Air pollution and equity impacts of the proposed Tampa Bay Next program

from a Health in all Policies perspective

Center for Transportation, Environment, and Community Health

Final Report

by

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DISCLAIMER

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Author contributions

T. Kocak performed the bulk of the literature review, simulations, and writing of the original draft for Part 1 of this report; he also performed much of the Health in All Policies literature review, contributed the initial qualitative Tampa Bay Next document review, and drafted several sections incorporated in Part 2. N. Menon performed additional qualitative document analysis the quantitative document analysis, the key informant interviews and their analysis, the HiAP matrix rating, and drafted related sections of Part 2 of this report. S. Gurram helped to design the experimental setup, ran the transport simulations, and assisted with the pollution and exposure simulations for Part 1 of this report. R. Bertini advised on all aspects of the work from its inception, including serving as a committee member for T. Kocak's master's thesis and supervisor for N. Menon; he also provided writing review and editing. A. Stuart conceptualized the project, oversaw development of the methodology, prepared the IRB documents, supervised T. Kocak's work, advised on N. Menon's work, wrote portions of both parts of the report, revised the report in its entirety, and administered the project and project funding.

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16. Abstract

The impacts on air pollution and health equity of Tampa Bay Next, an ongoing transportation planning program in the Tampa area, were investigated in this study. Part 1 of this report describes simulations performed using a high-resolution modeling system to estimate changes in pollutant emissions, concentrations, population exposures, and exposure equity that may result from the proposed freeway changes under the program. Inequity in the distribution of exposures among racial-ethnic and income groups was also estimated. Part 2 describes the application of a Health in All Policies (HiAP) perspective to the program, through literature review, review of program documents, interviews with key informants, and evaluations using a rating matrix. Results from the simulation analyses indicate that the planned freeway expansion may slightly decrease daily NO_x exposures on average, while increasing exposure densities during peak periods in some localities. Group-average exposures decreased for all population subgroups, but disparities in exposure increased for the black and the below-poverty groups. Results from the HiAP analysis suggest that health and equity have not been central considerations in program planning, and multi-sectoral collaboration has been limited, resulting in many stakeholders outside the transportation sector concerned that the program costs and benefits are unfairly distributed. Historical silos in the mode focus and funding structure of the transportation sector also appear to hamper designs and changes that could improve equity and health outcomes. Improving the equity and health impacts of this and other large-scale metropolitan transportation programs will likely require political commitment to the participation of more extensive multi-sectoral cooperative bodies, including the health sector, from the early stages of program planning, along with changes to the funding structures that allow consideration of investments in alternative modes of transportation simultaneously with roadway expansion.

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PART 1

Modeling the impacts of the Tampa Bay Next freeway expansion program on air pollution and equity

1 Introduction

Transportation has a strong influence on public health and equity (Braveman et al., 2011). For example, transportation infrastructure decisions and policies can impact air pollution exposures, which have been associated with cardiovascular and respiratory diseases and death worldwide (Forouzanfar et al., 2015). Furthermore, transportation decisions can also impact disparities in exposure to air pollution and its health outcomes (Gurram et al., 2015).

Road expansion programs are commonly applied to improve human mobility and economic exchange within transportation systems of growing urban areas, but the resulting air pollution and equity impacts are not well understood. Although some studies suggest that roadway capacity expansion, such as road widening, can reduce vehicle travel times and air pollutant emissions (Antipova and Wilmot, 2012; Fields et al., 2009; Shamsher and Abdullah, 2015), others suggest that roadway expansion increases vehicle miles traveled (VMT), emissions, and air pollution, particularly in the longer term (Cowie et al., 2012; Williams-Derry, 2007). Tolling is also often used as a means to fund roadway infrastructure expansion (Fields et al., 2009), but can also reduce improvements in system emissions and their distribution (Antipova and Wilmot, 2012). Furthermore, several studies have shown that minority and low-income population subgroups are often disproportionately exposed to traffic-related air pollution (Grineski et al., 2007; Yu & Stuart, 2013; Hajat, et al., 2015; Gurram et al., 2015). However, only a few studies (Yu & Stuart, 2017; Gurram, Stuart, & Pinjari, 2019) have investigated impacts of large-scale transportation infrastructure decisions on exposures to air pollution and their inequality outcomes.

The planned Tampa Bay Next (TBNext) transportation modernization program provides a useful case for investigating the impact of a large-scale transportation design program on exposure disparities. Although other improvement plans, such as new bicycle and pedestrian facilities, transit development, and freight mobility, are in the early stage of planning, TBNext primarily consists of proposals for interstate freeway expansion with both toll and general-purpose lanes. In this study, we focus on investigating the exposure and equity impacts of the planned interstate lane expansions, which have detailed planning-level designs available.

2 Methods

We applied an integrated agent-based modeling framework involving simulation of human and vehicle activity, pollutant emissions and dispersion, and human exposures. Below we describe the study area, study simulations, and resultant analyses for this work.

2.1 Study area and population

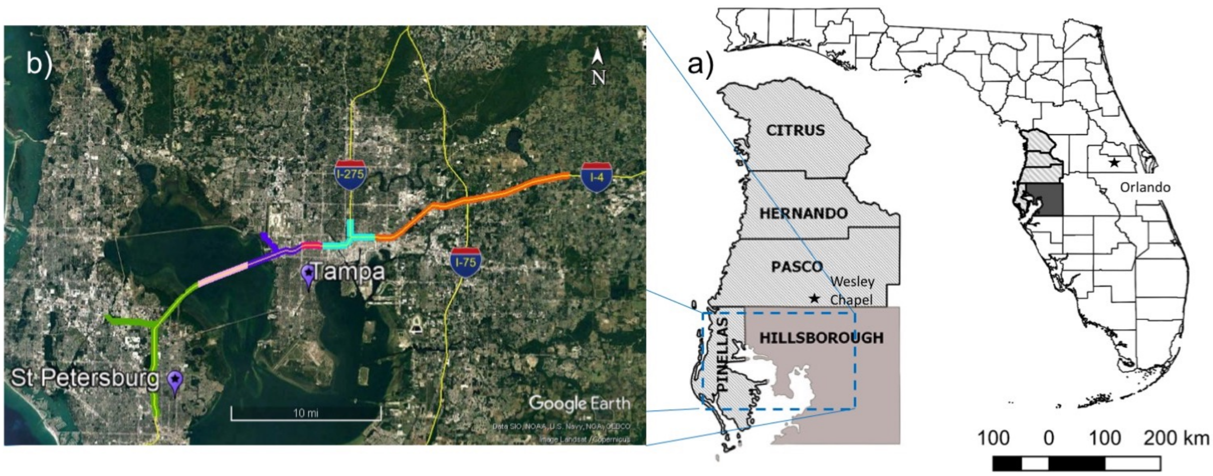

Figure 1. The study area within the context of the state for Florida (a) and the Tampa Bay Next master road expansion plan sections (b). County boundaries are shown in subplot a, with Hillsborough County shaded opaque grey; other counties included in the transportation modeling for this work are hatched. For subplot b, the colors correspond to the following road expansion plan segments: Gateway express (green), Howard Frankland bridge (pink), Westshore area interchange (blue) Westshore to downtown corridor (red), downtown interchange (aqua) and I-4 expansion (orange).

Hillsborough County, Florida, which contains the city of Tampa, is the focus of our study. The county is located on the western side of the state on the Tampa Bay, as shown in Figure 1. There are three interstate freeways serving the county. Interstate 275 (I-275) provides a connection from St. Petersburg in Pinellas County in the west to Wesley Chapel in Pasco County to the north. I-275 also merges in downtown Tampa with Interstate 4 (I-4), which connects Tampa to Orlando and points east. The third interstate, Interstate 75 (I-75), which runs to the east of downtown, serves north–south travel. As shown in Figure 1, major interstate modifications planned within Tampa Bay Next are along I-275 and I-4, with expansion elements in six specific corridors. Hillsborough county’s population in 2010 was 1,229,179, with population proportions categorized as white, black, Asian, and other at 74.5%, 17.8%, 4.3%. and 3.4%, respectively. 28.6% of the population was Hispanic or Latino (US Census Bureau, 2010).

2.2 Description of the modeling approach

In this study, we estimate the spatiotemporal locations of residents, vehicle volumes, speeds, and pollutant emissions on roadway links, pollutant concentrations, individual exposures, and exposure inequality for several population subgroups. We used the modeling framework and basic setup described by Gurram et al. (2019), consisting of detailed transportation, air pollution, and exposure modeling. Here, we have also added the calculation of two additional measures of exposure inequality to the framework. Details of the simulation scenarios and changes in the application of each modeling component for this study are provided below.

2.2.1 Simulation scenarios

To investigate the potential impacts of the TBNext planned freeway expansion program, we simulated two scenarios in this study. The first scenario, called the "base scenario" uses the 2010 roadway network and toll prices for the two existing non-interstate tolled highways in the study area. For the second scenario, called the "TBNext" scenario, we updated the roadway network with the toll and general-purpose lanes specified by the current TBNext plans. We conducted transportation, air pollution, and exposure modeling for each scenario separately, and then compared results to quantify the potential impacts of the TBNext roadway expansion on traffic volumes, emissions, air pollutant concentrations, exposures, and exposure inequalities.

2.2.2 Transportation modeling

Spatiotemporal locations of individual residents and hourly link-specific vehicle counts and average speeds during a typical weekday were estimated using the Multi-Agent Transport Simulation tool (MATSim), driven by travel demand from the Tampa Bay activity-based travel demand model (TBABM). MATSim is a traffic simulation tool that iteratively optimizes the travel demand of all individuals in the model (who are called agents) given the transportation network (Horni, Nagel, & Axhausen, 2016). MATSim produces detailed spatiotemporal coordinates for travel trajectories between fixed-location activities (e.g. home, work, shopping) for each agent. Output can also be aggregated to estimate link-specific hourly vehicle volumes and speeds. To drive MATSim, we used the same 2010 travel demand that was used by Gurram et al. (2019), and also based our roadway network on that study. The travel demand was derived from TBABM model output and contains activity and travel plans for each individual, including modes of travel between activities. The roadway network information contains road length, capacity, free-flow speed, number of lanes, travel modes, and toll data (if applicable) for every link.

For our base scenario, we updated the roadway network used by Gurram et al. (2019) to include the 2010 toll pricing scheme for the existing tolled roadways. These include the Selmon Expressway and Veterans Expressway, which are non-interstate tolled highways. We also added other available travel modes (transit bus, cycling, walking, ride sharing, and school bus) to supplement the auto mode already included. Transit bus infrastructure and scheduling information necessary for MATSim modeling were based on the 2010 Tampa Bay Regional Planning Model's transit plans included in the TBABM. Because other modes of travel may not be constrained by the auto roadway network or affect the network capacity, a simple approach was used for their treatment in MATSim. Specifically, we assumed a mode-specific travel speed and a travel distance equal to the distance between the origin to destination activity locations multiplied by a mode-specific path tortuosity factor. Travel speeds were set at 1.4 m/s, 4.2 m/s, 11 m/s, and 11 m/s for walking, cycling, ride share, and school bus respectively. Path tortuosity factors were set at 1.3 for walking and cycling, and 1.45 for ride share and school bus.

For the TBNext scenario, we updated the roadway links with the planned interstate toll and general-purpose lanes, using the TBNext concept plans and fact sheets (Florida Department of Transportation, n.d.). These plans include adding toll lanes to I-275 from St. Petersburg to downtown Tampa, Howard Frankland Bridge, and I-4 and modifying the Westshore and downtown Tampa interchanges with general purpose lanes (Figure 1). Toll prices for the TBNext scenario were based on the Tampa Bay Next 2025 weekday AM peak toll pricing estimates (Florida Department of Transportation, 2017) scaled down for the underlying 2010 model roadway network; scaling was based on the ratio of the actual 2010 toll rate to that for 2025 for an existing toll corridor (Veterans Expressway). For simplicity, we assumed road pricing to be static for the modeling scenarios.

Most MATsim simulation specifications used for this study were the same as those used by Gurram et al. (2019) and are detailed there. However, we reduced the number of optimization iterations to 200, which was adequate to reach an equilibrium state. We also used an updated approach to perturbing agent plans that combines rerouting and departure time adjustment (with 20% of agent plans perturbed from the best-utility plan at each iteration), and uses a default time perturbation of 15 min.

Table 1. Proposed lanes and estimated toll rates for the TBNext scenario

Roadway section	Proposed lanes	Toll rate
South of Gandy Boulevard to 4th Street North	1 toll lane in each direction	$ 1.0
US 19 to west of I-275	2 toll lanes in each direction	$ 0.5
Bayside Bridge to west of I-275	2 toll lanes in each direction	$ 0.5
Howard Frankland Bridge	2 toll lanes in each direction 4 general purpose lanes from west to east	$ 1.0
West section of Westshore interchange	3 toll lanes from west to east 2 toll lanes from east to west 6 general purpose lanes in each direction	$ 0.5
North section of Westshore interchange	3 toll lanes in each direction 6 general purpose lanes from north to south 7 general purpose lanes from south to north	$ 1.0
East section of Westshore interchange	4 toll lanes in each direction 5 general purpose lanes in each direction	$ 0.5
Westshore to downtown corridor	2 toll lanes in each direction	$ 1.0
West section of downtown interchange	3 toll lanes in each direction 4 general purpose lanes from west to east 6 general purpose lanes from east to west	$ 0.5
North section of downtown interchange	4 general purpose lanes in each direction	
East section of downtown interchange	3 toll lanes in each direction 7 general purpose lanes in each direction	$ 0.5
I-4 from downtown interchange to the Polk Parkway in Polk County	3 toll lanes in each direction	$ 1.0

2.2.3 Air pollution modeling

A diurnal cycle of link-specific emission rates of oxides of nitrogen (NO_x) on an average winter day were estimated using the Motor Vehicle Emission Simulator 2014a (MOVES) (Koupal et al., 2003). We focus on NO_x, the sum of NO_2 and NO, as both an important individual pollutant category and to represent the mix of pollutants from traffic. NO_x are known to play an important role in tropospheric ozone and particulate matter formation. Additionally, NO_2 is a criteria air pollutant under the U.S. Clean Air Act. Finally, NO_x are often used as a surrogate for the complex mixture of traffic-related air pollution in studies of health effects (Cheng et al., 2016;

Clark et al., 2010; Health Effects Institute, 2010). We focus on a winter day because near-road NO_x concentrations are usually heightened in winter (Shi and Harrison, 1997).

To set up MOVES, roadway link-specific vehicle volumes and speeds, vehicle age and fuel type distribution data, and meteorology data are needed. The diurnal cycle of hourly link-specific vehicle volumes and speed inputs for a typical weekday were obtained by aggregating the above MATSim simulation output. For meteorological data, the same diurnal cycle (temperature and relative humidity for each hour) of an average winter day used by Gurram et al. (2019) was applied here. We also used the MOVES default data for Hillsborough County 2010 to generate vehicle age and fuel type distributions.

Subsequent to MOVES, we applied RLINE, a line-source atmospheric dispersion model (Snyder et al., 2013) to estimate NO_x concentrations on a 500 m resolution receptor grid in the study area. RLINE uses a Gaussian-plume solution to estimate concentration at receptor locations impacted by a line source (Snyder et al., 2013; Venkatram et al., 2013). The diurnal cycle of roadway link-specific emission rates from MOVES were used to drive the RLINE simulations. We used the same RLINE run parameters and hourly winter meteorology as Gurram et al. (2019).

2.2.4 Exposure modeling and inequality analysis

To estimate individual exposures, we combined the spatiotemporal locations of individuals obtained from MATSim simulation with the spatiotemporally-resolved pollutant concentrations output from RLINE. Specifically, we calculated the daily exposure concentration of each individual as $C_E = \sum c_\sigma \Delta t_\sigma / T$, where C_E represents the daily exposure concentration of each individual, c_σ and Δt_σ are the pollutant concentration and time spent, respectively, at a spatiotemporal location, σ. T is the duration of total exposure ($\sum \Delta t_\sigma = 24$ hours here). The pollutant concentration (c_σ), at 500 m resolution, and time spent (Δt_σ), at 1-second resolution, were obtained from the RLINE and MATSim outputs, respectively. For the travel modes that were not loaded on the MATSim roadway network (cycling, walking, ride share, and school bus), we assumed a straight-line travel path and constant speed between origin and destination activity locations and times to estimate individual spatiotemporal exposure location.

After estimating the daily exposure concentration for each individual, we calculated summary statistics (minimum, 25th percentile, mean, median, 75th percentile, and maximum) of exposure concentration for the population and for several subgroups. Subgroup populations were categorized by race (white, black, Asian, and other), ethnicity (Hispanic and not Hispanic), and household income level (above $75,000, above poverty to below $75,000, and below poverty), as described by Gurram et al. (2015).

In addition to comparing group mean exposures, we used three comparative indices to measure inequality in subgroup exposures. These include the subgroup inequity index used in the original modeling framework. Here, we also add calculation of two other commonly used indices, the comparative environmental risk index, and the toxic demographic quotient index (Harner et al., 2002). We compare results from these indices to determine whether findings are robust across indices.

The subgroup inequity index (SII) has been used in several studies by our research group to measure disparities in exposure between population subgroups. It can be defined as $SII = \log_{10}\left(\frac{p_{a_r}/p_r}{p_a/p}\right)$, where p_{a_r} is the population of subgroup a that is at risk, p_r is the total population at risk, p_a is the total population of subgroup a, and p is the total population of all people in the study. The at-risk population can be defined in a number of ways, such as based on the population residing within a buffer zone around a pollution source (Stuart et al., 2009), residing within an area having ambient concentrations that exceed a threshold level (Yu & Stuart, 2013, 2016), or having individual daily exposure concentrations that exceed a threshold value (Gurram et al., 2015, 2019). The SII quantifies the degree to which members of a specific population subgroup are at risk compared to their proportion in the overall population. The logarithmic transformation results in positive SII values indicating disproportionately high exposures and negative values indicating disproportionately low exposures.

The comparative environmental risk index (CERI) has also been used to identify whether a population subgroup is more exposed to a hazard than the rest of the population (Harner et al., 2002). It is formulated similarly to relative risk in epidemiology (dos Santos Silva, 1999) as $CERI = \frac{p_{a_r}/p_a}{p_{na_r}/p_{na}}$, where p_{na_r} is the population of the remaining people (not of subgroup a) that are at risk, and p_{na} is the total population of those remaining people in the study. (p_{a_r} and p_a are defined as above).

The toxic demographic quotient index (TDQI) compares a subgroup's at-risk population to the same subgroup's not-at-risk population to quantify exposure disparities (Harner et al., 2002). It can be defined as $TDQI = \frac{p_{a_r}/p_r}{p_{a_{nr}}/p_{nr}}$, where $p_{a_{nr}}$ is the population of subgroup a that is not at risk, p_{nr} is the total population not at risk, and the not-at-risk population is the population with risks below the specified level. (p_{a_r} and p_r are defined as above). The interpretations of the CERI and TDQI are similar—if a subgroup's index value is greater than 1, they are disproportionately at risk. If it is less than one, they are disproportionately not at risk.

For the analyses here, the at-risk population was defined as individuals whose daily exposure concentrations were above a threshold exposure concentration; individuals whose exposures were below the threshold level were considered not to be at risk for the TDQI calculations. We calculated index values for three different threshold levels, set at the 85th, 90th, and 95th percentile of the cumulative distribution of individual exposure concentration; these represent reasonable upper range exposures. The same population subgroups defined above for calculating group summary statistics were used to investigate disparities by race, ethnicity, and income.

3 Results and discussion

Table 2. Spatiotemporal summary statistics of human activity duration density, NO_x emissions, concentration, and exposure density for the base scenario and the TBNext scenario.

	Human activity (person-hr/km^2)		Emissions (gram/meter)		Concentration (μg/m^3)		Exposure (μg/m^3 × person-hr/km^2)	
	Base	TBNext	Base	TBNext	Base	TBNext	Base	TBNext
Mean	863	863	0.284	0.228	8.68	8.66	18,932	18,804
Minimum	0.14	0.14	0	0	0	0	0.2	0.2
25th percentile	247	248	0.032	0.032	0.49	0.48	1,115	1,107
Median	654	656	0.120	0.121	1.88	1.87	4886	4788
75th percentile	1229	1231	0.356	0.353	6.14	6.10	17,434	17,380
Maximum	16,218	16,242	28.45	22.41	8,997	6,858	1.67 x10^6	1.61x10^6
Population size	21,048		295,968	302,232	43,232,848		21,048	

3.1 Distributions of human activity

Spatial differences between the scenarios (TBNext – base) in the distribution of aggregate human activity for a few hours of the simulated winter day are shown in Figure 2 (top row). Summary statistics of the spatiotemporal distributions for each scenario are presented in Table 2. Activity duration densities (duration normalized by block group area) for each block group (n = 877) and hour of the day (n = 24) comprise the spatiotemporal population of values. During peak periods (7 to 9 am and 6 to 8 pm), duration densities were considerably higher for the TBNext scenario in the University of South Florida (USF), Westshore, downtown Tampa, north Tampa, and Seminole Heights areas. However, the differences in other regions and during the rest of the day were small. Overall, values of most summary statistics were slighty higher for the TBNext scenario than the base scenario, but the means were the same (a *t*-test for difference in the means resulted in a *p* value of 0.92).

3.2 Distributions of vehicle activity

Total vehicle count was higher between 7 – 9 am and 4 – 8 pm than the rest of the day for both the base and TBNext scenarios (not shown). This diurnal pattern is similar to that found by Gurram et al. (2019). For the base scenario, the highest vehicle count for a single link (7,349) was observed at 6 pm between Westshore and the downtown corridor for the base scenario. However, for the TBNext scenario, the highest vehicle count for a single link (7,463) was on the Howard Frankland Bridge at 6 pm. This could be due to the proposed addition of lanes on the bridge. Moreover, during the peak hours from 5 to 9 am, from 4 to 7 pm, and from 11 pm to midnight, the TBNext scenario had higher vehicle counts than the base scenario, but the base scenario had higher counts for rest of the day.

The average vehicle speeds were slightly higher in the TBNext scenario than in the base scenario during the morning and evening peak periods through the Westshore and downtown interchanges (not shown). In addition, some links in the northern region of Tampa had significantly higher speeds in the TBNext scenario than in the base scenario. There wasn't any substantial difference in hourly mean speeds from 1 to 5 am between scenarios. Other than these, most speed differences were less than 0.3 miles/hour during the day on the rest of the roadway network. Detailed data on simulation vehicle counts and speeds is available in Kocak (2019).

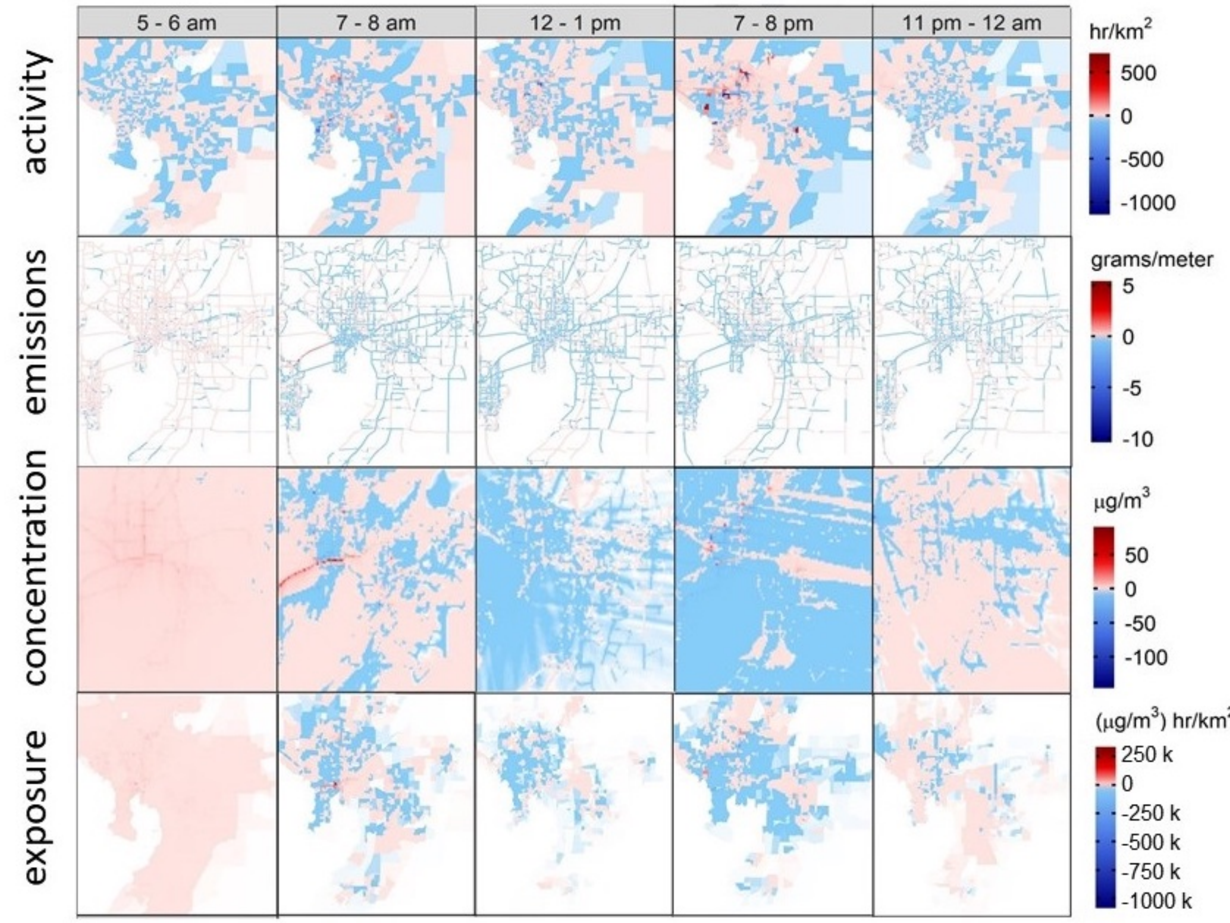

Figure 2. Differences between the TBNext scenario and the base scenario in the distribution of human activity duration density (top row), roadway NOx emission (second row), concentration (third row), and aggregated individual exposure (bottom row) for a few hours of an average winter day. Red indicates that the TBNext scenario value is higher; blue indicates it was lower. Activity and exposures are shown at the block group resolution, concentrations are at 500 m resolution, and emissions are resolved to roadway segment.

3.3 Distributions of emissions

The spatial distribution of differences between the scenarios in roadway-link emissions is visualized for a few hours of the day in Figure 2 (second row); summary statistics of the spatiotemporal distribution are presented in Table 2. Note that because lanes were added as part of TBNext program, the number of links was somewhat different between scenarios, resulting in different population sizes (links multiplied by hours of the day). For most of the day, emissions were lower for the TBNext scenario on the I-275, the I-4, and the Howard Frankland bridge. However, from 5 to 8 am and from 5 to 7 pm, emissions were higher for the TBNext scenario on the north part of I-275, on the Howard Frankland bridge, and in the downtown and Westshore areas. Additionally, the majority of the roadway network (except for I-4) had higher emissions at 6 am in the TBNext scenario than in the base scenario. Values of most summary statistics of link emissions were slighty lower for the TBNext scenario than the base scenario, with the *p* value for a *t*-test for difference in the means of $4x10^{-16}$. Overall, the results indicate that the TBNext scenario generally had lower roadway emissions than the base scenario. However, major business centers and two of the three interstate highways (I-275 and I-75) had higher emission rates during peak periods for the TBNext scenario.

3.4 Distributions of concentration

Spatial differences in NO_x concentration between the scenarios are shown in Figure 2 (third row); summary statistics of the spatiotemporal distributions are provided in Table 2. Concentrations at each RLINE receptor and hour of the day comprise the population, for a total size of 43,232,848 values. From 5 to 6 am, the TBNext scenario had substantially higher concentrations than the base scenario on the I-275, the Veteran Expressway, the Selmon Expressway, and the downtown and Westshore interchanges. From 5 to 8 pm, I-275 also had higher concentration for the TBNext scenario. However, the differences in the concentrations between the two scenarios started to decrease from 8 to 9 am, and by 7 to 10 pm, the concentrations in the urban core were higher in the base scenario. For other areas and the rest of the day, no substantial differences are apparent between the two scenarios. Similar to emissions, we found values of most summary statistics of concentration to be slighty lower for the TBNext scenario than the base scenario (*p* value of $2x10^{-4}$ for a *t*-test for difference in the means). Mean NO_x concentrations found here are intermediate to those found in two previous studies of the same study area (4.7 $\mu g/m^3$ and 12 $\mu g/m^3$ for Gurram et al. 2019 and Yu and Stuart 2013, respectively), with the direction of differences between studies consistent with differences in pollution sources and time frame. We have included addition travel modes, including NO_x-emitting transit buses, that were not included by Gurram et al. (2019). However, we have not included stationary point and area sources of NO_x, as done by Yu and Stuart (2013) for the model year (2002).

3.5 Distributions of exposure

Differences between the scenarios in the spatial distribution of aggregated NO_x exposure density for a few hours of an average winter day are shown in Figure 2 (bottom row); summary statistics of the spatiotemporal distribution for each scenario are provided in Table 2. Here, exposure densities (normalized by block group area) for each block group and hour of the day comprise the spatial population of values. Overall, values of the summary statistics were lower for the TBNext scenario, but the means were similar (*p* value of 0.26). Despite these small overall differences, interesting patterns are revealed by looking at the spatiotemporal distribution. Specifically, from 12 midnight to 3 am, the TBNext scenario had lower exposure densities than the base scenario in south Tampa, the Westshore area, downtown Tampa, and the Carrollwood area, consistent with the overall statistics. However, from 3 to 6 am, the exposure densities in the TBNext scenario were higher than the base scenario in the Tampa urban core. Between 5 and 6 am, in particular, the exposure densities in the TBNext scenario were slightly higher throughout Hillsborough County. During the evening peak periods (from 5 to 7 pm), exposure densities were once again higher for the TBnext scenario in downtown Tampa, the USF area, and Temple Terrace. However, the largest difference in exposure density between the two scenarios was also found at 6 pm in downtown Tampa, with exposure density in the base scenario higher by 170 %. Between 8 and 10 pm, exposure densities in the TBNext scenario were lower than the the base scenario throughout Hillsborough County, except at the Westshore interchange and the USF area. However, between 11 pm and 12 am, the TBNext scenario again had higher exposure densities than the base scenario in south Tampa, Westshore area, downtown Tampa, USF area, Carrollwood area, and Brandon.

Considering the distributions of individual exposure concentrations instead, summary statistics for both scenarios are provided in Table 3. The population-mean individual NO_x exposure concentrations estimated here for both scenarios (approximately 18 $\mu g/m^3$) is similar to that (17 $\mu g/m^3$) estimated by Gurram et al. (2015) and higher than that (10.2 $\mu g/m^3$) estimated by Gurram et al. (2019) for the same study area. Differences with the earlier Gurram et al. study are consistent with the addition of travel modes not included in the previous study, including transit and school buses, cycling and walking. The addition of transit buses can increase vehicle counts and emissions, while cycling and walking modes can increase exposures. For the resident population as a whole, values of all statistics except the minimum were slightly lower for the TBNext scenario that the base scenario; the *p* value for difference in the mean was 2.2×10^{-16}. Values of group statistics (except the minimum) were also lower for the TBNext scenario than the base scenario.

Table 3. Summary statistics of the distribution of individual NOx exposure concentration (µg/m3) for the Hillsborough county resident population and by race, ethnicity, and income level for both scenarios.

	Population size (n)	Mean	Minimum	25th percentile	Median	75th percentile	Maximum
			Base scenario				
Population	1,048,575	18.3	0.45	11.7	16.6	22.1	241
Below poverty	104,660	20.6	1.41	13.1	18.2	23.5	240
Middle income	546,961	18.7	0.45	12.1	17.1	22.6	241
High income	396,954	17.2	1.40	10.9	15.6	21.2	234
Black	163,538	19.2	1.59	12.4	17.4	22.7	240
Asian	27,129	18.5	2.32	11.7	16.9	22.4	233
Other race	62,628	18.4	1.41	11.8	16.9	22.2	232
White	795,280	18.1	0.45	11.5	16.5	22.0	241
Hispanic	218,993	18.8	1.41	12.0	17.1	22.5	237
Not Hispanic	829,529	18.2	0.45	11.6	16.5	22.0	240
			TBNext scenario				
Population	1,048,575	18.1	0.46	11.5	16.4	21.8	229
Below poverty	104,644	20.5	1.48	13.1	18.1	23.4	229
Middle income	546,967	18.5	0.46	12.1	17.0	22.2	229
High income	396,964	17.1	1.35	10.8	15.5	21.0	225
Black	162,908	19.1	1.62	12.4	17.3	22.4	229
Asian	27,815	18.4	2.19	11.7	16.8	22.1	223
Other race	62,546	18.3	1.48	11.8	16.8	21.9	216
White	795,306	18.0	0.46	11.5	16.4	21.8	229
Hispanic	218,994	18.7	1.22	12.0	17.0	22.2	225
Not Hispanic	829,528	18.1	0.46	11.5	16.4	21.8	229

3.6 Inequality in exposure

Table 3 provides summary statistics of average exposure by demographic group. We found the highest average NO_x exposure concentration for the below-poverty group in both scenarios, with the black group and Hispanic group averages ranked second and third highest. Average exposure concentrations for these groups were higher than the population mean in both scenarios. Average exposure concentrations were also higher than the mean for the middle-income group, Asians, and the 'other race' group. Of all groups, the high-income group had the lowest average

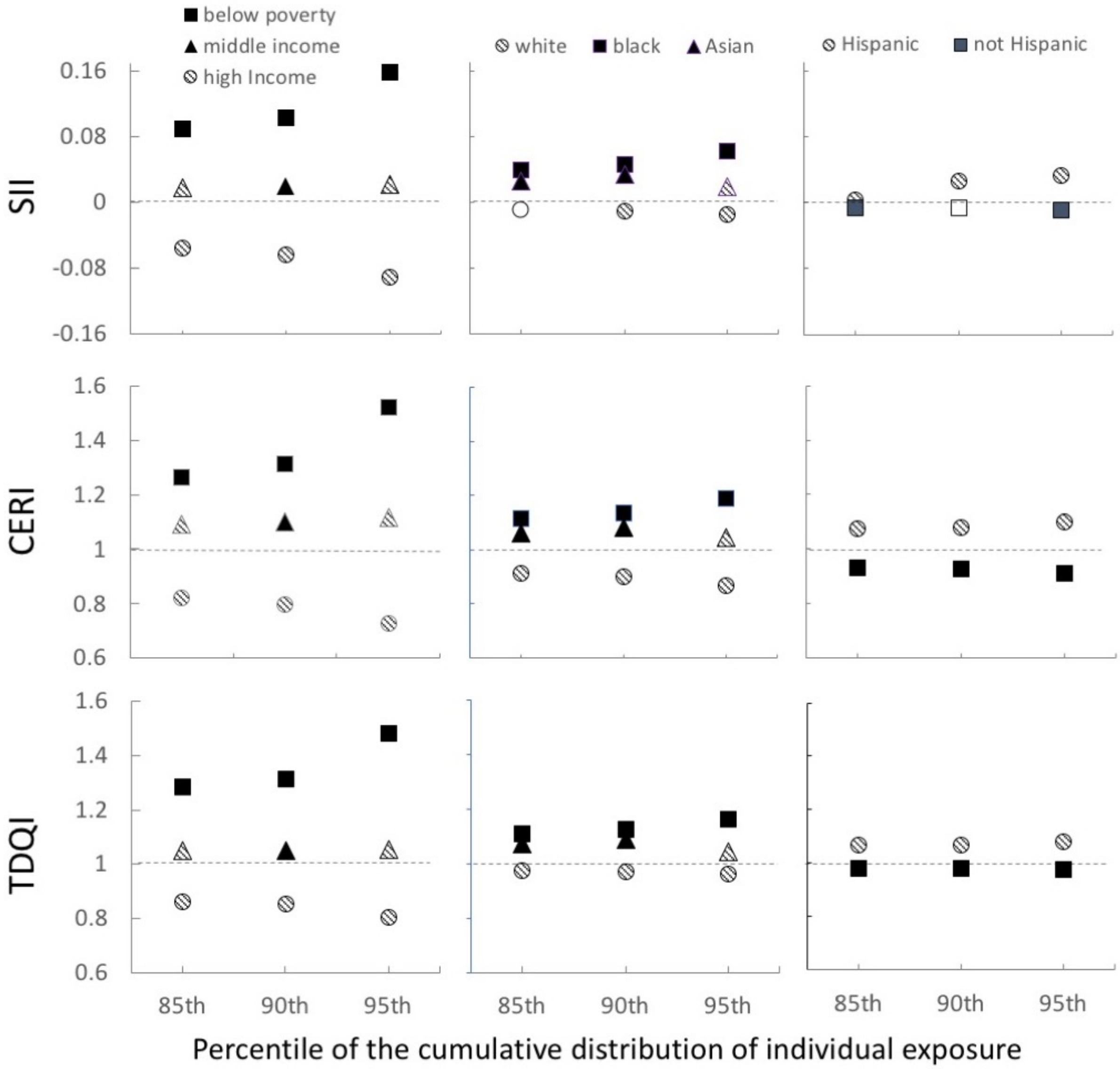

Figure 3. Inequality index value versus exposure level for the TBNext scenario, by income, race, and ethnicity. Solid filled markers indicate that the TBNext scenario value was higher than the base scenario value, hatched fill indicates that the base scenario value was higher, no fill indicates that there was no difference. SII is the subgroup inequity index, CERI is the comparative environmental risk index, and TDQI is the toxic demographic quotient index.

NO_x exposure concentration in both scenarios, with average exposure concentration decreasing as income increased. Average exposure concentrations were lower than the population means for the highest-income group and the white group in both scenarios. Average exposure concentration for the non-Hispanic group was slightly lower than the population mean in the base scenario and equal to the population mean in the TBNext scenario. Overall, results suggest inequality in exposures by income, race, and ethnicity for both scenarios, with the lowest-income, black, and Hispanic people experiencing the highest exposures on average, while high-income, white, and non-Hispanic people experience lower exposures. These results are consistent with several previous studies in the study area (e.g. Gurram et al., 2015; Yu et al., 2016) and provide the basis for considering how the TBNext scenario impacts inequality.

Table 4. Comparative inequality index values by race, ethnicity, and income for three exposure levels.

	Threshold level* and scenario					
	85th percentile		90th percentile		95th percentile	
	Base	TBNext	Base	TBNext	Base	TBNext
	Subgroup inequality index (SII)					
Below poverty	0.088	0.090	0.100	0.104	0.156	0.160
Middle income	0.018	0.018	0.019	0.020	0.022	0.022
High income	-0.055	-0.055	-0.060	-0.063	-0.090	-0.091
Black	0.039	0.039	0.045	0.046	0.062	0.062
Asian	0.022	0.025	0.030	0.033	0.021	0.019
Other race	0.008	0.006	0.007	0.005	0.014	0.016
White	-0.010	-0.010	-0.011	-0.012	-0.016	-0.016
Hispanic	0.025	0.002	0.026	0.026	0.033	0.032
Not Hispanic	-0.007	-0.007	-0.007	-0.007	-0.009	-0.009
	Comparative environmental risk index (CERI)					
Below poverty	1.256	1.262	1.296	1.311	1.504	1.520
Middle income	1.093	1.093	1.098	1.101	1.117	1.115
High income	0.823	0.822	0.807	0.800	0.731	0.727
Black	1.112	1.113	1.131	1.135	1.188	1.188
Asian	1.054	1.062	1.073	1.082	1.050	1.045
Other race	1.019	1.015	1.018	1.012	1.035	1.039
White	0.914	0.914	0.901	0.899	0.866	0.866
Hispanic	1.077	1.075	1.079	1.079	1.102	1.100
Not Hispanic	0.928	0.930	0.927	0.927	0.907	0.909
	Toxic demographic quotient index (TDQI)					
B]Below poverty	1.275	1.282	1.296	1.311	1.465	1.480
Middle income	1.050	1.050	1.050	1.051	1.056	1.055
High income	0.864	0.863	0.858	0.853	0.806	0.803
Black	1.111	1.112	1.122	1.125	1.164	1.164
Asian	1.063	1.072	1.079	1.089	1.052	1.046
Other race	1.021	1.016	1.019	1.012	1.034	1.038
White	0.974	0.974	0.971	0.971	0.962	0.962
Hispanic	1.071	1.069	1.069	1.068	1.084	1.082
Not Hispanic	0.981	0.982	0.982	0.982	0.978	0.979

*The threshold exposure levels are percentiles of the cumulative distribution of individual exposure.

To further elucidate inequality, Figure 3 presents values of the comparative inequality indices (SII, CERI, and TDQI) for each demographic group under the TBNext scenario, along with trends in index value with exposure level. (Values are listed for both scenarios in Table 4). All index values are consistent with the overall findings on exposure inequality suggested by comparing the group-average exposures but reveal additional details. Looking at the income category (Figure 3 column 1), we see that the index value is higher than the central index value (0 for the SII, 1 for CERI and TDQI) for the below-poverty and middle-income groups. This indicates disproportionately high exposures for these groups. Conversely, the index value is lower than the central value for the high-income group, indicating disproportionately low exposures. The below-poverty group has the most disproportionately high exposures (highest value above the central value) among all groups studied, with the disparity in exposure increasing as the exposure level increases from the 85th to 95th percentile of exposure. Conversely, the index value decreases with exposure level for the high-income group, indicating that as exposure level increases, this group has even more disproportionately low exposure. For the racial category (column 2), the index values indicate disproportionately high exposures for the black and Asian subgroups, and disproportionately low exposures for the white subgroup. For the ethnicity category (column 3), the Hispanic group has disproportionately high exposures, while the non-Hispanic group has disproportionately low exposures. Similar to the below-poverty group, the disparity increases as exposure level increases for the black and Hispanic subgroups. However, no clear trends are seen for the other groups with exposure level.

Changes in inequality between the TBNext scenario and the base scenario are also presented in Figure 3, with detailed difference values listed in Table 5. As shown by the solid filled markers in Figure 3, the index values for the below-poverty and black groups increased under that TBNext scenario compared with the base scenario. These groups had disproportionately high exposures under the base scenario (see Table 4), but under the TBNext scenario, their exposures were even more disproportionate. Conversely, the index values decreased for the high-income and white groups (shown by the hatched filled markers), indicating that their exposures were more disproportionately low under the TBNext scenario than the base scenario. Hence, the disparity between the low- and high-income groups, and between the black and white groups, both grew for the TBNext scenario. For the Asian racial group and the middle-income group, impacts of the TBNext scenario are mixed, with increasingly disproportionate exposures at some levels, but reduced inequality for other levels. For the ethnicity category, the TBNext scenario decreases disparities, with both disproportionately high and low exposures reduced for the Hispanic and non-Hispanic groups, respectively. Overall, these results indicate that the TBNext scenario largely increased exposure disparities by race and income, but decreased disparities between the Hispanic and non-Hispanic ethnic groups.

Table 5. Difference in the comparative inequality index values between the TBNext and base scenario*

	Threshold level		
	85th percentile	90th percentile	95th percentile
Subgroup inequality index (SII)			
Below poverty	1.9E-03	4.6E-03	4.0E-03
Middle income	-1.0E-04	6.0E-04	-3.0E-04
High income	-5.0E-04	-2.6E-03	-1.3E-03
Black	2.0E-04	1.3E-03	1.0E-04
Asian	3.1E-03	3.6E-03	-2.3E-03
Other race	-1.8E-03	-2.4E-03	1.6E-03
White	0	-3.0E-04	-1.0E-04
Hispanic	-2.3E-02	-2.0E-04	-8.0E-04
Not Hispanic	1.0E-04	0	2.0E-04
Comparative environmental risk index (CERI)			
Below poverty	6.3E-03	1.6E-02	1.6E-02
Middle income	-5.0E-04	3.0E-03	-1.6E-03
High income	-1.6E-03	-7.3E-03	-3.2E-03
Black	7.0E-04	3.8E-03	3.0E-04
Asian	7.8E-03	9.2E-03	-5.6E-03
Other race	-4.7E-03	-6.1E-02	4.1E-03
White	-2.0E-04	-1.7E-03	-5.0E-04
Hispanic	-2.0E-03	-7.0E-04	-2.9E-03
Not Hispanic	1.7E-03	6.0E-04	2.4E-03
Toxic demographic quotient index (TDQI)			
Below poverty	6.9E-03	1.6E-02	1.5E-02
Middle income	-3.0E-04	1.3E-03	-8.0E-04
High income	-1.3E-03	-5.7E-03	-2.6E-03
Black	7.0E-04	3.6E-03	3.0E-04
Asian	9.1E-03	1.0E-02	-5.8E-03
Other race	-5.1E-03	-6.4E-03	4.0E-03
White	-1.0E-04	-5.0E-04	-1.0E-04
Hispanic	-2.5E-03	-5.0E-04	-2.3E-03
Not Hispanic	5.0E-4	2.0E-04	7.0E-04

*TBNext scenario value minus the base scenario value

Finally, if we compare the results from the three indices (SII, CERI, and TDQI), we see that the difference in formulations of the indices (Section 2.2.4) results in somewhat different specific values. Additionally, the central value marking the transition from disproptionately high to disproportionately low exposures differs for the SII (0) from that for the CERI and TDQI (1). Nonetheless, all indices provide the same messages regarding inequality in exposure for each group, the trend in the disparity with exposure level, and the change in disparity between the base and TBNext scenario. Hence, inequality results are consistent, irrespective of the index used.

3.7 Limitations

The findings of this study are limited in several ways. First, the TBNext program's design process is constantly evolving. For example, toll lanes were originally planned for the north part of I-275, but were recently canceled (Winer, 2018). Additionally, all toll lanes were assumed to be statically priced in this work. However, some of the proposed toll lanes would likely have dynamic pricing options. Therefore, the findings from this study may not represent the final form of the TBNext program. Second, the timeframe for the roadway network and other data in the modeling system used here was 2010. This allows an exploration of potential impacts, but cannot predict the actual impacts, particularly considering that the road expansion process will not be completed until after 2024. Third, because we only estimated NO_x concentrations from the on-road mobile sources, results are not representative of NO_x exposures from other sources or all NO_x exposures. Furthermore, although NO_x is an established surrogate for traffic-related air pollution (TRAP) in this study, patterns of pollution and exposures can differ between pollutants. Hence exposures found here may not represent all TRAP. Finally, changes in exposure due to indoor activity locations was not considered in this study. Hence actual personal exposure levels could be higher or lower than estimated here.

4 Conclusions

In this study, we applied a modeling framework that incorporates transportation, air pollution, and exposure models to investigate potential air quality and equity impacts of a large-scale toll road expansion program that is a part of the planned Tampa Bay Next highway modernization. Simulation results suggest that the expansion program (the TBNext scenario) would decrease total NO_x emissions, average concentrations, and average individual exposures to traffic-related air pollution (TRAP) in Hillsborough County. However, it would also increase emission rates and pollutant concentrations on major roadways during the morning and evening peak periods. Furthermore, although exposures were found to decrease on average, currently existing inequalities in exposure to TRAP by race and income may be exacerbated by the toll road expansion program. Specifically, the TBNext scenario resulted in more disproportionately high exposures for people living in poverty and black people, and more disproportionately low exposures for high-income and white people. In other words, the program may widen the exposure gap between these groups. However, the road expansion scenario was found to slightly decrease exposure disparities between the Hispanic and non-Hispanic ethnic groups. These results suggest that during the development and study of large-scale transportation programs there is a need for more detailed inequality analyses, rather than impacts analyses that focus only on average exposures. Finally, results of all three indices of inequality were qualitatively similar, indicating that the specific measure chosen for analysis may not be critical.

PART 2

A Health in All Policies analysis of the Tampa Bay Next transportation program

1 Introduction

As more people migrate to urban areas worldwide, cities are becoming increasingly important centers of human community (Rise of the City, 2016). Innovations in technology occurring with urban expansion, from "smart" homes to automated vehicles, have potential to improve quality of life (Townsend, 2013). However, the automobile-based transportation infrastructure that has supported urban growth has also had detrimental impacts, including air pollution and poor health (Newman & Kenworthy, 1999). Health impacts include increased obesity and diabetes from lack of physical activity and access to healthy foods (Ewing et al., 2003), cardiovascular and respiratory disease and death from air pollution (Forouzanfar et al., 2016), and traffic-accident-related mortality and morbidity (World Health Organization, 2018). Additionally, it is clear that the costs and benefits of urban infrastructure are not shared equally; vulnerable groups often bare a larger burden of the costs and fewer benefits (Morello-Frosch et al., 2011; Gössling, 2016). Hence, approaches to urban transportation design and management are needed that produce sustainable, healthy, and equitable outcomes. However, due to the complexity of the inter-related systems and sectors involved, there is a lack of understanding of processes that lead to such outcomes (Ramaswami et al., 2016). Although studies have begun looking at the air pollution, health and equity impacts of policy options, more studies are needed that specifically examine these outcomes and determine levers for their improvement for real cases.

In this paper, we examine a case study transportation program in the Tampa metropolitan area, Tampa Bay Next (TBNext), through the lens of a Health in All Policies (HiAP) perspective. Our goal was to identify and elucidate levers of influence for improved equity in large-scale metropolitan transportation infrastructure projects. This paper is organized as follows. Section 2 describes the scope of the analysis and the methods applied in this study; this includes a literature review, TBNext document review, key informant interviews, and a rating scale evaluation. Section 3 presents and discusses the results; this includes discussion of the current state of health and equity considerations in transportation, previous applications of the HiAP framework to transportation programs, and a HiAP perspective on TBNext. Section 4 summarizes the findings and provides recommendations for future work to improve the health and equity impacts of large-scale transportation infrastructure programs.

2 Methods

We describe here the Tampa Bay Next program and the Health in All Policies paradigm, followed by details of our analysis methodology. These methods included a literature review on HiAP and related case studies review of available print- and web-based documents on the program, key informant interviews of relevant project stakeholders, and a matrix-based rating scale evaluation synthesizing the occurrence of HiAP attributes within the TBNext development.

2.1 Tampa Bay Next (TBNext)

TBNext is an ongoing program of the Florida Department of Transportation (FDOT) that is aimed at modernizing the transportation infrastructure in the Tampa-St. Petersburg metropolitan area [www.tampabaynext.com]. TBNext projects in the most advanced stage of planning and design involve the extension of existing roadways with both express toll and general-purpose lanes. As shown in Figure 1 of Part 1 of this report, road extension plans start from I-275 in Pinellas County, with the addition of toll lanes. There are also design plans to connect Bayside Bridge to I-275 in the area. The toll lanes go from there to I-4 through Tampa and extend until Plant City. General lane additions to the Westshore and downtown interchanges have also been proposed. In addition to roadway expansion, FDOT is studying a variety of other solutions under TBNext. Future initiatives of the program are expected to include improving bicycle and pedestrian infrastructure, implementing complete streets, improving freight mobility, and supporting local transit system improvements and autonomous shuttle programs. However, no detailed plans are yet available for these initiatives.

Although there is diversity in the list of proposed projects under TBNext, the road extension plans have been a source of controversy. The program is the second generation attempt by FDOT to implement similar express lane projects; the original program, called TBX, ran into public relations issues due in part to perceptions of inequitable impacts. TBNext remains controversial. For example, one of the planned express corridors was recently moved from I-275, where it would have run through disadvantaged communities, to the more rural I-75. Hence, TBNext provides an ideal case to investigate the air quality, health, and equity impacts of a large-scale transportation infrastructure program. For the purposes of this study, we consider the development of the Tampa Bay Next program through the summer of 2019.

2.2 Health in All Policies (HiAP)

Health in All Policies (HiAP) is a paradigm endorsed by the World Health Organization (WHO). It is designed to improve public health, equity, and sustainability outcomes of government decision-making (WHO, 2015). Since the Declaration of Alma Ata highlighting both the gross inequality in health globally and the need for governmental action (WHO, 1978), it has been recognized that government policies in many sectors have the potential to impact public health (Rudolph et al., 2013). However, the HiAP paradigm first emerged as a unique perspective in 2006 in guidance from the Government of Finland (Ståhl et al., 2006). HiAP grew out of the need to address limitations of health impact assessment, an approach used extensively to inform decision makers about health and equity impacts (Delany et al., 2014). These limitations include a narrow scope that focuses on the project level, rather than the process level (Koivusalo, 2010), lack of consideration of opportunities to improve health and equity during the policy implementation process (Government of South Australia's Department of Health, 2010), and too little focus on the social environment and the complex relationships of multiple interacting system components (Leppo et al., 2013). To address these limitations, the HiAP paradigm focuses on intersectoral government collaboration, stakeholder involvement, benefits across sectors and stakeholders, and structural and process changes (Rudolph et al., 2013).

As an example, South Australia implements HiAP across many sectors including transport, justice, education, environment & natural resources, correctional services, planning & infrastructure, and primary industries with various types of initiatives (Baum et al., 2017). Some of these initiatives include improving road safety, providing educational services about parental engagement, implementing transit-oriented developments, encouraging active transportation, and providing resources for the health and wellbeing of international students (Baum et al., 2017).

For the context of transportation decision-making, HiAP defines a healthy city as one the continually improves physical and social environments and expands community resources (WHO, 2015). Because transportation is an important social determinant of health, government policies and plans for transportation infrastructure and management are included in decision-making that impacts health (Rudolph et al., 2013). Hence, for this study, we use the HiAP perspective to investigate and evaluate the Tampa Bay Next Program development, and to identify opportunities to improve health and equity impacts of TBNext and similar large-scale transportation programs.

Table 1. Key HiAP attributes

Attribute	Description	Possible evidence of attribute consideration
Health at core	Health should be at the center of the policy or program, as a main objective.	The program has health goals (Ollila, 2011). All sectors are encouraged to improve health. (Ståhl et al., 2006, p. 11). A health impact assessment was performed (WHO, 2015 p. 146). The program has been analyzed through the health lens. (Rudolph et al., 2013, p. 81).
Equity	Inclusion in decision-making and the fair distribution of benefits and burdens	The program has health equity goals (Ollila, 2011). Inequity analysis was performed (WHO, 2015, p. 27). The outcomes will be equitably distributed. All potentially-impacted groups were involved in decision-making.
Damage limitation	Efforts to limit negative health-related impacts	Efforts (or plans) to limit potential damage to the public health and the environment are present (Ollila, 2011).
Win-win strategy	All parties should see benefits	The program provides outputs that create mutual interests for all parties involved, including the health sector. (Ollila, 2011). The needs of parties from multiple sectors were met.
Multi-sectoral cooperation	Sectors that are involved or impacted should work in cooperation, including the health sector	The program provides opportunities for multi-sectoral cooperation (Rudolph et al., 2013). Conditions that favor effective intersectoral collaboration (WHO, 2015 pp 129): a policy has public support; intersectoral interaction is well-planned with clear objectives, roles and responsibilities (WHO, 2015 p. 169); there are plans to monitor and sustain outcomes; and alliances are built using multiple structures and mechanisms across sectors.
Stakeholder engagement	Stakeholders of all types should be actively engaged in the decision-making process	A stakeholder analysis was performed and managed (WHO, 2015 module 7). If no stakeholder analysis was performed, the degree of stakeholder engagement can be assesses using WHO guidance (WHO, 2015 pp. 105-107).
Structural process change	Structures and processes should change so that health and equity are embedded from an early stage of decision-making	Consideration of health and equity goals or impacts should be evident in multiples program processes. Examples include bill analyses, budget change proposals, state guidance documents, grant guidelines, contracts, strategic planning, and program review and evaluation (Rudolph et al., 2013).
Political commitment	A driving force that provides sustainability throughout the policy process	Actions that are intended to support political commitment are performed. These include (WHO, 2015): effective publicizing and dissemination of evidence for action; strong, effective leaders in the bureaucracy; government support and encouragement of intersectoral action; the issue has high political importance and urgency; laws exist or are planned to support the proposed policy; alliances across sectors and stakeholders exist through multiple structures and mechanisms.

2.3 Review of the literature on HiAP in transportation

As a first step in evaluating TBNext through a HiAP lens, we performed a review of the literature on the integration of health and equity considerations in transportation decisions making, with a specific focus on applications of Health in All Policies to the transportation sector. This review formed the basis of the subsequent analyses through the identification of key attributes that define the HiAP perspective; inclusion of these attributes in the decision-making process are expected to promote improved public health and equity outcomes. Table 1 lists the key attributes, along with brief descriptions. A detailed discussion of each attribute and its demonstration through case studies is provided in the Results section. The final column of Table 1 also provides types of evidence indicated by the existing literature to signal that this attribute was included in the decision-making process; these were used to identify each attribute in our subsequent methods.

2.4 TBNext document review

After reviewing this general literature, we performed a specific review of documents related to the TBNext program. All publicly available documentation on the TB Next program and its associated projects were considered, from the time of inception as the Tampa Bay Express (TBX) program in 2013 to the summer of 2018. Documents considered can be divided into three major categories: 1) news media articles covering the TBNext program, 2) stakeholder meeting minutes from the TBNext community involvement efforts, and 3) publicly available documentation from the Florida Department of Transportation (FDOT) on the TBNext program.

The goal of our review was to elucidate the history of the program, including changes to plans over time and the impact of equity issues and community involvement on those changes. We also aimed to assess the political context of the program and to identify key multi-sectoral decision-makers, community leaders, and other stakeholders involved in the project as potential key informants (see section 2.5). To do this, each document was reviewed to determine both the perspective represented and the inclusion of HiAP concepts. Documents were classified as representing the perspectives of one or more of the following groups: the general public, activist groups, or a governmental agency. We also recorded which of the HiAP attributes were discussed in each document. The inclusion of either direct references to the HiAP attributes (i.e. through use of HiAP terminology) or indirect references (i.e. the discussion of related concepts without using that terminology) were recorded.

To confirm the above qualitative assessment, and to quantify the inclusion of HiAP attributes in the document collection, we also applied text mining tools. To facilitate this analysis, we first assembled a list of keyword stubs associated with each of the eight HiAP attributes. A list of over forty keywords (and word stubs) was initially generated, as shown in Table 2. We ultimately chose a smaller subset of 16 keywords (shown in italics) for text mining analysis. For the analysis, we used Voyant Tools [voyant-tools.org] to determine the number of times that each keyword was present in the document collection, and within each category of document. Voyant Tools is an open source, web-based text reading and analysis environment, that has been previously used in a wide variety of studies in the sciences and humanities (Maramba et al., 2015; Daines III et al., 2018; Hetenyi et al., 2019).

Table 2. Keywords corresponding to each HiAP attributes

HiAP Attribute	Keywords (and word stubs)
Health at the core	active, air, bicycl*, bike*, complete streets, *health**, park, pedestrian, pollut*, recreation, trail, transit, transport*, walk*, *well-being*
Equity	disparity, equality, equitable, *equit**, *inequit**, *injustice*, *justice*
Damage limitation	alternative, *damage, harm*, impact, sustain*, vulnerable
Win-win	accommodat*, compromise, *win-win*
Multi-sectoral cooperation	*collaborat*, cooperat**, damage
Stakeholder engagement	communit*, *stakeholder*, engage**, neighbor, population
Structural process change	evaluat*, *policy*, program*, social, *process*
Political commitment	*commitm**, politic*

*Signifies all possible endings of the word that are relevant to this study.

2.5 Key informant interviews

To assess the perspectives of different stakeholders on TBNext and its equity implications, we also conducted key informant interviews. Categories of stakeholders with direct knowledge or involvement in TBNext were first identified through our previous document review (described above). These categories are listed in Table 3, below. Some of the specific organizations that we targeted to find key informants were the Hillsborough County Metropolitan Planning Organization (MPO), City of Tampa, Hillsborough Area Regional Transit authority, Tampa Bay

Area Regional Transit Authority, the Tampa Hillsborough Expressway Authority, the local office of the Florida Department of Health, the MPO citizen advisory committee, Sunshine Citizens, the Tampa Downtown Partnership, and the University of South Florida. Our goal was to obtain interviews from a few members of each of the categories. Specific individuals were chosen for recruitment based on their apparent knowledge and involvement in TB Next, as ascertained through the document review and recommendations for other researchers and interviewees.

Table 3. Key informant interview categories

Category	Key informant category description	Number of interviews
A	Officials, staff, and consultants of the Florida Department of Transportation	1
B	Officials and staff of regional or local transportation planning agencies	2
C	Officials and staff of governmental health agencies	3
D	Officials and staff of other governmental or non-profit policymaking organizations	6
E	Members of the public, advocacy groups, and community/neighborhood associations	4
F	University researchers with experience related to TB Next, its affected communities, and associated impacts	5
G	Journalists	0

After recruitment of interviewees through email and telephone calls, a total of 21 key informant interviews were conducted from October and December 2019. (Table 3 also provides the number of interviews conducted per category). Most interviews were conducted in-person, although a few were performed over the telephone. Most interviews were also recorded electronically (with specific consent from the interviewee), for later review and analysis. For those interviews that were not recorded, the interviewer took notes for later analysis. The list of questions used to guide each interview is provided in Appendix A. Four types of information were solicited. The first set of questions was aimed at establishing the nature of the interviewee's involvement in the TBNext program development. The second set focused on the informant's knowledge and perspectives related to the manifestation of key HiAP attributes in TBNext (general impacts and benefits, health and equity impacts, the involvement of stakeholders and sectors in the program development, and structural process changes that may have occurred).

The third set of questions asked about the participant's knowledge and experience with HiAP specifically. The final questions provided an opportunity for a more open-ended response. The protocol for key informant interviews was reviewed by the Institutional Review Board (IRB) and the University of South Florida (IRB#: Pro00041189) and was certified exempt.

Recordings and notes from each interview were reviewed for recurring themes and patterns among respondents and within respondent categories. Response were used to provide context for the information obtained from the document review, in order to provide multiple layers of evidence regarding the inclusion of HiAP attributes in the TBNext program development.

2.6 Evaluation and rating of TBNext from a HiAP perspective

Table 4. Rating scale

Score	Description
6	Attribute was a clear focus of the program development, with many direct mentions of the attribute and its keywords in project documents. This focus is supported by key informant interview responses.
5	Attribute is/was a priority of the program development, but secondary to other concerns. Mentions appear throughout many documents and interview responses.
4	Consideration of the attribute is clear in many documents and interview responses, with some direct mentions and substantial indirect references. Related considerations appear to have increased with time, due to community feedback.
3	Mention of the attribute was cursory in most program documents; if considered, consideration appears to be an afterthought. Nonetheless, strong evidence of the attribute's importance was revealed in the key informant interviews.
2	Mention of the attribute was cursory in most program documents; if considered, consideration appears to be an afterthought. There were also only cursory related references from the key informant interviews.
1	Mention of the attribute was absent from most program documents. However, interviews included some minor related references.
0	Mention of the attribute was absent from all program documents and key informant interviews.

To synthesize the results from the document review and key information interviews, we used a rating matrix approach. Specifically, we designed a rating scale to assess inclusion of HiAP attributes in the TBNext projects and plans. The rating scale was designed to rate the level of consideration of a specific HiAP attribute in the program, with a rating of 6 signifying the highest level and 0 signifying the lowest level. The scale, including a description of the meaning of each quantitative score is provided in Table 4. Using this scale along with the data from the document review and key informant interviews, we discuss the evidence for the consideration of each HiAP attribute in the TBNext program development. We also identify levers of influence that could potentially move project decision-making toward more sustainable and improved health and equity outcomes.

3 Results and Discussion

Below we present the results of our literature review, including discussion of the key attributes of HiAP, and how equity and health have been considered in transportation planning. This is followed by results from the review of TBNext documents, the document key word analysis, and results from the key information interviews. Finally, we present and discuss our integrated ratings of the Tampa Bay Next program from a HiAP perspective.

3.1 Key attributes of HiAP

Several key attributes (listed in Table 1) of a HiAP approach emerged through review of case studies of the application of HiAP to governmental decision-making. These attributes have been found to promote improved public health and equity outcomes. Below, we provide a detailed discussion of each attribute and its manifestation in case studies.

Health at the core. This attribute prescribes that health should be at the center of a policy (Ollila, 2011). Promoting health should be a main objective regardless of the policy (WHO, 2015). This encourages decisionmakers to analyze a policy through the lens of healthful outcomes (Rudolph et al., 2013). One example of a policy with 'health at the core' was the definition of health and equity goals for all transportation designs by the California Department of Transportation (Caltrans) (Brown et al., 2015). Specifically, Caltrans aspires to provide a safe transportation system for everyone including cyclists, pedestrians, and road construction workers by providing education and multimedia campaigns about safe driving and cycling. The department also plans to increase the share of zero-emission and low-emission vehicles in the transportation system to decrease greenhouse gases and criteria air pollutants (Brown et al., 2015). Another step in this direction has been achieved by encouraging the use of green transportation modes through incentive programs (California Public Utilities Commission, 2019). The damage limitation attribute, is related to the health at the core attribute, but requires a less extensive focus on health. Instead it requires that efforts are present to limit negative health and environmental impacts.

Equity is a second core attribute that can be seen throughout HiAP applications. The persistence of inequalities in health and environment makes the equity attribute an inseparable part of HiAP (Baum & Laris, 2010; Brownell, 2003). The equity attribute states that the benefits and burdens of a policy or program should be divided among individuals fairly and equally regardless of their socioeconomic, racial, and ethnic differences (Dahlgren & Whitehead, 1991). As an example, Australia implemented many programs including fair financing, equal access to essential services, and gender equality in work to provide an equal distribution of money, resources, and power to all segments of society (Kickbusch & Buckett, 2010). In addition, many countries including Argentina, Chile, Brazil, New Zealand, and Canada implement a social determinants of health approach to tackle health inequities (Marmot & Allen, 2013). The social determinants of health approach focuses on improvement of the underlying conditions within which people live and interact throughout the course of life (Marmot et al., 2012).

The win-win attribute describes policy collaboration in which all partners benefit from a decision (Ståhl et al., 2006) and mutual interests for all parties are involved in a policy (Ollila, 2011). The win-win attribute also encourages government and private agencies to be involved in HiAP implementation because each sector receives benefits to committing to the policy process (Molnar et al., 2016). Moreover, while addressing health considerations, the win-win attribute does not derogate the primary objectives of the sectors involved in a policy (Freiler et al., 2013). It is particularly important to engage multiple sectors in policy implementation and can be achieved through multi-sectoral cooperation (Ollila, 2011). As an example of the win-win attribute, reduction of violence promotes public transportation and has co-benefits for other sectors such as air quality, law enforcement, and housing agencies (Rudolf et al., 2013). In another example, Kahlmeier et al. (2010) states that promoting cycling reduces the mortality rate and hence, provides economic savings.

Multi-sectoral cooperation and stakeholder engagement are other related fundamental attributes of HiAP. The importance of multi-sectoral cooperation was first emphasized in the declaration of Alma-Ata (WHO, 1978). Ståhl et al (2006) states that sectors that are involved in a policy should work in cooperation with the health sector and each other. Additionally, HiAP promotes the integration and collaboration across sectors and other non-government stakeholders (Freiler et al., 2013). For example, transportation, public health, and environmental agencies worked cooperatively to implement active transportation plans in Massachusetts (Association of

State and Territorial Health Officials (ASTHO), 2016). Similarly, Caltrans implemented a health-centered transportation management plan that encouraged leadership, strategic partnership, and multi-sectoral collaboration to identify transportation options that were accessible and suitable for everyone (Brown et al., 2015).

To improve health and equity impacts of policies and programs, health and equity should be considered in the early stage of a policy development rather than as a post-decision process (Rudolph et al., 2013). In other words, they should be embedded in all structures and processes from the early stage of the decision-making process (Rudolph et al., 2013). Moreover, structures and processes that consider health and equity should become permanent throughout the process (WHO, 2015). This permanence provides opportunities of procedural change that supports HiAP and promotes public health (Ollila, 2011). This attribute is called structural or process change. An example of this attribute is seen in Massachusetts. The local government enacted a law in 2009 that HIA is required for major transportation programs to inform decision-makers about the potential health impacts of the programs (National Association of County and City Health Officials (NACCHO), 2017).

Lastly, developing and implementing a policy is a complex process that can take a long time. In order to sustain the policy development process, political commitment is required (Ståhl et al., 2006). This commitment can be ensured by announcing the practices that put health at the front and establishing inter-sectoral alliances (WHO, 2015). The evidence of political commitment in policy includes the presence of the leaders who advocate public health and equity in bureaucracy as well as the presence of laws and regulations that support the HiAP paradigm in major government policies (Fox et al., 2014). In order to emphasize the importance of political commitment, Howard and Gunther (2012) concluded in their literature review that political commitment is a prerequisite for implementing HiAP successfully.

The above attributes are the essential components of the HiAP paradigm. However, depending on the policy or practice, more strategies, such as capacity building (Freiler et al., 2013), can be used to implement HiAP. Regardless of which strategies are used, the ultimate aim of HiAP is to promote health and equity. Furthermore, the key attributes are interconnected with each other. For instance, in order to display the 'win-win' attribute, a well-organized multi-sectoral collaboration is needed (Molnar et al., 2016). Similarly, the 'multi-sectoral approach' and 'stakeholder engagement' were found to facilitate maintaining health and equity (Barr et al., 2008). For example, in a Finland case study, the Coronary Heart Disease Committee was established to reduce heart disease rates (Melkas, 2013). The committee included representatives across different sectors to address the problem. The Ministry of Finance was responsible for reducing taxes on vegetable oil and low-fat milk, the Ministry of Agriculture and Forestry agreed to promote production of foods that are made of low-fat milk and edible oil, the Ministry of Education took responsibility for education to students about healthy diet, and lastly, the Ministry of Trade and Industry was responsible for improving labeling on food products (Melkas, 2013). The 'health at core', 'multi-sectoral approach', 'stakeholder engagement', and 'win-win' attributes are explicitly seen in this case study. The 'create structural or process change' attribute is also implied because different sectors involved in the committee agreed to update their management plan in favor of health promotion. This case study illustrates explicitly that all attributes are necessary components for the HiAP paradigm.

3.2 Equity, health, and HiAP in transportation planning

It has come to be understood that transportation has substantial ramifications for the health and equity of the nation, with a direct link between transportation systems, land use, and human health (Frank, 2000). For example, research shows that nearly one third of the U.S. population is transportation disadvantaged, which means they have no easy access to basic needs such as food, medical care, jobs, education, and other economic opportunities (Malekafzali, 2009). Further, disparities created by automobile-centric transportation systems have been found to impact people of color disproportionately. To frame the discussion of health and equity considerations in transportation planning, we first describe the current federal regulatory framework for these considerations. We then discuss knowledge gained from cases studies in the literature that have applied a HiAP approach.

3.2.1 Federal regulatory framework for equity (and health) in transportation

State and regional transportation agencies are required by law to consider the equity implications of their transportation decisions involving federal funding. A host of federal laws and Executive Orders extend certain protections to specific demographic groups for this purpose. These include Title VI of the Civil Rights Act of 1964, the Americans with Disabilities Act (ADA), the Fixing America's Surface Transportation (FAST) Act, and Executive Orders 12898 (Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations) and

13166 (Improving Access to Services for Persons with Limited English Proficiency), which further require consideration of the needs of minority, low-income, and limited English proficiency (LEP) populations. The primary process for addressing equity and related issues is set forth in the National Environmental Policy Act (NEPA) of 1970, which requires transportation agencies to evaluate the social, economic, and environmental impacts of transportation actions. The NEPA process provides the public with opportunities to participate in identifying and evaluating the impacts of a proposed transportation action and its alternatives, as well as ways to avoid, minimize or mitigate impacts.

In terms of transportation improvement programs (TIPs) specifically, transportation agencies are required at a minimum to identify and provide "interested parties" with information about the TIP and its projects, and to comply with a previously adopted Non-Discrimination Statement. However, guidance for implementing Title VI goes well beyond these minimum requirements. The "Memorandum on Implementing Title VI Requirements in Metropolitan and Statewide Planning" released jointly by the Federal Highway Administration (FHWA) and the Federal Transit Administration (FTA) in 1999 contains a series of questions used to evaluate the quality of Title VI compliance in transportation planning relative to public involvement, as well as the analysis and contents of transportation plans.

Two updates clarified state and regional transportation agency responsibilities in relation to equity and environmental justice. In 2012, the U.S. Department of Transportation (USDOT) issued an update to Departmental Order 5610.2(a) "Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (USDOT, 2012), reaffirming the commitment to environmental justice, clarifying aspects of the 1994 Executive Order and distinctions between Title VI and environmental justice (EJ) analysis during the NEPA review process, and asserting the importance of EJ in early planning (USDOT, 2012). Rules for Title VI in public transportation were also updated in 2012 in Federal Highway Administration Order 6640.23A (FHWA, 2012) and Federal Transit Administration Circular 4703.1 (FTA, 2012), offering additional guidance in implementing Title VI in planning. The FTA circular defines the benefits that shall be considered, such as increased transportation options, enhanced connectivity, improved air quality, increased property values, expanded employment opportunities, and reductions in travel time, as well as issues relative to performance and fares (FTA, 2012).

The 2012 updates laid out key responsibilities for transportation agencies receiving federal funds, and discuss health impacts directly. These include "explicit consideration of effects on minority and low-income populations" for "activities that have the potential to have a disproportionately high and adverse effect on human health or the environment", ensuring equitable "access to public information about human health or environmental impacts of programs", and "involvement by members of minority population and low-income populations during the planning and development" (USDOT, 2012, pg. 6-7). States and MPOs are also required to use demographic data to identify underserved communities and determine if they are burdened by disproportionately high or adverse impacts (USDOT, 2012). Any impacts that are unavoidable must be mitigated or minimized (USDOT, 2012).

3.2.2 Applications of HiAP to transportation

Although there is a rich history and regulatory framework for consideration of equity in transportation planning, explicit consideration of health is more recent. Nonetheless, due to the growing understanding of the links between transportation, equity and health, the Health in All Policies (HiAP) approach has begun to be implemented in transportation programs across the United States. Below, we discuss a few case studies that have pioneered the use HiAP principles in transportation programs.

The Safe Routes to School Local Policy Guide recommends several strategies such as construction of complete streets, reducing speed limits around schools, health impact assessment (HIA), sales taxes to promote active transportation, and bicycle and pedestrian safety education (Cowan et al., 2011). In addition, Rudolph et al. (2013) suggest inclusion of health and equity metrics in Regional Transportation Plans to track traffic-related air pollution and chronic diseases as well as to mitigate greenhouse gasses. Moreover, the American Public Health Association (APHA) (n.d.) recommends several strategies to promote health and equity, including providing safety in public transit use, providing education about health benefits of active transportation, providing affordable access to active transportation modes for everyone, and improving connectivity that supports safe biking, walking, and public transportation between neighborhoods and business centers. In addition, the Welsh Government used HIA to identify potential impacts of a road construction project on health equity (Wismar & Ernst, 2010). Due to the HIA, the government informed stakeholders about the negative impacts of the road construction project on minorities and low-income people, resulting in a stop to the planned construction (Wismar, & Ernst, 2010).

One of the most important case studies that implemented a HiAP approach is the California HiAP Task Force that was established to provide social and environmental equity, reduce chronic diseases, and control climate change (Polsky et al., 2015). The task force followed an approach that created multi-sectoral cooperation to accomplish health and equity promotion in transportation planning (Rudolph et al., 2013). One of the initiatives of the Task Force was the improvement of active transportation in school facilities (Caplan et al., 2017). In addition, a multi-sectoral working group that includes transportation, land use, and air pollution agencies worked collaboratively to decrease air pollution exposure disparities (Wernham & Teutsch, 2015). These efforts led to a transportation sector outcome, specifically that California Department of Transportation integrated health and equity objectives in their management plan (Brown et al., 2015).

In another case study, Massachusetts initiated a health impact assessment (HIA) requirement for large-scale transportation designs in 2009. HIA is a practice that is used to analyze a policy or program through a health lens to identify potential negative health effects and inform decision makers during the planning stage (Dannenberg et al., 2014). Upon the emergence of the concept of HiAP, which provides a broader look at health and equity consideration than HIA, HIA became one of the tools under the HiAP umbrella. The World Health Organization (2015) states that HIA is a key factor that shows health is at the center of a policy. In addition, HIA provides opportunities to promote health and equity in transportation programs, thus it became a requirement for transportation programs in Massachusetts in 2009 (NACCHO, 2017). In order to implement HIA, transportation, public health, and environmental experts in Massachusetts started to work cooperatively in the early stage of transportation programs (ASTHO, 2013). Along with similar work in other locations, this work confirmed the importance of transportation as a determinant of health and equity (Dannenberg et al., 2014).

The Minnesota Department of Transportation and the Department of Health worked together to implement several transportation strategies that promote health and equity. Some of these strategies include encouraging active transportation use, improving bicycle and pedestrian infrastructure, designing complete streets, and implementation of HIA in transportation programs (APHA, 2019). There are also other HiAP implementation examples that promote active transportation and complete streets such as in Seattle/King County, Boston, and Nashville/Tennessee (Wernham & Teutsch, 2015). Additionally, the Nashville Area Metropolitan Planning Organization developed an active transportation funding policy to design programs that promote mass transit, biking, and walking (Center for Training and Research Translation, 2012). Besides active transportation improvement, San Francisco's health, equity, and sustainability program implemented a collaborative action to reduce indoor air pollution near major roadways and minimize pedestrian injuries in transportation designs (Wernham & Teutsch, 2015).

The above case studies are examples of HiAP implementation in the transportation sector. Overall, they suggest that health and equity consideration should be embedded in transportation designs and policies as a primary objective. Further, they suggest that promotion of active transportation (biking, walking, public transportation, and wheeling), construction of complete streets, and conducting HIA as a part of transportation design all help to promote health and equity outcomes of transportation programs. Finally, the assembly of a team that can apply HiAP principles and multi-sectoral cooperation that includes the public health sector are also needed (WHO, 2015). Additional benefits of the application of a HiAP approach include raising awareness of the relationship between transportation and health, informing decision-makers about the potential health impacts of transportation designs, and encouraging local management to include health and equity objectives in their transportation development plans.

3.3 History and development of the Tampa Bay Next program

In order to contextualize our HiAP evaluation of the Tampa Bay Next program, we discuss here the history of the program revealed through our document review. Interstate modernization started in the Tampa Bay with the approval of the Tampa Interstate Study (TIS) in 1989 (Greiner, Inc., 1989). TIS included modifications of I-275, I-4 and the crosstown Expressway (now called the Selmon Expressway). The final environmental impact statement (EIS) for the TIS was approved in 1996 (Greiner, Inc., 1996). In the EIS report, equity analysis showed that the relocation process would impact 1014 family residences and 159 businesses, affecting predominantly low-income and minority groups (Greiner, Inc., 1996). From the air quality perspective, the EIS report estimated that the carbon monoxide (CO) concentration in the TIS project would be lower than the CO concentration in the no-action alternative. No public health sector experts were involved in the preparation of the EIS for the 1996 TIS project. Experts involved in the preparation of the EIS included environmental scientists, civil engineers, archeologists, transportation experts, landscape architects, one ecologist, one air quality specialist, and one water resources expert.

TB Next was originally announced as Tampa Bay Express (TBX) in 2015. After the announcement, a volunteer organization called Sunshine Citizens arranged a public meeting to discuss their concerns with local people (TBX Toll Lanes, 2015). The toll lanes immediately caused concerns for several reasons. First, there was concern that the destruction of some houses along the planned toll lanes would oblige people living in the area to sell their homes (Understanding Tampa Bay Express, 2015) and potentially change their neighborhood. Related concerns were that this would change the general structure of the neighborhoods and expose some residents to increased traffic-related pollution (air, noise, and visual). Florida Department of Transportation (FDOT) actions to begin buying properties in the area further exacerbated this concern.

Another controversial point of the project is that the toll transaction price will change dynamically. This means that if there is heavy traffic, the money to be charged per mile will be higher. In order to meet this amount of payment, people have to be above a certain level of income, but not every segment of the society has an income at that level (Understanding Tampa Bay Express, 2015). In addition, the use of toll lanes also poses a problem for the low-income community. The people who live near the proposed lanes will carry the environmental burden but they won't be able to benefit from the toll lanes, while wealthier people will have benefits from the toll lanes (Johnston, 2016). Other concerns raised by locals include limited access to three employment centers (downtown, Westshore, and University of South Florida), economic loss due to the cost of highway expansion, and environmental damage (TBX Toll Lanes, 2015).

In 2016, the Tampa City Council opposed the interstate expansion part of TBX because the neighborhood around the north part of I-275 was expected to be affected disproportionately from the construction work (Danielson, 2016). Later, similar inequity concerns were expressed that minorities and low-income people will be the most affected from the relocation process due to the roadway expansion (Johnston, 2016). In April 2017, FDOT officials announced that the TBX toll lane addition plan would be reevaluated due to the public concerns (Johnston, 2017b). Then in the May, the TBX name was changed to Tampa Bay Next, but reevaluation of toll lanes was ongoing (Johnston, 2017a).

Subsequently, FDOT announced the cancelation of toll lanes on the north part of I-275 based on public feedback in May 2018 (Winer, 2018). However, the planned express lanes for the Gateway Connector in Pinellas, the Howard Frankland Bridge, I-275 Westshore to downtown corridor, and I-4 and the Selmon Expressway Connector remained (Newborn, 2017). In addition, the idea of adding toll lanes on I-75 emerged (Winer, 2018). During the whole process, FDOT conducted several public outreach events and community workshops to engage with stakeholders. As planning continues, it is likely that further modifications to the designs will occur.

3.4 HiAP concepts included in the TBNext documents

Table 5 presents the frequency of inclusion of the HiAP attribute keywords (from Table 2) in TBnext documents, by document category type, based on the text mining analysis. Many keywords were found in the documents more often than listed, but only those instances that were qualitatively determined to be relevant to the HiAP attribute were counted here. Appendix B provides results of addition qualitative categorization of the presence of the HiAP attributes in documents by category of group perspective represented by the document.

Results from the TBNext document review and keyword analysis suggest that the TBNext documents have included some mention of HiAP concepts but have not focused on them. Health and equity concerns were discussed frequently in the FDOT documents, with equity being more common in the meeting minutes (e.g. in Johnston, 2016; Danielson, 2016; Rozyla, 2018). While there was no direct discussion on the need to prioritize health as a primary outcome of the TBNext programs and plans, several community members and stakeholders discussed the need for fostering healthful outcomes from TBNext during the community working group meetings conducted in 2017 (Pasco and Hernando Counties Community Working Group, 2017; North and West Hillsborough Community Working Group, 2017). Only one of the news media articles examined discussed health specifically. There was also some discussion of the stakeholder engagement process (Johnston, 2017; Dovey, 2017), with *policy* and *process* mentioned consistently across all three document categories. An emphasis on damage limitation was also present in the TBNext programs and plans (Danielson, 2016; Dovey, 2017; Leigh, 2017). Similarly, *collaborat** was mentioned substantially in the stakeholder meetings but was relatively absent from the other two document categories.

Table 5. Relevant keyword frequencies

HiAP attribute	Keywords (and stubs)	News articles[a]	Meeting minutes[b]	FDOT documents[c]
Health at the core	health	1	4	70
	well-being	0	0	0
Equity	equit*, inequit*,	1	16	29
	injustice, justice	0	0	46
Damage limitation	damage*	3	0	0
	harm	0	0	4
Win-win	win-win	0	0	0
Multi-sectoral cooperation	collaborat*	3	51	10
	cooperat*	1	0	9
Stakeholder engagement	stakeholder*	2	4	3
	engage*	6	10	6
Structural process change	policy	3	12	30
	process	15	19	37
Political commitment	commitm*	5	3	16

[a]based on 26 news articles with 23,790 total words, and 3,400 unique words; [b]based on 8 meeting minutes with 42,045 total words, and 3,559 unique words; [c]based on 4 FDOT technical reports with 646,629 total words, and 34,281 unique words.

While a large majority of the news media articles that were reviewed discussed the perspectives of citizens, neighborhood associations, affected community stakeholders, and FDOT, the community working group meetings provided an opportunity for the general public to bring their perspectives on TBNext to the forefront. However, it is not evident in the documents whether some of these general public perspectives were considered in FDOT planning or incorporated into future programs and plans for TBNext during the reset stage.

3.5 Perspectives from the key informant interviews

Table 3 provides a listing of the key information categories and the number of interviews conducted in each category. Overall, we were able to interview at least one person from each target category, except the journalist category. Below, we discuss the general patterns of attitudes, knowledge, and opinions on HiAP concepts and their inclusion in the TB Next program that were revealed from the interviews. Additional details and evidence for each HiAP concept is provided in Section 3.6.

All respondents belonging to categories A (officials, staff, and consultants of FDOT) and B (officials and staff of regional or local transportation planning agencies), and a minority of those from category D (officials and staff of other governmental or non-profit policymaking organizations) had positive opinions about most aspects of TBNext. They remarked on its potential to reduce congestion and foster better health outcomes, the consideration of equity impacts, collaborative efforts concerted by FDOT, and inclusion of considerations and concerns of stakeholders from affected residential areas, communities, industries, and other organizations. They also seem to agree that while achieving health outcomes was not the foremost priority of the TBNext program, the program is capable of delivering more positive than negative health-related outcomes. Respondents from these categories also generally believe that TBNext may herald more system-level positive equity impacts than negative.

On the other hand, all respondents belonging to categories C (officials and staff of government health agencies), E (members of the public, advocacy groups, and community/neighborhood associations), F (university researchers), and the majority of respondents from category D (officials and staff of other governmental or non-profit policymaking organizations) were skeptical of the large-scale benefits occurring with the TBNext program in the aforementioned aspects.

3.6 Integrated ratings of the Tampa Bay Next from a HiAP perspective

Integrated results evaluating the TBNext program for the inclusion of key HiAP attributes, based on the document review and key informant interviews, are summarized in Table 6. The rating scale descriptions are provided in Table 4, above. Focusing on each attribute in turn, we discuss the evidence of its consideration in the program development, along with justification for the rating received.

<u>Health at the core:</u> Inclusion of health as a core priority of a government program is a key attribute of the HiAP approach. For TBNext, there is no evidence from the news media articles, community working group reports, and FDOT documents that health has been a main priority. Nonetheless, health is mentioned in some of the documents reviewed. Positive health-related outcomes described by FDOT are that "managed lanes offer reduced levels of congestion …thereby reducing vehicle emissions, to improve air quality. Improving traffic flow also reduces the time vehicles spend idling…" (FDOT, 2019b, pp. 70; FDOT, 2019b, pp. 126). In addition, FDOT concludes that one of the benefits of a TBNext alternative considered is "improved overall health with improvements and extensions of the trail system and safety improvements…" (FDOT, 2019b, pp. 133). Furthermore, the key informant interviews revealed that health concerns have been considered in program development, with respondents from categories A and

B (officials, staff and consultants of FDOT and regional and local transportation planning agencies) suggesting that TBNext would improve a few health-related outcomes. For example, one respondent stated that “air quality would improve…along the project corridor due to the managed lanes…”, while another suggested that “noise abatements would happen near the interstate…due to the construction of noise walls…”. However, respondents from the community and public health sector did not agree with this positive outlook. Respondents from category C (officials and staff of government health agencies) expressed concern regarding the high levels of air pollution and emissions intake in the surrounding neighborhoods of the proposed TBNext project corridors. For example, one respondent discussed “…higher levels of asthma incidence along the study corridor, greater infant mortality rates along the project corridors, and higher rates of obesity…”. A respondent from the category E (members of the community and advocacy groups) suggested that noise walls “are not very useful, and they are also ugly…” Because there is no evidence that improved health is a central goal of the TBNext Program, but some evidence from the key informant interviews that planners considered some health-related outcomes as a part of planning, we give the inclusion of the ‘health at the core’ attribute a rating of 3.

Table 6. Matrix rating for inclusion of HiAP key attributes in TBNext

HiAP attribute	Quantitative rating*						
	6	5	4	3	2	1	0
health at the core				■			
equity			■				
damage limitation					■		
win-win					■		
multi-sectoral cooperation						■	
stakeholder engagement				■			
structural process change						■	
political commitment							■

The rating scale indicates the degree of inclusion of this attribute in the TBNext program, with 6 indicating the highest inclusion and 0 indicating none. Description of each rate level are provided in Table 4.

<u>Equity:</u> The consideration of equity is clear in TBNext documents and interview responses, with mentions increasing in frequency over time. Many equity concerns from the public and advocacy groups are evident from articles written during the community resistance to

TBExpress (TBX), and during the reset stage in which TBX was renamed TBNext (Johnston, 2016; Danielson, 2016; Rozyla, 2018). Equity impacts of expected adverse outcomes for lower-income families or users are also discussed in a few news media articles (Morrow, 2017). Further, concerns about equity are evident from the interviews of key informants from categories C (official and staff of health agencies), E (members of the public, advocacy, and community groups), and F (university researchers). For example, one interviewee stated that TBNext, in its current form with "reliance on cars/automobiles…" and the lack of alternatives, "presents an equity problem…" Discussion of equity in the FDOT program documents largely pertains to the changes in the program (reevaluation of toll lanes and cancellation of toll lanes on the north side of I-275) that were introduced as part of the reset stimulated by equity concerns from the community. Other discussions of equity in the FDOT documents are largely confined to detailed literature reviews to help understand the equity issues associated with pricing as it relates to low-income drivers, and policies that are in place for ensuring equitable implementation (FDOT, 2019b, pp. 129). In its sociocultural effects assessment of TBNext as a part of a Tampa Interstate Study Supplemental Environmental Impact Statement (SEIS), FDOT argued that the No Further Action alternative would reduce economic activity, worsen congestion, increase traffic, reduce job growth, and raise commute costs across all sections of the society, despite having no disproportionate impacts on minority and/or low-income communities in terms of displacement (FDOT, 2019b, pp 72). In comparison, FDOT found that the 2018 Express Lane Alternative, while creating disproportionate impacts across certain study segments, is likely to create positive effects in terms of economic activity, job growth, travel time reduction, commute costs, and traffic congestion (FDOT, 2019b, pp 126). Further, the key informant interviews of state department officials with direct professional commitments to TB Next (category A) indicated that the FDOT "has considered equity impacts during the planning stages, as it is required to undergo the NEPA process on all projects…" Overall, despite discussion of equity in the FDOT documents and interviews, equity appears to be substantially subordinate to other concerns in FDOT planning. However, more consideration of equity does appear to have resulted from vocal public opposition to earlier versions of TB Next program and plans. Hence, we rate the consideration of equity with a score of 4 on the rating scale.

<u>Damage limitation:</u> The Tampa Bay Next program received a score of 2 regarding damage limitation. The consideration of this attribute is not clear in the program documents or

interviews. For example, damage limitation was minimally addressed in the Tampa Interstate Study SEIS document (FDOT, 2019b); specifically, the document described how the FDOT would follow due diligence in paying fair value for acquired property and/or damages to the property (FDOT, 2019b, pp. 123). Even though an interviewee from category D (officials and staff of policymaking organizations) pointed out that "noise walls would lead to noise reductions…", an interviewee living near the TB Next project corridors (category E) suggested that these noise walls "are not very useful, and they are also ugly…". Nonetheless, considerations related to damage limitation of the proposed TBNext projects increased after severe public opposition to earlier plans of TBX. Some of these discussions are mentioned in news media articles (Danielson, 2016; Dovey, 2017; Leigh, 2017).

Win-win: There is no explicit discussion in the TBNext development documents of win-win strategies that would provide mutual benefits to all parties. However, ways in which some parties will see benefits are discussed For example, FDOT discusses future inclusion of multimodal transportation modes along the TBNext corridors, which could potentially reduce congestion on the roadways by making each mode attractive enough to induce some mode shift (FDOT, 2019b, pp. 53-54; FDOT, 2019b, pp. 70). They also discuss designing complete streets that could foster more walkable neighborhoods (FDOT, 2019b, pp. 80). FDOT documents further describe how tolled lanes would add capacity to the highway system, decongesting the existing general-purpose lanes and local roads (FDOT, 2019b, pp. 68). However, responses from the key informant interviews (categories B, E, and F) suggest that some of the proposed benefits, including decongestion of general capacity lanes, are unlikely due to the effects of induced demand due to the added capacity. Further, an example response from these informant categories that represents a majority of the interview responses, suggested that the neighborhoods and communities adjacent to the TB Next project corridors will "face disproportionate impacts during construction and operational stages…" of the projects. Overall, although somewhat idealistic benefits to multiple parties were considered in program development, a sincere strategy to balance benefits to multiple sectors and groups is not evident. Hence, we also rate inclusion of the win-win attribute in the Tampa Bay Next program development with a score of 2.

Multi-sectoral cooperation: There is very limited evidence of extensive multisectoral collaboration in the TBNext program development documents, except where such collaboration was mandated by law (for instance, in the creation of the SEIS document and the analysis of the impacts). Nonetheless, it is foreseeable that the proposed inclusion of multimodal transportation modes and their operation along TBNext corridors, when implemented, would require collaborations across transit agencies, FDOT, cities, and state officials; this suggests the likelihood of multisectoral cooperation in the future. Key informant interviews indicated that FDOT was a "difficult partner to work with…" (category B, officials/staff of regional/local transportation planning agencies) with "limited flexibility to their plans…" (category D, officials/staff of policymaking organizations). Hence, we rated the inclusion of multisectoral cooperation in TBNext with a score of 1.

Stakeholder engagement: The Tampa Bay Next program received a score of 3 on stakeholder engagement. Some of the key informant interviewees from categories A and D (officials/staff of FDOT and other governmental/non-profit policy organizations) indicated that the stakeholder engagement efforts FDOT has used in the development of TBNext are at par with the industry standard due to the NEPA process. However, respondents from categories C (official and staff of health agencies), E (members of the public, advocacy, and community groups), and F (university researchers) feel the NEPA process provides only a minimum standard of stakeholder engagement for promoting positive, healthful outcomes and bridging inequity that would result from this project. Post the reset, FDOT increased its public engagement activities due to the opposition that the Tampa Bay Express plans and policies had received from residents, community members, and the media (Dovey, 2017; Kinane, 2017; Johnston, 2017). Part of that effort has been focused around Community Working Groups (CWG) – meetings held across the Tampa Bay region to discuss plans and policies, and potential impacts of the TBNext projects along the neighborhood and the surrounding communities (North and West Hillsborough Community Working Group, 2017; Pasco and Hernando Counties Community Working Group, 2017). This was revealed in key informant interviews from categories A, C, D, and F (officials/staff of FDOT, governmental health agencies, other governmental or non-profit policy organizations, and university researchers), indicating that FDOT has increased efforts to engage with stakeholders and "show that they care…". Additionally, the documents from community working groups and TBNext-related updates to the MPO and other organizations have all highlighted FDOT's growing stakeholder engagement efforts on TBNext, thereby enhancing the quantitative ratings here.

Structural process change: There is little clear evidence across news media articles, FDOT documentation, the Community Working Group meeting minutes or from the key informant interviews that suggests that TBNext and its related developments have created enduring structural process changes that help to embed health and equity concerns from an early stage of transportation program decision-making in the region. The only evidence of process changes has been the increased efforts on the part of the FDOT to engage with affected stakeholders. Despite the lack of documentary evidence, it is clear from discussions with policy makers across multiple organizations, that FDOT is thinking more about health and equity, and considering how to address them more clearly in its communications, at least. However, it is not clear that this has led or will lead to any real structural process changes. Rather, it may merely be a situation-specific response to community opposition and related program delays. Nonetheless, there may be potential for the beginning of real change. Overall, we rate the inclusion of structural and process change in the Tampa Bay Next program development at a 1.

Political commitment: There is clear evidence of political commitment from FDOT to the interstate modernization projects (roadway widening and enhancement) that comprise a substantial portion of the TBNext Program investments. These projects have been in planning and development for decades and continue to move forward, in a relatively similar form, despite substantial opposition from some community members, organizations, and leaders. Evidence from the key informant interviews also suggests that some local organizations that focus on economic development (category D) view this project "as an opportunity to foster job creation and enhance overall regional economic development". However, there appears to be substantially less political commitment by program investment decision-makers to the other projects in TBNext that have been added to the program to address community health and equity concerns, including bicycle, pedestrian, and transit improvements. Overall, there appears to be a lack of a champion within the program decision-making body that effectively promotes the program components or structural changes that can produce more positive health and equity outcomes. Hence, based on the key informant interviews from categories C, E, and F (officials/staff of health agencies, members of the public and community groups, and university researchers), the vast majority of program stakeholders still believe that the program will produce more negative impacts than benefits to the general public, and are skeptical of the eventual success of the latter types of program components. Overall, we rate the Tampa Bay

Next program with a score of 0 regarding political commitment to sustained consideration of health and equity issues in the program development.

4 Conclusions

This study investigated the levers of influence for improved equity in large-scale transportation programs by applying a Health-in-All-Policies (HiAP) perspective to the Tampa Bay Next transportation program (TBNext). This was done through a review of available documents related to the program, interviews with key multi-sectoral stakeholders, and evaluation of the program development using a novel rating scale to assess the extent of inclusion of HiAP attributes in TBNext. Below we summarize the main findings of this work, provide recommendations for improving equity outcomes of TBNext and other large-scale transportation programs, and discussion study limitations.

4.1 Main findings

It is clear from the document review and stakeholder interviews that health and equity objectives have not been central to the planning and development of the TBNext program. Due to NEPA requirements for transportation planning, there has been some consideration of damage limitation, equity outcomes, and stakeholder involvement in project development. However, these considerations appear to be side concerns that have received only minimally required attention and resources. The central objectives of the program decision-makers appear to be large-scale economic development of the region and reduction of traffic congestion. There also appears to be an inherent bias in program planning on efficiency over equity outcomes, and traditional transportation infrastructure (roadways and cars) over alternatives (transit and bike and pedestrian infrastructure). Not surprisingly, this has led to the development of plans that many stakeholders outside of the transportation sector believe will place a smaller proportion of positive impacts and a larger proportion of the negative impacts on already-marginalized groups. For example, negative impacts are expected for the lower-income historically disadvantaged communities close to the roadway project corridors, while benefits are expected for long-distance commuters and those who are wealthy enough to pay corridor tolls.

Furthermore, although changes to the program have occurred due to opposition to the original Tampa Bay Express plans, it is not clear to what degree these changes will bring substantially improved equity and health outcomes for this program or other near-term large-scale programs in Florida. Three important changes to the program are notable. The first was the addition of initial plans for program elements involving transit, bicycle and pedestrian infrastructure, complete streets, and other improvements, in concert with rebranding of the program from Tampa Bay Express to Tampa Bay Next. The second was an increase in FDOT's focus on stakeholder engagement through Community Working Groups and other outreach activities. Most recently, a road-widening and toll project along one of the corridors that passes through a socially disadvantaged neighborhood was cancelled. Despite these changes, it is unclear how much commitment and resources are being dedicated to the alternative-mode TBNext projects; the original interstate modernization projects remain substantially more developed and resourced, with few detailed plans for the added elements available. There is also little evidence that the improvements to stakeholder engagement have been internalized into real fundamental structure and process changes to transportation planning in the region. Finally, the decision to cancel one of the corridor roadway projects may be targeted at expediting an already-substantially-delayed roadway program, rather than indicating political commitment to improved equity outcomes. Nonetheless, it is clear that ideas about health and equity have been inserted into the thinking of some transportation decision-makers in the region, even if they have not solidified into concrete and sustained structural or process change.

Another clear finding of this analysis is that multi-sectoral cooperation (and related HiAP concepts of a win-win strategy and stakeholder engagement) have also not been a focus of the development of the TBNext program. Project and program plans were developed largely within the transportation sector alone, with minimal participation or engagement of other sectors, except as required by the NEPA process. Furthermore, this engagement doesn't appear to have had a substantial influence on goal setting or program objectives, but rather has been applied in order to minimally meet constraints. Conversely, the evidence found in this analysis suggests that some stakeholders feel it is challenging to work with FDOT, who they feel have not been very receptive to cross-sectoral cooperative efforts.

An explanatory context that emerged as potentially hampering both cooperative efforts and the integration of health and equity considerations in transportation program development in the region are the inertia and insularity in the regional transportation engineering and decision-making sector. Established transportation decision-makers are more likely to have been trained and have extensive experience in an era and political context that focused almost exclusively on roadway capacity enhancement and personal automobiles for satisfying mobility needs. Hence, they may be more likely to prefer solutions that align with their experiences and knowledge. Those with expertise and training related to newer concepts in transportation planning that focus on alternative modes of transport for meeting mobility needs, a broader range of objectives (including health and equity), and interdisciplinary collaboration, may not yet be in a position to substantially influence decision-making. This could help to explain why positive health and equity outcomes are not considered to be important objectives of transportation improvement programs in Florida, while some states such as California, have recently extensively integrated them into transportation programs and policymaking.

Discussions with stakeholders also revealed limitations to the management and funding structure for the transportation project development that hamper cooperation both within the transportation sector and between the sector and other sectors. Specifically, the separation of oversight, responsibility, and funding by mode of travel may be particularly problematic. Historically, FDOT has invested primarily in roadway capacity projects, making it unsurprising that programs and plans that they lead prioritize roadway capacity enhancements.

Finally, it is important to note some findings regarding the usefulness of the HiAP perspective for understanding and promoting improved equity in large-scale transportation programs. Although, we found HiAP concepts and attributes to be very useful as a lens through which to evaluate the development of the Tampa Bay Next program, the current usefulness of HiAP for guiding action toward improved outcomes is more limited. Most fundamentally, the HiAP focus on health at the core may appear to other sectors to contradict a true win-win strategy and hamper multi-sectoral cooperation. We found that by focusing on health at the core, the HiAP perspective suggests to some members of other sectors that health is a more important objective than the traditional objectives of their fields. Hence, it presents a dubious starting point for establishing multi-sectoral cooperation. Second, although there exist many case studies in transportation planning that nominally put themselves within the HiAP framework, each developed its own methods to apply HiAP principles. Overall, there is no clear and specific guidance from a HiAP perspective regarding recommended strategies to improve health and equity in transportation planning and program development that considers a varies of scales and contexts. Further, no HiAP case studies extensively consider road widening projects; while these types of project may not be the best approaches for improving equity and health, they are likely to continue and need to be considered in guidance.

4.2 Recommendations

Based on these finding, we suggest recommendations for improving equity in the TBNext program and large-scale transportation planning programs more broadly.

The clearest recommendation that emerged from this study is the need for FDOT specifically, and the transportation engineering sector generally, to increase multi-sectoral cooperation in its processes. They should develop a program development infrastructure that integrates agencies and stakeholders across sections from the initial stages of program planning, including in the definition of program objectives. To improve health and equity outcomes, the public health sector, including the local and state health department, should especially be engaged (WHO, 2015). This could particularly help with the performance of health impact assessment and other health-related evaluations (NACCHO, 2017) as a routine process of transportation planning. Improved cross-sectoral collaboration could also improve mutual education of all sectors on potential win-win approaches and help to promote transportation-related attitudes and behaviors that are conducive to health and equity. For example, currently FDOT community meetings largely involved presentation of alternative toll lane scenarios. Members of the public health sector could be engaged in presentation and community education regarding active transportation, and health outcomes of transportation choices and behaviors.

Second, all of the HiAP case studies we reviewed recommend improvement in alternative modes of travel, particularly active transportation. Improvement of bicycle and pedestrian infrastructure and promotion of walking, biking, and the use of public transit have been shown to improve health and equity (Caplan et al., 2017; APHA, 2019; Wernham & Teutsch, 2015). Although there are now components in the TBNext program that consider these modes, the program heavily focuses on a motor vehicle-dependent transportation design; this may result in increased traffic congestion and air pollution in the long term, along with disproportion exposures for marginalized populations (Giles-Corti et al., 2016; Duranton & Turner, 2011; Williams-Derry, 2007). Therefore, program decision makers should focus more on the improvement of active transportation modes than on vehicle capacity expansion and should adequately resource these improvements. Other strategies suggested by previous HiAP case studies include limiting speeds in sensitive areas, constructing complete streets, reducing taxes on transit vehicles, improving safety along streets and in public transits, and increasing green spaces near walking, cycle, and public transit infrastructure (Cowan et al., 2011).

In addition to the above recommendations, there are ways that the HiAP perspective could be improved to better address transportation planning. First, refocusing on win-win strategies above health-at-the-core may be needed to truly encourage multi-sectoral cooperation. Second, clear HiAP guidance that recommends strategies to improve health and equity in transportation planning is needed. By this, we mean guidance prepared by multiple experts, from multiple sectors including the health sector, who work collaboratively to collect data and come up with applicable strategies for the transportation planning that promote public health and equity at a variety of scales and context. Furthermore, more HiAP case studies and recommendations that consider interstate modification and road widening designs, are needed. Although improving active transportation modes may be most important for promoting health and equity, interstate modification and road widening designs should also be assessed from the HiAP perspective. They remain the most common types of transportation development, and are likely to endure particularly for travel between cities or counties.

Finally, we suggest that more work is needed to understand and address the limitations of the transportation management and funding system, both in the region and more broadly, for comprehensively improving the health and equity impacts of the multi-modal transportation system. Approaches for overcoming inertia in transportation decision-making expertise and attitudes are also needed.

4.3 Limitations

One important limitation of this study lies in the scope of document review. Although we reviewed a substantial number of documents related to the TBNext program, we were limited to those that are currently publicly available. Some relevant program documents that are not readily available may have been missed, potentially biasing our review. This is particularly true of the proposed plans, for which archived documentation is more limited. All documents reviewed here could also contain intentional or unintentional biases from their authors.

A second limitation of the study may be the representativeness of the key informant interview sample. While several state department officials with direct knowledge of the TBNext program (category A) were approached as potential interviewees, we were only able to secure one such interviewee, who was presented as the spokesperson for the group. This suggests that some perspectives from this group may not be represented in the interview responses. The controversial nature of TBNext program, including its relatively constant presence in the media may have contributed to this problem.

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