Case Study #1 – Assessing the health impacts of road pricing in San Francisco: *a case study of land use and transportation planning decisions*

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San Francisco Department of Public Health

Presentation Walking Trail

- Policy Background
- Screening
- Scoping
- Assessment and Methods, focusing on:
  - Active Transportation: Existing and Future Conditions, Lives Saved
  - Vehicle-Pedestrian Injury Collisions: Existing and Future Conditions
- Next Steps

What is road pricing?

US Department of Transportation – Federal Highway Administration

- **Pricing:** fees or tolls on a vehicle's use of the road that vary with demand based on ***time of day, location, type of vehicle, number of occupants, or other factors***
  - also referred to as congestion pricing, value pricing, variable pricing, peak-period pricing, or market-based pricing
  - used to account for and manage demand:
    - generating revenue
    - while achieving other goals, such as reduced congestion, environmental impacts, or other external costs occasioned by road users.

- *As opposed to* **Tolling:** per-use (typically flat) fee on motorists for a given highway facility to generate revenue; may vary by number of axles, distance driven, but not by time of day.

- *Revenue* reinvested in transportation system - capacity expansion, operations and maintenance, repayment for long-term debt (toll roads), etc.

Road Pricing Defined at: www.fhwa.dot.gov/ipd/revenue/road_pricing/defined/index.htm

Notably, road pricing includes both the pricing of roads and the re-investment of that revenue back into the transportation system in a number of ways including those listed on the slide as well as other potential improvements.

National Context

Road and parking policy decisions: Increasingly debated locally and nationally (HOT Lanes, variable or extended metering, variable bridge tolls, congestion pricing, etc.)

Transportation infrastructure: Funding crises, need to leverage limited public resources for multiple objectives

Residential development: Increasing in density, urban, near transit

Traffic, congestion, travel time: Continues to increase with status quo

Revenue investments: Support "business as usual" or more sustainable, healthy transportation modes and populations?

Congestion pricing is being studied in San Francisco, California

- Feasibility study approved by the San Francisco County Transportation Authority (SFCTA) Board: December 2010

The Northeast Cordon (AM/PM) was the best performing among dozens of scenarios:

- 12% fewer peak period auto trips
- 21% reduction in VHD
- 16% reduction in Northeast Cordon GHGs (5% citywide)
- $60-80M annual net revenue for transportation services and amenities
- 20-25% transit speed improvement

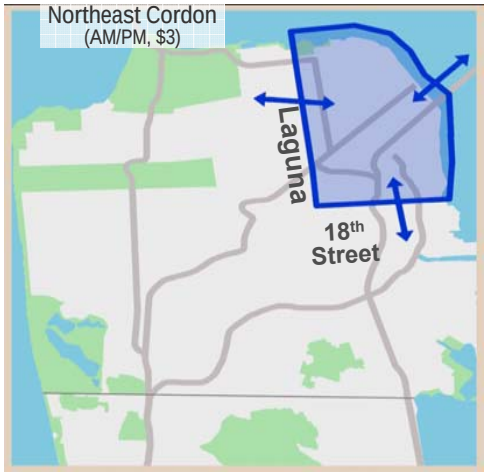
- Next steps: further study/analysis, including environmental review
- Implementation decision: likely 2-3 years, following environmental review

SFDPH noted SFCTA study assessing:

- **Transportation System Performance**
- **"3 Es": Environment; Economy; Equity**

www.sfcta.org/sfmobility | twitter.com/SanFranciscoTA | www.facebook.com/sfmobility

Health Impacts? The SFDPH-led HIA is examining the Northeast Cordon scenario that charges motorists $3 during AM/PM rush hours to travel into or out of the northeast quadrant of San Francisco (*see map*, below).



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NE Cordon scenario determined by: density of congestion today (average speeds on over half of streets in downtown areas operate below 10mph for motor vehicles and 8mph for transit vehicles); areas where planned growth likely to exacerbate existing congestion, or create new availability of transit; flexibility/feasibility to improve transit services and other modes of travel to/from/within the area; availability of net revenues generated to produce sufficient funding to cover cost of improved services.

Program details included in the scenario, to be analyzed further in next phase: variety of discounts for key groups including disabled persons, low-income travelers, residents & immediate abutters of zone; exemptions for transit vehicles, taxis, emergency vehicles but not government; maximum daily cap of $6 to help mitigate impacts on delivery-oriented businesses, families w/school-age children, etc (which would be further mitigated by programmatic enhancements to be outlined further in next phase of evaluation); impacts do not include mitigations that would be programmatic in nature, such as streetscape & landscape improvements, school ridesharing, etc that may further help to enhance travel options or mitigate/minimize traffic and potential environmental impacts (also to be outlined further in next phase of evaluation).

Revenues re-invested in transportation improvements: including transit services, signal timing, bicycle access, streetscape enhancements, etc.
Additional information regarding the SFCTA Feasibility Study can be accessed at the link at the bottom of this slide.

Healthy Transportation Networks = Healthy People

Able to walk, bike, take transit, play, access basic needs – safely:

traffic injury, physical activity, obesity, depression, cancer, heart disease, diabetes, social cohesion

Able to sleep well, concentrate, communicate:

traffic-related noise levels associated with stress, hypertension, blood pressure, heart disease, learning delays, sleep disturbances, hearing impairment, community annoyance

Able to breathe clean air:

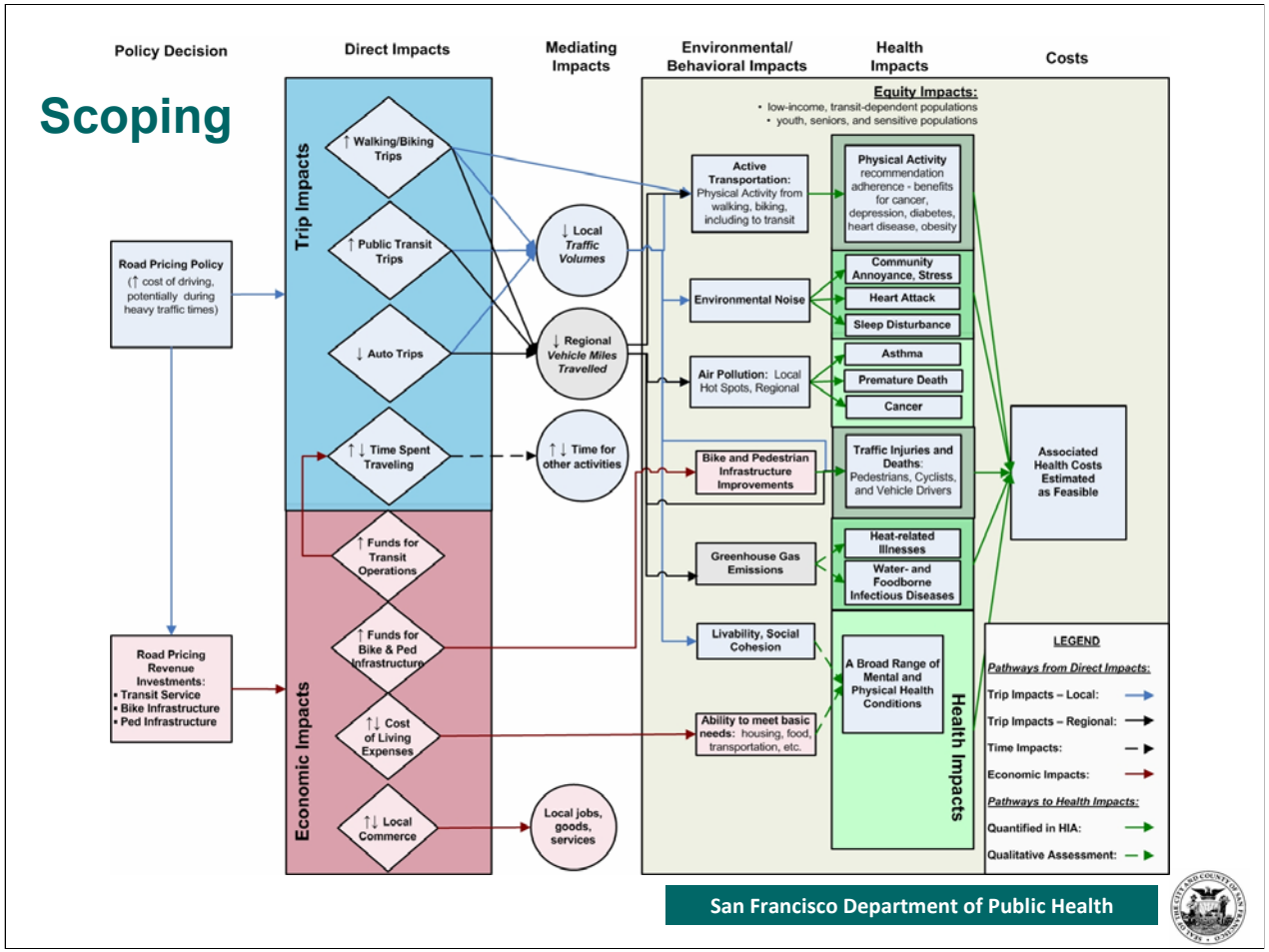
air pollution and proximity to heavy traffic resulting in reduced lung function, increased asthma hospitalizations, asthma symptoms, bronchitis symptoms, and medical visits; air toxics like diesel exhaust and benzene are carcinogens

Environmental justice, Equitable access:

for all populations and subgroups regardless of age, ethnicity, income, immigrant status, etc.

Screening: *HIA Valuable? Feasible?*

- Study area: large portion of San Francisco's land, existing and future residents, employees
- Policy being studied; health impacts not quantified
- Local/regional stakeholders concerned - air pollution, traffic hazards, equity
- Opportunity to build collaboration between transportation and health sectors
- Innovative, novel policy with many unanswered questions
- Analyses could inform policy design, revenue investments
- Tools available to assess the health impacts of transportation decisions
- HIA framework/approach could be applied to future transportation analyses



This pathway diagram depicts the multiple ways in which road pricing can have an impact on health. The pathways in the tan box on the right of the slide are the focus of the HIA. Stakeholder feedback informed our scope re: potential impacts via meetings, interviews, presentations and participation in public meetings, webinars, and technical advisory committee meetings led by the SFCTA. Concerned stakeholders include: community residents; local and regional transportation, planning, and health government agencies; local and regional NGOs focused on issues related to walking, biking, environmental policy, environmental justice and social equity; commerce; and freight. Simpler pathway diagrams for specific health pathways are included later in this presentation.

Assessment: Health impacts

Active Transportation by Age, Mortality Reductions *
Vehicle-Pedestrian Injury Collisions *
Air Pollution and Premature Mortality
Noise and Sleep Disturbance, Annoyance, Myocardial Infarction
Air Pollution and Noise Levels Near Schools
Vehicle-Cyclist Injury Collisions
Equity Analyses: Distribution of Health Impacts by Income, Age, Race
Cost Analyses: Air Pollution, Pedestrian and Cyclist Injury Collisions
Pedestrian Environmental Quality Assessment, Targeted Areas
Empirical Evidence Related to Transit Access, Climate Change, and Other Livability Impacts
**** Preliminary Results Presented in the Presentation***

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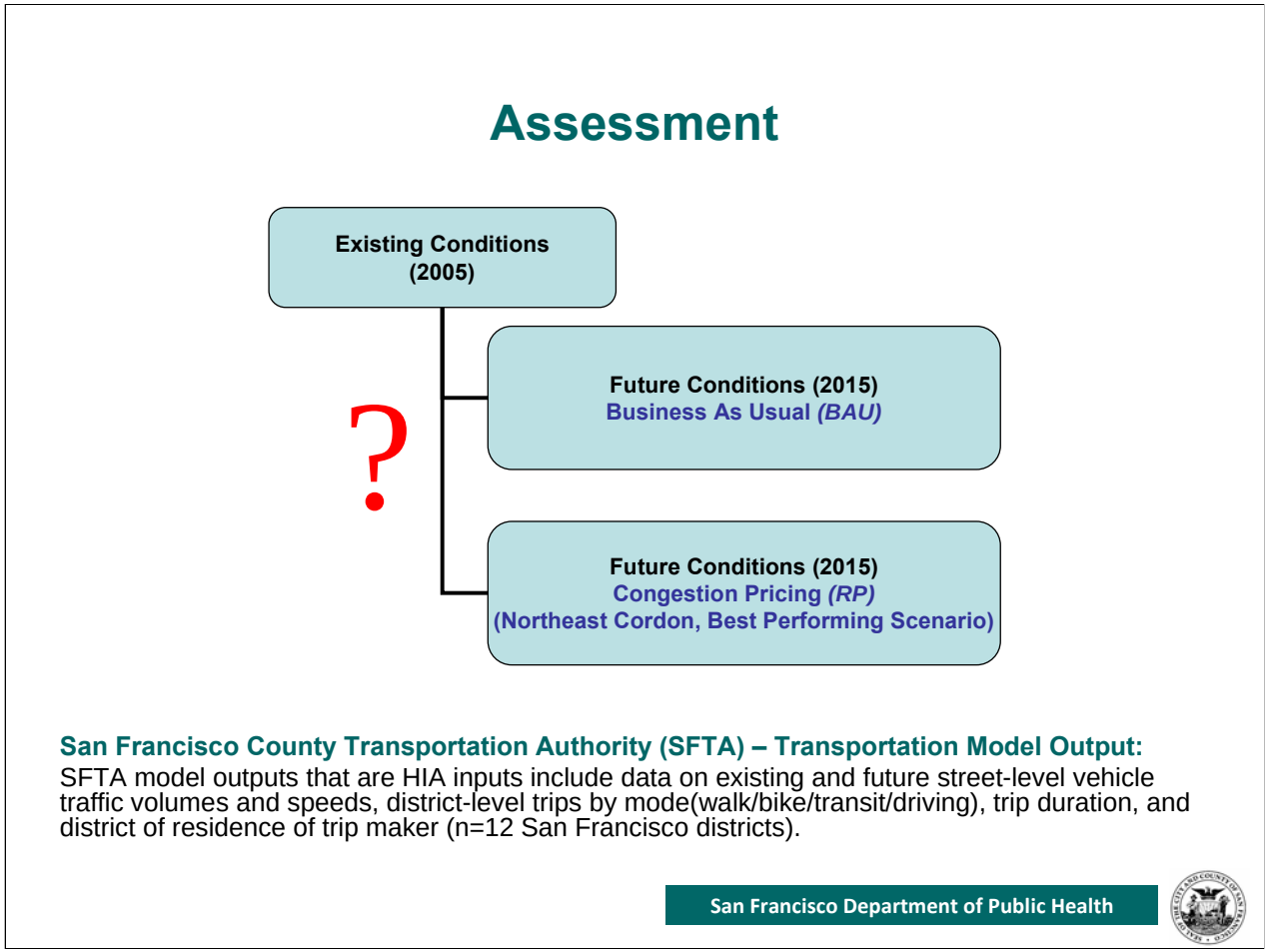
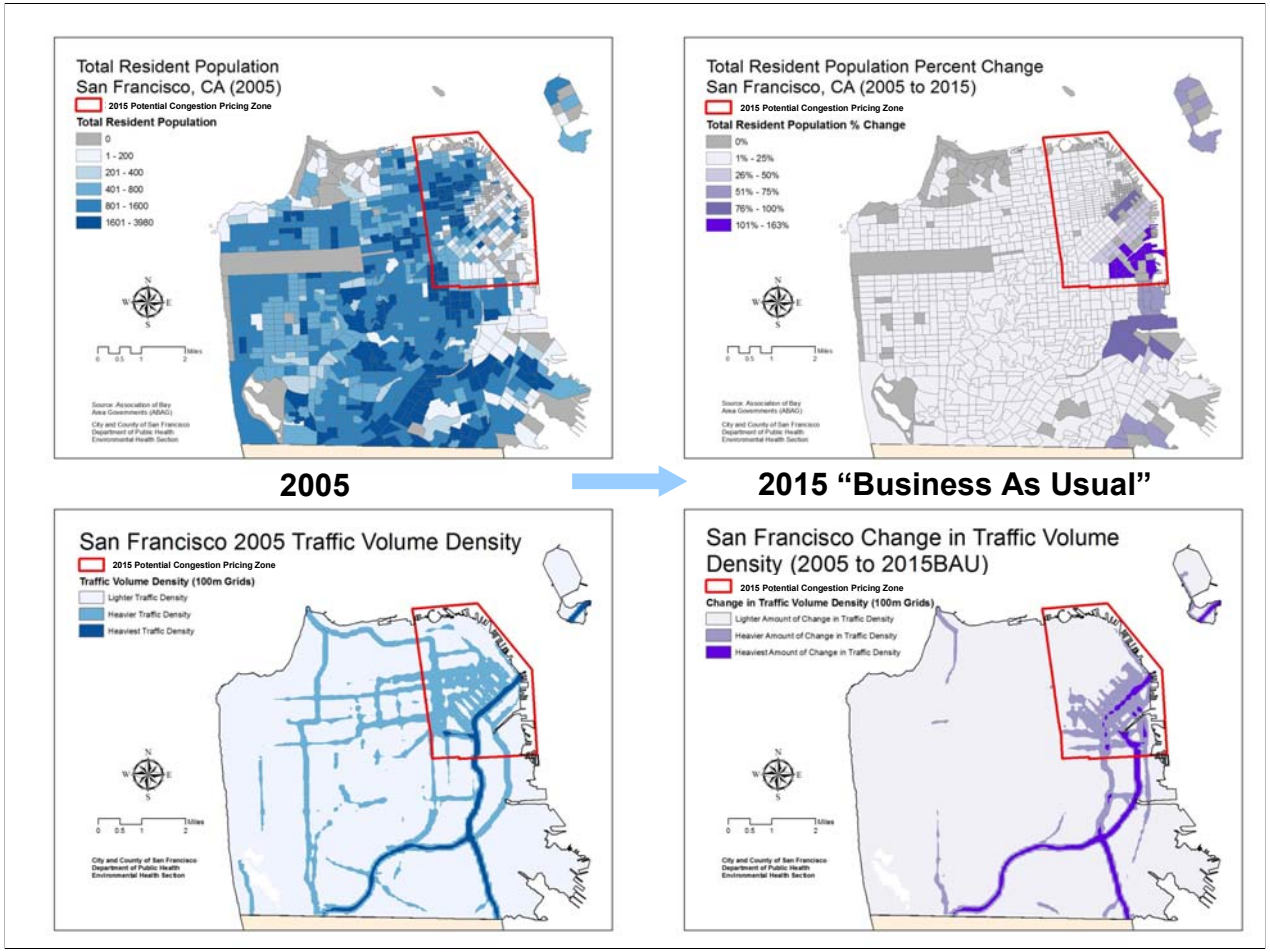
Based on the HIA scoping, we are looking at multiple health impacts associated with changes in vehicle trips, walking or biking as a part of the HIA – including active transportation, traffic-related injuries, and traffic-related noise and air quality health impacts. For today's workshop I will be focusing on HIA methods and preliminary results from our active transportation and pedestrian injury collision analyses.



The HIA looks at health impacts and conditions in 2005 Existing Conditions (using the same baseline year as the San Francisco County Transportation Authority's analysis), comparing conditions and impacts in 2005 to 2015 under "Business as Usual" (BAU), and conditions and impacts in 2015 BAU compared to 2015 with Congestion Pricing (i.e., RP - Road Pricing) in the aforementioned Northeast Cordon scenario.

Key HIA inputs are SFCTA Transportation Model outputs for 2005, 2015 BAU, 2015 RP conditions, including:

- street-level vehicle traffic volumes and speeds (street-level volumes were aggregated for analysis purposes)
- district-level trips by mode (walk/bike/transit/driving), trip duration, and trip-maker district of residence (n=12 districts).



This slide further details 2005 Conditions compared to 2015 Business As Usual (BAU) in San Francisco with respect to increasing residents and increasing traffic. The cordon zone, outlined in red, includes a diversity of neighborhoods including the downtown business district, Union Square, North Beach, Chinatown, off/on ramps from the Bay Bridge, as well as South of Market, Mission Bay, and northern Potrero Hill.

Under BAU in San Francisco, we see increasing traffic and increasing residential population density, particularly in the cordon zone, and often in formerly industrial areas, near freeways and busy roadways.

Increasing Residents, Increasing Traffic			
	2005	2015 BAU	2005 - 2015 BAU (%)
TRAFFIC			
Citywide	80,032,000	85,431,000	**7%**
In Cordon	27,357,000	30,085,000	**10%**
RESIDENTS			
Citywide	796,000	824,000	**4%**
In Cordon	172,000	183,000	**6%**

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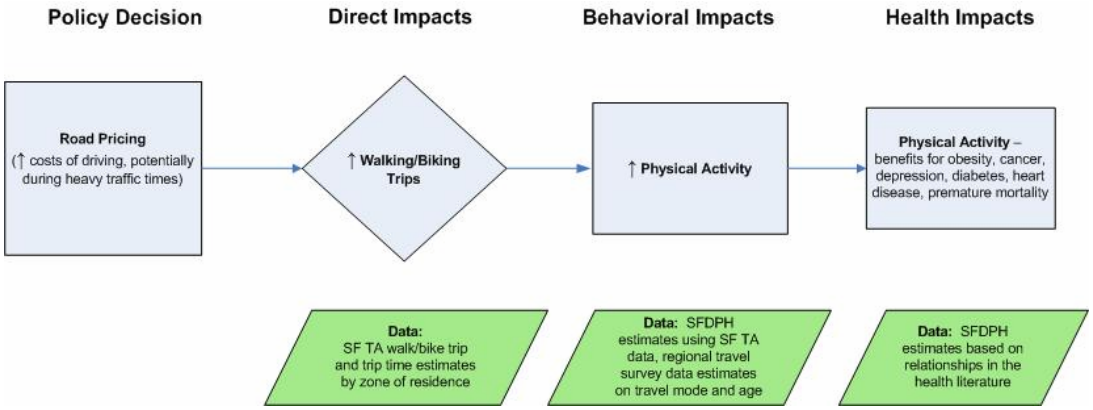
Continuing from the previous slide, as detailed in the table, new residential development – and associated increases in vehicle trips under BAU conditions - are more concentrated in the cordon zone (“In Cordon”) that is the focus area for the congestion pricing study.

Active Transportation: *Assessment*



Existing and Future Conditions Data:

- Walk & Bike Trips, Times by Residence District (SFTA Model)
- Residential Population, Age (SF TA, census-based estimates)
- Weekday Trips and Trip Mode by Age Category (Bay Area Travel Survey)

Assumptions/Uncertainties: High confidence in evidence for health impacts, age estimates; moderate confidence in area-level trip estimation method by age; high-moderate confidence in mortality estimate.

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This diagram details the pathway through which road pricing policy impacts changes in walk and bike trips and therefore physical activity and related health impacts. We used existing and future conditions data from the SFCTA to assess walk and bike trips and trip times for trips made by residents living in 12 geographic districts in San Francisco that are used for transportation analyses. We also used data for existing and future conditions for area-level resident population and age. Because data was not available on trip making and travel mode by age in San Francisco, we estimated trip making by age and transportation mode based on the Bay Area Travel Survey data, assuming the proportion making weekday trips and transportation mode by age were similar across the Bay Area region. This slide also depicts some of the assumptions and uncertainties in the analyses, which will be further detailed in the HIA final report.

Active Transportation Impacts: Walking

	2005		2005 - 2015 BAU		2015 BAU - 2015 RP	
	Walk Trips Per Capita	Walk Minutes Per Capita	Walk Trips Per Capita	Walk Minutes Per Capita	Walk Trips Per Capita	Walk Minutes Per Capita
In The Zone						
Age Under 5	1.6	30	6%	7%		
Age 5-19	2.5	46	6%	7%		
Age 20-44	1.8	32	5%	7%		
Age 45-64	1.1	20	5%	6%		
Age 65 and Over	2.0	36	5%	6%		
TOTAL	***1.7***	***31***	***5%***	***7%***	***2%***	***2%***
On the Fringe						
Age Under 5	0.9	18	0%	1%		
Age 5-19	1.3	27	0%	1%		
Age 20-44	1.0	21	0%	1%		
Age 45-64	0.6	13	0%	1%		
Age 65 and Over	1.0	22	0%	0%		
TOTAL	***0.9***	***19***	***0%***	***1%***	***3%***	***3%***
Outer Districts						
Age Under 5	0.6	11	-1%	0%		
Age 5-19	0.9	17	-1%	0%		
Age 20-44	0.6	13	-1%	0%		
Age 45-64	0.4	8	-1%	0%		
Age 65 and Over	0.7	14	-1%	-1%		
TOTAL	***0.6***	***12***	***-1%***	***0%***	***2%***	***1%***

Results are preliminary and are undergoing technical review in Spring 2011.

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While there is a lot of data included in this slide that we look forward to describing further in our final report, including breakdowns by age, for this presentation we want to focus on changes in walking and biking under BAU compared to RP. We collapsed the 12-districts in San Francisco into three districts for this analysis, defined with respect to their geographic location relative to the Northeast Cordon road pricing zone (depicted with a blue boundary on the map). The three zones are "In the Zone," turquoise, comprised of the districts mostly in the cordon zone; "On the Fringe," yellow/mustard, comprised of the districts just outside of the cordon zone; and the "Outer Districts," those further away from the cordon zone in pink.

In 2005 conditions people are walking more "In the Zone" – almost double that of people "On the Fringe" and approximately three times that of people in the Outer Districts. This is consistent with increased residential density, decreased parking availability and car ownership, and increased transit and other neighborhood factors support of walking "In the Zone," relative to the other districts. Under 2015 BAU compared to 2005, we see notable increases in walk trips and time per capita only "In the Zone" – as the number of residents increases in that area and particularly in areas with land use and transportation characteristics supportive of walking. Under 2015 with RP compared to 2015 BAU, we see modest increases in walk trips across all districts – including a 3% increase "On the Fringe," which makes intuitive sense as those residents have shorter trip distances to the road pricing boundary that could be made via walking when the cost of driving increases. Just a note, percentages are listed only for the total in the 2015 BAU – 2015 RP scenario because they are constant across age groups given the assumptions used for the estimates.

Active Transportation Impacts: Cycling

	2005		2005 - 2015 BAU		2015 BAU - 2015 RP	
	Bike Trips Per Capita	Bike Minutes Per Capita	Bike Trips Per Capita	Bike Minutes Per Capita	Bike Trips Per Capita	Bike Minutes Per Capita
In The Zone						
Age Under 5	0.0	0.4	9%	11%		
Age 5-19	0.3	2.7	10%	12%		
Age 20-44	0.2	2.6	9%	10%		
Age 45-64	0.1	0.8	8%	10%		
Age 65 and Over	0.1	0.6	7%	9%		
TOTAL	***0.2***	***1.8***	***7%***	***9%***	***-2%***	***-1%***
On the Fringe						
Age Under 5	0.0	0.5	7%	6%		
Age 5-19	0.2	3.2	6%	6%		
Age 20-44	0.2	3.1	7%	7%		
Age 45-64	0.1	1.0	7%	7%		
Age 65 and Over	0.0	0.7	6%	6%		
TOTAL	***0.2***	***2.2***	***5%***	***5%***	***5%***	***4%***
Outer Districts						
Age Under 5	0.0	0.5	4%	6%		
Age 5-19	0.2	2.9	4%	6%		
Age 20-44	0.1	2.7	3%	6%		
Age 45-64	0.0	0.9	3%	5%		
Age 65 and Over	0.0	0.6	3%	5%		
TOTAL	***0.1***	***1.8***	***2%***	***4%***	***3%***	***3%***

Results are preliminary and are undergoing technical review in Spring 2011.

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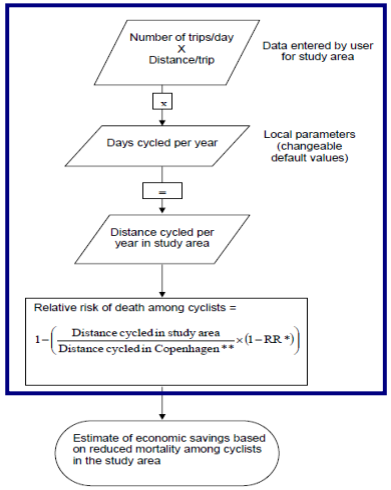
In 2005 we see relatively low bike trips and time travelling per capita across the zones – which makes sense relative to the walking data given that everyone walks and not everyone bikes, with more variation between age groups.

Under 2015 BAU compared to 2005 we see notable increases in bike trips per capita across the zones, consistent with increases in biking that we have been seeing in SF due to changes in transportation conditions that make biking more attractive (e.g., worsening driving and transit conditions) and increases in residents in areas with environments more supportive of bike trips.

Under 2015 RP compared 2015 BAU we see additional increases in bike trips "On the Fringe" and in the "Outer Districts" – intuitive as those residents can replace longer car trips with free bike trips across the cordon as the cost of driving increases. Per capita bike trips slightly decrease "In the Zone" under 2015 with road pricing, in part due to increases in transit trips replacing bike trips as road pricing revenue investments improve transit service in that area (per SFDPH's discussion with the SFCTA). An important note is that active transportation via walking + biking increases in all areas under 2015 RP.

Active Transportation Impacts: Lives Saved from Cycling

Figure 1. Basic workings of the HEAT for cycling



*RR = relative risk of death in underlying study (0.72) (Andersen et al., 2000)

**Distance cycled in Copenhagen calculated based on 3 hours per week for estimated 36 weeks/year at estimated 14km/h

	2005	2015 BAU	2015 RP	*Confidence In Preliminary Results Given Available Methods, Assumptions*
Lives Saved Annually From Cycling (Ages 25-64)	28	30	31	***High - Moderate***

Using the Health Economic Assessment Tool (HEAT) for Cycling

Results are preliminary and are undergoing technical review in Spring 2011.

The HEAT was developed with support from the World Health Organization, and is available and downloadable online:

•*www.euro.who.int/en/what-we-do/health-topics/environmental-health/Transport-and-health/activities/promotion-of-safe-walking-and-cycling-in-urban-areas/quantifying-the-positive-health-effects-of-cycling-and-walking/health-economic-assessment-tool-heat-for-cycling*

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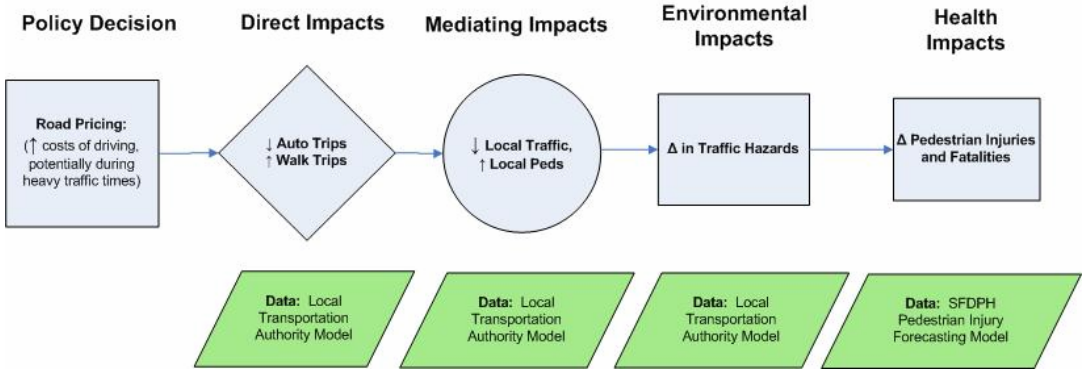
To quantify the health benefits from increases in cycling, we used the HEAT (Health Economic Assessment Tool) for Cycling. This tool was developed with support from the World Health Organization and is downloadable online from the link on the slide. We used the cycle trip and duration estimates for people aged 25-64 as the key inputs into the Tool, along with local data on mortality rates to estimate lives saved from cycling. Our preliminary results indicate that increases in cycling will save an additional 2 lives each year under 2015 "business as usual" compared to existing conditions, and one additional life each year beyond BAU with 2015 RP. We anticipate applying a similar approach to estimating the health benefits of increased walking. Notably, there are numerous other health benefits from active transportation; lives saved/reductions in mortality are the most severe among a spectrum of impacts (literally, the difference between life and death).

Pedestrian Injury Collision Impacts



SFDPH has developed a multivariate, linear area-level (census tract) regression model* to *predict the natural log of vehicle-pedestrian injury collisions in San Francisco's n=176 census tracts:*

$$\ln(\textit{Ped Injury Collisions}) = b_0 + \sum b_i X_i$$

Significant predictors of area-level collisions ($b_i X_i$):

- Traffic volume (+, ln)
- **Arterial streets (+) w/o surface transit**
- **Neighborhood commercial zoning (+)**
- Employees (+, ln)
- Residents (+)
- **Land area (-)**
- Below poverty level (+)
- Age 65 and over (-)

Assumptions/Uncertainties: High confidence in evidence for health impacts; high-moderate confidence in estimates of model predictors (includes pedestrian volume proxies); high-moderate confidence in forecasting approach.

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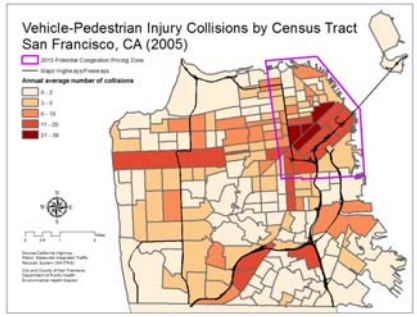
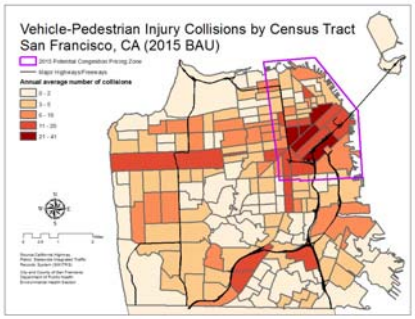
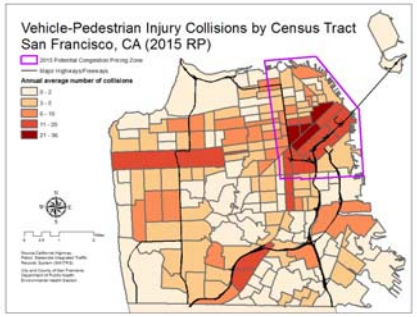
* Wier et al. (2009) *Accident Analysis & Prevention.*

The diagram details the pathway through which road pricing policy impacts changes in trips and therefore traffic hazards and vehicle-pedestrian injury collisions. SFDPH developed a vehicle-pedestrian injury collision forecasting model to predict the number of collisions at the census tract level in San Francisco based on land use, transportation and socio-demographic factors. Significant predictors in the model are listed on the bottom left of the slide; variables for which we used estimates changes under future (2015) conditions are highlighted in turquoise. We used this model to estimate changes in collisions under 2005 vs. 2015 BAU and 2015 BAU vs. 2015 RP using existing and future conditions data from the SFCTA model on traffic volume as well as planning projections regarding changes in the number of employees, residents, income and age. This slide also depicts some of the assumptions and uncertainties in the analyses, which will be further detailed in the HIA final report.

Vehicle-Pedestrian Injury Collisions







Results are preliminary and are undergoing technical review in Spring 2011.

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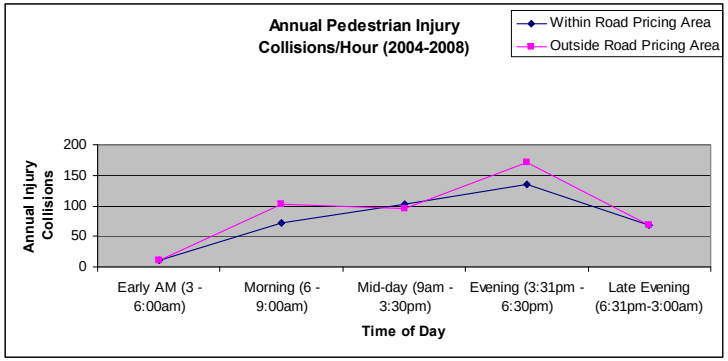
The maps on this slide depict area-level changes in the annual average of vehicle-pedestrian injury collisions in 2005, 2015 BAU and 2015 RP conditions. We see increases in collisions under BAU – with increases most notable in areas in the road pricing zone as well as some tracts south of the zone near the freeway. In 2015 with RP, we see reductions in the road pricing zone relative to 2015 BAU conditions – explained by reductions in traffic volumes in those areas. Note that the highest category for the annual average number of collisions changes under 2015 BAU conditions.

Please note that SFCTA traffic model assumptions do not include programmatic or off-model improvements to address/reduce potential neighborhood impacts.

The HIA analyses will help to inform design of the program mitigations and benefits as needed.

Vehicle-Pedestrian Injury Collisions

	2005	2015 BAU	2015 RP	Change: 2005-2015 BAU	Change: 2015 BAU - 2015 RP	*Confidence In Preliminary Results Given Available Methods, Assumptions*
Vehicle-Pedestrian Injury Collisions (Annual, N)				**%**	**%**	***High - Moderate***
Citywide	810	860	810	6%	-6%	
In Cordon	360	395	360	10%	-9%	



Results are preliminary and are undergoing technical review in Spring 2011.

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The table summarizes changes in vehicle-pedestrian injury collisions citywide and in the cordon. While vehicle-pedestrian injury collisions increase from 2005 to 2015 BAU (as residential populations increase in the areas where there is the most traffic), there are comparable decreases from 2015 BAU to 2015 RP (back to 2005 existing conditions levels) both citywide and in the cordon zone. It is notable that similar proportional decreases were seen with the introduction of congestion pricing in London.

We also included a summary of the time of day of pedestrian injury collisions in San Francisco – the blue line indicating numbers within the pricing area, and the pink line citywide. There are evident peaks during the AM and PM peak periods, additional evidence regarding the plausibility of traffic reductions during those times as contributing to reductions in pedestrian injury collisions. We anticipate conducting additional sensitivity analyses of these preliminary results in the coming months.

Summary

Preliminary results:

2005 - 2015 BAU - ***Estimating the health impacts of "Business As Usual" (BAU)***

- increases in active transportation primarily in the cordon zone (with increased residential development) and a modest increase in lives saved from cycling
- increases in pedestrian injury collisions (largely predicted by increased traffic volumes) particularly in the cordon zone

2015 BAU – 2015 RP - ***Estimating the health impacts of congestion pricing on BAU***

- increases in active transportation exceeding those in 2015 BAU, including areas outside the cordon zone, with a modest increase in lives saved above 2015 BAU
- reductions in vehicle-pedestrian injury collisions, notably in the cordon area, to 2005 levels

HIA Methods and Process:

- Supports engagement of health in transportation policy decisionmaking
- A quantitative approach to estimating policy impacts on health
- *Next Steps…*

Results are preliminary and are undergoing technical review in Spring 2011.

Next Steps

Next steps and timeline:

- **February – April 2011:**
  - **Technical review of preliminary results**
  - **Additional assessment including health impacts via air pollution, noise, equity as well as cost analyses for specific outcomes**
  - **Recommendations for policy design, revenue investment**
- **May - June 2011: Public report draft for review, conduct public outreach**
- **July 2011: HIA Report finalized, conduct additional public outreach**

Project Website for Updates:

www.sfphes.org/HIA_Road_Pricing.htm

Acknowledgements

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San Francisco Injury Center
San Francisco Office of Economic Analysis
UC Berkeley - School of Public Health

San Francisco Department of Public Health