A Comparison of Public Electric Vehicle Charging Access across the United States

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***Abstract*—While the rate of new electric vehicle registrations was only 10% in 2023 in the United States, electric vehicle users still need access to public charging points. This study aimed to characterize the differences in public charging point access across the United States, and to estimate if low access was associated with state-level rurality and low socioeconomic conditions. Based on data available from the United States census and Department of Energy, state-level public charging point access was defined two ways: As public charging points per 10,000 residents, and as a ratio of registered electric vehicles per public charging point. Descriptive, geographical, correlation and regression analysis was conducted to explore associations between socioeconomic variables and public charging point access between states, and to compare access between states. When comparing all states and the District of Columbia (n = 51), we found that public charging points per 10,000 residents ranged from 0.9 to 9.9 (median 2.4, interquartile range 1.7 to 3.4), and electric vehicles per public charging point ranged from 9.2 to 76.5 (median 30.4, interquartile range 19.3 to 39.7). In regression analysis, median state income was statistically significantly negatively associated with public charging points per 10,000 residents, and percentage with college degrees was strongly statistically significantly positively associated with this rate. No socioeconomic variables were statistically significantly associated with electric vehicles per public charging point.**

Keywords*—*Electric vehicles; public charging points; United States; socioeconomic status; public policy.

I. Introduction

Electric Vehicle (EV) ownership is low in the United States (US) relative to other countries; while the rate of new EV registrations in the US was 10% (representing 1.4 million) in 2023, it was just under 25% in Europe and about 60% in China in the same year [1]. EVs must be charged, and in 2021, the National Renewable Energy Laboratory (NREL) estimated that between 78% and 98% of US EV owners had access to residential charging [2]. It has been estimated in the US in 2023 that 50% to 80% EV charging sessions occurred at the residence, although less than 50% of households have parking areas available where residential EV charging could take place [3]. For example, residents of multi-unit dwellings in the US have specific challenges to setting up residential EV charging [2][3].

Setting aside the obstacles of establishing EV charging at certain residence types, another important downside to residential EV charging is that it strains the energy grid [4]. An additional consideration is that all EV charging cannot take place residentially if EV users want to take long trips that necessitate access to chargers available in the community [5][6]. To account for this in the US, the Biden administration set a goal of creating a national network with 500,000 EV public Charging Points (CPs), and a law was passed providing $7.5 billion to support this expansion [5][7]. Under a scenario where 50% of all new vehicle sales are Zero-Emission Vehicles (ZEVs) by 2030 (to be in line with federal targets), it is estimated that the US will need to have established approximately 1.2 million public EV CPs and 28 million private chargers by that year [8][9].

Although many other countries have also invested in their public EV charging infrastructures, disparities have been identified with respect to public CP accessibility [10]. Studies in the US and other countries show that those who purchase EVs are more likely to have higher income (largely due to the high EV initial purchase price) and educational attainment [11–16] . One study has shown that the availability of public CPs in the US is correlated with the density of EV ownership, which illustrates one aspect of such disparities [17]. This issue has been termed the “chicken and egg” problem, whereby public CPs are set up where EV ownership is higher, and this incentivizes more EV ownership in the region where public CPs are established [18]. Nevertheless, other studies in the US have found that the availability of public CPs is not correlated with population density, and is instead associated with higher income, older age, larger percentage those identifying as white race, and proximity to highways [13][14][18][19]. Another US study found that disadvantaged communities (defined as those exposed to a disproportionate share of environmental, health, and climate-related burdens) have 64% fewer public CPs compared to other communities [20]. In the US and in other countries, the availability of public CPs has been found to be lower in rural areas [21][22].

Public CP access is generally compared between regions using either CPs per population, or CPs per EV [6][23][24]. Zema et al. [24] developed a top ten list of European countries with the highest density of public CPs per population, and the lowest rates of EVs per public CP. Their analysis found that densities of public CPs per 10,000 population for the top ten European countries ranged from 10.4 to 52.5, and the densities of EVs per public CP for the top ten European countries ranged from 0.6 to 3.0 [24].

While several research reports identify factors associated with public CP access disparities in the US, their approaches typically do not look at the differences between states [10][19–21] . For a few examples, one study of inequity in public CP access in the US examines this phenomenon at the census track level [21]; others consider attributes of US regions in proximity to public CPs without regard to political boundaries (such as census tracts, counties, or states) [10][19]; another compares public CP access in US communities with particular attributes [20]; and others investigate public CP access within specific locations, such as King County in Washington state [25], New York City (NYC) [26], and California [27]. These approaches, while legitimate, cannot take into account the potential impact of state-level policies supporting EV ownership and the development of a public EV infrastructure [26][27]. California has passed laws and funded projects aimed at increasing EV ownership and public CP access, and projects to increase access to public CPs are also underway in NYC, Kansas City in Missouri, and in the states of Washington, New Jersey, and Ohio [13][26][27].

Additionally, socioeconomic conditions differ between states which can impact disparities between states in terms of the public CP infrastructure [13][28]. States also differ in their proportions of non-white residents, low income households, and rural locations, attributes which have been shown to be associated with increased energy burden [28]. Also, states have different levels of housing types (such as multi-unit dwellings) that can impact the ability of residents to engage in EV charging at home [13]. Therefore, the aim of this investigation was to characterize the differences in public CP access across the states in the US, and to estimate if low access was associated with state-level rurality and low socioeconomic conditions.

In this paper, Section II presents our methodology, including the data sources we used and our analytic approach. Section III provides our results, including a descriptive analysis, followed by correlations, Analysis of Variance (ANOVA), and regression analysis. Section IV presents a discussion, including the strengths and limitations of the analysis, and the paper concludes with Section V, which provides a conclusion and discusses future work.

II. METHODOLOGY

A. Data Sources

For this analysis, each state in the US (including Washington DC) was considered an experimental unit (n = 51). State-level rurality was operationalized as non-urban areas and was estimated from the gazetteer files provided by the US census as a proportion. In the proportion, the numerator was estimated by subtracting Urban Square Miles (SQMI, represented by SQMI for metropolitan areas) from total state SQMI [29]. The denominator was estimated as total state SQMI. Where metropolitan areas crossed multiple states, they were divided equally among each state. State-level socioeconomic conditions were operationalized as median state income (median earnings in the past 12 months in 2024 inflation-adjusted dollars for the population aged 25 years and over with earnings) and proportion of residents age 25 years and over with bachelor's degree or higher 2024. These data were obtained online for each state from the US census [30].

Public CP access was operationalized in two ways: As number of public CPs per 10,000 state population (*CPPrev*), and as a ratio of number of EVs the state divided by number of CPs in the state (*EVPerCP*). Number of EVs per state registered in 2024 and number of CPs per state were obtained from the Alternative Fuels Data Center (AFDC) provided by the US Department of Energy; CP data were filtered to only include EV CPs that were available as of September 16, 2025 [31]. State population was estimated using the US census [30]. States were also analyzed in terms of divisions and regions (see Table 1).

B. Analytic Approach

First, a descriptive analysis was performed on each state individually, including mapping, then aggregated by division and region. Next, correlations were explored between predictors and public CP access measures (*CPPrev* and *EVPerCP*). ANOVAs were conducted with region and division as predictors and public CP access variables (*CPPrev* and *EVPerCP*) as dependent variables.

Finally, a linear regression model was developed for each public CP access measure as the dependent variable including the independent variables of proportion non-urban, median income, proportion with a college degree, and division as indicator variables (compared to the East South Central division, see Table 1). For the regression model predicting *CPPrev* (Model A), 1,000s of registered EVs in 2024 was included as an independent variable, and for the regression model predicting *EVPerCP* (Model B), 10,000 of population was included as an independent variable. For all analyses with statistical tests, α was set at 0.05. For regression models, variables were retained if they met or approached statistical significance. Statistical analysis was done using R GUI [32] and maps were developed in Python.

III. RESULTS

A. Descriptive Analysis

Descriptive statistics were developed to characterize each state, including adult population, proportion of non-urban area, median income, and proportion of the population with college degrees (data not shown). The results were that the median population of all the states was 3,531,346 (Interquartile Range [IQR] 1,471,384 to 6,148,676), the median proportion non-urban was 0.98 (IQR 0.94 to 0.99), the median annual income was $51,472 (IQR $50,113 to $57,208), and the median proportion with college degrees was 0.36 (IQR 0.32 to 0.39). Descriptive statistics regarding EVs and CPs were also developed for states (data not shown). The median number of CPs per state was 714 (IQR 375 to 1,899), and the median *CPPrev* was 2.4 (IQR 1.7 to 3.4, range 0.9 to 9.9). The median number of EVs per state was 25,565 (IQR 8,108 to 71,152) and the median *EVPerCP* was 30.4 (IQR 19.3 to 39.7, range 9.2 to 76.5). These results are summarized by division and region in Table 1.

As shown in Table 1, *CPPrev* ranged from 1.6 to 6.1, and *EVPerCP* ranged from 18 to 61. Figure 1 shows the number of EVs and public CPs per state. In Figure 1, the category boundaries follow close to the quartile estimates to facilitate

TABLE I
DESCRIPTIVE STATISTICS ABOUT ELECTRIC VEHICLES AND CHARGING POINTS BY DIVISION AND REGION

Division*	Number of States	Number of Public Charging Points	Charging Points per 10,000 Populations	Number of Registered Electric Vehicles 2024	Electric Vehicles per Public Charging Point
ENC	5	7,290	1.9	251,294	34
ESC	4	2,447	1.6	61,475	25
MA	3	9,111	2.7	336,157	37
MTN	8	6,859	3.4	291,764	43
NE	6	7,611	6.1	136,775	18
PAC	5	24,572	5.8	1,501,370	61
SA	9	13,931	2.5	614,617	44
WNC	7	4,112	2.4	93,767	23
WSC	4	5,320	1.6	268,226	50
Region**					
MW	12	11,402	2.1	345,061	30
NE	9	16,722	3.6	472,932	28
S	17	21,698	2.1	944,318	44
W	13	31,431	5.0	1,793,134	57

Note: * ENC = East North Central, ESC = East South Central, MA = Middle Atlantic, MTN = Mountain, NE = New England, PAC = Pacific, SA = South Atlantic, WNC = West North Central, WSC = West South Central. ** MW = Midwest (includes WNC and ENC), NE = Northeast (includes MA and NE), S = South (includes WSC, ESC and SA), W = West (includes MTN and PAC).

a fair comparison. As shown in Figure 1, there are slight differences in the density of EVs compared to the density of public CPs per state across states. For example, several states in the South Atlantic (SA), East North Central (ENC) and Mountain (MTN) divisions appear to have a higher density of EVs compared to public CPs. Figure 2 visualizes *CPPrev* and *EVPerCP* by state. As with Figure 1, in Figure 2, the category boundaries roughly follow quartiles to facilitate a fair comparison. In Figure 2, although states in the West region have high *CPPrev*, they also have a high *EVPerCP*. States with low *CPPrev* and high *EVPerCP* include Illinois, New Jersey, Florida, Oklahoma and Texas, suggesting EV owners have the most limited access to public CPs in those states. Several states in the Northeast region have high *CPPrev* but low *EVPerCP*, suggesting that EV adoption by the population is outpaced by the public CP charging infrastructure.

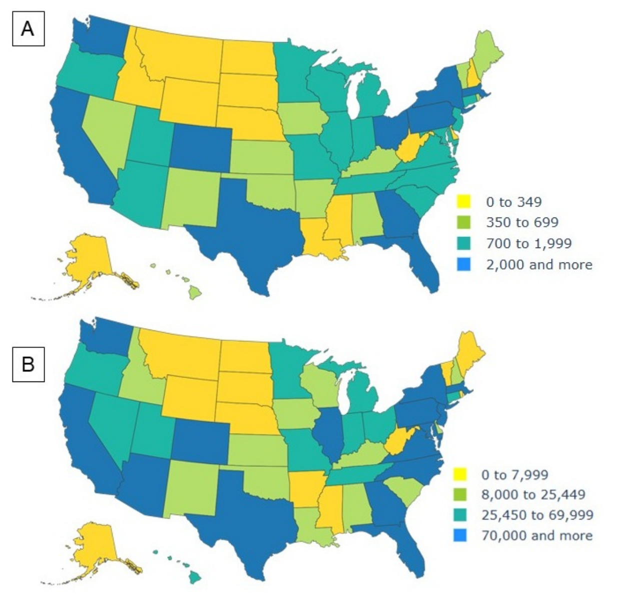

Figure 1. Number of Electric Vehicles and Public Charging Points per State. A: Number of public charging points. B: Number of electric vehicles.

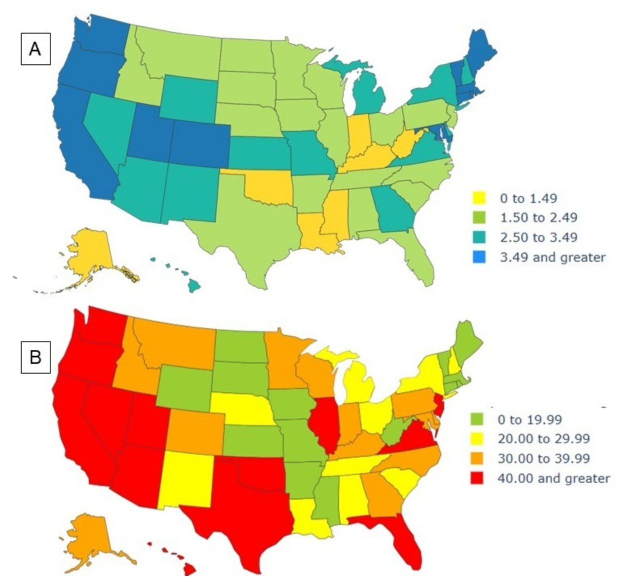

Figure 2. Public Electric Vehicle Charging Points by 10,000 Population and by Number of Electric Vehicles per State A: Public electric vehicle charging points per 10,000 population. B: Electric vehicles per public charging point.

B. Correlation and Analysis of Variance

In correlation analysis, adult population was strongly positively statistically significantly correlated with number of registered EVs in the state (r = 0.8054, $p < 0.0001$) and number of public CPs in the state (r = 0.8448, $p < 0.0001$), and number of registered EVs was even more strongly positively statistically significantly correlated with number of public CPs (r = 0.9747, $p < 0.0001$). In terms of access measures, with respect to *CPPrev*, a strong positive statistically significant correlation was seen with proportion with college degrees (r = 0.7035, $p < 0.0001$), and a moderate positive statistically significant correlation was found with state median income (r = 0.5715, $p < 0.0001$). A weak but statistically significant negative correlation was seen between *CPPrev* and proportion of non-urban land (r = -0.3631, p = 0.0088). In terms of *EVPerCP*, there was a moderate, positive statistically significant correlation with state adult population (r = 0.4847, p = 0.0003). All other correlations were not statistically significant.

For ANOVA results, with respect to *CPPrev*, both division (p = 0.0001) and region (p = 0.0007) were statistically significant, and similar results were found for *EVPerCP* (division p = 0.0054, region p = 0.0399).

C. Regression Analysis

Both Model A (with *CPPrev* as the dependent variable) and Model B (with *EVPerCP* as the dependent variable) were developed. To develop a final equation for each model, for Model A, only the following covariates were retained in the model: 1,000 registered electric vehicles 2024, median income, proportion with college degrees, and the indicator variable for NE. For the final Model B equation, the following covariates were retained: 10,000 population and the indicator variable for PAC. The results were:

Model A

$$\hat{y} = -1.1959 + 0.0026_{\text{EV}} - 0.0001_{\text{MI}} + 23.4885_{\text{PCD}} + 2.3771_{\text{NE}}$$

Model B

$$\hat{y} = 24.8170 + 0.0121_{\text{POP}} + 16.7633_{\text{PAC}}$$

where *EV* is number of EVs in the state, *MI* is median income, *PCD* is proportion of residents with college degrees, *NE* is New England division, *POP* is adult population, and *PAC* is Pacific Division. The adjusted r^2 for final Model A was 0.7126, and for final Model B, the adjusted r^2 was 0.2935. These measures indicate that while the covariates in Model A explained about 71% of variance in *CPPrev*, the covariates in Model B only explained about 29% of the variance in *EVPerCP*, indicating that the model fit for Model B was far inferior to the model fit for Model A. While the higher r^2 for Model A indicates strong in-sample explanatory power, this does not by itself guarantee predictive performance on new data, which is sufficient for the current analysis which is not intended to be predictive.

In Model A, which predicts *CPPrev*, 1,000 registered EVs was statistically significant (slope = 0.0026, p = 0.0016), as was proportion with college degrees (slope = 23.4885, $p <$ 0.0001) and the NE division (slope = 2.3771, $p < 0.0001$). All other covariates in the model were not statistically significant. However, median income, which had a negative association with *CPPrev* in the model, approaches statistical significance (slope = -0.0001, p = 0.0627). As those with college degrees typically have a higher income than those without, the contradiction between the positive slope for proportion with college degrees and the negative slope for median income may reflect collinearity between the two covariates in the model. All statistically significant slopes were positive, indicating a positive association with *CPPrev*, and the magnitude of the slope for proportion with college degrees was much higher than the others, indicating that controlling for other factors, this covariate has a very strong positive association with *CPPrev*.

The results from Model B, which predicts *EVPerCP*, were quite different from Model A. The slope for the covariate for 10,000 population was positive and statistically significant (slope = 0.0121, p = 0.0009), as was the slope for Pacific division (slope = 16.7633 p = 0.0168). As was seen in Model A for the slope for proportion with college degrees, the magnitude of the slope for the Pacific division in Model B was very high. None of the other covariates are statistically significant in the model.

IV. Discussion

Our analysis showed that there were wide differences in public CP access across the different states in the US. In final regression models, neither measure of public CP access we used was associated with state-level rurality. However, the access measure of public CPs per 10,000 population was slightly negatively associated with median income and strongly positively associated with the proportion of population holding a college degree in the state. While the correlation analysis revealed a moderate positive statistically significant correlation between public CPs per 10,000 population with state median income, this association became slightly negative when included in the full regression model in the presence of other covariates. The access measure of EVs per public CPs in the state was not associated with any socio-economic variables in final models. In final models, it was found that state division membership mattered, in that for public CPs per 10,000 population, the NE division was strongly independently positively associated, and for EVs per public CP, the PAC division was strongly independently positively associated.

Several important observations can be made from this analysis. First, public CPs per 10,000 residents in each state ranged from 0.9 to 9.9. With respect to that metric, even the top state is lower than the lowest of the top ten European countries, which is Denmark at 10.4 [24]. With respect to EVs per public CP, the range for states was 9.2 to 76.5, which is much higher than the least accessible of the top ten European countries, which is Hungary at 3.0 [24]. This shows that while there is much variation state to state on these access metrics, overall, compared to European countries, public CPs are generally less accessible in the US.

Next, socioeconomic indicators in this analysis were associated with public CPs per 10,000 residents in each state, but not with EVs per public CP. Median income had a slight negative association, showing that higher median income is associated with fewer public CPs per 10,000 residents. However, proportion with college degrees in the state had a strong, positive association, suggesting that how educated the population is strongly influences the number of public CPs. As described earlier, EV owners tend to be more highly educated [11–16] , yet proportion of college degrees was not correlated with number of EVs in the state. Therefore, the persistence of college degrees being associated with higher rates of public CPs per population in the regression analysis is likely a result of a more educated populace selecting leaders that prioritize CP access as part of public policy. Although having a college degree is generally associated with enjoying a higher income, states with depressed economies generally have a lower median income, regardless of the level of education of their population.

That the NE division was strongly positively associated with CPs per population, and that the PAC division was strongly positively associated with EVs per CP also is likely a reflection of public policy initiatives. With respect to the NE division, public policy has emphasized expanding the public CP infrastructure, and programs to expand public CP access have been implemented in Rhode Island, Massachusetts, and New Hampshire [33–35]. However, the states in PAC had significantly higher EVs per public CP, which suggests that CP access is much poorer in that division. This is likely due to an emphasis in public policy toward EV adoption without a comparable emphasis on expanding the public CP infrastructure to accommodate the increasing number of EV users. The California ZEV program, which was started in 1990, aims to reduce Greenhouse Gas (GHG) vehicle emissions through establishing vehicle standards, and other PAC states such as Oregon and Washington (as well as states in other divisions) have developed their own programs based on ZEV [36][37]. Because the focus in the PAC division states has been on EV adoption rather than public EV charging infrastructure, it appears that EV ownership has now outpaced the development of public CP access. While many studies examine a lack of equity in EV adoption within California and other PAC states [25][27][38][39], comparing access to the public CP infrastructure between these states and states in other divisions has not been a focus of research (although it has been acknowledged that there is a tradeoff between subsidizing EV adoption and investing in a public CP infrastructure in California specifically [39].

This analysis has both strengths and limitations. The main strength is that it provides an evidence-based descriptive comparison between states with respect to public CP access. While this is a strength, it limits the granularity of the analysis; as an example, the center of a large city may not have a heightened demand for public CP access because of the availability of public transportation, while an area in the city with a lower population density may have a higher need for public CP access. Other limitations include using only estimated measures of public CP access and socioeconomic status, as well as having sample size limited to the number of states in the analysis (which is likely why other research on public CP access in the US tends to use smaller geographic regions for comparisons [10][19][21]. We acknowledge that our research did not find an association between rurality and charger access at the state level, which contradicts prior studies that find lower charger density in rural areas [5][10][21][33]. The discrepancy likely stems from our use of broad state level rurality percentages rather than more precise measures (such as rural tract counts, or distance to nearest charger). As a result, our analysis may underestimate the true rural access gap. Further, the regression analysis of EVs per public CP (Model B) showed a relatively poor fit, indicating that substantial unexplained variability remains, potentially due to omitted factors, measurement noise, or nonlinear relationships not captured by the linear specification.

V. Conclusion and Future Work

Our analysis aimed to characterize the differences in access to public CPs between states in the US, as well as seek evidence as to whether low access was associated with attributes correlated with low public CP access identified in existing analyses, namely state-level rurality and low socioeconomic conditions. We did this by utilizing public data to conduct a state-by-state comparison, and by using regression to estimate whether rurality and low socioeconomic conditions were associated with low public CP access while adjusting for other variables. While a state to state comparison did not find an association between rurality and public CP access, number of public CPs per 10,000 population was found to be associated with socio-economic variables. Further, states in the NE division were found to have significantly better public CP access, while states in the PAC division were found to have significantly worse public CP access (compared to other divisions). Overall, public CP access in states was much worse when compared to access in European countries.

We acknowledge that the current analysis reflects the status of EVs and CPs in the US in 2024 only. Given the rapid growth of EV adoption and public CP development, our findings may become outdated quickly. For future research, we intend to track EV ownership and public CP access longitudinally, which will facilitate observing the impacts of policy changes and market dynamics in the US over time. Also, while this analysis only explored the socioeconomic variables of income and education, future research will consider other equity dimensions such as race/ethnicity and age when studying which subpopulations are most affected by public CP scarcity. Future research could also consider areas at a higher level of granularity, such as regions within a particular metropolitan area.

While public CP access is likely influenced by many factors, one of the strongest influences is public policy. States with many registered EVs but low levels of public CP access should now turn their attention to developing public initiatives aimed at increasing number of public CPs, as well as increasing access to them through lowering charging costs or other incentives [25][27][33–39] . As EV adoption continues on an upward trajectory in the US, it will be necessary for federal and state policies to prioritize ensuring public CP access to keep pace with this increase. Future research should investigate the most efficient methods for expanding public CP access in the US, especially among states where EV ownership is already high.

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