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A Survey of North American Electric Bicycle Owners

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by

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Abstract

Rapid recent growth in the popularity of electric bicycles (e-bikes) has captured the attention of transportation researchers and policymakers seeking safe, sustainable, and active alternatives to conventional transportation modes. This thesis presents an investigation of e-bike owners in North America, complementing previous efforts in 2013 and 2017, and suggests implications for North American transportation planning.

An online survey was distributed to e-bike owners in the United States and Canada through email outreach, purchase incentive programs, and social media. The survey included questions on the respondents' demographics, e-bikes, purchase decisions, travel behavior, perceptions of e-bikes, crash experience, maintenance needs, and receipt of purchase incentives.

Owners generally have a positive impression of e-bikes and their benefits. The market continues to be dominated by white, male, and affluent riders, but there is a higher share of women than in previous years. Young and old respondents have taken on the technology for differing reasons: transportation and recreation, respectively. There is some indication that the e-bike market is exiting the early adopter phase; however, the demographic profiles of e-bike riders still differ heavily from the general population. E-bikes are used primarily for utilitarian trips. Their proven ability to offset vehicle miles traveled supports investment in incentives and infrastructure from governments of all levels pursuing climate, health, and transportation equity goals. In particular, targeted initiatives aimed at addressing specific demographic segments and geographical contexts may foster more equitable

uptake. Riders expressed a desire to ride their e-bikes more often, and for dedicated infrastructure and secure parking facilities. Few households with children allowed them to ride e-bikes. Respondents demonstrated a general misunderstanding of their e-bikes' class and capabilities. Improper disposal of e-bike batteries does not seem to be a major concern.

Dedication

To Kate.

May our shared future be filled with joy, adventure, and bicycles.

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Table of Contents

List of Tables

List of Figures

Preface

Positionality Statement

Cameron Bennett is a master's student at an urban university with a predominantly white student body and faculty. He is a lifelong resident of the Pacific Northwest, having grown up in the Portland metropolitan area and lived in Corvallis, Oregon and Boise, Idaho. Cameron is able-bodied and regularly rides bicycles, both electric and non-electric. Cycling is his primary form of transportation, and he lives and works in an urban area that is conducive to cycling due to its built form, supportive infrastructure, and accepting culture.

His upbringing included strong support for engineering and public health, instilled by his parents working in those respective fields. Coming from a college-educated middle-class background, he has had access to cycling equipment and education throughout his life.

Cameron presents and identifies as cis, straight, white, and male. He does not have any children, live in a harsh climate, present or identify as a woman or racial/ethnic minority, or experience any of the other typical barriers to accessing or participating in cycling. He has not – to date – been the victim of severe vehicular violence while riding a bicycle.

In light of the realities of climate change, the dynamics of induced demand, and the pursuit of a safe systems approach to Vision Zero goals, Cameron understands that cycling *must* be a core part of our shared transportation future.

Cameron's research and education have been funded in part by grants from the United States Department of Transportation and PeopleForBikes.

1 Introduction

1.1 Potential of Electric Bicycles in North America

Electric bicycles (e-bikes) are a low-emission mode of transportation that offers communities benefits in public health, transportation planning, cost, street safety, traffic congestion, air pollution, noise pollution, and energy security (Benoît et al., 2011). E-bikes enable more people to ride a bicycle for longer distances despite physical limitations, difficult terrain, and the presence of cargo (MacArthur et al., 2018). In the most recent U.S. National Household Travel Survey (NHTS), completed in 2022, 28% of trips made in single-occupancy vehicles (SOVs) were two miles or shorter, while 52% of trips were five miles or shorter (Federal Highway Administration, 2024). These trip distances are within 8- and 20-minute travel ranges for an e-bike, assuming an average speed of 15 miles per hour (mph). Initial studies on mode substitution by e-bikes indicate that they have a strong potential to replace vehicle trips (Bigazzi & Wong, 2020). E-bikes have long proven their ability to play a central role in the transportation system in China, Europe, and elsewhere (Fishman & Cherry, 2016). Additionally, e-bikes provide a more accessible and cost-effective option than other alternatives to private vehicles. Due to the addition of pedal assistance or a throttle from an electric motor, e-bikes are more accessible for a wider range of demographics and use cases than conventional “acoustic” bicycles because range, cargo capacity, and accessible terrain are all increased. The purchase price for e-bikes is typically less than 10% than that of an electric vehicle, and operation and infrastructure costs are minimal compared to private vehicles or transit. Therefore, e-bikes provide a promising

pathway for legislators to address their transportation-sector emissions, mode share, and vehicle miles traveled (VMT) reduction goals, as well as pursue goals related to physical activity, transportation equity, and livability.

1.2 E-Bike Purchase Incentives

North American metropolitan areas of all sizes have established climate or transportation plans that set objectives for cycling mode shares far above current levels, typically in excess of 5% of trips (ACEEE, 2021). Because these goals require mode replacement – rather than fuel replacement as in the case of electric vehicles – cycling must be seen as an attractive alternative to driving for many trips. In order to accomplish this, a high rate of e-bike adoption is likely necessary due to their increased ability to travel longer distances under various use cases. In the context of mode share and VMT reduction goals, optimistic North American policymakers would likely consider the market for utilitarian e-bikes to have considerable room for growth. To meet environmental and operational objectives and increase the number of people cycling, how can e-bikes be shifted out of the early adopter phase? A core group of early users has been established in North America; bridging the chasm of e-bike's technological adoption curve is the next major challenge in the market (Bennett et al., 2022; Moore, 1991). Provision of safe "all ages and abilities" infrastructure, as well as knowledge and acceptance of e-bikes as a form of transportation, provide hurdles to adoption. However, for many consumers, purchase price provides a very significant barrier to entering the market for a relatively unfamiliar product (Dill & Rose, 2012; Popovich et al., 2014).

A March 2022 survey of major e-bike brands and models found an average price of around $2,600 (n=50, median=$2,400) for commuter and leisure e-bike models, and $5,000 (n=10, median=$4,500) for cargo e-bike models (Bennett et al., 2022). A survey of self-selected e-bike owners in North America found that, on average, an e-bike costs $2,600 to purchase (MacArthur et al., 2018). For comparison, a mountain bike has an average wholesale cost of $620 in the U.S. (Bicycle Retailer and Industry News, 2018). A conventional bicycle purchased at a specialty store costs $753, on average, in the U.S., and a conventional bicycle purchased at a department, discount, or chain toy store costs $89, on average (National Bicycle Dealers Association, 2015). Clearly, a price disparity exists.

The European Cycling Federation suggests that e-bike incentive programs are an effective part of the solution to overcoming the price barrier to e-bike ownership (Haubold, 2017). These programs provide recipients with financial incentives to purchase an e-bike, usually through point-of-purchase discounts, post-purchase rebates, or tax incentives (Bennett et al., 2022). Recent polling in Britain indicates that a rebate of 25% of the purchase price may be enough to convince half of people to strongly consider purchasing an e-bike (BikeIsBest, 2022).

1.3 Research Objectives

The purpose of this master's thesis is to re-assess the state of e-bike ownership in the North American context. A survey was designed and distributed widely to e-bike owners in the United States and Canada. Respondents were asked a wide range of questions, including information on their e-bike, considerations around their purchase decision, incentives, their

use of the e-bike and perceptions thereof, safety, their previous cycling experience, their demographics, service needs, and battery disposal.

Knowledge of the rules and regulations pertaining to e-bikes have come under increasing scrutiny over the past few years while many states, municipalities, and land managers have introduced restrictions on their use. A number of questions were included that provide a background on attributes of interest to policymakers, including owners' knowledge of their e-bikes' class, whether e-bikes are in use by minors, rates of helmet usage, and whether owners have driver's licenses.

The effects of e-bike purchase incentives are also considered. In particular, this paper seeks to identify whether e-bike purchase incentives encourage inframarginal purchases, whether recipients exhibit different demographics or use patterns from those who purchased their bikes independently, and whether these incentive programs help to convert people with differing perceptions of e-bikes to adopting the technology.

The survey was modeled to reflect previous surveys completed by the Transportation Research and Education Center (TREC) at Portland State University (PSU) in 2013 (MacArthur et al., 2014) and 2017 (MacArthur et al., 2018). Using the results from these previous studies, this thesis infers some temporal trends in e-bike adoption and use over the last decade. Additionally, this most recent data point allows an assessment of the effects of the recent "bike boom" on the purchase and use of e-bikes.

2 Background

2.1 E-Bike Adoption

E-bike ownership in North America has increased drastically over the past five years. Insight to the exact sales numbers is limited due to the share of the market held by direct-to-consumer (DTC) sales, online independent bicycle dealers, and third-party online sales. Limited estimations of the market's growth and total value is possible through figures from Independent Bicycle Dealers and Rest of Market sales (sporting goods specialty, mass market, and online), which are thought to represent roughly one- to two-thirds of all units sold in the United States. Per market data provided by PeopleForBikes, it's thought that the "bike boom" associated with the COVID-19 pandemic ushered over one-and-a-half million new e-bikes into U.S. homes between January 2021 and May 2023, for a likely total of over 2.5 million owned nationwide (Circana, 2023; Johnson et al., 2023). It's estimated that more e-bikes units were sold in the U.S. than electric vehicles in 2021 (Boudway, 2022). A graph of estimated annual e-bike sales for 2015 through March 2023 is shown in Figure 1.

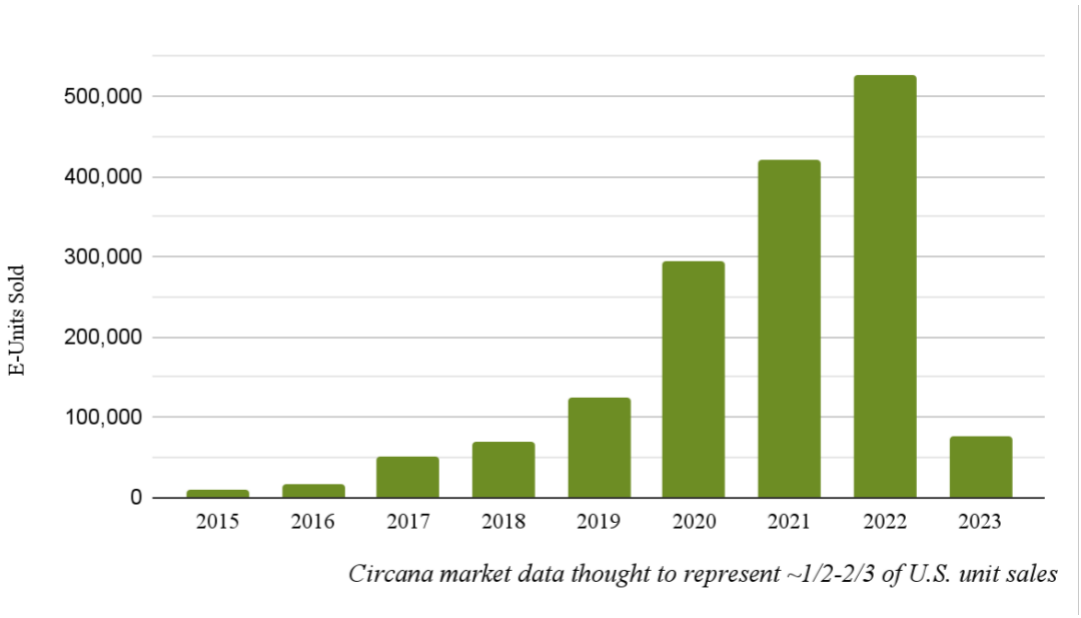

Figure 1. Annual U.S. E-Bike Unit Sales, 2015 through March 2023 (Circana, 2023)

As reported in the aforementioned market data, e-bikes sold in the U.S. as of March 2023 are roughly broken into 31% transit/fitness, 13% mountain bike, 11% leisure/lifestyle, 3% road, and 43% other styles.

In North America, e-bikes are regulated on the state or province level, with a range of policies regarding their attributes and use. Generally, laws regulating e-bikes use a three-class system (PeopleForBikes, 2024). Under this system, e-bikes are classified based on their maximum assisted speed and the presence or absence of a throttle that engages the motor without the user pedaling. Class 1 e-bikes have a maximum assisted speed of 20 mph and are pedal-assist only, Class 2 e-bikes have a maximum assisted speed of 20 mph and have a throttle, and Class 3 e-bikes have a maximum assisted speed of 28 mph and are pedal-assist only. Generally, all three classes are subject to a maximum power output of

750 watts (1 horsepower). All but ten U.S. states currently use this three-class system to regulate e-bikes' use, typically including provisions on whether an e-bike is regulated as a bicycle, motorcycle, or otherwise, the maximum allowable power output, and helmet, age, and licensure requirements.

In the past decade, there has been increasing interest in incorporating e-bikes and other forms of electric micromobility into the transportation engineering and planning environment. Most often, this has come in the form of relaxed regulations on the use of public space by micromobility vendors like scooter and bikeshare companies, the evolution of design guidance to provide passing space in bike lanes (NACTO, 2023) – sometimes rebranded as "mobility lanes" – and the introduction of incentivization programs to encourage the uptake of e-bikes, in particular (Bennett et al., 2022).

Despite the recent fervor surrounding e-bikes in North America, the adoption rate of the novel transportation mode lags well behind that of other parts of the world – China and Western Europe in particular. As a result, scholarship investigating the effects of e-bike adoption is focused largely outside of the United States and Canada (Bourne et al., 2020; Fishman & Cherry, 2016). The design and regulation of e-bikes varies across the globe. Notably, most e-bikes in China have throttles and are often modified to have no pedals by the retailer or consumer (Fishman & Cherry, 2016). As a result, scholarship regarding the adoption, use, and perceptions of e-bikes in China may not be directly applicable to the present study.

2.2 E-Bike Owner Surveys – Demographics, Usage, Adoption, etc.

Despite the increase in ownership in recent years, a full picture of the impacts of e-bike ownership in the North American context has not yet come into view. A number of studies have been conducted on e-bike owners in Europe, and to a lesser extent in North America and Australasia – only 17% and 3%, respectively in a 2020 review study (Bourne et al., 2020). In general, privately-owned e-bikes have been found to increase the frequency and duration of cycling as compared to non-powered bicycles (Fyhri & Beate Sundfør, 2020; Söderberg F.K.A. Andersson et al., 2021; Sundfør et al., 2024). They are also used primarily for utilitarian trips, with recreational trips typically being longer distances and a higher share of total trips among older adults. E-bike trips often replace private vehicle trips, although the rate at which they do depends on the riders' preferred travel mode prior to e-bike adoption, the purpose of their e-bike trips, and their geographic location, with significantly higher rates of auto substitution outside of China (Bigazzi & Wong, 2020; Bourne et al., 2020). E-bikes help riders overcome typical barriers to cycling (Rérat, 2021), and to provide older adults with the opportunity to continue cycling later into life (Kachadoorian, 2023). Cargo e-bikes, in particular, fill a gap in the urban transportation picture by allowing young adults with children to avoid car use for everyday trips (Bissel & Becker, 2024; Marincek et al., 2023; Thomas, 2021).

E-bike travel information is often collected using self-reporting. GPS tracking, odometer measurements, and travel logs are used to a lesser extent (Bourne et al., 2020). Some app-based approaches, including Strava, may allow for effective trip-based recording of GPS

data that is not subject to over-reporting in the same ways as self-reported trip logs (Fitch et al., 2022).

Recruiting of survey participants in e-bike studies is achieved through a variety of means. Typically, survey participants are self-selected, with researchers employing snowball sampling techniques and performing direct outreach to cyclist communities (Dill & Rose, 2012; MacArthur et al., 2018; Thomas, 2021). Solicitation through formal e-bike promotion programs is also common and will be discussed further in the following section.

The most applicable previous work to this study is the previous editions of the same survey by researchers at Portland State University (MacArthur et al., 2014, 2018). These surveys provided snapshots of the population of e-bike owners in 2013 and 2017. Questionnaires for these surveys were more limited in scope than the one conducted for this thesis but represented the key concerns regarding e-bike ownership in North America at the time. Many of these concerns are still salient today and are included in this study: travel patterns, motivations and barriers, demographics, and the ways that different groups engage with the technology. A limited comparison with these prior studies is included in the Results section of this thesis.

Key takeaways from these prior studies included the following. E-bikes enable existing cyclists to increase the amount they bike and provide opportunities for people to bicycle that wouldn't have otherwise due to physical limitations or proximity to destinations. While only 15% and 29% of respondents were women in the respective surveys, shares of women, older adults, and people with physical limitations were significantly higher than the general

cycling population. Generally, younger participants were more motivated to adopt e-bikes as a car-replacing mode of travel, while older adults were more motivated by the technology's health and accessibility benefits as a fitness tool. Respondents generally felt safer on an e-bike than on a conventional bicycle, and frequently reported that their e-bike had helped them avoid a crash. There was a conversion in cycling frequency among adopters that did not previously ride a bicycle as an adult; 94% now ride weekly or daily. Of those who rode an e-bike as an adult, weekly or daily riding rates increased from 59% to 91% after purchasing an e-bike. Nearly half (45.6%) of reported trips substituted vehicle trips, a quarter (27.3%) substituted active transportation and transit, and a quarter (25.3%) were newly induced and would not have otherwise happened.

Further discussion of the results from the previous study is included in the Results section of this report. This survey being the third such study in a 10-year period provides a unique opportunity to assess the changing landscape of e-bike ownership in North America.

2.3 Survey of E-Bike Incentive Recipients

In parallel with increased e-bike adoption rates over the last decade, North American municipalities have begun to recognize their potential benefits as a transportation mode and incentivized their purchase and use through a variety of mechanisms. Chief among them are purchase incentives, which provide some portion of the cost of an e-bike to a constituent, customer, or employee, most often as a post-purchase rebate, a point-of-purchase discount, or a tax waiver or credit. In the U.S. and Canada, these financial incentives have emerged as a popular technique; more than 165 active, lapsed, or proposed

programs have been identified to date (Bennett & MacArthur, 2023). Other forms of incentive for e-bike adoption exist, including low-interest loans, ride-to-own schemes, free e-bikes, shared e-bikes and lending libraries, temporary e-bike loans with purchase options, ridden mileage reimbursement (pay-to-ride) programs, and employer-sponsored programs. While these approaches may have high rates of efficacy – especially e-bikes loans (Bliss, 2021), and especially when a purchase option is available (Fitch et al., 2022) – they have not been extensively studied and were not considered in the design of this survey.

There has been a limited attempt to model the effect of various parameters of e-bike incentive programs' economic efficiency in the North American context (Bigazzi & Berjisian, 2021; Jones et al., 2024) and elsewhere (Anderson & Hong, 2022; de Kruijf et al., 2018; Moser et al., 2018). Inframarginal participation rates for e-bike incentives have not been well-researched to date. The share of incentive recipients that would not have otherwise purchased an e-bike ranges widely in the literature, with estimates at 64% (Anderson & Hong, 2022), 29% (Bigazzi & Berjisian, 2021), and 14-18% (Jones et al., 2024), varying widely due to differences in program structure and incentive amount.

The study of e-bike incentive recipients themselves is fairly limited, and a comparison of their demographics, use, and perceptions in comparison to the greater population of e-bike owners is relatively nonexistent. Most incentive programs are funded to address goals in carbon emissions reduction and transportation equity; it's important to understand whether the people receiving incentive funds are furthering those goals in a meaningful way, and thus whether their target audience needs to be narrowed or whether public funds could

more effectively encourage and enable transportation cycling and e-bike uptake in other ways.

The only formal scholarship performed on e-bike incentive recipients in North America to-date was completed by researchers at the University of California, Davis investigating the outcomes of three Northern California incentive programs (Johnson et al., 2023). Incentive recipients from The Redwood Coast Energy Authority (RCEA), Peninsula Clean Energy (PCE), and Contra Costa County (CCC) rebate programs were found to be 60% male, 46% over 55 years old, 70% white, and 46% with household income over $100,000. The most common reported benefits were that e-bikes were a good alternative to a car, that they were good for recreation, that they could travel longer distances, and that they took less effort than a regular bike. Fear of vandalism and theft was the most-reported barrier to riding e-bikes. While three-quarters (78%) of respondents listed their car or motorcycles as their primary mode, 14% of them listed their e-bike, and 1.2% listed their non-electric bike. There was a modest increase in the percentage of recipients that reported riding a bicycle daily, and a 20% bump to 50% in those that reported riding 1-3 times per week. Over 40% reported replacing one or more car trips a week with their e-bike. Younger and lower-income respondents exhibited higher rates of car trip replacement. Over half (56%) of reported trips were recreational. Half (51%) of respondents reported riding 50 miles or less per month.

An assessment was also completed on an employer-based e-bike loan and purchase incentivization program that was started at Google in Mountain View and Sunnyvale,

California in 2015 (Fitch et al., 2022). A long-term increase in bike commutes of 1.3-1.9 days per week over rates before the e-bike loan program was observed among program participants. Recipients used Strava – a fitness tracking mobile application – and self-reporting forms to track their commute trips. Strava users generally recorded fewer commutes, indicating potential over-reporting from self-reported participants to satisfy the program requirement of use of the loaned e-bike for commuting. Notably, conventional bikes were even more successful in offsetting SOV commutes than e-bikes, but the authors note that e-bikes may still be a necessary component for the program to broaden its applicability to a wider range of participants.

Another employer-based e-bike lending program at a hospital in Portland, Oregon showed a substantial increase in bike use and increase in cycling confidence (MacArthur et al., 2017). The program took place at three large employment campuses – two suburban and one urban – and reported trip data was recorded on one mid-program survey and one after program survey. While the narratives developed from this case study provide meaningful insight to the experiences of e-bike riders, the sample size of 150 complete survey series was relatively small to draw meaningful conclusions on behavior change, and three-quarters of participants had been bike commuters in the past, a notably different rate compared to the general population.

An in-depth review of the incentive program administered by the City and County of Denver was produced in early 2023 by the City and County of Denver, PeopleForBikes, Bicycle Colorado, Ride Report, and the Rocky Mountain Institute. Income qualified

residents were found to be using their e-bikes nearly 50% more than standard voucher recipients. Two-thirds (65%) of recipients were using their e-bikes daily, and 90% were doing so at least weekly. The average trip length was 3.3 miles, with 84% of trips being less than 5 miles (Seaward et al., 2022).

In the course of coordinating with North American e-bike incentive program managers for survey distribution, results have been collected from programs' internal surveys and reporting. The sample sizes for these surveys are generally small, and the figures provided here lack academic and statistical rigor. Nonetheless, they provide valuable insight to typical effects and outcomes of e-bike incentive programs.

A year after receiving an incentive, 335 participants of the 511 Contra Costa program reported average trip distances of 10.4 miles, and median trip distances of 8.0 miles. Half (51%) of trips substituted a car, truck, or motorcycle, a quarter (25%) would not have been made without the e-bike, and 10% substituted walking trips. Over half (53%) of respondents indicated that they believed that they had influenced somebody they knew to buy an e-bike. Average reported annual mileage was 990 miles, and the median annual mileage was 605 miles.

Of the 327 eligible applicants to the GO Santa Cruz program, 31% were low-income, defined in this case as participating in a low-income program in the State of California. Interestingly, low-income applicants passed through the required education course and purchased an e-bike at a higher rate than non-income-qualified applicants, with 39% of purchased bikes going to low-income applicants. Over half (53%) stated that they would

still have bought an e-bike without the program's assistance. Most (70%) indicated that their errand-running habits had changed to include more e-bike trips, and 75% indicated the same for their commute trips.

Of the 272 e-bike applications submitted for the Nova Scotia incentive program, 219 were approved. 131 rebates were applied for by individuals, three by an organization, and 85 applications were received from retailers who offered the rebate at point of sale. The average age of the participants was 55 years old. The average price of e-bikes subsidized was $2,419 CAD ($1,800 USD).

The 108 applicants for the Devou Good Foundation program for the Cincinnati, OH region were predominantly white (84%), male (64%), younger than 40 (63%), and did not have a physical limitation (92%). Three quarters (74%) commuted to work using a private vehicle before owning an e-bike.

The Sonoma Clean Power program in California received 107 responses to a follow-up survey with its recipients. Under half (41%) reported riding their e-bike weekly or daily. Most (81%) reported using their e-bikes for fun, recreation, or exercise, while two-thirds (67%) reported using their bikes for utilitarian purposes. Two-thirds (67%) indicated that they use their car less than before. Less than half (43%) believe that they replace 25 or more vehicle miles per month with their e-bike.

A willingness-to-pay analysis performed in preparation for the Corvallis, OR program was completed by 52 people and found that people with incomes less than 80% of the area median income were typically willing to pay around 40% of the cost of an e-bike, and that

70% were interested in a personal loan. Six recipients from the program completed a three-month follow-up survey and were evenly split between exercise and car replacement in their usage of the e-bike. The average reported trip distance was 4.8 miles. Half of respondents listed fears of theft as a barrier to using their e-bike more.

Of 40 respondents to a survey conducted by the Banff, AB program, three quarters (78%) indicated that the e-bike they purchased with the Town rebate was their first e-bike. Only one-quarter (28%) indicated that they would have bought an e-bike even without the rebate. Nearly all respondents (93%) reported that they used their bike for errands, two-thirds (66%) for commuting, and over three-quarters (80%) for recreational reasons. Respondents' primary reasons for use were evenly split between commuting (37%), recreation (36%), and running errands (25%). Over one third (35%) plan to use their e-bike in the winter. All respondents owned a motor vehicle.

The seven surveyed participants of the Fort Collins, CO incentive program indicated that trip tracking was a challenge for them under the requirements of their program, that concerns about theft had kept them from riding more, and that they felt they might have wanted more education before receiving their e-bike.

3 Methods

To address the need to understand e-bike adoption and use in the North American context, an e-bike owner survey akin to those conducted by Portland State University in 2013 and 2017 was designed and administered. The steps to design and administer the survey and to clean, validate, and analyze responses received are described in this section. Consideration of the limitations associated with this experimental design is included in the Discussion section.

3.1 Survey Instrument Design

A survey instrument was designed to assess the state of e-bike ownership and usage in the United States and Canada. Questions were included to address the following themes:

- E-bike information (make, model, type, class, etc.)
- Purchase decision and process (price, reasons for purchase, etc.)
    - Purchase incentives
- Travel and perceptions
- Safety
- Previous cycling experience
- Demographics
- Optional section (service, battery disposal, etc.)

A full reproduction of the survey instrument can be found in Appendix A.

The basis for survey development was the most recent previous edition of this survey from Portland State University. Further questions were generated through the review of recent e-bike owner surveys conducted on smaller scales by academic colleagues at the University of British Columbia and the University of California, Davis, and to address the specific research interests of the research team. Among these specific interests were the introduction of questions relating to the receipt of purchase incentives, e-bike class, and battery replacement.

The introduction of a large number of e-bike incentive programs in the U.S. and Canada has potentially made the technology more accessible to a wider range of people. Questions regarding incentives allows this survey to assess whether incentives were an important purchase choice factor for those who received them, and whether the incentives attract a demographically different group from the general marketplace for e-bikes. In addition, a direct investigation of this group provides an understanding of the efficacy of e-bike purchase incentive programs pursuing mode shift, emissions reduction, and transportation equity goals.

Questions related to e-bike class were ordered to assess whether respondents correctly selected the class of their e-bike as inferred by later questions on its maximum speed and throttle. Owner knowledge of class is becoming increasingly important as regulators adopt e-bike legislation based on the three-class system. Having estimates of the proportion of e-bike owners that correctly identify their own bikes will provide some basis for estimated compliance rates with signage and other regulation communications.

Optional questions were included regarding e-bike maintenance and battery recycling. Responses to these questions will help inform present and future public education and resource management programs by the electric micromobility industry and environmental stakeholders.

Working drafts of the survey were shared with partners at PeopleForBikes, including their Electric Bicycle Subcommittee, which consists of representatives from a number of e-bike manufacturers. Feedback and general comments were solicited through these interactions and incorporated into the final version of the survey. Questions were designed to be generally impartial to the technology rather than to reflect the preconceived opinions of the researchers or industry partners.

The survey was designed to take 15-20 minutes to complete. Testing from the researchers and a number of colleagues and friends was used to confirm that this was an accurate estimate.

3.1.1 Comparability to Previous Editions of the Survey

When considering the ability to compare results to previous editions of the survey, the researchers chose to prioritize a stronger survey instrument over providing for direct comparability. For example, the question regarding recent travel from the 2017 edition of the survey was changed in the following manner (<u>underlined text</u> notes the differences):

- 2017 edition: “Think back on the last three times you used an e-bike… How did you use it? How far did you go? If you had not taken your e-bike, how would you have traveled to your destination?”
- 2023 edition: “Think back on the last three times you used an e-bike leaving home and returning again with any number of stops along the way. How did you use it? How far did you go? When was the trip (date in MM/DD/YYYY format)? If you had not taken your e-bike, how would you have traveled?”

In this example, the changes made allow for a more standardized measure of trip length and trip frequency but result in a question that is not directly comparable to the one asked in previous editions of the survey. This strengthens the survey’s ability to answer questions regarding travel behavior but weakens its ability to track the change in e-bike usage over time through the three editions of the survey. This approach was taken numerous times in the design of the survey and is noted in the discussion of results when appropriate.

3.2 Survey Participant Recruitment

The survey was distributed through a wide variety of channels and was open April 5th to May 15th, 2023 (40 total days). During this time, the researchers conducted a single large outreach push during the first week with continuous communication efforts throughout. Outreach consisted of direct distribution through email, dissemination through incentive program managers, advertisement on social media, and publication through a variety of media contacts and cycling clubs, advocacy, community, and professional groups.

3.2.1 Direct Distribution

Direct email outreach was conducted to known and likely e-bike owners through two channels. During the 2013 and 2017 editions of the survey, researchers at the Transportation Research and Education Center (TREC) at Portland State University (PSU) collected a list of emails (n=1,640) from participants who agreed to be contacted for future surveys. A survey prompt was distributed to this list. Through the use of a tracking link, this list is known to make up around 5% of the valid responses in the analyzed sample. The survey was distributed via email to a large (n≈450,000) panel of people who had previously agreed to participate in survey opportunities through PeopleForBikes. The recipients of this outreach effort are known to compose approximately 33% of the total number of valid surveys received.

3.2.2 Incentive Program Distribution

Because a particular focus of this investigation was the comparison of incentive recipients to e-bike owners who bought their e-bikes without incentives, outreach was conducted through the incentive programs themselves. The researchers conducted two waves of outreach to incentive program managers through email, asking them to share the survey with their program's participants. Confirmation was received from 23 programs that the survey was shared in some way – either via email to incentive recipients or via email or social media to a general audience. Tracking links were requested by three programs: the Vermont Agency of Transportation (1.2% of valid responses), the City of Eugene, OR (0.4%), and the Santa Barbara County Association of Governments in California (0.4%).

3.2.3 Social Media

The researchers shared graphics promoting the survey on their personal and institutional social media accounts, including on X (formerly known as Twitter), Facebook, LinkedIn, and Reddit. A reproduction of the graphic used in most cases is shown in Figure 2.

Figure 2. Survey Flier

A $98 ad was purchased on Facebook and Instagram, targeted at the following audience using Meta's ad tools:

- Location – living in: Canada, United States
- Age: 18 - 65+
- People who match:

- Interests: Road bicycle, Mountain biking, Sport bike, Electric vehicle, Electric bicycle, Minibike, Bike (magazine), Specialized Bicycle Components, Scooters, Local bike shop or Bicycle
- Behaviors: Commuters
- School: Biking
- Employers: Specialized Bicycles, Trek Bicycle or Bike Mechanic
- Job title: Bicycle mechanic or Rider

Social media outreach efforts were directed to the general link for the survey; pass-through rates for each channel were not collected.

3.2.4 Other Outreach Mechanisms

Further outreach was conducted through email and social media chat to cycling- and environment-focused advocacy and community groups, media contacts, transportation professional organizations, and research groups with e-bike-related work. A local Portland, OR media outlet, BikePortland, ran a story on the survey with a tracking link; 3.6% of the survey sample is known to have arrived from this source (Griggs, 2023).

3.2.5 Incentives for Survey Participants

Participants were recruited in part through entry to a drawing for incentives contingent on their successful completion of the survey. Fifty $20 Visa gift cards and three Topo Designs backpacks with PeopleForBikes branding (value $100) were given away by PeopleForBikes. Participants entered the drawing using a separate survey to which they

were redirected at the end of the main survey. This drawing entry survey was limited to people redirected directly from the main survey and allowed only one response per unique IP address to avoid possible fraud. The drawing entry survey asked only two questions:

- *If you'd like to be entered in a drawing for the prizes shown below, please provide us with an email address where we can reach you. This information will not be shared with any of our partners, and will not be connected to your survey responses.* (text box response)
- *May the researchers contact you for participation in future transportation studies?* (Yes/No multiple-choice response)

Respondents who answered "yes" to the second question will have their information saved for recruitment for future transportation surveys from Portland State University, while those who answered "no" will not have their information retained.

3.3 Data Cleaning

3.3.1 Filtering and Removal of Automated Responses

The data was exported from Qualtrics and was initially inspected visually using Microsoft Excel. It quickly became evident that a significant portion of the gathered responses were falsified, automated, or otherwise invalid. Therefore, the dataset required significant cleaning before it could be used for analysis. Of many problems identified, specific problems with the data that initially indicated obviously falsified responses included repeated IP addresses (duplicate responses), responses to text entry questions not in

English, non-real U.S. zip codes or Canadian postal codes, and stated receipt of purchase incentives from programs that do not exist. A wide variety of flagging criteria were developed to remove invalid responses. Automated responses were found to span a large range of quality and believability, with the least sophisticated responses violating numerous flagging criteria, and the most sophisticated only uncovered with a more in-depth analysis of the data. Numerous cases were also removed by hand for their responses to text-entry questions being nonsensical, submitted repeatedly, or not in English altogether. Cases were also removed for a number of reasons that would exclude them from any survey pool. These were incomplete surveys, surveys completed before the survey opened to the public, respondents that marked they don't own an e-bike, and cases flagged by Qualtrics as "spam" or "preview".

A small number of cases were also forcibly included when filtering was found to be too strict. Because purchase price was used as a filter, the top and bottom ends of the price bell curve were checked by hand and a number of responses were placed back in the included dataset because their answers to make and model agreed with their purchase price, and they exhibited a small number of other flags for removal. Text-entry questions were reviewed, and a small number of cases were returned to the data set if they provided convincing evidence of their being submitted by a real person.

Specific steps undertaken for data cleaning are described in Appendix B. Further discussion of the implications of these automated responses and filtering techniques on the validity of this study can be found in the Discussion section.

All filtering was completed in Microsoft Excel. Verification that this process did not result in errors was completed using the raw dataset in SPSS statistical software.

The dataset as received from Qualtrics was composed of 10,968 cases. In the first filter, 2,844 cases were found ineligible for inclusion due to them being incomplete, submitted early, not having an e-bike, and/or being flagged as spam or preview. A further 3,656 cases were removed because they violated at least one filter designed to catch automated responses (see Appendix B for more information on these filters). Yet 422 more cases were removed by hand due to them having nonsensical or non-English responses to text entry questions. Fifty cases were marked for inclusion manually due to the listed price being plausible given the model and/or incentives received, or a convincing comment left in a text-entry question. Combined, this process resulted in a dataset of 4,096 usable cases. A flowchart indicating the volumes passing each step of the filtering and automated response removal process can be found in Figure 3.

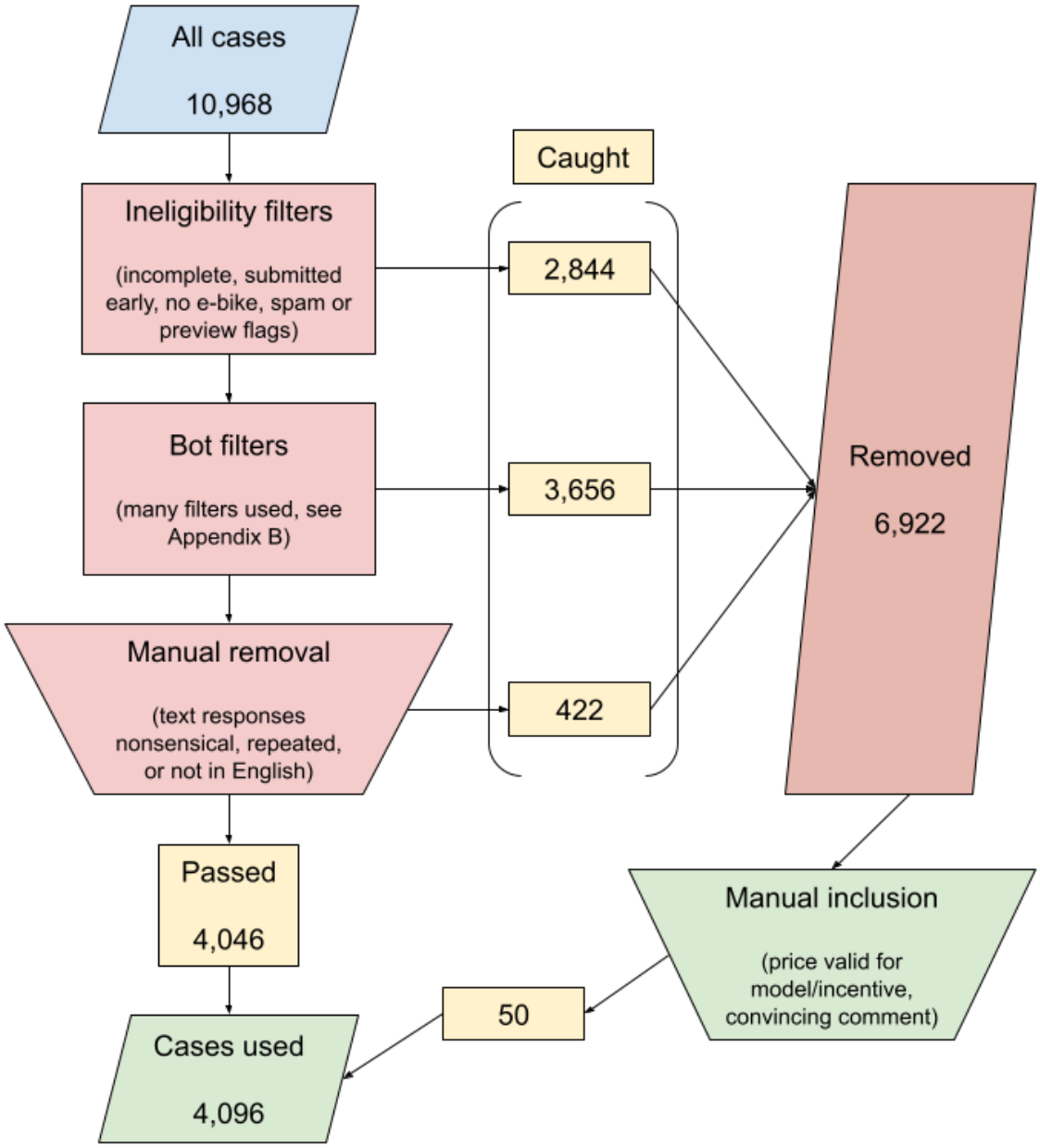

Figure 3. Case Removal and Inclusion Flowchart

3.3.2 Variable-Specific Cleaning

A number of variables included text responses or "other" options to multiple choice arrays that required some judgment in recategorizing and cleaning. This was conducted by hand and may have resulted in some bias and a lack of replicability by other researchers given the same dataset. Often, responses to "other" options on multiple choice questions corresponded with possible answers in the original set and were re-sorted back into these categories. Sometimes, new categories emerged from the "other" options. These derived categories are made clear in italics in the tables of the results section when appropriate.

There was a need to define a group of incentive recipients that was distinct from the general sample to answer some of the research questions for this study. Because the sample size answering that they had received an incentive was relatively small, those respondents were placed under additional scrutiny before they were analyzed. Program specifics and postal codes were checked by hand against the incentive program tracker maintained by TREC (Bennett & MacArthur, 2023) to verify that the respondents' claims were plausible before their inclusion in the sample of incentive recipients. A number of respondents indicated that they received an incentive in the form of a simple discount at purchase, such as when an e-bike was on sale. Others listed that they received or hoped to receive an incentive from a program that had not been approved or become active yet at the time of the survey. In these cases, the response was removed from the group marked as incentive recipients.

3.4 Data Validation

The valid responses were checked against known quantities of the population of e-bike owners. Data from Circana were obtained through PeopleForBikes for total e-bike sales broken down by bicycle type for 2015 through early 2023. These data represent only the retail sector, including Independent Bicycle Dealers (IBDs) and Rest of Market sales (ROM; sporting goods specialty, mass market, and online), making up approximately one third of e-bike sales in the United States. The data omits the direct-to-consumer (DTC) sales used primarily or exclusively by most major e-bike manufacturers. However, the rough year-on-year sales increases and breakdowns by bicycle category were assumed to remain consistent for the DTC sector, with the exception of cargo bikes, which are likely under-represented in the retail sector due to the recent addition of cargo models to the lineup of brands with a retail presence. These profiles were compared to the equivalent questions in the survey, pertaining to purchase year and stated e-bike type. The survey sample was found to be within a reasonable range.

Demographic profiles of removed responses were also checked against those that were not flagged as bots. A large proportion of nonresponses or complex responses to gender and race questions indicated that many automated responses had been removed. The same was true for distributions for purchase year and education level. However, the similarity in proportion between removed and unremoved cases for many demographic categories indicated that many legitimate responses had been removed in filtering. The filtering mechanisms were determined to have been conservative and sample size was judged to be sufficient, so no effort was made to bring these responses back into the dataset for analysis.

The rate of valid responses from sub-samples that arrived from tracking links varied from 46.2% for the PeopleForBikes email group to 73.9% for one of the incentive programs' distribution lists. Only 31.8% of responses not arriving from a tracking link were considered valid after the cleaning process. These tracking links may have provided a decent-quality sample alone but using them as the primary filtering mechanism may have resulted in additional bias, and the resulting sample size would have been considerably smaller: at most 3,664.

3.5 Data Analysis

The cleaned and coded survey data were analyzed for general characteristics using summary statistics, cross-tabulation, and basic field calculations as described in the Results section. Inter-group comparisons were checked for significance using chi-squared analysis. Statistical analysis was completed utilizing SPSS statistical software.

4 Results

This section describes the results of analysis of the survey sample, including feedback received on the survey's design, clarity, and functionality, a description of the sample, findings concerning the general sample of e-bike owners, comparison with previous editions of the survey, and a comparison of incentive recipients and non-recipients.

4.1 Survey Reception

The median time-to-complete for the survey was 21 minutes. The mean time was over two hours, likely due to the fact that many respondents left the survey open on their device for some time before returning to complete it.

It was difficult to highlight specific issues with question clarity due to the large share of automated responses. However, the proportion of text-entry questions to "other" options which were able to be re-coded on multiple choice questions was similar to other surveys that the author has conducted in the past.

The issue of households with multiple e-bikes arose both in comments and in the survey itself. Many text responses indicated that the respondent wished to describe more than one e-bike or e-bike purchase. However, this was not determined to have any significant effect on the outcomes described in this section.

4.2 Respondent Demographics

Survey respondents were asked to provide the postal code for their current place of residence. The overwhelming majority (96.5%) of the 4,096 survey respondents indicated they lived in the United States, with the remaining 3.5% living in Canada. Two-fifths (38.9%) were from the Pacific coast in California (18.3%), Oregon (10.5%), Washington (8.6%), and British Columbia (1.5%). A significant number of responses were also recorded in Colorado (7.6%), Wisconsin (4.2%), and Massachusetts (3.2%). Every state, province, and territory was represented except Newfoundland and Labrador, Prince Edward Island, and Nunavut. Full state and province breakdowns are in Table 1 and Table 2, and a map of the survey responses received is shown in Figure 4.

The survey respondents were predominately white (84.2%), male (60.8%), 45 years and older (61.3%), and highly educated (78.2% with a bachelor's degree or higher). Respondents were generally financially affluent, with the majority (66.4%) earning over 400% of the U.S. Census Bureau's federal poverty guideline (FPG) – a measure that is scaled by household size and typically used for administrative purposes like the distribution of incentives. Most were employed (68.5%) and married or living with a partner (78.7%). The majority (87.5%) of respondents that were unemployed were aged 55 and older, with unemployment rates for those younger than 55 being only 6.9%. Basic demographic characteristics of the respondents are provided in Table 3.

Table 1. State of Origin

State/District/ Territory	Count	Percent (within U.S.)	Percent (total)	State/District/ Territory	Count	Percent (within U.S.)	Percent (total)
Alabama	10	0.3	0.2	Montana	16	0.4	0.4
Alaska	13	0.3	0.3	Nebraska	20	0.5	0.5
Arizona	59	1.5	1.4	Nevada	23	0.6	0.6
Arkansas	14	0.4	0.3	New Hampshire	18	0.5	0.4
California	751	19.0	18.3	New Jersey	30	0.8	0.7
Colorado	310	7.8	7.6	New Mexico	23	0.6	0.6
Connecticut	35	0.9	0.9	New York	97	2.5	2.4
D.C.	56	1.4	1.4	North Carolina	87	2.2	2.1
Delaware	10	0.3	0.2	North Dakota	1	0.0	0.0
Florida	102	2.6	2.5	Ohio	89	2.3	2.2
Georgia	64	1.6	1.6	Oklahoma	19	0.5	0.5
Hawaii	5	0.1	0.1	Oregon	430	10.9	10.5
Idaho	21	0.5	0.5	Puerto Rico	1	0.0	0.0
Illinois	89	2.3	2.2	Pennsylvania	78	2.0	1.9
Indiana	44	1.1	1.1	Rhode Island	10	0.3	0.2
Iowa	37	0.9	0.9	South Carolina	12	0.3	0.3
Kansas	27	0.7	0.7	South Dakota	7	0.2	0.2
Kentucky	20	0.5	0.5	Tennessee	47	1.2	1.1
Louisiana	3	0.1	0.1	Texas	97	2.5	2.4
Maine	12	0.3	0.3	Utah	45	1.1	1.1
Maryland	66	1.7	1.6	Vermont	82	2.1	2.0
Massachusetts	131	3.3	3.2	Virginia	103	2.6	2.5
Michigan	94	2.4	2.3	Washington	352	8.9	8.6
Minnesota	60	1.5	1.5	West Virginia	14	0.4	0.3
Mississippi	3	0.1	0.1	Wisconsin	173	4.4	4.2
Missouri	40	1.0	1.0	Wyoming	3	0.1	0.1
				Total	**3,965**	**100.0**	**96.5**

Table 2. Province of Origin

Province/Territory	Count	Percent (within Canada)	Percent (total)
Alberta	17	11.9	0.4
British Columbia	62	43.4	1.5
Manitoba	3	2.1	0.1
New Brunswick	1	0.7	0.0
Nova Scotia	7	4.9	0.2
Northwest Territories	1	0.7	0.0
Ontario	32	22.4	0.8
Quebec	9	6.3	0.2
Saskatchewan	5	3.5	0.1
Yukon	6	4.2	0.1
Total	**143**	**100.0**	**3.5**

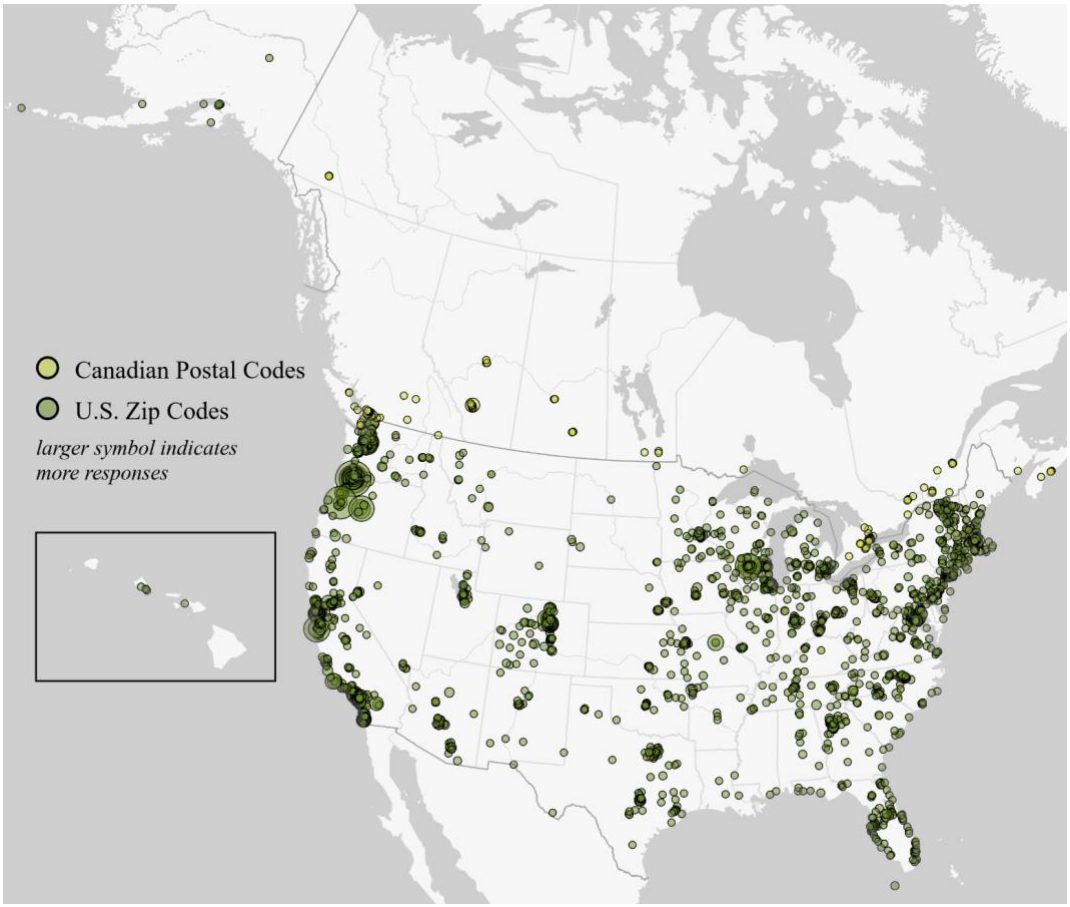

Figure 4. Map of Respondent Postal Codes

Table 3. Respondent Demographics

Gender identity (n=4,082)	Value (%)
Male	60.8
Female	36.2
Nonbinary	1.4
Multiple or another	0.5
I prefer not to answer	1.1

Age (years) (n=4,009)	Value (%)
Younger than 18	0.2
18 to 24	1.7
25 to 34	15.3
35 to 44	21.6
45 to 54	15.3
55 to 64	19.0
65 to 74	20.3
75 or older	6.7

Race/ethnicity (n=4,088)	Value (%)
White or Caucasian	84.2
Multiple or other	3.8
Asian	3.5
Hispanic, Latinx/o/a, or Spanish origin	2.6
Black or African American	1.8
American Indian or Alaska Native	0.8
Native Hawaiian or Pacific Islander	0.4
Middle Eastern or North African	0.2
Prefer not to say	2.7

Married or living with a partner (n=4,285)	Value (%)
Yes	78.7
No	19.5
I prefer not to answer	1.7

Education (n=4,090)	Value (%)
High school or less	2.8
Some college, no degree	11.7
Associate degree	6.5
Bachelor's degree	36.6
Graduate or professional degree	41.6
I prefer not to answer	0.9

Are you currently employed? (n=4,081)	Value (%)
Yes	68.5
No	29.7
I prefer not to answer	1.7

Household income – based on 2021 Federal Poverty Guidelines, U.S. respondents only (n=3,773)	Value (%)
Less than 100% FPG	1.9
100-200% FPG	6.4
200-300% FPG	10.3
300-400% FPG	15.0
More than 400% FPG	66.4

Respondents were generally in a very good or excellent self-reported state of health (64.8%), with only 7.7% claiming they had a fair or poor state of health and only 12.1% claiming that they had physical limitations that make riding a non-electric bicycle difficult or impossible. Among those with limitations, 89.2% had a permanent physical limitation.

Table 4. Respondent Health Characteristics

Self-described general state of health (n=4,076)	**Value (%)**
Excellent	22.0
Very good	42.8
Good	27.2
Fair	6.6
Poor	1.1
I prefer not to answer	0.4
Which of the following statements best fits you? (n=4,079)	**Value (%)**
I am physically able to ride a bicycle.	87.8
I have physical limitations that make riding a non-electric bicycle difficult.	11.1
I am physically unable to ride a non-electric bicycle.	1.0
Among those who have physical limitations: Is this a temporary or permanent condition (n=489)	**Value (%)**
Temporary condition	10.8
Permanent condition	89.2

Two-thirds (67.2%) of respondents had two adults in the household, and around half (47.7%) had two people in the household, total. One-fifth (19.3%) had children. There were a significant proportion of missing responses to the questions regarding the number of children in the household. A response of zero was assumed for responses that indicated a

number of adults but did not indicate a number for one or more of the children age categories. A full breakdown of household characteristics can be found in Table 5.

All but 6.7% of respondents had at least one car, van, truck, or motorcycle available at home, and all but 13.2% had at least one non-electric bicycle. A small number of respondents (2.1%) reported that they did not currently have any functioning e-bikes in their household. A tabulation of available vehicles in the household can be found in Table 6.

Table 5. Household Composition (n=4,066)

Adults	**Value (%)**
1	13.7
2	67.2
3 or more	19.0
Total household size	**Value (%)**
1	12.8
2	47.7
3	17.4
4+	22.1
Children present in household	**Value (%)**
No children	72.1
Children under 10 only	17.5
Children 10-15 only	6.9
Children 10-15 and under 10	3.5

Children younger than 10	**Value (%)**
0	78.9
1	12.4
2	7.7
3 or more	1.0
Children 10-15	**Value (%)**
0	89.6
1	7.6
2	2.5
3 or more	0.3
Total children 15 or younger	**Value (%)**
0	80.7
1	10.3
2	7.0
3 or more	2.0

Prior to purchasing an e-bike, 59.0% of respondents reported riding non-electric bicycles weekly or daily, while 33.8% were occasional riders riding monthly or less, and 7.3% never

rode a bicycle as an adult. When asked about the frequency at which they used non-electric bicycles for specific activities, a higher proportion of respondents reported riding more frequently, with 68.4% being daily or weekly riders and 29.6% riding once a month or less. Only 1.9% reported never riding a bike prior to purchasing an e-bike in this question.

Table 6. Vehicles Available in the Household (n=4,096)

Number of working/ functioning vehicles in the household	Value (%)			
	Cars, vans, trucks, or motorcycles	Adult non-electric bicycles	E-bikes	Children's bicycles
0	6.7	13.2	2.1	61.5
1	35.2	20.1	57.9	11.8
2	39.3	22.1	30.5	7.9
3 or more	18.3	42.5	8.7	5.3
Did not answer	0.5	2.1	0.8	13.5

4.3 E-Bike Characteristics and Purchase Details

A large majority (86.8%) of respondents bought their e-bike new and complete, while 7.8% purchased a used e-bike and the remaining 5.5% converted a non-electric bicycle to an e-bike.

Respondents were asked to report the top assisted speed of their e-bikes and whether or not they had a throttle that engaged the motor without pedaling. E-bike class was inferred from these qualities. Over a third (36%) of e-bikes in the sample were class 1, with less being class 2 (27.2%) and even less being class 3 (14.1%). Nearly a quarter (22.6%) of respondents reported out of class e-bikes, with top assisted speeds faster than 28 mph/45 kph, or a top assisted speed of 28 mph/45 kph with a throttle. It should be noted that this inferred class value is error-prone as owners often misreported the attributes of their e-bikes. Rad Power Bikes are known to be class 2 unless modified by the owner after purchase. Only 84.6% of Rad owners reported characteristics of their bike in accordance with class 2, with 2.0% mis-attributing the characteristics of class 1 bikes, 11.0% as class 3, and 2.5% as out of class.

Respondents were asked to self-identify the style of e-bike that most closely resemble theirs based on a set of photos (reproduced in Appendix A). Almost one third (32.3%) of respondents had city/hybrid/commuter style e-bikes, followed by long-tail cargo (13.5%), step-thru/beach cruiser (13.5%), and mountain (10.7%). A full breakdown of e-bike characteristics in the survey population is in Table 7.

Cargo bike ownership (combined long-tail and front-loading styles) rose sharply when children were present in the household and when respondents were aged 25-55. This phenomenon is visualized in Figure 5.

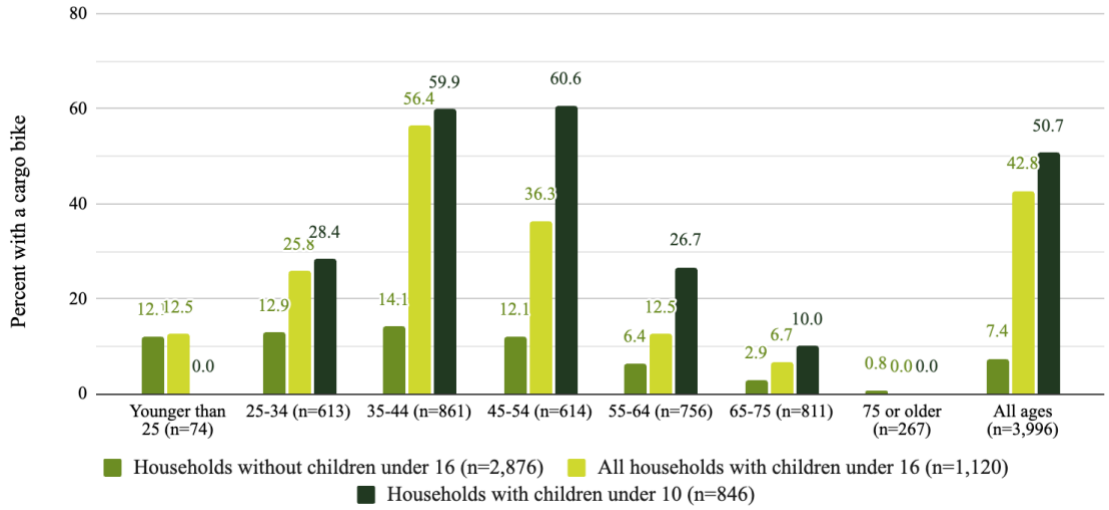

Figure 5. Cargo Bike Ownership Rates by Age and Children in the Household

Rates of ownership of e-bikes with throttles decreased with age, with 78.4% of those 24 and younger having throttled e-bikes, compared to 30.1% of those 75 and older. This trend is visualized in Figure 6. People with physical limitations had e-bikes with throttles at a statistically significant higher rate than those without (52.0% and 43.9%, respectively; chi-squared test $p<0.001$).

Table 7. E-Bike Purchase Characteristics and Purchase Details

Purchase or convert (n=4,096)	Value (%)
Purchased a new e-bike	86.8
Purchased a used e-bike	7.8
Converted a non-electric bicycle	5.5
Year bought (n=3,808)	**Value (%)**
2020 or later	78.7
2016-2019	19.2
2015 or earlier	2.1
Purchase Price (n=3,904)	**Value (%)**
$1,000 or less	12.9
$1,001-2,000	33.6
$2,001-3,000	17.4
$3,001-4,000	12.6
$4,001-5,000	8.7
$5,001-7,500	9.3
$7,501 or more	5.4
Purchase location (n=4,049)	**Value (%)**
A bicycle shop that has some e-bikes	33.1
Online from the bike manufacturer	28.9
Specialty e-bike shop	21.4
Used goods marketplace	5.0
Big Box Store, Superstore, General Merchandise/Outdoor Retailers	4.6
Online from somewhere else	3.5
Specialty electric vehicle shop	1.2
Friend/relative/acquaintance	1.1
In person from the manufacturer	0.7
Other	0.4

E-bike style (n=4,089)	Value (%)
City/hybrid/commuter	32.3
Long-tail cargo	13.5
Step-thru/beach cruiser	13.5
Mountain	10.7
Fat tire	8.1
Drop-bar road/gravel	7.9
Folding	5.9
Front-loading cargo	3.8
Sport/moto-style cruiser	2.2
Tricycle	0.9
Recumbent (inc. tricycle)	0.9
Tandem	0.2
Removable battery (n=4,086)	**Value (%)**
Yes	81.8
No	18.2
Top speed (n=4,091)	**Value (%)**
20 mph (32 kph) or less	60.7
28 mph (45 kph)	30.9
Greater than 28 mph (45 kph)	4.4
I don't know	3.9
Throttle (n=4,090)	**Value (%)**
Yes	44.9
No	55.1
E-bike class as inferred from top assisted speed and throttle (n=3,927)	**Value (%)**
Class 1 (20 mph/32 kph, no throttle)	36.0
Class 2 (20 mph/32 kph, with throttle)	27.2
Class 3 (28 mph/45 kph, no throttle)	14.1
Out of class	22.6

Italics indicate a category derived from text responses to "other" options on multiple-choice questions.

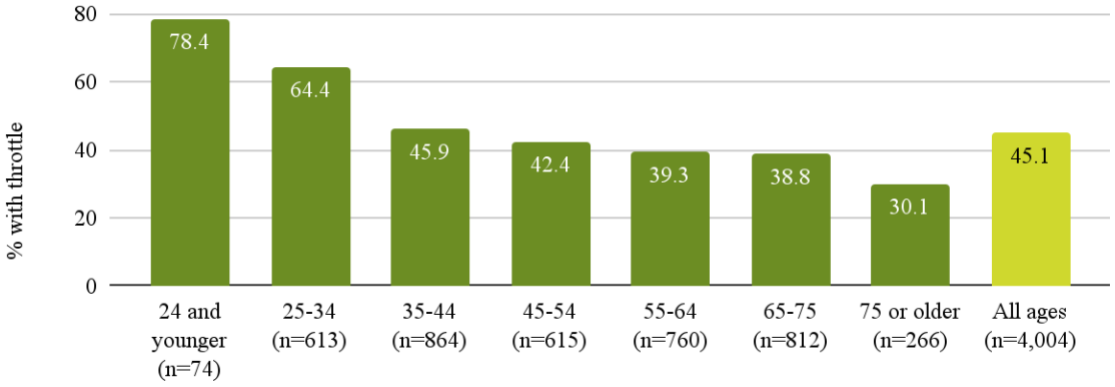

Figure 6. Throttle Presence by Age

E-bike purchases have increased exponentially over the past decade in the sample, with two thirds (66.0%) of respondents having purchased their e-bike 2021 or later. Figure 7 visualizes year-on-year sales. Note that the survey was conducted April 5th through May 15th of 2023, so the sales figures for 2023 should not be compared directly with those from prior years.

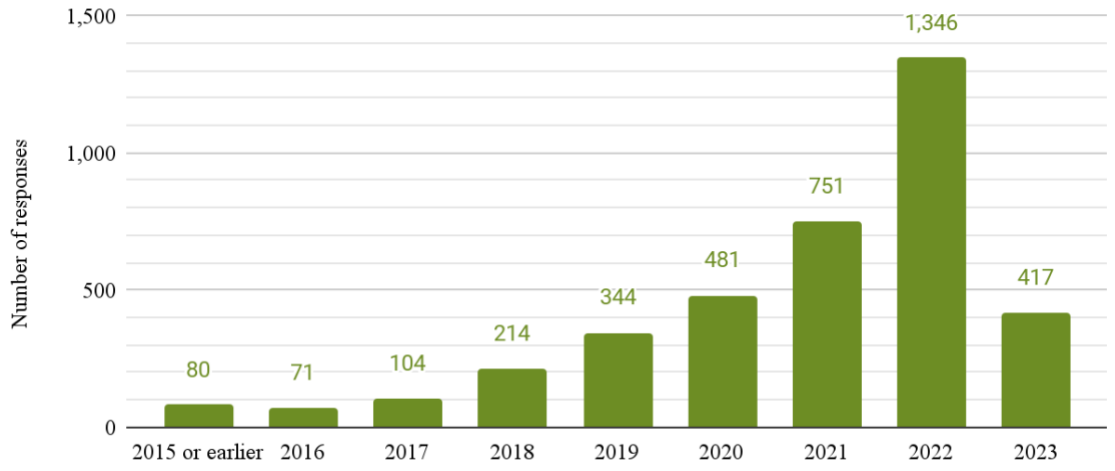

Figure 7. E-Bike Purchase Year, 2015 through March 2023 (n=3,808)

The eighteen e-bike brands making up at least one percent of survey responses for owners of ready-built e-bikes – as opposed to conversions – are shown in Table 8. Rad Power Bikes holds a 14.9% share of the market among those surveyed, followed by Specialized (10.6%), Trek (8.5%), Tern (5.2%), and Aventon (5.0%).

Table 8. Top E-Bike Brands (n=3,866)

E-Bike Brand	Count	Value (%)
Rad Power Bikes	575	14.9
Specialized	409	10.6
Trek	329	8.5
Tern	202	5.2
Aventon	192	5.0
Gazelle	132	3.4
Riese und Müller	86	2.2
Giant	83	2.1
Pedego	67	1.7
Blix	64	1.7
Lectric	62	1.6
Yuba	61	1.6
Electra	53	1.4
Cannondale	47	1.2
Urban Arrow	45	1.2
Co-op Cycles	44	1.1
Juiced	43	1.1
Orbea	39	1.0
All other brands	*1,333*	*34.5*

Respondents were asked to select and rank the top three reasons they decided to buy an e-bike or convert a standard bicycle. They were given a list of 14 prescribed possibilities to

choose from with the additional option of providing a reason not listed. Most (90.5%) chose three options, with 3.0% choosing two and 6.5% choosing one. The most common reasons selected were replacing the hassle of car trips and riding with less effort or arriving less sweaty. Replacing car-based hassle and carrying cargo or kids were the most-commonly selected top reasons for buying an e-bike. A full breakdown of respondents' reasons for buying an e-bike is shown in Figure 8.

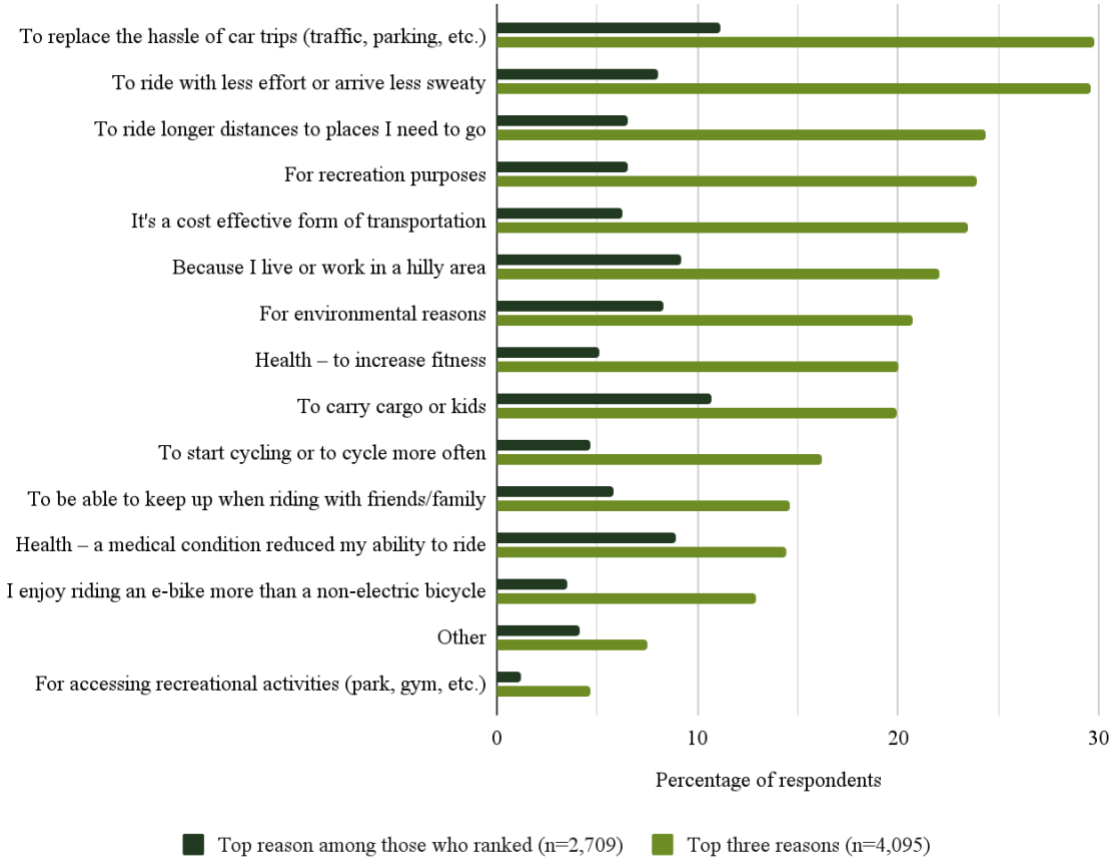

Figure 8. Top Reasons for Buying or Converting to an E-Bike

Comments for the “other” category noted that the e-bike was purchased to replace public transit during the COVID-19 pandemic, to help to mitigate speed differentials with traffic, to be a model for e-bike adoption for others, to keep cycling with old age, assist with commuting in the wind and weather, and to avoid having to purchase another car after a significant life event like moving or having a child.

The bike type or style and price were listed as the most-considered attributes of the bike itself during the purchase process. Available incentives and safety certifications were the least-considered attributes. A breakdown of all attribute considerations is shown in Figure 9.

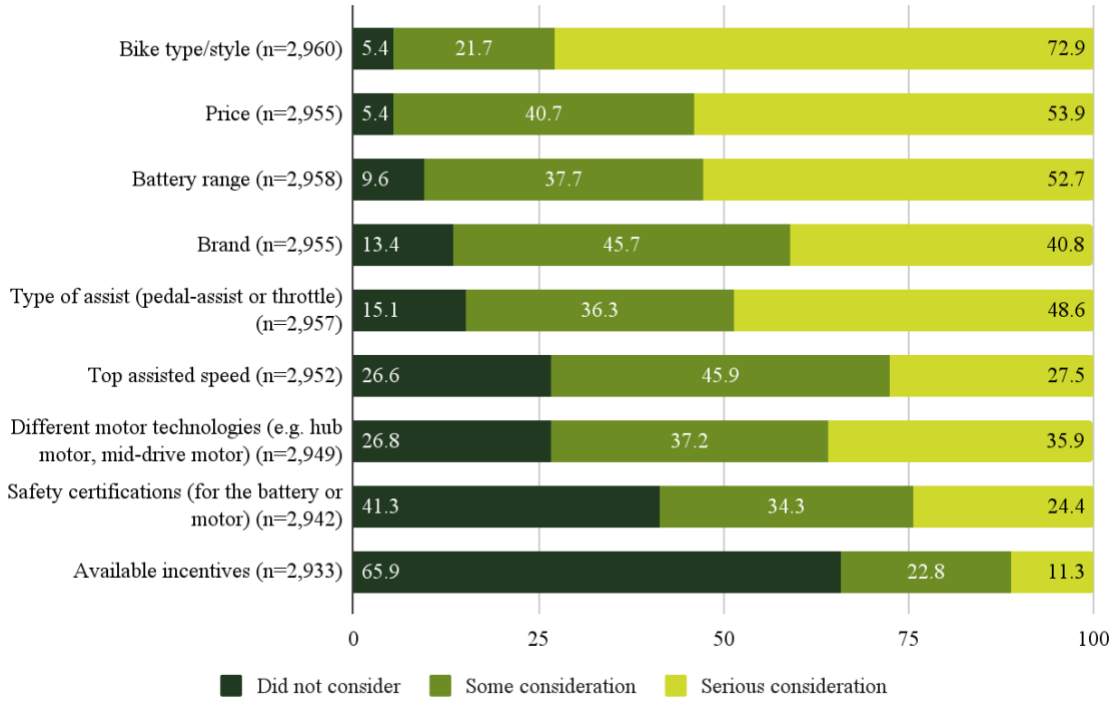

Figure 9. E-Bike Characteristics Considered at Purchase

When asked to describe the single most important factor in choosing the e-bike they purchased, some of the reasons provided were build quality, weight, the ability to carry children or other cargo, portability with their vehicle, cost, availability – particularly during the COVID-19 pandemic – battery life and range, brand reputation, and various components or features such as top speed or belt drive compatibility.

Significant differences were noted in the purchase considerations of various demographics. Bike style was considered more strongly by those with higher incomes, white respondents, older adults, people without children, and people with physical limitations. Price was considered more strongly by those with lower incomes, non-white respondents, younger adults, people with children, and people with less experience cycling. Available incentives were considered more by those with lower incomes, younger adults, and those with less prior cycling experience. Older adults more strongly considered battery range, type of assist, and motor technology. Those with physical limitations more strongly considered battery range, type of assist, motor technology, and the brand of the bicycle. A complete breakdown of purchase considerations by owner demographics can be found in Table 9.

Table 9. Purchase Considerations by Owner Demographics

At the time of purchase, did you consider...	Seriously considered (%)																	
	Total		200% FPG		400% FPG		Race		Gender		Age		Children		Prior cycling frequency		Physical limitation	
	Count	%	>	<	>	<	Non-white	White	Non-male	Male	<55	≥55	None	1 or more	Infre-quent	Weekly+	No	Yes
Bike type/style	2,960	72.9	**73.6**	**63.7**	74.0	70.4	**66.3**	**73.8**	74.2	72.1	**70.5**	**75.5**	**73.8**	**70.4**	72.5	73.5	**72.0**	**79.4**
Price	2,955	53.9	**53.1**	**60.7**	**51.0**	**60.0**	**59.3**	**52.5**	54.9	53.3	**60.9**	**45.7**	**51.3**	**61.2**	**57.2**	**51.9**	54.3	51.0
Battery range	2,958	52.7	**53.0**	**45.3**	52.8	51.5	**51.6**	**52.5**	**48.6**	**55.3**	**47.7**	**58.2**	**56.3**	**42.4**	50.5	53.5	**62.4**	**51.2**
Type of assist (pedal assist or throttle)	2,957	48.6	48.9	47.3	**49.2**	**47.7**	42.9	49.4	49.4	48.0	**43.3**	**54.3**	**51.9**	**38.7**	48.9	48.7	**47.4**	**56.4**
Brand	2,955	40.8	41.7	31.3	42.1	38.3	**41.6**	**40.7**	40.9	40.7	**38.3**	**43.4**	40.2	42.4	**38.0**	**43.0**	40.7	42.1
Different motor technologies (e.g., hub motor, mid-drive motor)	2,949	35.9	36.2	31.3	35.7	36.2	35.7	35.9	**25.9**	**42.4**	**32.7**	**38.8**	36.7	33.6	33.3	38.0	**35.5**	**39.3**
Top assisted speed	2,952	27.5	28.0	30.3	28.8	26.6	**33.4**	**26.6**	**22.1**	**31.0**	27.5	27.7	**29.1**	**22.8**	27.7	27.9	**28.4**	**22.2**
Safety certifications (for the battery or motor)	2,942	24.4	24.3	25.0	**22.9**	**27.6**	27.4	23.7	25.6	23.6	23.3	25.3	24.5	23.9	23.9	24.7	24.1	25.9
Available incentives	2,933	11.3	**10.8**	**18.0**	**10.1**	**14.3**	13.2	10.7	12.1	10.8	**11.8**	**10.5**	**11.3**	**11.3**	**13.6**	**10.7**	11.3	10.7

Bold indicates significant differences between groups for their "Did not consider/Some considered/Serious Consideration" response to the various purchase considerations based on a chi-square test across the two groups noted in the table ($p<0.05$).

Valid sample sizes (n) for the cross-tabulation of demographics and purchase considerations vary.

4.4 Travel Characteristics

Respondents whose e-bike was equipped with a throttle or button that could propel the bike without pedaling were asked what proportion of the time they use the throttle without pedaling while riding. A small proportion (17.7%) never used the throttle, while even fewer (13.1%) used the throttle more than half of the time. One third (31.9%) claim that they use the throttle just for startups, 8.3% just for hills, and 8.1% for both startups and hills.

Respondents were asked whether they were the only ones that rode their e-bike. Most (83.6%) reported that their e-bike is used by them alone, while 16.4% share their e-bike with someone else in their household.

In aggregate, the purchase of e-bikes tends to lead to moderate decreases in non-electric cycling, and notable increases in cycling overall. More than half (59.0%) of respondents reported riding a non-electric bicycle at least weekly before purchasing an e-bike, while only 37.0% did afterward. The vast majority (88.7%) of e-bike owners report riding weekly or daily, while only 3.3% report riding "a few times a year" or less. These behavior changes are visualized in Figure 10.

Participants were asked to "think back on the last three times [they] used an e-bike leaving home and returning again with any number of stops along the way." They were then asked to provide details for each trip, including distance (approximate miles) and the purpose of trip (dropdown choices provided), and were asked "if you had not taken your e-bike, how would you have traveled to your destination?" The results of their trip characteristics are reported in this section.

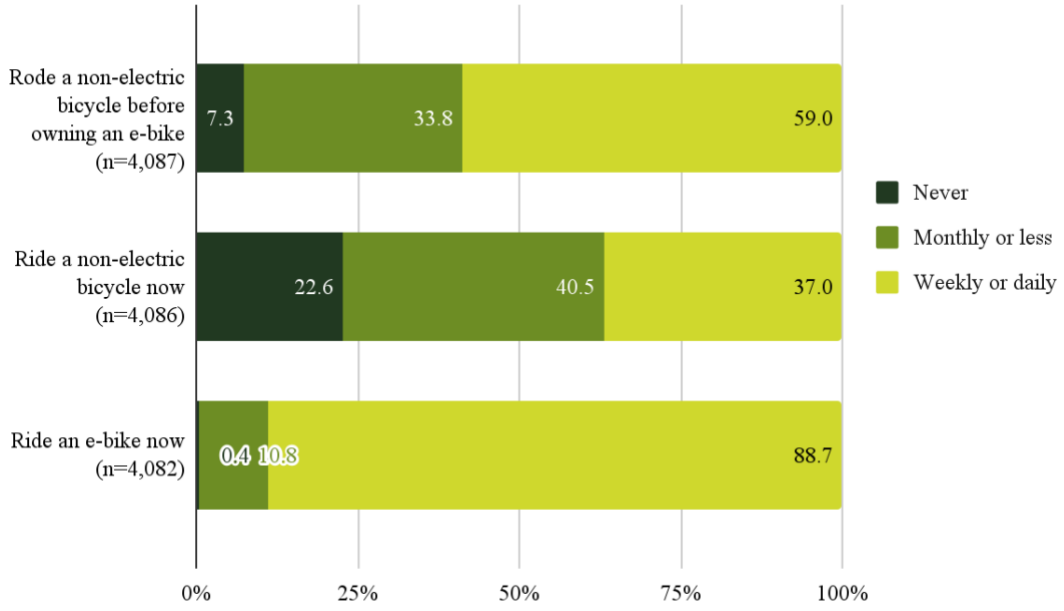

Figure 10. Changes to Cycling Frequency with E-Bike Purchase

E-bike owners typically ride their bikes for utilitarian purposes. Only one-third (36.6%) of trips were for exercise and recreation. About a quarter (28.3%) were commute trips, followed by personal errands (22.1%), with the rest being entertainment or social. One quarter (23.2%) of respondents only reported recreational trips, among those reporting at least one non-recreational trip or three recreational trips (n=3,925). A summary graphic of trip purpose is shown in Figure 11.

E-bike trips most often substituted car trips of various forms (45.3%), including drive alone, carpool/passenger, taxi/Uber/Lyft, or carshare. One-fifth (21.4%) of trips were induced – i.e., they would not have happened if the respondent did not have the e-bike. Nearly a quarter (23.5%) substituted active transportation trips, and 8.7% substituted public

transit. Mode substitution differed heavily between utilitarian (commute, errands, entertainment, or visiting family and friends) and recreational trips. Two-thirds (62.7%) of utilitarian trips substituted motor vehicle trips, while only 12.3% of recreational trips did. The prevalence of this response among utilitarian trips may be due to respondents interpreting the question to mean that they used their e-bike to access exercise or recreational activities that they otherwise would have gotten to by car, such as going to the gym. This dynamic is visualized in Figure 12.

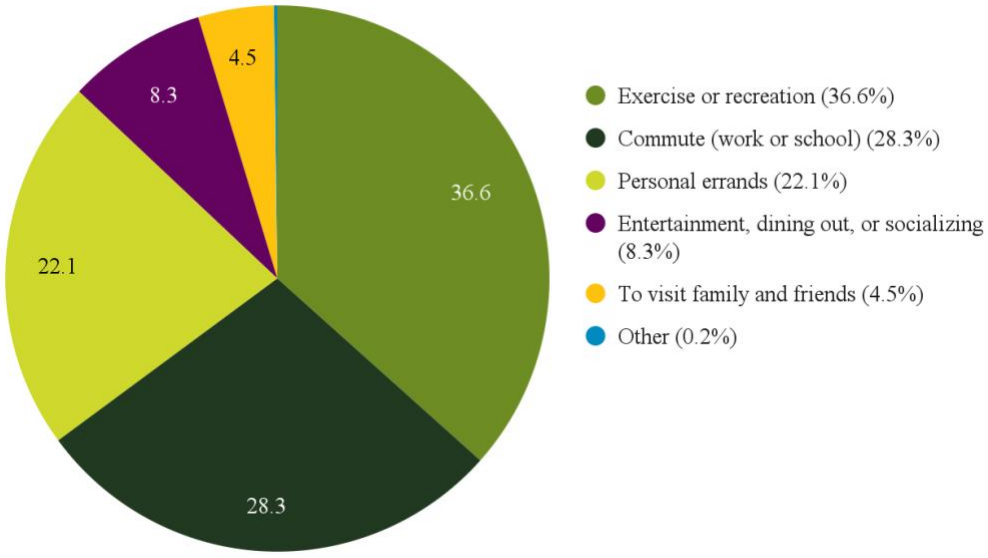

Figure 11. Trip Purpose for Last Three E-Bike Trips (n=11,827)

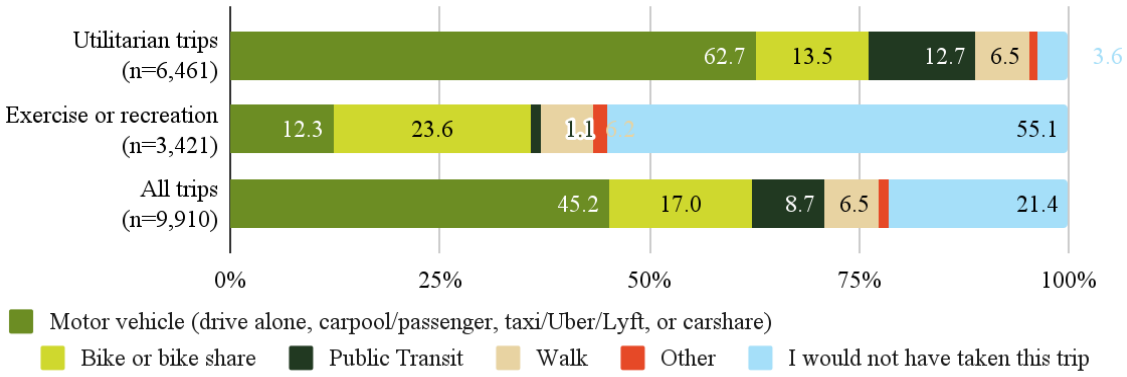

Figure 12. Substituted Mode by Trip Type, Utilitarian vs. Recreational

When asked directly, respondents estimated that they substituted an average of 41% and a median of 32% of their vehicle miles traveled (VMT) with their e-bike in a typical week. Utilitarian riders (n=2,569) replaced a median of 43% of their VMT with their e-bike, compared to 5% by recreation-only riders (n=508).

The mean round-trip distance for 9,876 tours with recorded distances and substituted modes was 12.5 miles and the median distance was 10.0 miles. Trips replacing car share, induced trips, and trips replacing bike trips tended to be the longest, while trips replacing driving and walking tended to be shorter. A summary of trip distance by substituted mode is shown in Table 10.

Table 10. Round-Trip Distance by Substituted Mode

	Trip Distance (miles)			
Substituted Mode	**Mean**	**Median**	**St. Dev.**	**Count**
Walk	5.7	3.0	7.2	639
Carpool/passenger	9.8	6.7	8.8	481
Drive Alone	10.0	7.1	8.6	3,735
Public Transit	11.2	8.7	9.0	859
Taxi/Uber/Lyft	14.4	9.6	12.2	174
Bike	14.6	11.1	11.9	1,612
Bike Share	15.6	11.2	13.1	71
I would not have taken this trip	17.9	15.0	12.5	2115
Car share (e.g. Car2Go, ZipCar)	19.8	16.2	15.7	74
Other	13.1	10.5	9.5	116
Total	12.5	10.0	10.9	9,876

Round-trip trip tour distances were notably longer for recreational trips (median=15.0 miles) than for utilitarian trips (median=6.3 miles). Distances for both trip types were heavily positively skewed. The relationship between trip type and round-trip travel distance is shown in Table 11.

Table 11. Round-Trip Distance by Trip Type

	Trip Distance (miles)			
Trip Type	**Mean**	**Median**	**St. Dev.**	**Count**
Recreational	18.1	15.0	12.4	3,603
Utilitarian	9.5	6.3	8.6	6,493
Other	13.5	12.4	7.4	27
Total	12.6	10.0	10.9	10,123

The majority (65.5%) of respondents indicated that they ride for different purposes or to different destinations with their e-bike than they would with a non-electric bicycle. This proportion was nearly identical among people who rode a non-powered bicycle daily or weekly (65.8%) and among people who rode infrequently (66.6%) before purchasing an e-bike. In comments, they reported that this was typically due to the ability to go further, go faster, climb hills more easily, or carry cargo for errands or family transportation. Many respondents noted that they viewed their e-bike as a transportation tool and riding their non-electric bicycle as a recreational activity.

When trip purpose and substituted mode are disaggregated by age, a bi-modal use of the technology becomes apparent. Younger e-bike owners use their bikes primarily for utilitarian trips, while older respondents engage in recreational, induced trips at much higher rates. This switch seems to take place between the ages of 55 and 64, when commute trip purposes are likely heavily reduced due to retirement. Trip purpose and substituted mode by age are shown in Figure 13 and Figure 14, respectively.

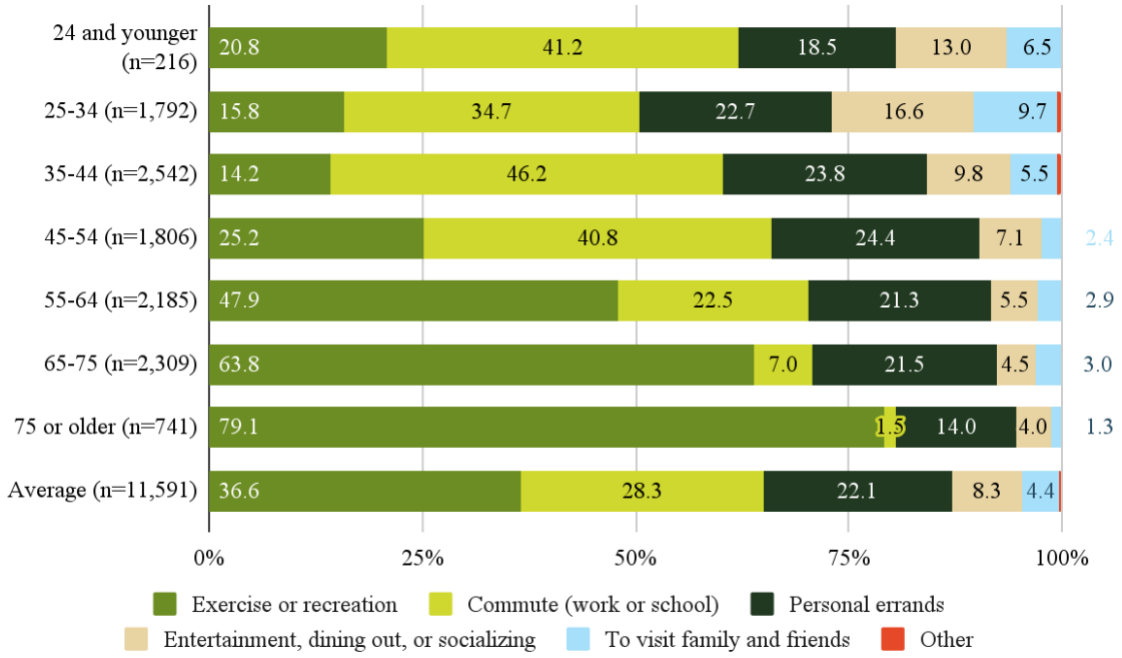

Figure 13. Trip Purpose for Three Most Recent E-Bike Trips by Age

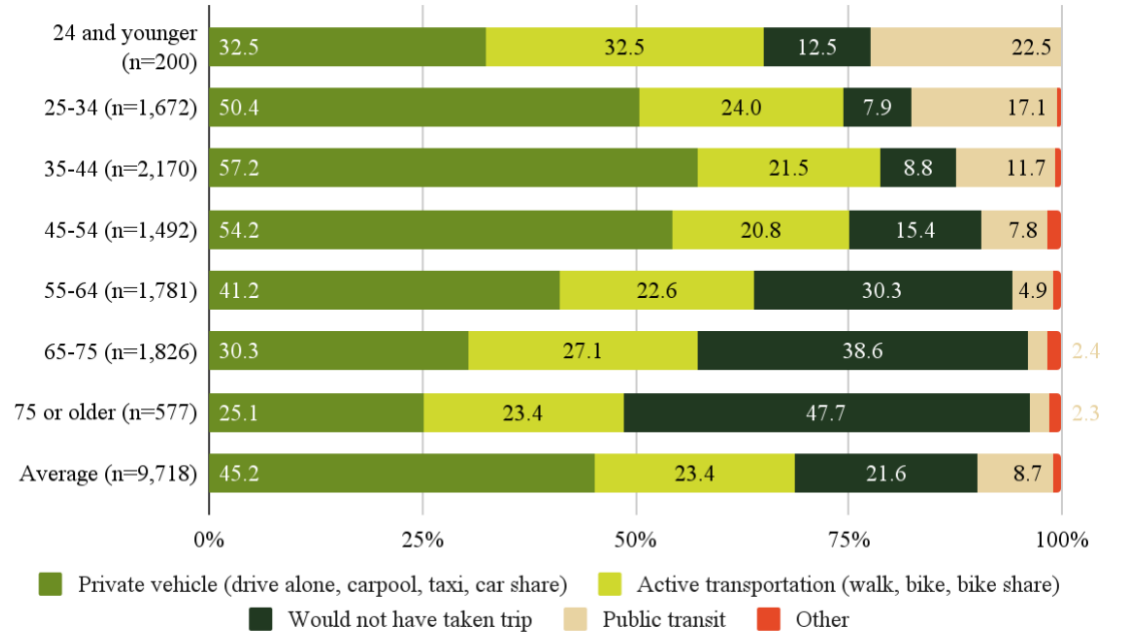

Figure 14. Substituted Mode for Three Most Recent E-Bike Trips by Age

This bi-modal split in e-bike usage is more obvious when the proportion of respondents reporting only recreational trips is displayed by age. Only 2.3% of 25–34-year-olds reported riding their e-bike exclusively for recreational purposes, while 65.0% of those 75 and older did. This trend is visualized in Figure 15.

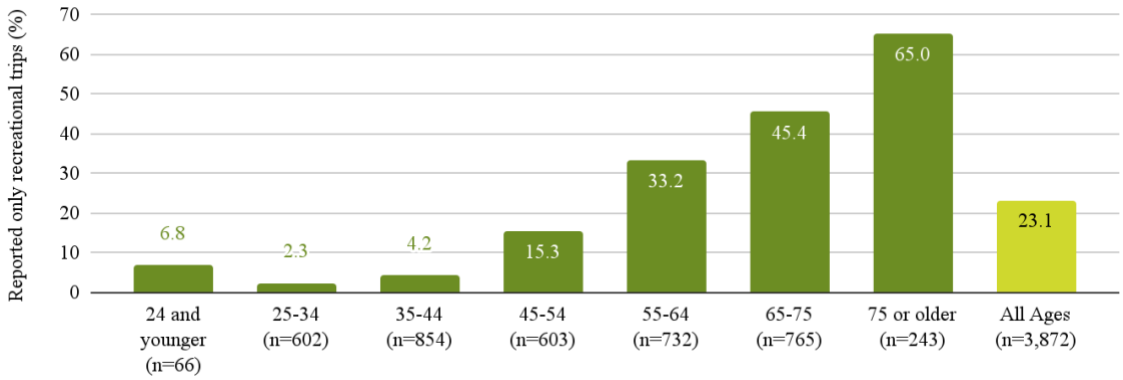

Figure 15. Recreation-Only Riders by Age

4.5 Perceptions

E-bike owners generally had positive attitudes regarding their bikes. Most indicated that they enjoyed their overall experience (95%), found their bike to be a convenient way to get from one place to another (84.6%), and would prefer to ride their bike more often (81.7%). They claimed they would ride their e-bike more with better infrastructure (84.1%), expressed a desire for physical protection from vehicle traffic to enable them to ride more (78.5%), and expressed worry about being hit by a motor vehicle (67.7%). E-bike riders generally wear a helmet (89.9%). A summary of attitudes relating to the benefits of e-bikes is shown in Figure 16, and attitudes relating to challenges in Figure 17.

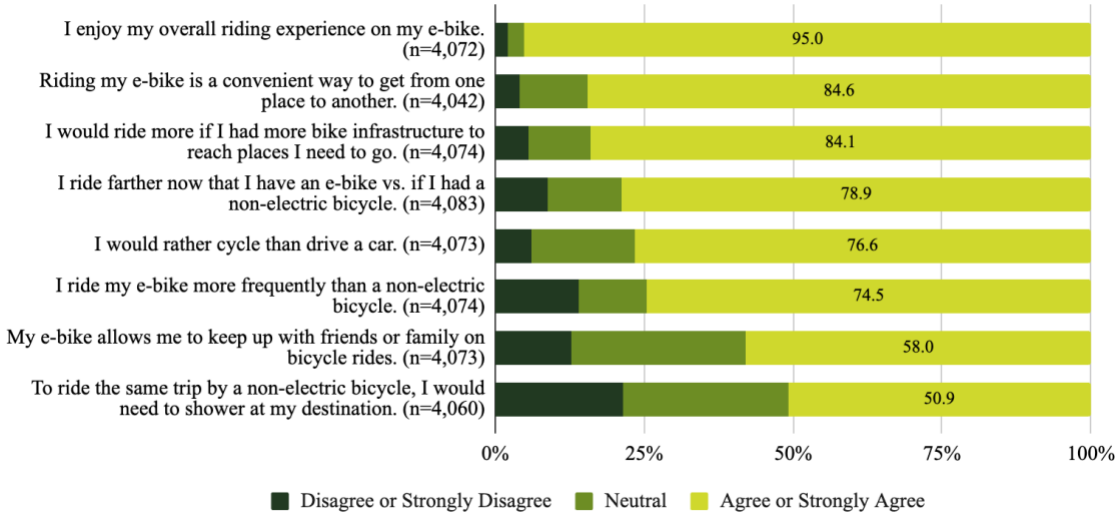

Figure 16. Attitudes Related to the Benefits of E-Bikes

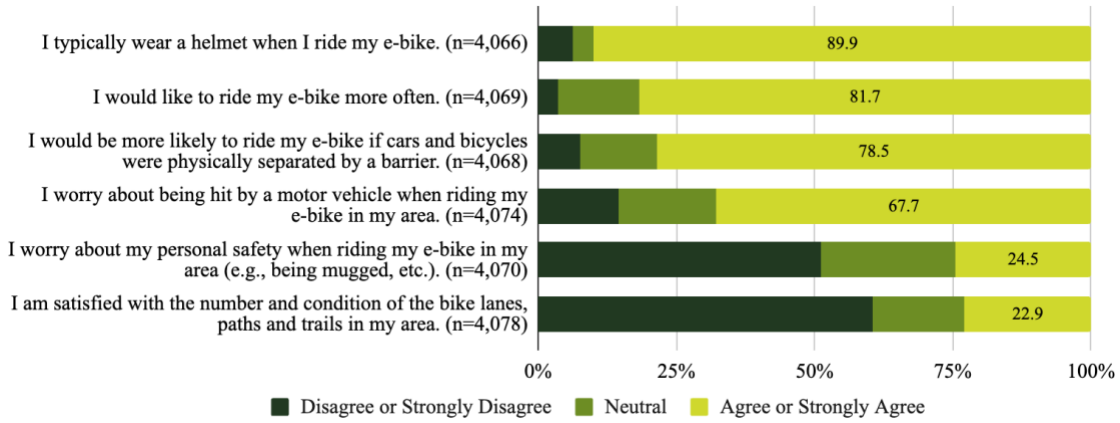

Figure 17. Attitudes Related to the Challenges of Riding Bicycles

The most-selected barrier to riding their e-bike more that respondents reported was the weather; nearly half reported this challenge. Parking security, lack of safe infrastructure, and heavy vehicle traffic were each reported by nearly 40% of respondents. Only very few respondents reported that hills, their physical ability, and an aversion to being sweaty were barriers, indicating that e-bikes can effectively eradicate these challenges to non-motorized cycling. A full summary of reported barriers is shown in Figure 18.

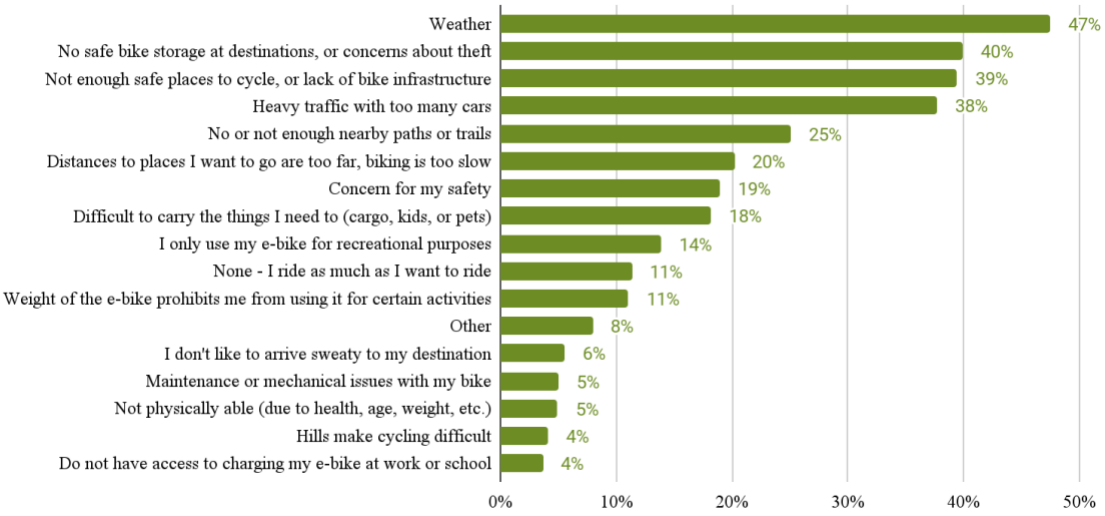

Figure 18. Barriers to Riding an E-Bike More (n=4,086)

4.6 Safety

When asked about their experiences, survey respondents generally feel safe on their e-bikes (agree or strongly agree 77.1% of the time), find that their e-bikes help them go faster than they would on a standard bicycle (77.1%), and that they travel faster than other cyclists (58.4%). Respondents felt marginally safer on an e-bike than on a standard bicycle. A third (34.4%) of respondents felt that other road users misjudge their speed. Figure 19 visualizes the safety perceptions of the survey sample. A number of commenters noted that their use of their e-bike has decreased following the pandemic due to increased theft and poor motorist behavior.

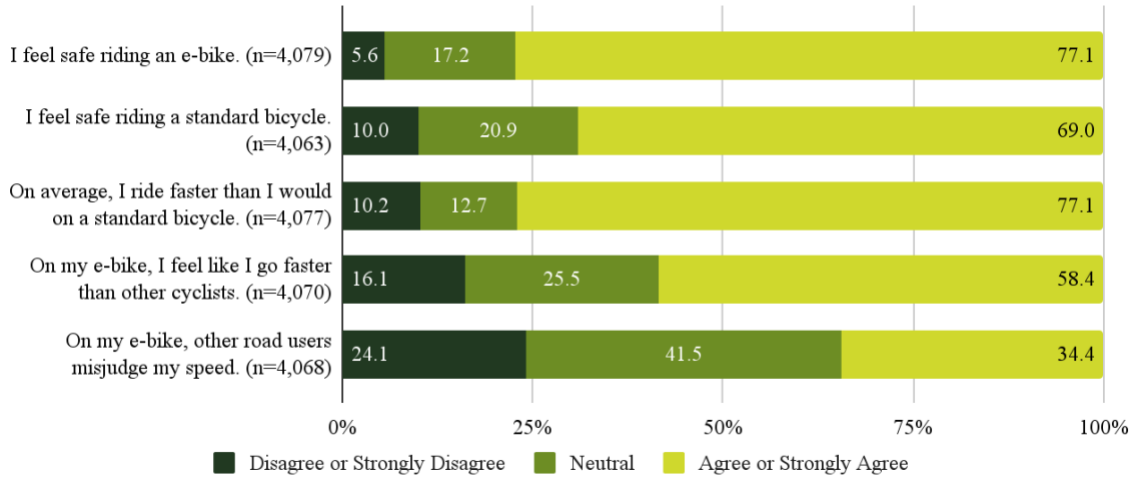

Figure 19. Safety Perceptions of E-Bike Riders

The survey asked respondents how many crashes they had experienced in the last two years. Two-thirds (66.0%) of the sample responding to the crash frequency question had purchased their bikes within two years of the survey date; reported crash rates were

moderated by purchase year to account for this. Those having purchased their e-bikes in 2023 were assumed to have owned them for two months on average due to the survey being available April 5th to May 15th. Crash rates for respondents that purchased their bikes in 2022 and 2021 were also adjusted accordingly. On average, respondents reported experiencing 0.31 crashes/year, or one crash every 3.27 years.

Respondents were then asked about the details of their most recent crash. Over three-quarters (77.3%) of crashes did not involve another road user. In 44.1% of crashes, an object or uneven surface was involved, and a third (33.2%) of the time the rider simply lost control of their e-bike. The majority of crashes (86.7%) resulted in no injury or injuries minor enough to remedy at home, while only 13.3% resulted in a serious injury and/or the inability to continue cycling. Very few crashes (8.4%) resulted in a police report, while around a quarter (26.4%) resulted in a visit to a medical professional. Only one in five (20.0%) of severe injury crashes resulted in a police report, while riders in almost all (95.6%) of the same crashes sought medical care. Less than half (37.9%) of crashes with a motor vehicle resulted in a police report. A similar proportion of e-bike/motor vehicle crashes resulted in the e-bike rider seeking medical care (40.8%). A summary of crash characteristics is included in Table 12.

E-bike class had a statistically significant effect on crash severity (chi-squared test across all classes and severities; p=0.047). Out-of-class e-bikes showed slightly higher rates of moderate and severe crashes than classed e-bikes, as did class 3 bikes to a lesser extent. The relationship between e-bike class and crash severity is visualized in Figure 20.

Table 12. Crash Characteristics

In your most recent crash, who or what was involved? (n=725)	Value (%)
No other road users	77.3
Nothing – I lost control/Fell over	33.2
Loose gravel/sand/debris in the road	22.1
A pothole or other road object	14.8
A roadside object (tree/pole/parked car/etc.)	7.2
Motor vehicle	17.2
Another cyclist	4.7
Pedestrian	0.8
What was the severity of the crash? (n=728)	**Value (%)**
No injury	19.8
Mild (scrapes, bruises)	48.6
Moderate (cuts, bleeding)	18.3
Severe (trip to hospital, broken bone, inability to continue cycling, etc.)	13.3
File a police report following the crash (n=725)	**Value (%)**
Yes	8.4
No	91.6
Sought medical care following the crash (n=732)	**Value (%)**
Yes	26.4
No	73.6

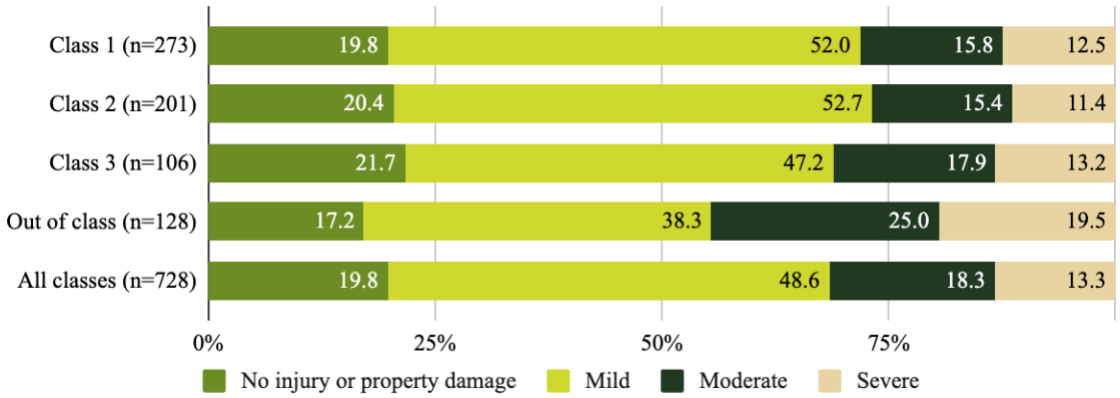

Figure 20. Crash Severity by E-Bike Class

What parties were involved in a crash had a noticeable impact on the severity of the crash. Crashes involving motor vehicles were most likely to result in serious injuries (17.7% of the time) but were not extraordinarily different in severity distribution from other crash types. Only 22.7% of severe injury crashes occurred in conflict with motor vehicles; the majority (72.2%) did not involve another road user at all. A full cross-tabulation of crash severity and involved parties is visualized in Figure 21 and Figure 22.

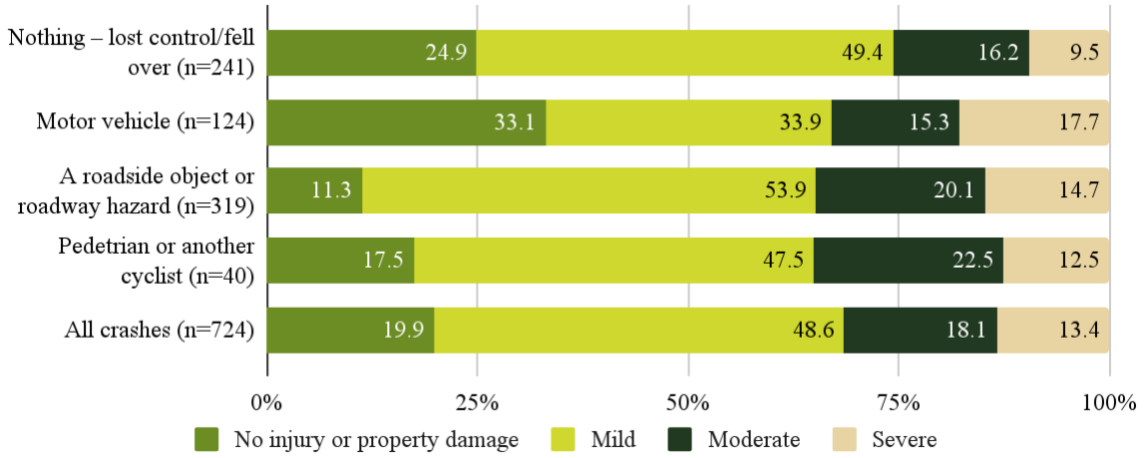

Figure 21. Crash Severity by Involved Parties

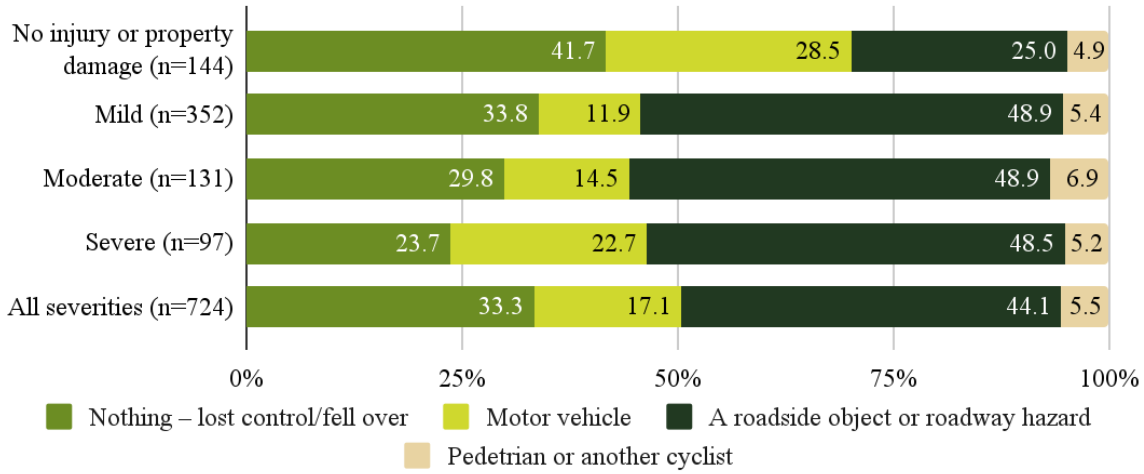

Figure 22. Involved Parties by Crash Severity

4.7 Regulatory Concerns

Only a small proportion of households with children in them allowed their children to ride their e-bikes (14.7%). A chi-squared test indicated that the age of the children present in the household is a significant predictor of whether or not the children spent any time operating the e-bike ($p<0.001$). Usage rates were significantly higher for households with children 10-15 years old, riding e-bikes 31.3% of the time, than in households with children younger than 10 alone, who only rode e-bikes 4.5% of the time. Households with children 10-15 and younger than 10 allowed their children to ride an e-bike 32.4% of the time. Use of e-bikes by the children is tabulated in Table 13.

Table 13. Use of E-Bikes by Children

Do any of the children in your home spend time operating an electric bicycle (not as passengers)?	Value (%)	
	Yes	No
Households with children under 10 only (n=710)	4.5	95.5
Households with children 10-15 years old only (n=281)	31.3	68.7
Households with children under 10 and 10-15 years old (n=142)	32.4	67.6
All households with children (n=1,133)	14.7	85.3

Seven states currently require e-bike riders to have a driver's license. This may not be a meaningful consideration; almost all respondents (97%) reported having a driver's license.

Respondents were asked at the beginning of the survey what class their e-bike was and were shown Classes 1, 2, 3, and "I don't know" as options. They were later asked to describe the top assisted speed and the presence of a throttle on their e-bikes, from which

the correct class of the e-bike could be inferred. Less than half (47.8%) of respondents guessed their e-bike's class correctly. Nearly a quarter (23.2%) admitted to not knowing what class their e-bike was, with nearly a third (28.9%) guessing incorrectly. Due to the uncertainty regarding the true class of the e-bikes reported by respondents, an analysis was run on a subset of the data for which e-bike class was known with relative certainty. Rad Power Bikes are known to be class 2 unless modified after purchase and were the most represented brand in the survey sample (14.9%). Less than two thirds (60.7%) of Rad owners correctly identified their bikes' class as class 2.

Respondents overwhelmingly wore helmets when they rode their bikes, selecting "Agree" or "Strongly Agree" to "I typically wear a helmet when I ride my e-bike." 89.9% of the time. Helmet usage rates were slightly lower for people with class 2 and class 3 e-bikes than those with class 1 or out-of-class bikes, but rates were generally similar among all classes of e-bike. Helmet usage rates by e-bike class are shown in Figure 23.

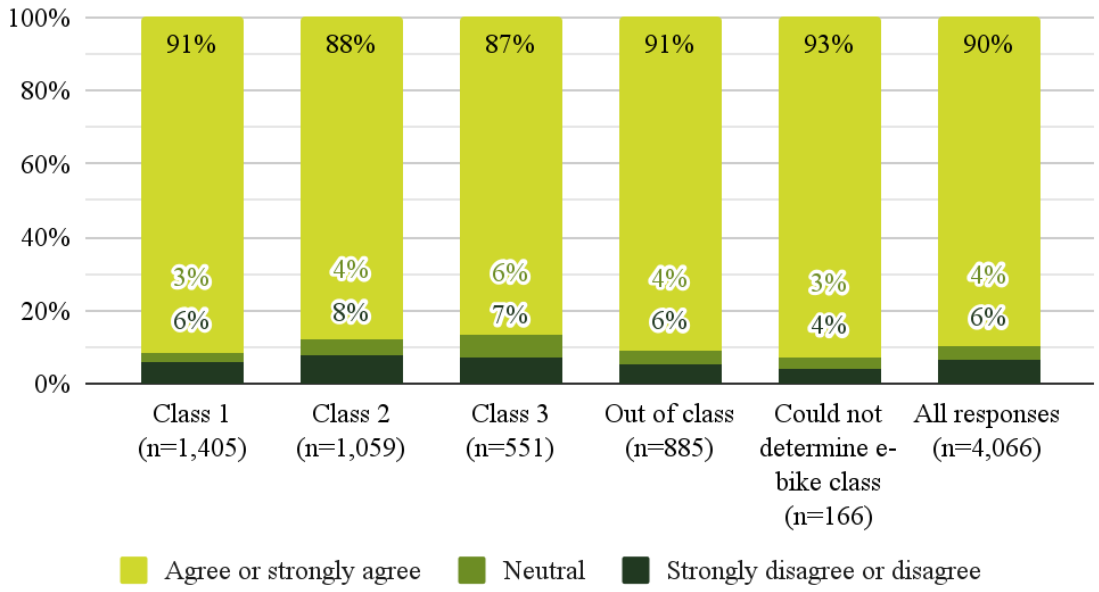

Figure 23. Helmet Usage by E-Bike Class, "I typically wear a helmet when I ride my e-bike."

4.8 Maintenance

Three quarters (75.3%) of e-bike owners have required no service on their bike to-date, with only one in twenty (5.0%) having needed service three times or more. Among those that have had service done, half (51.1%) have had normal tune-ups or fixes done, with repairs to electronics (29.8%), repairs to the motor (23.6%), and repairs or replacement of the battery (21.4%) being the next-most common. Tire replacement, repairing crash damage, fixing faulty or worn wiring, warranty or recall replacements, and troubleshooting software challenges were listed as other common reasons for needing service.

For those who had experienced a failed battery, the most common approach was to deliver it to their local bike shop (40%). A quarter (23.2%) have kept the battery stored at home, while 13.5% have recycled it and 8.4% have repaired it. Very few respondents (0.4%) threw away their failed battery in the residential trash. The majority of respondents selecting “other” for a hypothetical question of their battery failing indicated that they intended to contact their bike’s manufacturer or their local bike shop to inquire about their options, or that they intended to repair the battery or have it repaired by someone else. A summary of the e-bike service experience of respondents is shown in Table 14.

Table 14. E-Bike Service Needs

How many times have you had your e-bike serviced because of an issue related to the battery, motor or electronic system? (n=2,964)	Value (%)
No service needed to date	75.3
1	13.7
2	6.0
3 or more times	5.0
Why did you need to have your e-bike serviced? (n=732)	**Value (%)**
Normal bicycle-related tune-ups or fixes	51.1
Repairs to the electronics/display	29.8
Repairs to motor	23.6
Repair or replace battery	21.4
Other	22.3
What did you do with the failed battery? (n=155)	**Value (%)**
My local bike shop took it	40.0
I still have it stored at my home	25.8
I delivered it to a recycling center or battery drop box	13.5
I repaired it or had it repaired	*8.4*
I sent it back to the manufacturer	7.7
I still use it, if only occasionally	*2.6*
I sold battery alone and kept the bike	*1.3*
I threw it away in my residential trash	0.6
What would you do if a battery failed or stopped working? (n=2,787)	**Value (%)**
Take it to my local bike shop for disposal or recycling	45.1
Deliver it to a recycling center or battery drop box	22.8
Send it back to the manufacturer	13.7
Keep it stored at my home	1.9
Sell my e-bike and battery together	1.3
Throw it away in my residential trash	0.5
Throw away my e-bike and battery together	0.4
Other	14.2

Italics indicate a category derived from text responses to “other” options on multiple-choice questions.

4.9 Comparison to Previous Editions of the Survey

A comparison of the 2023 survey results to previous editions of this survey paints a picture of a changing population of North American e-bike owners. Notably, the percentage of the sample that identified as male has dropped precipitously from 85% in 2013 to 61% today. Modest changes in the racial demographics of owners are notable; 84% of respondents today identify as white, compared to 90% in 2013 and 85.2% in 2017. Fewer respondents claim they suffer from physical limitations, the share falling from 30% in 2013 to 12% today. The age of e-bike owners has changed to include more younger and older people over time; there is a higher share of respondents under the age of 45 (34%) and over the age of 65 (27%) than there were in previous survey years. A graphic of these changes is included in Figure 24.

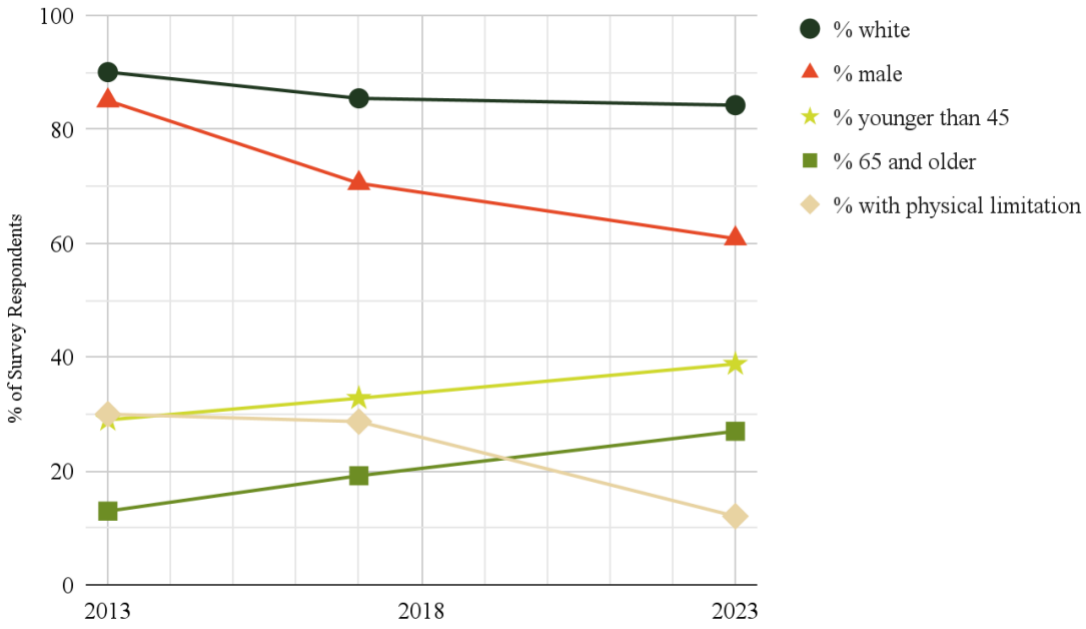

Figure 24. Demographic Change Among E-Bike Owners, 2013 to 2023

Over time, the e-bike market has shifted dramatically from conversions to ready-built new e-bikes. In the 2015 edition of the survey, 52% of respondents rode conversions, compared to 21.3% in 2018 and 5.5% today. This change is shown in Figure 25.

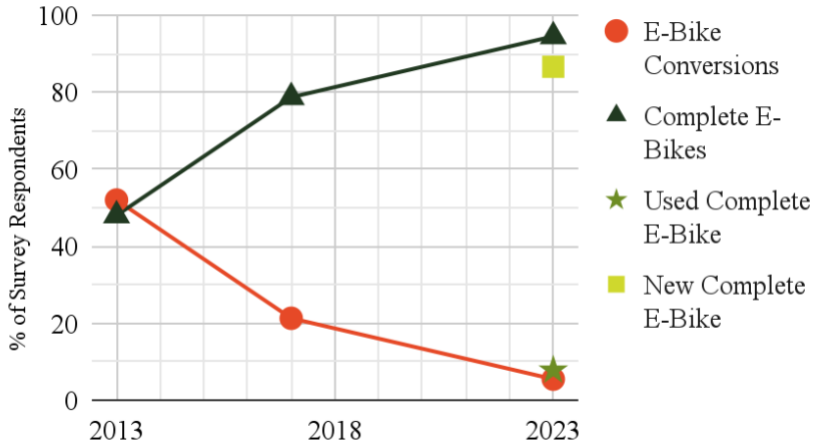

Figure 25. E-Bike Conversions and Complete E-Bikes, 2013 to 2023

The share of e-bike owners with and without previous cycling experience has stayed relatively steady over time. Less than 6% of owners were non-riders prior to purchase in 2013, and this figure has only risen modestly to 7.3% in 2023. The reported share of riders having ridden weekly or more prior to e-bike purchase has risen slightly from 55.0% to 59.0%. This trend is illustrated in Figure 26.

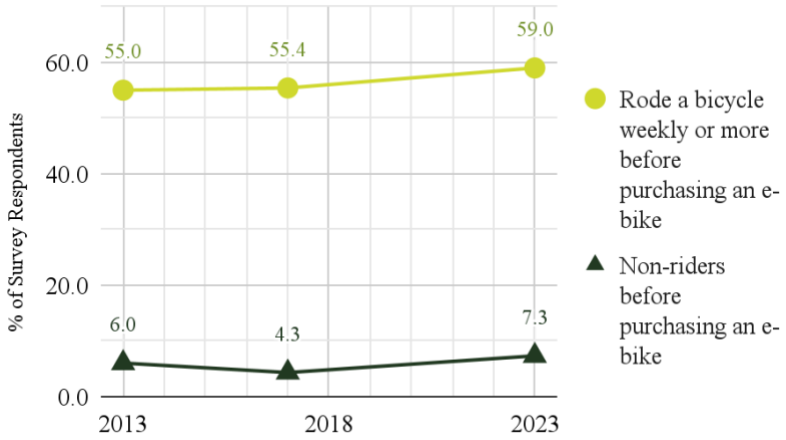

Figure 26. Frequency Riding a Bicycle Before Purchasing an E-Bike, 2013 to 2023

E-bike trip purposes have shifted substantially over the last decade. Some of the variability in the data, particularly in the "other" and "local trips" categories is due to changes in the way that trip purposes were recorded in the three surveys. However, the commute trip option has remained constant throughout each survey iteration, making the decrease in commute trips from 45% to 28% is notable. Likewise, the share of recreational trips has increased since 2013, but remained relatively constant since 2017. Trip purposes over the three survey periods is shown in Figure 27.

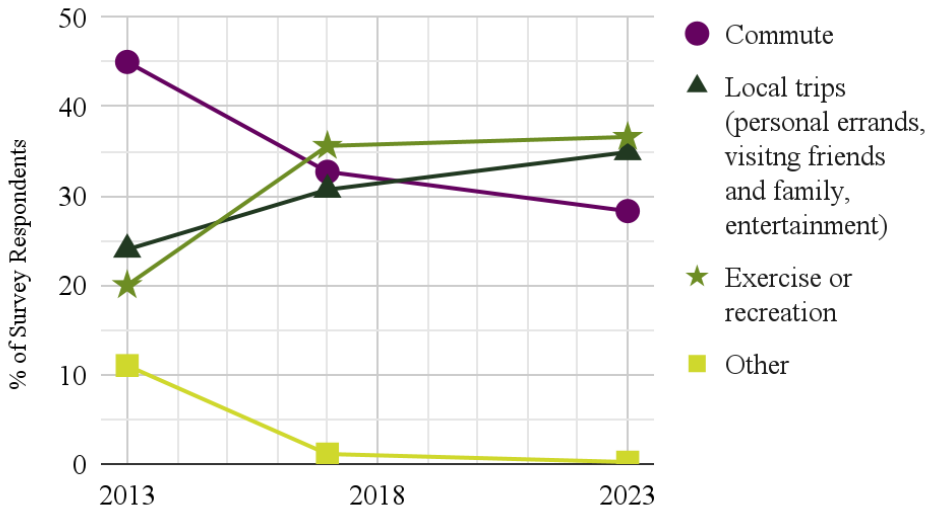

Figure 27. E-Bike Trip Purpose, 2013 to 2023

Mode substitution changed substantially between the 2017 and 2023 surveys. Car replacement rose by 9.4 percentage points (a 27% increase), while induced trips dropped by 8.5 percentage points (a 28% decrease). This trend is illustrated in Figure 28.

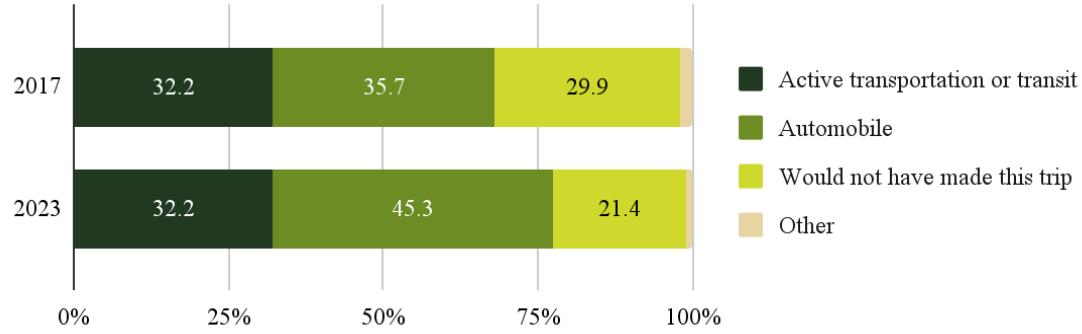

Figure 28. Mode Substituted by Three Most Recent E-Bike Trips, 2017 vs. 2023

Trip distances were notably longer in the 2023 cohort than in 2017. However, this increase is very likely the result of a reworded prompt for the trip questions. Respondents were asked explicitly to consider trips as round-trip activities: “Think back on the last three times you used an e-bike leaving home and returning again with any number of stops along the way.”, rather than “Think back on the last three times you used an e-bike…how would you have traveled to your destination?” in the 2017 survey. A breakdown of trip distances by substituted mode is shown in Figure 29.

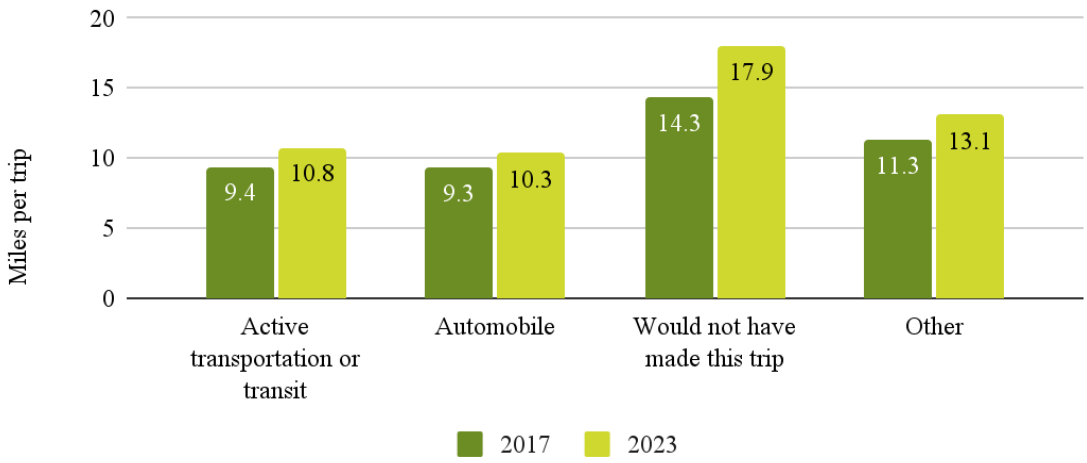

Figure 29. Trip Distance by Substituted Mode, 2017 vs. 2023

4.10 E-Bike Purchase Incentive Recipients

Available incentives were seriously considered at purchase by 18.0% of those making less than 200% FPG and 14.3% of those making less than 400% FPG, a statistically significant difference to the 10.8% and 10.1% that seriously considered available incentives with incomes over those thresholds, respectively.

A relatively small sample (n=236) of e-bike purchase incentive recipients remained after data cleaning. Among these, most incentives (69.0%) were $500 or less and were provided by a power provider (32.6%) or a local government (26.3%). More than half (62.3%) of incentives were delivered as a post-purchase rebate. The City and County of Denver, CO (18.2%) and State of Vermont (16.8%) were by far the most represented programs. A full breakdown of incentive programs represented in the sample is included in Appendix D. A third (33.9%) of incentive recipients indicated that they would not have purchased their e-bike without an incentive, while 15.3% indicated that they would have purchased a different model. Table 15 describes the incentive program statistics represented in the sample.

In a comparison between incentive recipients and non-recipients, incentives were found to have a significant correlation with converting higher rates of seldom or non-cyclists that bicycled less than weekly before owning an e-bike, representing 45.6% of incentive recipients as compared to 30.8% of non-recipients. Incentive programs also correlated with a significant positive change in the proportion of non-male riders, from 38.6% to 50.9%. Incentive programs were not significantly correlated with higher proportions of people who

had children present in the household, 55 years old or older, were nonwhite, had low incomes, or had physical limitations. Table 16 provides a full breakdown of these attributes compared between incentive recipients and non-recipients.

Table 15. Incentive Receipt in the Survey Sample

Did you (or do you expect to) receive a purchase incentive, cash rebate, or tax rebate when you purchased your e-bike? (n=4,068)	Value (%)
Yes	7.1
No	92.9

Incentive amount (n=235)	Value (%)
$0-250	23.0
$251-500	46.0
$501-1,000	19.1
$1,001-2,000	10.2
$2,000+	2.1

Would you have purchased your e-bike without the incentive or rebate? (n=236)	Value (%)
Yes	50.8
No	33.9
I would have purchased a different model of e-bike	15.3

Incentive provider type (n=236)	Value (%)
Power provider	32.6
Local government	26.3
State/Province/Territory government	19.5
Multiple	7.2
Nonprofit	6.4
Air quality management authority	5.1
Employer	2.5
Unsure/don't remember	0.4

Incentive delivery mechanism (n=236)	Value (%)
Post-purchase rebate	62.3
Point-of-purchase discount	33.9
Multiple incentives with different mechanisms	1.7
Tax rebate	1.3
Free e-bike	0.8

Table 16. Demographic Difference Between Incentive Recipients and Non-Recipients

	Count	Total incentive recipients	Value (%)		Chi-squared
			Incentive recipients	Non-Recipients	
Seldom/non-cyclist before purchasing an e-bike (n=3,763)	3,763	215	**45.6**	**30.8**	**<0.001**
Non-male (n=4,054)	4,054	234	**50.9**	**38.6**	**<0.001**
Children under 16 in the household (n=4,046)	4,046	235	22.6	28.2	0.061
Age 55 or older (n=3,985)	3,985	230	40.9	46.4	0.103
Nonwhite (n=3,948)	3,948	229	10.0	13.7	0.120
Income < 200% FPG (n=3,747)	3,747	214	10.7	8.1	0.176
Income < 400% FPG (n=3,747)	3,747	214	36.9	33.3	0.282
Physical limitation (n=4,051)	4,051	235	13.6	12.1	0.500

Bold indicates significant differences between groups based on a chi-square test across the two groups shown in the table ($p<0.05$).

Incentive recipients less often purchased an e-bike for recreational reasons or due to a physical condition, and more often considered the hassle and cost of auto trips and environmental reasons important to their purchase decision. Other reasons for purchase did not provide significant differences between the two groups. A full breakdown of these differences is shown in Table 17.

Table 17. Top Three Reasons to Purchase or Convert to an E-Bike, Incentive Recipients vs. Non-Recipients

Reason to purchase or convert to an e-bike	Value (%)		Chi-squared
	Incentive recipients (n=236)	Non-Recipients (n=3,832)	
Health – a medical condition reduced my ability to ride a non-electric bicycle	**6.8**	**15.0**	**<0.001**
For environmental reasons	**28.4**	**20.3**	**0.003**
To replace the hassle of car trips (traffic, parking, etc.)	**37.7**	**29.2**	**0.005**
To be able to keep up when riding with friends/family	**8.5**	**15.0**	**0.006**
It's a cost effective form of transportation	**30.1**	**23.1**	**0.014**
Health – to increase fitness	**14.0**	**20.4**	**0.017**
Because I live or work in a hilly area	26.3	21.8	0.111
To start cycling or to cycle more often	19.5	16.1	0.175
For recreation purposes	20.3	24.1	0.184
To ride longer distances to places I need to go	28.0	24.2	0.193
I enjoy riding an e-bike more than a non-electric bicycle	10.2	12.9	0.215
For accessing recreational activities (park, gym, etc.)	5.9	4.5	0.313
To ride with less effort or arrive less sweaty	30.9	29.5	0.650
To carry cargo or kids	20.3	19.9	0.865
Other	6.8	7.4	0.708

Bold indicates significant differences between groups based on a chi-square test ($p<0.05$).

Nearly three-quarters (71.6%) of trips by incentive recipients were utilitarian in nature, with the remaining 28.4% being exercise or recreational rides. A statistically significant (chi-squared test $p<0.001$) smaller proportion of incentive recipients only took recreational trips (11.9%, n=227) as compared to the rate among non-recipients (23.9%. n=3,698), among those reporting at least one non-recreational trip or three recreational trips. A complete breakdown of trip purposes among incentive recipients is shown in Figure 30.

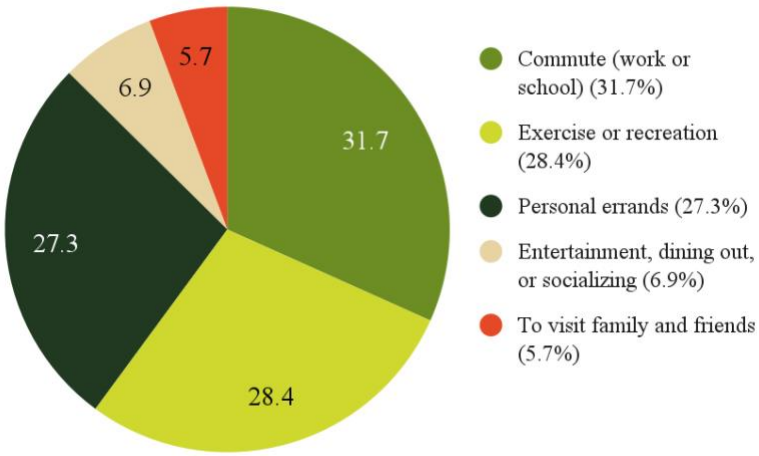

Figure 30. Trip Purpose, Last Three Trips by Incentive Recipients (n=682)

Half (49.5%) of trips by incentive recipients substituted automotive trips in the form of drive alone, carpool/passenger, or taxi/Uber/Lyft. One-fifth (20.5%) would not have otherwise happened, and the rest (28.7%) substituted active transportation and transit. A full breakdown by substituted mode is shown in Figure 31.

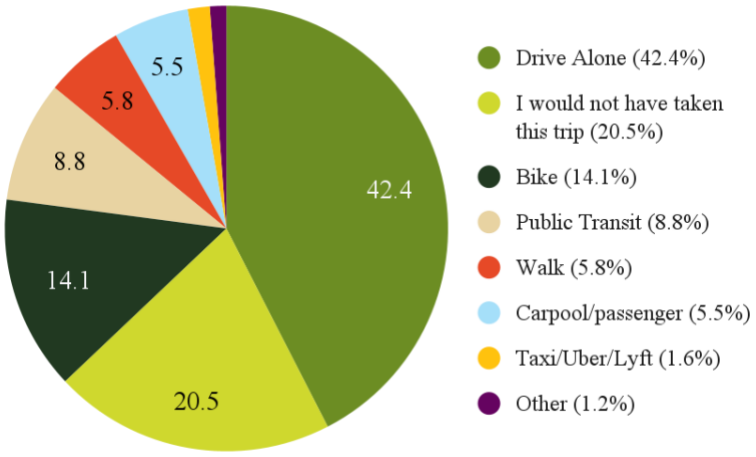

Figure 31. Substituted Mode, Last Three Trips by Incentive Recipients (n=566)

Trips by e-bike owners were generally more utilitarian than the general public and substituted drive-alone trips at a higher rate. Incentive recipients used their e-bikes for exercise or recreation 28.4% of the time, as compared to 37.2% of the time among non-recipients. They also substituted drive-alone trips 42.4% of the time, compared to 37.4% of the time by non-recipients. The differences in trip purpose and substituted mode are shown in detail in Figure 32 and Figure 33.

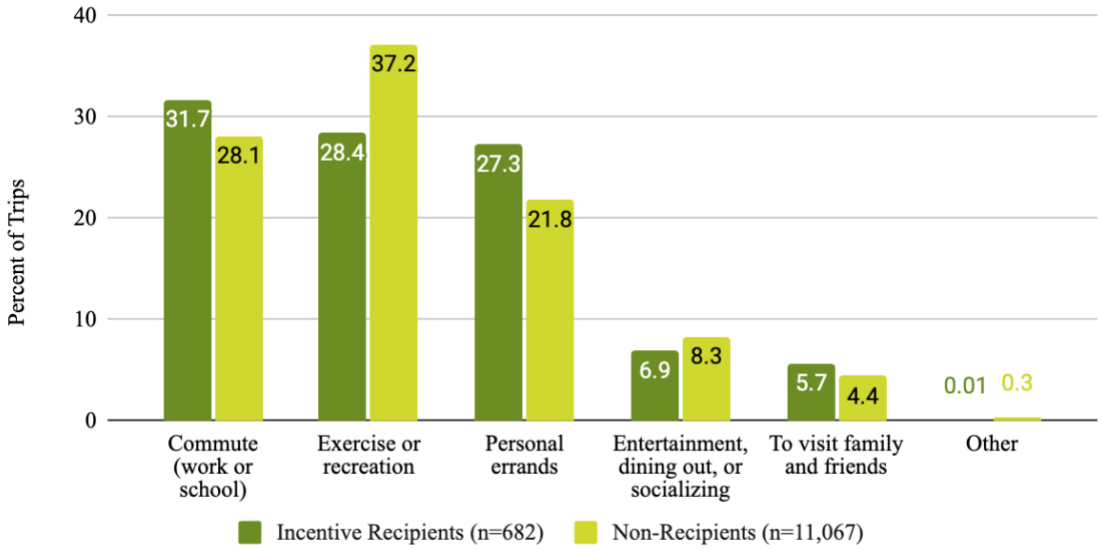

Figure 32. Trip Purpose, Incentive Recipients vs. Non-Recipients

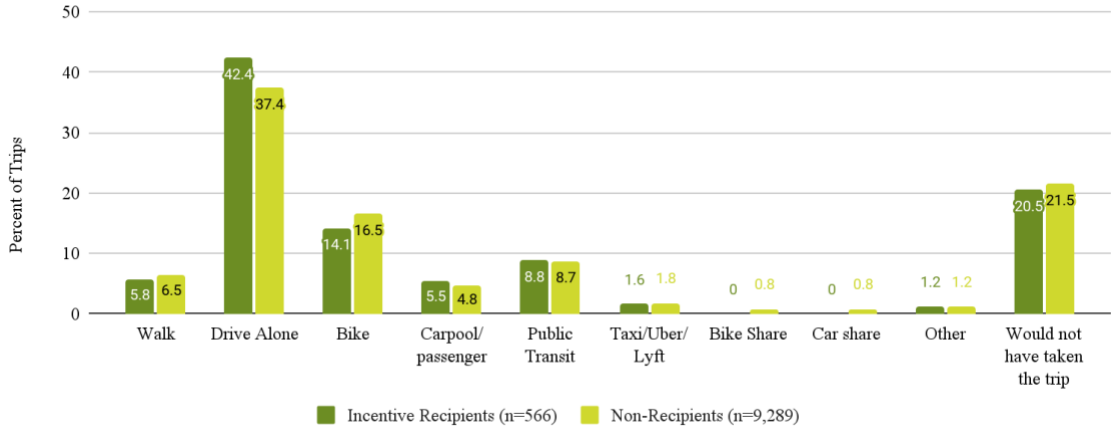

Figure 33. Substituted Mode for Trips, Incentive Recipients vs. Non-Recipients

Incentive recipients generally spent a smaller amount out-of-pocket on their e-bikes than non-recipients did. Mean purchase prices were 21% lower than those for non-recipients, and median prices were 13% lower, as shown in Table 18. Over half (54.8%) of incentive recipients spent $2,000 or less on their e-bike, compared to 46.0% of non-recipients. The relationship between purchase price and incentive receipt is visualized in Figure 34.

Table 18. Purchase Price, Incentive Recipients vs. Non-Recipients

	Mean Purchase Price	Median Purchase Price	St. Dev.
Incentive recipients (n=228)	$2,511.74	$2,000.00	$1,931.98
Incentive non-recipients (n=3,667)	$3,179.82	$2,300.00	$3,270.50
All respondents (n=3,895)	$3,176.94	$2,375.00	$3,212.38

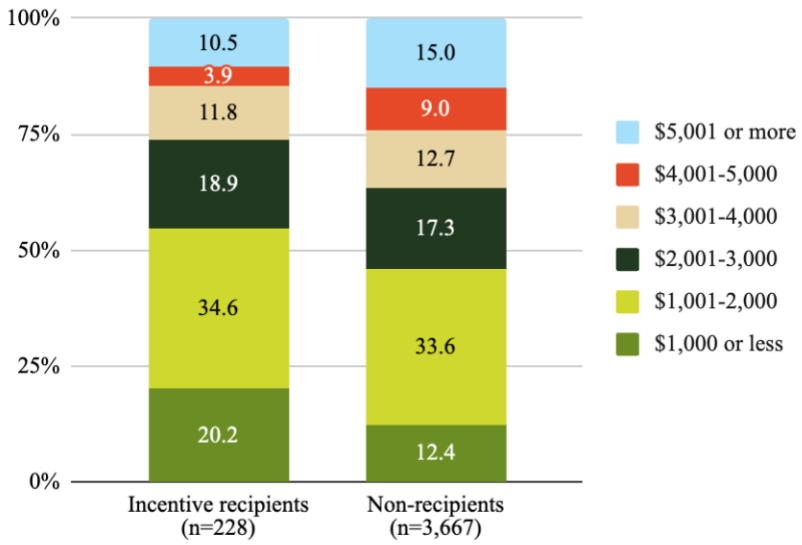

Figure 34. Purchase Price After Incentive, Incentive Recipients vs. Non-Recipients

When incentive values were added to the purchase price of the e-bike, incentive recipients were found to have purchased e-bikes of approximately equal value to non-recipients. Average total value decreased by 2%, while median value increased by 5% for incentive recipients. This dynamic is shown in Table 19. Incentive recipients purchased bikes worth $2,000 or less only 36.8% of the time, compared to 46.0% of the time by non-recipients. The proportion of e-bikes worth $3,000 or more was almost identical between the two groups (37.7% and 36.7%, respectively). This relationship is shown in Figure 35.

Table 19. Purchase Value, Incentive Recipients vs. Non-Recipients

	Mean E-Bike Value	Median E-Bike Value	St. Dev.
Incentive recipients (n=228)	$3,130.52	$2,425.00	$2,068.02
Incentive non-recipients (n=3,667)	$3,179.82	$2,300.00	$3,270.50
All respondents (n=3,895)	$3,176.94	$2,375.00	$3,212.38

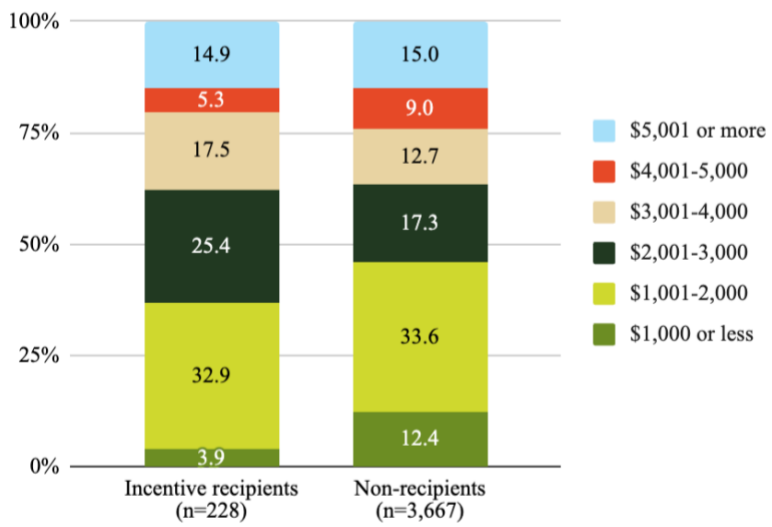

Figure 35. Purchase Price Plus Incentive Value, Incentive Recipients vs. Non-Recipients

5 Discussion

5.1 Discussion of Results

This thesis sought to provide insight into e-bike ownership in North America through the fulfillment of nine primary objectives. Taken as a whole, these objectives are related to the potential for e-bikes to tap latent demand for bicycle transportation and to increase frequency of riding and distances traveled by bicycle.

The first objective was to assess the demographic information provided by respondents to get a better understanding of who e-bike users are. Second, the survey was to provide an understanding of the specifics of the e-bikes themselves, and considerations that went into the purchase decision. Third was to understand the types of trips e-bikes are being used for and their capacity to replace other modes of travel, especially automobiles. Fourth was to provide insight to the perceptions and motivations of people riding e-bikes. Fifth, to explore the safety implications of e-bikes and how e-bike users perceive safety while riding. Sixth, common regulatory concerns were addressed via a data-based approach. Seventh, trends in e-bike maintenance and battery replacement and retirement needs were explored.

Eighth, a limited comparison between this survey and findings from previous surveys on e-biking in North America (MacArthur et al., 2014, 2018) was conducted. A larger sample size and a more robust questionnaire permitted a more complete understanding and additional insight into previously unexplored topics. This study revealed some findings that do not correspond with the previous survey, some of which indicate a growth of e-bikes to

a broader market. This report presents the results of the 2023 survey and compares results to the previous studies when appropriate. The data of the two surveys are not statistically compared in this report. This task may be undertaken in future analyses.

Lastly, the effects of e-bike purchase incentives were also considered. An investigation was undertaken to identify whether e-bike purchase incentives are driving inframarginal participation in the market, whether recipients exhibit different use patterns from those who purchased their bikes independently and whether these use patterns support program goals for mode replacement and transportation equity, and whether these incentive programs help to convert people with differing demographics, use patterns, perceptions, motivations of e-bikes to adopting the technology.

This discussion section includes many comments from survey respondents. These quotes are often edited slightly for clarity, to remove personal details and brand names, and to maintain consistency in verbiage (e.g., e-bike vs. eBike).

5.1.1 Demographics

The survey respondents skewed coastal, with 58.1% coming from the west coast (38.9%) or the Northeast region (19.1%). A further 7.6% came from Colorado alone. This figure is in many ways reflective of the population distribution of North America more so than the distribution of e-bike owners, per se – additional clusters of responses are visible in major cities across the continent, particularly in Florida and the Chicago regions.

Participant ages were slightly bimodal, suggesting that two different segments of the population have found utility in e-bikes. A younger crowd, aged about 25 to 44, has adopted the technology as a car-replacing transportation mode, and an older crowd, composed of those 55 and up, enjoys the mobility, recreation, and fitness benefits of e-bikes. This bi-modal use of the technology is clearly indicated in the spread of ages of owners (Table 3), and the differential in trip purpose and substituted mode by age (Figure 13, Figure 14, and Figure 15).

> *"I am older (63) and riding my e-bike lets me bike more, because I'm sure I will be able to get back."*

> *"It is another option to go with the five bikes hanging in my garage. As I get older I suspect I will ride it more often on long rides with my riding group." (age 77)*

> *"We watch the wonderful YouTube channel NotJustBikes and listen to the podcast The War on Cars. We still have a car we share as a family and use it sometimes. We avoid using it though. Cars are the worst. We need the e-bike to make things work with the steep hills where we are..." (age 42)*

> *"My e-bike has made running errands so much easier and is much preferable to driving, finding parking, dealing with traffic, etc. I primarily use my e-bike to replace trips I otherwise would have made via automobile." (age 36)*

Respondents were disproportionately "stereotypical" cyclists: white, highly educated, affluent, and male. While it is hard to differentiate whether this finding is the result of the

survey outreach methods employed or the population of e-bike owners, the results are striking, nonetheless.

Respondents were generally in a good state of health and physically able. However, for many, e-bikes provided an avenue for physical activity that would not otherwise have been possible.

> *"I have been liberated by my e-bike. It is one of the best things in my life and truly became a mental/physical health savior during the pandemic. I have aggressive multiple sclerosis. Before the disease I was a regular biker, then as the balance issues came on I quit riding altogether as I would fall at stop signs because of the equilibrium shifts of stopping and restarting. I thought I'd never be able to be a cyclist again. But the throttle on my e-bike makes it so I essentially skip over the wobbles that had me falling on a regular bike…This e-bike has completely changed my life."*

The vast majority of respondents had vehicles and non-electric bicycles available in the household, as well as driver's licenses, indicating that the e-bike is often a mobility choice rather than a necessity when used for transportation.

5.1.2 E-Bikes and Purchase Decisions

The vast majority of e-bikes reported were purchased complete and new. A small number of brands had a large share of the market within the study sample, with Rad, Specialized, Trek, Tern, Aventon, Gazelle, Riese und Müller, Giant, and Pedego together constituting

half of respondents' bikes. City/hybrid/commuter-style bikes make up a third of the market, with long-tail cargo and step-thru cruisers rounding out a cumulative half of the e-bikes in North America today. Most feature removable batteries and have pedal assistance or throttle that tops out at 20 mph. Around a third of bikes are class 1 or class 2, respectively, while the final third are faster – class 3 or out-of-class. However, there is serious reason to believe that respondents often misreport the capabilities of their bikes and do not know their bikes' class, so these findings should not be taken at face value.

Most e-bikes were purchased for under $3,000, but there was a considerable segment of the market that spent $5,000 or more on their bikes. As e-bike prices have shifted down over time, there has been considerable value added by low-cost cargo bikes to make the benefits offered by these often-inaccessible models more affordable and explorable for potential buyers.

> *"The most important factor when purchasing was the price then the brand. I needed an entry-level cargo bike to see if this was a true lifestyle change."*

> *"I have convinced many people to use e-bikes but cost prevents adoption."*

The effects of the COVID-19 "e-bike boom" are fully visible in the sales data alone; purchases in the survey sample nearly doubled year-on-year between 2020 and 2021 and again 2021 to 2022. A number of comments reflected a desire to replace a suddenly dangerous commute on public transportation, get more fresh air during quarantine, or take up a new solo hobby.

> *"My e-bike has changed my life for the better. It helped me improve my mental health during the hardest, most isolated times of the pandemic. Riding with my children on the bike with me has created a wonderful tradition for us. I feel healthier and more physically active. I would recommend an e-bike to anyone!"*

A significant number of commenters also noted that they had decreased their e-bike activity since the start of the pandemic due to working from home and increases in concerns around theft and driver behavior. A significant number of comments noted that the most important consideration in purchasing their e-bike was availability due to pipeline issues during the pandemic.

Alternative bicycle designs, such as tricycles, recumbents, and tandems, are a segment of the market unforeseen in the design of the survey. Despite the option not being provided when asked about their e-bike's style, over 2% of respondents wrote in one of these form factors. Many respondents lauded their benefits in cargo-hauling, riding into older age, and riding with a partner.

> *"My recumbent trike is super comfortable for my aging body as opposed to an upright bike. It seems to me that a combination of recumbent comfort with electric assist is a much overlooked configuration that many older folks would find appealing and useful."*

> *"I have to ride a trike because of balance issues. The e-trike is one of my few options for exercise or recreation. As such, I ride a lot."*

"I ride a tandem e-bike with my handicapped adult son. The e-bike supplements his inconsistent pedaling and allows us to go further than if I had to do all the pedaling."

Riders found utility in the presence of a throttle on their bike, with nearly half of respondents reporting that theirs had one. The higher prevalence of throttles among those with physical limitations and utilitarian users indicate that the feature provides an important added utility for some use cases, particularly among people with physical limitations.

"I basically only ride an e-bike with throttle because I have messed up knees and ankles and getting the bike moving is hard. Once it's going I can take over."

However, ownership of e-bikes with throttles decreased with age. This was likely the result of the differences in use case by age where older adults use their e-bikes more for exercise and recreation but may also be ascribed to the fact that many of the cheapest available e-bike models – more easily afforded by younger people – are class 2.

Nearly a third of respondents noted that replacing the hassle of auto trips and the ability to ride with less effort or sweat in their top three reasons for purchasing an e-bike. A quarter indicated the ability to travel further distances was important. Only a quarter listed recreation purposes, and a fifth listed fitness, indicating that e-bikes are generally adopted more as a utilitarian technology than a recreational one. Respondents were generally more interested in the high-level characteristics of their e-bikes than in specific motor technologies and safety certifications when considering a purchase. Significant differences in purchase priorities were noted among demographic groups. Notably, older adults, people

with physical limitations, those with children, and households below 200% FPG exhibited different preferences. Prior cycling experience and gender played less of a role than anticipated.

5.1.3 Travel Characteristics

E-bikes undoubtedly increase total cycling among adopters. Almost no respondents claimed to never ride their e-bike, with almost nine out of ten riding at least weekly. Before purchase, less than 60% could say the same about riding their non-electric bicycle. Respondents decreased their use of non-electric bicycles notably, but likely increased their overall physical activity on a bicycle, a finding which is consistent with previous literature on the topic.

Most e-bike trips were utilitarian. Around a third were exercise-related, and a fifth were induced and would not have happened had the respondent not owned an e-bike. E-bike trips replacing bicycle trips were generally longer compared to those replacing other modes. This was the result of recreational trips, which tended to be longer. Large variations in trip reason and mode replacement were noted with age, with people using their e-bikes more for recreation and less for utilitarian trips with age.

The fact that a majority of respondents indicated that they ride for different purposes or to different destinations with their e-bike than they would with a non-electric bicycle indicates that e-bikes do not adhere to a traditional mode substitution framework, even for people who were frequent cyclists prior to purchasing an e-bike. Clearly, e-bikes provide utility

beyond what a non-powered bicycle and impacts to travel need to be considered with more nuance as they are adopted on a broader scale.

5.1.4 Perceptions

The majority of e-bike owners indicated general satisfaction with their bikes. Most respondents indicated that they enjoyed the benefits of using an e-bike over a car and expressed that they would like to ride more often.

> *"I suffer from depression and biking is a wonderful way for me to socialize with friends and get outside, the e-MTB helps me to do that even when I may not feel like it, physically or mentally."*

Concerns about theft often turned people off from riding more, second only to the weather among barriers to riding an e-bike more.

> *"I look forward to using it for errands but am concerned about it getting stolen even with two locks."*

People using their e-bike with their children often noted the technology's ability to facilitate meaningful experiences.

> *"It's probably the best purchase I've made in my adult life. Watching my child grow up in front of me was amazing. Every ride was a parade and a chance to wave to everyone as we passed. Our preschool trip went through a college campus and I'm sure we opened some eyes that having a kid doesn't mean you need to get a minivan.*

I had so many wonderful times during my kid's early years. So many great conversations that can't happen when you have to concentrate on driving."

A general dissatisfaction with the state of bike infrastructure, interactions with drivers, heavy traffic, and other safety concerns were also major barriers to e-bike use.

"I am afraid to ride on streets – drivers do not pay attention, ever."

Riders reported that their bikes opened the opportunity to ride to more destinations and for more reasons. These included carrying children, carrying cargo, and biking to destinations that would require a shower on a non-powered bicycle.

"My e-bike is essential to get my children to two different schools and then into my office while dressed professionally."

Owners often noted that they see themselves as evangelists of the technology – a potential indicator that the general perception is that e-bike adoption is still in its nascent stages, and the peak of the technology adoption curve is yet to be reached.

"Every party I go to I let people test ride my e-bike out, hoping to convert others – and I always do."

"Game changer. When non-bike riders try an e-bike they are convinced and many buy one."

5.1.5 Safety

While the survey likely exhibits significant response bias due to the self-selection of people who actively ride e-bikes and are willing to share their experiences, respondents generally felt safe riding an e-bike, marginally more so than when riding a non-electric bicycle. There is some dissonance between general perceptions of barriers and the reported feelings of safety from e-bike riders. A high proportion listed safety-related barriers to riding more, while still reported generally feeling safe on their e-bikes. This suggests that, while generally feeling safe riding their e-bikes, safety continues to be a concern for many e-bike riders and plays a role in selecting which trips they use their e-bike for.

> *"I would really love it if there were more people getting around on e-bikes, then motorists would be more aware of us. I have thought about riding it to my music lessons but worry about crashing and damaging my instrument, so I drive or take the bus instead."*

Some respondents noted the added safety benefit that speed provides in mixing with vehicle traffic, especially with class 3 or out-of-class e-bikes.

> *"My 30 mph e-bike lets me comfortably ride in 35 mph speed limit roads that are more direct to my destination that I would never feel safe doing on a normal bike. The higher speeds reduce the speed difference between myself and motor vehicles allowing more time for them to notice me and pass safely. On a regular bicycle that would not be the case and I would be forced to use less time efficient routes or go on the sidewalk potentially frustrating pedestrians."*

Reported crash rates among the sample of e-bike owners were less than one every three years, and less than one in one-hundred crashes involved a pedestrian. The general concern with e-bike/pedestrian conflicts present in the public discourse around e-bikes is not reflected in the survey results. Fears about conflicts with other vulnerable road users seem to generally be unfounded or overblown, and likely rely largely on anecdotal information for credence. The lack of interactions may be due to e-bike users' general avoidance of pedestrian spaces due to the inability to enjoy the speed and acceleration of their bikes.

> *"When on my e-bike I avoid routes that are crowded with pedestrians, like the river path, because I want to go fast."*

> *"I am not doing great speeds unless I am in open countryside away from traffic."*

The majority of reported crashes took place with the cyclist alone; only one in five involved another road user. Far fewer crashes received a police report than medical care – including among severe injury crashes – indicating that medical records may be a more comprehensive avenue to gathering information on e-bike crashes for future research than police records.

It is important to note that the survey did not ask respondents about any near misses they may have experienced. Evaluating near misses is challenging; different road users likely have different thresholds for what they consider to be a near miss. For example, pedestrians being passed by a fast-moving cyclist may feel that they have experienced a near miss due to them receiving relatively little warning of the possible conflict, while the cyclist doing the passing might not categorize the incident as a near miss because they were in control

and had more time to anticipate the interaction. Likewise, e-bike riders of different experience levels would likely report near misses differently, as their tolerance for close interactions with other road users changes with their skill level, crash experience, and past interactions with other road users.

Serious and fatal injuries were almost certainly underrepresented in the sample. Those who died in e-bike crashes are not able to participate in the survey, and many people who experience serious crashes measurably reduce their cycling frequency afterwards (L Fraser & Meuleners, 2020). These people are significantly less likely to have continued owning an e-bike or to have been willing to complete a lengthy survey reporting their experiences as an e-bike owner. The U.S. Consumer Product Safety Commission has estimated that there were over 100 fatalities of e-bike riders between 2017 and 2022 (Tark, 2023). Approximately 2% of all traffic fatalities in the U.S. are cyclists in a typical year.

5.1.6 Regulatory Concerns

There is significant conversation in regulatory circles about potential restrictions to the use of e-bikes. Typical concerns include the use of e-bikes by children, on trails and other pedestrian spaces, at unsafe speeds, and without helmets. This survey indicates that many of these concerns are unfounded.

Most families with children under ten years old do not allow their children to ride their e-bikes, and those with children 10-15 years old only do so less than one-third of the time. The vast majority of e-bike riders wear a helmet when they ride. Almost all e-bike owners

are licensed drivers, indicating that an understanding of the rules of the road is no larger challenge among e-bike owners than it is among the general public.

Because most potential e-bike legislation hinges on regulations enforced by e-bike class, it's important to know whether e-bike owners are aware of their bike's class. The results of this survey indicate that not only do owners misreport their bike's class, but they may also often misreport their top speed. Nearly a quarter of riders admitted not knowing their bike's class, while another quarter provided incongruous class guesses and e-bike characteristics.

Comments indicate that e-bike riders are generally avoidant of pedestrian spaces such as sidewalks, busy trails, and multi-use paths. The increased level of conflict, tight spaces, and frequent obstacles inhibit riders' enjoyment. However, the survey also indicates an untapped demand for more supportive infrastructure, meaning that many riders are likely often forced into these spaces, regardless of their natural aversion. For many, these safe space refuges are under threat by regulation.

> *"I will ride a non-e-bike on trails that don't allow e-bikes. Seeing as I'm getting older, I really wish pedal assist e-bikes could return to trails they are no longer allowed on."*

> *"I'm worried that there will be a backlash that will limit the use of class 3 bikes with throttles for equilibrium issues. This is an accessibility and disability justice issue. E-bikes are not because people are lazy, they are a mobility necessity for many."*

Over a third of e-bikes in the survey had top speeds of 28 mph/45 kph or more, indicating that many e-bikes are capable of speeds in excess of those that non-powered bikes can easily reach.

5.1.7 Maintenance and Battery Recycling

In a likely corollary to the high volume of very recent purchases, most e-bikes represented in the survey have not yet seen any service need. When they have, normal tune-ups or fixes, repairs to electronics, repairs to the motor, and repairs or replacement of the battery were the most common.

In comments describing specific problems with their e-bike's function, respondents noted a wide range of specific issues. This is a likely result of the complexity of e-bike systems when compared to non-powered bicycles, and the relative newness of the technology and resulting lack of established standards and manufacturing uniformity. Brakes were noted in a large number of comments, which is unsurprising due to the increased weight and speed of e-bikes and their cargo over non-powered bicycles. Spoke and chain breakage was also reported more frequently than is likely true of non-powered bicycles.

There seemed to be a general understanding that failed batteries do not belong in the landfill. There was only a miniscule proportion of owners who stated that they had thrown away a battery or e-bike or planned to do so in the case of a failed battery. Rather, most disposed of failed batteries responsibly at their local bike shop, through their e-bike manufacturer, or at a recycling center. Others simply kept it at home or repaired it. These

insights may help to refine current public education efforts being undertaken by advocacy groups and e-bike industry members.

5.1.8 Comparison to Previous Editions of the Survey

In the last decade, e-bike ownership has become more bi-modal by age – there has been an increase in owners 65 and older and owners younger than 45. The share of males, white people, and those with physical limitations have all decreased.

An increasingly small share of conversions and a not-yet-mature used market have conspired to allow new e-bikes dominate the market. Prior ridership indicates that new non-cyclists are not yet being converted to riding bikes at a significantly different rate than they were a decade ago. This indicates that there is still massive potential for the e-bike market to scale as demand for the product continues to grow outside of the cycling community.

Trip purposes have shifted notably over time, with commutes making up a lower share of trips and exercise and local errands making up the difference. Each of the three trip types now make up about a third of all e-bike trips, whereas commute trips were 45% of all trips in 2013. Some of the decrease in commute trip share may be attributed to the marked increase in remote work in the last decade. It also may indicate a shift to a different demographic of users.

5.1.9 E-Bike Purchase Incentives

E-bike purchase incentive programs are most often established to pursue environmental and transportation equity goals. Their success is predicated on encouraging inframarginal participation in the e-bike market, and on those induced purchases being used to offset vehicle travel and enable trips that otherwise would not have been possible.

One-third of incentive recipients reported that they would not have otherwise made the purchase of their e-bike, indicating that incentive programs are encouraging inframarginal purchases at a relatively high rate. However, this proportion is likely overestimated due to confirmation bias. Many respondents were recruited directly through their respective incentive programs, so they were likely prepared to return praise for those same programs because they were grateful for having received value from them and/or truly believe that the purchase incentives positively influenced their decisions. The inframarginal participation rate measured in this sample is within the range of other studies that modeled this behavior, but it should be noted that the literature has not reached a strong consensus to-date, and that the programs represented in the sample vary widely in structure and incentive value.

Trip characteristics indicate that the incentivized e-bikes are being used for utilitarian reasons over two-thirds of the time and that half of trips substituted car trips. This suggests that the e-bikes are used for transportation access and vehicle replacement, supporting the stated goals of most incentive programs.

As compared to non-recipients, incentive recipients were more often seldom or non-cyclists before purchase and were more often non-male than their non-recipient counterparts. They less often purchased an e-bike for recreational reasons or due to a physical condition, and more often considered the hassle and cost of auto trips. Their trips were generally more utilitarian than the general public and substituted drive-alone trips at a higher rate. Together, this indicates that the sample of recipients is meaningfully different from non-recipient e-bike owners. However, opportunity still exists for e-bike incentive programs to pursue transportation equity, encourage inframarginal participation, and broaden the market. Low-income and nonwhite people did not buy e-bikes through incentive programs at a higher rate than otherwise, indicating that programs could do better to target specific underrepresented populations that have not yet adopted the technology at a high rate. Incentive recipients generally spent less out-of-pocket when purchasing their e-bikes and obtained e-bikes of approximately similar value to non-recipients.

> *"My eyeballs tell me most e-bikes are sold to the 50-70 year old demographic using the e-bike for exercise, recreation and personal errands. I think that's because that age demographic has the income to support e-bike purchase. Hopefully, more e-bikes will be sold in the future to younger people that own e-bikes in lieu of a 2nd (or 1st) car. Incentive programs by city, state or federal governments would help the younger age group purchase an e-bike."*

Discrepancies in response rate between responses to trip purpose and replaced mode (n=682 and n=566, respectively) potentially indicate the presence of automated responses in the sample of incentive recipients.

It should be noted that the share of survey respondents receiving an incentive is not representative of the general population of e-bike owners. Incentive recipients were directly recruited for participation in the survey and their responses were more closely examined during the data cleaning process to ensure the largest possible sample size. Together, these efforts artificially increased their representation in the study sample.

The incentive programs represented (listed in Appendix C) are generally representative of the incentives distributed in North America to-date, based on the prior experience of the author conducting research in that topic (Bennett et al., 2022). The demographic profiles of incentive recipients are expected to shift in the coming years as more high-budget equity-focused programs are established. The planned programs administered through the City of Portland, OR, state of California, and state of Colorado are examples of such programs; more are likely to follow. Each of these programs are significantly larger than typical programs before them and have a significant proportion of their budget, if not all of it, set aside for recipients making under an income threshold (Bennett & MacArthur, 2023).

5.2 Effects of Automated Responses

The removal of automated responses to the survey is estimated to have introduced minimal bias. Nonetheless, a large number of legitimate responses were likely removed. The distribution of a number of sample variables was similar enough between the filtered and unfiltered groups that the removal of these legitimate responses was not determined to have a significant effect on findings.

One of the more obvious ways in which the data quality was improved through the filtering process was the removal of inattentive respondents. Those taking less than 7.5 minutes to respond to the survey were removed, regardless of the presence of other flags on their response. This filter may have removed a contingent of respondents that did not read questions carefully or provide a high level of detail on their experiences.

Of the 1,639 cases marked for exclusion by hand based on their responses to text-entry questions, 422 (25.7%) were not caught by the other filters designed to exclude automated responses from the dataset. While somewhat an artifact of the way in which cases were manually reviewed, this high proportion indicates that measures taken to remove automated responses were likely insufficient to fully weed the dataset of illegitimate or responses and responses with errors and inconsistencies present. This inclination is supported by other observations in the data, such as minute inconsistencies and suspicious elements noted during data analysis.

Future web-based survey studies providing public links should consider including additional anti-automation mechanisms in their designs. Specific tactics not used by this

study that may be employed include the use of Captcha or other automated response detection software tools, tracking links and password protection to quarantine access points for automated responses, and dual authentication methods. However, these tools may decrease completion rates among legitimate respondents due to the increased time and effort required; this is the reason they were not employed in this study's design. The inclusion of particular questions that test institutional knowledge, check for consistency throughout the survey, or ask common-sense or attention-checking questions may allow for easier identification of automated responses. It's worth noting that scammers have large incentives for constantly improving their ability to fool survey solicitors, and that a review of recent literature is warranted when designing an incentivized survey in order to include the most up-to-date anti-bot measures (Goodrich et al., 2023).

5.3 Sources of Bias

A number of study design choices likely resulted in some selection bias in the observed traits of the survey respondents. The extent to which the patterns observed were an effect of the population of e-bike owners at large or of the recruitment methodology employed is unclear.

The survey design and distribution methodology is likely to have resulted in substantial bias. Because the outreach mechanisms employed generally relied on respondents to be subscribed to bicycle-related content prior to their participation, respondents are very likely to skew towards highly cycling-inclined. While the status quo is shifting in recent years, cycling-inclined groups have historically tended to be very white, male, and affluent; the sample gathered in this survey is no exception. Future e-bike owner survey efforts should consider other mechanisms to reach a broader swath of e-bike riders, particularly those who do not regularly engage in cycling media and with cycling groups. These riders are understudied. In particular, "deliveristas" – an emerging class of e-bike riders who deliver for app-based food delivery services – are almost certainly underrepresented in the study here, and under-studied in general. As the gig economy continues to grow in much of the developed world, an understanding of their unique experiences, choices, and perceptions will be an important consideration for programmatic and infrastructural interventions for electric cycling. Intercept surveys may be one such approach that would provide more equal recruitment of e-bike owners across demographics and cultural affiliations.

The survey was relatively lengthy – designed to take respondents 15-20 minutes to complete and provided a low chance of incentive prizes and no immediate or direct benefit to the participants. As a result, it is likely that self-selection for participation introduced some bias to the findings. In particular, the sample was likely skewed towards a more affluent, more highly educated population who had available time to participate in the survey and an understanding of the importance of their participation in research outcomes. Demonstrated by their voluntary participation in a long survey, respondents were also likely to be very eager to share their – typically positive – experiences with e-bikes.

5.4 Limitations of Survey Design and Distribution

Some limitations identified in the experimental design process are described here.

Results from the survey are specific to North America, as the survey was limited to people indicating that they lived in the United States and Canada only. Respondents were required to list a valid US or Canadian postal code as their place of residence.

Respondents were selected through a convenience sample. Because of the outreach and survey administration methodology, differential self-selection bias is likely present in the data. It is likely that populations with more free time to take a long survey (generally those with higher incomes), interest in research (generally those with higher levels of education), and vested interests in e-bikes and cycling in general (positive perceptions and high levels of use of e-bikes) are overrepresented in the sample. Survey results should not be considered perfectly generalizable for the population of e-bike owners in North America.

The survey was only made available in English. Only 0.4% of American Community Survey (ACS) respondents reported that they spoke English less than "very well" (United States Census Bureau, 2023), while 13.8% of Canadians did not have an ability to conduct a conversation in English (Government of Canada, 2017). Over half of non-English speakers in the US cite speaking Spanish at home, while 11.9% of the Canadian population speaks French only. This indicates that translating the survey into French and Spanish would provide access to participation for the vast majority of people in the US and Canada. However, the lack of translation for this survey is not expected to provide significant barriers to an appropriate survey of the North American population outside of Quebec.

All of the survey distribution methods used were web-based. This was not expected to significantly reduce the population of prospective participants due to a high level of internet and smartphone use by the North American population. Over 90% of Americans are estimated to be internet users. This statistic is true across almost all age ranges (88% of people aged 65+), races, genders, incomes (87% of people making less than $30,000/year), education levels (90% of people with a high school diploma or less), and community locations (Pew Research Center, 2024a). Additionally, 90% of US adults own a smartphone, and 79% of people making less than $30,000/year do (Pew Research Center, 2024b).

The survey was available to e-bike owners only. Respondents were not allowed to complete the survey if they chose "I do not own or regularly ride an e-bike" for:

Questions in this section are about the e-bike you own or use regularly: For the e-bike that you ride most often, did you purchase an e-bike or did you convert a non-electric bicycle?

- *I purchased a new e-bike*
- *I purchased a used e-bike*
- *I converted a non-electric bicycle to an e-bike*
- *I do not own or regularly ride an e-bike*

The decision to exclude non-owners omitted bikeshare users, non-electric bicycle riders, and non-riders from the survey. This choice was made to limit the scope of the study. Importantly, an opportunity to solicit perceptions of e-bikes from likely future owners was lost because of this.

As discussed previously, the survey was not designed as a perfect longitudinal study, and thus the comparability of its results to previous editions of the survey suffered. This limitation is further noted in the results section where appropriate.

5.5 Opportunities for Further Research

There are many potential further lines of inquiry that have been identified in the course of completing this work.

- The data cleaning mechanism used here has room for refinement. The various filters employed were not all equally effective, and the sensitivity of the outcomes of the study on the filtering mechanism was not thoroughly investigated. With a more

developed process, more legitimate responses could likely be included in the sample, improving sample sizes and statistical significance, and more certainty could be obtained that filtering adequately removed automated responses.

- This survey missed an opportunity to pursue insight from particular e-bike user groups, such as the emerging faction of "deliveristas" – food delivery workers in urban environments that ride e-bikes for faster delivery times and lower transportation costs. Questions regarding employment details, shift times, and other available modes may provide insight to a wider swath of use cases than are typically represented in e-bike-related social circles. Recruiting significant samples in these groups would likely require different outreach mechanisms, as these riders don't often partake in the listservs and social groups leveraged for survey distribution in this study.
- Non-owners were not allowed to participate in this survey at all. Future work surveying people who don't own e-bikes may provide valuable insight to avenues to grow e-bike ridership in the future. While it may be challenging to limit bias in recruiting participants, people that already own bikes or consume cycling media, such as those on the PeopleForBikes email list leveraged in this study, may be targeted. The literature also supports the notion that a significant portion of the general public is "interested but concerned" about cycling (Dill & McNeil, 2016), indicating that recruiting people from the general population may be a sufficient mechanism to develop an adequate survey sample. A combination approach that recruits both owners and non-owners would provide an opportunity to develop

questions that would allow the attitudes and activities of both groups to be directly compared.

- The effect of prior exposure to e-bikes is an important dynamic that was not explored in this study. There has been a substantial increase in micromobility providers, e-bike demo events, lending libraries, and social interactions with e-bikes over the past few years. Each of these provides the general public with more opportunities to become familiar with e-bike technology, potentially leading to adoption.
- Other specific topic areas not explored in this survey that may be considered in future research on the e-bike owners include purchase financing and e-bike storage.
- The statistical rigor of this analysis was also fairly limited in scope. Because of the large sample size obtained and the large number of variables collected, opportunities for in-depth multivariate synthesis are many.
    - Cross-tabulation or complex variable interaction would allow future research to more specifically identify different groups of users – such as young men or women with children – and their associated experiences, choices, and perceptions with e-bikes. Modeling distinct groups of users through the development of typologies may provide further insight to use cases, patterns, and opportunities for support and incentivization (Marincek et al., 2023).
    - More complex statistical techniques would also allow for elimination of some bias through weighting for statistically significant predictors of

behavior or through the development of multivariate models for particular qualities or behaviors. Modeling could be further used to address sample selection bias. There are also ample opportunities to model willingness to pay, purchase behavior, travel behavior, and a variety of other potential subjects.

- E-bike trip dates were gathered and could be processed into an estimate of trip frequency. This task was not undertaken in this thesis because the dates provided by the respondents require a significant amount of cleaning. With further attention, this variable could provide insight to a variety of patterns in a future project utilizing this data.
- There is potential to use the results from this study to develop more sophisticated e-bike adoption and travel pattern change models for incentive recipients and the general sample of e-bike owners. Geographic information from respondents' postal codes provides enough specificity to identify built environment context and may also be matched with bicycle infrastructure scores, such as those developed by PeopleForBikes or The League of American Bicyclists. Thorough demographic profiles also allow for tuning of the model to specific programs or communities. A recently published tool from Rocky Mountain Institute (Grunwald et al., 2023) provides a model for such analysis that could be further tuned using the dataset generated with this survey.
- The effectiveness of purchase incentives could be further studied through more sophisticated modeling of income, purchase price, and incentive value to estimate

how much of the incentive is passed through to the consumer rather and how much goes to the market through participants simply upgrading their purchases. The effect of cost inflation due to e-bike retailers anticipating incentives could also be considered in future analysis.

- There is a large and growing base of research in electric vehicle (EV) subsidies in North America. The adoption of EVs is not directly analogous to the adoption of e-bikes because EVs readily replace combustion engine vehicles for most trips. Despite this, there are likely many opportunities to link the electric mobility subsidy evaluation techniques with research on e-bike purchase incentives that are yet untapped.

5.6 Recommend Changes to Study Design

Beyond changes to limit the number of automated responses, a number of other study design modifications are recommended for the next edition of this survey.

One challenge with the data analysis for this project was the prevalence of non-answers to various questions or sub-questions. As an example, many people did not select any option for the number of children in their household, despite doing so for the number of adults. These responses were assumed to have values of zero, but this approach biased the sample towards the value chosen. Likewise, respondents may have chosen no answer rather than "did not consider" for purchase consideration questions (Q76), or not provided a ranking when answers appeared ranked in their preferred order (Q23). Requiring answers to every question in the survey would have eliminated some of these sources of error while creating an additional barrier to completing the survey and likely reducing the viable sample size.

The ability for respondents to describe multiple e-bikes or purchases in the survey is another added feature that may be considered in future study designs. This would help to eliminate some ambiguity of response and need for manual coding performed for this study.

Respondents were only given the option to report trip distances in miles. In the future, survey logic could be used to provide Canadians the option to report in kilometers. Likewise, the income variables were coded only for U.S. respondents. No equivalent conversion was developed for Canadian income levels using the Canadian dollar due to the small sample size.

6 Conclusions

General observations of the e-bike population have not changed substantially from previous studies; owners have a generally positive impression of e-bikes and their benefits. The market continues to be dominated by "stereotypical" cyclists who white, male, and affluent. However, a higher share of women is now present in the survey respondents, and a higher share of young and old respondents have taken on the technology for differing reasons – transportation alternatives for the young and health and recreation for the old. People with physical limitations and people with converted e-bikes make up a notably smaller proportion of riders than they did a decade ago – a reflection of the market continuing to grow further into the general population at an exponential rate.

There is some indication that the e-bike market is exiting the early adopter phase. Over time, the prevalence of e-bike conversions has shrunk massively, and ready-built complete e-bikes have taken over the market. This ten-factor decrease in e-bike conversions is likely the result of a wider variety of e-bikes being more readily available at traditional cycling marketplaces. Additionally, people with physical limitations now make up a much smaller proportion of e-bike owners in the sample, indicating that a wider population is discovering e-bikes' benefits beyond a mobility tool for those unable to ride non-powered bicycles.

However, rates of prior bicycling experience have remained relatively steady, and the demographic profile of e-bike riders are still very different from the general population in North America. In particular, people with low incomes are still underrepresented despite

the new prevalence of incentive programs targeted at their adoption of the technology and the potential transportation cost savings of replacing vehicle trips with an e-bike.

E-bikes continue to be used primarily for utilitarian trips, indicating that they continue to be a promising emerging mode in a modernizing transportation system. Their further adoption and proven ability to offset vehicle miles traveled makes investing in incentives and infrastructure a worthwhile consideration for governments of all levels pursuing climate, health, and transportation equity goals. Riders expressed a desire to ride their bikes more often and for improved infrastructure and secure parking facilities at their destinations to support that change.

A low rate of children rode e-bikes when they were available, primarily once they were over the age of 10. Respondents demonstrated a general misunderstanding of their bikes' class and capabilities, indicating that regulations, signage, and enforcement based on these qualities is not likely to be successful. Further regulation of the technology should be avoided; new laws on mobility have a well-documented tendency to disproportionately affect people of color and dissuade them from adopting new modes of transportation, particularly vulnerable active modes such as e-bikes. Such regulations could affect the long-term equitable adoption of e-bikes as a transportation mode, and distribution of its benefits across society. Rather, groups intent on creating regulations around e-bikes should focus on the provision of supportive infrastructure to minimize threats to the safety, comfort, and security of e-bike users and the other road users they may encounter. Industry-level regulations regarding production standards, particularly around electronics, may

address more potent pain points and safety concerns for riders and other members of society.

Improper disposal of e-bike batteries does not seem to be a major concern at this time; most respondents indicated that they had or planned to return retired batteries to their local bike shop, dispose of it at a recycling center, or keep it at home for occasional use.

Recipients of purchase incentives used their e-bikes in utilitarian ways at even higher rates than the non-recipients, indicating that purchase incentives are likely a promising mechanism for encouraging uptake to reach climate, health, and transportation equity goals. A full third of respondents would not have purchased their e-bike without an incentive, and incentives allowed another 15% to upgrade their purchase. However, incentive programs are not doing enough to facilitate the entry of new people and different demographics to the e-bike market. Future equity- and climate-focused purchase incentive programs should be more intentional with their use of low-income or geography-specific prioritization, partnership with target communities, and educational outreach events.

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Appendix A – Survey Instrument

This appendix provides a reproduction of the survey instrument used, including the necessary details on survey flow and the internal logic and response requirements of the survey.

E-Bike User Survey 2023

Survey Flow

Block: Intro/Consent (4 Questions)
Embedded Data
Q_Source – Value will be set from URL.
Standard: Section 1: E-Bike Information (9 Questions)
Standard: Section 2: Purchasing your E-Bike (10 Questions)
Standard: Section 3: Travel (12 Questions)
Standard: Section 4: Safety (5 Questions)
Standard: Section 5: Previous cycling experience (5 Questions)
Standard: Section 6: Final Thoughts (1 Question)
Standard: Section 7.1: Demographics (8 Questions)
Embedded Data
Household size = SUM of answers to # of Adults (anyone over 16 years old), Children 10-15 years old, and Children younger than 10 year old in household from Q53
Standard: Section 7.2 Demographics_Income and Rest (19 Questions)
Standard: Section 8.1: Optional Questions_Opt-In (1 Question)
Branch: New Branch
If Thank you for taking the time to provide us with your response! If you have five more minutes, we... Continue to optional questions Is Selected
Standard: Section 8.2: Optional Questions (9 Questions)
Standard: Drawing Entry Info (1 Question)
End of Survey page
Standard: Drawing Entry Info (1 Question)
End of Survey page

Symbol Key

** = Answer required
🔀 = Option order randomized
⊗ = Exclusive option (if selected, other options cannot be selected)

Notes on answer options and requirements included in italics

Start of Block: Intro/Consent

Q1 **

E-Bike Owner Survey

Thank you for taking our survey!

The Transportation Research and Education Center at Portland State University is conducting a nationwide survey of e-bike riders. We want to hear about your experiences purchasing and using your e-bike. In the last decade, electric bicycles (e-bikes) have become common in parts of Asia and Europe. In the United States, e-bikes have not yet become a mainstream form of transportation. We would like to ask you some questions to learn more about the role e-bikes can play in our transportation system.

The survey should take around **15-20 minutes**.

Thank you for taking the time to participate. Your responses are valuable and will help us understand more about how people use e-bikes.

At the end of the survey, you can enter a drawing for one of 50 $20 Visa Gift Cards and three Topo Designs Backpacks (value $100) provided by PeopleForBikes.

Statement of Informed Consent

Participants will share their e-bike experiences. Your participation is voluntary. You may opt out of the survey at any time. There are no expected physical or psychological impacts from taking part in the study. Your individual survey responses are anonymous and confidential. We will store the survey data on secured servers at Portland State University. It will not be possible to tell who said what in any reports. We do not anticipate any risk to you in answering the survey. No one will be able to identify you or your answers, and no one will know whether or not you participated in the study. Individuals from the Institutional Review Board may inspect these records. If the data is published, no individual information will be disclosed.
Portland State University does not release information about how any individual answers the survey and will not sell or give away the lists of respondents who participate in our research.

Any questions?
The Portland State University Institutional Review Board has reviewed this project. If you have any concerns about your rights in this study, please contact the PSU Office of Research Integrity at (503) 725-2227 or email hsrrc@pdx.edu. If you have questions about the study itself, please contact John MacArthur by telephone at (503) 725-2866, by e-mail at macarthur@pdx.edu, or by mail at Transportation Research and Education Center (TREC), P.O. Box 751, Portland State University, Portland, OR 97207-0751.
Our research can only be successful with the generous help of people like you. We hope you will enjoy answering our questions. Thank you for taking part in our e-bike survey!

Do you agree to participate in this survey? By clicking “Accept”, you are consenting to participate in this survey. If you do not consent, please click “Decline” to navigate away from the survey.

- o Agree
- o Decline

Skip To: End of Survey If E-Bike Owner Survey Thank you for taking our survey! The Transportation Research and Education... = Decline

Q2 **
In what country do you currently reside?

- o United States
- o Canada
- o Other

Skip To: End of Survey If In what country do you currently reside? = Other

Display This Question:

If In what country do you currently reside? = United States

Q3 **
Please enter your current 5-digit ZIP code.

- o ZIP Code _____

Display This Question:

If In what country do you currently reside? = Canada

Q4 **
Please enter your current postal code.

- o Postal Code _____

End of Block: Intro/Consent

Start of Block: Section 1: E-Bike Information

Q5 **

Questions in this section are about the e-bike you own or use regularly.

For the e-bike that you ride most often, did you purchase an e-bike or did you convert a non-electric bicycle?

- o I purchased a new e-bike
- o I purchased a used e-bike
- o I converted a non-electric bicycle to an e-bike
- o I do not own or regularly ride an e-bike

Skip To: End of Survey If Questions in this section are about the e-bike you own or use regularly. For the e-bike that you... = I do not own or regularly ride an e-bike

Display This Question:

If Questions in this section are about the e-bike you own or use regularly. For the e-bike that you... = I converted a non-electric bicycle to an e-bike

Q6
What make/brand and model is your e-bike conversion kit?

_____

Display This Question:

If Questions in this section are about the e-bike you own or use regularly. For the e-bike that you... = I purchased a new e-bike

Or Questions in this section are about the e-bike you own or use regularly. For the e-bike that you... = I purchased a used e-bike

Q7
What make/brand and model is your e-bike?

- o Make/Brand _____
- o Model _____

Q8
What class is your e-bike?

- o Class 1
- o Class 2
- o Class 3
- o I don’t know

Page Break

Q9
Which of these most closely resembles your e-bike?

Long-tail cargo:

Drop-bar road/gravel:

Front-loading cargo:

Sport/moto-style cruiser:

City/hybrid/commuter:

Fat tire:

Step-thru/beach cruiser:

Moped:

(question continued on next page)

Mountain:

Other (please describe):

Folding:

Q10
What is the top *assisted* speed of your e-bike?

- 20 mph (32 km/hour) or less
- 28 mph (45 km/hour)
- Greater than 28 mph (45 km/hour)
- I do not know

Q11
Does your e-bike have a throttle or button that engages the motor without pedaling?

- Yes
- No

Display This Question:

If Does your e-bike have a throttle or button that engages the motor without pedaling? = Yes

Q12
What proportion of the time you are riding do you use the throttle without pedaling? (Select all that apply)

- ☐ None
- ☐ Less than half
- ☐ More than half
- ☐ Just for startup
- ☐ Just for hills

Q13
Is your e-bike's battery easily removable or removable without using tools?

- o Yes
- o No

End of Block: Section 1: E-Bike Information

Start of Block: Section 2: Purchasing your E-Bike

Q14

Questions in this section relate to your decision to purchase your e-bike or convert a non-electric bicycle. For the purpose of this survey, a non-electric bicycle has no assist and is only propelled by the rider.

Where did you purchase your e-bike or conversion kit?

- o A bicycle shop that has some e-bikes
- o Specialty e-bike shop
- o Big Box Store, Superstore, General Merchandise/Outdoor Retailers (e.g. Walmart, Costco, REI, etc.)
- o Online from the bike manufacturer's website
- o Online from somewhere else (please specify) _____
- o Specialty electric vehicle shop (e.g. also sells scooters without pedals & other e-bikes)
- o Used goods marketplace (facebook marketplace, craigslist, ebay, pro's closet, etc.)
- o Other (Please specify) _____

Q15

In what year did you purchase your e-bike or conversion kit?

▼ 2023, 2022, 2021, ..., 2006, 2005 or before

Q16

Approximately how much did your e-bike or conversion kit cost to purchase after any incentives, discounts, sales, or taxes (enter a dollar value)? Do not include any other purchases (such as lights, helmet, or lock) made at the same time in your estimate.

- o $ _____

Q17

Some local governments, power providers, and nonprofits offer incentives for purchasing an e-bike. Did you (or do you expect to) receive a purchase incentive, cash rebate, or tax rebate when you purchased your e-bike?

- o Yes
- o No

Display This Question:

If Some local governments, power providers, and nonprofits offer incentives for purchasing an e-bike... = Yes

Q18

What organization or entity provided the incentive or rebate that you received?

_____

Display This Question:

If Some local governments, power providers, and nonprofits offer incentives for purchasing an e-bike... = Yes

Q19
What was the dollar amount of the incentive or rebate that you received?

_____

(input constrained to number with maximum 2 decimal places)

Display This Question:

If Some local governments, power providers, and nonprofits offer incentives for purchasing an e-bike... = Yes

Q20
How was the incentive or rebate delivered to you?

- o Post-purchase rebate
- o Point-of-purchase discount
- o Tax rebate
- o Rebate/discount from the manufacturer
- o Other (please describe) _____

Display This Question:

If Some local governments, power providers, and nonprofits offer incentives for purchasing an e-bike... = Yes

Q21
Would you have purchased your e-bike without the incentive or rebate?

- o Yes
- o No
- o I would have purchased a different model of e-bike

Page Break

Q22 🔀
What were the **top three** reasons why you bought an e-bike or converted a non-electric bicycle? (Please select three)

- ☐ Health – a medical condition reduced my ability to ride a non-electric bicycle
- ☐ Health – to increase fitness
- ☐ Because I live or work in a hilly area
- ☐ To ride with less effort or arrive less sweaty
- ☐ To be able to keep up when riding with friends/family
- ☐ To carry cargo or kids
- ☐ To start cycling or to cycle more often
- ☐ To ride longer distances to places I need to go
- ☐ It's a cost effective form of transportation
- ☐ To replace the hassle of car trips (traffic, parking, etc.)
- ☐ For environmental reasons
- ☐ For recreation purposes
- ☐ For accessing recreational activities (park, gym, etc.)
- ☐ I enjoy riding an e-bike more than a non-electric bicycle
- ☐ Other _____

(response limited to 1-3 choices)

Display This Question:

If If What were the top three reasons why you bought an e-bike or converted a non-electric bicycle? (Pl... q://QID23/SelectedChoicesCount Is Greater Than 1

Carry Forward Selected Choices - Entered Text from "What were the top three reasons why you bought an e-bike or converted a non-electric bicycle? (Please select three)"

Q23

Please rank your top reasons for buying an e-bike (drag and drop to re-arrange).

_____ Health – a medical condition reduced my ability to ride a non-electric bicycle
_____ Health – to increase fitness
_____ Because I live or work in a hilly area
_____ To ride with less effort or arrive less sweaty
_____ To be able to keep up when riding with friends/family
_____ To carry cargo or kids
_____ To start cycling or to cycle more often
_____ To ride longer distances to places I need to go
_____ It's a cost effective form of transportation
_____ To replace the hassle of car trips (traffic, parking, etc.)
_____ For environmental reasons
_____ For recreation purposes
_____ For accessing recreational activities (park, gym, etc.)
_____ I enjoy riding an e-bike more than a non-electric bicycle
_____ Other

End of Block: Section 2: Purchasing your E-Bike

Start of Block: Section 3: Travel

Q24

Questions in this section are about your recent travel patterns, specifically, after you bought your e-bike.

Think back on the last three times you used an e-bike **leaving home and returning again** with any number of stops along the way.

- How did you use it?
- How far did you go?
- When was the trip (date in MM/DD/YYYY format)?
- If you had not taken your e-bike, how would you have traveled?

	Purpose of Trip	Distance	If you had not taken your e-bike, how would you have traveled to your destination?	When was the trip?
		(Approximate Miles)		MM/DD/YYYY
Ride 1	▼ Commute (work or school) ... Other		▼ Walk ... I would not have taken this trip	
Ride 2	▼ Commute (work or school) ... Other		▼ Walk ... I would not have taken this trip	
Ride 3	▼ Commute (work or school) ... Other		▼ Walk ... I would not have taken this trip	

Options:

	· *Commute (work or school)* · *Entertainment, dining out, or socializing* · *Personal errands* · *To visit family and friends* · *Exercise or recreation* · *Other*		· *Walk* · *Drive Alone* · *Bike* · *Carpool/passenger* · *Public Transit* · *Taxi/Uber/Lyft* · *Bike Share* · *Car share (e.g. Car2Go, ZipCar)* · *Other* · *I would not have taken this trip*	

Display This Question:

If Questions in this section are about your recent travel patterns, specifically, after you bought y... : Purpose of Trip = Ride 1 [Other]

Q25
You indicated that the purpose of your first trip was something other than what was listed. Briefly describe the purpose of that trip.

_____

Display This Question:

If Questions in this section are about your recent travel patterns, specifically, after you bought y... : Purpose of Trip = Ride 2 [Other]

Q26 You indicated that the purpose of your second trip was something other than what was listed. Briefly describe the purpose of that trip.

_____

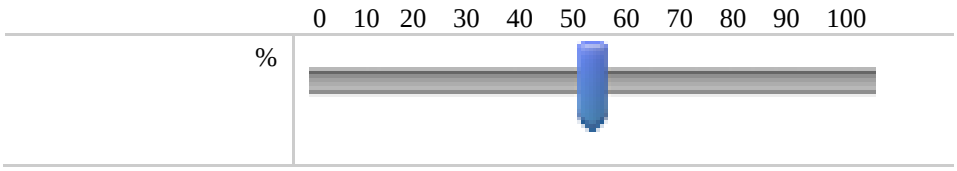
Display This Question:

If Questions in this section are about your recent travel patterns, specifically, after you bought y... : Purpose of Trip = Ride 3 [Other]

Q27
You indicated that the purpose of your third trip was something other than what was listed. Briefly describe the purpose of that trip.

_____

Q28
What percentage of your previous weekly private vehicle (car, truck, or van) travel distance have you replaced *with* your e-bike?
(If you traveled 100 miles on average per week by car, what % of that distance have you replaced traveling by e-bike)



Q29
Which mode of travel do you **primarily** take to each of the listed activities?

Commuting (e.g. work, school)	▼ I do not partake in this activity ... Other
Personal errands (e.g. groceries, appointments)	▼ I do not partake in this activity ... Other
Visiting family or friends	▼ I do not partake in this activity ... Other
Entertainment, dining out, or socializing	▼ I do not partake in this activity ... Other
Exercise or recreation	▼ I do not partake in this activity ... Other
To access recreational activities (e.g. park, gym)	▼ I do not partake in this activity ... Other

Options:

- *I do not partake in this activity*
- *Walk*
- *Non-electric bicycle*
- *E-bike*
- *Drive alone*
- *Carpool/passenger*
- *Public Transit*
- *Taxi/Uber/Lyft*
- *Bike share*
- *Car share (e.g. Car2Go, ZipCar)*
- *Other*

Q30
How many days per week do you normally commute to work or school?

▼ I work from home, I am not currently employed or enrolled in school, 1, 2, 3, 4, 5, 6, 7

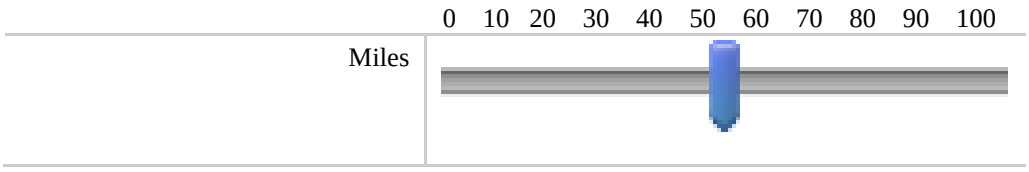
Display This Question:

If How many days per week do you normally commute to work or school? != I work from home.

And How many days per week do you normally commute to work or school? != I am not currently employed or enrolled in school.

Q31

About how far is your current daily commute (enter the approximate **miles in one direction**)? Enter 0 if you don't have a daily commute to work or school. Enter 100 if your commute is 100 miles or more.



Q32

How often do you use your e-bike for the following activities?

	Daily	Weekly	Monthly	A few times a year	Once a year or less	Never
Commuting (e.g. work, school)	o	o	o	o	o	o
Personal errands (e.g. groceries, appointments)	o	o	o	o	o	o
Visiting family or friends	o	o	o	o	o	o
Entertainment, dining out, or socializing	o	o	o	o	o	o
Exercise or recreation	o	o	o	o	o	o
To access recreational activities (e.g. park, gym)	o	o	o	o	o	o

Q33
Do you agree with the following statements?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
My e-bike allows me to keep up with friends or family on bicycle rides.	o	o	o	o	o
To ride the same trip by a non-electric bicycle, I would need to shower at my destination.	o	o	o	o	o
I enjoy my overall riding experience on my e-bike.	o	o	o	o	o
I ride my e-bike more frequently than a non-electric bicycle.	o	o	o	o	o
I would rather cycle than drive a car.	o	o	o	o	o
I would ride more if I had more bike infrastructure to reach places I need to go.	o	o	o	o	o
I ride farther now that I have an e-bike vs. if I had a non-electric bicycle.	o	o	o	o	o

Page Break

Q34
Do you agree with the following statements?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
Riding my e-bike is a convenient way to get from one place to another.	o	o	o	o	o
I worry about being hit by a motor vehicle when riding my e-bike in my area.	o	o	o	o	o
I would like to ride my e-bike more often.	o	o	o	o	o
I would be more likely to ride my e-bike if cars and bicycles were physically separated by a barrier.	o	o	o	o	o
I worry about my personal safety when riding my e-bike in my area (e.g., being mugged, etc.).	o	o	o	o	o
I typically wear a helmet when I ride my e-bike.	o	o	o	o	o
I am satisfied with the number and condition of the bike lanes, paths and trails in my area.	o	o	o	o	o

Page Break

Q35

What are the reasons that keep you from riding your e-bike more often? (check all that apply)

- ☐ ⊗None - I ride as much as I want to ride
- ☐ Not enough safe places to cycle, or lack of bike infrastructure
- ☐ Distances to places I want to go are too far, biking is too slow
- ☐ I only use my e-bike for recreational purposes
- ☐ No safe bike storage at destinations, or concerns about theft
- ☐ Do not have access to charging my e-bike at work or school
- ☐ Difficult to carry the things I need to (cargo, kids, or pets)
- ☐ Weather
- ☐ Concern for my safety
- ☐ No or not enough nearby paths or trails
- ☐ Weight of the e-bike prohibits me from using it for certain activities
- ☐ Maintenance or mechanical issues with my bike
- ☐ Not physically able (due to health, age, weight, etc.)
- ☐ Heavy traffic with too many cars
- ☐ Hills make cycling difficult
- ☐ I don't like to arrive sweaty to my destination
- ☐ Other _____

End of Block: Section 3: Travel

Start of Block: Section 4: Safety

Q36

This section is about safety on your e-bike.

Do you agree with the following statements?

	Strongly Disagree	Disagree	Neutral	Agree	Strongly agree
I feel safe riding an e-bike.	o	o	o	o	o
I feel safe riding a standard bicycle.	o	o	o	o	o
On my e-bike, other road users misjudge my speed.	o	o	o	o	o
On my e-bike, I feel like I go faster than other cyclists.	o	o	o	o	o
On average, I ride faster than I would on a standard bicycle.	o	o	o	o	o

Q37

Have you experienced any crashes while riding your e-bike in the last two years?

- o Yes – How many? _____
- o No

Display This Question:

If Have you experienced any crashes while riding your e-bike in the last two years? = Yes – How many?

Q38
Think about the most recent crash... Who or what was involved?

- o Motor vehicle
- o Another cyclist
- o Pedestrian
- o A roadside object (tree/pole/parked car/ etc.)
- o A pothole or other road object
- o Loose gravel/sand/debris in the road
- o Nothing – I lost control/Fell over

Display This Question:

If Have you experienced any crashes while riding your e-bike in the last two years? = Yes – How many?

Q39
What was the severity of the crash?

- o No injury
- o Mild (scrapes, bruises)
- o Moderate (cuts, bleeding)
- o Severe (trip to hospital, broken bone, inability to continue cycling, etc.)
- o Property damage

Display This Question:

If Have you experienced any crashes while riding your e-bike in the last two years? = Yes – How many?

Q40
Following the crash, did you…

	Yes	No
File a police report	o	o
Seek medical care	o	o

End of Block: Section 4: Safety

Start of Block: Section 5: Previous cycling experience

Q41

Questions in this section are about your experiences with riding non-electric bicycles.

Before you owned an e-bike, how often did you ride a non-electric bicycle?

- o Never
- o Once a year or less
- o A few times a year
- o Monthly
- o Weekly
- o Daily

Display This Question:

If Questions in this section are about your experiences with riding non-electric bicycles. Before y... != Never

Q42

Before you owned an e-bike, how often did you use your non-electric bike for the following activities?

	Daily	Weekly	Monthly	A few times a year	Once a year or less	Never
Commuting (e.g. work, school)	o	o	o	o	o	o
Personal errands (e.g. groceries, appointments)	o	o	o	o	o	o
Visiting family or friends	o	o	o	o	o	o
Entertainment, dining out, or socializing	o	o	o	o	o	o
Exercise or recreation	o	o	o	o	o	o
To access recreational activities (e.g. park, gym)	o	o	o	o	o	o

Q43

How often do you ride a non-electric bicycle now?

- o Never
- o Once a year or less
- o A few times a year
- o Monthly
- o Weekly
- o Daily

Q44

Do you ride for different purposes or to different destinations or take different routes on your e-bike than you would on a non-electric bicycle?

- o Yes
- o No

Display This Question:

If Do you ride for different purposes or to different destinations or take different routes on your... = Yes

Q45

Please describe the reasons why you ride an e-bike for different purposes or to different destinations or take different routes than you would on a non-electric bicycle.

_____

_____

_____

End of Block: Section 5: Previous cycling experience

Start of Block: Section 6: Final Thoughts

Q46
Do you have any comments about your e-bike that you would like to share with us?

_____

_____

_____

End of Block: Section 6: Final Thoughts

Start of Block: Section 7.1: Demographics

Q47

Thank you for participating in our survey! You are almost done. Please answer a few demographic questions so we can learn a bit more about you.

What categories describe you? (check all that apply)...

- ☐ White or Caucasian
- ☐ Hispanic, Latinx/Latino/Latina, or Spanish origin
- ☐ Black or African American
- ☐ Asian
- ☐ Middle Eastern or North African
- ☐ American Indian or Alaska Native
- ☐ Native Hawaiian or Pacific Islander
- ☐ Other _____
- ☐ ⊗ Prefer not to say

Q48
What is your age in years?

_____
(response constrained to a number 0-100)

Q49
How do you currently describe your gender identity?

- ☐ Male
- ☐ Female
- ☐ Non-binary
- ☐ Not listed (type response in box) _____
- ☐ ⊗ I prefer not to answer

Q50
What is the highest level of education you have completed?

- o High school or less
- o Some college, no degree
- o Associates degree
- o Bachelor's degree
- o Graduate or Professional degree
- o I prefer not to answer

Q51
Are you currently employed?

- o Yes
- o No
- o I prefer not to answer

Q52
Are you married or living with a partner?

- o Yes
- o No
- o I prefer not to answer

Q53
Including yourself, how many people are in your household?

	0	1	2	3	4	5	6	7	8 or more
Adults (anyone over 16 years old)	o	o	o	o	o	o	o	o	o
Children 10-15 years old	o	o	o	o	o	o	o	o	o
Children younger than 10 years old	o	o	o	o	o	o	o	o	o

Display This Question:

If Including yourself, how many people are in your household? [Children 10-15 years old] (Recode) >= 1

Or Including yourself, how many people are in your household? [Children younger than 10 year old] (Recode) >= 1

Q54
Do any of the children in your home spend time operating an electric bicycle (not as passengers)?

- o Yes
- o No

End of Block: Section 7.1: Demographics

Start of Block: Section 7.2 Demographics_Income and Rest

Display This Question:

If Household size <= 1

Q55
What is your household's annual income?

- Less than $15,000
- $15,000 to $29,000
- $29,000 to $44,000
- $44,000 to $58,000
- More than $58,000

Display This Question:

If Household size = 2

Q56
What is your household's annual income?

- Less than $20,000
- $20,000 to $39,000
- $39,000 to $59,000
- $59,000 to $79,000
- More than $79,000

Display This Question:

If Household size = 3

Q57
What is your household's annual income?

- Less than $25,000
- $25,000 to $50,000
- $50,000 to $75,000
- $75,000 to $99,000
- More than $99,000

Display This Question:

If Household size = 4

Q58
What is your household's annual income?

- Less than $30,000
- $30,000 to $60,000
- $60,000 to $90,000
- $90,000 to $120,000
- More than $120,000

Display This Question:

If Household size = 5

Q59
What is your household's annual income?

- Less than $35,000
- $35,000 to $70,000
- $70,000 to $105,000
- $105,000 to $141,000
- More than $141,000

Display This Question:

If Household size = 6

Q60
What is your household's annual income?

- Less than $40,000
- $40,000 to $81,000
- $81,000 to $121,000
- $121,000 to $161,000
- More than $161,000

Display This Question:

If Household size = 7

Q61
What is your household's annual income?

- Less than $45,000
- $45,000 to $91,000
- $91,000 to $136,000
- $136,000 to $182,000
- More than $182,000

Display This Question:

If Household size = 8

Q62
What is your household's annual income?

- Less than $51,000
- $51,000 to $101,000
- $101,000 to $152,000
- $152,000 to $202,000
- More than $202,000

Display This Question:

If Household size = 9

Q63
What is your household's annual income?

- Less than $56,000
- $56,000 to $111,000
- $111,000 to $167,000
- $167,000 to $223,000
- More than $223,000

Display This Question:

If Household size = 10

Q64
What is your household's annual income?

- Less than $61,000
- $61,000 to $122,000
- $122,000 to $183,000
- $183,000 to $243,000
- More than $243,000

Display This Question:

If Household size = 11

Q65
What is your household's annual income?

- Less than $66,000
- $66,000 to $132,000
- $132,000 to $198,000
- $198,000 to $264,000
- More than $264,000

Display This Question:

If Household size = 12

Q66
What is your household's annual income?

- Less than $71,000
- $71,000 to $142,000
- $142,000 to $213,000
- $213,000 to $284,000
- More than $284,000

Display This Question:

If Household size = 13

Q67
What is your household's annual income?

- Less than $76,000
- $76,000 to $153,000
- $153,000 to $229,000
- $229,000 to $305,000
- More than $305,000

Display This Question:

If Household size >= 14

Q68
What is your household's annual income?

- Less than $81,000
- $81,000 to $163,000
- $163,000 to $244,000
- $244,000 to $326,000
- More than $326,000

Q69
How would you describe your general state of health?

- Excellent
- Very good
- Good
- Fair
- Poor
- I prefer not to answer

Q70
Which of the following statements best fits you?

- o I am physically able to ride a bicycle.
- o I have physical limitations that make riding a non-electric bicycle difficult.
- o I am physically unable to ride a non-electric bicycle.

Display This Question:

If Which of the following statements best fits you? = I have physical limitations that make riding a non-electric bicycle difficult.

Or Which of the following statements best fits you? = I am physically unable to ride a non-electric bicycle.

Q71
Is this a temporary condition (like a sprained ankle) or is it a permanent condition that makes it difficult or impossible to ride a non-electric bicycle?

- o Temporary condition
- o Permanent condition

Q72
How many of each of the following working/functioning vehicles are currently in your household?

	0	1	2	3	4	5	6 or more
Registered automobiles, vans, trucks, or motorcycles (please do not include RVs, motor homes, or off-road vehicles)	o	o	o	o	o	o	o
Adult non-electric bicycles	o	o	o	o	o	o	o
E-bikes	o	o	o	o	o	o	o
Children's bicycles	o	o	o	o	o	o	o

Q73
Do you have a driver's license?

- o Yes
- o No

End of Block: Section 7.2 Demographics_Income and Rest

Start of Block: Section 8.1: Optional Questions_Opt-In

Q74

Thank you for taking the time to provide us with your response!

If you have five more minutes, we would love to ask for your feedback on a few more questions. You'll help us out a lot. Your responses will allow us to learn more about how people choose and use their e-bikes. Otherwise, we appreciate your time.

Your willingness to answer additional questions will not affect your chances of winning the drawing for one of 50 $20 Visa Gift Cards.

- Complete survey – I'm done!
- Continue to optional questions

End of Block: Section 8.1: Optional Questions_Opt-In

Start of Block: Section 8.2: Optional Questions

Q75

Thanks for sticking with the survey. Here are a few additional questions.

Is your e-bike yours alone, or shared with someone else in your household?

- o Mine alone
- o Shared with someone else

Q76

At the time of purchase, did you consider...

	Did not consider	Some consideration	Serious consideration
Different motor technologies (e.g. hub motor, mid-drive motor)	o	o	o
Battery range	o	o	o
Bike type/style	o	o	o
Brand	o	o	o
Safety certifications (for the battery or motor)	o	o	o
Top assisted speed	o	o	o
Type of assist (pedal-assist or throttle)	o	o	o
Price	o	o	o
Available incentives	o	o	o

Q77

What, if any, was the most important factor in choosing the e-bike you purchased?

_____

Q78
How many times have you had your e-bike serviced because of an issue related to the battery, motor or electronic system?

- o No service needed to date
- o 1
- o 2
- o 3
- o 4
- o 5 or more times

Display This Question:

If How many times have you had your e-bike serviced because of an issue related to the battery, moto... != No service needed to date

Q79
Why did you need to have your e-bike serviced? (Select all that apply)

- ☐ Normal bicycle-related tune-ups or fixes
- ☐ Repairs to the electronics/display
- ☐ Repairs to motor
- ☐ Repair or replace battery
- ☐ Other (Please specify) _____

Display This Question:

If Why did you need to have your e-bike serviced? (Select all that apply) = Repair or replace battery

Q80 🔀
What did you do with the failed battery?

- o I threw it away in my residential trash
- o I still have it stored at my home
- o I sent it back to the manufacturer
- o My local bike shop took it
- o I delivered it to a recycling center or battery drop box
- o I sold my e-bike and battery together
- o I threw away my e-bike and battery together
- o Other (please specify) _____

Display This Question:

If Why did you need to have your e-bike serviced? (Select all that apply) != Repair or replace battery

Q81 
What would you do if a battery failed or stopped working?

- o Throw it away in my residential trash
- o Keep it stored at my home
- o Send it back to the manufacturer
- o Take it to my local bike shop for disposal or recycling
- o Deliver it to a recycling center or battery drop box
- o Sell my e-bike and battery together
- o Throw away my e-bike and battery together
- o Other (please specify) _____

Q82
If your current battery ages and loses enough range to meet your travel needs, what do you plan to do with the battery or with the bike?

_____

_____

_____

Q83
Have you had any specific problems with how your e-bike functions? If so, please describe.

_____

_____

_____

End of Block: Section 8.2: Optional Questions

Start of Block: Drawing Entry Info

Q84

Thank you for completing the survey!

If you have any questions about the study, please contact us at macarthur@pdx.edu or 503-725-2866.

Click here or paste the link below in your browser to be redirected to a page where you can enter our drawing for one of 50 $20 Visa Gift Cards and three Topo Designs Backpacks (value $100) provided by PeopleForBikes.

https://portlandstate.qualtrics.com/jfe/form/SV_1AL8nSEXvUI6rJA

End of Block: Drawing Entry Info

End of Survey Page

Thank you for your time. You may now close this window.

If you want to learn more about e-bike research from the creators of this survey, you can visit:
https://trec.pdx.edu/e-bike-research
https://www.micromobilityresearch.com/

If you have any questions about the study, please contact us at macarthur@pdx.edu or 503-725-2866.

Appendix B – Removal of Ineligible and Automated Responses

This appendix describes the data cleaning procedures employed to reduce the number of automated responses present in the dataset.

There were 10,968 total cases in the dataset as downloaded from Qualtrics (the survey platform). Using the following process, 2,844 cases were found ineligible for inclusion, 3,656 cases were removed because they violated at least one filter designed to catch automated responses, 422 cases were removed by hand, and 50 cases were marked for inclusion manually. Combined, this resulted in a final dataset of 4,096 cases.

1. Data were exported from Qualtrics in SPSS and Microsoft Excel formats.
2. Cases were marked for removal that met any of the following **ineligibility criteria**:
    a. Incomplete surveys (Qualtrics-provided)
        i. Surveys were marked as incomplete if they were less than 86% completed, as reported in a variable produced by Qualtrics. This corresponded with the end of the demographics section and the beginning of the optional questions at the end of the survey.
    b. Completion date prior to survey release to the public – these were cases generated during testing (Qualtrics-provided)
    c. Status variable from Qualtrics to mark spam, preview, etc. (Qualtrics-provided)
    d. Answered "I do not own or regularly ride an e-bike" (Q5)
3. Cases were marked for removal that met any of the following **automated response exclusion criteria**:
    a. None or bad postal code (Q3)
        i. Cases were marked for removal where no zip code was given; this was the first question and respondents were required to answer it.
        ii. A list of all valid zip codes was downloaded from: https://www.unitedstateszipcodes.org/zip-code-database/
            1. US zip codes were checked against this list. A random sample of those marked as illegitimate were checked again at https://tools.usps.com/zip-code-lookup.htm?citybyzipcode. No incorrectly marked codes were found.
    b. Latitude and longitude outside of the U.S. and Canada (Qualtrics-provided)

i. A bounding box was created for the most extreme points of the United States and Canada at (83.111389, -172.437778) to (18.910833, -52.619444)
    1. U.S. points were obtained from: https://en.wikipedia.org/wiki/List_of_extreme_points_of_the_United_States#Westernmost
    2. Canada points were obtained from: https://en.wikipedia.org/wiki/List_of_extreme_points_of_Canada
    3. The bounding box was checked at: https://linestrings.com/bbox/#-172.437778,18.910833,-52.619444,83.111389
ii. The latitude and longitude given by Qualtrics were checked against this bounding box. Responses outside of the bounding box were marked for removal.

c. 3 or more total cases from the same IP address (Qualtrics-provided)
d. 2 or more total cases at same start or end time (Qualtrics-provided)
e. Duration less than 7.5 mins (Qualtrics-provided)
    i. This was determined to be the minimum amount of time any good faith effort to complete the survey might take.
f. No race, age, and gender provided (Q47, 48, 49)
g. 0 adults in the household (Q53_1)
h. Household size > 7 (Q53)
    i. Less than 1.5% of U.S. households meet this criterion.
i. Number of vehicles in household >15 (Q72)
j. Purchase price >=$16,000 or <$350 (Q16)
    i. Cases caught by this filter were reviewed manually. Those with high-value e-bike models reported or incentives covering the majority of the purchase price were marked for inclusion.
k. Purchase price has a decimal reported (Q16)
l. Trip distance > 90 miles round-trip (Q24)
m. No make or model provided (Q7)
n. *Moped* style selected for "Which of these most closely resembles your e-bike?" (Q9)
o. Q45 text-entry comment is longer than 17 characters and not unique.
p. Q46 text-entry comment is longer than 17 characters and not unique.
q. Q82 text-entry comment is longer than 25 characters and not unique.
r. Q83 text-entry comment is longer than 18 characters and not unique.

s. Reported married or living with partner and 1 adult in the household (Q52, Q53)
t. Reported a shared e-bike and 1 person in the household (Q53, Q75)

4. Cases were marked for *removal* that met any of the following **manually evaluated criteria**:
    a. Bicycle make/model provided is not an e-bike (Q7)
        i. As the first text-entry question, answers were used to exclude entire cases because the use of random characters, automotive vehicle models, or other nonsensical inputs indicated an illegitimate case.
    b. Suspicious clustering of text responses (Q7, Q45, Q46, Q83)
        i. Data were sorted by start time, complete time, and recorded time; clusters were inspected at times with multiple similar or identical responses to any of the text entry questions – many clusters were identified and marked as spam.
    c. Nonsensical or repeated responses to text-entry questions (Q7, Q45, Q46, Q83)
    d. Non-English responses to text-entry questions (Q7, Q45, Q46, Q83)
5. Cases were marked for *inclusion* that met any of the following **manually evaluated criteria**:
    a. Sensical prices given the e-bike model reported or incentives covering the majority of the purchase price were marked for inclusion (Q16-Q19)
        i. Cases were manually reviewed that were caught by the purchase price filter or that indicated the receipt of a purchase incentive.
    b. Convincing text responses (Q7, Q45, Q46, Q83)
        i. A small number of cases were included due to convincing text response questions that related directly to other answers left on the survey.

A summary of the number of responses flagged by each filter is included below.

	Ineligibility Criteria	Total responses filtered	Filtered alone	Filtered with one or more other ineligibility criteria	Filtered with one or more automated response exclusion criteria
Automatic	Incomplete surveys (Qualtrics-provided)	2,087	8	11	2,079
	Completion date prior to survey release to the public (Qualtrics-provided)	26	2	14	24
	Answered "I do not own or regularly ride an e-bike" (Q5)	721	0	9	721
	Status variable from qualtrics to mark spam, preview, etc. (Qualtrics-provided)	41	0	26	41
	Automated Response Exclusion Criteria	**Total responses filtered**	**Filtered alone**	**Filtered with one or more other automated response exclusion criteria**	**Filtered with one or more ineligibility criteria**
Automatic	No make or model provided (Q7)	3,018	329	2,688	1,813
	2 or more total cases at same start or end time (Qualtrics-provided)	1,182	324	858	368
	Purchase price >=$16,000 or <$350 (Q16)	910	220	689	62
	Reported married or living with partner and 1 adult in the household (Q52, Q53)	377	218	159	0
	Q82 text-entry comment is longer than 25 characters and not unique	333	147	186	0
	0 adults in the household (Q53_1)	213	98	114	1
	Moped style selected for "Which of these most closely resembles your e-bike?" (Q9)	444	93	351	52
	3 or more total cases from the same IP address (Qualtrics-provided)	557	79	478	176
	Q46 text-entry comment is longer than 17 characters and not unique	388	63	325	0
	Household size > 7 (Q53)	413	41	371	5
	Q45 text-entry comment is longer than 17 characters and not unique	189	37	151	2

	Automated Response Exclusion Criteria (continued)	**Total responses filtered**	**Filtered alone**	**Filtered with one or more other automated response exclusion criteria**	**Filtered with one or more ineligibility criteria**
Automatic	Purchase price has a decimal reported (Q16)	48	36	12	4
	Duration less than 7.5 mins (Qualtrics-provided)	2,397	30	2,365	1,942
	None or bad postal code (Q3)	804	28	775	407
	Trip distance > 90 miles round-trip (Q24)	74	21	53	3
	Number of vehicles in household >15 (Q72)	158	15	143	0
	Latitude and longitude outside of the U.S. and Canada (Qualtrics-provided)	264	7	257	15
	No race, age, and gender provided (Q47, 48, 49)	3,151	6	2,744	2,823
	Q83 text-entry comment is longer than 18 characters and not unique	83	6	77	0
	Reported a shared e-bike and 1 person in the household (Q53, Q75)	25	3	22	0
By hand	Suspicious clustering of text responses (Q7, Q45, Q46, Q83)	1,228	646	521	92
	Bicycle make/model provided is not an e-bike (Q7)	371	149	202	47
	Non-English responses to text-entry questions (Q7, Q45, Q46, Q83)	66	12	53	30
	Nonsensical or repeated responses to text-entry questions (Q7, Q45, Q46, Q83)	17	6	11	0
	Inclusion Criteria	**Total responses marked**	**Marked for inclusion alone**	**Marked, overriding ineligibility criteria**	**Marked, overriding automated response exclusion criteria**
By hand	Sensical prices given the e-bike model reported or incentives covering the majority of the purchase price were marked for inclusion (Q16-Q19)	61	25	2	43
	Convincing text responses (Q7, Q45, Q46, Q83)	34	25	34	14

Appendix C – Incentive Programs Represented

Thanks is due to the following people for distributing our survey to their participants: Amanda Cesar (Pueblo County, CO), Alex Salcedo (MassBike), Dave Cohen (VBike, VT), Juan Serpa Muñoz (Eugene Water & Electric Board, OR), Katy Lang (District Department of Transportation, DC), Kirsten Riker (511 Contra Costa, CA), Lisa Reed (Holy Cross Energy, CO), Loreena Dobson (Yukon, Canada), Lucy Gigli (Alameda Transportation Management Association, CA), Mary Medeiros McEnroe (Silicon Valley Power, CA), Matt Butler (Devou Good Foundation), Mike Salisbury (Colorado Office of Climate Action, Sustainability & Resiliency), Patrick Murphy (Vermont Agency of Transportation), Sandee Cirian (Community Cycles, Boulder, CO), Sara Canabarro (Rhode Island Office of Energy Resources), Sarah Thorne (Colorado Energy Office), and Ty Bell (Monterey Bay Air Resource District).

The following people providing materials from their incentive program surveys for our review: Amy Naranjo (GO Santa Cruz, CA), Kathryn Duvall (Corvallis, OR), Kirsten Riker (511 Contra Costa, CA), Mary Medeiros McEnroe (Santa Clara, CA), Matt Butler (Devou Good Foundation, KY/OH), Michael Hay (Town of Banff, AB), Rachel Ruhlen (Fort Collins, CO), Sarah Balloch and Sam (Electrify Nova Scotia, NS), and Scott Salyer (Sonoma Clean Power).

The following table provides a list of the incentive programs represented by respondents.

Incentive Program(s)	Count	Percent
511 Contra Costa (CA)	2	0.8
Alameda Municipal Power (CA)	5	2.1
Austin Energy (TX)	13	5.5
Bay Area Air Quality Management District (CA)	1	0.4
Benton County (OR)	1	0.4
Boulder County (CO)	2	0.8
Burlington Electric Department (VT)	6	2.5
Central Coast Community Energy (CCCE)	8	3.4
Central Coast Community Energy (CCCE); GO Santa Cruz	1	0.4
Central Coast Community Energy (CCCE); GO Santa Cruz; Monterey Bay Air Resources District (CA)	1	0.4
Central Coast Community Energy (CCCE); GO Santa Cruz; Monterey Bay Air Resources District; Employer - Undisclosed (CA)	1	0.4
Central Coast Community Energy (CCCE); Monterey Bay Air Resources District (CA)	2	0.8
City & County of Denver (CO)	43	18.2
City of Ashland (OR)	1	0.4
City of Boulder (CO)	1	0.4
City of Paris (France)	1	0.4
Contra Costa County (CA)	4	1.7
DDOT/goDCgo (DC)	5	2.1
Devou Good Foundation (KY/OH)	9	3.8
Ecology Action Santa Cruz (CA)	1	0.4
Employer - City of Petaluma, CA	1	0.4
Employer - Dell	1	0.4
Employer - Undisclosed	2	0.8
Eugene Water and Electric Board (EWEB) (OR)	21	8.9
Green Mountain Power (VT)	12	5.1
Holy Cross Energy (CO)	2	0.8
I don't remember (located in Monterey Bay, CA, where multiple programs are available)	1	0.4
La Plata Electric Association (LPEA) (CO)	1	0.4

Incentive Program(s)	Count	Percent
Longmont Power & Communications (CO)	1	0.4
Massachusetts Bicycle Coalition (MassBike)	3	1.3
Monterey Bay Air Resources District (CA)	10	4.2
Pedal Ahead (CA)	1	0.4
Peninsula Clean Energy (CA)	2	0.8
Province of British Columbia	4	1.7
Province of Nova Scotia	5	2.1
Pueblo County (CO)	2	0.8
Sonoma Clean Power (CA)	3	1.3
South Coast Air Quality Management District (CA)	1	0.4
State of Rhode Island	1	0.4
State of Utah	1	0.4
State of Vermont	27	11.4
State of Vermont - Drive Electric Vermont	1	0.4
State of Vermont; Burlington Electric Department	2	0.8
State of Vermont; Green Mountain Power	8	3.4
State of Vermont; Washington Electric	2	0.8
State of Washington	1	0.4
Stowe Electric (VT)	1	0.4
Territory of Yukon	6	2.5
University of Utah	2	0.8
Vermont Public Power Supply Authority (VPPSA)	1	0.4
Yampa Valley Electric (CO)	1	0.4
Yolo Transportation Management Association (CA)	1	0.4
Total	**236**	**100**