Impacts of Transportation Related Air Pollution (TRAP) on Environmental Justice (EJ) Communities

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Abstract

Because of the negative impacts they bring to society, traffic-related air pollution (TRAP) due to vehicular emissions remain a critical issue. Disadvantaged communities (DAC) are given high priority as their poor transportation conditions enable the problem to persist. Common factors include traffic densities, vehicle types, and proximity to the road. To better understand the situation, a possible solution is implemented where electric vehicles (EVs) are introduced to an urban-based test site to reduce the number of emissions there. While the results tend to vary, it was shown that border-based low-income DACs were more likely to experience pollutants from vehicular emissions, much of which came from both heavy-duty vehicles and medium-duty vehicles. To resolve the uncertainties that were encountered, further research is required.

Introduction

Although transportation in recent times has offered people a variety of options to travel freely, society as a whole still faces issues regarding traffic-related air pollution (TRAP) due to vehicular emissions. As economic levels differ with each community, it is possible that socio-economic factors serve as the primary contributors to the number of pollutants produced on average. Areas categorized as disadvantaged communities (DACs) were more likely to experience TRAPs because of how they are associated with poor transportation conditions such as high road congestion and proximity to major highways. Each of these factors result in substantial public exposure to pollutants. This is especially true for urban-based DACs, as their higher population densities can maximize the effects of an average-sized DAC.

Compounding this is how a wide variety of vehicles are used in these areas, ranging from light-duty trucks to heavy-duty trucks. Furthermore, an assortment of harmful pollutants exists within the corresponding vehicular emissions. One possible solution that was conceived was to introduce electric vehicles to DACs, as they make use of a process known as electrification that administers electricity to the pollutants to reduce their impact on the environment.

Using what is known about urban areas, this study’s primary focus will be on a metropolitan district to better assess the impacts of TRAP on DACs. The high population density allows the research team to analyze multiple vehicles in the area while being able to easily identify the effects of vehicular pollutants on civilization.

Analysis

A test district was selected based on the available census data that indicated whether a given area contains a moderate level of DACs suitable for the study. For this study, the North Central Texas Council of Governments region was selected due to it containing 16 counties, which is considered satisfactory for experimentation.

Prior to testing, several models were developed to assist the calculation process by calibrating the data for maximum accuracy. The ones that were primarily used were the Climate and Economic

Justice Screening Tool (CEJST) and the Equitable Transportation Community (ETC Explorer). The former was designed to identify DACs in each area while the latter gauges the burden of those DACs.

As part of achieving a full comprehension of the topic, various scenarios were envisioned for this study. For instance, the Justice 40 initiative was applied in some DACs, as the purpose of this plan is to have these areas financially benefit from the 40% of federal investments that was given to them. In that regard, transportation conditions could change with respect to the altered economic levels.

The following data processing was accomplished in the data visualization software Tableau. First, the Excel files containing raw data from the study were imported into the software for formatting. Then, the following variables were calculated: such as the total number of vehicles in each period, the total number of trucks, and the total number of trucks for each classification. These variables were then used to calculate the following measures: the ratio of truck types in each period, the number of trucks it takes to offset for market force, and the number of trucks it takes to offset for hypothetical high projections. Each of these calculations were dragged onto the software's dashboard, where maps and tables illustrating their values were displayed.

Results

At the given roadway network, the ratio of trucks in the area was calculated for the following categories: AM for morning hours, PM for evening hours, and OP for all other hours. The distribution of trucks for each category is depicted in Tableau.

It should be noted that the dark (teal) colored portions indicate an area that is tightly packed while the light (aquamarine) colored portions represent an area that is sparsely populated.

Figure 1 represents the number of trucks in the area during AM hours. Judging from the predominant aquamarine color scheme, it can be inferred that the roadway network during this time encounters very few trucks, much less heavy traffic.

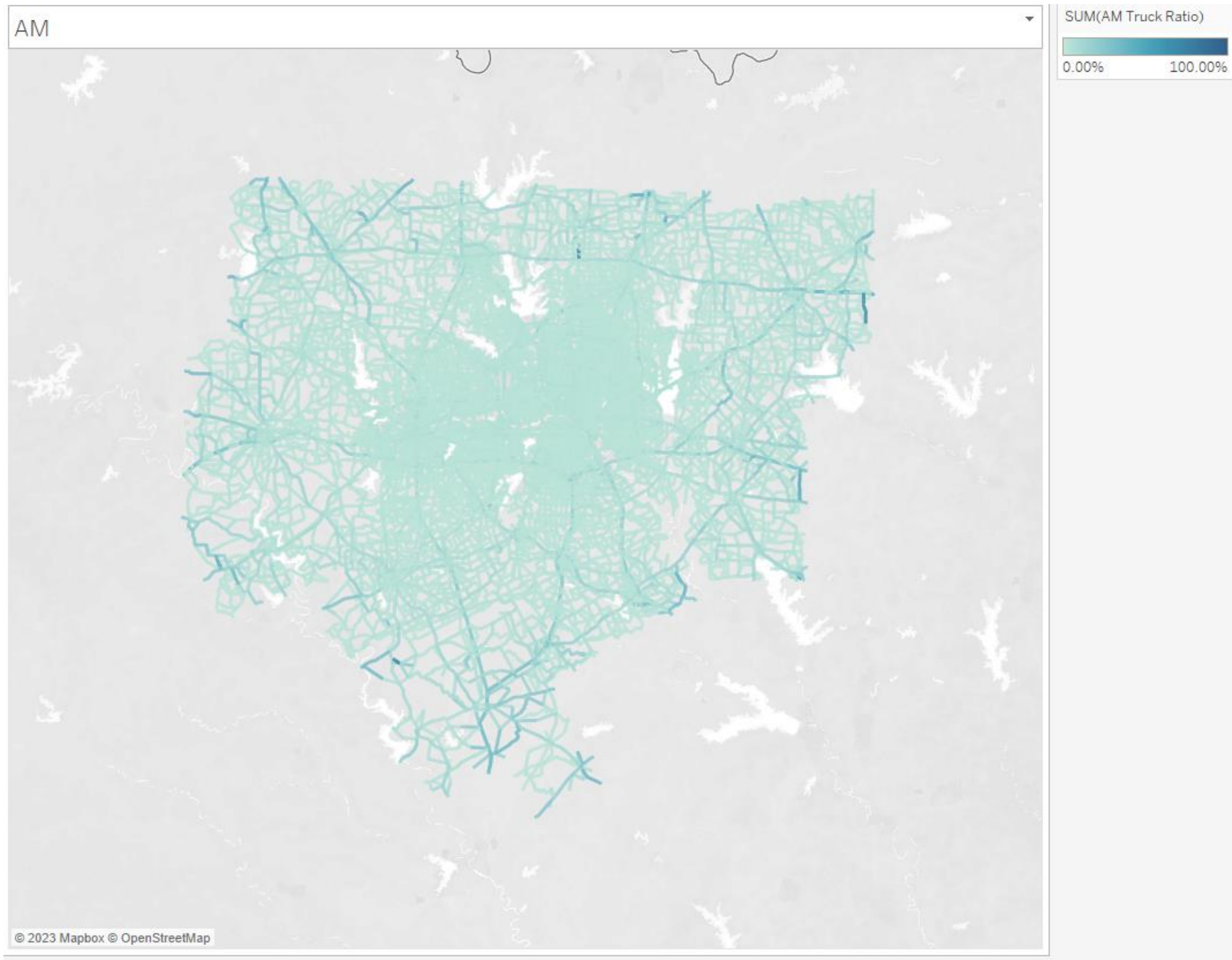

Figure 1 - Map of Truck Traffic During AM Hours

Figure 2 represents the number of trucks in the area during PM hours. As with Figure 1, Figure 2 ovelays the area with aquamarine colors. However, Figure 2 contains subtle differences, such as how the upper portion of the network contains fewer teal parts compared to that of Figure 1. Overall, this suggests that the area experiences very little traffic during this time.

Figure 2 - Map of Truck Traffic During PM Hours

Figure 3 represents the number of trucks in the area during OP hours. While near identical to the previous figures, Figure 3 differs slightly in that it contains teal portions that are scattered throughout the network, with most of them either being on the edge of the map or near the center of the map. This implies that the number of trucks during this time was not only greater than those in the previous hours but that there were common in the aforementioned areas.

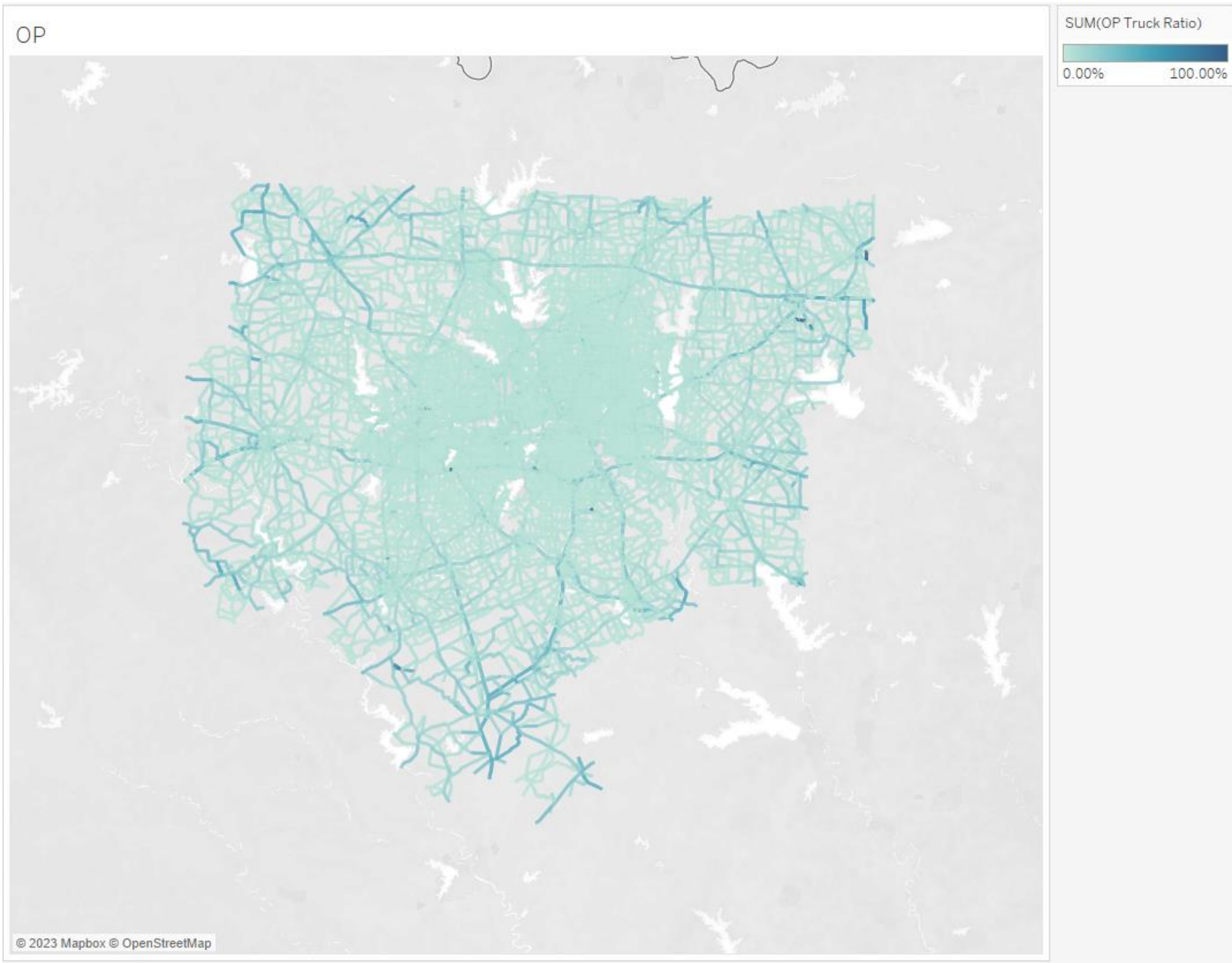

Figure 3 - Map of Truck Traffic During OP Hours

One pattern that was found for each of the three figures was that higher traffic density occurred on the edge of the roadway network while lower traffic density occurred within the interior of the roadway network. From this, it can be inferred that the former point represents traffic jams that are the result of multiple vehicles attempting to either enter or exit the network simultaneously, while the latter point represents vehicles that were able to freely traverse the network after clearing traffic.

Considering how traffic tended to be concentrated in certain areas throughout the day, it can be deduced that the hours affected the flow of traffic in the network. During AM hours, trucks were commonly found in both the upper portion and the exterior of the map, while during OP hours, trucks were primarily spotted in both the center portion and the exterior of the map. The former point likely represents the trucks entering the network through those locations to access certain areas like workplaces while the latter point possibly represents the trucks roaming the network by cutting through those sections of the map.

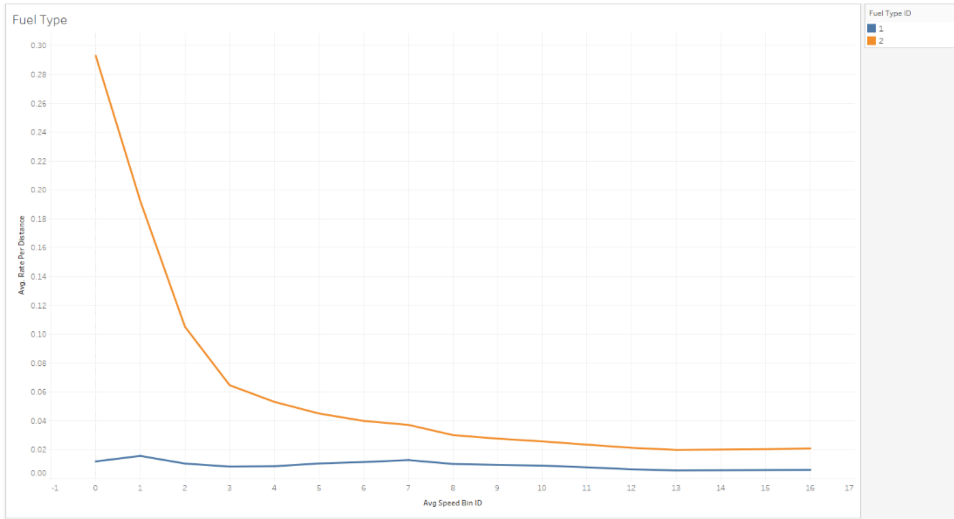

Figure 4- The Effect of Fuel on a Vehicle's Travel Performance

Figure 4 depicts the effect a vehicle's speed has on its travel performance. This portion of the study was conducted using two different fuels. Fuel Type 1 represents gasoline-based fuel while Fuel Type 2 is diesel-based fuel.

Vehicles that ran on diesel initially exhibited substantial speed, began gradually covering less distance at higher speeds, and finally drove at a consistent rate. Vehicles that ran on gasoline were shown to move at more consistent rates with minimum changes, even as their speed increased.

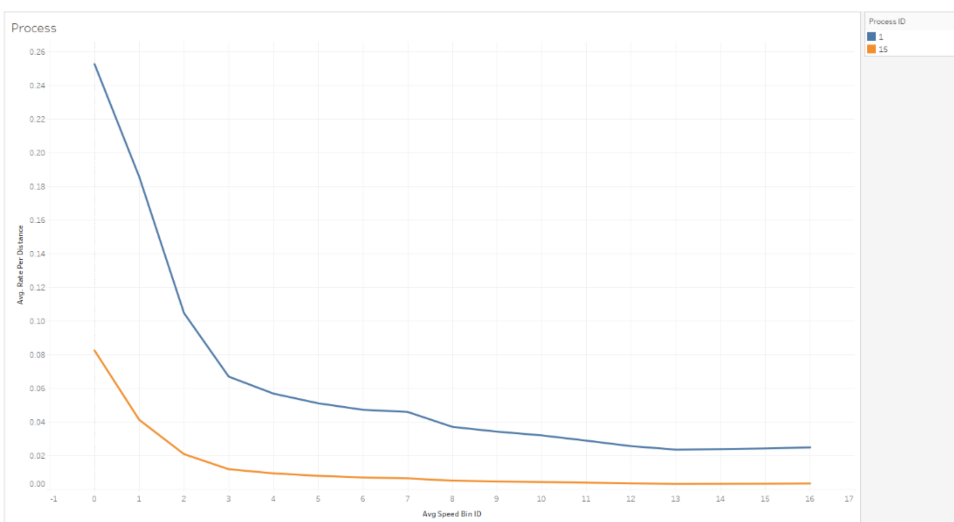

Figure 5 - The Effect of Emissions on a Vehicle's Travel Performance

Figure 5 illustrates the relationship between the speed of the vehicles and the distance traveled when taking into consideration the emission methods that were utilized. Process Type 1 represents exhaust emissions while Process Type 15 represents crankcase emissions.

Vehicles that relied on exhaust emissions were initially shown traveling great distances before gradually decelerating over time. Vehicles that relied on crankcase followed a similar pattern, albeit at slower speeds that culminated in a complete stop.

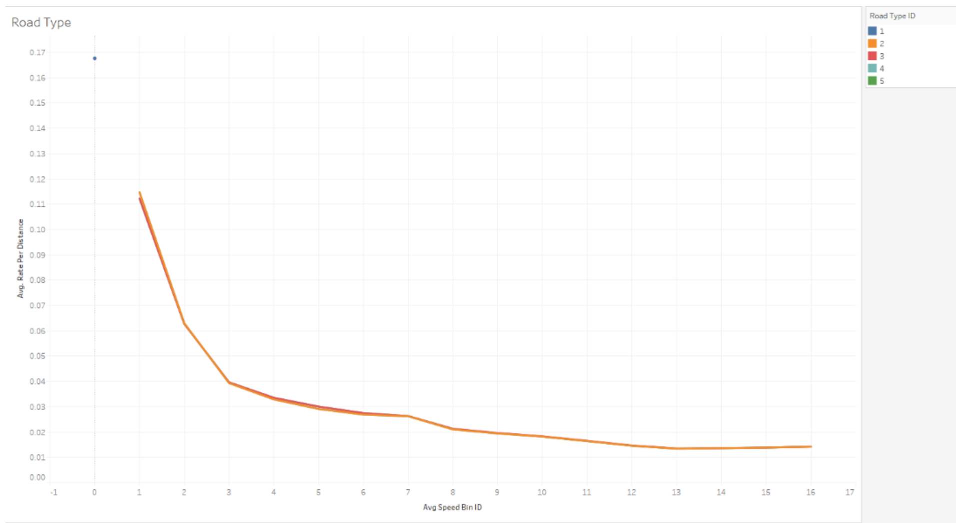

Figure 6 - The Effect of Road Types on a Vehicle's Travel Performance

Figure 6 depicts the effect a vehicle's speed has on its travel performance with respect to its path. Road Type 1 represents all other road types, Road Type 2 represents rural restricted access roads, Road Type 3 represents rural unrestricted access, Road Type 4 represents urban restricted access, and Road Type 5 represents urban unrestricted access.

All vehicles displayed the exact same pattern for each road type: initially travelling at high speeds, they reach a point where they transition to slower speeds before proceeding with a standard. It should be noted that the results for Road Type 3 feature some slight fluctuation with the data, indicating that rural unrestricted access roads are uneven in nature and can lead to interrupted travel periods.

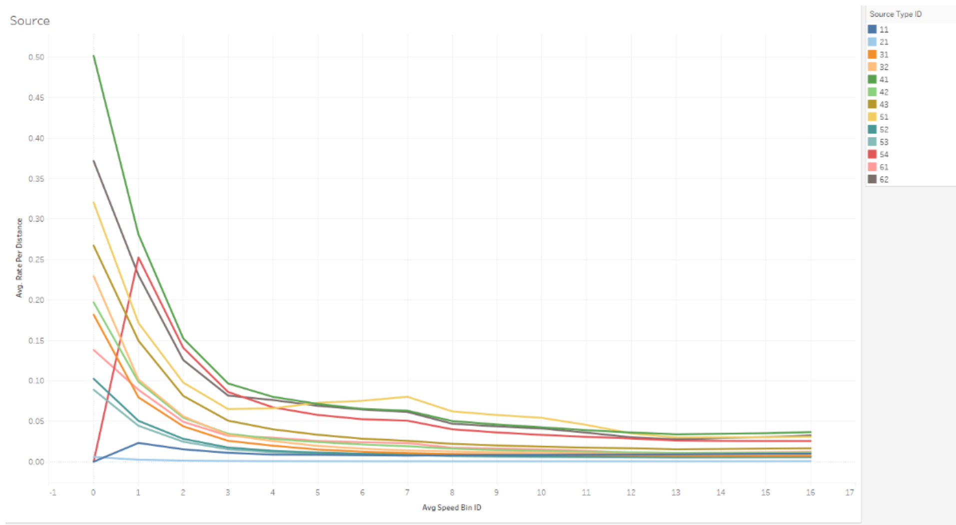

Figure 7 - The Effect of Truck Types on a Vehicle's Travel Performance

Figure 7 illustrates the relationship between the speed of the vehicles and the distance traveled when taking into consideration the different truck types involved. Out of all the truck types, three of them were central to the study. They are Source Type 21 (representing light-duty trucks), Source Type 52 (representing medium-duty trucks), and Source Type 62 (representing heavy-duty trucks).

Each of the truck types were shown travelling at their respective maximum speeds before decelerating to a standard that they maintain for the rest of the study. Out of the three types, Source Type 62 is depicted with the highest curve while Source Type 21 is depicted with the lowest curve. Considering how the builds vary for each truck type, it is implied that the designs are what primarily influence fuel usage. The vehicular weight of heavy-duty trucks might complicate a driver's control over their vehicle, thus requiring more fuel to compensate. In contrast, the vehicular weight of light-duty trucks makes it more manageable to control, thus requiring less fuel to maintain.

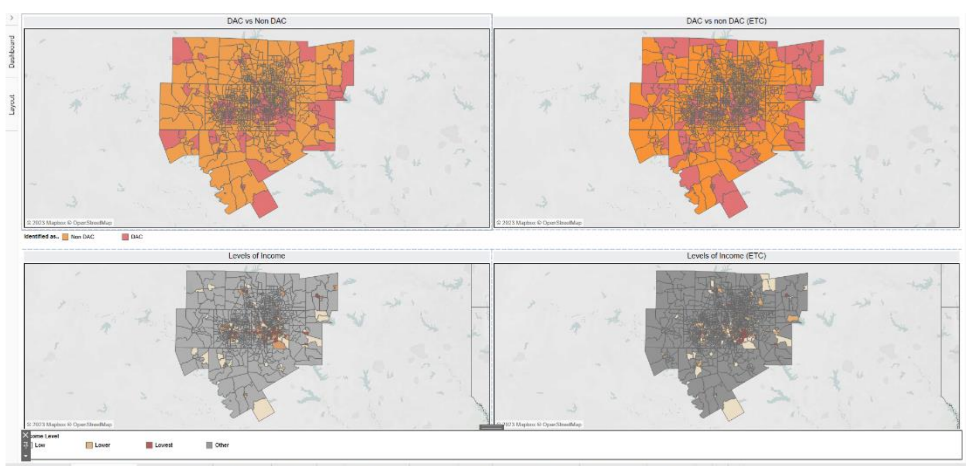

Figure 8 - Classification of the Test Region by DAC Status and Income Level

The top half of Figure 8 represents the number of communities in the roadway network that were identified as either DAC or Non-DAC, while the bottom half of Figure 8 represents the income levels that were classified within the roadway network. For this portion of the study, two different variants based off the roadway network were used: an unaltered version of the district and a version that utilizes the Equitable Transportation Community Explorer (ETC) tool to determine any transportation-related issues found within the district.

The former section depicts two heat maps with each representing the roadway network variables. The Non-ETC map was presented in a pastel orange color scheme with occasional light red blotches found near the center portion and the exterior portions of the district. The ETC map strongly resembles that of the non-ETC map, but with a greater abundance of light red blotches on the outermost portions of the district. While both maps present the roadway network as a secure collection of communities, the presence of the light red blotches indicates that the region might have an issue regarding disadvantaged communities. This is best illustrated by the ETC map due to how the increase in light red spots implies that those areas within the network experience transportation-based issues which are often connected to disadvantaged communities.

The latter section depicts two heat maps with each representing the income levels found within both roadway network variables. The Levels of Income map was primarily gray in color, although beige spots were found near the exterior portions of the map while both dark red spots and pastel orange spots were gathered near the center of the map. Meanwhile, the Levels of Income (ETC) map parallels that of the Levels of Income map, but with a slightly higher concentration of pastel orange spots near the center of the region. Both maps indicate that, while the roadway network has a moderate-income distribution, certain communities appear to be struggling financially. Considering how the heat maps in the upper portion of this figure classify both the central locations and the exterior locations as DACs, it is probable that these specific areas would be experiencing economic issues.

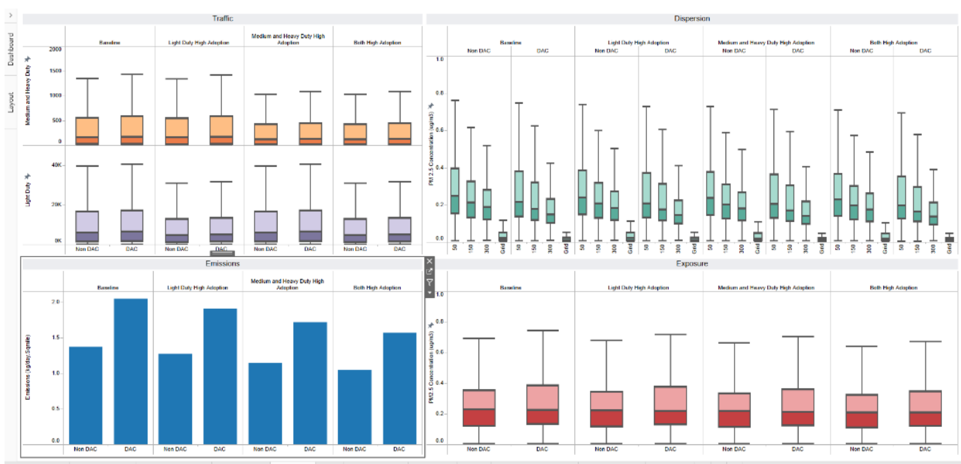

Figure 9 - The Number of Vehicles and Emissions Found Within Justice 40 Communities

Figure 9 depicts not only the number of vehicles in both DAC locations and non-DAC locations within Justice 40 communities but also the number of emissions that were absorbed by each location type. While this part of the study focused on general emissions, concentrations of PM 2.5 emissions were used to assess the retentive characteristics of both community types with respect to specific pollutants. The results for each section were presented in the form of box-and-whisker plots apart from the “Emissions” section, as it was presented in bar graph format.

The “Traffic” section represents the number of emissions from each vehicle type that were absorbed by DAC locations and non-DAC locations. While the results appear to be roughly the same in some cases, DAC areas were shown to accumulate higher emissions on average than non-DAC areas. This implies that DAC locations are more prone to synthesizing vehicular emissions compared to their non-DAC counterparts, a statement that is supported by results from previous figures.

The “Dispersion” section illustrates the distribution of PM 2.5 concentrations in both DAC locations and non-DAC locations with respect to adjacent roadways. Both districts were shown to experience higher PM 2.5 concentrations from each vehicle type 50 meters from the road. This inference appears to be feasible as communities that are near roadways are more likely to experience pollutant-based issues than communities that are farther from roadways. Moreover, this circumstance could have contributed to the emissions problems found in DAC locations by inferring that most of the pollutants originated from vehicular emissions near the DAC areas.

The “Emissions” section depicts the total amount of vehicular emissions that were accumulated in DAC locations and non-DAC locations. The number of emissions found in DAC areas were consistently shown to be higher than those found in non-DAC areas, further supporting the idea that DAC locations are more likely to gather large quantities of pollutants from various sources.

The “Exposure” section compares the number of PM 2.5 concentrations from each emission type that were endured in both DAC locations and non-DAC locations. Because the mass of PM 2.5 concentrations in DAC areas were shown to be higher than those in non-DAC areas, it can be safely assumed that the former is not only more susceptible to pollutants than the latter, but that they can collect varying types of pollutants, with PM 2.5 concentrations being one example.

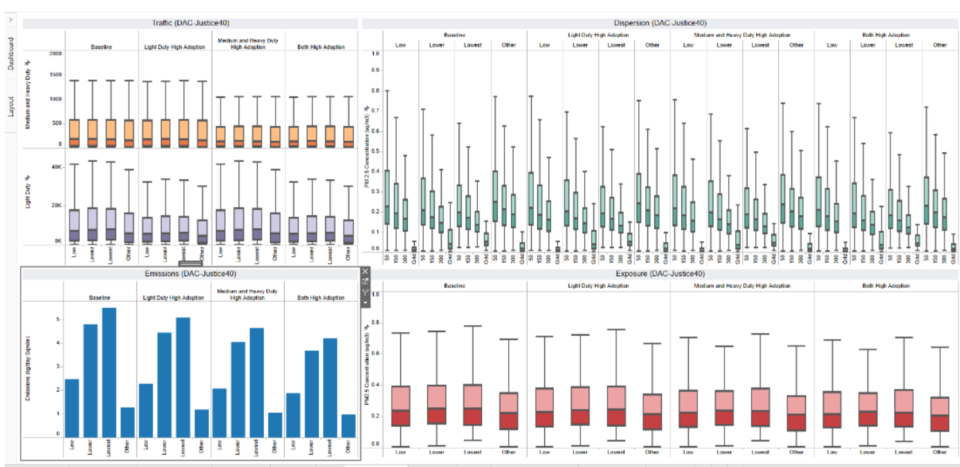

Figure 10 - The Number of Vehicles and Emissions for Each Income Level Within a DAC

Figure 10 depicts not only the number of vehicles found for each income level in Justice 40-based DAC locations but also the number of emissions that were absorbed by each economic type. While this part of the study focused on general emissions, concentrations of PM 2.5 emissions were used to assess the retentive characteristics of both community types with respect to specific pollutants.

The results for each section were presented in the form of box-and-whisker plots apart from the "Emissions (DAC-Justice40)" section, as it was presented in bar graph format.

The "Traffic (DAC - Justice40)" section depicts the number of emissions due to each vehicle type that were collected at each of the economic levels. While the results for both medium-duty emissions and heavy-duty emissions were shown to be approximately equal at each economic level, the results for light-duty emissions were more varied, to the point where the "Lower" category and the "Lowest" category were shown to have had the highest emissions in the DAC locations. From here, it can be inferred that any location that is classified as either of the two categories are more likely to experience issues with light-duty emissions than medium-duty emissions or heavy-duty emissions.

The "Dispersion (DAC - Justice40)" section of the figure illustrates the distribution of PM 2.5 concentrations in both DAC locations and non-DAC locations with respect to adjacent roadways. All income levels were shown to experience higher PM 2.5 concentrations from each vehicle type 50 meters from the road. This inference appears to be feasible as communities that are near roadways are more likely to experience pollutant-based issues than communities that are farther from roadways. Moreover, this circumstance could have contributed to the emissions problems found in the "Lower" category and the "Lowest" category by inferring that most of the pollutants originated from vehicular emissions near any DAC areas that were classified as either of the two.

The "Emissions (DAC - Justice 40)" section of the figure depicts the total amount of vehicular emissions that were accumulated at each economic level. The number of emissions found within the Justice 40 DAC-based locations were consistently higher at both the "Lower" category and the "Lowest" category, further supporting how areas within those income levels are more likely to gather large quantities of pollutants from various sources.

The "Exposure (DACs - Justice 40)" section of the figure compares the number of PM 2.5 concentrations from each emission type that were endured at all income levels. Although the results were more varied, the "Lowest" category was consistently portrayed as experiencing the highest concentration of PM 2.5 emissions, with either the "Low" category or the "Lower" category coming in a close second. While this observation can be attributed to a possible processing error during analysis, it can also be interpreted as the non- "Lowest" areas being just as susceptible to PM 2.5 emissions as the "Lowest" areas, implying that certain pollutants have far-reaching effects.

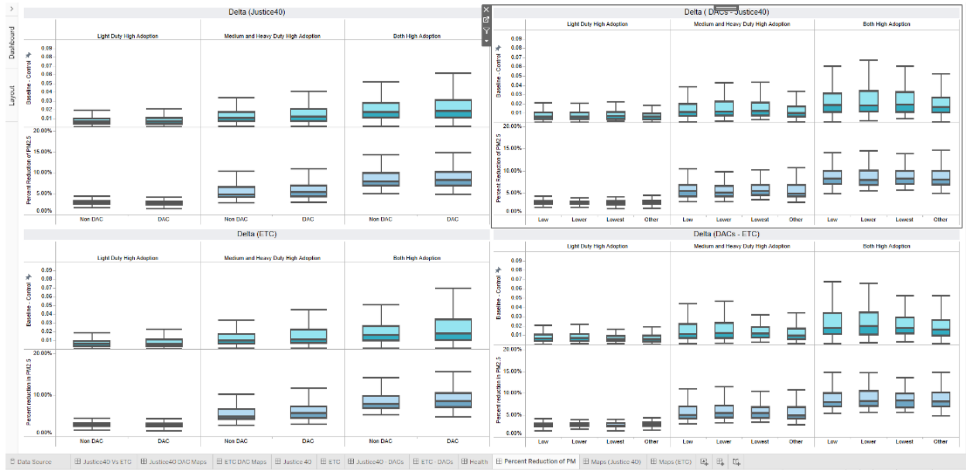

Figure 11 - The Efficiency of Pollutant Reductions for Each Location Type

Following this, Figure 11 represents the efficiency of both Justice 40 locations and ETC locations in minimizing vehicular pollutants within their respective communities. For this portion of the study, concentrations of PM 2.5 were used for evaluation purposes.

The “Delta (Justice40)” section and the “Delta (ETC)” section express the reduction of PM 2.5 in each community type through box-and-whisker plots. While the number of reduced light-duty PM 2.5 emissions in DAC locations were roughly equivalent to those of non-DAC locations, the number of reduced medium-duty PM 2.5 emissions and reduced heavy-duty PM 2.5 emissions were shown to be more varied for both community types. In general, it was demonstrated that DAC locations were able to reduce PM 2.5 concentrations more than their non-DAC counterparts. This indicates that pollutants are more likely to be found within DAC-based areas, thus requiring diligent efforts to moderate them.

The “Delta (DACs - Justice40)” section and the “Delta (DACs - ETC)” section express the reduction of PM 2.5 at each income level within DAC locations through box-and-whisker plots. Although the results were shown to vary widely for each income level, it was revealed that both the “Low” category and the “Lower” category experienced the highest pollutant reductions, implying that any DAC location that fits into either of the two categories would not only encounter vehicular pollutants, but would also require persistent efforts to control them.

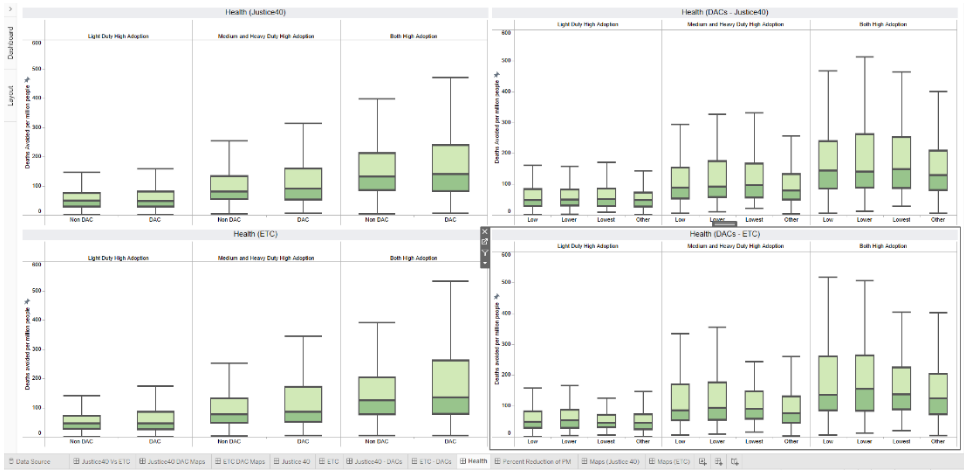

Figure 12 - The Number of Deaths That Were Prevented for Each Location Type

Figure 12 illustrates the degree at which both the Justice 40 locations and the ETC locations were able to handle health-based issues due to vehicular pollutants.

In the “Health (Justice40)” section and the “Health (ETC)” section, the number of emissions-related deaths that were avoided in each community type were presented in the form of box-and-whisker plots. The number of prevented deaths due to light-duty emissions in DAC locations were roughly equal to those of non-DAC locations. By contrast, the number of prevented deaths due to both medium-duty emissions and heavy-duty emissions were more varied in magnitude for both locations. On average, it was shown that DAC locations were able to prevent more emissions-related deaths compared to non-DAC locations. This implies that DAC locations are more susceptible to the harmful effects of vehicular pollution than non-DAC locations, thus the former would require greater efforts at reducing pollutant concentrations.

In the “Health (DACs - Justice40)” section and the “Health (DACs - ETC)” section, the number of emissions-related deaths that were prevented at each income level within DAC locations were presented in the form of box-and-whiskers plots. The number of prevented deaths due to light-duty emissions were considerably lower compared to the number of prevented deaths due to medium-duty emissions and heavy-duty emissions. This further reinforces the idea that medium-duty emissions and heavy-duty emissions can have significant effects on human health, thus rendering them a high priority for DAC locations to manage. While the results in the “Health (DACs - Justice 40)” section were shown to vary widely, the “Low” category, the “Lower” category, and the “Lowest” category exhibited the highest number of deaths prevented, indicating that impoverished areas within the Justice 40 communities are at risk of experiencing emissions-based health hazards. Meanwhile, the results for the “Health (DACs - ETC)” section consistently portrayed the “Low” category and the “Lower” category as the income levels that could prevent the most deaths. This implies that any DAC location that belongs to either of the two categories will require a great effort to diminish any harmful pollutants in the area.

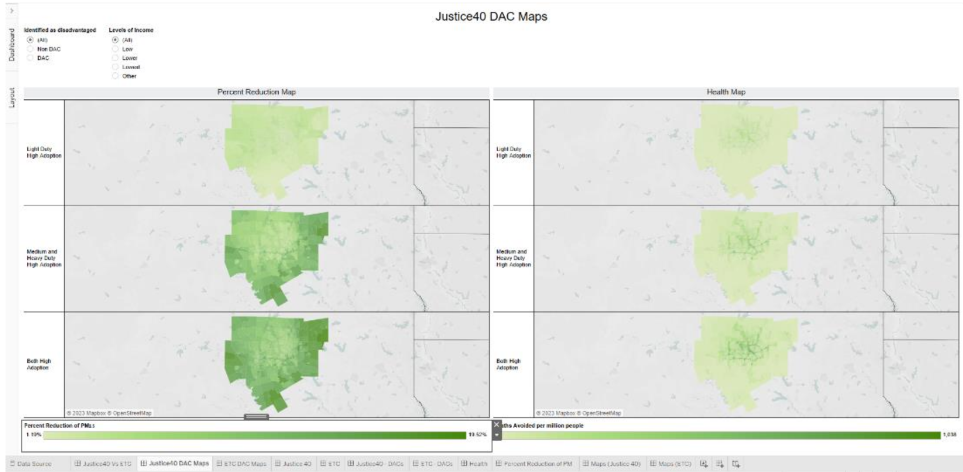

Figure 13 - The Number of Emissions and Deaths That Were Reduced in DACs Within Justice 40 Communities

The left side of Figure 13 illustrates how much of the PM 2.5 emissions from each vehicle type were reduced in DAC-identified locations within Justice 40 communities while the right side of Figure ("Justice40DACMaps") represents the possible number of deaths that were prevented in each DAC area.

The former section features three heat maps, each representing the concentration of PM 2.5 emissions from each vehicle type. The "Light Duty High Adoption" map was presented as light green in color. The "Medium and Heavy-Duty High Adoption" map has a dark green hue on its boundaries, but the center is portrayed in a lighter shade of green. The "Both High Adoption" map resembles that of the previous map, but with more of a dark green contrast. The first two maps imply that light-duty vehicles generate fewer emissions on average compared to both medium-duty vehicles and heavy-duty vehicles. This can be attributed to how the former's deductions on PM were non-existent compared to those of the latter two. However, the darker colors on the third map reinforce the idea that emissions of any kind must be treated as soon as possible to prevent any possible health issues.

The latter section features three heat maps, each representing the number of deaths due to each vehicle type that were prevented. The "Light Duty High Adoption' map was presented as light green in color, although an inconspicuous forest green hue can be seen near the center of the map. The "Medium and Heavy-Duty High Adoption' map is like that of the previous map, but the forest green hue is noticeably darker in shade. The "Both High Adoption' map resembles that of the preceding map, except that the forest green hue is once again darker in color. The first two maps further support the idea of light-duty emissions being sparse within DAC locations by demonstrating how the number of light-duty related deaths that were reduced were marginal in scope compared to the number of prevented deaths due to both medium-duty emissions and heavy-duty emissions. Regardless, the results for the third map emphasize how prevalent emissions can be within Justice 40 communities, an observation that encourages people to become more aware of the problem as they continue preventing future deaths in DAC locations.

One thing to note about this portion of the study is that the left side of the figure indicates that heavier concentrations of PM 2.5 were more common near the outskirts of the Justice 40 community whereas the right side of the figure implies that the number of pollutants were more frequent at the heart of the Justice 40 community. While this can be attributed to a possible processing error during analysis, this finding can also be interpreted as the PM 2.5 concentrations demonstrating the ability to shift position from the boundaries of the community to the center of the community. Any emissions that are found within DAC locations should be handled properly to ensure optimal health for the citizens.

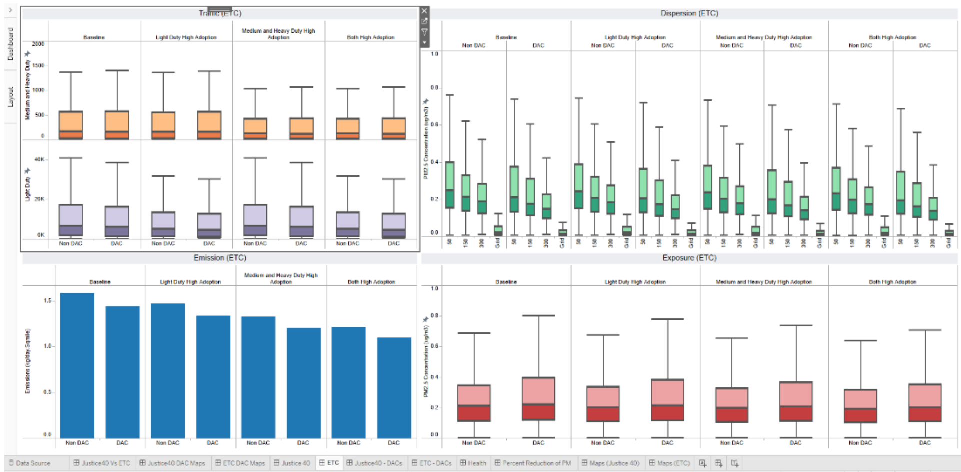

Figure 14 - The Number of Vehicles and Emissions Found Within ETC Communities

Figure 14 depicts not only the number of vehicles in both DAC locations and non-DAC locations within ETC communities but also the number of emissions that were absorbed by each location type. While this part of the study focused on general emissions, concentrations of PM 2.5 emissions were used to assess the retentive characteristics of both community types with respect to specific pollutants. The results for each section were presented in the form of box-and-whisker plots apart from the "Emissions (ETC)" section, as it was presented in bar graph format.

The "Traffic (ETC)" section represents the number of emissions from each vehicle type that were absorbed by DAC locations and non-DAC locations. While the results appear to be roughly the same in some cases, non-DAC areas were shown to accumulate higher emissions on average than DAC areas. This implies that non-DAC locations in ETC communities are more prone to synthesizing vehicular emissions compared to their DAC counterparts.

The "Dispersion (ETC)" section illustrates the distribution of PM 2.5 concentrations in both DAC locations and non-DAC locations with respect to adjacent roadways. Both districts were shown to experience higher PM 2.5 concentrations from each vehicle type 50 meters from the road. This inference appears to be feasible as communities that are near roadways are more likely to experience pollutant-based issues than communities that are farther from roadways. Moreover, this circumstance could have contributed to the emissions problems found in non-DAC locations by inferring that most of the pollutants originated from vehicular emissions near the non-DAC areas.

The "Emissions (ETC)" section depicts the total amount of vehicular emissions that were accumulated in DAC locations and non-DAC locations. The number of emissions found in non-DAC areas were consistently shown to be higher than those found in DAC areas, further supporting the idea that non-DAC locations are more likely to gather large quantities of pollutants from various sources.

The "Exposure (ETC)" section compares the number of PM 2.5 concentrations from each emission type that were endured in both DAC locations and non-DAC locations. However, the mass of PM 2.5 concentrations in DAC areas were shown to be higher than those in non-DAC areas. While this observation can be attributed to a possible processing error during analysis, it can also be interpreted as

DAC areas being just as susceptible to PM 2.5 emissions as their non-DAC counterparts. Furthermore, the excess of PM 2.5 concentrations in the former implies that they have a long-lasting effect on DAC-based locations, further supported by how poor transportation conditions exist in DAC areas.

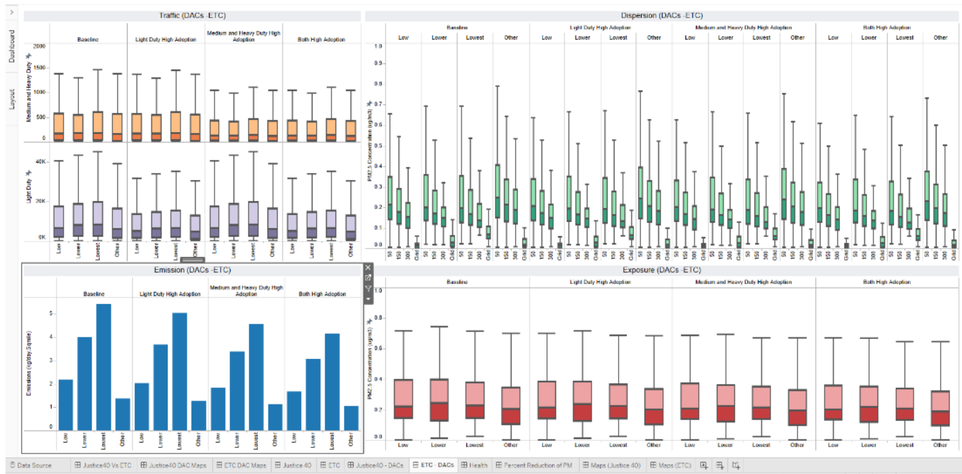

Figure 15 - The Number of Vehicles and Emissions Found in Each Income Level Within ETC Locations

Figure 15 depicts not only the number of vehicles found for each income level in ETC-based DAC locations but also the number of emissions that were absorbed by each economic type. While this part of the study focused on general emissions, concentrations of PM 2.5 emissions were used to assess the retentive characteristics of both community types with respect to specific pollutants. The results for each section were presented in the form of box-and-whisker plots apart from the “Emissions (DACs-ETC)” section, as it was presented in bar graph format.

The “Traffic (DACs - ETC)” section depicts the number of emissions due to each vehicle type that were collected at each of the economic levels. The results pointed to both the “Lower” category and the “Lowest” category as having had the highest emissions quantity in the DAC locations. Additionally, the light-duty emissions were all shown to be greater in scope compared to both the medium-duty emissions and the heavy-duty emissions. From here, it can be inferred that any location that is classified as either of the two categories are more likely to experience issues with light-duty emissions than with either medium-duty emissions or heavy-duty emissions.

The “Dispersion (DACs - ETC)” section of the figure illustrates the distribution of PM 2.5 concentrations in both DAC locations and non-DAC locations with respect to adjacent roadways. All income levels were shown to experience higher PM 2.5 concentrations from each vehicle type 50 meters from the road. This inference appears to be feasible as communities that are near roadways are more likely to experience pollutant-based issues than communities that are farther from roadways. Moreover, this circumstance could have contributed to the emissions problems found in the “Lower” category and the “Lowest” category by inferring that most of the pollutants originated from vehicular emissions near any DAC areas that were classified as either of the two.

The “Emissions (DACs - ETC)” section of the figure depicts the total amount of vehicular emissions that were accumulated at each economic level. The number of emissions found within the ETC DAC-based locations were consistently higher at both the “Lower” category and the “Lowest” category, further supporting how areas within those income levels are more likely to gather large quantities of pollutants from various sources.

The “Exposure (DACs - ETC)” section of the figure compares the number of PM 2.5 concentrations from each emission type that were endured at all income levels. Although the results somewhat varied, the “Lower” category was consistently portrayed as experiencing the highest concentration of PM 2.5 emissions, with either the “Low” category or the “Lower” category coming in a close second. While this observation can be attributed to a possible processing error during analysis, it can also be interpreted as the non- “Lower” areas being just as susceptible to PM 2.5 emissions as the “Lowest” areas, implying that certain pollutants have far-reaching effects.

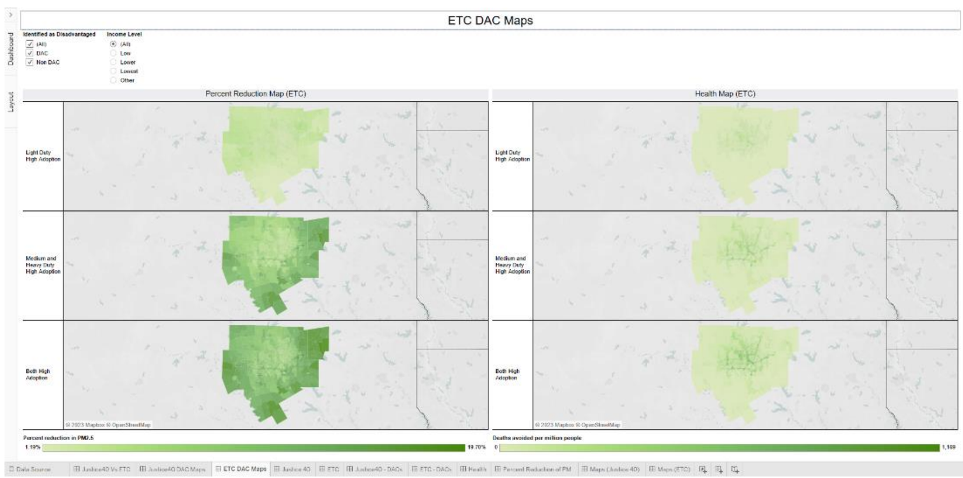

Figure 16 - The Number of Emissions and Deaths That Were Reduced Within ETC Communities

The left side of Figure 16 illustrates how much of the PM 2.5 emissions from each vehicle type were reduced in DAC-identified locations within ETC-based while the right side of Figure 16 represents the possible number of deaths that were prevented in each DAC area.

The former section features three heat maps, each representing the concentration of PM 2.5 emissions from each vehicle type. The “Light Duty High Adoption” map was presented as light green in color. The “Medium and Heavy-Duty High Adoption” map has a dark green hue on its boundaries, but the center is portrayed in a lighter shade of green. The “Both High Adoption” map resembles that of the previous map, but with more of a dark green contrast. The first two maps imply that light-duty vehicles generate fewer emissions on average compared to both medium-duty vehicles and heavy-duty vehicles. This can be attributed to how the former’s deductions on PM were non-existent compared to those of the latter two. However, the darker colors on the third map reinforce the idea that emissions of any kind must be treated as soon as possible to prevent any possible health issues.

The latter section features three heat maps, each representing the number of deaths due to each vehicle type that were prevented. The “Light Duty High Adoption' map was presented as light green in color, although an inconspicuous forest green hue can be seen near the center of the map. The “Medium and Heavy-Duty High Adoption' map is like that of the previous map, but the forest green hue is noticeably darker in shade. The “Both High Adoption' map resembles that of the preceding map, except that the forest green hue is once again darker in color. The first two maps further support the idea of light-duty emissions being sparse within DAC locations by demonstrating how the number of light-duty related deaths that were reduced were marginal in scope compared to the number of prevented deaths due to both medium-duty emissions and heavy-duty emissions. Regardless, the results for the third map emphasize how prevalent emissions can be within ETC communities, an observation that encourages people to become more aware of the problem as they continue preventing future deaths in DAC locations.

One thing to note about this portion of the study is that the left side of the figure indicates that heavier concentrations of PM 2.5 were more common near the outskirts of the ETC community whereas the right side of the figure implies that the number of pollutants were more frequent at the heart of the ETC community. While this can be attributed to a possible processing error during analysis, this finding can also be interpreted as the PM 2.5 concentrations demonstrating the ability to shift position from the boundaries of the community to the center of the community. Any emissions that are found within DAC locations should be handled properly to ensure optimal health for the citizens.

Conclusion

Lower income sections of DACs were shown to be more at risk of accumulating harmful pollutants than their non-DAC counterparts. This effect is further amplified for areas that border urban districts, as the exterior communities serve as a gateway for vehicles to enter the testing region.

A closer inspection of the data reveals that both heavy-duty vehicles and medium-duty vehicles were the primary contributors to pollutant concentrations. The results were further magnified when either vehicle utilized both diesel-based fuels and exhaust emissions. As heavy-duty vehicles and medium-duty vehicles were designed with different mechanics compared to those of light-duty vehicles, the former two required substantial amounts of diesel-based fuel to operate which consequently generated high pollutant concentrations from the resulting emissions.

Finally, when EVs were introduced to the testing region, they were shown to reduce a significant number of pollutants in DAC-based areas. This further reinforces how EVs can produce cleaner air in DACs, which can have far-reaching applications for areas more prone to pollutants such as sections within proximity to major highways.

Although the results generally displayed a strong correlation between each factor, certain outcomes such as the fluctuating data depicted in Figure 14 imply that further research might need to be conducted to not only provide coherent results but to also inspire potential solutions.

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