2 years
Fuel Price Prediction	5	Prediction for fuel prices over the next decade
Actual and Perceived Barriers to Change		
GHG Reduction Suggestions	16	Strategies recommended for reducing GHG emissions to meet statewide goal
Reducing Gas Challenges	10	Challenges the participant sees to reducing the amount of gas used by members of their community

Topic	Number of Subcodes	Description
Electric Vehicles		
Electric Vehicle Rebate Awareness	3	Awareness of existing EV incentive program
Electric Vehicle Incentives	6	Opinion on the effectiveness of Vermont's EV incentive program
Electric Vehicle Ownership	11	Likelihood of owning an electric vehicle at some point
Modes of Transportation		
Public Transit Access	3	Access, or lack thereof, to public transportation and frequency of use
General Travel Behavior		
General Travel Challenges	12	Challenges expressed about general travel in the participants' community
General Travel Likes	8	Components of travel that work well in the participants' community
Travel Improvement Suggestions	15	Suggestions for improving local or regional travel
Move to Change Travel	11	Likelihood of participant moving to change or reduce their current travel
Travel Comparison	17	How the participant sees their travel compares to members of their community

Intercoder reliability (ICR) was evaluated to ensure reliability across the three coders coding the interview transcripts (*57*). Of the 151 usable interviews, 27 (18%) were tested using ICR. It is recommended to test between 15 and 25% of the total sample using ICR (*58*). By using the coding comparison query tool in NVivo, the percent agreement and disagreement and Cohen's kappa coefficient are reported. The kappa coefficient is reported in NVivo for each code and file separately. In this report, the average kappa coefficient for each coding theme is reported. Research suggests that percent agreement or disagreement is not a sufficient reporting tool, whereas a kappa coefficient is more widely accepted as they are more likely to account for chance agreements or disagreements (*59*). The range of possible kappa values is from -1 to 1 with a value of 0 meaning agreement by chance, values below 0 meaning agreement less than chance, and values above 0 meaning some level of agreement. A value of 1 indicates perfect agreement that is not related to chance. The formula for calculating kappa is shown below in Equation 2. The kappa coefficients for each coding category across the 27 transcripts tested for ICR are presented in Table 4.

$$\kappa = \frac{A_0 - A_e}{1 - A_e} \quad (2)$$

Where:

A_0 = the observed agreement between coders;

A_e = the expected agreement as a result of chance

Table 4. Coding Scheme Kappa Coefficients

Code Category	Mean Kappa Coefficient
Electric Vehicle Incentives	0.903
Electric Vehicle Ownership	0.944
Electric Vehicle Rebate Awareness	0.903
Fuel Price Impact	0.929
Fuel Price Prediction	0.937
Future Fuel Price Impact	0.916
General Travel Challenges	0.952
General Travel Likes	0.986
GHG Reduction Suggestions	0.928
Length of Vermont Residence	0.936
Move to Change Travel	0.931
Overall Travel After Pandemic	0.972
Overall Travel During Pandemic	0.919
Primary Mode	0.832
Public Transit Access	0.866
Reducing Gas Challenges	0.958
Travel Comparison	0.961
Travel Improvement Suggestions	0.964
Walk-Bike Purpose During Quarantine	0.961
Walk-Bike-Vehicle Change After Pandemic	0.955
Walk-Bike-Vehicle Change During Pandemic	0.883

The coefficients shown in Table 4 show an overall very high level of agreement, with a minimum value of 0.832 and a mean of 0.926. Research suggests that values of 0.8 are generally accepted by most standards and all standards agree that values over 0.9 are acceptable (*58*). One of the most widely cited pieces of literature on measuring agreement between observers or coders states that kappa coefficients between 0.81 and 1 represent almost perfect agreement (*60*). Based on these standards, the coding presented in this research is valid and can be used for analysis.

Results

Demographic Survey

The optional demographic survey presented to participants was completed by 139 individuals who reside in 43 towns in Vermont. The cities and towns represented in our sample are shown in the map provided in Figure 6. Sampled Cities and Towns by Proportion of Total Sample. The northwestern portion of the state, where most of the sample occurred, is home to the majority of the state's population and developed land. There are a wide range of land use patterns and covers all types of community on the urban-rural continuum. This survey was updated to include additional variables as the study progressed, so employment and gender were completed by fewer respondents than the other variables. The representation of gender mirrored that of the state, although it was based on a smaller sample as it was added to the demographic survey after some responses had already been collected. The sample demographics are presented in Table 5. Sample Demographics Descriptive Statistics and compared to 2019 American Community Survey (ACS) five-year average values for available demographic characteristics. Employment status information was collected from the US Bureau of Labor Statistics 2020 Employment Profile and is only available for employed or unemployed and eligible to be in the workforce. The sample collected in this research is representative of statewide US Census data for race, while our sample underrepresents high income households earning over $100,000. Employment status is not directly comparable as only those eligible for the workforce are shown for the statewide comparison.

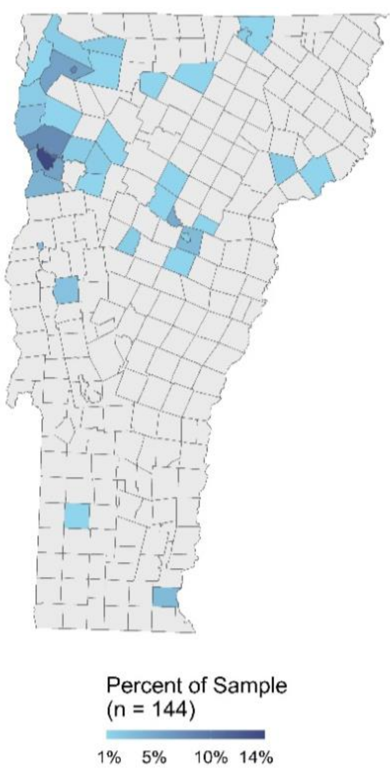


Figure 6. Sampled Cities and Towns by Proportion of Total Sample

Table 5. Sample Demographics Descriptive Statistics

Variable	Count	Study Sample	2019 ACS
Gender			
Female	26	54.2%	51.0%
Male	22	45.8%	49.0%
Other	0		
Race			
American Indian or Alaska Native	2	1.4%	0.5%
Asian or Asian American	3	2.1%	1.4%
Black or African American	3	2.1%	1.5%
White	131	93.8%	93.8%
Other	1	0.6%	2.8%
Income			
Less than $34,999	43	30.7%	26.6%
$35,000 – $49,999	16	11.4%	12.3%
$50,000 – $74,999	22	15.7%	19.0%
$75,000 – $99,999	24	17.1%	13.7%
Over $100,000	29	20.7%	28.4%
Prefer Not to Answer	6	4.4%	
Employment Status			
Employed (part-time or full-time)	78	63.9%	63.2%
Self-Employed	9	7.4%	7.6%
Retired	20	16.4%	
Student	3	2.5%	
Unable to Work	1	0.8%	
Unemployed	11	9.0%	2.2%
Number of Adults in the Household			
1	28	20.1%	31.6%
2	86	61.9%	39.2%
3	9	6.6%	13.5%
4 or more	16	11.4%	15.5%
Number of Children (under 18 years) in the Household			
0	92	66.2%	71.6%
1	17	12.2%	13.0%
2	19	13.7%	10.9%
3	5	3.6%	3.4%
4 or more	6	4.3%	1.1%
Number of Vehicles Available in the Household			
0	2	1.5%	6.9%
1	37	27.2%	35.9%
2	55	40.4%	39.5%
3	26	19.1%	12.5%
4 or more	16	11.8%	5.2%

Interview Responses

The responses provided by the participants are organized into themes that are reflected in the following sections. Of interest to this research are general attitudes towards rural travel behavior, including culture around vehicles and public transportation, attitudes towards EVs, and responses to transportation costs. As part of the interview, participants were asked to self-identify their town or city of residence as urban, suburban, rural or a village center. The community type of four respondents was unknown due to audio recording issues (background noise) or because the respondent was unsure how to describe their community type. The distribution of responses is shown in Table 6.

Table 6. Distribution of Self-Identification of Rurality

Classification	Count	Percent of Total Sample
Urban	45	32.4%
Suburban	24	17.3%
Rural	64	46.0%
Village Center	2	1.4%
Unknown	4	2.9%
TOTAL	139	100%

General Attitudes on Transportation and Means of Travel

A participant from a rural area articulated quite clearly the reason for this study and stated, "I think my general messages is pay closer attention to, you know, to rural areas…urban areas; that's where a lot of people, you know, a lot of the population is concentrated, but I think that there's a lot more attention that could be paid to rural communities". This response indicates that individuals residing in rural areas may feel overlooked when it comes to transportation planning and decision making. In this section we discuss how respondents in different community types travel and what their transportation challenges are.

One thing that comes with rural communities is a predominant culture around vehicles and automobile dependence, often as a result of isolation from services and lack of public transportation. The primary mode for the majority of respondents in all community types was a personal vehicle (Figure 7). Only a minor portion of suburban (20%) and rural (12%) respondents indicated another mode for their primary means of travel. Urban residents were more likely to report walking as their primary means of travel (29%) and transit (12%). Very few respondents in any community type use a bicycle as their primary means of travel (less than 5% in all community types).

Although public transportation is not the primary mode of transportation, all respondents from urban areas stated they have access to public transportation and 42% of them use it on some occasion (Figure 8). Most suburban respondents also have access to public transportation 80%) but very few use it (13%). Fewer rural respondents reported having access to public transportation (42%) than suburban respondents and they were even less likely to use it (4%). Reasons given for not using public transit, particularly in rural areas, were easier access to a vehicle or public transportation did not get them where they needed to go. A participant from a suburban area mentioned that there is a bus stop at the end of her street, but they do not even think to take it because getting in the car and driving “just because it's easiest”. When examining these results shown in Figure 3 using a χ^2 test, a p-value of 0.01 was calculated, showing that the differences in responses across urban, suburban, and rural groups were statistically significant.

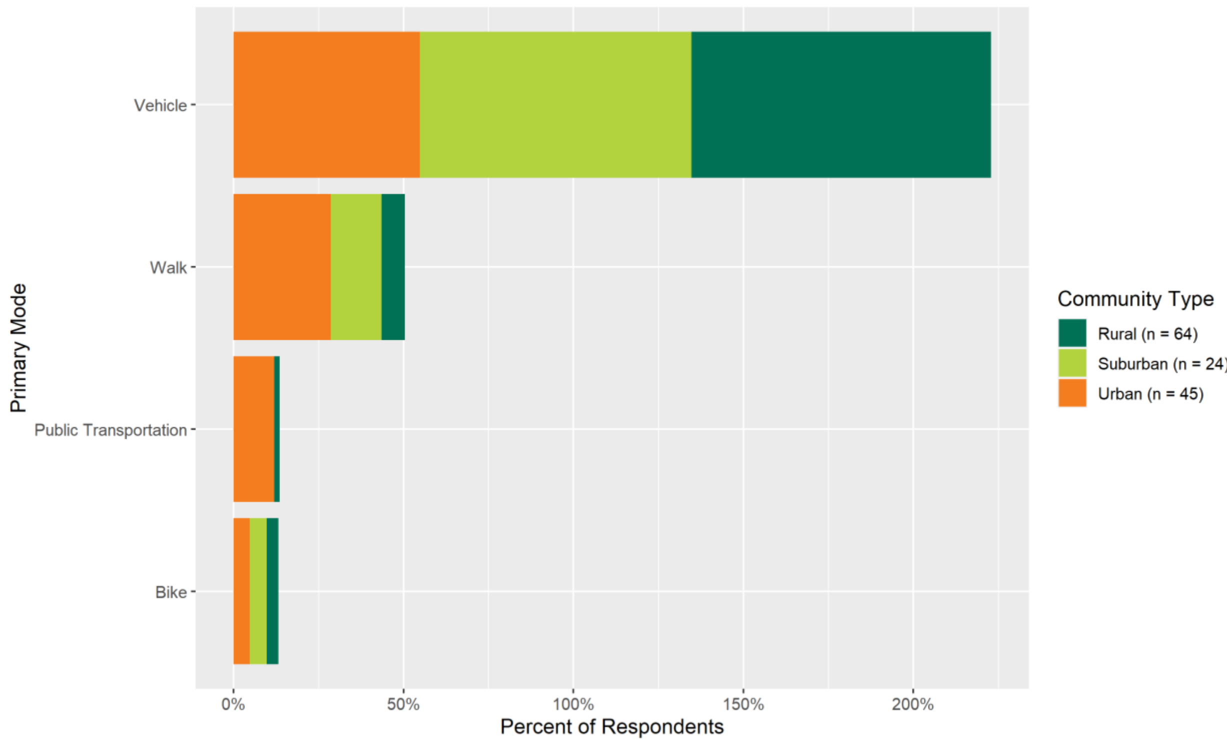


Figure 7. Primary Mode of Transportation

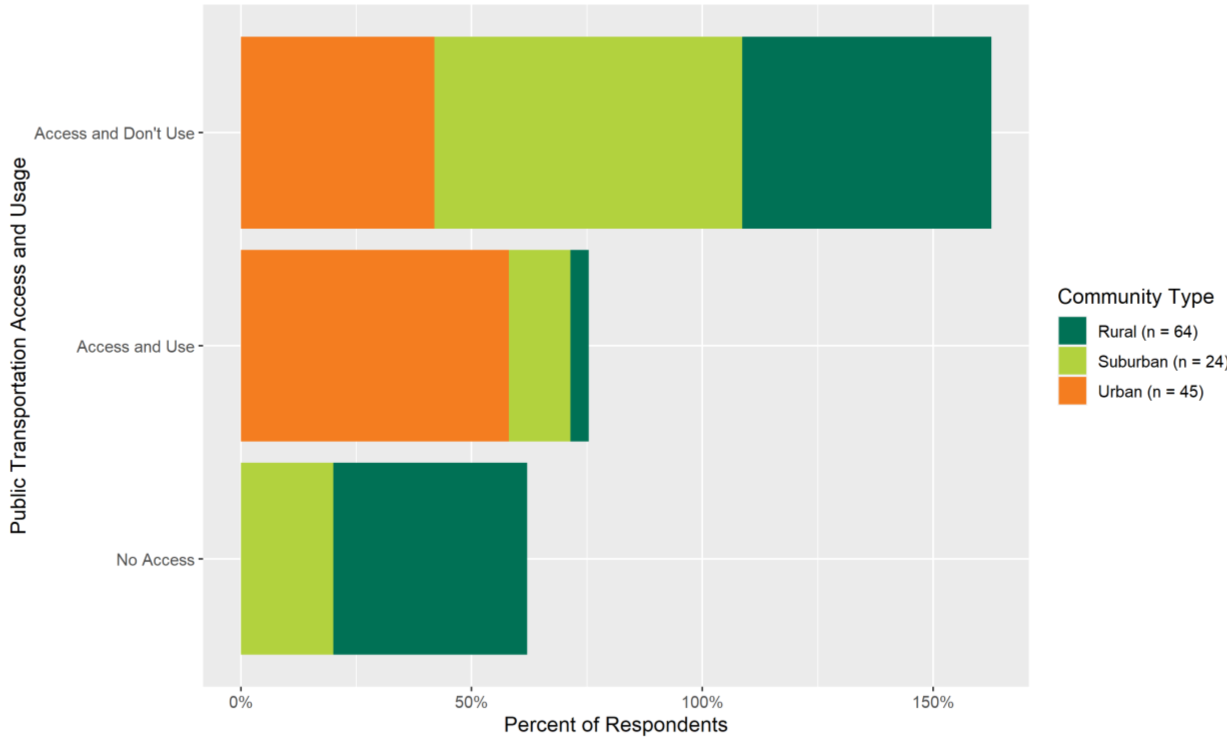


Figure 8. Public Transportation Access and Usage

Most respondents did not indicate they face any significant transportation challenges (Figure 9). Traffic was the most frequently cited concern for urban (18%) and suburban (23%) residents while road conditions (13%) and distance to services (18%) were the primary concerns of rural residents. Affordability was also a concern for some urban (8%) and suburban (8%) residents in addition to a lack of travel options (12%) and safety (8%) for suburban residents. We also asked respondents what they thought worked well or what they liked about traveling in their community. Most respondents did not respond to this question, but those who did most frequently mentioned that they enjoyed Vermont's natural scenery (12%) with no apparent difference between community types (Figure 10). Other positive views were relatively infrequent were not statistically significant across community types.

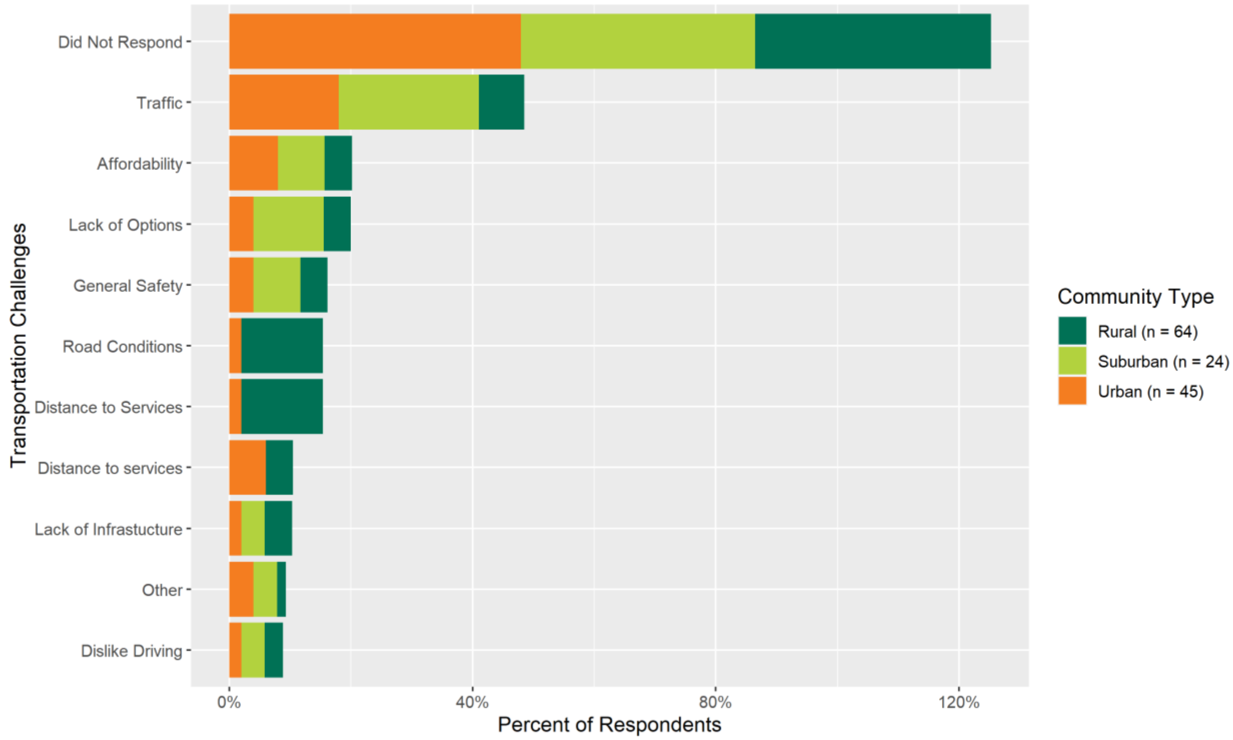


Figure 9. Travel Challenges in Vermont

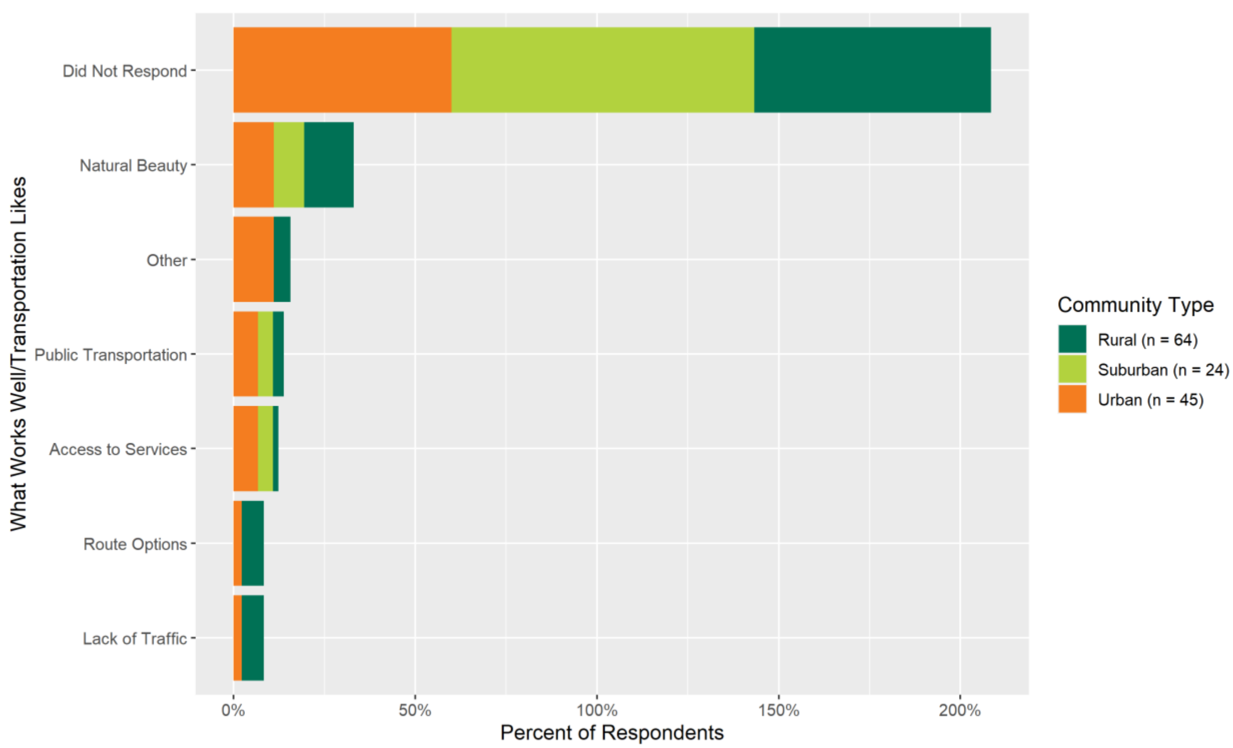


Figure 10. What Works Well or is Liked About Travel in Vermont

Attitudes on Electric Vehicles

Another component of the interview asked about knowledge of EV rebate programs offered by the state, if they think these rebates are effective, and if they would consider purchasing an EV. A recurring theme throughout our interviews was that most people (41%) were not aware of the rebates. Awareness of rebates was similar across community types with approximately 30% of respondents from each community type being aware (Figure 11). Many respondents stated that they wished they had known about EV incentives, that there should be more education and outreach to inform Vermonters about EV incentives, and that they would likely tell their friends and family about them. When asked about effectiveness of the EV rebates, most people were unsure or felt unqualified to answer. 25% of suburban participants and 20% of urban participants stated they were definitely effective whereas only 14% of rural participants saw them as being definitely effective.

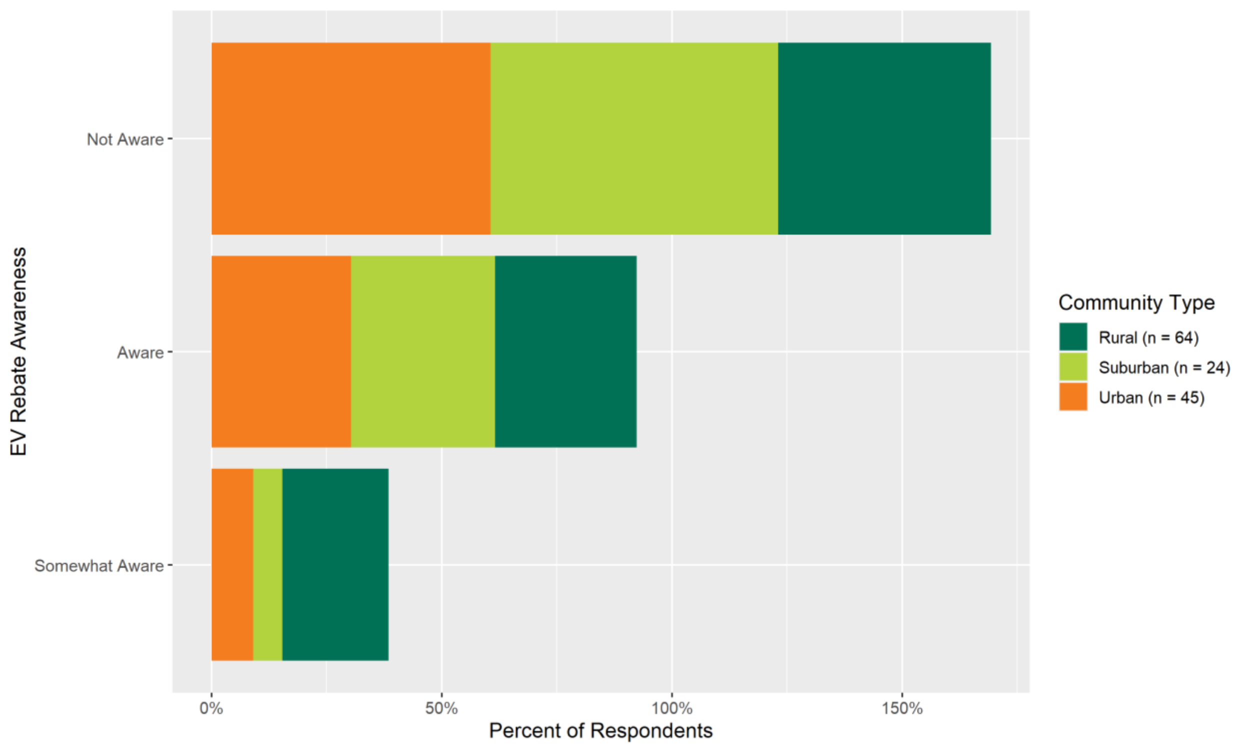


Figure 11. EV Rebate Program Awareness

Most respondents indicated that they would consider owning an EV (Figure 12). Rural residents were more resistant to considering an EV (15%), with relatively fewer suburban (11%) and urban (13%) residents stating they would not consider owning an EV. The largest share of those that would definitely own an EV were from suburban areas (47%). Cultural factors may play a role in greater EV resistance in rural areas. For example, one respondent from an urban community stated, "I think because there's such a culture here. I can't see people switching to tiny little electronic cars" and another rural responded stated, "a lot of people will still fight that image of being the Prius driving hippie". For those considering EVs, costs and charging were the largest concerns. For example, a rural respondent said, "…my husband was just looking at them and my issue was the smaller ones are too small. I don't feel like they're safe enough for my kids. And then the SUVs are too expensive, so I can't afford them" and another respondent said, "I feel like electric vehicles are really targeted to a certain income bracket of people…whereas I would be choosing an electric vehicle over being able to pay the rest of my bills." We also evaluated how EV consideration varied with knowledge of EV incentives, finding no apparent affect.

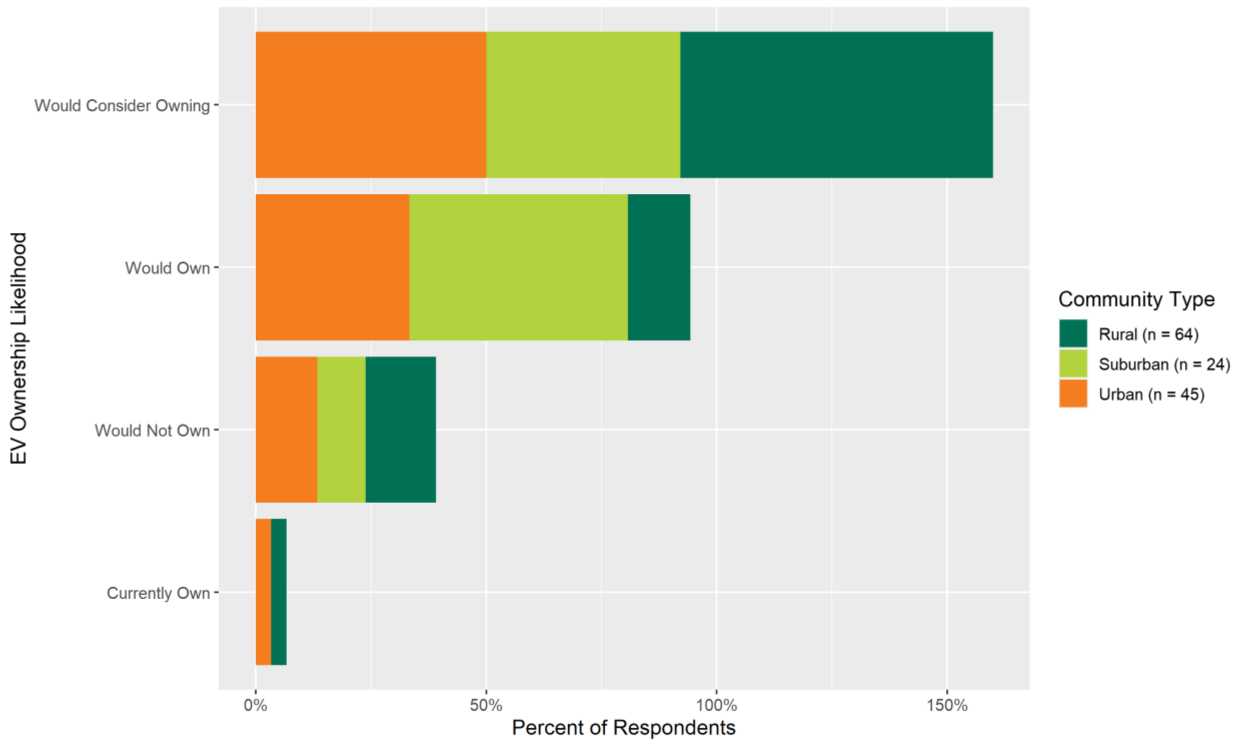


Figure 12. Ownership Likelihood vs. Rurality

Impacts of Fuel Prices

Interviewees were informed that between 2009 and 2011, gasoline and diesel fuel prices went up by about $1.00 per gallon and increased another $0.60 per gallon between 2014 and 2016. They were then asked if this had an any impact on how they travel behavior or the vehicle they use.

Overall, most respondents indicated that rising fuel prices had little impact on how they travel or their vehicle choice (Figure 13). Rural residents were most likely to report no effect on how they travel (66%), followed by urban (53%) and suburban (39%) residents. Some suburban residents (38%) indicated they had started to or were considering using more fuel-efficient vehicles, but few residents in any community type indicated they had or were considering reducing the amount they drive. These results agree with prior studies that have found travel to be inelastic to changes in fuel costs and point to high levels of automobile dependence in all community types in Vermont. One rural participant put it succinctly saying, "the price you have to pay is the price you have to pay". A participant from a suburban area also stated, "We still go where we're going to go. We don't not go somewhere because price was going up”. One respondent from a rural area even mentioned that they would work additional hours just to pay for gasoline so that they could travel the way they wanted to with their family, even if gas prices were upwards of $6.00 per gallon. We also asked respondents if they have considered moving to change how they travel. Most indicated they would not (66%), with rural participants most frequently citing that they liked where they live, were close to their job or thought other places were not affordable. Respondents who indicated they would consider moving were motivated by avoiding traffic and being closer to services. Other factors including affordability and a desire to use other modes of travel were infrequently mentioned as reasons that one would move.

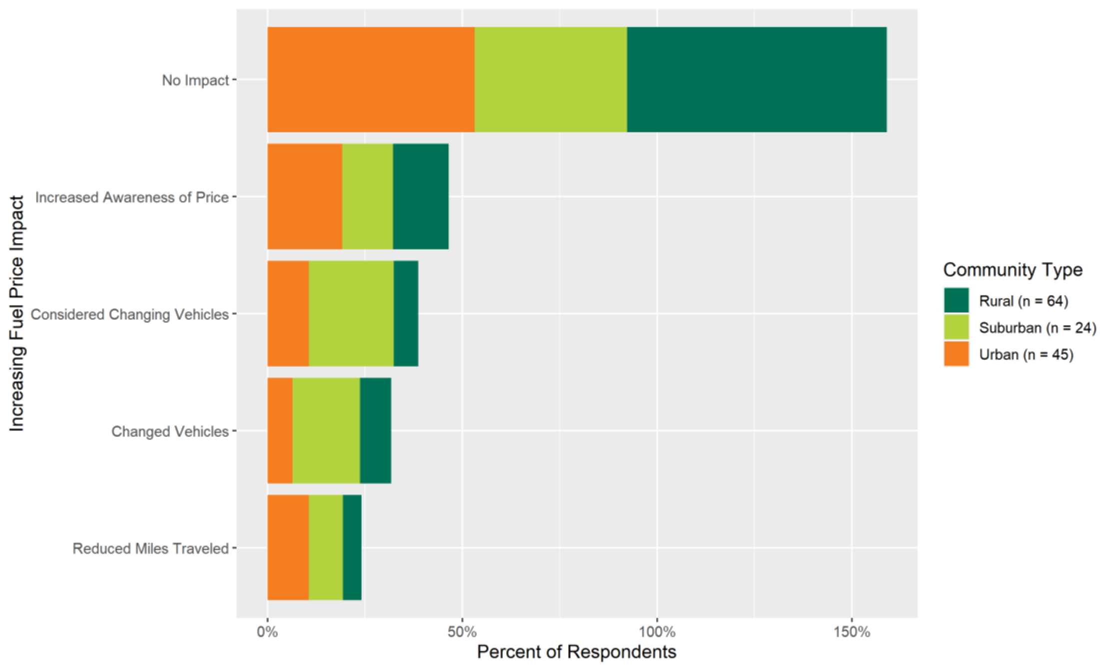


Figure 13. Increasing Fuel Price Impact vs. Rurality

We also asked respondents if they thought fuel prices would go up, down, fluctuate, or stay the same over the next 5 – 10 years to understand if price expectations influence attitudes towards EVs and other behaviors that could reduce fuel use. Most respondents (63%) said they thought prices would increase, with little difference in this response across the three community types (Figure 14). We evaluated how responses regrading EV adoption and moving to change how one travels varied with price expectations, finding little to no association. There were a few people expressed that they hoped gas prices would increase so that EVs would become more widely appealing. A rural respondent mentioned, “I hope they will increase as a way of encouraging people to seek alternative forms of transportation.”

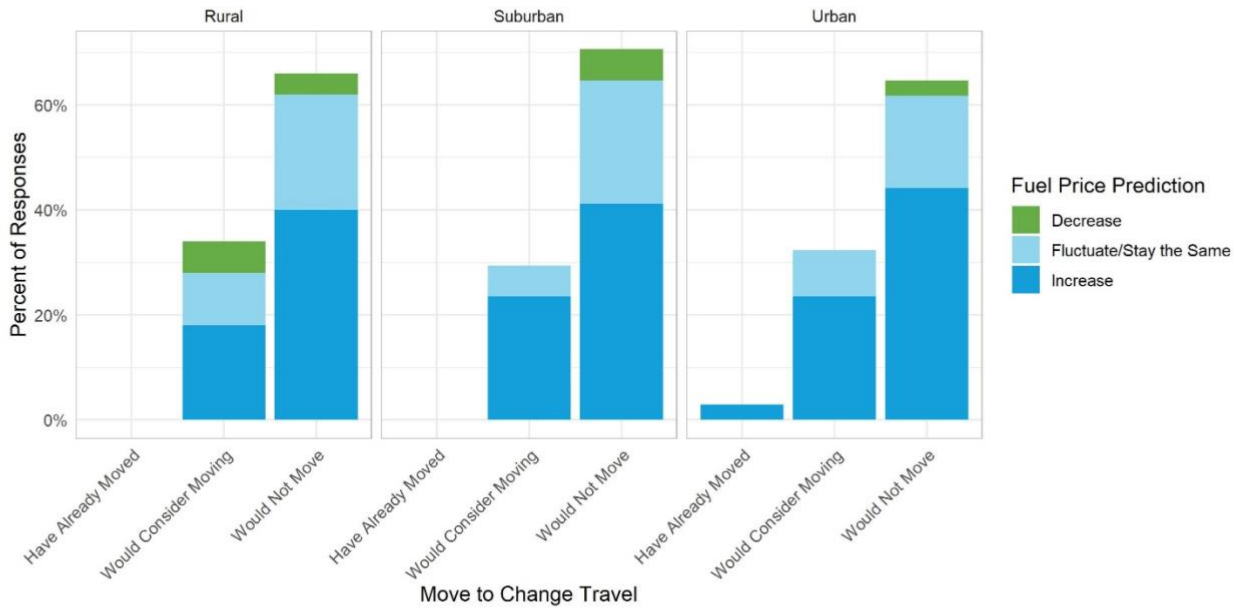


Figure 14. Moving to Change Travel vs. Fuel Price Prediction by Rurality

Attitudes on Reducing Greenhouse Gas Emissions

During the interviews we informed respondents about Vermont's climate goals and asked them what could be done in their communities to help meet this goal regardless of whether they thought the goals were necessary or climate change was a problem. One of the most common answers was to increase access to public transportation. Responses around transit included recommending increasing frequency, the number of stops, and the number or routes. A participant from a suburban area stated, "I think buses are the answer…but I think it's just the reputation… wish somehow government could put the resources into changing public perception of taking the public bus.". The second most common response was to increase the number of EVs on the road. This was a more common answer in rural areas than urban areas. Another common answer in rural areas was to increase carpooling options. One rural respondent said, "I think there's a lot of opportunity for carpooling that doesn't happen", when referencing people traveling to their place of work. When asking rural participants what they see as the largest challenges to reducing gas use in their community, nearly 26% noted distances to services, 22% said lack of sustainable alternatives, and 16% thought there was general resistance to change. This aligns well with the challenges they see to reducing gas. It may be possible to draw the conclusion that if services are going to be far away in rural areas, there should more EVs making those trips or there should be public transportation to get them there. The complete range suggestions for GHG reductions organized by rurality is shown in Figure 15.

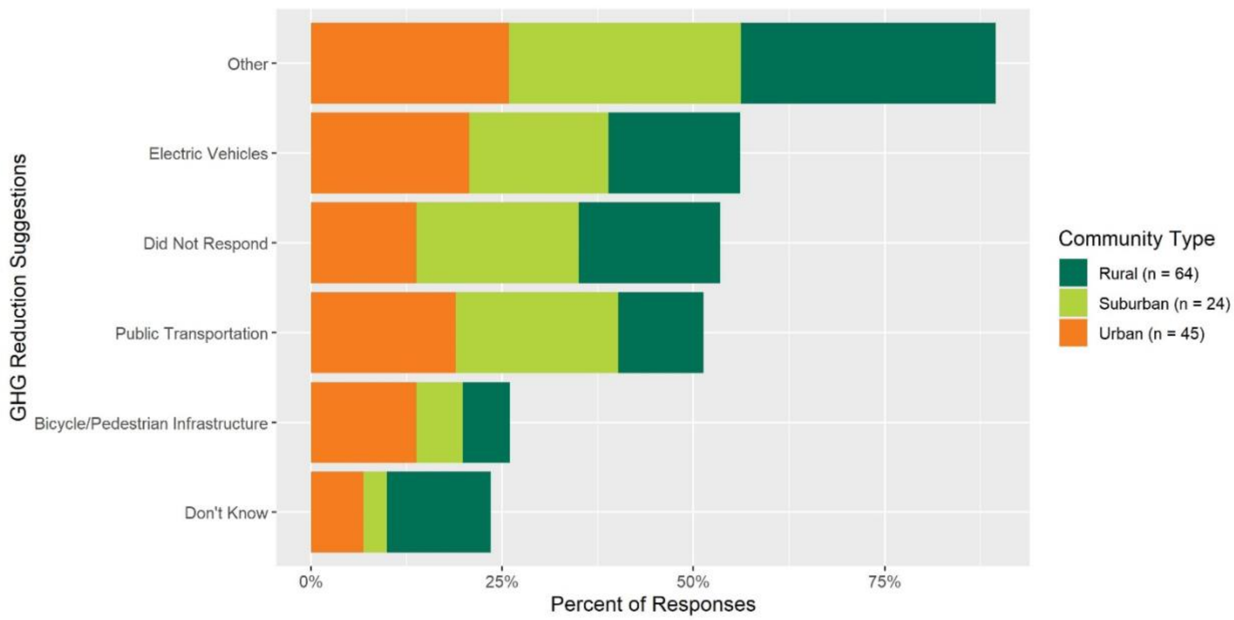


Figure 15. Greenhouse Gas Reduction Suggestions vs. Rurality

Discussion

The main objective of this study was to collect new information about what barriers people living in a range of small and rural communities face when traveling and looking to reduce GHG emissions as well as their responses to increasing transportation fuel costs. The aim is to identify challenges deserving additional research attention since the travel behavior of people and households in smaller and rural communities has been studied much less than those in larger metropolitan areas. One hurdle to overcome when conducting research in smaller and rural communities is recruiting a diverse range of participants. We pivoted from an initial plan to conduct focus group meetings in various communities to interviews in public places as a response to COVID-19 restrictions on group meetings. By intercepting individuals in public places and conducing short interviews, we were able to collect information from a modest number of individuals in many different types of communities that included participants with a range of socioeconomic characteristics that aligned reasonably well with Vermont's overall adult population. The interviews were relatively quick to complete, and most people agreed to be interviewed upon being approached. We think that in-person recruitment, whether an interview is conducted or not, offers an effective and efficient means to recruit individuals for place-based research, particularly where more difficult to research populations are of interest such as people living in rural communities.

This research showed some key differences between urban and rural areas which are relevant to understanding how we can shift to reduce GHG emissions. In this study, all urban-dwelling participants had access to public transportation, whereas less than half of rural-dwelling participants did not have access. Of those that had access in rural areas, they usually did not use it because the services were inadequate, or they preferred to use their vehicles. Increasing routes and frequency of public transportation in rural communities may make transit a more viable option for commuting and other travel needs. Another notable difference was in the daily challenges people faced in rural versus urban areas. In rural areas, people most frequently commented on the road conditions or the distance they must travel for services whereas in urban areas, the common challenge was traffic. The distances to services may be abated by the encouragement of denser, mixed-use village centers which can allow for closer access to basic needs like food and retail services. Density, even if in small clusters, provides opportunities for more active and public transportation (*61*).

While there are vast differences between urban and rural areas, there are shared characteristics, some of which can be leveraged to reduce GHG emissions from transportation whereas others create a barrier for change. Most people are satisfied with their travel and where they live. Most people did not indicate significant challenges or feel they would move to travel differently. For those who did indicate they would consider moving to change how they travel, this was generally to avoid traffic or increase accessibility rather than avoid costs or switch modes. Automobile dependence is high in all communities. Most people stated that higher fuel prices are unlikely to change the amount they travel. If anything, they would consider using a more efficient or electric vehicle. This aligns well with national level research on fuel price elasticities, but we cannot say if individuals in small and rural communities are more or less price sensitive than those in more urban places with the data we have collected.

Most participants indicated they have some level of transit access, yet few use it as their primary means of travel. Based on what we heard, unless transit can compete with the convenience and speed of private vehicles its unlikely to enjoy much use in Vermont since travel costs were infrequently mentioned as a concern. Traffic in urban areas and roadway conditions and distance to services in rural communities seem much more important than costs and it's unclear that better transit service would directly address these concerns, particularly in rural places. People did seem to walk and use transit more in urban areas, raising the potential that more compact development in rural and other small communities could result in some substitution of vehicle trips for walking and transit. Few people bike and there was little difference in attitudes towards bicycling across community types. Our sample size and the very low bicycle mode share in Vermont limits any meaningful conclusions about factors that could influence bicycling in different community contexts in Vermont.

The most common barrier to EV ownership is the cost, yet most people are unaware of the rebate and incentive programs offered by the state and for those that are aware, many do not think they are enough to counteract the cost of the vehicle. Even with awareness, it has been seen that cost is generally a barrier to entry into the EV market for consumers (*62*). Increasing education and awareness of these programs, while also bolstering them to provide larger incentives, may push many Vermonters to make the switch to an EV. If adoption of EVs becomes widespread, lifecycle emissions can be reduced by upwards of 10 – 20% per kilometer of travel (*63*). The transition to EVs will take time, an increase in supply of vehicles, a more diverse array of vehicle styles, increased infrastructure, and overall lower costs, but there are opportunities to encourage this transition through subsidies, incentives, and education.

Most people we spoke with indicated that increasing the use of EVs and transit were the most effective means to reduce GHG emissions and meet the state's climate goals. Active travel was also frequently cited. Notably, few people we spoke to use transit regularly, use active travel modes outside or urban areas or have purchased an EV which points to the challenges a rural state like Vermont may have in meeting its climate goals. Reducing the amount of travel was not something considered by most. In fact, many respondents indicated they would continue using their vehicle regardless of costs which one indicates that pricing policies may be costly Vermonters if their demand response is as inelastic as they state, and that pricing and other demand reduction strategies may receive little public support.

This study has shown that people living in urban, suburban, and rural areas in Vermont vary in terms of the daily challenges they face while traveling, but also share some notable attributes. This has impacts on current and future policy decisions aimed at changing behavior to reduce GHG emissions. Many researchers and policymakers have claimed that pricing policies are going to be effective in reducing emissions, and they are in some areas, but this may not be the case in rural communities. This research sought to further investigate this responsiveness to fuel prices. Many Vermonters expressed that they would do what they must do to pay for fuel, regardless of prices. This perceived inelasticity may have merit over the course of long-term price increases. When a sudden price shock hits, people tend to be more responsive, however these changes do not always withstand the test of time, even if prices do not go back down (*64*). This idea of dependence often leads people to be opposed to gas taxes because they say that they will pay whatever they have to in order to maintain their current travel patterns. Stated preference surveys have shown that people say they would seek alternative forms of transportation if gas prices were to reach six dollars per gallon (*65*). The relationship between stated preference and revealed data is often studied as humans do not always act in the ways in which they say they will, meaning their stated preferences do not align with the eventual revealed preferences. This is particularly prevalent when asked to perform valuations of public goods. In these cases, valuations are frequently overexaggerated (*66*, *67*).

Further research is suggested to examine this more closely and analyze whether people truly maintain their behavior or if there are changes in behavior in response to increasing prices. We plan to use these study conclusions to launch more detailed studies in how to remove barriers to behavior change and better understand opportunities to reduce GHG emission from transportation in small and rural communities. Our present findings suggest that many individuals are receptive to using more efficient and electric vehicles. Reducing demand and shifting towards transit and active travel appear more challenging since this would generally require more compact development and encouraging individuals to move towards more compact places. Most people were very satisfied with where they currently live and how they currently travel (using a private automobile). This points to a need to further understand how attitudes and housing preferences could be modified.

We are using data from these interviews to implement a more comprehensive stated-preference survey to dig deeper into what it would take to change rural travel behavior and increase the sustainability of rural travel. The research presented here draws from a diverse, but small sample size. There were also limited questions asked to keep the interviews short and maximize participation. Future research aims to capture a larger sample of individuals across many small and rural communities. The lines of questioning may include scenarios with specific gas prices or distance to bus service to establish elasticities of individuals who may change their behavior. Additional research can help to establish a baseline of where people are at with their behavior and where they may change to reduce emissions from transportation. There is likely no silver bullet for reducing transportation emissions in small and rural communities, but through a deeper understanding of the challenges that people face and changes they are willing to make, a diverse suite of options for reducing GHG emissions can be developed and implemented over time. By using in-person interviews conducted in public places, this research provides a unique point of view in studying individuals who are often neglected in the current body of literature on travel behavior. This study has increased understanding of the barriers and opportunities in rural communities across Vermont, and likely in similar regions, for changing behavior for the sake of reducing GHG emissions from transportation. Climate change is a global crisis that must be combatted and with over one third of emissions coming from transportation, we must act quickly and encourage behavior that is conducive to a world in which we can thrive sustainably. Behavior change is a complex thing to achieve, but it is only possible through continued study and close communication with the people that are directly impacted.

Chapter 4: The Impacts of COVID-19 on Travel Behavior in Small and Rural Communities

Julia Clarke, Erica Quallen, Clare Nelson, and Gregory Rowangould

Introduction

The COVID-19 pandemic has caused a dramatic change in travel behavior across the globe and in the United States (*68*, *69*). Many people stayed home to comply with government mandates, worked and attended school remotely, and relied increasingly on the delivery of goods rather than shopping in person. Passenger vehicle traffic plummeted in most places (*70*). and transit use also declined significantly or was suspended (*71*) .During the pandemic, it was also widely observed that bicycling increased in the United States (*72*) while the impact on walking has been mixed (*73*, *74*). The pandemic has raised two interesting questions that are the subject of many recent and current transportation research studies. Which travel related changes ushered in by the pandemic are likely to remain when COVID-19 is hopefully a distant memory? Similarly, for whom did travel change most and who stands to benefit (or suffer) from changes that may represent more durable shifts in behavior? While time will likely reveal the answers to these questions, in the present we have the opportunity to encourage beneficial changes and to address inequities that have been exposed. In this study, we focus on a population that has received relatively little attention in the COVID-19 travel behavior research arena—rural populations.

The impacts of COVID-19 have not been experienced equally. Stay at home orders and other containment measures varied across states, employers, and school districts. Those deemed to be essential workers, such as medical providers, grocery store workers, and others, remained on the job, in-person, while many worked from home and others lost their jobs. One outcome of these disparate impacts is that lower income households and people of color were less likely to change their travel behavior, likely because many are essential workers and employed in jobs that cannot be done remotely (*69*, *75*, *76*).

Furthermore, most studies evaluating how travel behavior changed during the pandemic and identifying disparate impacts have focused solely on urban areas(*69*, *72*, *77–81*). Jiao and Azimian (*69*) summarized the recent COVID-19 travel behavior literature. Their summary includes an evaluation of the factors considered by each study, but geography or type of community (i.e., urban, suburban, or rural) is not included, presumably because this was not a commonly evaluated factor. Furthermore, papers discussing travel behavior change that were included in the recently published COVID-19 special issue of Transport Letters did not address the potential differing experiences in urban or more rural populations (*78*). Impacts on households in smaller and rural communities are likely to have varied from what has been widely reported in urban areas or from the nation, which often varies in demographics, socioeconomic status, and travel behavior. While most studies have focused on those urban areas, some data can be found which points to the impacts on rural areas.

Data from Streetlight indicates that there was a smaller decrease in vehicle miles traveled (VMT) in rural areas (*70*). A survey-based study in a rural region of Germany also found a smaller decline in vehicle travel in rural areas and noted a smaller increase in bicycling and no change in walking (*82*). As was the case for lower income and people of color in many US cities, residents in rural Germany were more likely to work in occupations that could not be done remotely. Therefore, they were forced to continue commuting to work, which resulted in similar amounts of vehicle travel before, during, and after the pandemic.

In our study, we aim to add to the literature exploring how travel shift across different small and rural communities and if changes are likely to remain beyond the pandemic and periods of quarantine. The study area, Vermont, is a very rural region in the United States. The (2019) US Census reported a statewide population of 623,989 people and a population density of 68 people per square mile. The largest city in Vermont, Burlington, still only has a population of 42,545 people.

This research study collected data on travel behavior through in-person interviews conducted in public places across a range of small cities, towns and rural places. Data was collected regarding travel frequency, mode choice, and behavioral shifts pre and post pandemic. The following sections of this paper describe our data collection and evaluation methods, the interview results which vary between community type, and what the results reveal about urban/rural differences, and the equity of changes in travel behavior brought on by COVID-19.

Methods

The primary data used for this study were collected using in-person interviews throughout various towns in Vermont. The interview questions were written in order to examine how vehicular, bicycle, and pedestrian travel may have changed during and after the pandemic quarantines of early 2020, and how it differed across urban, suburban, and rural areas. The "pandemic" is referenced various times in this study's data analysis and is defined as the time period between March and August of 2020. The interviews were coded by three members of the research team to uncover any trends and/or relationships between level of rurality and travel behavior. Based on the best practices, a portion of the interviews were tested for consistency using intercoder reliability. The survey results were then analyzed using the following research questions: explore if and how people's travel behavior changed during and after the quarantines, if there were modal shifts in an individual's travel, the purposes for their non-vehicular travel during quarantines, and if the rural classification of their residence played any role.

Interview Data Collection

The primary data used in this study was collected using in-person interviews conducted across 43 towns and cities in Vermont. A total of 173 interviews were collected between three researchers over a 5-week span. Interviews were conducted between the times of 10-1 pm and again between 3-7 pm on both weekends and weekdays. The interviews took place in locations which attract a diverse population and are open to the public, including local and state parks, recreational areas, farmers markets, and outside of general stores, amongst others. The towns and cities varied in geographic, demographic, and population characteristics to capture a representative sample. The number of interviews collected per town varied, ranging from 2 to 20 interviews, with each interview session lasting between 5 and 15 minutes.

The location of the interviews were chosen based on the city and/or town's level of rurality. The population size and population density were used to determine which areas were rural, urban, or suburban. However, one of the first questions in the interview is asking the participant if they think they live in a rural, urban, or suburban area. The participant's response to that question was used in the analysis of this project rather than the criteria used to pick the interview locations. In certain interview locations, the background noises were too loud to transcribe the respondents' response and the classification of "unknown" were given for those interviews.

All interview respondents had to be a Vermont resident and at least 18 years of age. Participants who were seemingly not actively busy with another activity were requested to participate in our study. At each interview location there were one to three researchers conducting interviews. In order to not approach the same person twice when multiple researchers were present, spaces were divided into two or three sections for which each researcher would be responsible to enlist participants. In more densely populated places, every third person that passed a researcher was approached and asked to participate. Out of 232 attempted interviews, 173 were collected giving the researchers a 74.6% acceptance rate.

As previously noted, the interview questions asked involved various topics, but this research study focuses solely on the COVID-19 related questions and how the pandemic impacted the participants' travel behavior. Table 7 lists the questions that were analyzed in this study.

Table 7. Questions Asked Relating to COVID-19 and Impacted Travel Behavior

Interview Questions Asked Relating to COVID-19 and Travel Behavior
Do you consider where you live to be rural, urban, or suburban?
How has your overall travel behavior changed or not changed because of COVID-19?
During the initial stages of the pandemic quarantines, March to June of 2020, did your vehicular, bicycle, and/or walking levels change?
Now that our nation isn't experiencing lockdowns/quarantines, how has your vehicular, bicycle, and/or walking levels changed?
Do you find yourself walking and/or bicycling for recreational or essential purposes?

Interview Recording Analysis

With the consent of the participant, the audio from each interview was recorded. In some cases, due to background noise, some of the recordings were inaudible. A computer software program was used to transcribe the 151 usable interviews before being manually verified by a member of the researcher team.

Interview Analysis Method

The transcriptions were uploaded to NVivo and coded by three members of the research team to identify key characteristics and recurring themes for each question. Each researcher was assigned transcripts to code, with a portion of transcripts overlapping with another researcher to obtain intercoder reliability. The coding workbook included 21 parent codes of overarching themes and numerous child codes for detailed information to be used in the data analysis. Table 8 shows a description of the parent codes pertaining to the COVID-19 travel behavior interview questions. For the purpose of this study, recreational travel was defined as traveling for pleasure and essential travel was defined as traveling for everyday needs, such as household errands, commuting to work or school, etc.

Table 8. Parent Code Description

Parent Code	Description
Overall Travel After Pandemic	How respondent's overall travel behavior was after pandemic ended
Overall Travel During Pandemic	How respondent's overall travel behavior was during pandemic
Walk-Bike Purpose During Quarantine	If respondent's walk/bike activity was for recreational or essential purposes
Walk-Bike-Vehicle Change After Pandemic	How respondent's walk/bike/vehicle travel behavior changed after pandemic
Walk-Bike-Vehicle Change During Pandemic	How respondent's walk/bike/vehicle travel behavior changed specifically during lockdowns or quarantines

Out of the 151 usable interviews, 27 (16.5%) were tested using intercoder reliability, which falls between the literature recommended 15 and 25% of the total sample. The Cohen's kappa coefficient and the percent agreement and disagreement were reported for each parent code using the coding comparison query tool in NVivo. Research suggests that the Cohen's kappa coefficient is more widely used then the precent agreement and disagreement because it is more likely to account for chance agreements or disagreements. A kappa coefficient can range from –1 to 1, with a value of 0 meaning agreement by chance. Values below 0 represent agreement less than chance, values above 0 represent some levels of agreement, and a value of 1 indicates perfect agreement that is not related to chance. Table 9 depicts the kappa coefficients for each parent code from the 30 transcripts that were tested for intercoder reliability.

Table 9. Kappa Coefficients for Each Parent Code

Parent Code	Mean Kappa Coefficient
Overall Travel After Pandemic	0.972
Overall Travel During Pandemic	0.919
Walk/Bike Purpose During Quarantines	0.961
Walk/Bike/Vehicle Change After Pandemic	0.955
Walk/Bike/Vehicle Change During Pandemic	0.883

The mean kappa coefficients illustrated in the Table 9 above represent a very high level of agreement. The most agreed on coding scheme was for the overall travel after pandemic and the least agreed on was the walk/bike/vehicle change during pandemic. This could be the result of many things, different understanding of activity levels, unclear responses by respondents, etc. Research suggests that values of 0.8 or higher are accepted by almost all standards and values of 0.9 or higher are always accepted. Based off these standards, the research and data presented in this study are valid and can be analyzed.

Results

Demographic Survey

An optional demographic survey was given to the interview respondents after the interview was completed. 140 demographic surveys were logged from 43 towns and cities in Vermont. The survey was updated part way through the interview process to add gender and employment status to the list of questions asked. Table 10 below shows the demographic survey results.

Table 10. Demographic Survey Statistics

Variable	Number of Responses	Percent Total (%)	2019 ACS Precent (%)
Gender			
Female	26	54.2	51.0
Male	22	45.8	49.0
Other	0	1.4	
Race	2	2.1	
American Indian or Alaska Native	3	2.1	0.5
Asian or Asian American	3	93.8	1.4
Black or African American	131	0.6	1.5
White	1		93.8
Other			2.8

Variable	Number of Responses	Percent Total (%)	2019 ACS Precent (%)
Income			
Less than $20,000	22	15.7	26.6
$20,000-$34,999	21	15.9	26.6
$35,000-$49,999	16	11.4	12.3
$50,000-$74,999	22	15.7	9.0
$75,000-$99,999	24	17.1	13.7
Over $100,000	29	20.7	28.4
Prefer Not to Answer	6	4.4	
Employment Status			
Employed full-time	66	54.1	80.3
Employed part-time	12	9.8	18.4
Self-employed	9	7.4	
Retired	20	16.4	
Student	3	2.5	
Unable to Work	1	0.8	
Unemployed and Looking for Work	7	5.7	6.0
Unemployed and Not Looking for Work	4	3.3	6.0
Number of Adults in Household			
1	28	20.1	31.6
2	86	61.9	39.2
3	9	6.6	13.5
4 or more	16	11.4	15.5
Number of Children in Household			
0	92	66.2	71.6
1	17	12.2	31.0
2	19	13.7	10.9
3	5	3.6	3.4
4 or more	6	4.3	1.1
Number of Vehicles at Household			
0	2	1.5	6.9
1	37	27.2	35.9
2	55	40.4	39.5
3	26	19.1	12.5
4 or more	16	11.8	5.2

COVID-19 Related Interview Responses

The trends and relationships found in this study were produced by organizing the respondents' answers as to how they would identify their primary residential location as either urban, suburban, or rural and compared to the answer provided surrounding travel behavior impacts of COVID-19. In certain interview locations, the background noises were too loud to transcribe the respondents' response and the classification of "unknown" were given for those interviews. Table 11 below illustrates the distribution of responses. Most people identified their residential location as rural, with urban being the second most common.

Table 11. Distribution of Responses Based on Residential Location

Classification	Number of Responses	Percent Total (%)
Urban	42	28.6
Suburban	22	15.0
Rural	62	42.2
Village Center	1	13.5
Unknown	20	13.5

Overall Travel Behavior During Pandemic

The responses regarding the respondents' overall travel behavior during the pandemic varied, but there was a common theme found in many of the towns where interviews took place. Overall travel was defined as the respondent's own perception when thinking about their vehicular, bicycle, and pedestrian travel. In many cases respondents primarily thought of their vehicular travel and not their walking and/or biking levels. The question asked was, "How has your overall travel behavior changed or not changed because of COVID-19". Most people said that their in-state travel was not significantly impacted by the pandemic, but their out of state travel significantly decreased. One woman interviewed in Burlington, an urban area, said, "We felt life was pretty much the same, except we couldn't go out to dinner." When asked if their everyday travel changed during the pandemic one person from Grand Isle, a rural community, said "My everyday driving routine stayed about the same". It can be seen in Figure 16 through Figure 18 below that respondents in rural and suburban areas reported that their travel decreased or stayed the same more than residents in urban areas during the pandemic. When conducting interviews in downtown Montpelier one respondent shared, "It hasn't changed that much. I haven't been traveling to go out to restaurants and stuff like that. I've been doing a lot more hiking, so I've been traveling for things like that and just a lot of skiing". Many respondents shared a similar response to this question, which illustrates that even in the more urban areas of Vermont, the pandemic did not significantly impact travel behavior like it did in suburban and urban cities across the country.

Overall Travel Behavior After Pandemic

The responses collected from the participants regarding their overall travel behavior after the pandemic comparing rural, suburban, and urban areas followed similar trends but varied in the number of respondents. As seen below in Figure 16 through Figure 18, the participants generally reported their travel behavior was "more than normal" in rural, suburban, and urban areas after the pandemic. However, more respondents in rural areas reported that their overall travel was less than normal after the pandemic. More respondents in urban communities expressed that their travel behavior was more than normal compared to residents in rural and suburban areas. More people in suburban communities expressed that they had a desire to travel more, whereas residents in urban and rural communities did not.

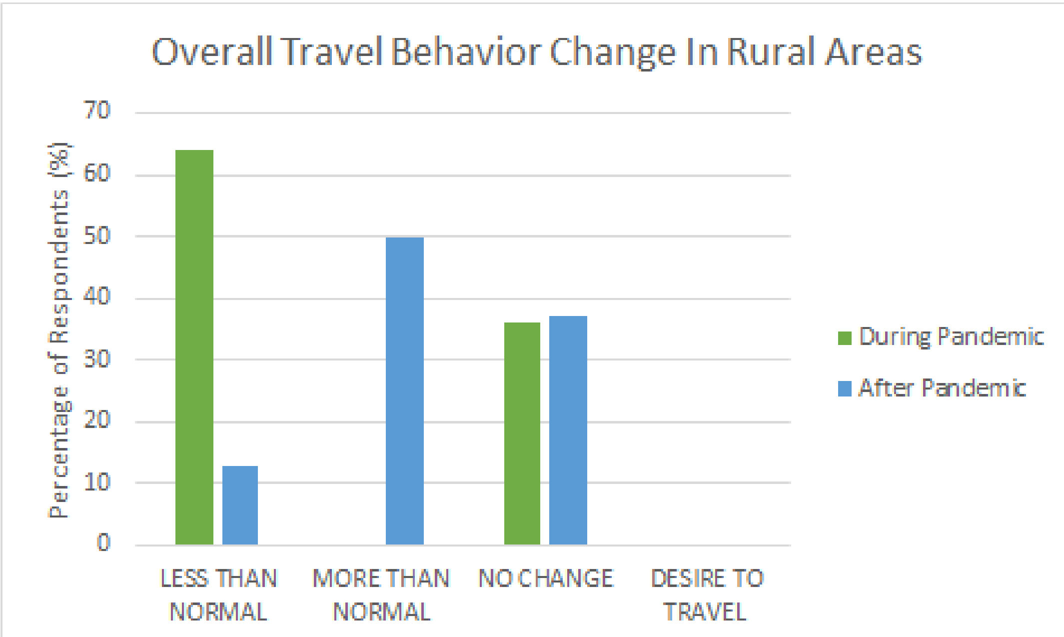


Figure 16. Overall Travel Behavior Change in Rural Areas During and After the Pandemic

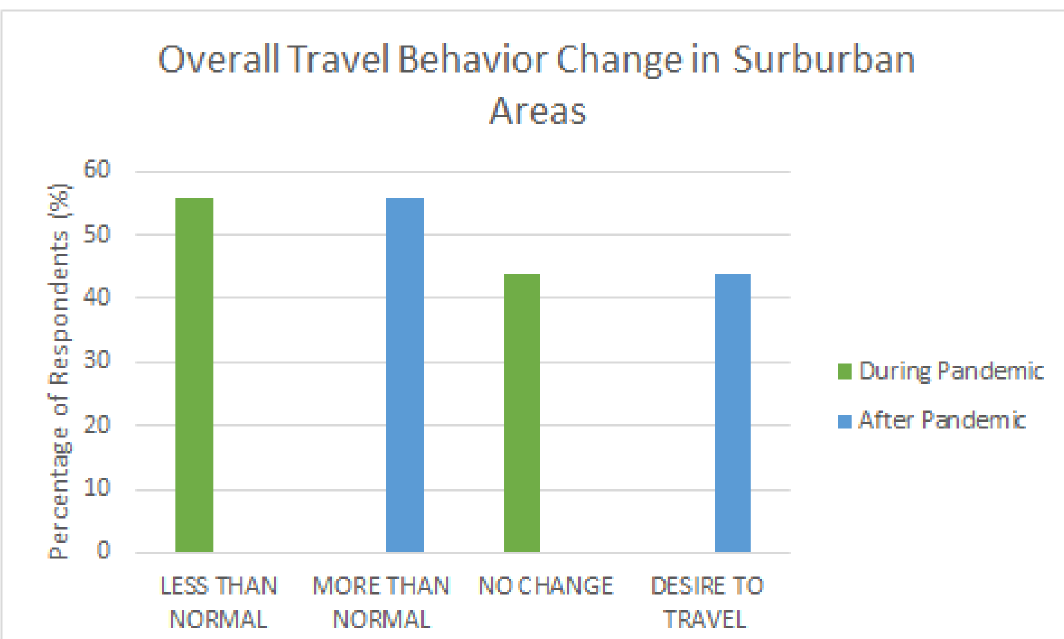


Figure 17. Overall Travel Behavior Change in Suburban Areas During and After the Pandemic

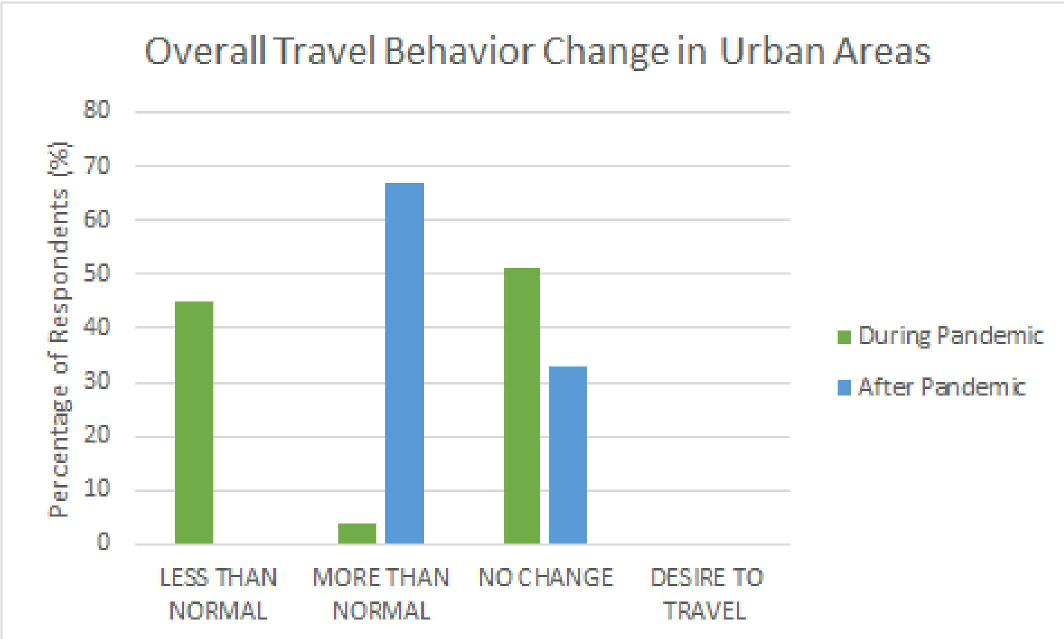


Figure 18. Overall Travel Behavior Change in Urban Areas During and After the Pandemic

Walk/Bike Purpose During Pandemic Quarantines

Many people started to walk and bike more than usual when the pandemic hit and states were issuing mandatory quarantines and lockdowns. In this section, the purpose of why people walked and/or biked was analyzed by comparing rural, suburban, and urban communities. The "purpose" of the respondent's walking and/or biking levels are categorized as either essential or recreational. Essential travel was defined as traveling to run errands, traveling to get to work/school, etc. while recreational travel was defined as walking and/or biking for pleasure. One respondent interviewed at City Park in Burlington said, "Because it just seems like it was the only way to get out instead of getting in your car and going somewhere. Especially on my lunch hour, I'd just get out and walk around just so I could get out of my workspace and see other people, even if it was from afar". Another respondent interviewed in downtown Montpelier shared a similar experience and said, "Walking and going outside pretty significantly for pleasure though I do drive for getting to places". A respondent from Cambridge, VT had a similar view as the first respondent sharing why they were walking more during the lockdowns, "Just because I wasn't driving back and forth to work, so that time allowed me to exercise". Figure 19 below illustrates the number of respondents and their level of rurality and the purpose of their walking and/or biking levels. From Figure 19, in urban, suburban, and rural areas people mostly reported walking and/or biking for recreational purposes, while fewer people were walking and/or biking for essential purposes.

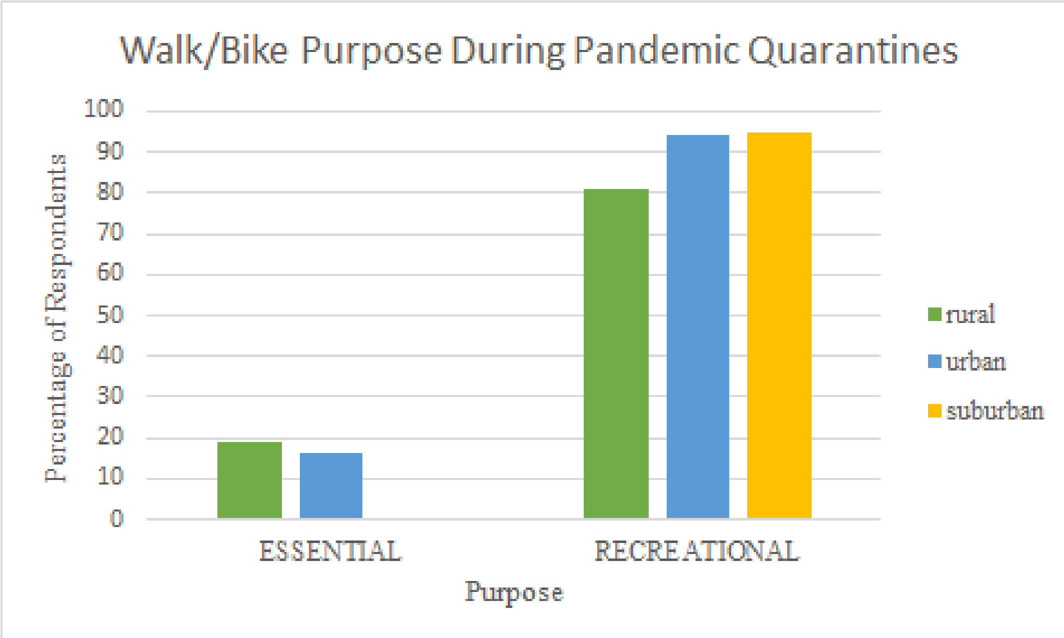


Figure 19. Walk/Bike Purpose in Rural, Urban, and Suburban Communities During Quarantine

Walk/Bike/Vehicle Change During the Pandemic

During the interview process it became clear that many people's walking, bicycling, and/or vehicular travel behavior changed during the pandemic. As seen in Figure 20 through Figure 22 below, respondents in rural, suburban, and urban areas reported that they were walking more. However, more respondents from rural areas said that their walking/biking/vehicular travel did not change during the pandemic. Vehicular levels were as expected, with respondents reporting that they drove less in rural, urban, and suburban areas during the pandemic. Overall, it can be said that most respondents experienced a change in travel behavior whether that was walking, biking, and/or driving. When interviewing in Brattleboro, VT one participant said, "Absolutely more walking, I wish there were more biking lanes" and another respondent shared, "Yeah I feel like the pandemic made Brattleboro feel more walkable which is awesome".

Walk/Bike/Vehicle Change After the Pandemic

As seen in Figure 20 through Figure 22 below, more respondents in rural areas reported that they experienced no change in their travel behavior after the pandemic than in urban and suburban areas. This behavior is similar to the one we see in Figure 16 above, illustrating that people's travel behavior in more rural areas was not significantly impacted by COVID-19. Biking levels stayed relatively the same during and after the pandemic, with a few more respondents biking more in urban areas during the quarantines. In Figure 21, more respondents in suburban areas reported that they were walking more after the pandemic than in urban and rural areas.

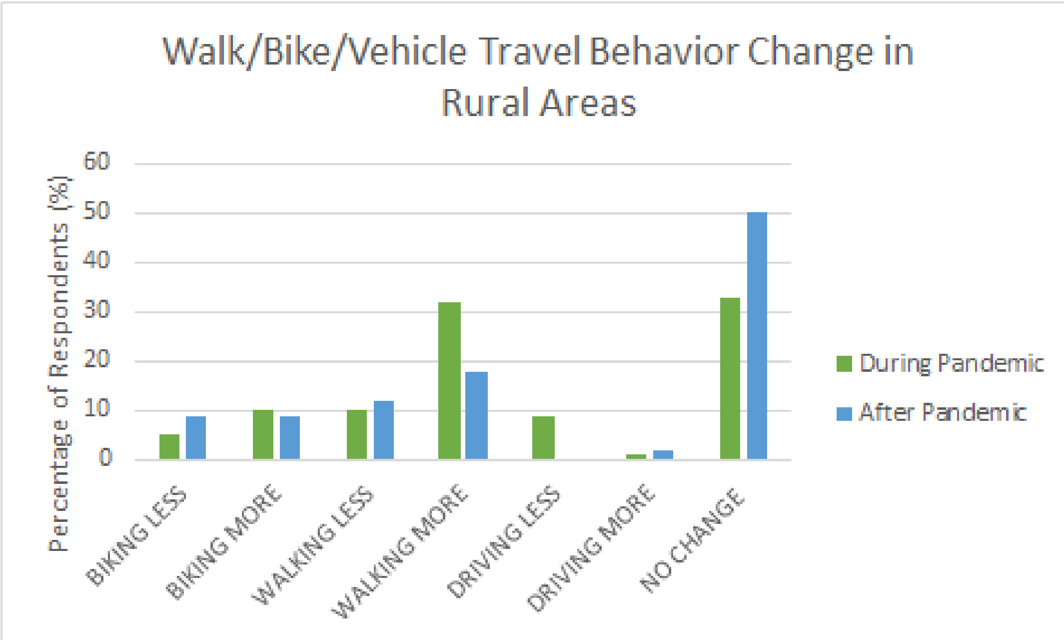


Figure 20. Walk/Bike/Vehicle Travel Behavior Change in Rural Areas

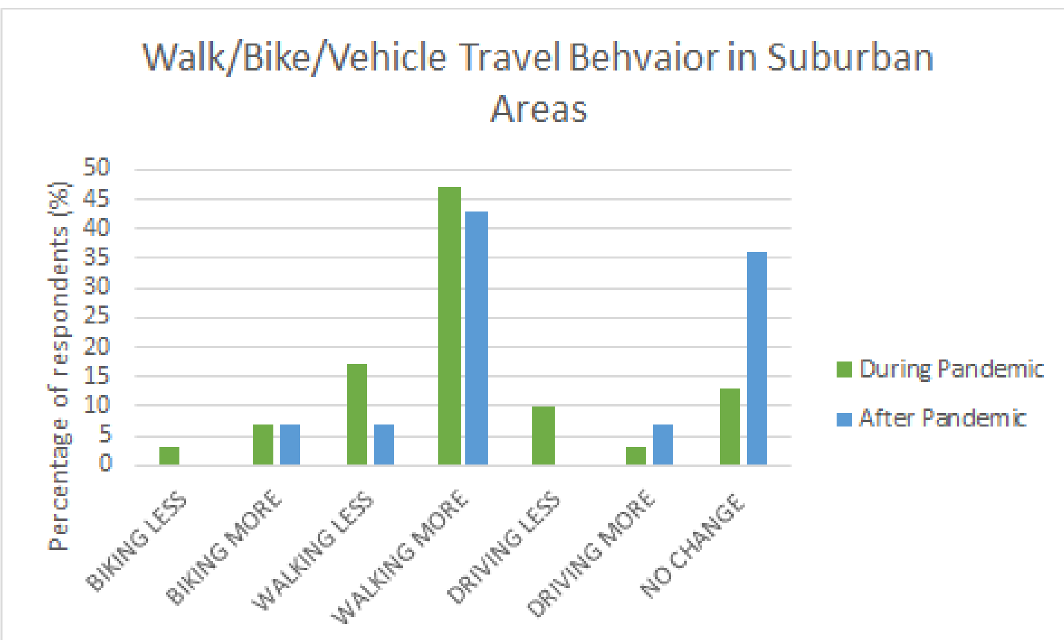


Figure 21. Walk/Bike/Vehicle Travel Behavior Change in Suburban Areas

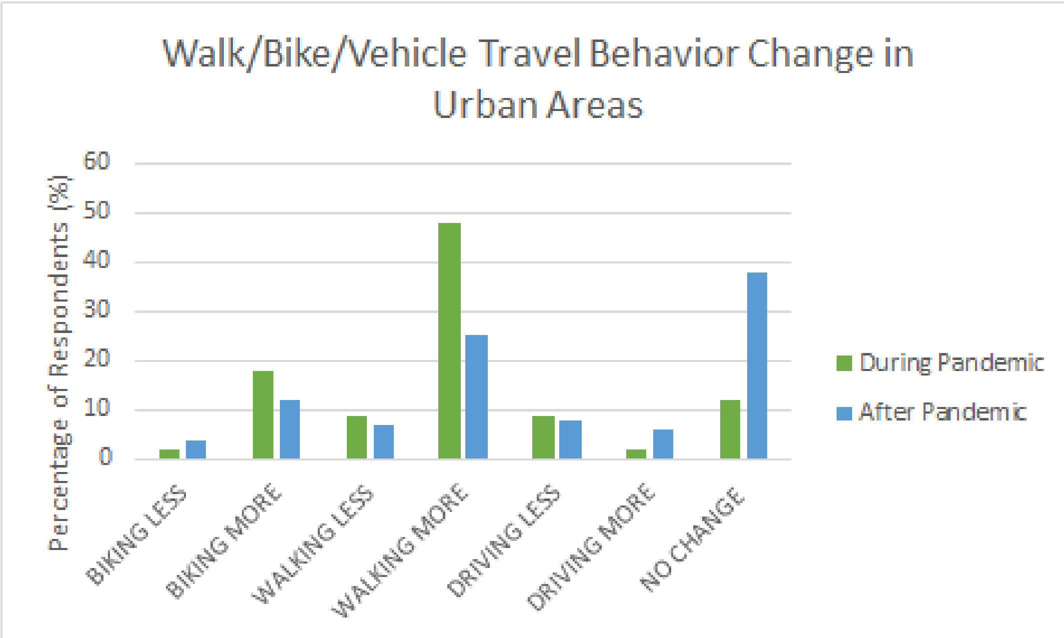


Figure 22. Walk/Bike/Vehicle Travel Behavior Change in Urban Areas

Discussion

The data collected in this research study examines how the level of rurality played a role in affecting travel behavior during and after the COVID-19 pandemic across the state of Vermont. The method of using in-person interviews provided unique and detailed data that has not previously been utilized for this topic of study. The pandemic affected rural towns in Vermont differently than urban and suburban areas. Overall, it was found that most respondents who identified living in a rural area reported that their travel behavior decreased more than respondents in urban and suburban areas, but it was not a significant change to how they were traveling prior to the pandemic. The data collected and analyzed during this study expresses the need for a different approach regarding transportation infrastructure and public policy in rural communities.

Respondents living in urban and suburban areas reported that they were walking and driving more during the pandemic than people in rural areas. Increased walking levels during the pandemic was an expected outcome due to travel bans and stay at home orders. Many respondents stated that since they didn't have to commute to work, they would use that time to get outside and/or take a walk. Overall vehicular levels were low during and after the pandemic in rural, urban, and suburban areas, which could contribute to the increased walking and/or biking levels. It is important to note that these travel behavior differences between rural, suburban, and urban areas exist because the needs and wants of a towns or city's primary residents will vary, which impacts public policy, roadway infrastructure, roadway safety, and much more. This topic also shines light on how people view their commute to work. Most respondents who had a long commute (30 minutes or more) stated that they used their commute time to get outside and engage in a physical activity during the pandemic. This can be seen as a positive outcome of the pandemic lockdowns and raises the question of whether remote jobs are better for people's health than office jobs.

As previously noted, people were walking and biking more during the pandemic for recreational purposes than for essential purposes. Many respondents shared that it was simply to “Just get out of the house” or “Out of boredom”. From this data, it is suggested that the state of Vermont consider these travel behavior changes and provide their residents with more walking and biking infrastructure. One respondent from Brattleboro shared that "As walkable of a place Brattleboro is and they do have bike paths and stuff. I personally am not someone who feels comfortable biking near cars. So I feel like there's still lack of access for someone like me, but I know a lot of people do bike around town. So I feel like just making those things more accessible". This quote exemplifies the urgent need for better and more accessible pedestrian and bicycle infrastructure in the state of Vermont. The data found in this study proves that in places like urban areas, where there are more biking and walking infrastructure, more people are likely to use it. If cities and towns improve their walking and biking infrastructure it will promote its use and likely raise walking and/or biking levels.

Although walking levels increased during the pandemic, people were quick to resume their normal everyday habits and routines after the pandemic ended. It can be seen in Figure 20 through Figure 22 above that walking and biking levels decreased after the pandemic ended. This data illustrates that the pandemic did inspire and motivate people to increase their walking levels. The decrease in pedestrian and bicycle levels can be the result of many factors including people’s work or school returning to in-person, the change in weather when entering the colder months, increasing longer distance travel, having more errands to run, or socializing with missed friends and family members. COVID-19 has caused a major public health crisis in our nation, but it also brought some good to our society as well. People were getting outside more, enjoying the fresh air, and exploring their surrounding environment. This research prompts the question of how do we increase pedestrian and bicycle travel behavior in areas where residents either don’t feel safe, don’t have the infrastructure, or the accessibility is low? This question not only impacts the health of the individuals living in these communities, but also could decrease greenhouse gas emissions and fight the battle against climate change.

From this research and the data collected and analyzed it is suggested that the state of Vermont consider updating and improving pedestrian, bicycle, and vehicular infrastructure in order to meet their residents' needs and wants. There should not be one single approach to designing and implementing transportation infrastructure. Every city and town, no matter its level of rurality, has different socially acceptable behaviors, economic statuses, previous infrastructure, obesity rates, etc. which should be taken into consideration when deciding what transportation infrastructure best supports its primary residents. The increase in adding more pedestrian and bicycle infrastructure has many benefits besides meeting the residents’ needs. Increased active transportation has a direct effect on public health, climate change, and the demand for gasoline.

The goal of this research study was to explore and uncover how the pandemic affected travel behavior in rural communities. Conducting in-person interviews served a great purpose in data collection and gave a unique perspective of how people's travel was affected because of COVID-19. The data found in this research study came from a small, but diverse sample size and interviews were kept short to maximize respondent participation. It is suggested that future research studies focused on travel behavior in rural areas, capture a larger sample size with more in-depth questions. Additional research in this area can help identify the problems rural communities face regarding their transportation infrastructure and societal behavior when it comes to driving, walking, and/or biking.

Chapter 5: Coping with High Prices: Evaluating the Response to Rapidly Increasing Transportation Fuel Prices in Small and Rural Communities

Narges Ahmadnia, Erica Quallen, and Gregory Rowangould

Introduction

Vermont has a goal to reduce its greenhouse gas emissions (GHG) by 50% below 1990 levels by 2028 and 75% by 2050 (10 V.S.A. § 578) but is not currently on track to achieve these targets (*39*). Since 40% of Vermont's GHG emissions come from transportation (*40*), reducing transportation emissions will be essential to making significant progress towards the state's climate goals. Vermont's situation is not unique among states in the northeastern United States and many of considered joining the Transportation and Climate Initiative (TCI). The TCI aims to bring northeastern and mid-Atlantic states together to cut GHG emissions from transportation through a regional carbon cap and invest program. TCI would place a cap on GHG emissions from on-road gasoline and diesel and invest the proceeds from the auction of emission allowances to incentivize households to reduce their driving or to purchase lower emitting vehicles. However, achieving significant buy-in from states to the market-based strategies at the core of TCI has been challenging.

Vermont, and other states with large rural populations, have expressed concerns with carbon pricing policies that may disproportionately impact the welfare of low income and rural households. Rural households are often more automobile dependent and transportation costs consume a larger share of household income (*41*–*46*). Very little data exists to evaluate how carbon pricing policies could affect travel in smaller and more rural communities, understand how to best spend revenues to further reduce GHGs (*42*, *48*), or how to design market-based policies to achieve greater efficiency and minimize inequities (*39*, *47*).

Information about how households in smaller and rural communities respond to changes in the cost of driving or price of fuels is required to evaluating the potential effectiveness, efficiency and equity of market-based transportation policies in these communities (*83*); however, little such information currently exists. While hundreds of gasoline price elasticity studies have been conducted (*51*), only a few have looked at differences between community type or in rural areas (*52*, *53*). Two studies that have used disaggregate travel data in California and Pennsylvania find that gasoline price elasticity estimates vary with household demographics (age and income), geographic area, and vehicle fleets (type and age of vehicle owned by households). The study in California found that rural household VMT seemed to be more responsive to changes in fuel prices than those in urban areas, challenging the findings of earlier studies that used more aggregate data. These findings underscore the need to further investigate how households in different communities' contexts respond to changes in travel costs.

We took advantage of the dramatic spike in gasoline and diesel fuel prices during the first half of 2022 as shown in Figure 23, when gasoline prices increased from $3.5 per gallon in March 2022 to a high of $5.02 per gallon in May 2022 to survey how people living in a wide range of communities in the U.S. state of Vermont responded and what they planned to do if prices remain high. We also investigated potential barriers to changes in travel behavior in response to the high prices, such as the lack of safe active travel infrastructure or access to nearby jobs and retail. The purpose of our study is better understanding how travel behavior and the ability to respond to an increase in transportation costs and fuel prices may differ between urban and rural communities where attitudes and beliefs concerning a range of salient issues are also likely to differ. This information can be used to inform more effective strategies for managing travel demand and evaluating equity concerns surrounding market based policies to reducing GHG emissions from transportation in regions beyond urban centers that have been the focus of most prior research.

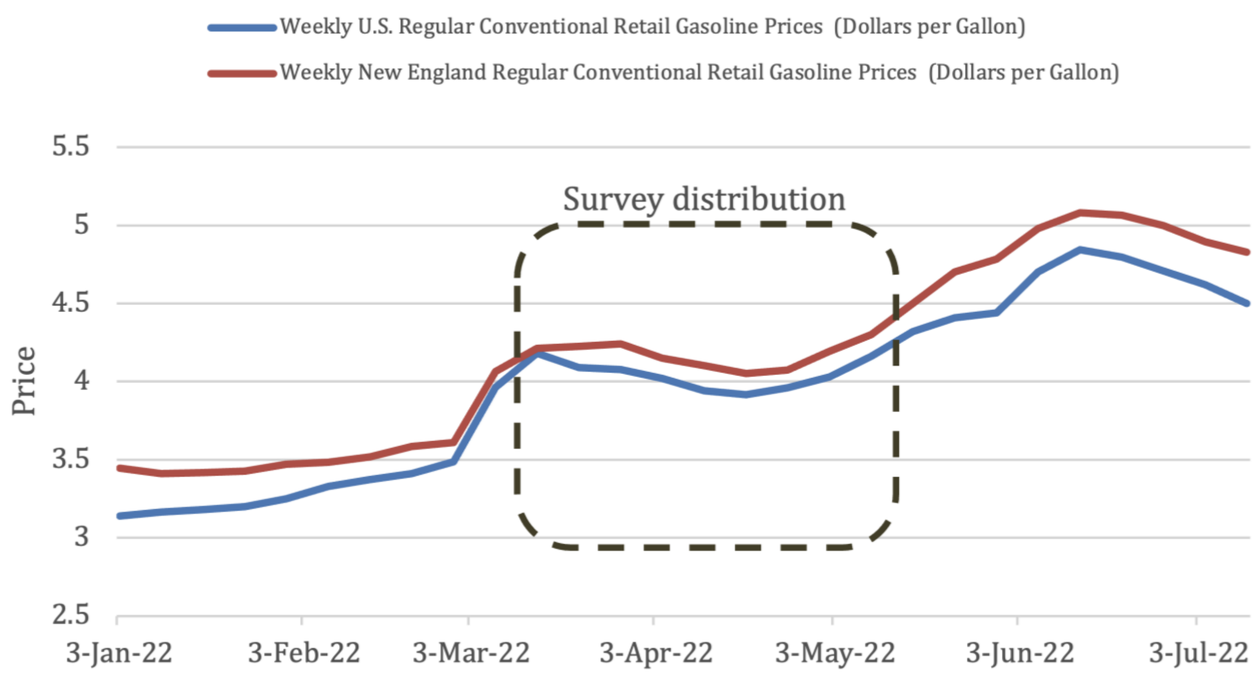


Figure 23. U.S. Retail Gasoline Price Trends During the Study Period[1]

Methods

The spike in gasoline and diesel fuel prices during the spring of 2022 provided a unique opportunity to evaluate how changes in transportation costs affect travel behavior, including changes in small and rural communities. We created an internet-based survey that asked people living in Vermont how they responded to the recent increase in gasoline and diesel fuel prices and what they plan to do if prices remain high. We included questions about changes in the vehicles they use and plans to purchase more fuel efficient or electric vehicles. We also

[1] Gasoline and Diesel Fuel Update - U.S. Energy Information Administration (EIA)

asked about changes made to travel for essential trips, including trips for work, education, medical appointments and food and less essential trips including visiting friends and family, recreational activities, and going to social events. For each trip type, essential and less-essential, respondents could make one or more selections from a list of possible actions that could have been taken in response to higher fuel costs. Actions included using alternative modes of transportation, completing more activities at or from home, carpooling and ridesharing, seeking closer destinations for essential and non-essential activities, trip chaining, moving to a more transportation efficient location and adjusting household budgets. Similarly, respondents were asked to indicate the likelihood that they would make any of the previously listed actions if prices were expected to remain high for more than one year on a 5-point Likert scale.

We also include a set of questions about potential barriers to taking action to avoid higher fuel costs. This included questions about concerns surrounding EV range, charging access and performance. We also asked if respondents would change (decrease or increase) the amount of driving they do if various improvements to public transportation and active travel infrastructure were made or the number of local employment, shopping and education opportunities were increased.

Prior research finds that attitudes and beliefs can be significant factors in explaining travel behavior and choices(*84*, *85*); therefore, we also consider attitudes and beliefs in our study. We asked about attitudes and beliefs related to sustainability, car culture and dependence, the role of government and technological advancement. We hypothesized that these attitudes and beliefs are not only important in explaining how people respond to increasing fuel prices but that they may also vary across community types (urban to rural). Lastly, we asked respondents to describe the type of community they live in (rural, suburban, or urban) and provide the name of the town where they reside along with a standard set of socioeconomic questions.

Survey Recruitment

We began by recruiting participants using a geolocated database of about 40,000 Vermont e-mail addresses (geolocated to the town level) obtained from a marketing company. The sample collected from this recruitment method skewed much older than the Vermont population but was otherwise broadly representative. We therefore recruited additional participants through Facebook and Instagram advertisements. The sample collected from the social media advertisements was, on average, 29 years younger. All participants were given a chance to enter a drawing for one of ten cash cards each worth $50, as an incentive. The survey was distributed in March 2022 and received 911 responses. After filtering out surveys that were less than 50% complete (these were mostly surveys that were started but never completed), the final size of the sample used in our analysis was 749. Missing values in the final sample were imputed in R using the MICE package. Numerical variables we imputed using Predictive Mean Matching (PMM) and categorical variables were imputed using Polytomous Regression (Polyreg) which is used for categorical variables with two or more than two levels.

Table 12. Descriptive Statistics of Sample Data (Sample size =749)

		Survey Respondents		Vermont [a]
		n	%	%
Gender	Male	349	49	49
	Female	355	50	51
	Other	8	1.1	-
Age (Years)	18-34	71	9.5	25
	35-54	180	24	31
	55-64	171	23	20
	>65	327	44	25
Ethnicity	Hispanic or Latino	13	1.7	2.0
	Non-Hispanic or Latino	736	98	98
Race	White	722	96	94
	Black or African American	5	0.7	1.3
	American Indian and Alaska Native	1	0.1	0.3
	Other	21	2.8	4.8
Annual income	Less than $20,000	37	4.9	14
	$20,000 to $34,999	71	9.5	13
	$35,000 to $49,999	105	14	12
	$50,000 to $74,999	148	20	18
	$75,000 to $99,999	155	21	14
	More than $100,000	233	31	28
Employment Status	Employed	459	61	63
	Unemployed	10	1.3	2.5
	Not in labor force	280	37	35
Level of Education	12th grade –no diploma	8	1.1	7.1
	High school graduate	100	13	28
	Some college, no degree	128	17	17
	Associate degree	101	13	8.6
	Bachelor's degree	222	30	23
	Graduate or professional degree	190	25	16
Number of Vehicles	No vehicles available	0	0	6.7
	1 vehicle available	202	27	35
	2 vehicles available	348	46	41
	3 or more vehicles available	199	27	18

[a] Data for regional demographics sourced from US Census Bureau American Community Survey 5-year estimates (*86*)

Table 12 presents descriptive statistics of the socio-economic characteristics of survey respondents and compares them with Vermont Census data. Based on this comparison our sample is somewhat representative of Vermont's adult population. The largest difference is that people older than 65 are overrepresented and people less than 35 are underrepresented in our sample. Our sample is also somewhat wealthier, more educated, and more likely to own more cars than Vermont's population. While these limitations affect the extent to which we can generalize about the response of typical Vermont residents to high fuel prices, the sample size is large and diverse enough for our primary research objective of understanding the factors associated with different types and levels of behavioral response.

Factor Analysis

We used principal axis factor analysis with an orthogonal (varimax) rotation to reduce the number of attitudinal and behavioral variables and to identify latent attitudinal factors using the R psych package. Based on the evaluation of a scree plot of eigenvalues, we determined that four factors were optimal and labeled them as technology concern, car travel enjoyment, environmental concern, and political activity (Table 13). Factors scores were estimated for each respondent using the Thurston method (a regression approach) and used in our regression modeling described below.

Table 13. Description of Attitudinal Factors

Factors	Factor Loading
Environmental Concern	
Environmental threats such as global warming and deforestation have been exaggerated.	-0.730
Being environmentally responsible is important to me as a person.	0.538
Humans are responsible for taking care of the environment	0.513
I am worried about the health impacts of air pollution	0.637
The balance of nature is not easily upset by human activities	-0.576
Unemployment and the high cost of living is a bigger threat than environmental pollution	-0.594
Global warming should be a priority for the government	0.807
More research should be funded for renewable energy sources	0.744
Tax rebates should be provided for people who purchase energy efficient vehicles	0.692
The government has no role in protecting ecologically sensitive areas	-0.565
Technology Concern	
Technology has made life easier	-0.528
Technology has done more harm than good.	0.719
It would be nice if we stopped building so many machines and went back to nature	0.584
People today have become too dependent on technology.	0.576
Technology has made life too complicated	0.583

Factors	Factor Loading
Car Travel Enjoyment	
I like traveling in a car.	0.570
Owning a vehicle provides me with freedom.	0.576
I plan to always own a vehicle.	0.547
My lifestyle is dependent on having a car	0.542
Political Activity	
I have contacted a local government official.	0.513
I have posted about politics on social media.	0.524
I donated to political organizations	0.676
I attended a rally, protest, or demonstration.	0.602

Clustering Multiple Response Questions

The multiple response questions (e.g., select one or more options from a list) used in our survey to record how people responded to high fuel prices pose challenges for multivariate analysis. Modeling each selection as a binary yes or no response in a logistic regression is simple but fails to capture the collection of actions made by each respondent. Constructing response variables that consider the unique collection of actions made by each respondent for use in a multinomial regression is limited by our sample size and would be challenging to interpret. Instead, we labeled each respondent's collection of actions as belonging to one of seven possible action clusters as shown in Figure 24. The action clusters shown in Figure 24 are organized from left to right in order of how aggressive the behavioral response to higher fuel price was. A respondent is labeled as belonging to the action cluster that includes their most aggressive response. For example, a person who purchased an EV and also started remote work is labeled as belonging to the EV cluster. A person who drove more efficiently and started walking more is labeled as belonging to the Mode Substitution cluster.

We used a similar approach to assign the responses to the prospective questions about the likelihood of taking various actions in a scenario where gas prices remain high for a year or more. The responses to these prospective questions were on a Likert scale. We considered responses of 4 or 5 as an indication that taking a specific action was likely. A respondent is then labeled as belonging to the action cluster that includes their most likely aggressive response. For example, a person who rated both moving and increase trips by walking with either a 4 or 5 is labeled as belonging to the moving cluster. We used these action clusters to label responses to essential and less-essential trips for current fuel prices and under the expectation that fuel prices remain high for more than one year.

We consider purchasing an EV or PHEV to be a very aggressive response since it is a large investment and an action that takes time to plan and execute. Similarly, moving is an aggressive response given the time, costs and complexity of finding a new place. Switching travel modes can be a somewhat aggressive action as it may require advanced planning (e.g., learning a transit routes and schedules), it could involve additional costs (e.g., purchasing a bicycle) and it may require making tradeoffs (e.g., longer travel time). We considered activity substitution to be moderately aggressive. Shopping more online and substituting activities that require a lot of driving with those that do not are actions that can be taken quickly without much planning and may not involve any additional costs. Working remotely or increasing the amount of time working remotely may require more planning than other types of activity substitution and is also subject to employer policies and job requirements. Still, working remotely for those who have the option can come at little to no cost and is an action that can generally be modulated as needed. We considered driving less but taking fewer trips, shorter trips or combining trips to be a less aggressive response. More than half of our respondents cut back on the amount they drove, and it is an action that can be taken immediately with little advanced planning. Finally, we considered a range of strategies aimed at driving more efficiently to be the least aggressive action. Driving more efficiently does not require making any changes to the mode or amount of travel and requires no preplanning.

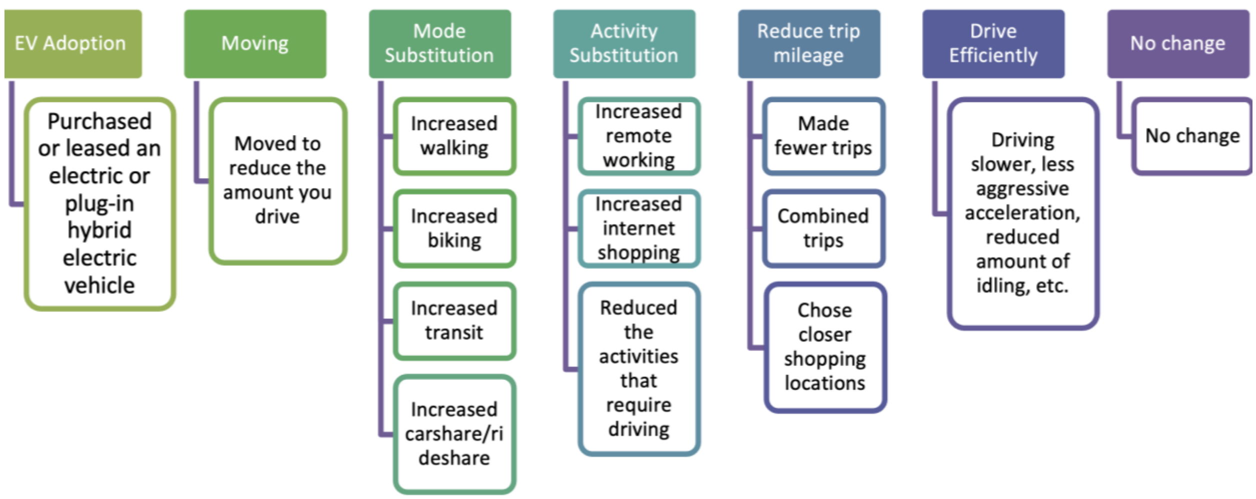


Figure 24. Definition of Action Clusters

Regression Modeling

We developed discrete choice models to evaluate the association between different travel behavior responses to higher fuel prices (i.e., action clusters) and socioeconomic, geographical (urban, suburban, or rural), and attitudinal factors related to technology, the environment, driving enjoyment, and political activism. Four models are created. Two modes evaluate the change in travel behavior made in response to the increase in fuel prices during the spring of 2022 for essential and less essential trips. Two additional models evaluate expected changes in travel behavior under the expectation of high prices continuing for more than one year for essential and less essential trips. We controlled for current use of each mode of travel and level of concern with the increase in gas prices. The survey asked respondents to indicate the frequency of that they travel by car, transit, walking and bicycle in a typical week using a scale of “everyday”, “more than 3 days a week”, “1-3 days a week”, “less than 1 day a week”, and “never”. The survey also asked respondents to rate the importance of reducing their driving expenses considering the recent rise in gasoline prices in Vermont, with the response options of “not at all important”, “somewhat important”, and “very important”. We aggregated the travel frequency responses into a smaller set of categories for regression modeling. Car use was considered frequent if respondents used a car “everyday” or “more than 3 days a week” and infrequent otherwise. For all other modes of travel, we considered “everyday” and “more than 3 days a week” as often, “1-3 days a week” and “less than 1 day a week” as sometimes, and “never” as indicating that the mode is not used.

Results

Overall, we find that 88% of respondents made changes to the way they traveled for essential trips in response to the higher gas prices experienced during the spring of 2022. A slightly smaller but still large share of respondents (82%) also made changes to how they traveled for less-essential trips. If high gas prices were expected to continue for a year or more, 86% of respondents indicated that would be likely to make additional changes to how they travel for essential trips, and 78% for less-essential trips, while a small percentage of respondents stated they would be unlikely to make additional changes (Table 15).

Table 14 presents the frequency of responses to the current and future increase in fuel prices. Driving more efficiently, reducing the number or distance of trips, and activity substitution were the most common actions taken in response to higher gas prices. The most prevalent action was reducing trip mileage (30%), achieved by making fewer trips (54.2%), combining trips (60.5%), and choosing closer shopping options (29.5%). Additionally, a considerable proportion of individuals (25.5%) opted for activity substitution with internet shopping being the most popular choice (31%) followed by remote work (14.3%). The switch to remote work, while lower than internet shopping, is still quite large considering that remote work is not an option for many workers and is irrelevant for those who are not working.

The response to high gas prices was generally similar for respondents living in different community types but there were a few notable differences. A surprisingly large and higher percentage of urban and suburban residents (15%) moved compared to rural residents (5.6%) in response to the increase in gas prices. While we did not ask about prior household location in the survey, these results likely reflect households that moved from rural areas to more urbanized areas to avoid high gas prices rather than the movement of urban households. The adoption rate of electric vehicles (EVs) and plug-in hybrid electric vehicles (PHEVs) by rural and suburban households (4%, 4.5%) was twice that of urban households (1.9%). A much higher percentage of urban households substituted single occupancy vehicle travel with alternative modes, compared to rural and suburban residents, with the rate of walking being five times higher for urban residents (24.9%) than rural residents (5.1%). The higher rate of mode substitution in urban areas reflects greater opportunities for walking, biking, carpooling, and use of transit in more compact communities.

The response to high gas prices was similar across essential and less essential trips, however, there were a few notable differences. A higher percentage of respondents substituted their mode of transportation for essential trips compared to less essential trips. Noticeable reductions were observed in shopping-related trips for less essential purposes, along with a higher portion of respondents who chose to maintain their travel habits unchanged despite the higher prices for less essential trips.

When comparing responses of the current increase in gas prices with the scenario of high gas prices expected to persist for over a year, the results show that the frequency of each response option has increased (Table 14). The percentage of respondents that would consider adopting an EV or PHEV increased by fivefold, from 3.6% to 19.1%. Likewise, the percentage of respondents who would consider moving increased from 9.5% to 19.2%. There is also an increase in percentage of responses falling under mode substitution action cluster including "increase trips by carpooling, walking, biking, transit, and rideshare". Rural households increase their trips by walking (13.4%) and biking (13%) if gas prices remain high for over a year. It is important to consider the feasibility of this scenario, as rural areas face challenges such as inadequate biking infrastructure and the dispersed nature of neighborhoods, which hinder walking as a viable mode of transportation. On the other hand, urban households are still more likely to consider alternative modes of transportation compared to rural households, as there is an increase in trips by walking (41%), biking (27.3%) and transit (21.7%) which is more than double the corresponding percentages observed during the current period of gas price increase.

Table 14. Frequency of Behavioral Responses to Current and Future Fuel Prices for Essential and Less-Essential Trips by Community Type

	Essential Trip				Less-essential Trip			
Fuel Price Response [a]	T[d]	U	S	R	T	U	S	R
Purchase or leased an EV or PHEV								
Current increase [b]	3.6%	1.9%	4.5%	4%	3.6%	1.9%	4.5%	4%
Over a year [c]	19.1%	19.9%	23.5%	16.9%	19.1%	19.9%	23.5%	16.9%
Move to reduce driving								
Current increase	9.9%	15%	15.1%	5.6%	9.9%	15%	15.1%	5.6%
Over a year	25.8%	28%	31.8%	22.2%	25.8%	28%	31.8%	22.2%
Increase trips by carpooling								
Current increase	6.5%	9.3%	6.1%	5.6%	6.1%	11.8%	5%	4.4%
Over a year	17.9%	24.9%	17.3%	15.4%	18.4%	27.3%	16.7%	15.6%
Increase trips by walking								
Current increase	10.1%	24.9%	8.45%	5.1%	8.4%	21.1%	7.3%	3.9%
Over a year	21.2%	41%	21.2%	13.4%	21.8%	39.1%	21.2%	15.1%
Increase trips by biking								
Current increase	4.8%	9.9%	5.6%	2.4%	3.3%	7.4%	2.2%	2.2%
Over a year	17.7%	27.3%	20.1%	13%	19.1%	27.9%	20.1%	15.1%
Increase trips by transit								
Current increase	3.9%	8.7%	4.8%	1.7%	2.8%	5%	3.3%	1.7%
Over a year	12.7%	21.7%	16.2%	7.6%	13.2%	23%	12.8%	9.5%

Fuel Price Response [a]	**Essential Trip** T[d]	U	S	R	**Less-essential Trip** T	U	S	R
Increase trips by rideshare/ carshare								
Current increase	1.7%	3.1%	1.7%	1.2%	0.8%	0.6%	0.6%	1%
Over a year	6.3%	14.3%	3.3%	4.4%	6.4%	11.2%	4.5%	5.4%
Increase remote work								
Current increase	14.3%	13.6%	15.6%	13.9%	-	-	-	-
Over a year	24.2%	23.6%	24%	24.4%	19.7%	16.1%	20.1%	21%
Increase internet shopping and/or home delivery								
Current increase	31%	36%	24%	32%	22%	24.8%	20.1%	21.8%
Over a year	54.1%	52.2%	54.7%	54.5%	42.6%	44.7%	41.3%	42.3%
Make fewer shopping trips								
Current increase	54.2%	54.6%	53.6%	54.3%	32.7%	31.7%	36.9%	31.3%
Over a year	54.1%	70.8%	70.4%	68.7%	49.1%	57.1%	50.3%	45.5%
Choose closer shopping options								
Current increase	29.5%	30.4%	27.9%	29.8%	31.8%	37.3%	30.1%	31.3%
Over a year	64.9%	69.6%	68.7%	61.4%	56.2%	58.4%	58.1%	54.5%
Combine trips								
Current increase	60.5%	54.6%	61.4%	62.3%	46.7%	41.6%	46.4%	48.9%
Over a year	-	-	-	-	-	-	-	-
Explore job options closer to home								
Current increase	-	-	-	-	-	-	-	-
Over a year	15.9%	17.4%	15.1%	15.6%	-	-	-	-
Try to drive more efficiently								
Current increase	59.9%	64.6%	59.8%	58.2%	59.9%	64.6%	59.8%	58.2%
Over a year	-	-	-	-	-	-	-	-
Make no changes								
Current increase	16.5%	17.4%	16.2%	16.7%	29%	26.1%	29.6%	29.8%
Over a year	27.2%	28.6%	23.5%	28.4%	25.6%	28.6%	26.2%	24.2%
Number of Responses	**749**	161	179	409	**749**	161	179	409

[a] Frequency of response to higher fuel price

[b] Corresponds to the changes people made in response to the current increase in fuel prices.

[c] Corresponds to the changes people would make if fuel prices remain high for over a year

[d] T Corresponds to Total, U corresponds to urban, S corresponds to suburban and R corresponds to rural

Regression Modeling Results

We estimated four MNL regression models to evaluate the association between household characteristics and respondent's attitudes and beliefs and the level of action households made in response to higher prices (e.g., which action cluster they fell into). Table 15 indicates the share of respondents who fell into each action cluster previously defined in Figure 24. Looking into changes in the action clusters, the results show that more respondents would make changes to how they travel, including more aggressive actions (Table 15) if high prices were expected to continue for a year or more. As mentioned earlier there is a noticeable increase in the percentage of respondents who fell into EV/ PHEV adoption and moving action clusters. As a result, we would expect fewer respondents in other action clusters despite a higher number of people selecting it; this is because more individuals chose purchasing EVs or moving. For example, there is a 20% reduction in the percentage of individuals who had previously fallen into "reducing their trip mileage" action cluster by making fewer trips or choosing closer shopping locations.

Table 15. Frequency of Expected Behavioral Responses with Continuation of High Fuel Prices for Essential and Less-Essential Trips by Community Type

	Essential Trip				Less-essential Trip			
Action Clusters [a]	T[d]	U	S	R	T[d]	U	S	R
EV or PHEV Adoption								
Current increase [b]	3.6%	1.9%	4.5%	4%	3.6%	1.9%	4.5%	4%
Over a year [c]	19.1%	19.9%	23.5%	16.9%	19.1%	19.9%	23.5%	16.9%
Moved								
Current increase	9.5%	15%	14%	5.4%	9.5%	15%	14%	5.4%
Over a year	19.2%	19.9%	26.3%	15.9%	19.2%	19.9%	26.3%	15.9%
Mode substitution								
Current increase	14%	23%	15.1%	10.3%	11.9%	22.4%	10.6%	8.3%
Over a year	16.2%	26.1%	11.2%	14.4%	18.1%	29.2%	12.8%	16.1%
Activity substitution								
Current increase	25.5%	20.5%	17.3%	31.1%	14.5%	13%	13.4%	15.6%
Over a year	21.4%	15.5%	19.6%	24.4%	13.2%	6.8%	11.2%	16.6%
Reduce trip mileage								
Current increase	30%	21.1%	33%	32.3%	29.6%	21.1%	27.9%	33.7%
Over a year	10.4%	6.8%	11.2%	11.5%	8.0%	5%	10.1%	8.3%
Drive More Efficiently [e]								
Current increase	5%	5%	6.7%	4.2%	13.1%	10.6%	15.1%	13.2%
Over a year	-	-	-	-	-	-	-	-
No change								
Current increase	12.2%	13.7%	9.5%	13%	17.7%	16.1%	14.5%	19.8%
Over a year	13.7%	11.8%	8.4%	16.9%	22.2%	19.3%	16.2%	26.2%
Number of Responses	749	161	179	409	749	161	179	409

[a] Percentage of respondents in Action Cluster
[b] Corresponds to the changes people made in response to the current increase in fuel prices.
[c] Corresponds to the changes people would make if fuel prices remain high for over a year
[d] T Corresponds to Total, U corresponds to urban, S corresponds to suburban and R corresponds to rural
[e] Individuals were provided with "Drive more efficiently" for the changes they made in response to the current increase in fuel prices

Results for four of the MNL regression models that we estimated are shown in Table 16 through Table 19. The results for the models describing changes for less essential trips are not shown as they were very similar to the results for essential trips. The goodness of fit for the models was modest for a behavioral model but sufficient for our analysis (*87*) with adjusted R^2 values between 0.16 and 0.19. The signs of the coefficient estimates were generally as expected.

Factor Associated with Responses to the Current Gas Price Increase

The MNL model results show that how people responded to the sudden increase in fuel prices for essential and less essential trips varied across community types (Table 16 and Table 17). Rural residents were much less likely to change their mode of travel or move than urban residents. Suburban residents were much more likely to reduce how much they traveled than urban residents, but no more likely to make other changes to their travel. Both rural and suburban residents were much more likely than urban residents to start using an EV in response to the higher gas prices. There was no significant difference in efforts to drive more efficiently or substitute activities in response to high gas prices between urban, suburban and rural residents. Respondent's level of concern about gas prices was one of the most significant factors in explaining changes made in response to high gas prices. Individuals who consider gas prices to be "somewhat important" or "very important" are more inclined to make significant changes in their travel behavior, such as mode substitution, moving, activity substitution, adopting EV or PHEV. Individuals who expressed a strong emphasis on gas prices being "very important" are found to be 55 times more likely to opt for mode substitution and 22 times more likely to consider relocation as a response to high gas prices. Similarly, respondents who indicated that gas prices are "somewhat important" are 19 times more likely to consider mode substitution as an alternative. The modeling results also show that attitudes and beliefs about the environment, technology, driving culture and politics have a significant association with how people respond to higher gas prices. Having greater concern for the environment was associated with increased odds of EV or PHEV adoption, mode substitution, activity substitution, and reducing trip milage when gas price increases. In contrast, those who enjoy driving a car were less likely to choose an alternative mode, substitute an activity or move. Furthermore, the likelihood of individuals purchasing EVs, or PHEVs decreased by 38% among those who expressed concerns regarding the technology. Individuals with higher scores indicating greater political activity are more likely to reduce trip mileage, engaging in substituted activities, considering relocation, or opting for EVs or PHEVs.

Table 16. Results of the MNL for Essential Trips (Current increase in fuel prices)

	Drive efficiently	Reduce trip mileage	Activity Substitu-tion	Mode Substitu-tion	Moved	EV Adoption
Predictors	*Odds Ratio*	*Odds Ratio*	*Odds Ratio*	*Odds Ratio*	*Odds Ratio*	*Odds Ratio*
Intercept	10.62	2.12	1.02	0.90	1.16	0.23
Age	**0.96** *	0.98	0.99	**0.95** **	**0.96** *	0.97
Gender (Male)	1.74	0.97	0.92	0.75	0.80	2.31
Child (One or more)	0.80	1.11	1.91	0.95	0.72	**5.87** *
Number of Adults	0.87	0.96	0.94	1.00	1.15	0.68
Vehicle (2 and more)	1.96	1.08	1.17	1.47	1.00	**0.27** *
Race (non-white)	2.09	1.09	1.49	2.11	1.57	0.45
Education (Associates degree)	1.06	0.55	0.57	1.81	1.26	1.89
Education (Bachelor's degree)	0.74	0.60	0.51	2.62	1.13	0.50
Education (Graduate degree)	1.41	0.49	0.58	1.83	0.92	0.79
Income ($35,000-$74,999)	**0.14** *	0.63	0.83	0.53	0.73	1.10
Income ($75,000-$99,999)	0.40	0.76	1.84	0.68	1.11	2.05
Income (>$100,000)	**0.15** *	0.41	0.73	0.39	1.31	0.94
Employment (Unemployed)	0.55	1.49	1.17	1.14	**2.73** *	1.57
Car (Frequent)	**0.25** *	1.00	0.61	0.57	0.44	0.80
Transit (Often)	**0.002** ***	0.91	0.72	1.84	0.87	**0.0004** ***
Transit (Sometimes)	3.26	2.37	1.40	2.53	1.31	1.28
Walk (Often)	2.22	1.28	1.62	1.35	**2.67** *	1.34
Walk (Sometimes)	1.94	1.60	**3.24** **	1.72	2.18	0.76
Bike (Often)	1.08	1.17	1.20	1.99	1.62	5.16
Bike (Sometimes)	1.04	1.04	0.96	**3.84** **	1.50	1.27
Suburban Community	2.68	**2.73** *	1.32	1.20	1.65	**8.76** *
Rural Community	0.79	1.66	1.63	**0.45** *	**0.35** *	**4.59** *
Gas price (Somewhat important)	**6.15** ***	**8.62** ***	**6.90** ***	**18.9** ***	**9.29** ***	1.53
Gas price (Very important)	2.02	**11.2** ***	**12.0** ***	**55.2** ***	**22.6** ***	**5.75** *
Environmental Concern	1.07	**1.45** *	**1.56** **	**2.75** ***	1.29	**3.52** ***
Technology Concern	1.29	1.19	0.96	1.08	1.03	**0.62** *
Car Travel Enjoyment	0.75	0.77	**0.70** *	**0.48** ***	**0.54** **	1.11
Political Activity	0.82	**1.34** *	**1.42** *	1.37	**1.43** *	**2.67** ***
Observations	749					
R^2 / R^2 adjusted	0.188/0.187					

* p<0.1 ** p<0.01 *** p<0.001

Table 17. Results of the MNL for Less-essential Trips (Current increase in fuel prices)

	Drive efficiently	Reduce trip mileage	Activity Substitu-tion	Mode Substitu-tion	Moved	EV Adoption
Predictors	*Odds Ratio*	*Odds Ratio*	*Odds Ratio*	*Odds Ratio*	*Odds Ratio*	*Odds Ratio*
Intercept	0.75	0.24	0.61	2.02	0.48	0.11
Age	0.98	1.01	0.99	**0.96 ****	**0.97 ***	0.98
Gender (Male)	1.68	**1.64 ***	1.00	1.27	1.21	**3.40 ***
Child (One or more)	1.71	**1.89 ***	**2.37 ***	1.25	0.98	**7.56 ****
Number of Adults	0.89	0.92	0.87	0.98	1.12	0.67
Vehicle (2 and more)	0.92	0.96	1.60	0.99	0.88	**0.24 ***
Race (non-white)	0.74	2.70	1.54	2.92	2.00	0.57
Education (Associates degree)	0.91	**0.50 ***	0.66	1.22	1.29	2.02
Education (Bachelor's degree)	0.59	**0.39 ***	0.53	0.81	0.81	0.40
Education (Graduate degree)	0.70	0.60	0.48	1.54	0.95	0.86
Income ($35,000-$74,999)	0.73	0.62	0.84	0.57	0.82	1.20
Income ($75,000-$99,999)	0.99	0.60	0.77	**0.27 ***	0.71	1.31
Income (>$100,000)	1.05	0.55	0.47	0.43	1.65	1.10
Employment (Unemployed)	1.23	1.06	1.09	1.27	**2.53 ***	1.43
Car (Frequent)	0.98	0.96	0.84	0.51	0.51	0.93
Transit (Often)	0.30	1.08	1.76	**3.87 ***	1.26	0.01
Transit (Sometimes)	2.25	**2.83 ***	**3.53 ***	**3.40 ***	1.69	1.72
Walk (Often)	0.67	0.87	0.55	0.81	1.53	0.76
Walk (Sometimes)	1.06	1.31	1.28	1.39	1.42	0.47
Bike (Often)	3.85	1.86	3.10	**5.15 ***	3.36	**10.58 ***
Bike (Sometimes)	**2.25 ***	1.28	1.47	**3.75 ****	1.78	1.57
Suburban Community	1.46	1.56	1.13	0.63	1.15	**5.92 ***
Rural Community	0.97	1.30	0.93	**0.32 ****	**0.28 ****	3.34
Gas price (Somewhat important)	**3.47 *****	**9.09 *****	**5.44 *****	**5.83 ****	**5.87 *****	0.95
Gas price (Very important)	**4.48 *****	**21.30 *****	**14.06 *****	**20.67 *****	**19.30 *****	**4.97 ***
Environmental Concern	1.07	1.23	**1.61 ****	**2.22 *****	1.10	**3.03 *****
Technology Concern	1.23	1.15	1.07	1.24	1.09	**0.65 ***
Car Travel Enjoyment	0.83	0.90	**0.73 ***	**0.72 ***	**0.67 ***	1.34
Political Activity	0.86	0.99	1.20	1.12	1.14	**2.15 *****
Observations	749					
R^2 / R^2 adjusted	0.158/.158					

* p<0.1 ** p<0.01 *** p<0.001

There were no other significant trends noted with regard to socioeconomic and travel factors other than age. Being older is associated with being less likely to move, substitute modes or drive more efficiently. The MNL model results for less-essential trips (Table 17) were generally similar to those for essential trips, however, there are some differences. Households with children exhibit a greater propensity to reduce trip mileage (combing trips, choosing closer shopping location) and substitute their activities (internet shopping).

Factors Associated with Anticipated Responses to Continued High Gas Prices

The MNL in Table 18 and Table 19 indicate that factors associated with how respondents anticipate responding to a scenario where fuel prices remain high for a year for essential and less essential trips, are more generally similar to how they have responded to the current increase fuel prices. However, there are a few differences. Individuals who walk more than one a week are more likely to make fewer trips or choose closer locations if gas prices remain high for over a year. This may indicate that given more time to plan, those who can walk for some trips now may be able to walk for more trips or find other alternatives to driving. The results also indicate that households with more adults are more likely to substitute modes if gas price remains high for more than a year as are individuals with higher levels of education. Having an associate, bachelor, and graduate degrees is associated with twice the likelihood of substituting transportation modes in response to high gas prices.

Even with the sustained high gas prices over a year, the likelihood of substituting mode of transportation for suburban and rural households is 58% and 67% less than it is for urban households, suggesting limited availability and accessibility to alternative transportation modes. Unlike the prior models, rural households exhibit a decreased propensity to adopt an EV or PHEV, as the odds of adopting EV decrease by 52% for rural households after a year of high gas prices. This disparity in EV adoption rates may be attributed to the response of individuals when confronted with the prospect of high gas prices lasting for an extended period.

Table 18. Results of the MNL for Essential Trips (Price remains high for over a year)

	Reduce trip mileage	**Activity Substitution**	**Mode Substitution**	**Moved**	**EV Adoption**
Predictors	*Odds Ratio*	*Odds Ratio*	*Odds Ratio*	*Odds Ratio*	*Odds Ratio*
Intercept	0.20	0.20	0.18	0.84	1.49
Age	0.98	1.00	0.99	**0.97** *	**0.97** *
Gender (Male)	1.56	1.07	0.78	0.87	**1.96** *
Child (One or more)	1.58	**2.78** *	**3.43** **	1.33	1.64
Number of Adults	1.12	1.16	**1.57** *	1.27	1.20
Vehicle (2 and more)	1.36	1.31	0.88	0.70	1.11
Race (non-white)	1.19	1.04	0.62	1.48	1.31
Education (Associates degree)	1.60	1.42	**2.49** *	1.99	**2.65** *
Education (Bachelor's degree)	2.21	1.01	**2.79** *	1.01	**2.71** *
Education (Graduate degree)	2.44	0.95	**2.68** *	1.26	2.48
Income ($35,000-$74,999)	0.88	1.32	1.55	1.78	1.56
Income ($75,000-$99,999)	0.54	1.08	1.11	1.74	1.69
Income (>$100,000)	0.44	0.85	0.89	2.53	1.61
Employment (Unemployed)	0.94	0.79	0.92	1.43	**0.43** *
Car (Frequent)	1.56	1.52	0.84	0.79	0.50
Transit (Often)	0.55	0.001	0.74	1.26	1.05
Transit (Sometimes)	1.65	1.26	**2.87** *	1.50	1.59
Walk (Often)	**3.12** *	1.18	1.36	1.78	1.77
Walk (Sometimes)	**2.50** *	1.20	1.48	1.60	1.44
Bike (Often)	0.69	0.84	1.48	1.59	1.18
Bike (Sometimes)	0.49	0.65	1.44	0.60	0.83
Suburban Community	2.10	1.35	**0.42** *	1.66	1.31
Rural Community	1.27	0.92	**0.33** **	0.54	**0.48** *
Gas price (Somewhat important)	1.58	**3.16** **	**2.88** *	**5.20** ***	0.93
Gas price (Very important)	**3.77** **	**10.67** ***	**14.68** ***	**21.24** ***	**4.68** **
Environmental Concern	**1.31** *	**1.56** **	**2.37** ***	**1.66** **	**4.03** ***
Technology Concern	0.96	0.88	0.79	0.81	**0.64** **
Car Travel Enjoyment	0.75	0.85	**0.61** **	**0.57** ***	**0.62** **
Political Activity	0.95	1.03	0.99	1.07	**1.63** **
Observations	749				
R^2 / R^2 adjusted	0.170/0.169				

* p<0.1 ** p<0.01 *** p<0.001

Table 19. Results of the MNL for Less-essential Trips (Price remains high for over a year)

	Reduce trip mileage	Activity Substitution	Mode Substitution	Moved	EV Adoption
Predictors	*Odds Ratio*	*Odds Ratio*	*Odds Ratio*	*Odds Ratio*	*Odds Ratio*
Intercept	**0.07 ***	**0.11 ***	0.80	1.67	2.95
Age	1.01	0.99	0.99	**0.97 ** **	**0.97 ***
Gender (Male)	0.87	1.33	1.26	0.94	**2.22 ** **
Child (One or more)	1.48	**2.00 ***	**2.13 ***	0.91	1.14
Number of Adults	1.37	1.13	**1.47 ***	1.25	1.19
Vehicle (2 and more)	0.88	1.52	0.84	0.62	1.00
Race (non-white)	**0.0008 *** ***	0.82	1.91	1.83	1.70
Education (Associates degree)	0.97	1.36	1.03	1.39	1.84
Education (Bachelor's degree)	0.63	1.38	1.48	0.77	2.16
Education (Graduate degree)	1.01	0.94	1.62	1.00	1.99
Income ($35,000-$74,999)	0.78	1.33	1.30	1.60	1.43
Income ($75,000-$99,999)	1.28	1.05	0.99	1.92	1.86
Income (>$100,000)	0.81	0.79	0.84	**2.72 ***	1.72
Employment (Unemployed)	0.77	0.67	0.94	1.38	**0.41 ***
Car (Frequent)	1.47	**0.42 ***	0.82	0.53	**0.33 ** **
Transit (Often)	0.97	**0.0005 *** ***	1.28	1.88	1.58
Transit (Sometimes)	0.72	0.67	**2.10 ***	1.01	1.13
Walk (Often)	0.62	1.00	1.16	1.27	1.28
Walk (Sometimes)	0.83	1.06	1.42	1.27	1.17
Bike (Often)	0.97	0.41	1.19	1.47	1.07
Bike (Sometimes)	0.58	1.18	1.36	0.76	1.08
Suburban Community	1.89	1.40	**0.37 ***	1.42	1.08
Rural Community	0.96	1.19	**0.35 ** **	**0.52 ***	**0.45 ***
Gas price (Somewhat important)	**3.11 ***	**7.39 ** **	1.02	**3.97 ** **	0.67
Gas price (Very important)	**4.29 ***	**14.45 *** ***	**2.11 ***	**8.35 *** ***	1.74
Environmental Concern	1.26	**1.62 *** ***	**3.15 *** ***	**1.69 *** ***	**4.30 *** ***
Technology Concern	1.06	1.16	1.01	0.93	**0.74 ***
Car Travel Enjoyment	0.76	**0.55 *** ***	**0.45 *** ***	**0.47 *** ***	**0.50 *** ***
Political Activity	0.80	**1.36 ***	1.18	1.23	**1.87 *** ***
Observations	749				
R^2 / R^2 adjusted	0.187/0.186				

* p<0.1 ** p<0.01 *** p<0.001

The results of our analysis reveal that attitudinal factors and level of concern towards gas prices were significant in all of the models, indicating that individuals' attitudes and beliefs play a critical role in their willingness to alter their travel behavior in response to rising gasoline prices. The findings for less-essential trips (Table 19) show similarities to the results of this model.

Barriers to Changing Behavior

In recognizing that some individuals may face constraints in altering their travel behavior when gas prices increase, particularly in rural areas where transportation options may be limited, as several respondents mentioned *"There is no public transportation options where I live…"*, or some severely reduced their driving, *"We can no longer afford non-essential travel…"*, it becomes crucial to understand these barriers. By gaining insights into these constraints, we can offer enhanced alternatives and strategies that facilitate changes in travel behavior and promote sustainable transportation practices. Our survey included questions that explored the importance of various factors influencing the adoption of Electric Vehicles (EVs) and identified the barriers individuals encounter when trying to reduce their amount of driving.

Respondents from all communities had a high level of concern for a range of factors related to EV adoption (Figure 25). No single EV adoption factor stood out as being most important. Costs, charging station availability, range, charging speed, 4-wheel drive and truck and SUV models were all important considerations for our respondents (Figure 25). Suburban respondents indicated they were more concerned about charging and range than rural or urban respondents. Urban respondents were lease concerned about truck, SUV and 4-wheel drive options. Understanding factors affecting adopting EV in different communities could help policymakers to develop new policies vary by community type as travel behavior varies in different communities. Better public transportation and greater accessibility appear to be the largest barriers to driving less (Figure 26). Most respondents indicated that improving transit, making biking, and walking safer, closer schools and more local employment opportunities were unlikely to reduce their driving. For the most part the responses did not vary much between urban, suburban, and rural respondents. Urban respondents were somewhat more likely to drive less if walking and bicycling infrastructure were improved. A modest share of respondents indicated that more local shopping opportunities would reduce their driving.

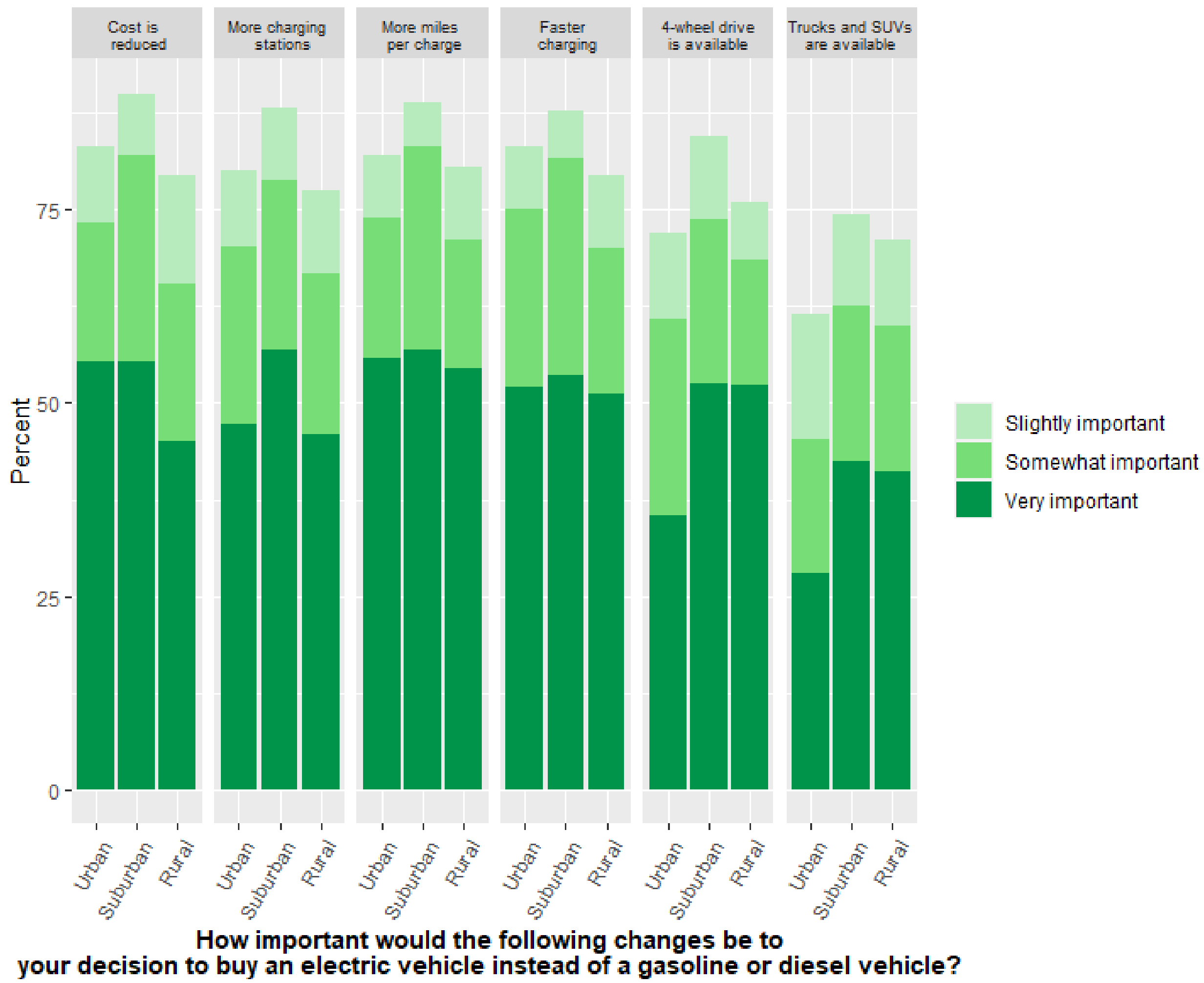


Figure 25. Factors Influencing EV Adoption

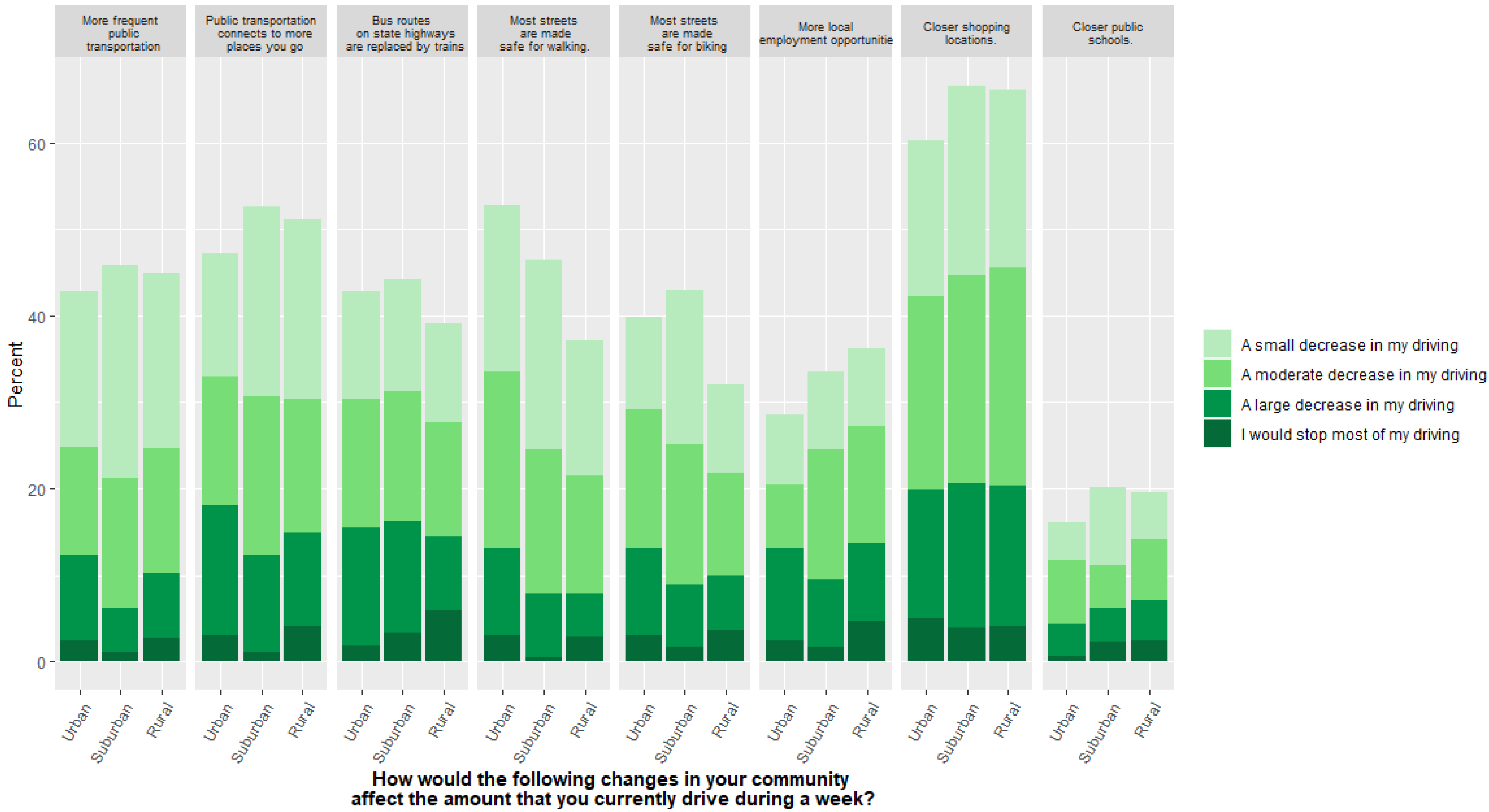


Figure 26. Factors Influencing the amount of Driving

Conclusions

The rapid spike in transportation fuel prices during the first half of 2022 provided a unique opportunity to evaluate how people in a range of small cities to rural communities respond to increasing fuel prices. This information can also provide clues to how people in smaller cities and rural communities would respond to increasing prices caused by carbon taxes or other market based climate policies.

We find that people living in small cities, towns, suburban and rural areas of Vermont were able to respond to high gas prices with a wide range of strategies in the short term and are likely to make additional changes over the longer term. Urban residents were more likely to substitute their mode of transportation or move and rural residents were more likely to adopt an EV; however, most people in all community types were able to reduce the amount they travel by making fewer or shorter trips. The key finding here is that individuals do indeed respond to changes in gas prices, even in regions that are automobile dependent. Although we did not calculate price elasticities, our findings demonstrate that market-based policies, such as carbon taxes and cap and trade policies, have the potential to be effective in influencing travel behavior. This contrasts with previous arguments based on the inelastic price elasticities found in many studies (*52*) implying that pricing measures would be largely ineffective or would necessitate politically unacceptable price hikes. Evaluating the efficiency of market-based climate policies in more rural areas requires quantitative information on the amount (e.g., vehicle miles traveled) by which households reduced their travel in response to the price spike which is information that is difficult to accurately collect through a survey.

The significance of attitudes and beliefs in influencing travel behavior and policy outcomes is another finding of our study. We find the attitudes and beliefs pertaining to sustainability, government, technology, and car culture can play a significant role in the choices people make when gas prices increase. It is not solely land use factors or socio-economic status that hinder people from making changes in their travel behavior; rather, their decisions are also driven by their personal preferences and values regarding climate change and the gratification they derive from driving a car. Attitudes and beliefs are challenging for policymakers to change, as it takes time to shift people's perspectives.

Greater accessibility and more transit options were noted as barriers to change, even in rural areas where accessibility and transit are generally not expected. Aligning the desires and preferences of rural residents with urban amenities and attributes, presents both a challenge and an opportunity for urban planning. This finding suggests that there is potential or even demand for creating more compact and mixed-use development within small towns and other rural areas and implementing innovative micro and one-demand transit solutions that could be feasible in more rural contexts. The challenge is providing the transportation efficiency of an urban area while maintaining characteristics that draw people to smaller towns and rural places.

There is still a lot of concern about EVs, and the differences are not very different across community types. Surprisingly, range is just as large a concern in urban areas as it is in rural areas. This finding seems to indicate that a large share of the population in Vermont is still generally wary of EVs and has not given much consideration to how an EV could work in different community contexts.

One of the main limitations of this study is the lack of information collected regarding the extent of individuals' actual changes in driving behavior, such as changes in vehicle miles traveled (VMT) or the number of trips made. While we collected information about the types of actions made or anticipated, including a number of actions that would reduce trip frequency or length, we cannot estimate how much driving or use of other modes changed. Conducting a more detailed study to gather such information was not feasible during the sudden increase in gas prices since asking about changes in distance driven or number of trips is exceedingly difficult to do in a survey. This limited our ability to estimate elasticities, which can provide additional and valuable insights. Additionally, the study's focus on Vermont restricts the generalizability of the findings to other locations, particularly large urban areas. However, this research new information about behavior changes and pricing in a wide range of smaller communities and rural areas that have been largely overlooked in prior travel behavior research.

Chapter 6: A Data Driven Analysis of Rural Equity and Cost Concerns for Mileage-Based User Fees in Vermont

Clare Nelson and Gregory Rowangould

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Introduction

There is consensus that the sustainability of transportation funding in the U.S. is at risk. Maintaining existing roadway networks is becoming a greater burden (*88*–*90*), and current revenue generation methods are failing to keep up. Currently, the motor fuels tax or "gas tax" is the largest proportion of funding for roadway maintenance and construction. In almost all states and at the federal level, the gas tax is an excise tax implemented as a flat tax per unit of gasoline or diesel fuel sold. As a flat per gallon tax, the revenue collected though the gas tax is unable to adjust for inflation without legislative action to increase the tax rate, which has been historically unpopular and difficult to achieve (*91*–*95*). Additionally, the rising adoption of more fuel efficient, hybrid, and electric vehicles has further eroded gas tax revenue (*93*, *96*–*98*). With the current trajectory of rising inflation combined with state and federal policies aimed at further increasing the fuel efficiency of the vehicle fleet and electric vehicle adoption, the U.S. can expect a significant gap in transportation funding in the coming decades.

In addition to declining revenue and purchasing power, the gas tax is frequently found to be regressive and inequitable, with low income and rural households facing higher tax burdens due in part to their propensity to own less fuel efficient vehicles, and in some situations drive more (*92*, *99*–*102*). In response to concerns over the gas tax, a variety of funding alternatives have been examined including congestion charging, tolling, and road-user fees (*91*, *103*–*106*). States have also explored supplementing transportation funding through increases in local option taxes such as income, property and sales taxes, although there are concerns over the long-term financial viability of these options (*103*, *106*).

Road user fees based on mileage, commonly referred to as a mileage-based user fee (MBUF), are actively being pursued by governing agencies as a more sustainable replacement for the gas tax. However, public concerns and misconceptions about MBUFs remain a significant implementation barrier (*91*, *107*). Based on prior surveys and focus group efforts at local, state, and federal levels, public hesitancy mainly focuses on three main concepts; perceptions of personal tax burden (as in, believing a MBUF would be much more expensive than their current gas tax payments), perceptions of inequity (as in, believing a MBUF would be largely unfair to rural and low income communities), and privacy concerns (related to discomfort with any governing body or agency knowing or tracking their mileage). Studies estimating changes in tax burdens under a MBUFs find minimal differences in per household and per capita costs compared to the gas tax on both statewide and national scales (*108–116*). Several studies have also considered impacts on households in different community types, finding that rural households would tend to benefit more from a MBUF than urban households would (*109–113*, *117*, *118*). Studies also find that low income households would have lower tax burdens than higher income households (*110*, *114*, *119*).

While these studies have begun to address public equity concerns revolving around MBUFs, there are potential pitfalls in their use of sparse and aggregate data to evaluate MBUF policies. In most cases, these studies used the National Household Travel Survey (NHTS) to examine tax burden. MBUF policy analyses based on NHTS data are limited by the survey's aggregation of respondent locations and the small sample sizes for small and medium-sized communities. Resulting analyses are, therefore, limited in their ability to discern the full range of cost variation across the diverse range of community types within states. Additionally, the NHTS provides data from only one day of travel, so researchers must rely on extrapolation to assess monthly or annual household cost differences under a MBUF.

There are currently efforts to expand upon prior MBUF equity research with larger vehicle datasets. For example, the Hawaii road-user charge (HiRUC) study used state vehicle registration records to estimate tax payments for each registered vehicle in Hawaii. The HiRUC study found rural and low income households would, on average, save money compared to their urban and higher income counterparts (*120*). These findings illustrate the value of using disaggregate data to explore the full range of costs experienced by households on the rural to urban and high to low-income spectrums.

Vermont Context

The Vermont Agency of Transportation (VTrans) is evaluating options to increase state transportation revenue through taxes on electric and hybrid vehicles. A recent study from VTrans confirms that Vermont will experience significant funding deficits if the gas tax is not increased, supplemented, or replaced in coming years. By assuming Vermont's socioeconomic and geographical landscape is comparable to states that have previously studied the financial and equity implications of replacing the gas tax with a MBUF, the VTrans study concludes that a revenue-neutral MBUF ranging from 1.3 to 1.5 cents per mile is a reasonable replacement for the state gas tax and has the potential to bridge impending funding gaps (*121*).

Our study expands on state interest to perform a robust analysis of disaggregated vehicle data available from the Vermont Department of Motor vehicles (DMV). We overcome the prior limitations of research relying on small datasets and aggregated location information to provide novel insights into the true costs of replacing the gas tax with either a MBUF or a flat vehicle fee on the per vehicle, per household, and per capita level. Our focus on Vermont, a primarily rural state, directly addresses public concerns regarding the equity of a MBUF for populations residing in a wide range of communities with various levels of income from various racial and ethnic groups.

Methods

The vehicle data we use in this study were originally collected by the UVM Transportation Research Center (TRC) for the 2021 Vermont Transportation Energy Profile (*122*). These data were further cleaned and analyzed for this report.

Data Source

Since 2016, Vermont has required all registered vehicles to be inspected every 365 days using a new electronic inspection reporting system. During each inspection, vehicle identification numbers (VINs) and odometer readings are recorded. Registration records are also available for each VIN, containing information about vehicle attributes and the registered vehicle address. We obtained additional details about each vehicle by querying a NHTSA database that decodes information contained within each VIN using an API developed for R (*123*).

Data Cleaning

We calculated annual vehicle miles travelled (VMT) for each vehicle using odometer readings from subsequent years and normalizing by the number of days between inspections. The inspection data were then merged with vehicle registration records using VINs which linked VMT data to home addresses. Detailed information about each vehicle obtained by decoding VINs was then used to pair vehicles with fuel economy ratings available from US EPA's fuel economy database (*124*).

Publicly available Enhanced 911 (E911) data for Vermont contains additional information on each address in Vermont, including a commercial-residential address indicator. We identified and removed all vehicles registered at non-residential addresses from our data. We also removed vehicles with a gross vehicle weight greater than 14,000 lb (Class 3 and above), leaving us with a data set containing mostly light-duty personal vehicles. This allowed us to evaluate the impact of gas tax alternatives on individuals and households. After removing vehicles that could not be matched with fuel economy data, the final data set contained 310,661 vehicles across 189,251 households.

Each vehicle was geocoded to is registered home street address using ArcGIS. The geocoded vehicle point locations were then spatially intersected with race and income data from the 2019 American Community Survey as well as community-type indicators from the 2010 USDA Rural Urban Commuter Area Codes (RUCA Codes).

Revenue Neutral Fee Calculation

The final data were analyzed to identify financial inequities across Vermont populations if the Vermont state gas tax was replaced by either a MBUF or a flat fee.

The MBUF and flat fee were calculated as revenue-neutral fees to discern the baseline impacts of a change in transportation revenue collection. From the latest Federal Highway Administration (FHWA) Highway Statistics report (*125*–*128*), 289.164 million gallons of gasoline and 72.796 million gallons of diesel were purchased in Vermont in 2018. The annual Vermont gas tax revenue was calculated by multiplying each quantity of purchased fuel by their respective state taxes ($0.307 per gallon of gasoline purchased and $0.31 per gallon of diesel purchased). This annual revenue was then divided by the estimated total annual Vermont VMT (7.346 billion miles) to calculate the MBUF and divided by the total number of registered vehicles in Vermont to calculate the flat fee. The resulting revenue neutral taxes were determined to be $0.015 per mile or $180 per vehicle per year. The calculation for the revenue neutral MBUF is shown in Equation 3.

$$MBUF = \frac{T_{gas}Q_{gas} + T_{diesel}Q_{diesel}}{VMT_{total}} \tag{3}$$

where,

MBUF = Revenue-neutral MBUF

T_{gas} = Vermont state gas tax

Q_{gas} = Total gallons of gasoline fuel purchased in Vermont

T_{diesel} = Vermont state diesel tax

Q_{diesel} = Total gallons of diesel fuel purchased in Vermont

VMT_{total} = Total annual Vermont VMT estimate

Financial Impact

The tax burden of switching to both a MBUF and a flat fee were calculated as dollar and percent differences relative to current gas tax spending. Negative tax burdens translate to lower annual costs (saving money) while positive tax burdens translate to higher annual costs (spending more money).

$$TB_{veh} = C_{gas} - C_{MBUF} \tag{4}$$

$$TB_{hh} = \sum_i (TB_{veh})_i \tag{5}$$

$$TB_{cap} = \frac{\sum_i (TB_{veh})_i}{HHS_j} \tag{6}$$

where,

TB_{veh} = tax burden for a vehicle

TB_{hh} = tax burden for a household

TB_{cap} = tax burden per capita

C_{gas} = annual gas tax costs for a vehicle

C_{MBUF} = annual MBUF costs for a vehicle

i = household (i.e., residential address)

j = census block group

HHS = average household size in a census block

This analysis was performed on a per vehicle, per household, and per capita level. Calculations for per vehicle, per household, and per capita costs are shown in Equations 4, 5, and 6 respectively. Household gas tax, flat fee and MBUF costs were calculated by summing the per vehicle tax burden at each address. Household costs were then normalized by the average household size in their census block to generate per capita gas tax, flat fee, and MBUF cost estimates.

Spatial Analysis

The large number of vehicles and households used in the analysis were difficult to visualize at a state-wide scale when using points. Spatial trends in tax burden were discerned by aggregating vehicle point data and, separately, aggregating household point data onto a state-wide grid using a two square-kilometer cell size. The resulting 2,919 grid cells contained the mean gas tax, flat fee and MBUF costs per vehicle, household, and capita within each cell. Out of the 2,919 grid cells, 512 did not contain any vehicles. These "holes" on the map are mostly due to the Green Mountains and other unpopulated natural areas, either privately owned or protected.

Equity Analysis

The tax incidence of a mileage-based user fee and a flat fee were examined across 10 income quantiles using the full data set (unaggregated). Tax burdens were assessed per vehicle, per household, and per capita. Incomes were obtained from median household income data available at the census block group level.

Race and ethnicity data were obtained at the census block level. Population weighted household costs were calculated for each racial and ethnic group, as shown in Equation 7.

$$C_{rg} = \frac{\sum_j C_j P_j}{\sum_j P_j} \quad (7)$$

where,

C_{rg} = population weighted household cost for a racial and ethnic group

C = mean annual household cost in a census block (either gas tax, flat fee or MBUF)

P = the population of a racial and ethnic group in a census block

j = census block

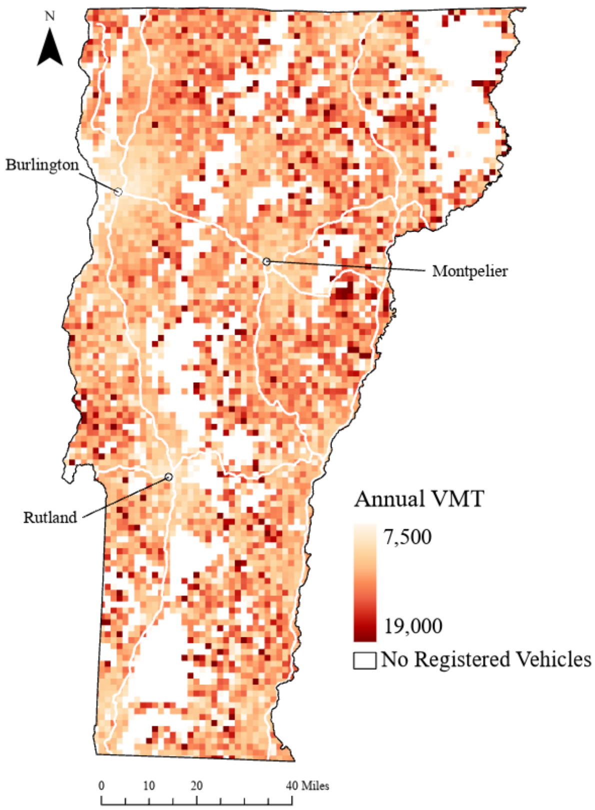
Tax incidence was also evaluated across 10 distinct Rural Urban Commuter Area Codes (RUCA Codes), which describe the way the single largest commuting share in a census tract. To reduce the number of variables, these codes were aggregated into four categories: area core, high-commuting, low-commuting, and rural (Table 20). When a tract is defined as an area core, it means more than 30% of the tract population is in an urbanized area and the primary flow is within the tract.

Table 20. RUCA Code Descriptions

RUCA Code	Description	Aggregated RUCA Codes
1	Metropolitan area core: primary flow within urbanized area	Area core
2	Metropolitan area high commuting: primary flow 30% or more to a UA	High commuting
3	Metropolitan area low commuting: primary flow 10% to 30% to a UA	Low commuting
4	Micropolitan area core: primary flow within an urban cluster of 10,000 to 49,999 (large UC)	Area core
5	Micropolitan area high commuting: primary flow 30% or more to a large UC	High commuting
6	Micropolitan area low commuting: primary flow 10% to 30% to a large UC	Low commuting
7	Small town core: primary flow within an urban cluster of 2,500 to 9,999 (UC)	Area core
8	Small town high commuting: primary flow 30% or more to a UC	High commuting
9	Small town low commuting: primary flow 10% to 30% to a UC	Low commuting
10	Rural areas: primary flow to a tract outside a UA or UC	Rural

When a tract is defined as high commuting, it means the primary flow (accounting for over 30% of the tract population) is to a tract defined as an area core. When a tract is defined as low commuting, it means the primary flow (accounting for less than 30% of the tract population) is to a tract defined as an area core. When a tract is defined as rural, it means the primary flow is within the tract or to other rural tracts.

Figure 27 provides spatial context for current vehicle use and ownership in Vermont. Annual gas tax payments were calculated using vehicle specific vehicle miles travelled (VMT) and fuel efficiency. For easier visualization, mean values of VMT and fuel efficiency were estimated for each 2 km^2 grid cell in Figure 27. All maps also note the locations of major highways and interstates running through Vermont as well as three Vermont cities: Burlington, Montpelier (the state capital), and Rutland.



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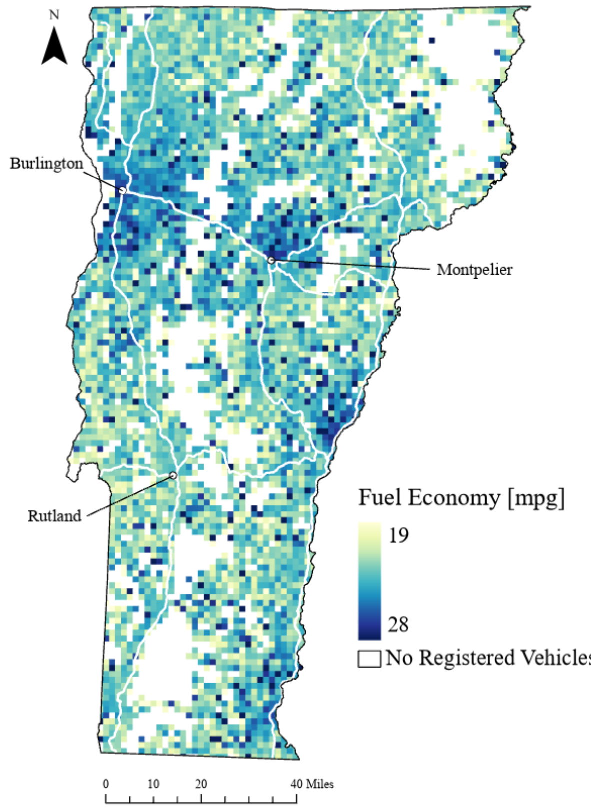
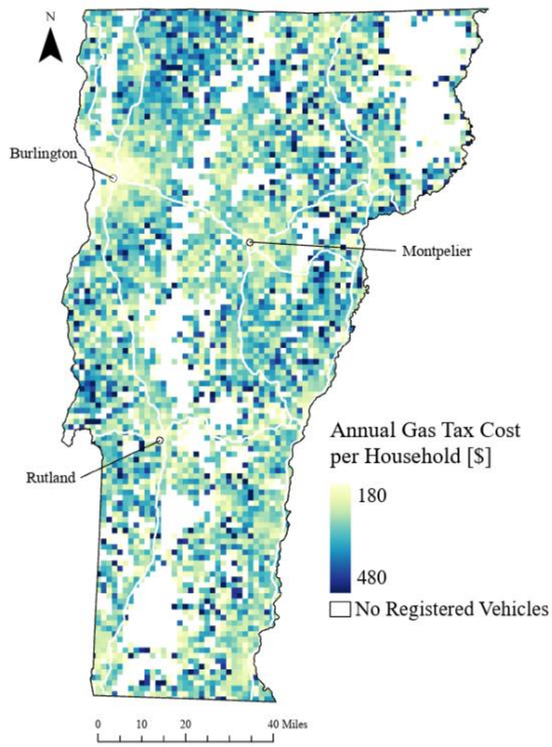


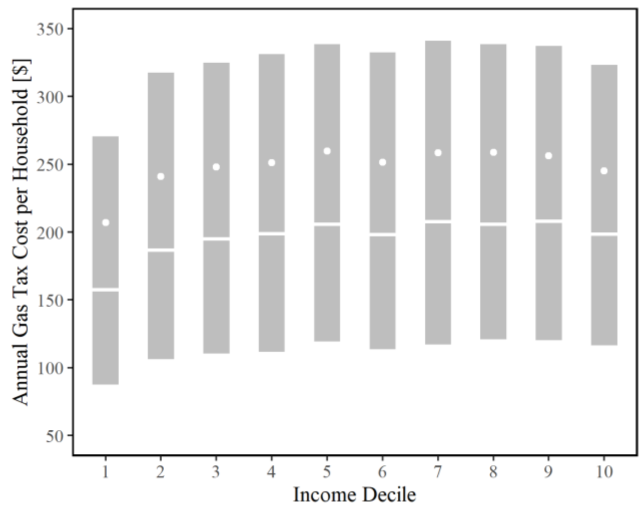
(b)

Figure 27. Vermont spatial trends using mean values per 2 km2 grid cell. a) Annual VMT per vehicle and b) Fuel economy in miles per gallon [mpg]. Interstates running through Vermont are shown as white lines.

Results

In Vermont, annual gas tax payments average $150 per vehicle, $250 per household, and $131 per capita. Household gas tax expenditure tends to increase with distance from city centers. As Figure 28 shows, households near denser areas such as Burlington, Montpelier, and Rutland pay less in gas taxes compared to rural households. Annual household gas tax payments show a slightly progressive trend at the lowest income brackets (less than $55,000 per year), but Vermont households making anywhere from $55,000 per year to millions per year see little to no difference in costs.





(a) (b)

Figure 28. Annual gas tax burdens for Vermont households in 2019 (a) Spatial distribution using mean values per 2 km2 grid cell. Interstates running through Vermont are shown as white lines. (b) Income distribution using median census block group household incomes, with means for each income decile represented as a white dot

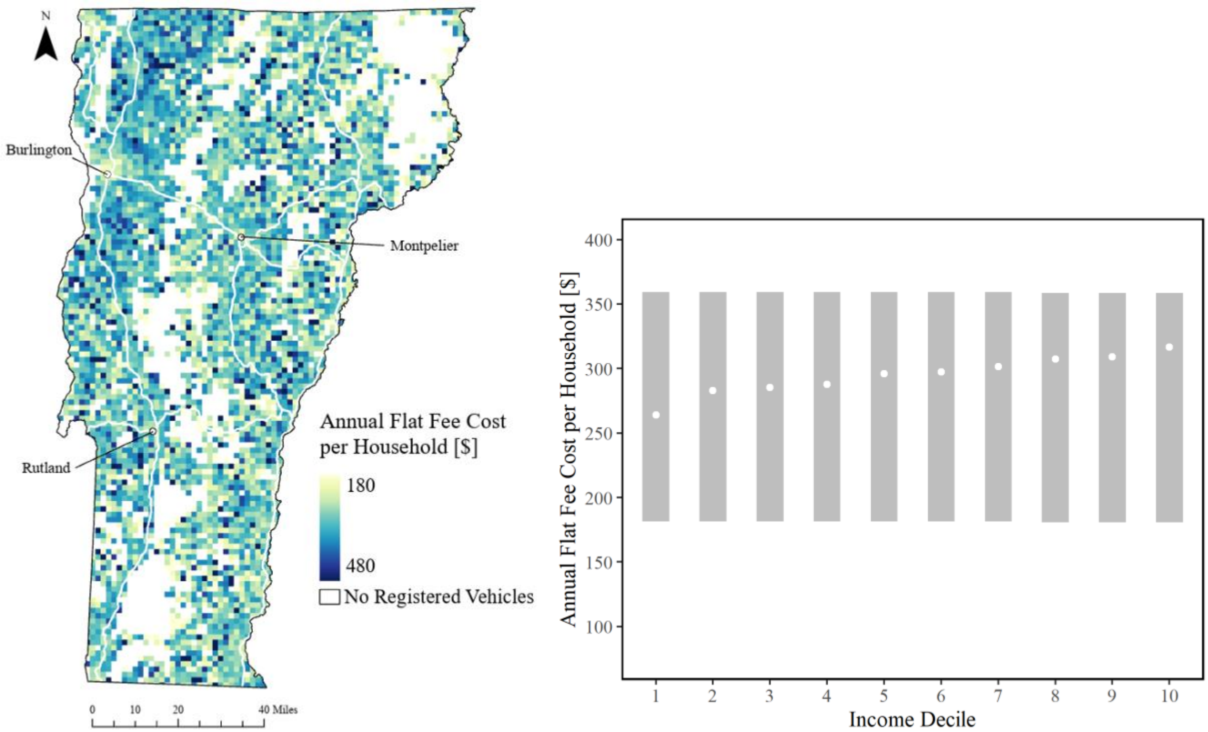
Two alternatives to this current taxing scheme were examined: a mileage-based user fee and a flat fee.

Alternative 1: A revenue neutral flat fee of $180 per vehicle per year replaces the VT gas tax.

Under a revenue neutral flat fee alternative, every vehicle owner (residential and commercial) pays $180 per vehicle per year in taxes. The following analysis only includes personal light-duty vehicles to understand the impact on Vermont households.

Compared to the gas tax, a flat fee of $180 per vehicle per year results in higher annual payments on average when examined at the per vehicle, per household, and per capita level. On average, each household would see a $50 increase in annual payments. Only 30% of Vermont residential households save money. Most households (75%) see changes in tax burdens ranging from saving $19 per year to paying $131 more per year. This scenario creates extreme cost differences across Vermont, with 12% of households saving over $100 per year, but 36% of households spending an additional $100 per year or more. Full summary statistics for flat fee costs and tax burdens relative to annual gas tax costs are in Table 21.

Where Vermonters live (their community type) and their income significantly impact their annual tax burden if the gas tax is replaced with a flat fee. For example, high-income urban households typically pay $75 more than medium-income low-commuting households (Table 22). On average, residents of urban areas see cost increases double that of their rural counterparts. Middle income households ($40,000 to $85,000) generally see the smallest price changes, and high-income earners (over $85,000) see the largest price increases. However, in high commuting and urban areas, the lowest income earners are responsible for the highest average costs per capita.



(a) (b)

Figure 29. Annual flat fee tax burdens for Vermont households in 2019 (a) Spatial distribution using mean values per 2 km2 grid cell. Interstates running through Vermont are shown as white lines. (b) Income distribution using median census block group household incomes, with means for each income decile represented as a white dot

Alternative 2: A revenue neutral mileage-based user fee of $0.015 per mile replaces the VT gas tax.

Under a revenue neutral MBUF scenario, every vehicle would be assessed a $0.015 per mile fee. The following analysis only includes light-duty vehicles registered at residential addresses to understand the impact on Vermont households.

Most Vermont households pay between $130 and $350 in annual MBUF payments. This translates to most households paying somewhere between an additional $50 per year to $5 less. On average, this is a $30 increase in annual tax burden and only 30% of Vermont residential households save money. The cost differences at the high and low ends of the spectrum, however, were small compared to cost differences associated with a flat fee, with only a few extreme cases of high savings (2%) and high losses (8%). Full summary statistics for mileage-based user fee costs and tax burdens compared to annual gas tax costs are in Table 21. The variation in annual costs across income and community types is minimal for MBUFs. For example, the largest annual cost difference is between low-income low commuting households and low-income rural households, with the former paying $15 more on average (Table 22).

Table 21. Summary Statistics for Annual Tax Burdens under the Gas Tax, a MBUF, or a Flat Fee

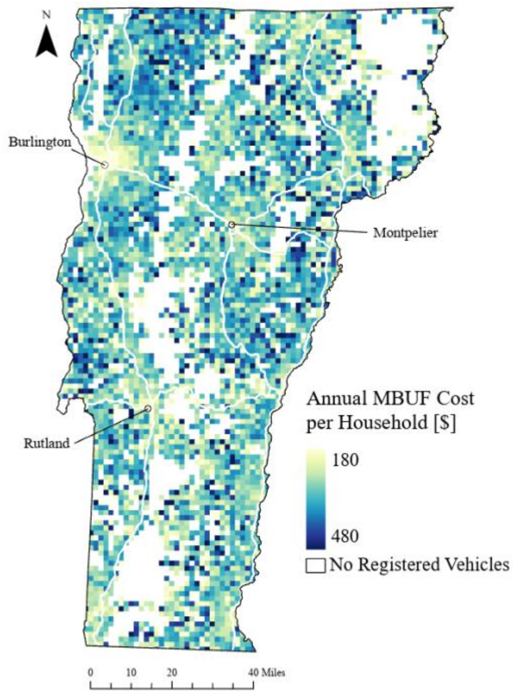
	Variable		Min	Q1	Median	Mean	Q3	Max
Per Vehicle	Fuel Economy [mpg]		11	19	22.5	23.6	26.8	124.8
	Annual VMT		0	6,162	9,949	11,003	14,418	99,905
	Cost [$]	Gas Tax	0	79.69	131.7	151.2	197.8	2,277
		MBUF	0	92.44	149.2	165.0	216.3	1,499
		Flat Fee	180	180	180	180	180	180
	Cost Difference from Gas Tax [$]	MBUF	-915.0	-7.90	9.99	13.83	34.51	1,485.88
		Flat Fee	-2,097	-17.78	48.26	28.79	100.3	180
	Percent Cost Difference from Gas Tax [%]	MBUF	-46.25	-7.17	9.93	83.54	30.94	10,000
		Flat Fee	-92.09	-8.99	36.64	309.8	125.9	3,389,811
Per Household	Cost [$]	Gas Tax	0	111.2	195.7	247.6	326.6	6,771
		MBUF	0	130.7	219.6	270.3	353.9	5,338
		Flat Fee	180	180	180	294.8	360	2,880
	Cost Difference from Gas Tax [$]	MBUF	-1,433	-5.61	16.71	22.65	47.13	1,474
		Flat Fee	-4,251	-18.87	63.67	47.15	131.19	1,499
	Percent Cost Difference from Gas Tax [%]	MBUF	-46.25	-2.98	10.56	51.03	28.59	10,000
		Flat Fee	-91.86	-6.79	33.84	171.7	106.0	1,085,912
Per Capita	Cost [$]	Gas Tax	0	53.14	95.33	131.3	164.9	8,942
		MBUF	0	62.18	107.4	143.0	179.43	8,350
		Flat Fee	0.33	86.67	122.4	155.2	186.7	9,540
	Cost Difference from Gas Tax [$]	MBUF	-1,929	-2.68	8.07	11.72	23.41	2,078
		Flat Fee	-3,665	-8.93	30.16	23.89	65.96	4,431
	Percent Cost Difference from Gas Tax [%]	MBUF	-386.3	-1.43	5.1	43.74	14.28	10,000
		Flat Fee	-487.8	-3.19	16.12	109.9	53.28	662,590

Table 22. Annual Change in Tax Burdens for Flat Fees and MBUFs Replacing the Gas Tax by Community Type and Income Level

			Flat Fee Cost Difference [$]			MBUF Cost Difference [$]		
Income	**Community Type**	**Number Households**	**Per Vehicle**	**Per Household**	**Per Capita**	**Per Vehicle**	**Per Household**	**Per Capita**
Low Income	Rural	2707	19	30	19	10	17	10
	Low commuting	64	27	41	23	21	32	21
	High commuting	0	--	--	--	--	--	--
	Urban	14,277	44	63	34	17	25	13
Medium Income	Rural	40,655	8	14	9	10	17	11
	Low commuting	2,992	5	8	5	10	17	9
	High commuting	37,243	15	26	14	11	20	10
	Urban	53,722	49	75	37	16	25	13
High Income	Rural	3,716	27	46	28	17	28	16
	Low commuting	0	--	--	--	--	--	--
	High commuting	13,003	18	32	15	15	27	12
	Urban	20,872	49	84	37	18	30	13

Low income = less than $40,000 / year, Medium Income = $40,000 to $85,000 / year, High Income = more than $85,000 / year

Keeping these small numbers in mind, residents of urban areas pay up to 1.5 times the costs of their rural counterparts. Those living in commuting areas, also referred to as suburbs, see similar or slightly larger price increases compared to urban residents. Middle income households ($40,000 to $85,000) experience the smallest price changes, while the highest income households (over $85,000) see the largest price increases.



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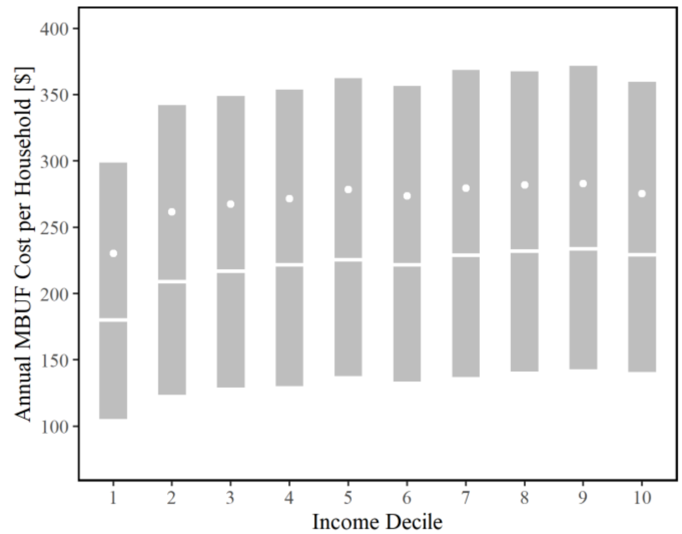

(b)

Figure 30. Annual MBUF tax burdens for Vermont households in 2019 (a) Spatial distribution using mean values per 2 km2 grid cell. Interstates running through Vermont are shown as white lines. (b) Income distribution using median census block group household incomes, with means for each income decile represented as a white dot

Cost Variation Across Vermont Communities

When spatially examining policy alternatives to the gas tax across the state of Vermont, differences in costs between community types are evident (Figure 31 and Figure 32). Areas farther from main city centers, generally considered rural areas, are more likely to save money. The impact of community type is further examined in Figure 33. In all cases, those located in urban areas see the largest cost increases.

Figure 31 and Figure 32 contain box plots depicting flat fee and mileage-based user fee cost impacts varying with income. The general trend reveals that flat fees are more regressive, with either stable or decreasing cost differences (lower costs) as income increases. MBUFs are more progressive, with either stable or increasing cost differences (higher costs) as income increases.

Cost Variation by Race and Ethnicity

Flat fee and mileage-based user fee cost impacts varying with race and ethnicity were also examined (Table 23). There was little to no difference in annual household cost payments between all race and ethnicity categories described by the census. Compared to the largest group in Vermont, meaning white and non-Hispanic/Latino/Spanish, most other groups paid similar amounts or less per household per year for both flat fees and mileage-based user fees. Non-Hispanic Native Hawaiian / Pacific Islanders, pay more than other race and ethnicity groups when transitioning to a MBUF or flat fee. Their overall tax burden is approximately $5 per year higher under a MBUF than the second highest paying group (Non-Hispanic Caucasian / White). Based on this analysis, there is little evidence to suggest there is a racial disparity in cost variation under a MBUF.

Table 23. Mean Tax Burdens for the Gas Tax, Flat Fees, and MBUFs by Race and Ethnicity

Race	Gas Tax	MBUF	Flat Fee
Hispanic / Latino / Spanish	$243.27	$266.78	$294.76
Caucasian / White (alone)	$255.34	$277.12	$299.38
African American / Black (alone)	$211.11	$236.22	$280.78
Asian (alone)	$215.89	$242.04	$289.72
Native American / Indian (alone)	$247.50	$268.91	$290.03
Native Hawaiian / Pacific Islander (alone)	$251.74	$283.13	$301.17
Other Race (alone)	$231.01	$250.96	$282.35
Two or More Races	$239.48	$261.76	$290.27

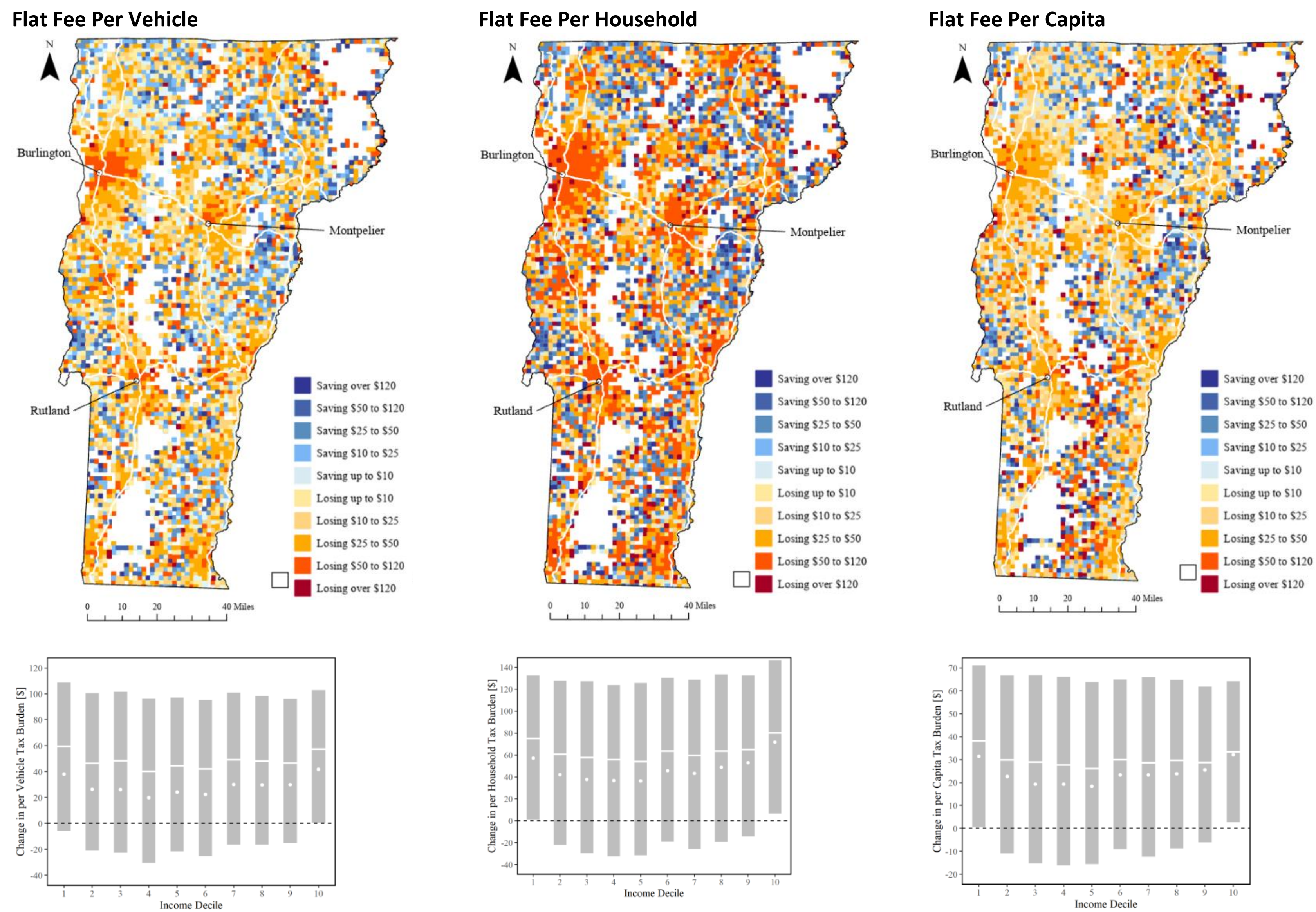

Figure 31. Annual Change in Tax Burdens for Flat Fees Replacing the Gas Tax

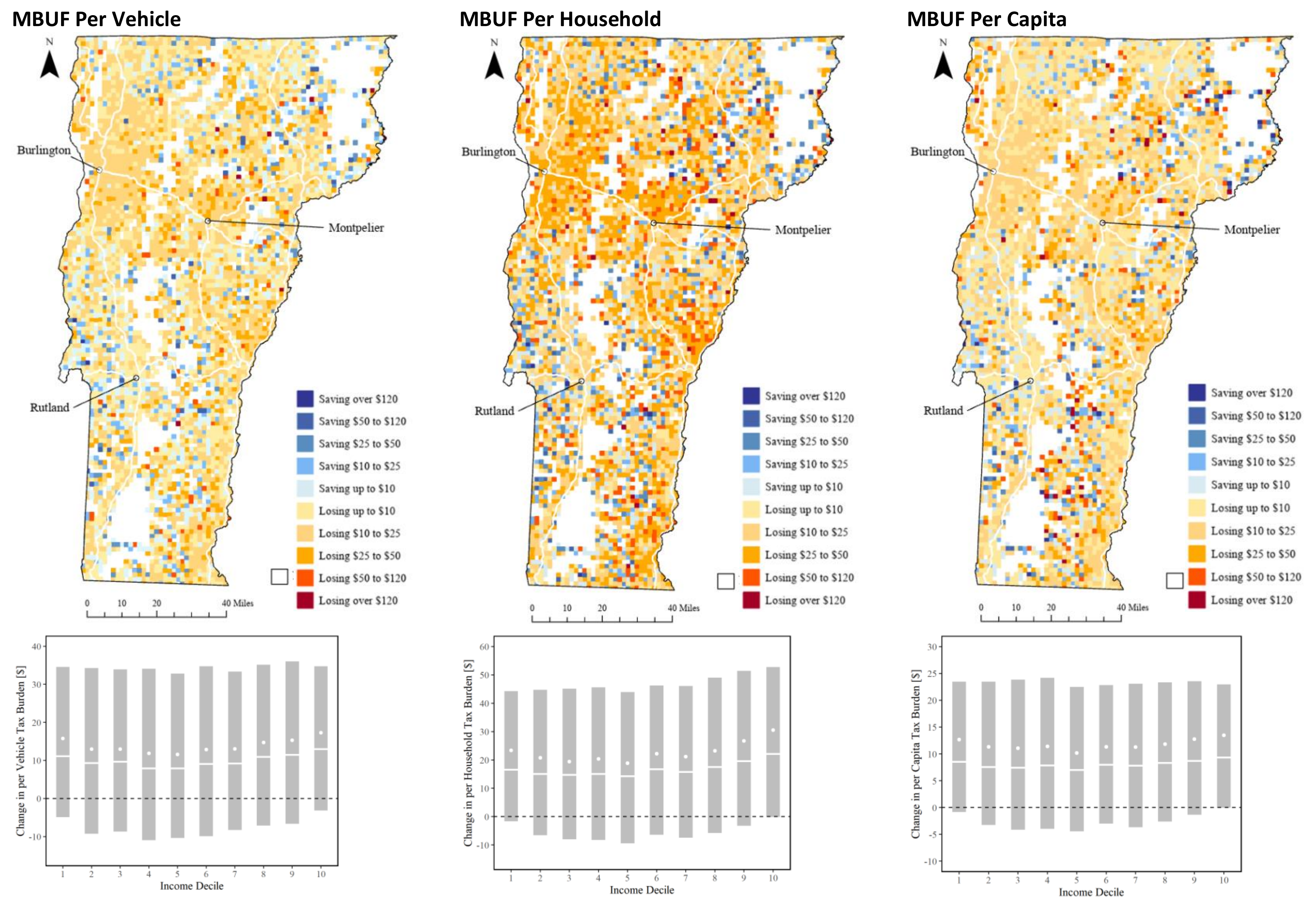

Figure 32. Annual Change in Tax Burdens for MBUFs Replacing the Gas Tax

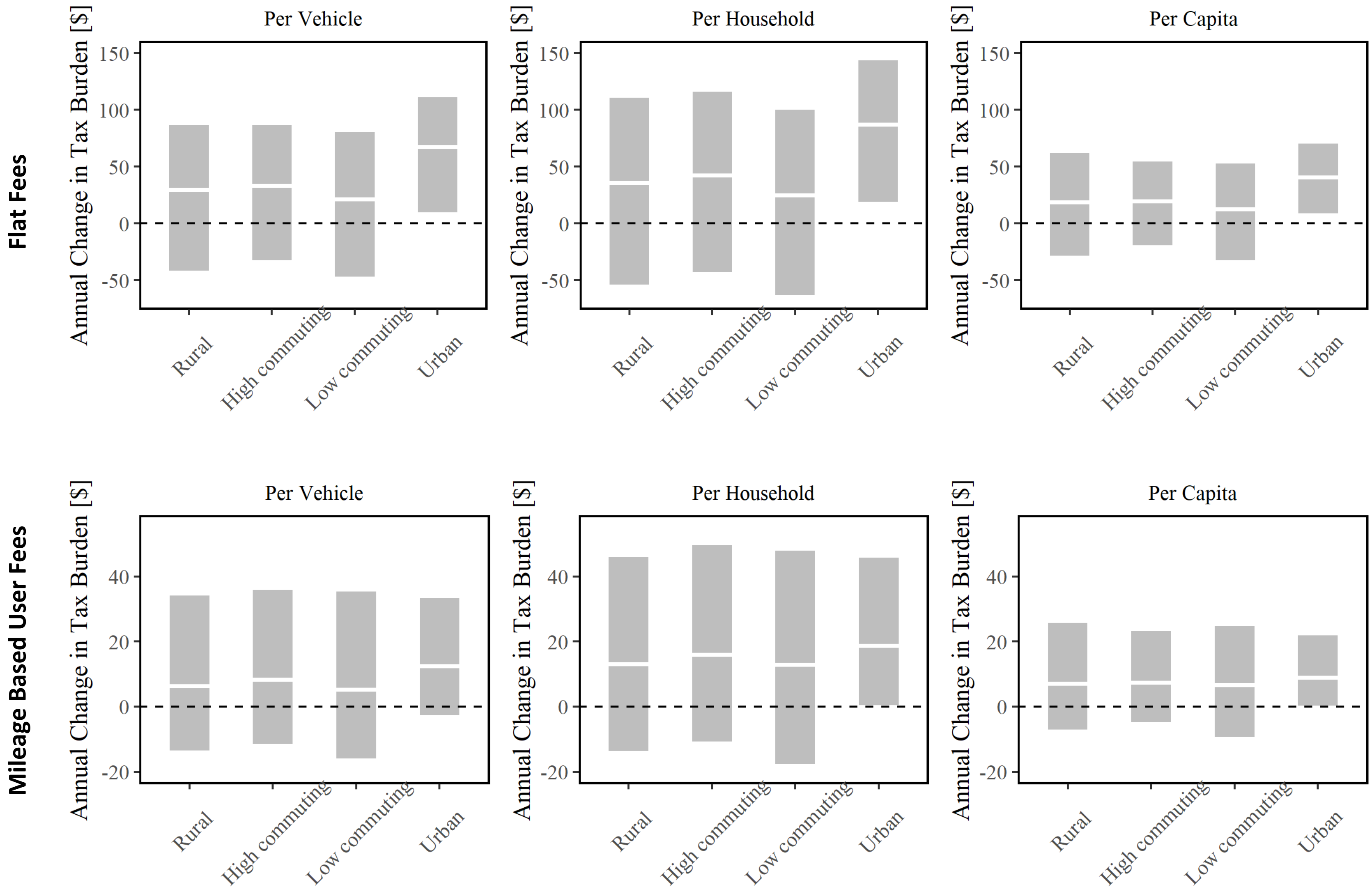

Figure 33. Annual Change in Tax Burdens for Flat Fees and MBUFs Replacing the Gas Tax by Community Type

Conclusions

We conclude that a MBUF fee would be a viable alternative to the gas tax in Vermont. Most households would see very small changes to their current annual gas tax payments. On average, Vermont households would pay an extra $23 per year. Rural and lower income households would generally see the smallest increases while urban and higher income households would see somewhat larger increases. Since rural households on average have much higher gas tax burdens than urban households, a MBUF would result in a somewhat more equitable distribution in rural user fees across community types. A MBUF is also somewhat more progressive (or less regressive) than the gas tax since lower income households would generally pay less than higher income households, although this varies across community types. These findings align with those of past MBUF studies that have considered cost burdens across income groups and urban and rural communities; however, our results using a larger and more spatially refined dataset reveals the heterogeneity in costs across the urban to rural continuum and the factors contributing to the broad spatial patterns we find.

We find that flat fees, on the other hand, would cause more extreme price variations, with the average Vermont household paying $47 more per year and larger incidences of extreme savings and losses. Furthermore, a flat fee would be a departure from the intent of the current gas tax to act as a road user fee and raises equity concerns insofar as it would charge vehicle owners the same user fee regardless of their use of public roads, including those who have minimized the among they drive, to save money or reduce their environmental impact. In this way, a flat fee fails to meet the benefit principle of equity.

While a MBUF is attractive from a revenue generation and user fee perspective, implementation faces numerous challenges including various equity concerns. The public alongside state and federal policy makers are concerned about impacts on rural and low-income communities. With our robust and data-driven analysis it may be possible to "myth-bust" these general misperceptions. For example, it's possible to see on a map at a very fine spatial scale the expected change in costs in every community across the state using real data about the actual travel and vehicle ownership of individual Vermont households. This information could be used, as demonstrated in the Hawaii HiRUC study, in public education campaigns as a means of increasing support for a MBUF program.

Our findings also point to an additional concern with the design of revenue neutral MBUF programs. A revenue neutral MBUF in Vermont would, on average, increase the tax burden for most Vermont households. This occurs because commercial, medium, and heavy-duty vehicles would on average pay less. Commercial vehicles have much lower fuel economies than personal vehicles, a factor that is not used in the calculation of a MBUF. Future efforts to develop fair and equitable MBUF policies may consider separate personal and commercial MBUF rates that aim for revenue neutrality within each category to minimize impacts on households.

Overall, the gas tax, as it stands, does not provide a reliable source of transportation funding due to its inability to adjust to inflation and failure to collect revenue from the exponentially increasing proportion of fuel-efficient vehicles. Finding a viable solution to the funding gap is an urgent matter. This analysis found that a switch from the Vermont state gas tax to a MBUF offers minimal cost differences for households, is more progressive than the gas tax, and reveals no pressing equity concerns across communities or racial-ethnic groups. However, other implementation barriers remain before a MBUF can be set into policy, many of which revolve around public attitudes and assumptions about MBUFs. For one, many believe that switching from a fuel-consumption based tax to a mileage-based tax will deter more fuel-efficient vehicle purchases. Additionally, many in the public see MBUFs as an invasion of privacy and are concerned about being tracked, which results in political apprehension to move forwards with the policy. Furthermore, our analysis did not consider any additional administrative costs related to implementing a MBUF. These costs could increase the relative costs of a MBUF compared to the gas tax. Future research and pilot programs should focus on addressing these additional barriers.

Chapter 7: Can Americans Support Alternatives to the Gas Tax? The Role of Information and Education on Policy Support

Clare Nelson and Gregory Rowangould

Introduction

The current state of transportation funding for the U.S. is unstainable and in need of replacement. Currently, motor fuels taxes, or "gas taxes", contribute a large proportion of revenue to transportation maintenance and construction. Federal gas taxes and most state gas taxes charge retail sellers per gallon of fuel sold. Their revenue-generating ability is therefore reliant on fuel consumption. In recent years, state and federal policies have solidified mandatory reductions in fuel consumption through higher fuel efficiency standards and greenhouse gas reduction goals (*96*, *97*, *129*). Many believe increasing the gas tax will abate the funding gap caused by decreasing fuel consumption trends (*98*, *130*, *131*), but critics note that it is unsustainable to rely on any tax that is infrequently adjusted to inflation (*129*, *132*–*134*). Additionally, as alternatively fueled vehicles become more widely available and popular, an increasingly large proportion of the population will not be contributing to the gas tax. Critics of the gas tax note that there are potential equity concerns with shifting the burden of funding our transportation systems onto those who still rely on gasoline or diesel (*135*).

Alternatives to the gas tax have been proposed, including congestion charging, tolling, and increases in income and sales taxes. Mileage fees, also commonly referred to as vehicle miles travelled (VMT) taxes, road user charges (RUCs), and mileage fees (MFs), are one of the most widely studied alternatives to the gas tax. These fees typically suggest charging vehicle users a per distance (i.e., mile) fee.

Before they can be implemented, mileage fees face some key challenges as a potential gas tax replacement. For one, public support for mileage fees is lacking. While there is widespread debate about the extent to which public opinion influences policy, it is generally believed that public support acts as a policy accelerant and is key to passing policies perceived to have large impacts on public welfare (*136*–*138*). The two main elements of mileage fees, being taxation and personal information, are directly tied to public welfare. Therefore, public support is integral to the success of state and federal mileage fee programs. In a review of 38 public opinion surveys ranging from 1995 to 2015, public support for mileage fees averaged 24%, with little variation across the years (*139*). Many survey respondents did not see a compelling reason to replace the gas tax and would favor raising the gas tax before implementing a mileage fee. More recent studies find greater variation in mileage fee support, ranging from 19% to 53% (*140*–*143*).

Public criticisms of mileage fees typically fall within three categories: cost, equity, and privacy. Most commonly, opponents of mileage fees believe that the per mile charge would create a disproportionate financial burden for low income and rural households (*139*, *141*). Extensive research on this topic unanimously shows that perceptions of mileage fee inequity are ungrounded. On average, mileage fees would result in lower tax burdens for rural and low-income households (*109*, *111*, *112*, *129*, *144*, *145*). Despite these findings, perceptions of inequity are still common (*140*, *143*).

Assuming a mileage fee replaces the gas tax, many raise questions about how their mileage information would be collected and who would have access to that information. There is widespread debate about the privacy of any mileage fee program utilizing GPS-enabled devices in personal vehicles (*139*). So far, mileage fee pilot programs have been effective at addressing and abating privacy concerns. To date, fourteen states have conducted mileage fee pilot studies where state residents self-select into the study, choose their preferred mileage collection method and payment scheme, and answer surveys throughout the duration of the pilot. In all reports, support for mileage fees increased from the pilot's start to finish (*103*, *106*, *121*, *146*, *147*). A few of these pilot programs have attempted to account for self-selection biases by inviting a random sample of participants and offering cash incentives. However, there is still minimal knowledge about support for mileage fees amongst those who do not choose to participate in pilot programs.

Surveys can capture a broader set of public opinions about policies, since they don't require the time and resource intensity of pilot programs. However, there are limitations in using policy surveys to gage public opinions about existing and proposed policies. For one, most opinion surveys of a general population tend to have a large number of respondents who are unfamiliar with the policy (*148*). Studies have shown that ill-informed respondents tend to answer more randomly than the well informed (*149*, *150*). Relying on traditional policy survey methods to inform public representatives and policy makers is unreliable.

To combat the unreliability of ill-informed policy opinions, some surveys have attempted to educate respondents with un-biased policy information throughout the survey. Through an iterative process of questioning, providing information, and allowing respondents to change their original opinion, studies have found that respondents declare significantly different opinions compared to traditional survey methods (*151*, *152*). These Information and Choice Questionnaires, or ICQs, have most commonly been used to study public opinion on greenhouse gas emission reduction strategies and other environmental topics (*148*, *153*, *154*). Their use is shown to yield more consistent, or stable, decision-making among respondents and limits the influence of respondent's political affiliations and political involvement on their policy opinions (*155*).

In this study, we employ an ICQ format to increase the reliability of the mileage fee opinion data we collect and to measure the influence of education on policy support. We hypothesize that most respondents are not well informed about how the gas tax functions or how a gas tax replacement, including a mileage fee program, would function. We also hypothesize that education may modify an individual's support for or against alternatives to the gas tax.

Using the ICQ format, we designed an experiment to test the effect of respondent education on support for gas tax alternatives and evaluated how differences in attitudes, travel behavior, socio-economic status, and community type affects the level of support modification. Respondents were sampled from populations in Northern New England to gauge public perception of the current fuels tax, a mileage fee alternative, and a flat fee alternative. The history, cost, equity, and privacy concerns of each tax alternative were addressed through quiz-style questions, concept checks, and an educational video.

Methods

We designed an internet-based survey to gather information about respondent's support for two revenue-neutral transportation funding schemes that could replace the gas tax: a flat fee and a mileage fee (Table 24). Each of these policies is currently being considered by the Vermont Department of Transportation as an alternative to the gas tax for electric and hybrid vehicle owners in Vermont (*121*). Our study expanded upon this vision to create hypothetical scenarios in which the gas tax is replaced by either a flat fee or a mileage fee for all vehicles.

Table 24. Charging Schemes for Transportation Funding Options

Transportation Funding Options	Policy Status	Charging Scheme
Gas Tax	Current	$ / gallon of fuel sold
Flat Fee	Alternative 1	$ / vehicle / year
Mileage Fee	Alternative 2	$ / mile travelled

Survey Implementation

We contracted with Qualtrics to recruit respondents for our survey using a quota-based sampling scheme from the three northern New England states of Vermont, New Hampshire, and Maine. These states have comparable climates, demographics, and community types. Responses were collected between May 6th and June 3rd of 2022. The data was screened to ensure at least 210 usable responses per state. The final data set contained 658 responses.

Survey Description

At the beginning of the survey questionnaire, respondents were asked a series of questions about their attitudes and beliefs. Respondents indicated their level of agreement with statements using a 5-point Likert scale. The questions ranged from topics of government, personal freedoms, technology, the environment and nature, and community awareness.
The next section of the questionnaire provided three opportunities for respondents to vote for or against each gas tax alternative. The effect of education was tested by providing educational activities in between subsequent voting opportunities. The voting opportunities were presented using a referendum format or voting ballot. Screenshots of the voting opportunities can be seen in Figure 34.

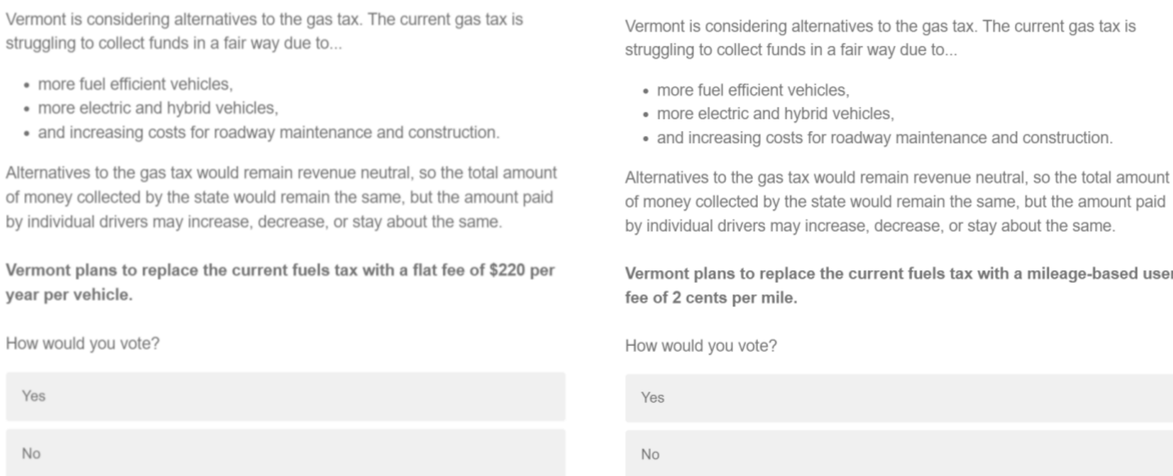

Figure 34. Sample Referendums: Vote 1, Vermont Survey

The first voting opportunity acted as a control, or baseline vote (Vote 1 in Figure 36). The first round of education used quiz-style questions to test respondents' knowledge of how the gas tax functioned in their state, followed by explanations of the correct responses (Gas Tax Education in Figure 36). Correct answers were reinforced using "concept checks" to make sure respondents were not selecting responses randomly and were paying attention to correct answers. Using self-reported primary vehicle information including vehicle type, fuel economy, and annual vehicle miles travelled, we then calculated personalized estimates of how much each respondent would pay annually if the gas tax remained the same, if it was replaced by a flat fee, and if it was replaced by a mileage fee. The alternative fees were calculated based on the average gas tax revenue, number of registered vehicles, and vehicle miles travelled from the Vermont, Maine, and New Hampshire Federal Highway Administration Highway Statistics reports (*125–128*). This resulted in a revenue-neutral flat fee of $220 per vehicle and a revenue-neutral mileage fee of $0.02 per mile travelled.

These personalized cost estimates were presented to respondents as a part of the second voting opportunity, where they were once again asked to vote for or against a flat fee and a mileage fee to replace the gas tax (Figure 35**,** Vote 2 in Figure 36). This second vote tested the impact of cost education on respondent policy opinions. Those who indicated they did not have access to a primary vehicle skipped the second vote, since we could not calculate cost estimates for them.

The last round of education discussed the equity implications of replacing the gas tax with a mileage fee or a flat fee and technological options for mileage collection under a mileage fee. This information was shown through a four-minute educational video developed for the purposes of this survey (Equity and Tech Education in Figure 36). Restrictions were enabled so respondents could not fast forward and could not advance in the survey until the video was completed. The video was followed by concept check questions reinforcing the education in the video. Then respondents were asked to consider all the information they'd learned throughout the survey before being presented with the final voting opportunity (Vote 3 in Figure 36).

Vermont is considering alternatives to the gas tax. The current gas tax is struggling to collect funds in a fair way due to...

- more fuel efficient vehicles,
- more electric and hybrid vehicles,
- and increasing costs for roadway maintenance and construction.

Alternatives to the gas tax would remain revenue neutral, so the total amount of money collected will remain the same.

Based on the information you provided about how much you drive and the vehicle you use, we estimate you currently pay $267 in gas taxes per year.

Vermont plans to replace the current gas tax with a flat fee of $220 per year per vehicle.

How would you vote?

Yes

No

Vermont is considering alternatives to the gas tax. The current gas tax is struggling to collect funds in a fair way due to...

- more fuel efficient vehicles,
- more electric and hybrid vehicles,
- and increasing costs for roadway maintenance and construction.

Alternatives to the gas tax would remain revenue neutral, so the total amount of money collected would remain the same.

Based on the information you provided about how much you drive and the vehicle you use, we estimate you currently pay $267 in gas taxes per year.

Vermont plans to replace the current fuels tax with a mileage-based user fee of 2 cents per mile. We estimate you would spend $ 245 in this fee per year.

How would you vote?

Yes

No

Figure 35. Sample Referendums: Vote 2, Vermont Survey

The next section of the questionnaire assessed respondent's survey experience and policy preferences beyond the "yes" and "no" votes. A series of 5-point Likert scale questions covering perceived fairness of mileage fees and preferences for the three ways of collecting mileage information described in the video (Closing Questions in Figure 36). We concluded the survey by collecting socio-demographic information including respondent age, household size, and annual household income (Demographics in Figure 36).

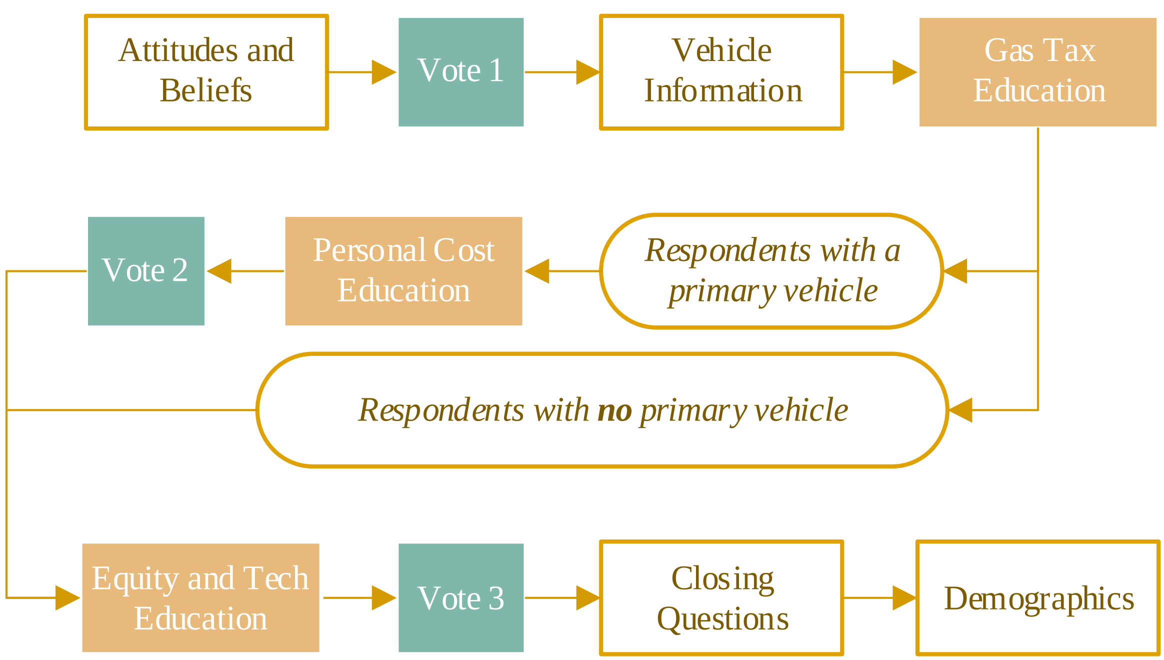

Figure 36. Survey Flow Chart

Respondent Demographic and Travel Behavior Characteristics

The socio-demographic information collected from respondents was summarized and compared to the population characteristics of Vermont, New Hampshire, and Maine to evaluate the representativeness of the sample (Table 25). State level population data was collected from the 2020 ACS 5-Year Survey.

Overall, the survey respondents were close representations of their state populations. Slightly underrepresented groups included those with educational achievements of a high school degree or less, those not in the labor force, those not identifying as Hispanic/Latino/Spanish, and households falling into the highest income bracket (more than $150,000 per year). Slightly oversampled populations included those who stopped education after receiving a bachelor's degree in college, the unemployed, those identifying as Hispanic/Latino/Spanish, and households with an income ranging from $35,000 to $49,999 per year. The extent to which populations were oversampled or under sampled was minimal, so it was deemed unnecessary to use weights in the following analysis.

The vehicle information collected from respondents was also summarized. Of the 658 usable responses, 89.9% indicated having access to a primary vehicle. Of those with a primary vehicle, most drove gasoline vehicles (86.6%), while the remaining drove non-plug-in gasoline hybrids (6.1%), diesel vehicles (3.4%), plug-in hybrids (2.4%), or fully electric vehicles (1.5%). Fuel economy ranged from 7.5 mpg to 35+ mpg, with a mean and median of 25.6 mpg. These fuel economies were gathered from respondents either through binned selection (i.e., Less than 10 mpg, 10-15 mpg, etc.) or assumed based on the vehicle type (i.e., average fuel economy and fuel type for a gasoline sedan, SUV, etc.). Annual vehicle miles travelled by respondents ranged from 2,000 to 35,000 miles with a mean and median of 11,422 and 12,500 miles respectively. These mileage estimates were also self-reported by respondents using range categories. Note that due to errors in self-reporting vehicle information, these fuel economy and VMT estimates may not be accurate. Rather, they provide a basis for comparison between respondents.

Table 25. Demographic Representation

Socio-Demographic Variable	Survey (Sample Data)		Study Area (Population Data)			
	Count	Percent	Vermont	New Hampshire	Maine	Average
TOTAL	658	100%	--	--	--	--
GENDER [1]						
Female	338	51.8%	50.6%	50.1%	51.0%	50.57%
Male	284	43.5%	29.4%	49.9%	49.0%	42.77%
Other	31	4.7%	--	--	--	--
EDUCATION [2]						
Less than high school degree	22	3.2%	7.5%	6.7%	6.8%	7.00%
High school graduate	145	22.0%	28.3%	27.3%	31.3%	28.97%
Some college but no degree	137	20.8%	16.7%	18.0%	19.2%	17.97%
Associate degree in college (2-year)	59	9.0%	8.8%	10.4%	10.2%	9.80%
Bachelor's degree in college (4-year)	182	27.7%	23.%	23.0%	20.3%	22.10%
More than a bachelor's degree in college	113	17.3%	16.1%	14.6%	12.2%	14.30%
EMPLOYMENT [3]						
Employed	408	62.0%	62.8%	64.6%	60.3%	62.57%
Unemployed	63	9.6%	2.5%	2.5%	2.5%	2.50%
Not in labor force	187	28.4%	34.6%	32.7%	37.0%	34.77%
RACE [1]						
White	602	91.4%	93.6%	92.8%	93.7%	93.37%
Black or African American	17	2.6%	1.3%	1.9%	1.4%	1.53%
Two or more races	13	2.0%	2.7%	1.8%	2.8%	2.43%
Asian or Asian American	12	1.8%	1.6%	3.1%	1.1%	1.93%
American Indian or Alaska Native	5	0.8%	0.3%	0.3%	0.7%	0.43%
Other	9	1.4%	0.5%	0.1%	0.3%	0.30%
ETHNICITY [1]						
Hispanic / Latino / Spanish	47	7.1%	2.0%	10.9%	1.7%	4.87%
Not Hispanic / Latino / Spanish	611	92.9%	98.0%	89.1%	98.3%	95.13%
INCOME [3]						
Less than $20,000	86	13.1%	13.8%	9.9%	15%	12.90%
$20,000 to $34,999	84	12.8%	13.2%	10.9%	14.2%	12.77%
$35,000 to $49,999	101	15.3%	12.3%	10.2%	13.1%	11.87%
$50,000 to $74,999	111	16.9%	18.3%	17.1%	18.5%	17.97%
$75,000 to $99,999	94	14.3%	13.9%	14.1%	13.8%	13.93%
$100,000 to $149,999	126	19.1%	16.4%	18.9%	15.0%	16.77%
More than $150,000	56	8.5%	12.1%	18.9%	10.4%	13.80%

[1] Study area (population data) sourced from Census Table DPO5: ACS Demographics and Housing Estimates
[2] Study area (population data) sourced from Census Table DP02: Selected Social Characteristics
[3] Study area (population data) sourced from Census Table DPO3: Selected Economic Characteristics

Community Type Analysis

Using respondent-reported zip codes, a community type indicator was developed to understand differences in policy opinion between urban and rural areas. We used the United States Department of Agriculture Rural-Urban Commuting Area (RUCA) codes. These codes were developed using population density, level of urbanization, and daily commuting measures from the 2010 U.S. decennial census and 2006-10 American Community Survey (ACS). RUCA codes are available at the census tract level (*156*).

Zip code shape files were spatially joined with census tract shape files containing their RUCA codes. Many zip codes boundaries intersected multiple census tracts. In cases where a zip code intersected census tracts with differing RUCA codes, the census tract containing the largest percentage of the zip code land area was used to assign a RUCA code. We then aggregated the 10 primary RUCA codes into three categories (area core, high-commuting, and rural) to reduce the number of categories for regression analysis (Table 26).

Table 26. RUCA Code Descriptions

RUCA Code	Description	Aggregated RUCA Codes
1	Metropolitan area core: primary flow within urbanized area	Area core
2	Metropolitan area high commuting: primary flow 30% or more to a UA	High commuting
3	Metropolitan area low commuting: primary flow 10% to 30% to a UA	Rural
4	Micropolitan area core: primary flow within an urban cluster of 10,000 to 49,999 (large UC)	Area core
5	Micropolitan area high commuting: primary flow 30% or more to a large UC	High commuting
6	Micropolitan area low commuting: primary flow 10% to 30% to a large UC	Rural
7	Small town core: primary flow within an urban cluster of 2,500 to 9,999 (UC)	Area core
8	Small town high commuting: primary flow 30% or more to a UC	High commuting
9	Small town low commuting: primary flow 10% to 30% to a UC	Rural
10	Rural areas: primary flow to a tract outside a UA or UC	Rural

Regression Modelling

Three modeling approaches were used to study the intertwined relationships between respondent characteristics, policy support, and our educational treatments. Since we were unable to calculate gas tax and gas tax alternative costs for non-vehicle owners, we were unable to test the effect of cost education for these respondents. Therefore, the following models only used the 590 responses from vehicle owners.

We begin our analysis with a logistic fixed-effect model to examine the extent to which the educational treatments can explain and are associated with the shifts in policy support across the survey. Logistic fixed-effect models, also known as conditional logistic models, are used to evaluate the effect of a treatment in panel data while controlling for unobserved individual level factors that do not vary over the study period (*157*). In this survey experiment, we have responses to three consecutive voting opportunities after different education treatments, and the fixed effects are the individual respondents whose characteristics are assumed to be constant between voting opportunities. The equation is as follows.

$$y_{it} = \beta x_{it} + \alpha_{it} + u_{it}$$

Where $i = 1, \ldots, N$ with N being the total number of survey respondents, $t = 1, \ldots, T$ where T is the total number of voting opportunities, α_{it} are respondent-specific intercepts that capture the heterogeneity across each individual respondents' votes, and u_{it} are the normally distributed error terms. The predictor variable, y_{it}, is a binary variable equivalent to 1 if a respondent voted "Yes" and equivalent to 0 if a respondent voted "No". The explanatory variable, x_{it}, is a binary indicator variable with levels for each voting opportunity. A level of x_{it} is equivalent to 1 if the respondent is at that voting opportunity and equivalent to 0 if the respondent is not at that voting opportunity. For example, if the first respondent voted "Yes" at Vote 2, $y_{1,Vote\ 2} = 1$, $x_{1,Vote\ 1} = 0$, $x_{1,Vote\ 2} = 1$ and $x_{1,Vote\ 3} = 0$.

We then examined the association between respondent characteristics and their first impression of alternatives to the gas tax using a binomial logistic regression. This analysis was followed up by multinomial logistic regression models to examine the association between respondent characteristics and changes in policy support pre and post educational treatments. The predictor variable levels were defined as those who maintained the same vote after an educational treatment (Yes:Yes, No:No), those who increased support after an educational treatment (No:Yes), and those who decreased support after an educational treatment (Yes:No). Those who maintained the same vote after an educational treatment were used as the reference group.

In each of the binomial and multinomial logistic regression models, we included variables describing respondent demographics (*age, gender, level of education, current employment status, race, ethnicity, household size, number of children, and income*), community type (*area core, high-commuting, and rural*), and respondent attitudes and beliefs (*views on technology, the environment/climate, vehicles, privacy, and the role of government*. Community type and income were interacted to account for differences across income levels within each community type. These models also included a variable for whether a respondent is expected to face a higher or lower tax burden under each alternative taxing scheme based on the information they provided in the survey.

Imputation

Of the 590 vehicle owners in our data, 583 completed every survey question. The remaining 7 responses contained missing values for between three and six questions. Missing values can lead to biased model interpretation if the data is missing for a reason. In an ideal scenario, missing data can be called "missing completely at random", or MCAR, indicating the missingness is not systematic and will not contribute to biased inferences. Using Little's (1988) chi-square test, the data was confirmed to be MCAR.

We chose to impute these missing values to use all possible survey responses in our model. Missing values in columns with numerical data were replaced with the mean of the column. Missing values in columns with categorical data were replaced at random in proportion to the number of observations within each category. This preserved the distribution of the data in each column.

Categorical Combinations

Categorical variables with over four response options were aggregated into more succinct categories to reduce the number of variables for regression. The educational achievement factor was simplified to those who went to high school, those who went to college (no degree), and those who received a higher education degree (including associate degrees). Annual household income ranges were aggregated to low (less than $50,000), medium ($50,000 to $74,999), and high (more than $75,000) income variables. The medium income category was chosen based on the mean household income from Vermont, New Hampshire, and Maine 2020 ACS 5-Year Estimates.

Factor Analysis

Respondents provided responses to 15 questions about various attitudes and beliefs using a 5-point Likert scale. Common factor analysis with the primary axis method (a maximum likelihood approach) in the R psych package was used to create a reduced number of variables that capture a latent and broader set of attitudes and beliefs held by respondents. A parallel analysis scree plot was used to identify the number of factors and an orthogonal (varimax) rotation was used to develop final factor loadings. Factor scores were estimated for each respondent using the Thurston method (a regression approach) in the R psych package and used in our regression modeling.

The final factors were given meaningful names using the questions with factor loadings greater than 0.4. The final categories for factors one through three were, in order, “Level of Altruism”, “Resistance to Change” and “Vehicle Dependence”. A correlation matrix was used to examine issues of multicollinearity between all numerical variables in the final data set, including these three attitudinal factors. All covariances were less than 0.30. Therefore, we determined there were no issues of multicollinearity.

Table 27. Factor Analysis

	Statement of Attitudes / Beliefs	F1	F2	F3
Q1_1	*Taxes are an irreplaceable form of funding for state and federal programs.*	0.40		
Q2_2	*Sometimes the government needs to pass laws to help protect vulnerable populations.*	0.51		
Q1_3	*I trust my state government.*	0.46		
Q1_4	*I would prefer less government involvement in my life.*		0.54	
Q1_5	*Funding for state programs is mismanaged.*		0.54	
Q1_6	*Environmental threats such as global warming and deforestation have been exaggerated.*		0.52	
Q1_7	*I frequently think about how my choices will impact my community.*	0.63		
Q1_8	*Vehicle emissions in my state have a large impact on air quality.*	0.60		
Q1_9	*I frequently think about whether my travel choices have an impact on the environment.*	0.69		
Q1_10	*Driving a car is good for society.*			0.66
Q1_11	*My lifestyle is dependent on having a car.*			0.73
Q1_12	*Owning a vehicle provides me with freedom.*			
Q1_13	*Technology does more harm than good.*		0.57	
Q1_14	*I'm tracked everywhere I go through my phone.*			
Q1_15	*Technology has made life too complicated.*		0.54	

Results

We used a combination of basic summary statistics and regression models to evaluate if education can shift policy support for gas tax alternatives, what respondent characteristics are associated with greater support for gas tax alternatives, and what respondent characteristics are associated with greater likelihood of changing policy support.

Summary Statistics

The "Gas Tax Education" section contained four questions quiz-questions about each state's gas tax. The first question asked about how the gas tax was charged. In Maine and New Hampshire, the gas tax is a price per gallon of fuel sold. Vermont's gas tax is also a price per gallon of fuel sold, with an additional fee when the previous week's gas prices average greater than $4/gallon. Findings showed that most survey respondents believed the gas tax was a sales tax (function of the *price* of gas sold) rather than an excise tax (function of the *quantity* of gas sold). Overall, 55% of respondents could not correctly identify how the gas tax was charged in their state.

The second gas tax question asked about tax increases. The gas tax was last increased between 8 and 12 years ago in all three surveyed states. Only 20% of respondents correctly identified the four-year time frame in which the gas tax was last increased in their state, while nearly half the survey respondents believed the gas tax had been increased very recently (in just the last few years). The last two questions asked about what gas tax revenue is allowed to fund. Less than half the respondents correctly identified that gas tax revenue can only be used in transportation related projects. One third of respondents incorrectly believed gas tax revenue could be spent on any state government program. After a “concept check” style question, which gave a specific example of a state project and asked if gas tax revenues would be allowed to fund that project, there was nearly a 40% increase in correct responses.

Table 28. Gas Tax Knowledge

Gas Tax Concept	Maine	New Hampshire	Vermont	Survey Average
Knew how the gas tax was charged in their state	46.8%	39.5%	45.9%	44.1%
Knew when the gas tax was last increased in their state	19.3%	27.3%	11.8%	19.5%
Believed the gas tax had been increased 1-3 years ago	41.7%	54.1%	53.6%	49.80%
Knew what the gas tax is spent on in their state	44.0%	40.9%	45.0%	43.3%
Believed gas tax revenues can be spent on any state government program.	30.7%	37.3%	36.4%	34.8%
Correctly identified what the gas tax was spent on in their state after education	71.6%	76.4%	71.8%	73.3%
Concept check effectiveness: increase in correct responses	+40.9%	+39.1%	+35.4%	38.5%

Mileage Fee Summary Questions

At the beginning of the survey, respondents were asked how comfortable they felt with their location information (also known as mobility data) being collected by the following systems or groups: vehicle navigation systems, the state government, the federal government, private companies like Google or Facebook, and mobile applications like weather or fitness apps (Figure 37). This question provides insight into how vehicle owners may prefer to have their mileage information collected.

Survey respondents were most concerned about private companies collecting their location information, as well as governing bodies. Concern with vehicle navigation systems and mobile apps collecting location information was more evenly split across respondents. There was minimal variation in responses by state.

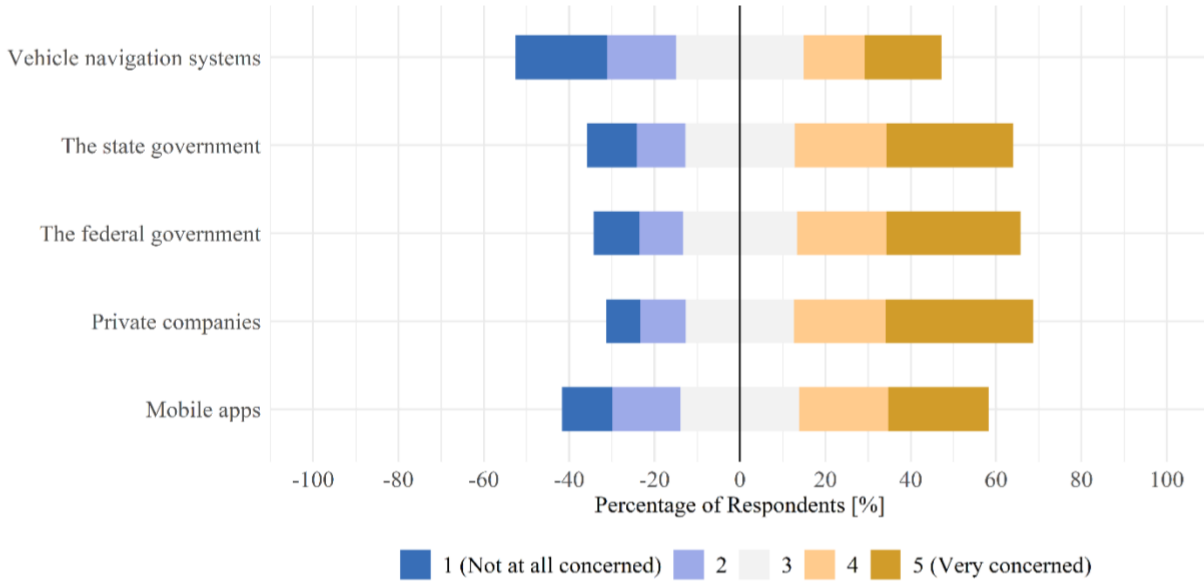

Figure 37. Attitudes towards Location Information Collection by Various Systems and Groups

The equity and technical education section of the survey contained a four-minute video discussing, amongst other things, the pros and cons of three main mileage-collection technologies: odometer readings, ID tags, and on-board devices (Figure 38). Periodically recording a vehicle's odometer provides a manual method for collecting mileage information from vehicle owners without any location tracking. ID tags contain information about a vehicle's average fuel economy and provide information to estimate vehicle miles travelled based on the amount of fuel purchased at the pump. They offer an at-the-pump option for mileage fee payment that does not track location. On-board devices are installed or placed in a vehicle to track miles travelled with either non-GPS or GPS technology. They have more capabilities, such as only charging a state mileage fee for miles travelled in the state borders. When asked to rank their support for each mileage-collection technology, respondents preferred options that collect less data from the user, like odometer readings. There was stronger opposition for on-board devices, which collect more data from the user.

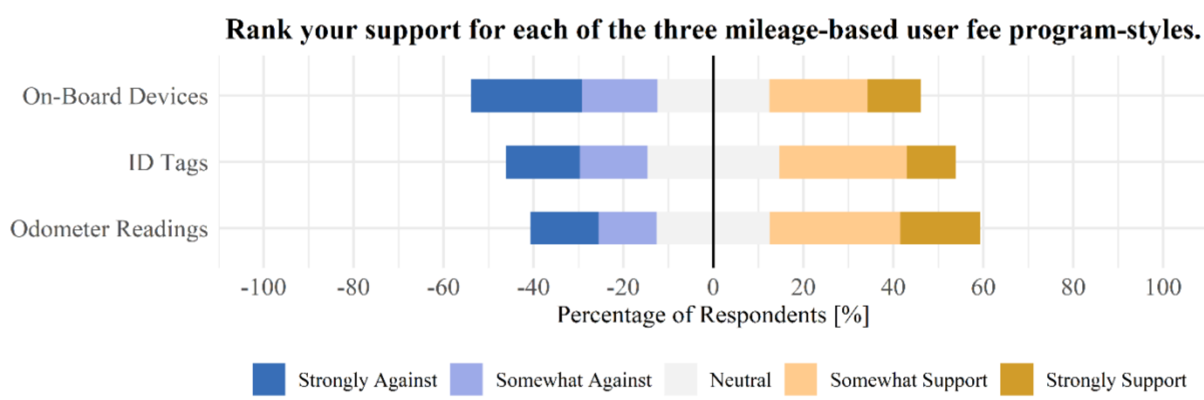

Figure 38. Attitudes Towards Mileage-Collection Technologies

At the end of the survey, respondents were asked to reflect on their opinions about the two proposed alternatives to the gas tax: a flat fee and a mileage fee (Figure 39). Most respondents indicated that a policy's ability to meet future funding needs, the cost of the alternative policy, and their perceived privacy concerns were all important. Of the three, the cost difference (the difference between current tax payments and those expected from alterative policies) was the most important.

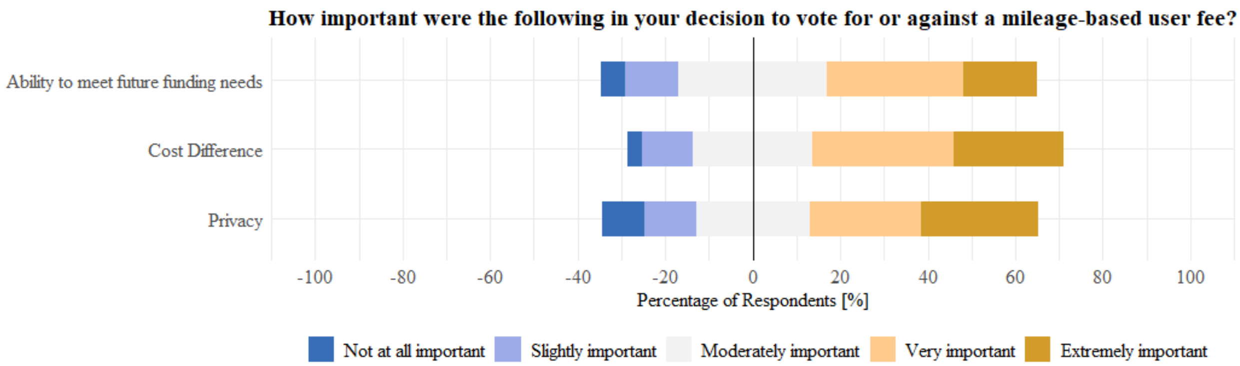

Figure 39. Perceived Importance of Privacy, Cost, and Future Funding when Voting

Respondents were also asked how fair they felt a mileage fee would be for different communities and income groups (Figure 40). Most respondents felt mileage fees would be less fair to rural and low-income populations, and more fair to urban and high-income populations. However, even respondents from rural and low income communities tended to agree that a mileage fee would be fair for themselves, as individuals, as well as others in their state.

Between the first voting opportunity and the third voting opportunity, respondent support for mileage fees increased by 11% and support for flat fees decreased by 4%. While most survey respondents showed a propensity for adhering to their original vote (Vote 1), approximately one-third of respondents changed their vote between the first and last voting opportunity (Figure 41 and Figure 42). We evaluate the effect of education in changing policy support in the next section.

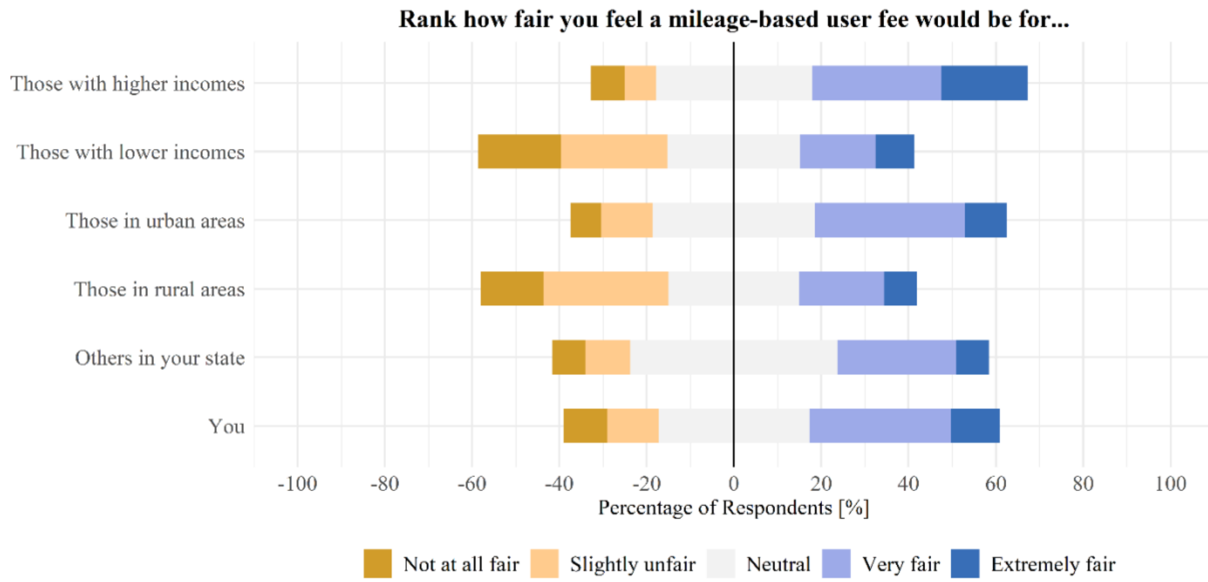

Figure 40. Perception of Fairness Varying with Income and Community Type

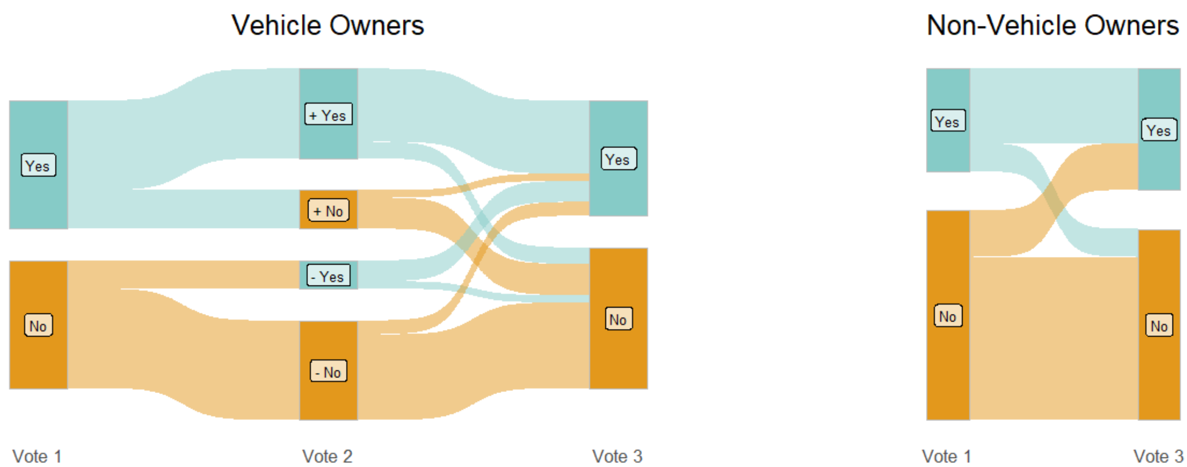

Figure 41. Voting Patterns for Flat Fees

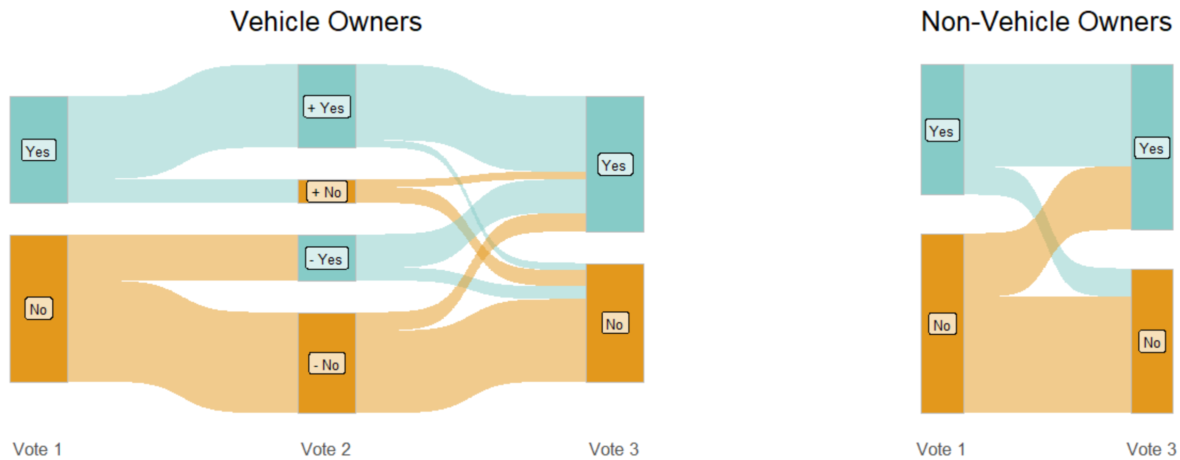

Figure 42. Voting Patterns for Mileage Fees

Educational Effects (Table 29)

Here we assess the extent to which our educational treatments are associated with the observed shifts in policy support. Recall that Vote 1 was the control vote at the beginning of the survey. Vote 2 was after the cost education treatment, where respondents were presented with personalized cost estimates for the current gas tax and each alternative policy based on their self-reported vehicle information. Vote 3, the final vote, was after the equity and tech educational treatment, where respondents could reflect on an educational video including a discussion of transportation taxation equity and the various mileage-collection options for a mileage fee.

The model fit is sufficient for testing the associations between voting change and educational treatments, but rather low if the purpose were to reliably predict voting outcomes. Each educational treatment in the logistic fixed-effect models is statistically significant at the 95% confidence level.

The model suggests that support for mileage fees increases as a respondent advanced through the survey education and voting opportunities while support for flat fees decreases. Respondents in our study were nearly twice as likely to support a mileage fee when provided with a personalized estimate of how much they would pay in comparison to the gas tax (cost education). After receiving both the cost and equity and tech educational treatments, respondents were nearly 2.5 times as likely to support a mileage fee. On the other hand, when respondents learn how much a flat fee will cost them relative to the gas tax, they were 25% less likely to support a flat fee. Support for a flat fee became even less likely after watching the equity and technology video.

Table 29. Effect of Increasing Levels of Education Controlling for Individual Fixed Effects

Predictors	Mileage Fees			Flat Fees		
	Odds Ratios	*std. Error*	*p*	*Odds Ratios*	*std. Error*	*p*
Vote 2	**3.10**	**0.66**	**<0.001**	**0.60**	**0.12**	**0.012**
Vote 3	**4.27**	**0.93**	**<0.001**	**0.53**	**0.11**	**0.002**
$N_{Respondent}$*	222			223		
R^2_{adj} **	0.142			0.096		

* Number of respondents who changed their vote at some point across the survey
** R^2_{adj} = 1 – [(Residual Deviance – K) / (Null Deviance)] where K is the number of additional parameters relative to the null model (*135*)

Overall, the results suggest that the information and education provided in our survey increases support for mileage fees and decreases support for flat fees while controlling for respondent fixed effects. Next, we evaluate how respondent characteristics, attitudes and beliefs affect support.

Personal Characteristics Associated with Initial Policy Support

Binary logistic regression models were used to examine the factors influencing respondent voting preferences in their initial vote. The models predict the likelihood of a respondent voting "Yes" to a gas tax alternative. Odds ratios greater than one signify factors associated with policy support (a "Yes" vote), while odds ratios less than one signify factors associated with policy opposition (a "No" vote). Significance was evaluated at the 90% confidence level (α = 0.10). What follows is a discussion of the significant variables in each model, which are highlighted in bold text in Table 30**.**

The models captured 20% of the variation in respondent's original flat fee vote and 22% of the variation in respondent's original mileage fee vote. Support for a flat fee to replace the gas tax was less likely amongst female-identifying respondents and those living outside of urban areas, while support more likely amongst respondents with more children. Support for mileage fees was more likely amongst Hispanic, Latino, or Spanish respondents as well as those who completed higher education such as a bachelors, masters, or PhD programs. Those who aligned more strongly with vehicle-dependent attitudes were less likely to support the mileage fee, along with those who believed a mileage fee would be disproportionately unfair to rural and low-income populations. Notably, the expected cost savings of a mileage fee was not a statistically significant variable in support during the first vote. Respondents who felt they'd save money with a flat fee, whose cost was displayed and known to respondents due to its constant nature, were nearly twice as likely to support the policy in the first vote.

In general, support for either alternative to the gas tax was more likely amongst those who valued their privacy and those who thought more about their community (level of altruism). Support for either alternative to the gas tax was less likely amongst those who believed the ability to secure future funding for transportation systems was important.

Personal Characteristics Associated with Changes in Policy Support After Education

Multinomial logistic regression models were used to examine the factors influencing changes in respondent voting after the educational treatments provided in our survey. The models predict the likelihood of a respondent changing their vote from “No” to “Yes” (No : Yes) or “Yes” to “No” (Yes : No) compared to the likelihood of a respondent keeping the same vote (Yes : Yes or No : No). In simpler terms, the models evaluate what personal characteristics are associated with responsiveness to educational treatments.

Cost Education (Vote 1 to Vote 2)

After comparing estimated annual costs under their state gas tax, a $220 flat fee, and a $0.02 per mile travelled fee (mileage fee), respondents were given an opportunity to change their vote. Our models was able to predict between 10% and 12% of the variation in respondent voting changes.

Respondents who originally voted “No” to replace the gas tax with a $220 flat fee were more likely to maintain their opposition to the flat fee if they had higher levels of altruism or were younger. Those with higher vehicle mileage, however, were nearly five times as likely to switch their vote to a “Yes”. Females, respondents who had only completed some high school education, and those living in high commuting areas were also more likely to increase their support for the flat fee after learning about the expected costs of each policy. Respondents who originally voted “Yes” to a flat fee were more likely to maintain their support if they learned they would save money with the flat fee. Respondents were more likely to decrease their support after cost education if they had more children.

Respondents who originally voted “No” to replace the gas tax with a $0.02 per mile travelled fee (mileage fee) were more likely to maintain their opposition if they felt privacy was important and mileage fees were unfair to those in rural communities. Respondents who originally voted “Yes” to the mileage fee were more likely to maintain their support if they learned they would save money with a mileage fee. Respondents were more than seven times to switch from a “Yes” to a “No if cost was an important factor in their decision making. Notably, the importance of cost was not a statistically significant factor in switching from “No” to “Yes”.

Full Education (Vote 1 to Vote 3)

After receiving both the cost education and watching the video about mileage fee collection options and transportation funding equity, respondents were given one last chance to change their vote. This section describes the models used to assess the factors associated with how a respondent voted in the first vote compared to how they voted in the last vote. The models were able to explain between 8% and 12% of the variation in voting changes.

Respondents who originally voted “No” to replace the gas tax with a $220 flat fee were approximately twice as likely to support the policy at the end of the survey if they identified as female, had stopped institutionalized education after some high school, and believed mileage fees were unfair to low-income populations. Respondents who had higher vehicle mileage than average were nearly four times as likely to support the flat fee, indicating they were likely saving money compared to their estimated gas tax costs. Respondents that aligned more with altruistic thoughts were more likely to maintain their opposition to flat fees across the educational experiences. Respondents who originally voted “Yes” to the flat fee were more likely to vote “No” at the end of the survey if they had more children and were more likely to maintain their support if they were Hispanic, Latino, or Spanish, if they believed that future funding for transportation systems is important, and if they learned they would save money with a flat fee.

For respondents who originally voted “No” to a mileage fee, those with lower incomes were nearly twice as likely to maintain their opposition, as well as the unemployed, those who completed a higher education and those with higher annual mileage. Respondents who originally voted “Yes” to a mileage fee were significantly more likely to switch to a “No” if they had higher vehicle mileage and aligned more with altruistic thoughts.

Equity and Tech Education after Cost Education (Vote 2 to Vote 3)

After receiving both the cost education and watching the video about mileage fee collection options and transportation funding equity, respondents were given one last chance to change their vote. This section describes the model used to assess the factors associated with how a respondent voted after the cost education (Vote 2) compared to how they voted after the full education (Vote 3). The models were able to explain between 7% and 8% of the variation in voting changes.

Respondents who voted “No” to a flat fee after learning how much it cost them were more likely to vote “Yes” on the final vote if they believed a mileage fee was unfair to low income respondents and were more likely to maintain their opposition if they aligned with vehicle dependent attitudes. Respondents who voted “Yes” to a flat fee after learning how much it cost them were twice as likely to switch to a “No” if they lived in a rural area. This is likely a response to respondents being shown a variety of studies talking about equity across community types in the educational video.

Respondents who voted “No” to a mileage fee after learning how much it cost them were more likely to vote “Yes” on the final vote if they had aligned with more altruistic thoughts and were twice as likely to vote “Yes” on the final vote if they lived in a rural area. Again, this is likely a response to the focus on transportation funding equity across community types discussed in the educational video, as most studies have shown that, on average, residents of rural areas would be more likely to save money every year if the gas tax was replaced by a mileage fee. Respondents who voted “Yes” to a mileage fee after learning how much it cost them were nearly three times as likely to vote “No” on the last vote if they lived in a high commuting area but were significantly more likely to maintain their support if they owned an electric or hybrid vehicle.

Table 30. Factors Affecting Vehicle Owners Control Vote for Alternatives to the Gas Tax

	Flat Fees		Mileage Fees	
Predictors	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*
(Intercept)	3.19	2.41	**4.96****	**3.88**
SOCIO-DEMOGRAPHICS				
Income (standardized)	1.30	0.52	0.73	0.31
Reference: Employed				
Retired	1.47	0.49	1.25	0.44
Unemployed	0.84	0.24	1.28	0.37
Reference: White				
Hispanic/Latino/Spanish	1.10	0.44	**2.37****	**0.96**
Other Race	1.17	0.43	1.15	0.41
Reference: Male				
Female	**0.66****	**0.14**	0.84	0.18
Other Gender	0.52	0.23	0.59	0.27
Reference: Some college education				
Completed higher education	1.05	0.27	**1.87****	**0.51**
Some High school	0.87	0.25	1.16	0.36
Age [yrs]	0.99	0.01	1.00	0.01
Children	**1.36*****	**0.14**	**1.18***	**0.12**
Household Size	0.94	0.12	0.82	0.11
ATTITUDES				
Level of Altruism	**1.79*****	**0.21**	**1.65*****	**0.20**
Resistance to Change	0.91	0.10	0.88	0.10
Vehicle Dependence	0.90	0.10	**0.81***	**0.09**
Reference: Neutral or fair opinion				
Believe MF is unfair for rural	0.90	0.08	**0.81****	**0.07**
Believe MF is unfair to low income	0.90	0.08	**0.73*****	**0.07**
Reference: Not important				
Future funding is important	**0.82****	**0.07**	**0.77*****	**0.07**
Privacy is important	**1.31*****	**0.13**	**1.20***	**0.12**
Cost is important	0.88	0.08	1.01	0.10
COMMUNITY AND TRAVEL				
Annual Vehicle Miles Travelled (standardized)	1.24	0.74	1.36	0.58
Reference: Does not drive electric/hybrid vehicle				
Drives electric/hybrid vehicle	1.84	1.00	1.65	0.86
Reference: Urban Core				
High Commuting	**0.66***	**0.15**	1.07	0.26
Rural	**0.66***	**0.15**	0.81	0.19
COST				
Reference: Losing money with the policy				
Saving money with the policy	**1.62***	**0.47**	0.99	0.23
Observations	590		590	
R^2 Tjur	0.204		0.221	

* p-value less than 0.10, ** p-value less than 0.05, *** p-value less than 0.01

Table 31. Impact of Cost Education on Support for Gas Tax Alternatives, Vote 1 to Vote 2

	Flat Fees				Mileage Fees			
	No:Yes		*Yes:No*		*No:Yes*		*Yes:No*	
Predictors	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*
(Intercept)	0.19	0.23	0.76	0.74	1.28	1.17	**0.22****	**0.16**
SOCIO-DEMOGRAPHICS								
Income (standardized)	**0.07*****	**0.06**	**0.28****	**0.17**	0.44	0.23	1.33	0.74
Reference: Employed								
Retired	0.79	0.49	1.67	0.71	0.81	0.33	1.24	0.55
Unemployed	0.74	0.28	1.08	0.41	0.75	0.24	0.18	0.19
Reference: White								
Hispanic/Latino/Spanish	0.78	0.48	**0.23***	**0.18**	0.42	0.24	0.94	0.50
Other Race	1.35	0.68	0.69	0.33	0.84	0.38	1.12	0.38
Reference: Male								
Female	**1.91***	**0.65**	0.69	0.19	**1.70****	**0.43**	1.32	0.95
Other Gender	1.96	1.33	1.20	0.63	1.98	1.02	1.24	0.54
Reference: Some college education								
Completed higher education	1.28	0.54	0.89	0.30	0.64	0.19	0.90	0.45
Some High school	**2.04***	**0.89**	1.14	0.42	0.88	0.29	0.99	0.01
Age [yrs]	**0.98****	**0.01**	0.99	0.01	1.00	0.01	0.84	0.15
Children	0.93	0.15	**1.41*****	**0.18**	0.94	0.12	1.23	0.25
Household Size	1.00	0.20	1.14	0.18	**1.31***	**0.19**	1.15	0.22
ATTITUDES								
Level of Altruism	**0.68****	**0.11**	1.08	0.16	0.91	0.12	1.05	0.19
Resistance to Change	1.06	0.18	0.82	0.12	0.94	0.12	0.89	0.15
Vehicle Dependence	1.05	0.18	0.86	0.12	1.02	0.14	0.83	0.13
Reference: Neutral or fair opinion								
Believe MF is unfair for rural	0.89	0.13	0.90	0.11	**0.78****	**0.09**	0.98	0.14
Believe MF is unfair to low income	1.15	0.16	1.05	0.12	1.00	0.11	**0.67*****	**0.09**

	Flat Fees				Mileage Fees			
	No:Yes		*Yes:No*		*No:Yes*		*Yes:No*	
Predictors	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*
Reference: Not important								
Future funding is important	0.96	0.13	**0.81****	**0.09**	1.00	0.10	0.94	0.15
Privacy is important	0.88	0.13	1.09	0.14	**0.81***	**0.09**	1.04	0.17
Cost is important	1.13	0.18	1.06	0.14	0.92	0.11	**7.04*****	**4.14**
COMMUNITY AND TRAVEL								
Annual Vehicle Miles Travelled (standardized)	**4.65***	**3.73**	1.65	1.38	0.40	0.23	2.48	1.56
Reference: Does not drive electric/hybrid vehicle								
Drives electric/hybrid vehicle	0.94	1.05	0.56	0.39	0.77	0.62	0.92	0.35
Reference: Urban Core								
High Commuting	**1.88***	**0.67**	1.03	0.30	1.40	0.40	0.82	0.32
Rural	1.22	0.44	**0.57***	**0.18**	1.09	0.30	**0.28****	**0.14**
COST								
Reference: Losing money with the policy								
Saving money with the policy	1.77	0.76	**0.41****	**0.17**	1.40	0.36	**0.28****	**0.14**
Observations	590				590			
R^2 Tjur	0.128 / 0.126				0.104 / 0.102			

* p-value less than 0.10, ** p-value less than 0.05, *** p-value less than 0.01

Table 32. Impact of Full Education on Support for Gas Tax Alternatives, Vote 1 to Vote 3

	Flat Fees				**Mileage Fees**			
	No:Yes		*Yes:No*		*No:Yes*		*Yes:No*	
Predictors	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*
(Intercept)	**0.06****	**0.07**	0.43	0.39	0.79	0.69	0.20	0.24
SOCIO-DEMOGRAPHICS								
Income (standardized)	0.40	0.25	0.46	0.24	**0.43***	**0.22**	0.46	0.32
Reference: Employed								
Retired	0.81	0.43	1.23	0.48	0.78	0.30	1.26	0.71
Unemployed	0.98	0.34	1.08	0.40	**0.58***	**0.18**	1.15	0.52
Reference: White								
Hispanic/Latino/Spanish	0.57	0.34	**0.33***	**0.21**	**0.27****	**0.17**	0.29	0.23
Other Race	0.97	0.47	0.80	0.37	1.32	0.52	0.92	0.49
Reference: Male								
Female	**2.32*****	**0.72**	0.92	0.23	**2.10*****	**0.52**	1.02	0.35
Other Gender	1.65	1.08	1.65	0.80	**2.31***	**1.16**	2.22	1.36
Reference: Some college education								
Completed higher education	1.46	0.58	1.24	0.40	**0.61***	**0.18**	0.83	0.36
Some High school	**2.94*****	**1.21**	1.23	0.46	1.02	0.33	0.94	0.46
Age [yrs]	**0.98***	**0.01**	1.01	0.01	1.00	0.01	1.00	0.01
Children	0.79	0.13	**1.43*****	**0.17**	0.83	0.11	0.99	0.16
Household Size	1.00	0.18	1.20	0.18	1.11	0.16	1.06	0.22
ATTITUDES								
Level of Altruism	**0.78***	**0.12**	1.16	0.17	1.14	0.15	**1.39***	**0.26**
Resistance to Change	1.07	0.17	**0.80***	**0.11**	1.01	0.13	1.20	0.21
Vehicle Dependence	0.97	0.15	0.97	0.13	0.97	0.13	0.76	0.13
Reference: Neutral or fair opinion								
Believe MF is unfair for rural	0.89	0.12	0.94	0.11	0.89	0.10	0.96	0.15
Believe MF is unfair to low income	**1.29***	**0.17**	0.98	0.11	1.00	0.11	0.91	0.13

	Flat Fees				**Mileage Fees**			
	No:Yes		*Yes:No*		*No:Yes*		*Yes:No*	
Predictors	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*
Reference: Not important								
Future funding is important	0.89	0.11	**0.84***	**0.08**	1.08	0.11	0.89	0.12
Privacy is important	1.14	0.15	1.06	0.13	0.93	0.10	1.07	0.17
Cost is important	1.05	0.15	0.89	0.11	0.88	0.10	1.08	0.18
COMMUNITY AND TRAVEL								
Annual Vehicle Miles Travelled (standardized)	**3.92***	**2.89**	1.14	0.94	**0.33****	**0.19**	**3.13***	**1.88**
Reference: Does not drive electric/hybrid vehicle								
Drives electric/hybrid vehicle	0.44	0.49	0.35	0.24	0.54	0.43	0.93	0.66
Reference: Urban Core								
High Commuting	1.63	0.53	0.99	0.28	1.18	0.33	1.21	0.43
Rural	1.18	0.39	0.86	0.24	1.08	0.28	0.53	0.22
COST								
Reference: Losing money with the policy								
Saving money with the policy	1.40	0.55	**0.36****	**0.14**	1.07	0.27	0.51	0.22
Observations	590				590			
R^2 Tjur	0.120 / 0.118				0.083 / 0.081			

* p-value less than 0.10, ** p-value less than 0.05, *** p-value less than 0.01

Table 33. Impact of Equity Education on Support for Gas Tax Alternatives, Vote 2 to Vote 3

	Flat Fees				Mileage Fees			
	No:Yes		*Yes:No*		*No:Yes*		*Yes:No*	
Predictors	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*
(Intercept)	**0.04*** **	**0.04**	**0.14***	**0.16**	0.19	0.22	**0.05****	**0.06**
SOCIO-DEMOGRAPHICS								
Income (standardized)	1.36	0.93	0.74	0.48	0.57	0.37	1.08	0.75
Reference: Employed								
Retired	1.03	0.66	0.97	0.51	1.48	0.74	1.64	0.98
Unemployed	1.27	0.53	1.05	0.48	0.59	0.26	0.88	0.43
Reference: White								
Hispanic/Latino/Spanish	0.81	0.55	1.49	0.89	0.22	0.23	0.76	0.52
Other Race	1.50	0.78	**2.40***	**1.18**	1.84	0.85	1.12	0.67
Reference: Male								
Female	1.46	0.53	1.41	0.47	1.68	0.55	0.91	0.33
Other Gender	1.31	0.93	2.52	1.50	2.02	1.28	2.59	1.57
Reference: Some college education								
Completed higher education	1.02	0.46	1.28	0.51	1.30	0.54	1.08	0.50
Some High school	1.61	0.76	0.76	0.38	1.81	0.83	1.55	0.78
Age [yrs]	0.98	0.01	1.01	0.01	0.99	0.01	1.00	0.01
Children	0.91	0.16	1.18	0.17	0.93	0.16	**1.33***	**0.21**
Household Size	1.01	0.21	1.14	0.23	0.82	0.17	0.95	0.21
ATTITUDES								
Level of Altruism	1.16	0.22	1.24	0.23	**1.44****	**0.26**	1.22	0.23
Resistance to Change	1.12	0.21	0.93	0.16	1.18	0.20	1.24	0.22
Vehicle Dependence	**0.75***	**0.13**	1.01	0.18	1.09	0.19	1.00	0.20
Reference: Neutral or fair opinion								
Believe MF is unfair for rural	0.87	0.13	0.94	0.14	1.13	0.17	1.05	0.17
Believe MF is unfair to low income	**1.51****	**0.24**	1.06	0.15	1.06	0.15	0.99	0.15

	Flat Fees				Mileage Fees			
	No:Yes		*Yes:No*		*No:Yes*		*Yes:No*	
Predictors	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*	*Odds Ratios*	*St. Error*
Reference: Not important								
Future funding is important	0.81	0.12	0.91	0.12	0.83	0.10	0.98	0.14
Privacy is important	1.24	0.20	0.86	0.13	0.98	0.14	0.89	0.14
Cost is important	1.04	0.18	0.80	0.12	0.89	0.13	1.01	0.17
COMMUNITY AND TRAVEL								
Annual Vehicle Miles Travelled (standardized)	1.92	1.79	1.32	1.31	2.16	1.29	1.63	1.16
Reference: Does not drive electric/hybrid vehicle								
Drives electric/hybrid vehicle	0.96	0.80	0.67	0.55	0.66	0.53	**0.01***	**0.000**
Reference: Urban Core								
High Commuting	1.28	0.50	1.25	0.49	1.41	0.51	**2.63**	**1.02**
Rural	1.37	0.53	**2.01**	**0.70**	**1.95**	**0.66**	1.71	0.71
COST								
Reference: Losing money with the policy								
Saving money with the policy	0.74	0.36	0.55	0.27	0.64	0.24	1.60	0.56
Observations	590				590			
R^2 Tjur	0.071 / 0.068				0.077 / 0.075			

* p-value less than 0.10, ** p-value less than 0.05, *** p-value less than 0.01

Respondent Comments and Concerns

At the end of the survey, respondents were given an opportunity to share their final thoughts in an open-ended response format. Most respondents who provided comments expressed appreciation for the opportunity to take the survey and mentioned having learned something. A few respondents said they planned to actively learn more about mileage fees and the gas tax. Overall, neutral or positive remarks encompassed approximately 70% of the comments.

The remaining respondents took the opportunity to share critical opinions on mileage fees. This included those who shared equity concerns, saying "Mileage-based user fees are skewed to hurt those dependent on cars to work and live", or "Unfair to those of us who want to live in the woods!".

Additional commentary reiterated the significance of respondent attitudes and beliefs. Comments like, "I do not want my behavior and locations monitored by the state!!!" and "No matter what or how a tax is devised, you can bet that the State will not or ever use the money for what it was intended" suggests government distrust may play a factor in policy opinions.

Others raised personal concerns, such as, "The main reason I oppose mileage-based fees because it can make travel/road-trips very expensive" and "I would vote yes to the flat fee because in that option I know exactly what I would pay, and it doesn't change. I drive a fair amount so it would be fair to me, but I know that option would not be fair to people that don't drive that much. But I like the certainty of knowing what the amount would be."

Finally, some shared concern about the environmental sustainability of a mileage fee program. Comments echoed opinions like, "The fuel economy of cars should still be taken into consideration", or "Those with fuel efficient cars are rewarded by having to pay for less gas."

Conclusions

Our findings demonstrate that most people in our study area know little about their state's gas tax. Most respondents believe the gas tax is a function of the price of gas, rather than a price per gallon. Additionally, most respondents believe the gas tax has increased in the last few years. These two fundamental misunderstandings likely play a large role in public perception of proposed gas tax increases and transportation funding alternatives. Developing methods to better assess the impact of this knowledge gap is vital to implementing more sustainable and reliable transportation funding schemes and academic pursuits alike.

Our voting opportunities confirm what previous studies have found: that mileage fee support is statistically significantly influenced by perceptions of mileage fee privacy, equity, and costs. However, our simple educational format geared towards myth busting misconceptions about the gas tax and policy alternatives reveals a promising opportunity to increase support for gas tax alternatives. We find that the education in our survey more than triples and may even quadruple a person's likelihood of supporting mileage fees. The findings suggest that when respondents learn more about mileage fee studies that have focused on equity across community types, residents in rural areas are nearly twice as likely to begin supporting the policy. Therefore, educational campaigns may be able to alleviate the equity concerns surrounding mileage fees, lowering an important implementation barrier. Future research should, however, explore how long the effects of information and educational campaigns last.

Our findings also highlight the importance of attitudes and beliefs. We find that a persons' level of altruism, defined in this study as concern for the environment and their community, is associated with increased support for alternatives to the gas tax. Simply put, our study suggests more altruistic individuals may be more likely to support policy changes, while individuals with more resistance to change are less likely to support policy changes. This suggests there are also practical limits to the amount of policy support that can be modified through relatively simple education campaigns. The education and information we provided addressed common knowledge gaps. It is possible that individual attitudes and beliefs are much more deeply held and formed through many life experiences and are thus more challenging to change. These findings also reinforce the importance of considering attitudes and beliefs in travel behavior and policy research (*158*–*161*).

Beyond evaluating the effect of education on policy support, our research sheds additional light on preferences for mileage fee program implementation. For one, respondents in our study preferred less sophisticated mileage collection options. Odometer readings had the strongest support out of the three options considered. However, while opposition to other mileage-collection options like on-board devices was common, it was not notably strong. There may be potential, with continued educational efforts, to shift public opinion in support of more robust data collection options.

Furthermore, the impact of cost on policy support cannot be understated; the respondents in our study were much more likely to support the policy that saves them money. While our study suggests that perceptions of equity for low-income communities may not be easily changed by simple educational efforts, providing personalized cost estimates may be a way to gain support from these communities. After all, the importance of cost for a respondent was much stronger amongst those who opposed the policy than amongst those who supported the policy, suggesting that if someone who opposes the policy learns they will save money, they will be more likely to support it. Alternatively, if they learn they will be spending more money, this may reinforce their loss aversion and deeper entrench their beliefs. That being said, prior research has found that rural and low-income households would typically save money under a mileage fee (*109*, *111*, *112*, *129*, *144*, *145*). Personalized cost estimates can be estimated and provided to households using state Department of Motor Vehicles records (*120*) or through additional surveys. Alternatively, cost profiles can be created and advertised based on unique factors such as community type, income level, average VMT, and other factors to help the public understand the expected financial impacts of a gas tax alternative for themselves and their community.

Overall, we find that responding to common public concerns with up-to-date and non-biased information with a relatively simple educational experience caused substantial changes in policy support. In sensitive policy situations, including in the case of mileage fees, public support is an essential ingredient to policy change and implementation. By ensuring policy opinions are gathered from informed respondents, we can provide more reliable information about policy support and the factors influencing support to policymakers and the research community.

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Data Summary

Products of Research

Three original datasets were created by this research project:

- Coded responses to interviews with Vermonters as described in Chapter 3;
- Cleaned and anonymous responses to our 2022 survey of Vermont household asking about how the responded to increases in gas prices as described in Chapter 5;
- Cleaned and anonymous responses to our New England mileage fee survey as described in Chapter 7.

Data Format and Content

All data are provided as tabular text files in CSV format. The meta data available on Dryad where these data can be accessed contains a complete description of how data were collected and the definition of each data element.

Data Access and Sharing

The data collected and used in this project can be accessed for free on Dryad using the following DOI links:

- Interviews, Comparing Travel Behavior and Opportunities to Increase Transportation Sustainability in Small Cities, Towns, and Rural Communities – https://doi.org/10.5061/dryad.b5mkkwhjv
- Vermont 2022 Household Gasoline Price Response Survey – https://doi.org/10.5061/dryad.3r2280gnp
- New England Mileage Fee Survey – https://doi.org/10.5061/dryad.vt4b8gtz8

Reuse and Redistribution

The data have a creative commons zero license (https://creativecommons.org/publicdomain/zero/1.0/). This is indicated in Dryad. There are no re-use restrictions.