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Electric Vehicle Adoption Deterrents: A Survey Analysis of High-Income Suburban Individuals on Key Concerns Impacting Electric Vehicle Purchase Decisions

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Abstract

The general population has many concerns about Electric Vehicles (EVs), but the concerns are significantly different for various income groups. This paper analyzes the concerns of a specific income group about purchasing a battery-powered electric vehicle. While previous studies have investigated people's concerns regardless of income, this study offers novel findings on high-income suburban individuals' sentiment. A 10-question google forms survey was sent out to collect data on EV perception. Based on the results, a T-test was used to see the differences in concern ratings between high-income EV owners and high-income non-owners along with differences in concern ratings in two different suburbs (West Windsor and Plainsboro, NJ, and Frisco, Texas). Interestingly, it suggests that the differences in ratings for apprehensions related to charging and battery efficiency are statistically significant(higher) for EV non-owners compared to owners. In addition, findings also suggest that Initial Cost is a concern for non-owners, but its rating is very similar to that of owners, suggesting that it isn't the primary reason for non-purchase of an EV. The conclusions of this study can facilitate further research in areas focused on educational and awareness building campaigns to address the key concerns regarding EV adoption along with future studies on EV perception.

Keywords: Identity, Gender, Socioeconomic class, Education, Politics

1. Introduction

Electric vehicles (EVs) run on electrical energy stored in their lithium-ion battery pack, unlike most vehicles today, which run on gasoline (a mixture of different fossil fuels). There are common types of electric vehicles, such as a plug-in hybrid, battery electric vehicle (BEV), and hybrid electric. All three involve the use of electricity for power, and they have drastically changed the car market. Their contribution to environmental sustainability is the major reason why the electric vehicle market has grown at a rapid rate during the 21st century and is continuing to do so. From 2011-2021, the percentage of car sales from electric vehicles increased by around 2300%. However, not all consumers are eager to switch to electric. According to a recent survey, less than 4 in 10 Americans say that they are somewhat likely or very likely to buy an electric vehicle (ResearchPew, 2023), suggesting that consumers aren't likely to make the switch anytime soon. While high initial cost continues to remain a significant deterrent, recent research from Statista suggests that only 33% of even high-income individuals considered purchasing an electric vehicle. This could present a significant opportunity since analyzing EV ownership trends within a base where cost may not be the biggest factor might provide insights into the key concerns about purchasing EVs compared to analyzing broader income segments.

This study aims to analyze the sentiment of higher-income (~$150,000-200,000) suburban individuals on deterrents related to EV purchase. While there have been studies on concerns about EV ownership, there have yet to

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be studies done on specifically high-income individuals' sentiments. The study also allows for an analysis of differences in concern ratings between current EV owners and non-owners, which can create new insights into EV perception among a homogenous group. Additionally, this study surveyed two suburban geographies within the US because most Americans (52%) live in suburban areas (HUDUSER, 2020). It can be predicted that non-owners will likely display more apprehension to most of the concerns compared to owners considering that the income groups for both owners and non-owners are homogeneous, suggesting that factors other than cost will likely be higher for non-owners, but the degree to which they differ is the primary component of the study because that will help identify the areas that need to be addressed to drive adoption. The paper will discuss the implications of the survey and what this means for future research, particularly in areas related to education and awareness, along with how the design study can be modified to include a larger population.

2. Materials and Methods

A survey was sent out to middle-aged residents (primary household owner age of 40-65) from the adjacent, suburban townships of West Windsor, NJ and Plainsboro, NJ to investigate further. The median income of individuals that age is $189,006 in West Windsor and $150,526 in Plainsboro (NJMLS, 2023). In addition, the survey also included middle aged individuals from Frisco, Texas to increase the geographical diversity of the responders. Frisco has a median income of $161,547 for residents aged (45-64), which qualified them for inclusion in the survey. Frisco is also a suburban township, but it is larger than West Windsor and Plainsboro and more metropolitan, which further increased the diversity of the study. However, this could be a potential limitation since more suburbs could've been included in the collection of data for more definite conclusions. While it is true that these incomes are much higher than the national average, the cost of living in both these locations is also significantly higher than the national average at 30% and 45% respectively. Also, the purpose of study was to start with the higher deciles of income and see if there is a difference in perception. Further research will need to be done across different income ranges to assess the validity of the conclusions, but this higher-income group would constitute a large market for EVs. In addition, because both locations have significantly higher costs of living, it makes comparing the two regions feasible for the study, especially considering that West Windsor and Plainsboro's averaged median income is more than that of Frisco, but it has a higher cost of living. Furthermore, other demographic indicators suggest a reasonably homogenous population- especially regarding ethnicity (~77% Asian and White population in West Windsor and Plainsboro compared to 75% in Frisco) (Niche, 2023), age (median ages between 35-44 for all 3 locations) (Niche, 2023), and highest education received (80% of West Windsor and Plainsboro Residents have a bachelor's degree or higher compared to 66% in Frisco- both are significantly higher than the national average of 34%) (Niche, 2023).

Next, a specific set of concerns was developed to include in the survey. The survey was primarily designed off past EV sentiment studies, such as the 2023 Global Automotive consumer study by Deloitte, but it was designed to select concerns that are relevant towards the demographics of my sample population along with the goals of the study. For example, one of the focus points of the study was to the attitudes of wealthier individuals toward EV initial costs, so initial car cost was included in the study. Concerns like 'Lack of charger at home' or 'Lack of choice' were not used because they would likely be less problematic for wealthier individuals. Additionally, many concerns were eliminated and combined to decrease the time participants would spend on the study since a shorter survey would likely increase the quality of the responses as people would likely spend more time per question. For example, concerns like 'Lack of alternate power source (e.g., solar) at home' were combined into a category with Electricity Costs because that would shorten the survey. Here is the final list of concerns:

- Initial car cost
- Replacement and maintenance costs (Ex: battery replacement)
- Electricity costs and home infrastructure modifications (Ex: Solar Panel Installation or amp capacity upgrade)
- Battery Efficiency (Miles per KWH)
- Public Charging Accessibility
- Charging Speed

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- Resale Value/Capability
- Insurance Premium

Then, the questions and style were developed. Because a statistical analysis was intended to be conducted in the study, a 10-point scale was used, and participants were asked to rate these concerns on how much it would affect their chances of buying an electric vehicle (1 meaning it would not be a factor and 10 meaning it would be a large factor). This was also done because responses like 'very problematic' or 'not problematic at all' would not help, and only knowing whether something is or is not concerning for someone wouldn't help for the type of analysis in this study- only information that would allow for numerical comparisons would work. The 10-point scale was specifically chosen over other numerical scales, such as a 5-point scale for the data to be as precise as possible. In addition, to account for the participants' knowledge and viewpoint on electric vehicles, the survey included a question asking them about their current ownership of electric vehicles ('yes', 'no', 'no-but planning to buy one') and a question asking them about their familiarity with electric vehicles ('very familiar', 'somewhat familiar', 'unfamiliar'). This way further investigation could be done to see if there were correlations between ownership and concern ratings, and knowledge and concern ratings.

Finally, the survey was sent out. It was sent through google forms and mainly through social media, primarily Facebook. No information regarding gender, age, ethnicity, or factors like the number of people in nuclear family was to preserve the anonymity of the responders, but this could be a limitation. However, factors like demographics and average township age were incorporated into the analyses and conclusions, and the survey was sent out to media platforms that have an older population compared to other media platforms. Additionally, because owners were responding to the survey based on their current perception, there could be some hindsight bias in their responses.

The organization of the data and statistical analyses was done through google sheets. The statistics used were averages, coefficient of variation, and p-values from T-tests. A T-test was performed on the ratings between EV owners and non-owners along with the ratings between West Windsor and Plainsboro responses and Frisco responses to test for statistical significance between any of the groups. For the T-Test, the alpha value was the standard 0.05, meaning that the result of the T-Test returning some less than 0.05 means that there is a statistically significant difference between the groups compared. Anything above the 0.05 level does not indicate statistically significant differences, but it can be used to get a general picture of the comparisons between the groups compared.

3. Results

3.1 Survey Results

A total of [N=135] responded to the survey (75 from Plainsboro and 60 from Frisco), where N represents the total number of participants. Only 3.7% of people responded that they were unfamiliar with electric vehicles. I removed those responses to maintain the accuracy of the study, so the data used in the analysis contains [N=130] responses. Out of the 130 responses in the dataset,72 were from West Windsor or Plainsboro and 58 were from Frisco.

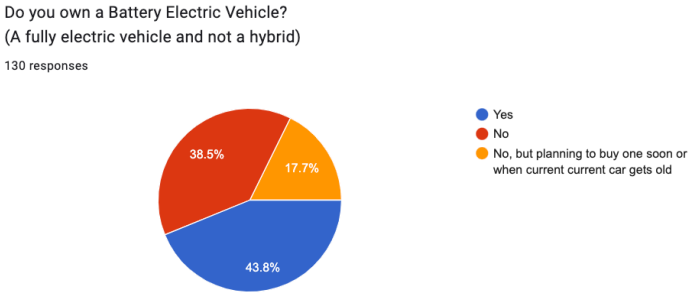

Figure 1: This figure shows a pie chart of the different percentages of responses for each category for the question 'Do you own a Battery Electric Vehicle?'

For the results of the study, more than 60% of responders reported being 'very familiar' with electric vehicles and 36.5% reported 'somewhat familiar'. Only 17.7% of responders said that they would buy an electric vehicle as their next car, which could mean that the responders who don't own an electric vehicle are less likely to make the switch for now.

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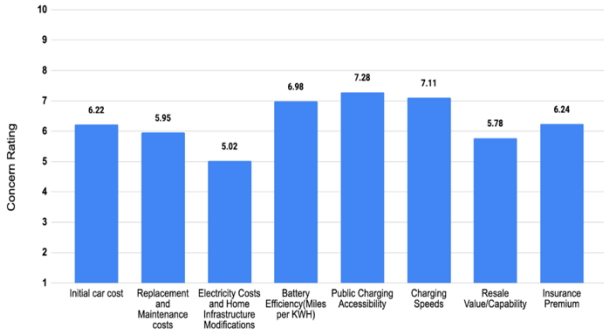

Figure 2: This graph shows the average rating on a scale of 1-10 of [N=130] participants on their concerns about electric vehicle ownership

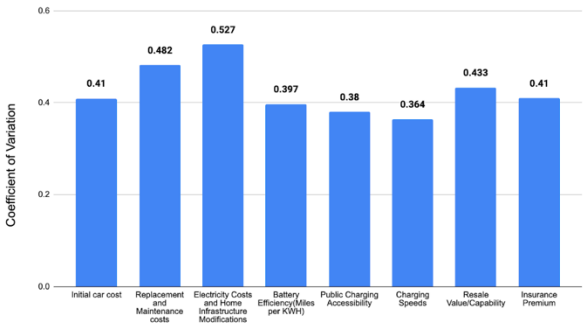

Figure 3: This graph shows the coefficient of variation(cov) of the responses [N=130] for each concern. It was calculated by dividing the standard deviation of each concern by the mean of each concern. Its purpose is to illustrate that certain concern ratings had less variance than others.
*cov<1 for all concerns, which indicates low variance in ratings

Public Charging Accessibility received the highest average concern rating, followed closely by Charging Speeds and Battery Efficiency. After that, there was a substantial drop-off in concern as Insurance Premium and Initial Cost were the next highest rated. Electricity Costs and Home Infrastructure Modifications received the lowest rating by a significant amount. The graph above doesn't factor in ownership or knowledge, but those factors played a major role in the concern ratings; for example, participants who reported being 'very familiar' with electric vehicles had far fewer concerns with any aspects of electric vehicles overall compared to participants who were 'somewhat familiar.

3.2 Ownership T-test

I used this data to specifically focus on certain groups' concern ratings. I aimed to analyze certain trends and find differences between the ratings of owners and non-owners; I combined the categories of 'no' and 'no but planning to buy one' because there were only 23 responses for the latter, which was not enough responses to draw conclusions individually (although the results for this category were even more extreme compared to the 'no' category). To do this, I first performed a T-test on the concerns to see if any differences between owners' ratings and non-owners were statistically significant. I separated the ratings for each concern above into an owner response or non-owner response, and I ended up with 57 responses on the owner side and 73 responses on the non-owner side for each of the 8 concerns analyzed. For the 4 parameters of the T-test, I used the first one for the owners' responses, the second one for the non-owners' responses, the third one for the number of tails, and the fourth one for the type of test. I chose to use 2 tails because I didn't have a specific hypothesis I wanted to test, and I chose to use a type 3 test as it is the two-sample, unequal variance test. The null hypothesis was that there would be no difference in the concern ratings between owners and non-owners. After performing the T-tests, I found that Initial Costs had a P-value of 0.851. However, Battery Efficiency, Public Charging Accessibility, and Charging speeds had P-values of 0.041, 0.031, and 0.004 respectively.

This demonstrates that the results of the T-test are statistically significant for Replacement and Maintenance Cost Responses, Battery Efficiency Responses, Public Charging Accessibility Responses, and Charging Speed Responses because they have P-values less than 0.05, thus rejecting the null hypothesis for these concerns that ownership doesn't affect concern ratings as the comparison was between owners' sentiment on the concerns compared to non-owners' sentiment on the concerns. The results of the T-test show that there is a clear difference in sentiment between owners and non-owners for these four categories. Each of those concerns had a difference of more than one when looking at owners' sentiment compared to non-owners' sentiment. The difference in average sentiment between owners and non-owners for Initial Cost was negligible. Replacement and Maintenance Costs ratings were significantly higher for non-owners compared to owners, making it the only money-related concern to have a statistically significant difference in sentiment between owners and non-owners. Overall, it can be concluded that for the participants in this study, Battery

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Efficiency, Public Charging Accessibility, and Charging Speeds are the biggest factors impacting EV ownership; Replacement and Maintenance costs are an important concern for non-owners; and Initial Cost plays a role in EV ownership but is not the reason that non-owners aren't buying them.

Table 1: This table shows the results of the T-test and the different Means, Variances, and P-values for [N=57] owners and [N=73] non-owners for each of the concerns.
*P<0.05 for Replacement and Maintenance Cost Responses, Battery Efficiency Responses, Public Charging Accessibility Responses, and Charging Speed Responses

Concern	Owners (N=57) Mean	Owners (N=57) Variance	Non-Owners (N=73) Mean	Non-Owners (N=73) Variance	P-Value
Initial Car Cost Responses	6.26	6.55	6.18	6.51	0.851
Replacement and Maintenance Cost Responses	5.09	9.19	6.55	6.86	**0.008**
Electricity Costs and Home Infrastructure Modifications Responses	4.60	6.60	5.34	7.12	0.109
Battery Efficiency Responses	6.42	7.89	7.42	7.19	**0.041**
Public Charging Accessibility Responses	6.68	8.43	7.75	6.66	**0.031**
Charging Speed Responses	6.37	6.84	7.68	5.91	**0.004**
Resale Value/Capability Responses	5.85	6.30	5.71	6.29	0.740
Insurance Premium	5.96	7.29	6.45	5.95	0.289

3.3 Geographic Comparison

To analyze the impacts of geography on the ratings, a comparative analysis was conducted on the differences in the ratings between West Windsor/ Plainsboro and Frisco.

The data illustrates that there are certain ratings that are higher in Plainsboro compared to Frisco, particularly the three non-financial concerns. Electricity Costs and Home Infrastructure Modifications and Resale Value/Capability did have differences in concern ratings as well, but they weren't analyzed further due to the low ratings they got. Additionally, the difference in Initial Cost ratings between the two locations was very low.

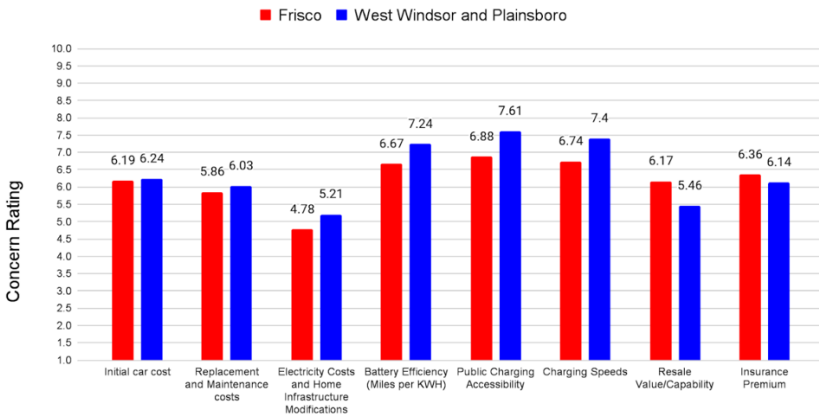

Figure 5: This graph shows the concern ratings for [N=72] participants in West Windsor and Plainsboro compared to [N=58] participants in Frisco

To analyze any differences between the responses in West Windsor and Plainsboro compared to Frisco, another T-test was performed, but this time it was between the participants in both locations. I used the same two-sample, unequal variance test with the same test parameters as earlier: a 2-tailed, type 3 (unpaired) test. However, I used the ratings of Frisco participants as my first parameter and the ratings of West Windsor and Plainsboro EV participants as my second parameter. The ratings for initial cost in both locations were close to identical, so for the test, I only focused on the concerns of Replacement and Maintenance Costs, Battery Efficiency, Public Charging Accessibility, and Charging Speeds because they were the only concerns to have a statistically significant difference in rating between owners and non-owners. This time, my null hypothesis was that location doesn't affect concern ratings. After performing the tests, none of the concerns had a p-value less than 0.05.

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Table 2: This figure shows the results of the T-test and the different Means, Variances, and P-Values for West Windsor and Plainsboro (WWP) participants and Frisco participants for each of the four concerns.

Concern	WWP (N=72) Mean	WWP (N=72) Variance	Frisco (N=58) Mean	Frisco (N=58) Variance	P-Value
Replacement and Maintenance Cost Responses	6.03	7.75	5.86	8.96	0.747
Battery Efficiency Responses	7.24	6.46	6.67	9.17	0.260
Public Charging Accessibility Responses	7.61	5.99	6.88	9.58	0.145
Charging Speed Responses	7.40	5.43	6.74	8.16	0.158

The results of this T-test demonstrate that none of the concerns have statistically significant differences based on ratings from the different locations. While West Windsor and Plainsboro participants did report higher concern ratings overall, there isn't enough evidence to suggest that this result is meaningful, especially because there were a higher percentage responses of EV owners from Frisco than those of West Windsor and Plainsboro. Thus, location doesn't undermine the conclusion that non-owners' sentiment of the statistically significant concerns is higher than that of the owners.

4. Discussion

4.1 Results Analysis

The results that high-income suburban individuals are more concerned with the practicality of driving electric vehicles rather than the monetary costs of ownership as the three largest concerns were related to convenience and reported a far higher rating compared to the rest of the concerns. All three of the non-financial concerns received the highest ratings and had statistically significant differences between owners and non-owners, supporting the idea that they are the primary reason that non-owners are hesitant to buy EVs. This is significant because the responders were all from suburban areas, and it was previously demonstrated the results in West Windsor and Plainsboro weren't drastically different from those in Frisco, so it suggests that non-owners potentially overestimate the difficulties related to charging and battery efficiency. Another interesting takeaway is that Replacement and Maintenance costs could play a significant role in EV ownership. It received the second lowest rating for owners but the fourth-highest rating for non-owners, and its results were barely different between the 2 locations. However, it had the highest variation in rating by far for owners and the second highest coefficient of variation overall, suggesting that it is a volatile concern for which the rating is primarily dependent on an individual's circumstances. Moreover, the concern was rated significantly lower than the other three statistically significant concerns, suggesting that it is a factor in ownership but not as important as the other three. It also suggests that non-owners might perceive this concern as more problematic than it is. Unsurprisingly, Initial Cost ratings showed the least difference between owners and non-owners. However, this is still important because it implies that non-owners view prices very similarly to owners, indicating that there are other reasons why non-owners aren't buying them. Moreover, it also supports the notion that non-owners don't find EV prices overrated because of the similar ratings between the two groups.

A key takeaway is that educating the public on EVs is critical to adoption. For example, even though over 80% of electric vehicle owners charge at home (Consumer Reports, 2023), my study and many other studies show that public charging accessibility is still a huge psychological concern for many, especially families that go on long road trips. However, the frequency of people charging electric vehicles at home combined with the results of the study brings up the question of how the government or EV companies can decrease the apprehension amongst non-owners. To decrease this apprehension, the government and EV companies should improve education regarding EVs. Despite the high-income demographics of the population, less than 60% reported being 'Very Familiar' with EV's. Furthermore, 63% of non-owners from my study reported being 'somewhat familiar' compared to only 37% for 'very familiar. This suggests that lack of knowledge of EVs creates hesitancy to buy them considering that non-owners had higher non-financial concern ratings than those of owners but reported being less knowledgeable about EVs. As a

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result, it makes sense for the government to invest in programs or advertisements that can help non-owners become more acquainted with EVs, particularly charging and range.

4.2 Education

Another key thing that automakers and the government should do to increase EV adoption is to improve EV education, particularly about range anxiety. Despite my study primarily receiving responses from individuals who earn significantly more than the average person, less than 60% reported being 'Very Familiar' with EV's. Furthermore, 63% of non-owners from my study reported being 'somewhat familiar' compared to only 37% for 'very familiar. Thus, regardless of income, organizations should strive to increase education on EV's across the country. One of the key steps to that is by decreasing range anxiety amongst the population. My study demonstrated how Battery Efficiency (Miles per KWH) was one of the highest-rated factors along with Public Charging Accessibility- both of which contribute to range anxiety. However, my study and others seem to support the idea that people could potentially be far more anxious about range anxiety than they should be.

This suggests that people are more apprehensive about EV range than they should be, so automakers and governments should target to decrease this apprehension. They can do so through mediums such as using technology by making it very clear for current or potential drivers to easily locate the nearest charging station and to give them a sense of perspective of how far their vehicle can travel before they must charge it. Automakers can advertise these features in their ads as these won't require that much time to demonstrate. Furthermore, the government can also advertise these features through things like PSA's, billboards, or collaborations with businesses. Regardless of how automakers and the government choose to decrease apprehension pertaining to range anxiety, they should ensure that they invest time and funding to devise the best education solution possible.

4.3 Future Research

The design and conclusions of this study can be applied to a wide range of scenarios. Firstly, analyzing a broader income and geographic band could yield more definitive conclusions and correlations between EV ownership and sentiment. Moreover, researchers could also analyze responses from groups of people who are considering buying EVs since this study discovered interesting, but statistically insufficient, data regarding populations like that. Additionally, one thing that the study couldn't do, due to not gathering personal information, was examine relationships between certain characteristics and EV concern ratings, so future studies could explore if there are any correlations between EV concern ratings and characteristics such as gender, ethnicity, or size of nuclear family. Regarding location, future research can be conducted on wealthy urban or rural towns to analyze their perspectives and compare those to suburban ones. That kind of research could also look at responses or information from a variety of states since different states have different policies and benefits for getting EVs.

4.4 Limitations

There were a couple of limitations with this study that may have impacted the conclusions. Participants' self-perception of their familiarity with EVs may not be reflective of their actual familiarity. Additionally, this study only analyzed two high-income suburban areas of the country, which may not be reflective of all high-income suburbs. Also, this study drew conclusions from a very narrow subset of high-income earners, so applications of it may not be applicable to some income owners, such as those making more than $250,000. Lastly, this study only focused on BEVs, so the responses of people who own hybrid EVs may have contaminated the responses of the non-owners since their concern ratings would've likely been a lot different than those of owners of gas-powered vehicles.

5. Conclusion

Overall, this study gave new insights into some common concerns about EVs for high-income suburban individuals in the US. Through surveying and analyzing a specific subset of individuals within a specific income range,

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this study was able to draw conclusions on the perception of individuals with similar demographics and location. The study was able to find that there were significant differences in concern ratings between EV owners and non-owners for Replacement and Maintenance Costs, Battery Efficiency, Public Charging Accessibility, and Charging Speeds and that the difference between Initial Cost concerns was negligible. The study was able also to demonstrate that there was no statistically significant difference between the two locations analyzed. The results of the study highlight key focus areas and concerns for future studies to analyze and awareness campaigns to help drive EV adoption.

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