Cataloguing and Assessing Urban Transportation Policies to Reduce Traffic-Related Emissions and Air Pollution

A Systematic Evidence Map

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Motivation

Urban areas are hotspots for traffic activity and exposures, and are growing

Cities are undertaking several “policies”, “actions”, “measures”, “strategies” and “practices” (“policy interventions”) to reduce emissions, air pollution, exposure, and negative health impacts

Number of available options increasing + technologies emerging → Evidence base is large but sporadic and not systematically assessed

Some reviews exist but only one reported methods a priori, and none hosted results in an open-access database or tool

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Urban policy interventions to reduce traffic emissions and traffic-related air pollution: Protocol for a systematic evidence map

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ABSTRACT

Introduction: Cities are the world's engines of economic growth, innovation, and social change, but they are also hot spots for human exposure to air pollution, mainly originating from road traffic. As the urban population continues to grow, a greater quantity of people risk exposure to traffic-related air pollution (TRAP), and therefore also risk adverse health effects. In many cities, there is scope for further improvement in air quality through targeted urban policy interventions. The objective of this protocol is to detail the methods that will be used for a systematic evidence map (SEM) which will identify and characterize the evidence on policy interventions that can be implemented at the urban-level to reduce traffic emissions and/or TRAP from on-road mobile sources, thus reducing human exposures and adverse health impacts.

Methods: Articles will be searched for and selected based on a predetermined search strategy and eligibility criteria. A variety of databases will be searched for relevant articles published in English between January 1, 2000 and June 1, 2020 to encompass the interdisciplinary nature of this SEM, and articles will be stored and screened using Rayyan QCRI. Predetermined study characteristics will be extracted and coded from included studies in a Microsoft Excel sheet, which will serve as an open access, interactive database, and two authors will review the coded data for consistency. The database will be queryable, and various interactive charts, graphs, and maps will be created using Tableau Public for data visualization. The results of the evidence mapping will be detailed via narrative summary.

Conclusion: This protocol serves to increase transparency of the SEM methods and provides an example for researchers pursuing future SEMs.

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Systematic Evidence Map

Urban policy interventions to reduce traffic-related emissions and air pollution: A systematic evidence map

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Exposure
Health
Climate
Co-Benefits

ABSTRACT

Background: Urban areas are hot spots for human exposure to air pollution, which originates in large part from traffic. As the urban population continues to grow, a greater number of people risk exposure to traffic-related air pollution (TRAP) and its adverse, costly health effects. In many cities, there is a need and scope for air quality improvements through targeted policy interventions, which continue to grow including rapidly changing technologies.

Objective: This systematic evidence map (SEM) examines and characterizes peer-reviewed evidence on urban-level policy interventions aimed at reducing traffic emissions and/or TRAP from on-road mobile sources, thus potentially reducing human exposures and adverse health effects and producing various co-benefits.

Methods: This SEM follows a previously peer-reviewed and published protocol with minor deviations, explicitly outlined here. Articles indexed in Public Affairs Index, TRID, Medline and Embase were searched, limited to English, published between January 1, 2000, and June 1, 2020. Covidence was used to screen articles based on previously developed eligibility criteria. Data for included articles was extracted and manually documented into an Excel database. Data visualizations were created in Tableau.

Results: We identified 7528 unique articles from database searches and included 376 unique articles in the final SEM. There were 58 unique policy interventions, and a total of 1,139 unique policy scenarios, comprising these

Research aims

- Identify, describe, and summarize global evidence on urban policy interventions to reduce traffic emissions and/or TRAP

→Primary outcomes of interest

- Recorded direction of impact reported (Increase, Reduction, No Change, Mixed Effect)

Research aims

- Secondary outcomes and items – direction of impact not reported:
  - Human exposure (yes/no + which pollutant)
  - Health effect or impact (yes/no + which pollutant + which outcome)
  - Co-benefits (which social, environmental + climate, economic)
  - Barriers and enablers to implementation (which ones)

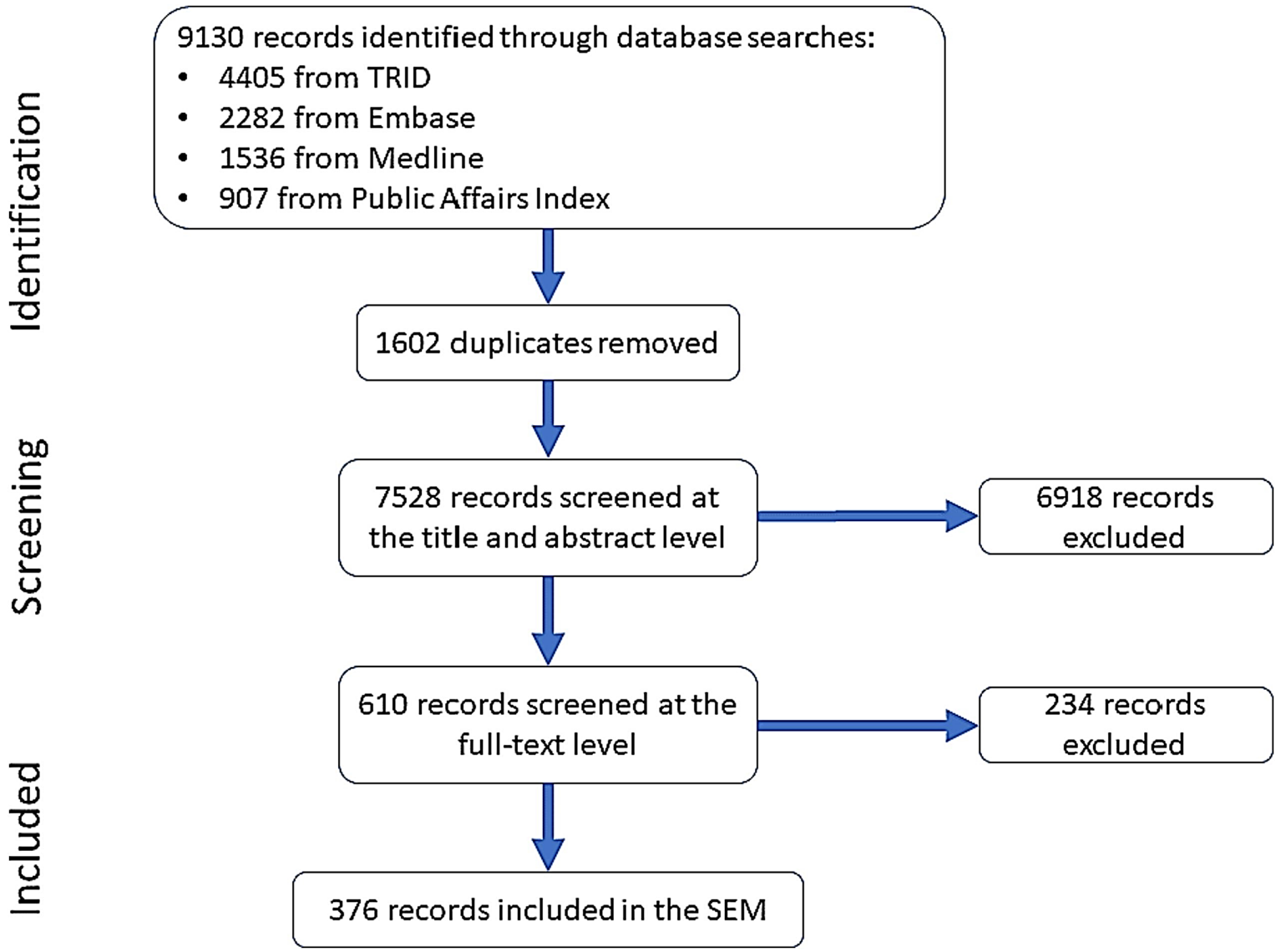
Inclusion criteria

- Articles that investigate policy interventions implemented in **urbanized areas** (densely settled territory ≥ 50,000 or more people) or **urban clusters** (≥ 2,500 people but < 50,000 people) as defined by the United States Census Bureau
- Articles that investigate urban-level policy interventions' i**mpact on traffic emissions (exhaust or non-exhaust) and/or TRAP** originating from mobile on-road traffic
- Articles that investigate **past, current, future or hypothetical** changes in traffic emissions and/or TRAP

  - Articles reported in the English language
  - Articles published between January 1, 2000, and June 1, 2020
  - Articles that are peer-reviewed

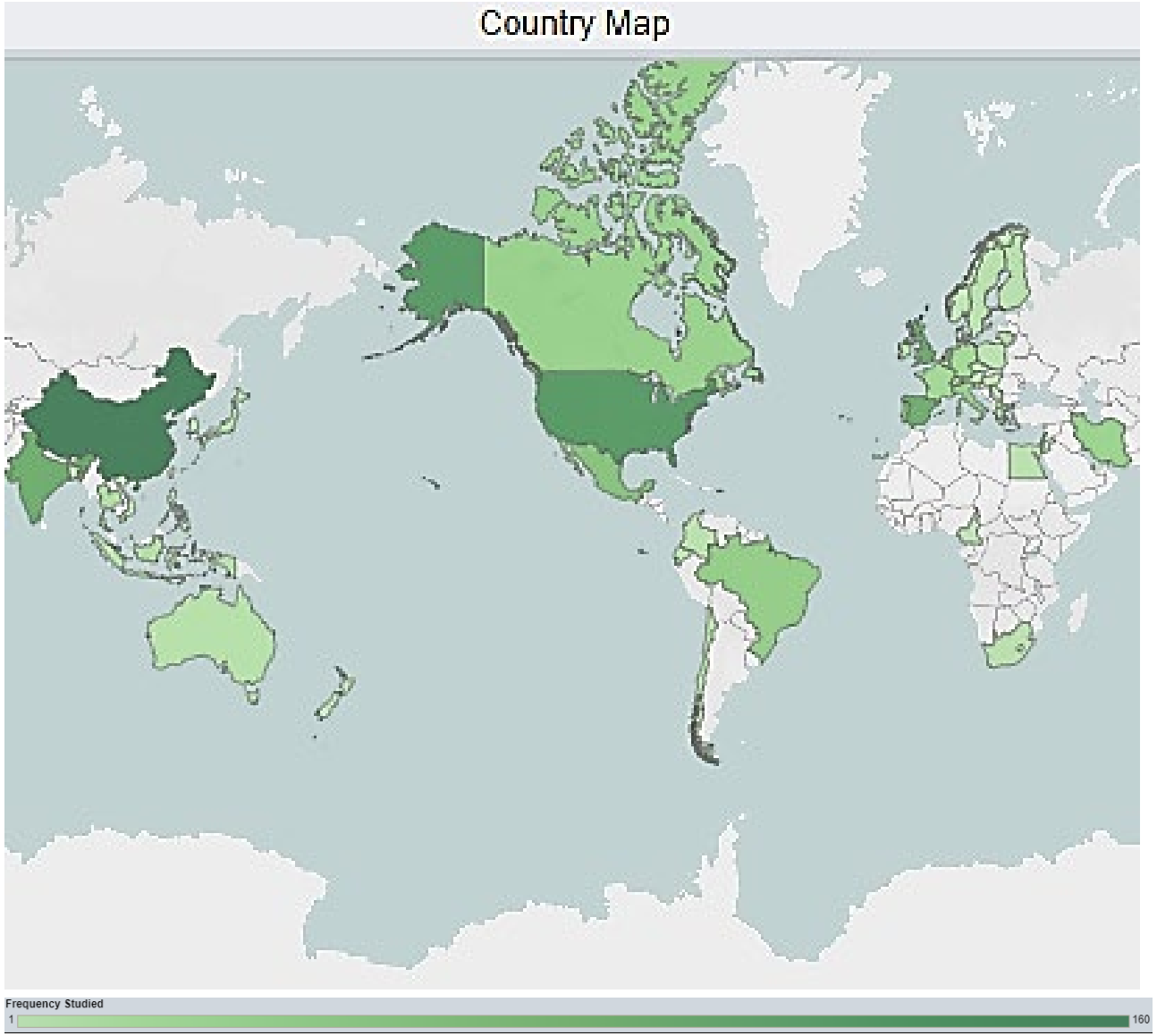
→ *No restriction on intervention type, pollutant, location or method for analysis*

Results


Identification
Screening
Included
9130 records identified through database searches:
• 4405 from TRID
• 2282 from Embase
• 1536 from Medline
• 907 from Public Affairs Index
1602 duplicates removed
7528 records screened at the title and abstract level
6918 records excluded
610 records screened at the full-text level
234 records excluded
376 records included in the SEM

Results

- 1,139 unique policy intervention scenarios
- 380 packages (33%)
- From 376 unique articles
- 58 types of unique policies
- 6 categories
- 52 countries
- 307 unique urban/urbanized locations
- Most policies studied in Europe (463), Asia (355), North America (206)
- Least in South America (57), Africa (10), Australia (7)
- Cities most studied
  - Beijing 81 scenarios
  - London 78 scenarios



Map prepared by Rohit Jaikumar, Texas A&M Transportation Institute

Pricing – 216 studied times

- Parking charges
- Road pricing
- Congestion charges

Land-use – 77

- Development density and mix
- Transit oriented development
- Parking expansion

Infrastructure – 210

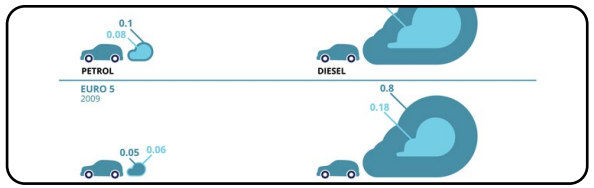
- Bus rapid transit
- Public and active transportation infrastructure
- Roadway development and intersection alterations

Behavioural – 116

- Public transport mode shift and promotion
- Active transportation mode shift and promotion
- Flexible working arrangements and ride sharing

Technology – 406

- Alternative fuel technology
- Vehicle retrofitting
- Alternative vehicle technology



Management, standards, and services – 807

- Vehicle emission regulation
- Vehicle retirement or replacement
- Vehicle use restriction

Results

- Only 3% of articles reported all elements of the full-chain

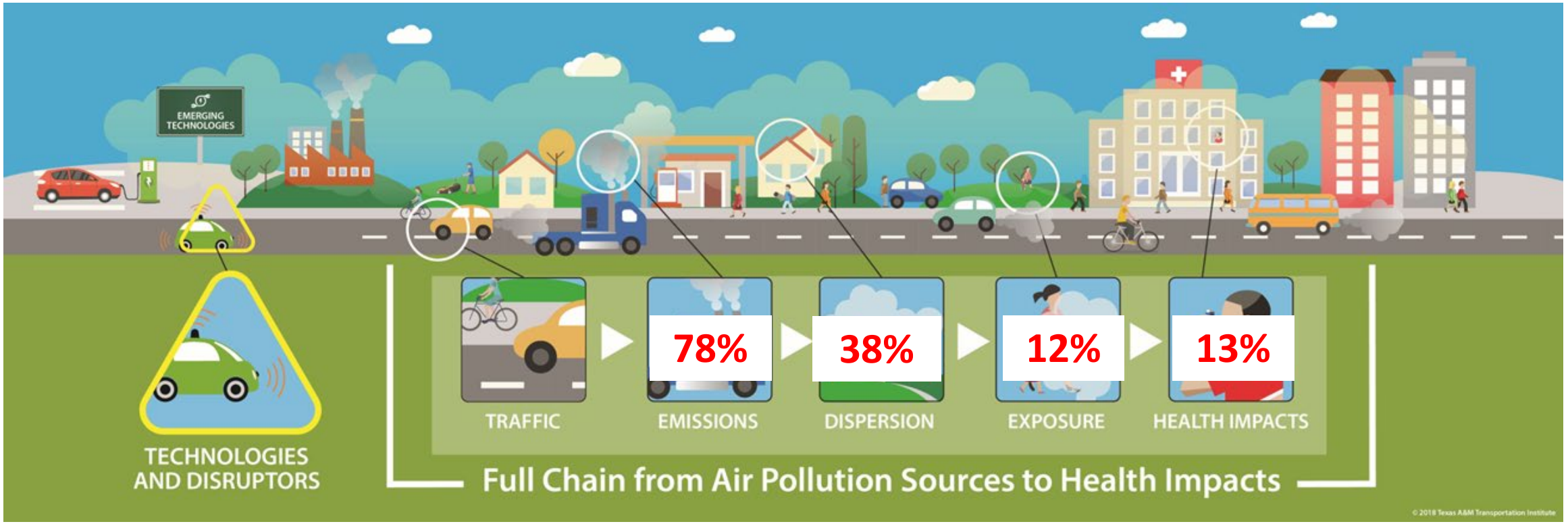
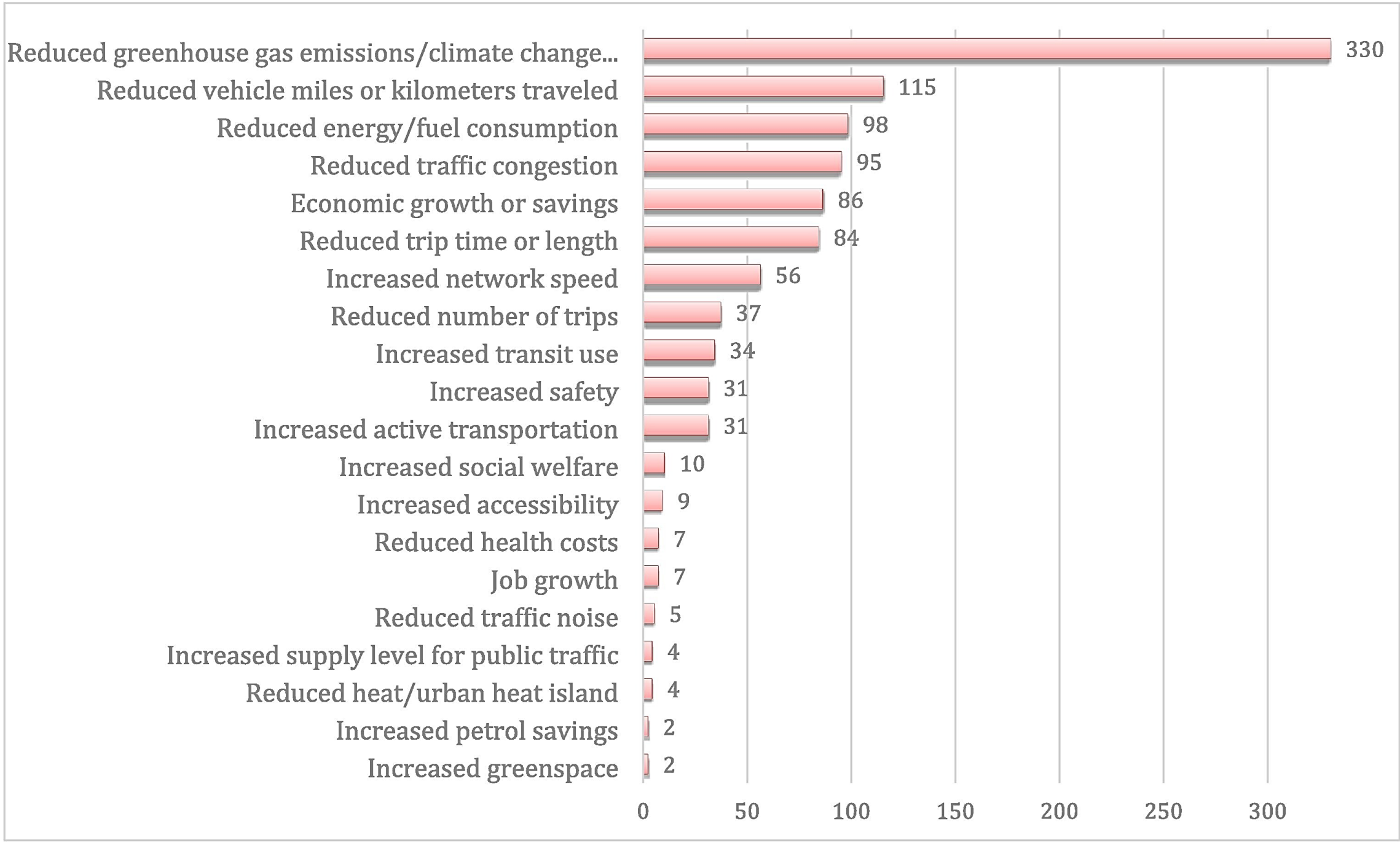
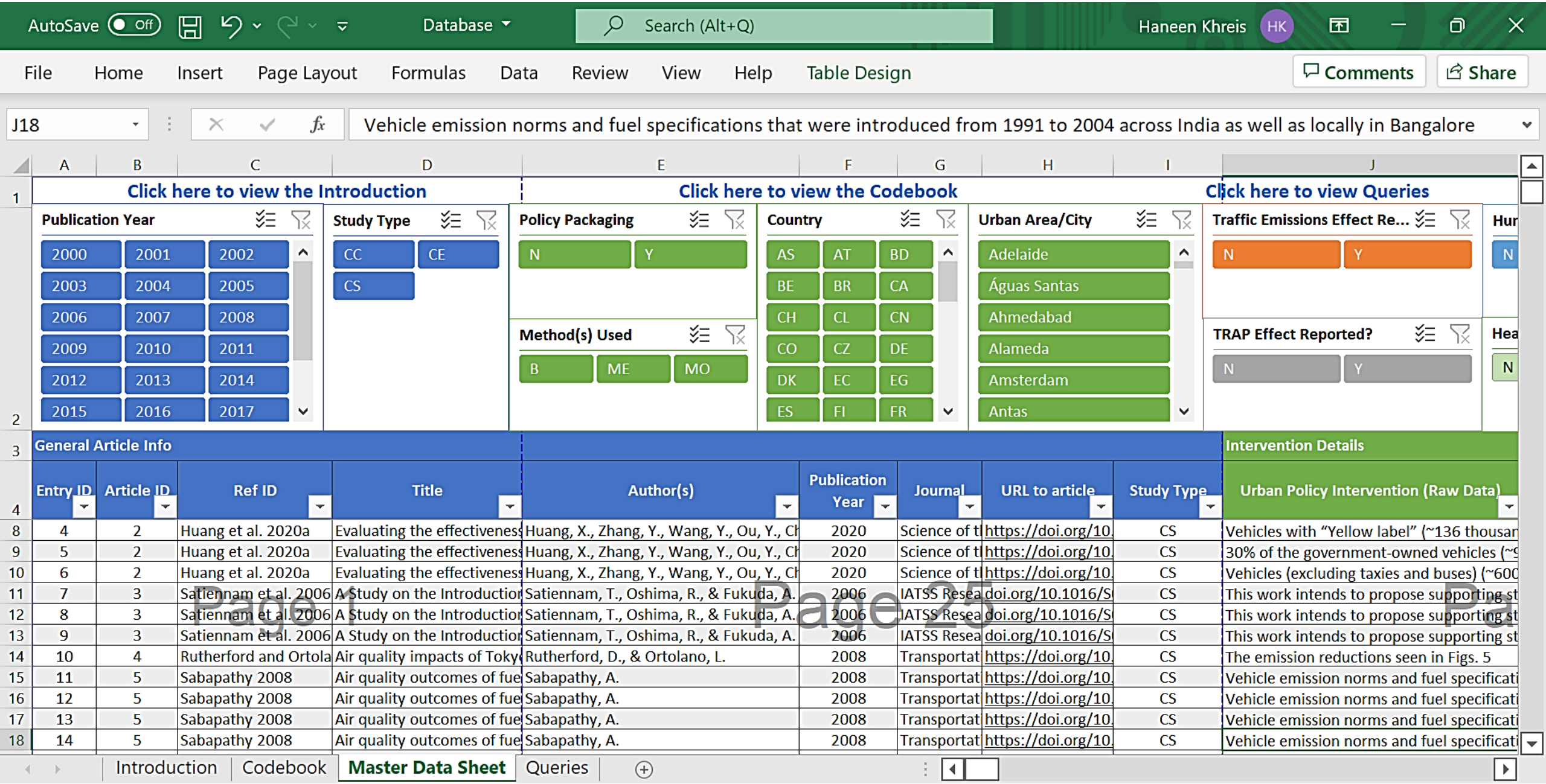


Image from carteeh.org



Co-benefits Recorded (raw data included in the database): reported a total of 1,047 times in 204 unique articles

Query-able database (online)



Query-able database (online)

Traffic Emission Direction																							
Traffic Emissions Effect Reported?	Ammonia NH3	Black Carbon BC	Black Smoke BS	Carbon Monoxide CO	Elemental Carbon EC	Hydrocarbons HC	Nitric Oxide NO	Nitrogen Dioxide NO2	Nitrogen Oxides NOX	Organic Carbon OC	Particulate Matter 1 PM1	Particulate Matter 2.5 PM2.5	Particulate Matter 10 PM10	Particulate Matter X PMX	Reactive Organic Gases ROG	Secondary Organic Aerosols SOA	Sulfur Dioxide SO2	Sulfur Oxides SOX	Suspended Particulate Matte	Total Carbon TC	Total Organic Gases TOG	Ultrafine Particles UFP	Volative Organic Compounds VOC	Other OTH
Y				ER																			
Y				ER																			
Y				ER																			
Y																							ER
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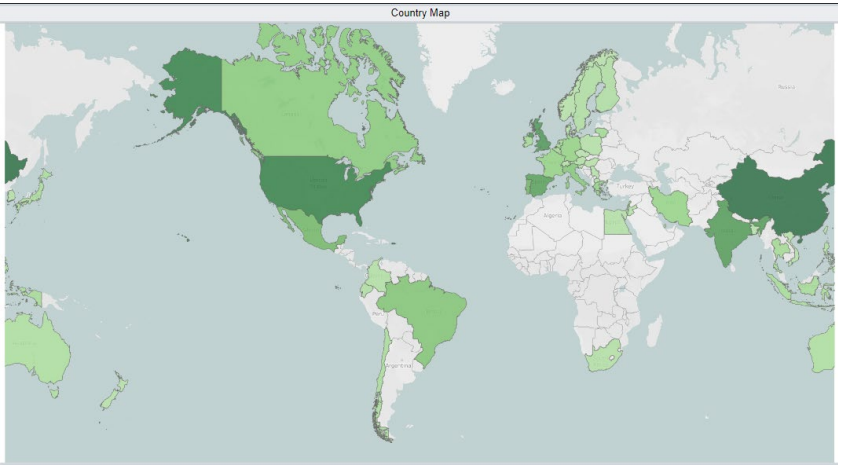

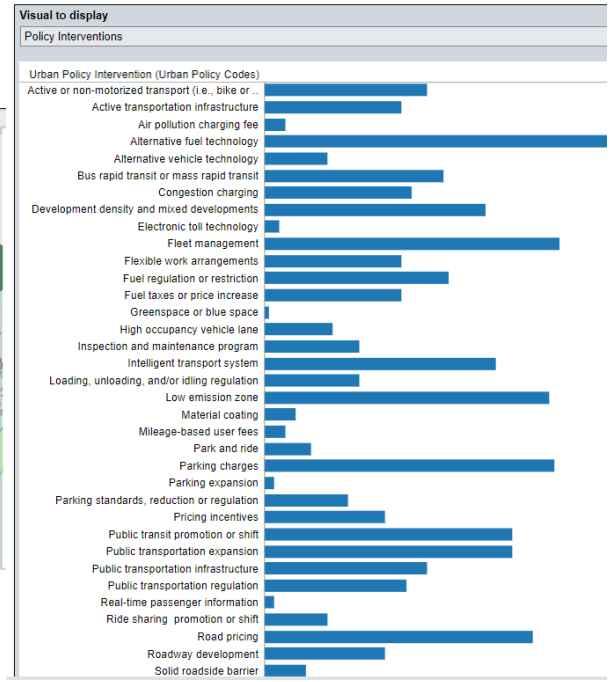

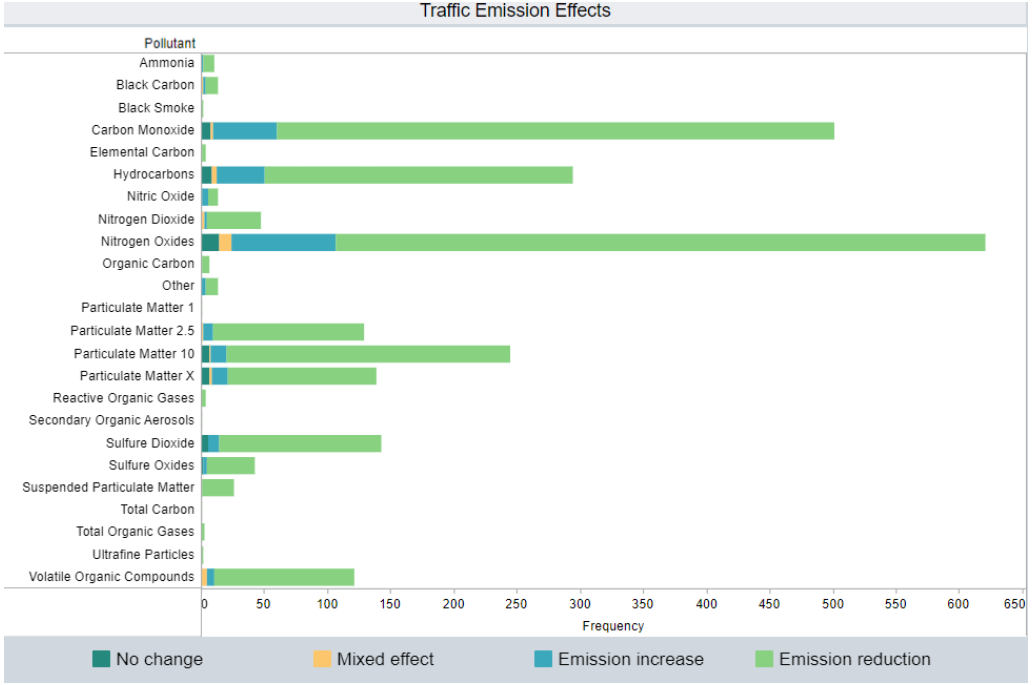

Interactive visualization tool (online)

Urban Policy Interventions to Reduce Traffic-Related Emissions and Air Pollution: Database for a Systematic Evidence Map

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Mark J. Nieuwenhuijsen, Barcelona Institute for Global Health, mark.nieuwenhuijsen@isglobal.org
Rohit Jaikumar, Texas A&M Transportation Institute, r-Jaikumar@tti.tamu.edu
Tara Ramani, Texas A&M Transportation Institute, t-ramani@tti.tamu.edu
Josias Zietsman, Texas A&M Transportation Institute, j-zietsman@tti.tamu.edu

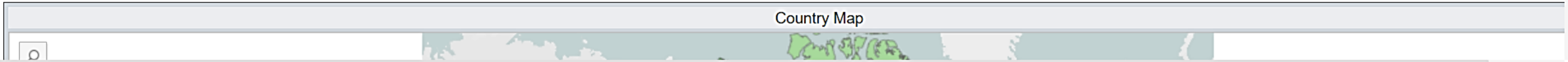
This dashboard hosts information from Urban Policy Interventions to Reduce Traffic Emissions and Traffic-Related Air Pollution: A Systematic Evidence Map. This project aimed to characterize the ev on urban-level policy interventions that can reduce traffic emissions and traffic-related air pollution (TRAP) from on-road mobile sources, thus potentially reducing human exposures and negative he effect and impact. The dashboard represents information for 376 articles and 1,139 policy scenarios included in the Systematic Evidence Map. Users may query the data according to different topics interest. Users may access the underlying Excel database from: https://carteehdata.org/library/dataset/urban-policy-intervention-f08c

Section 1

Pie charts display the proportion of policy scenarios which report traffic emissions, TRAP, exposures, health effects and impacts. Click on "Yes" or "No" in each pie chart to select the studies associat it.

Section 2

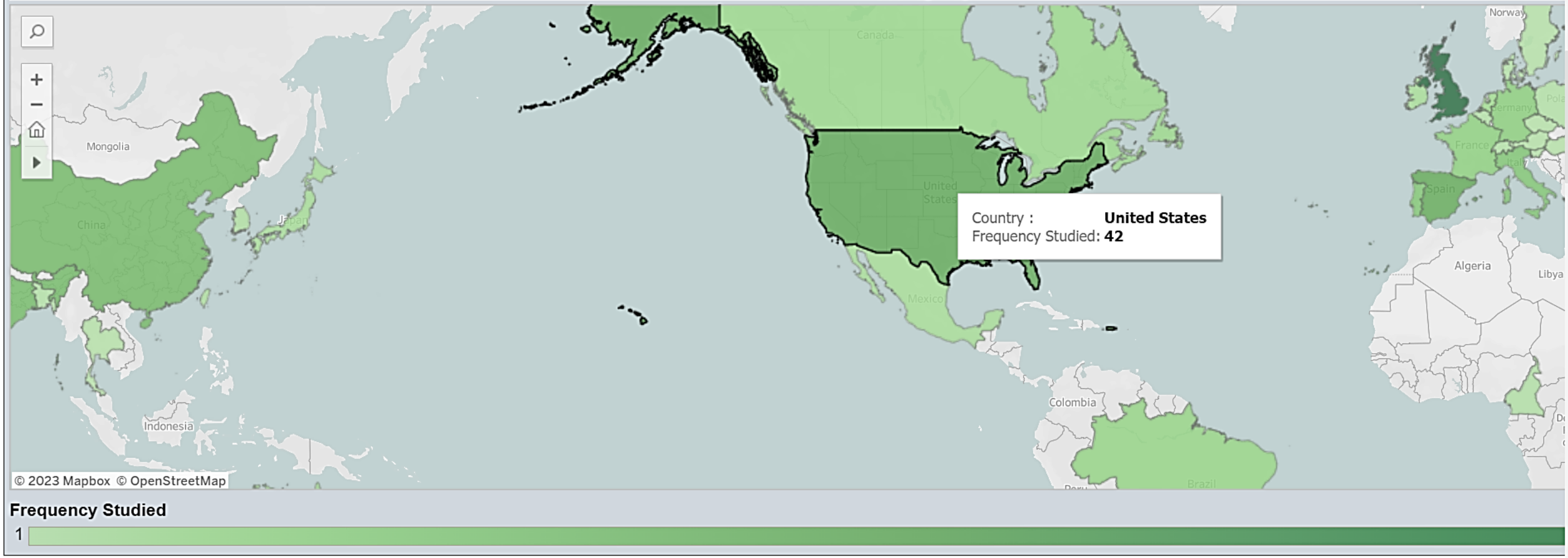
A geographic map displays the frequency of policy scenarios studied in each country. Click on a country to select the studies associated with it.



Section 2

A geographic map displays the frequency of policy scenarios studied in each country. Click on a country to select the studies associated with it.

Country Map

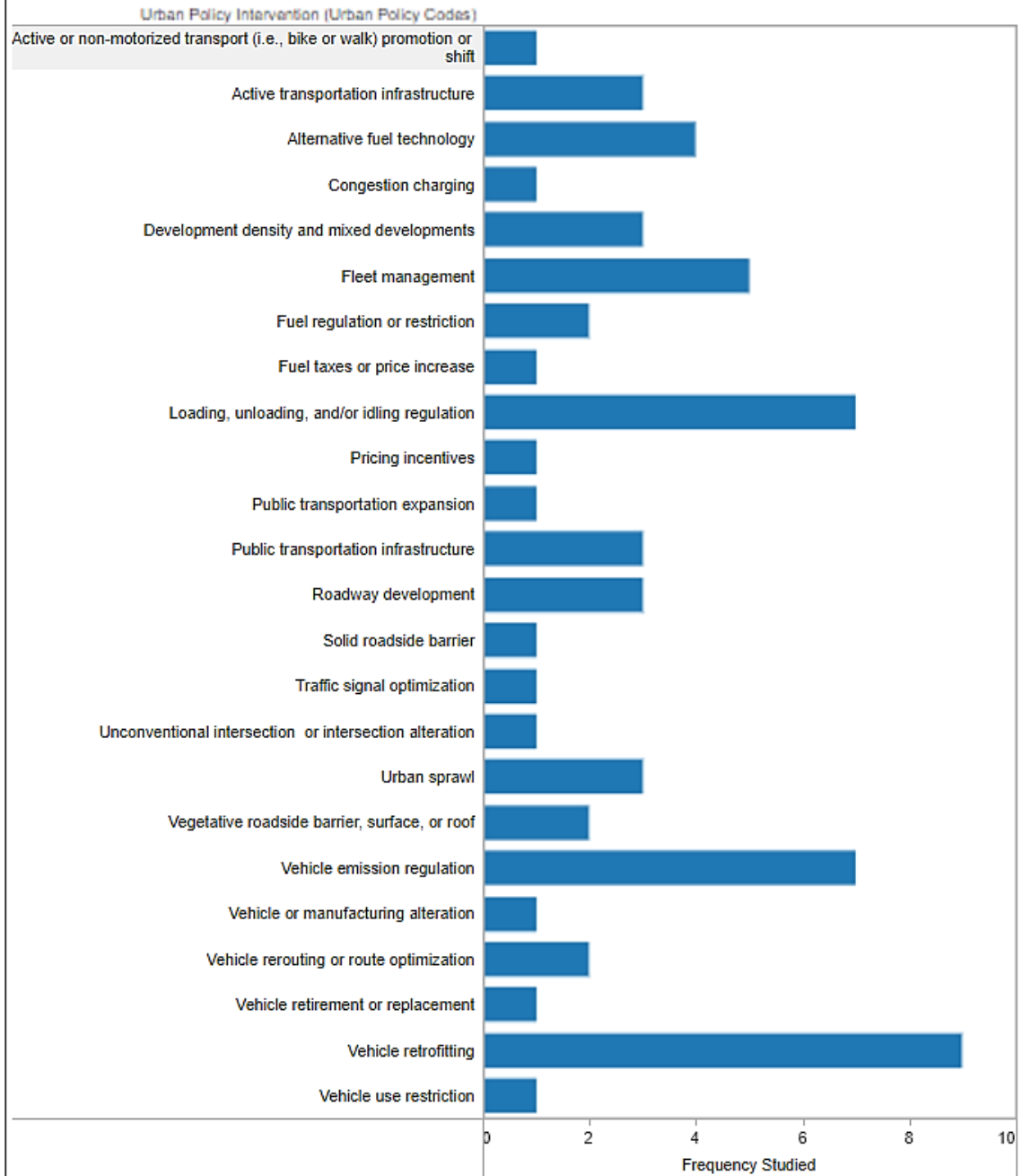


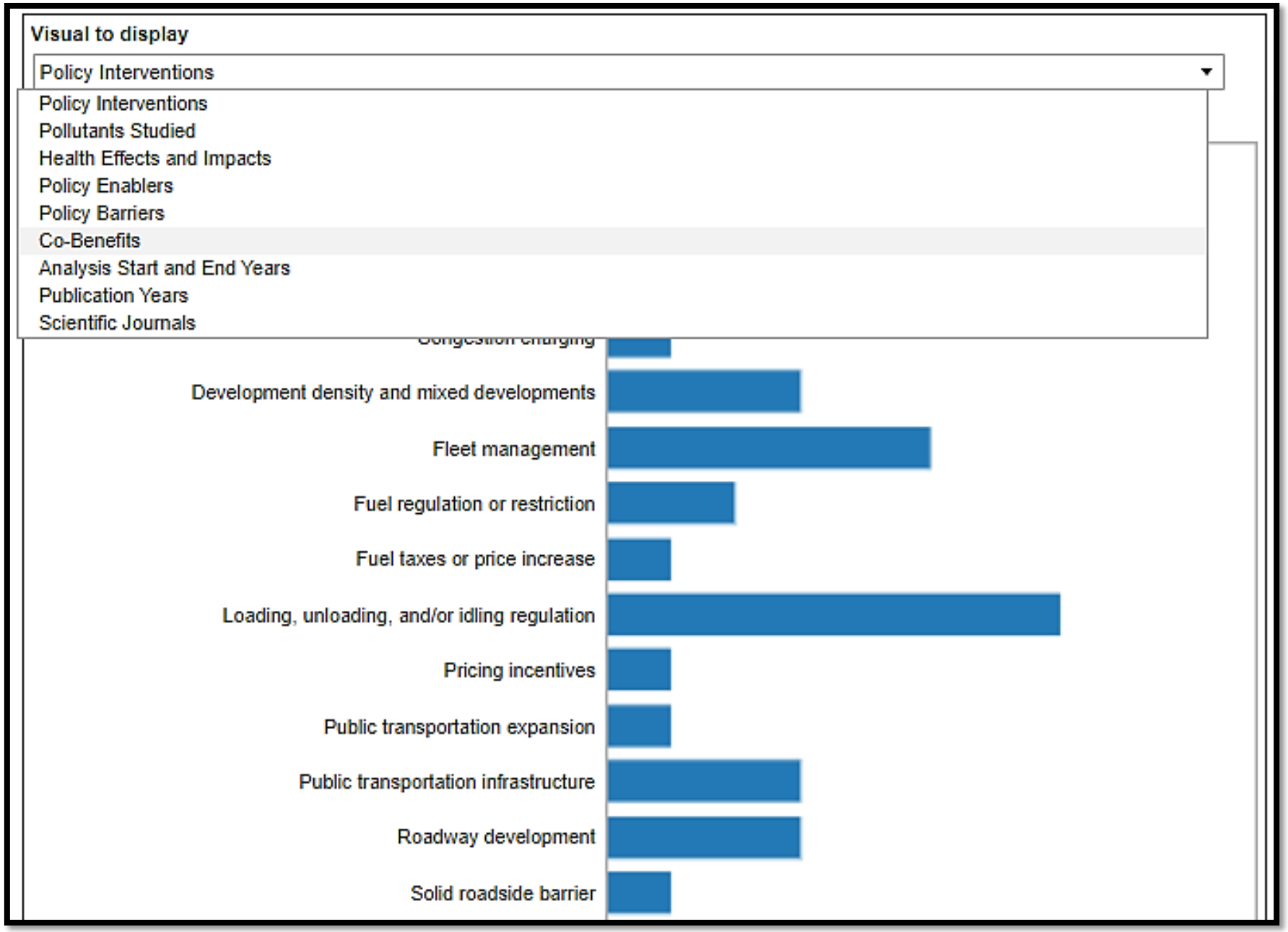
Frequency Studied

1

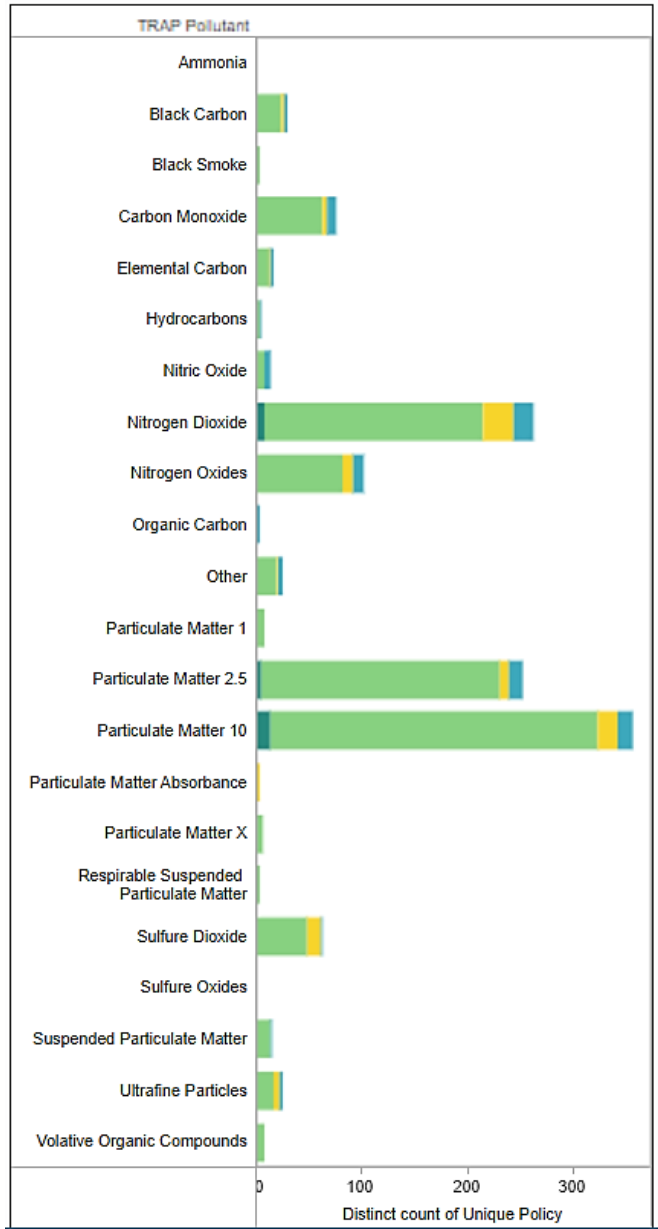
Visual to display

Policy Interventions

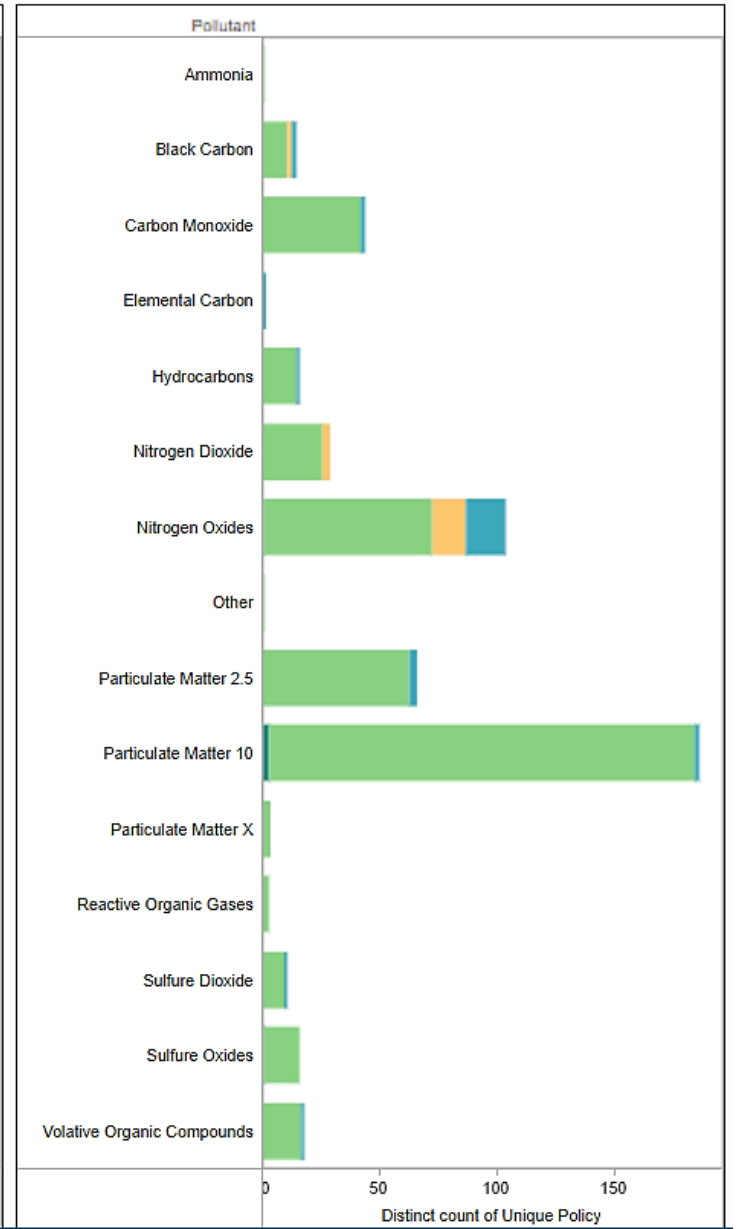



Visual to display
Policy Interventions
Policy Interventions
Pollutants Studied
Health Effects and Impacts
Policy Enablers
Policy Barriers
Co-Benefits
Analysis Start and End Years
Publication Years
Scientific Journals
Development density and mixed developments
Fleet management
Fuel regulation or restriction
Fuel taxes or price increase
Loading, unloading, and/or idling regulation
Pricing incentives
Public transportation expansion
Public transportation infrastructure
Roadway development
Solid roadside barrier

What is the direction of the effect on TRAP?



What is the direction of the effect on Traffic Emissions?

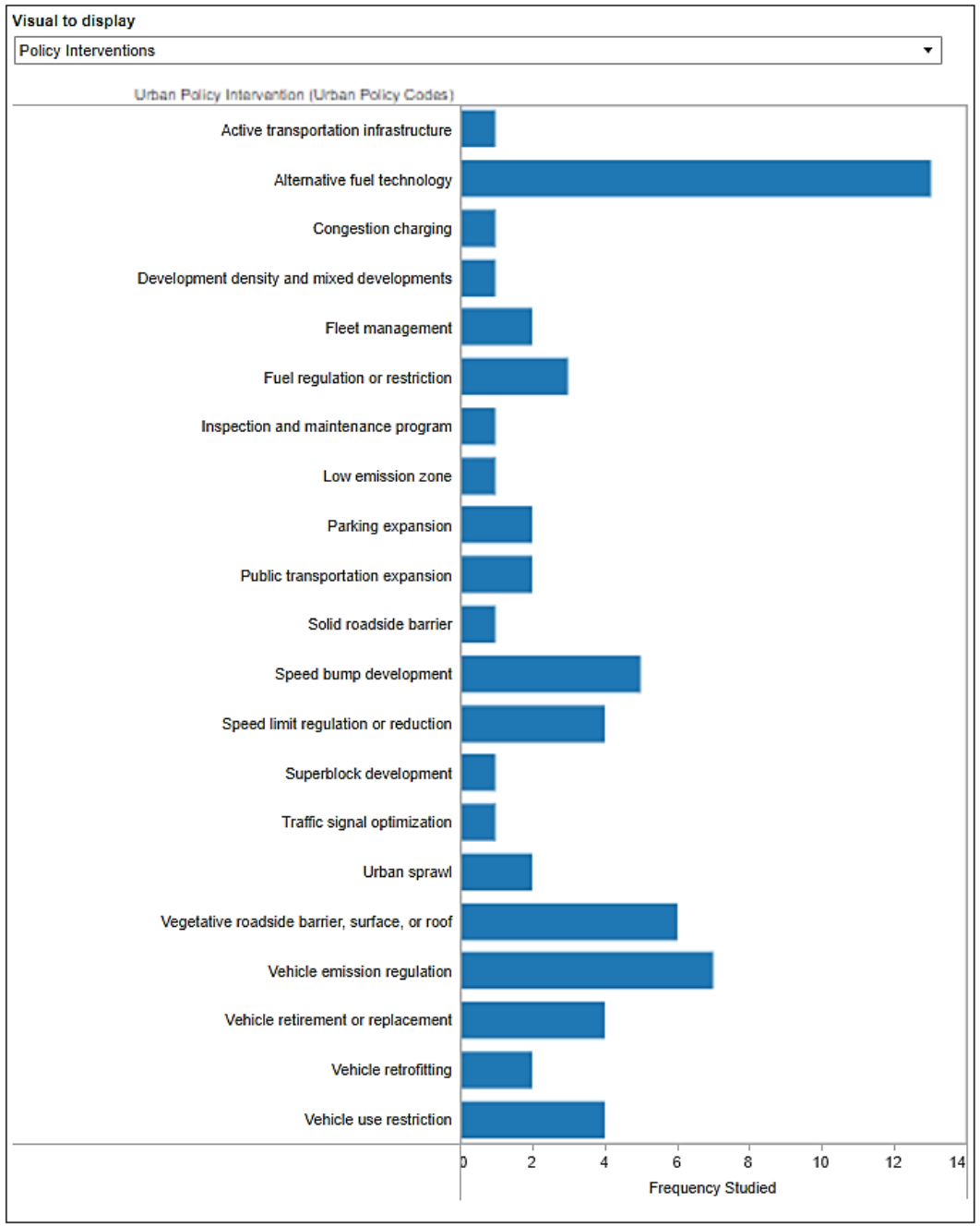


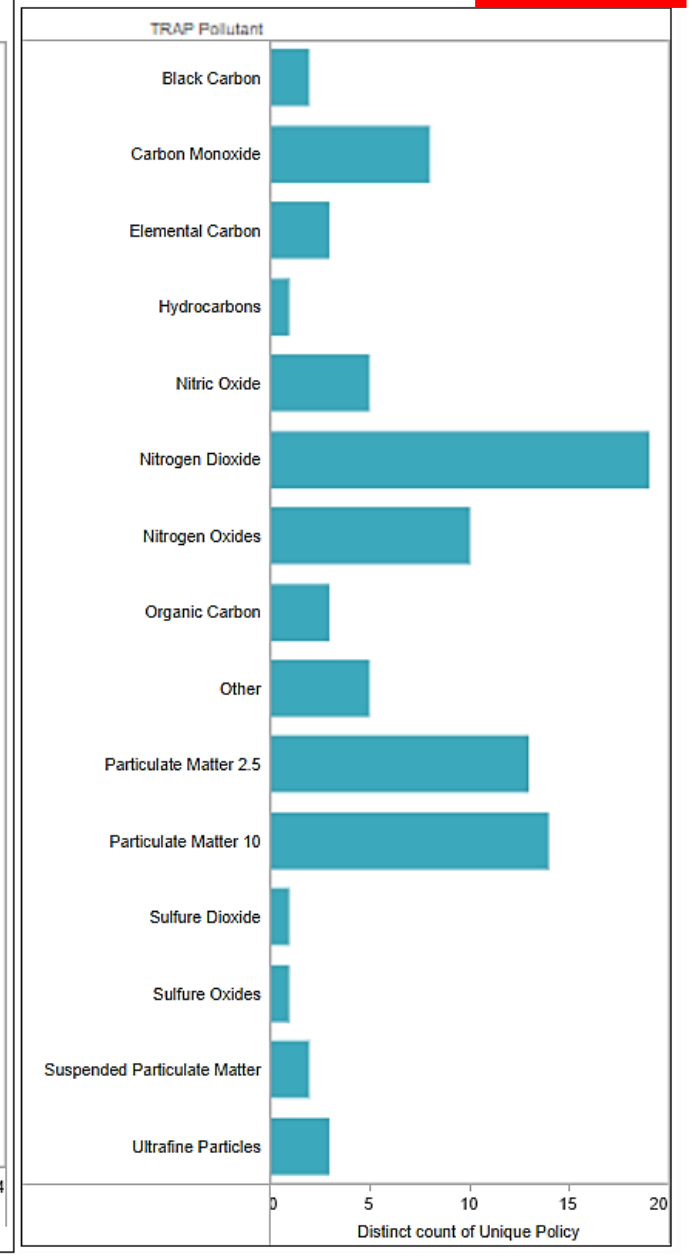
Section 4

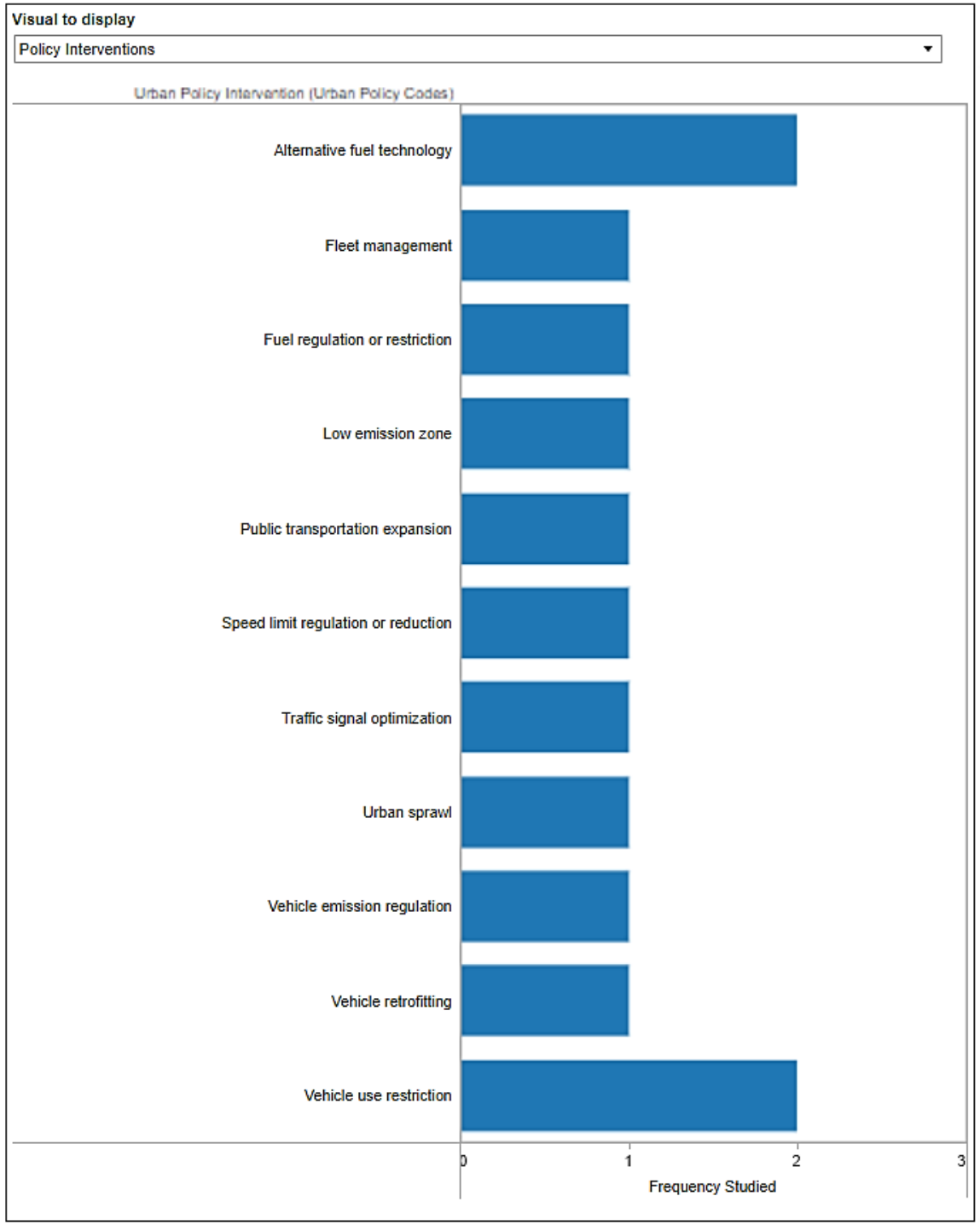
List the articles associated with selected parameters in Sections 1 to 3. Click on a reference to be redirected to the article page.

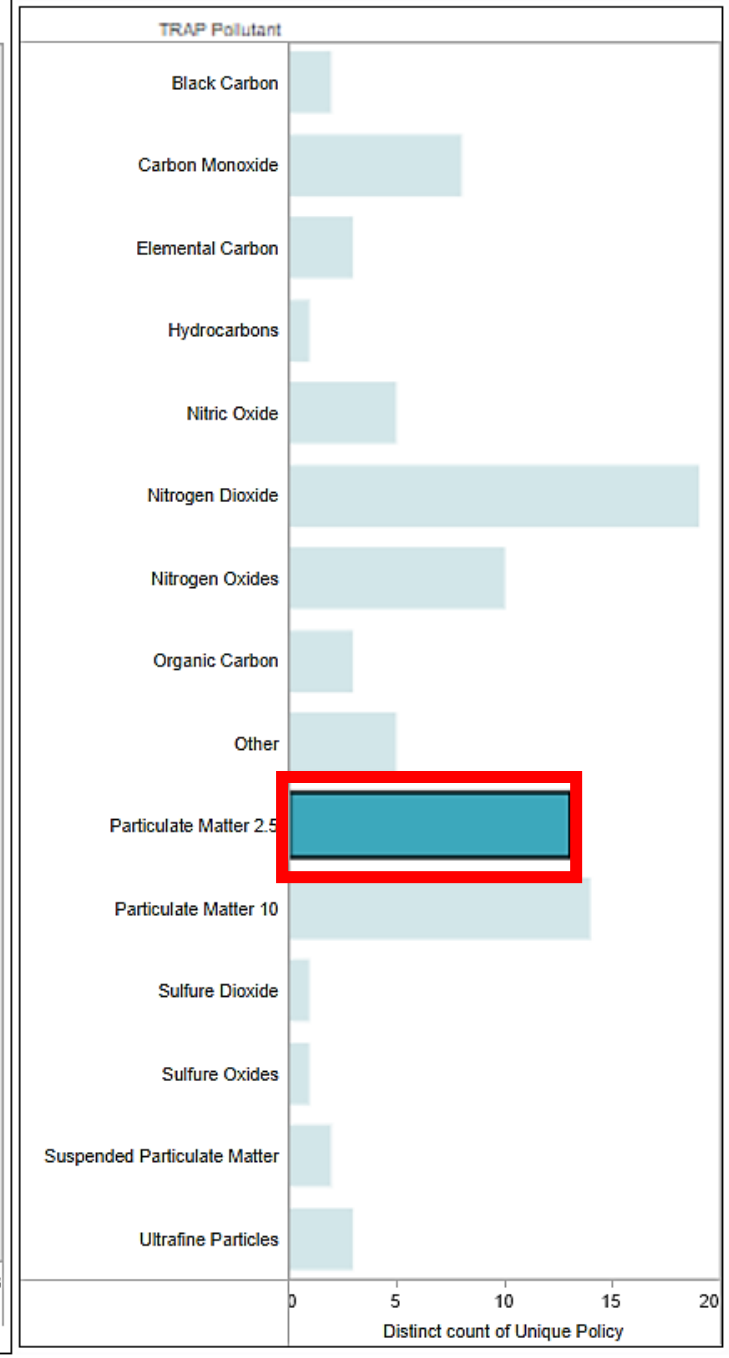
Article List	
Acero et al. 2012	Impact of local urban design and traffic restrictions on air quality in a medium-sized town
Adiang et al. 2017	Projecting impacts of two-wheelers on urban air quality of Douala, Cameroon
Aggarwal and Jain 2015	Impact of air pollutants from surface transport sources on human health: A modeling and epidemiological approach
Alam et al. 2014b	Traffic Emissions and Air Quality Near Roads in Dense Urban Neighborhood: Using Microscopic Simulation for Evaluating Effects of Vehicle Fleet, Travel Demand, and Road Network Changes
Amann et al. 2017	Managing future air quality in megacities: A case study for Delhi
Amato et al. 2010	A comprehensive assessment of PM emissions from paved roads: Real-world Emission Factors and intense street cleaning trials
Arghavani et al. 2019	Numerical evaluation of urban green space scenarios effects on gaseous air pollutants in Tehran Metropolis based on WRF-Chem model
Baik et al. 2012	Effects of building roof greening on air quality in street canyons
Baldasano et al. 2010	Air pollution impacts of speed limitation measures in large cities: The need for improving traffic data in a metropolitan area
Bechle et al. 2017	Does Urban Form Affect Urban NO2 ? Satellite-Based Evidence for More than 1200 Cities
Begum et al. 2006	Impact of Banning of Two-Stroke Engines on Airborne Particulate Matter Concentrations in Dhaka, Bangladesh
Bel and Holst 2018	Evaluation of the impact of Bus Rapid Transit on air pollution in Mexico City

6. Co-benefits: Frequency of policy scenarios that document each co-benefit.
7. Analysis Start and End Years: Frequency of policy scenarios that document each start and end analysis year.



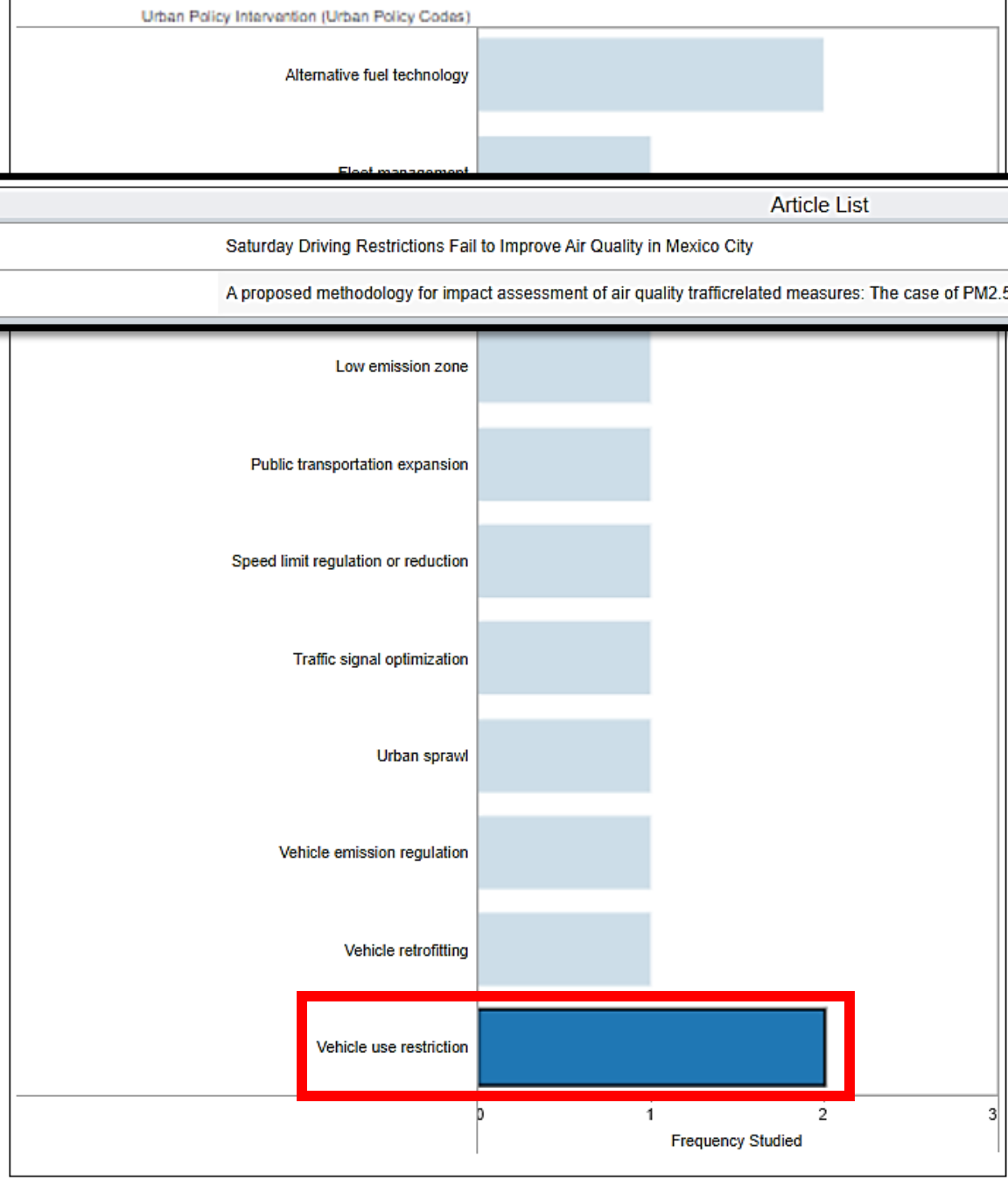


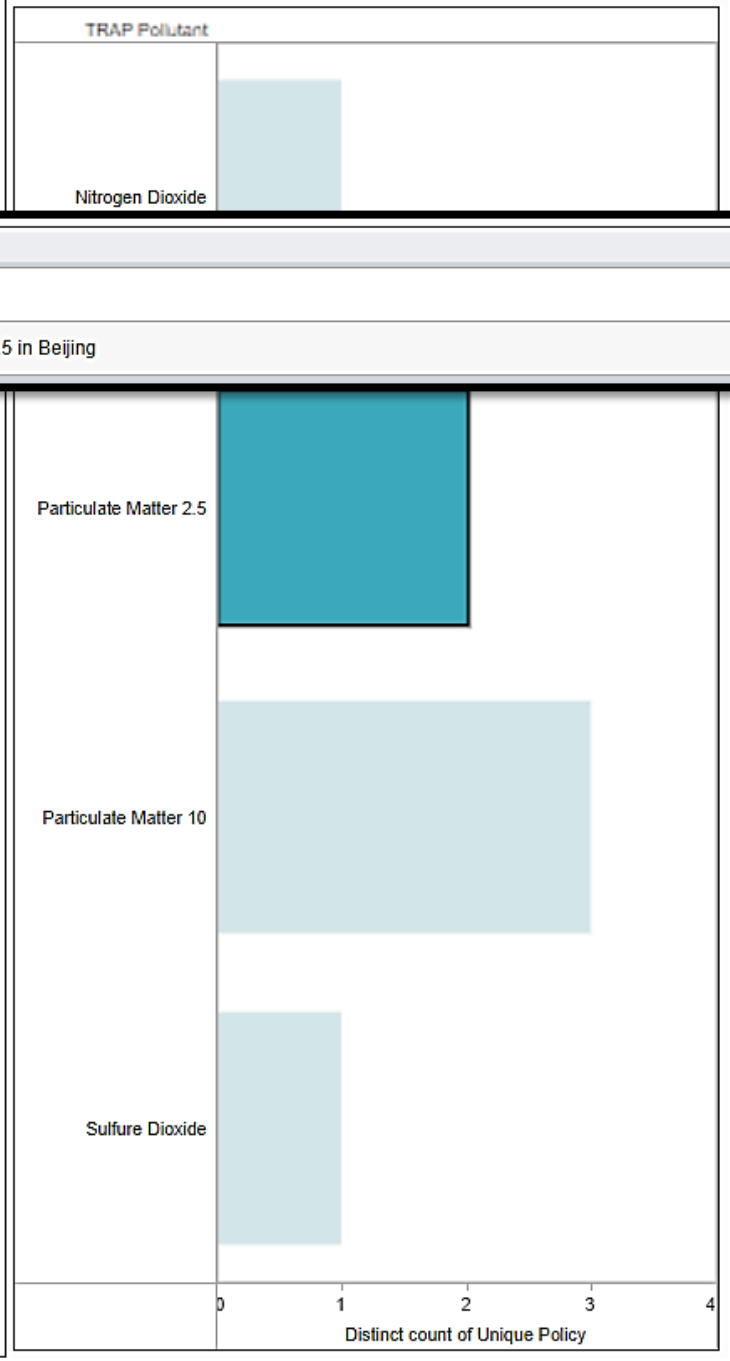

Visual to display
Policy Interventions
Urban Policy Intervention (Urban Policy Codes)
Alternative fuel technology
Fleet management
Fuel regulation or restriction
Low emission zone
Public transportation expansion
Speed limit regulation or reduction
Traffic signal optimization
Urban sprawl
Vehicle emission regulation
Vehicle retrofitting
Vehicle use restriction
0
1
2
3
Frequency Studied


TRAP Pollutant
Black Carbon
Carbon Monoxide
Elemental Carbon
Hydrocarbons
Nitric Oxide
Nitrogen Dioxide
Nitrogen Oxides
Organic Carbon
Other
Particulate Matter 2.5
Particulate Matter 10
Sulfure Dioxide
Sulfure Oxides
Suspended Particulate Matter
Ultrafine Particles
0
5
10
15
20
Distinct count of Unique Policy

Visual to display

Policy Interventions





Article List

Davis 2017	Saturday Driving Restrictions Fail to Improve Air Quality in Mexico City
Fontes et al. 2018	A proposed methodology for impact assessment of air quality trafficrelated measures: The case of PM2.5 in Beijing

SCIENTIFIC REPORTS

OPEN

Saturday Driving Restrictions Fail to Improve Air Quality in Mexico City

Received: 14 November 2016
Accepted: 20 December 2016
Published: 02 February 2017

Lucas W. Davis[1,2]

Policymakers around the world are turning to license-plate based driving restrictions in an effort to address urban air pollution. The format differs across cities, but most programs restrict driving once or twice a week during weekdays. This paper focuses on Mexico City, home to one of the oldest and best-known driving restriction policies. For almost two decades Mexico City's driving restrictions applied during weekdays only. This changed recently, however, when the program was expanded to include Saturdays. This paper uses hourly data from pollution monitoring stations to measure the effect of the Saturday expansion on air quality. Overall, there is little evidence that the program expansion improved air quality. Across eight major pollutants, the program expansion had virtually no discernible effect on pollution levels. These disappointing results stand in sharp contrast to estimates made before the expansion which predicted a 15%+ decrease in vehicle emissions on Saturdays. To understand why the program has been less effective than expected, the paper then turns to evidence from subway, bus, and light rail ridership, finding no evidence that the expansion was successful in getting drivers to switch to lower-emitting forms of transportation.

CO	NO	NO_2	NO_X	O_3	PM_{10}	$PM_{2.5}$	SO_2	Stacked
A. Mean Pollution, All Hours (in logs)								
−0.028*	−0.010	0.008	−0.001	0.011	0.024	0.027	0.011	0.005
(0.014)	(0.027)	(0.012)	(0.016)	(0.020)	(0.020)	(0.025)	(0.054)	(0.016)
B. Maximum Pollution, All Hours (in logs)								
−0.015	0.013	0.015	0.008	0.000	0.045	0.032	0.026	0.016
(0.022)	(0.035)	(0.019)	(0.024)	(0.024)	(0.026)	(0.031)	(0.073)	(0.019)

Table 2. The Effect of Driving Restrictions on Saturday Pollution Levels. Note: This table reports estimates and standard errors from 18 separate regressions all estimated using daily observations from 2005 to 2011. The dependent variable varies across regressions as indicated in the panel and column headings. CO is carbon monoxide, NO is nitric oxides, NO_2 is nitrogen dioxide, NO_x is nitrogen oxides, O_3 is ozone, PM_{10} is large particulates, $PM_{2.5}$ is small particulates, and SO_2 is sulfur dioxide. All dependent variables are measured in logs and all regressions control for a fifth-order polynomial in time, meteorological variables, and fixed effects for week-of-year and day-of-week. Standard errors, in parentheses, are robust to heteroskedasticity and arbitrary serial correlation within week-of-sample. An asterisk indicates statistical significance at the 5% level.

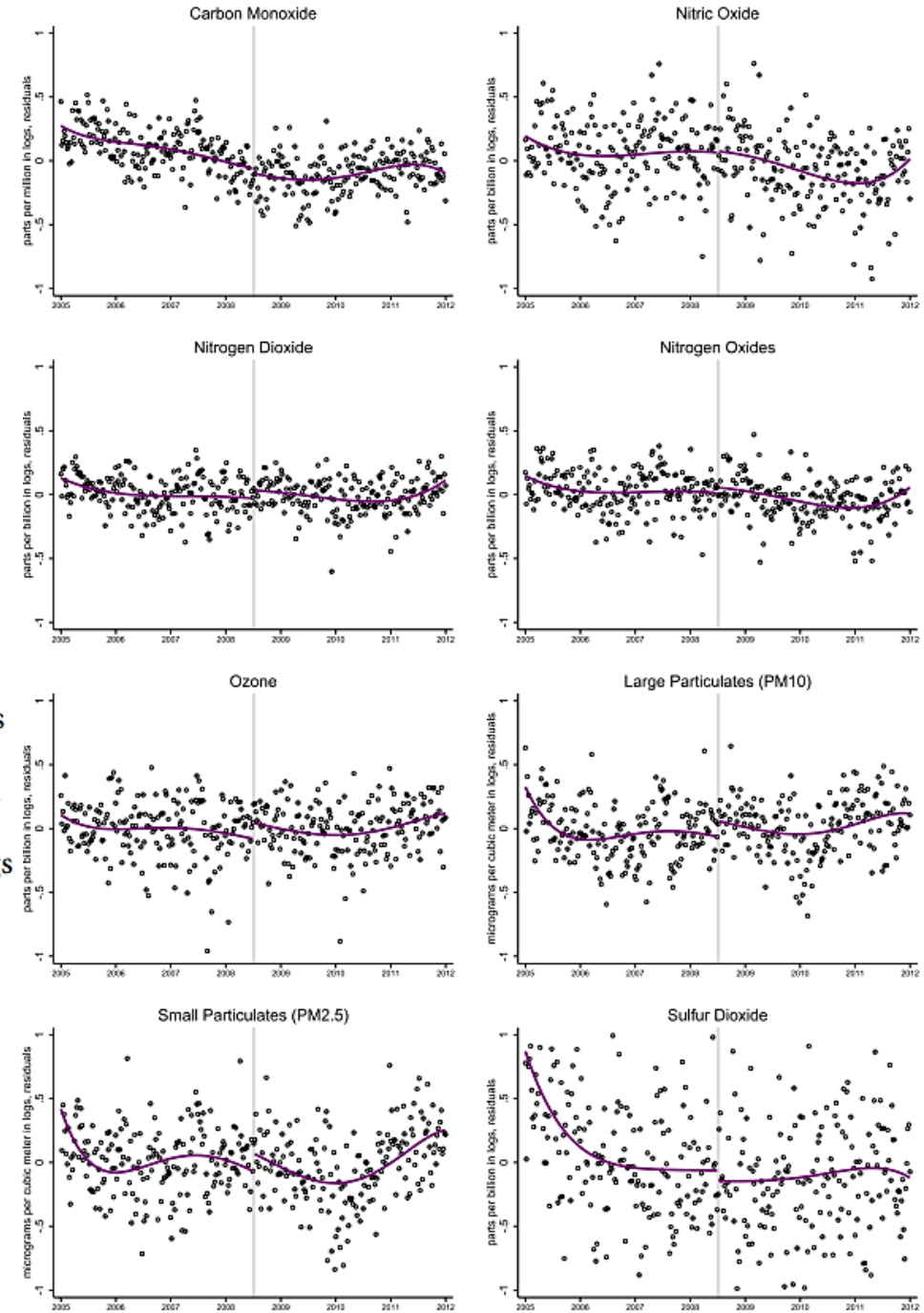


Figure 1. Mean Daily Air Pollution on Saturdays in Mexico City.

- *No information in our database on statistical significance level*
- *It is meant a starting point – not developed/final answers*
- *User engagement and critical assessment is expected (a lot of nuance that summarized info does not do justice)*

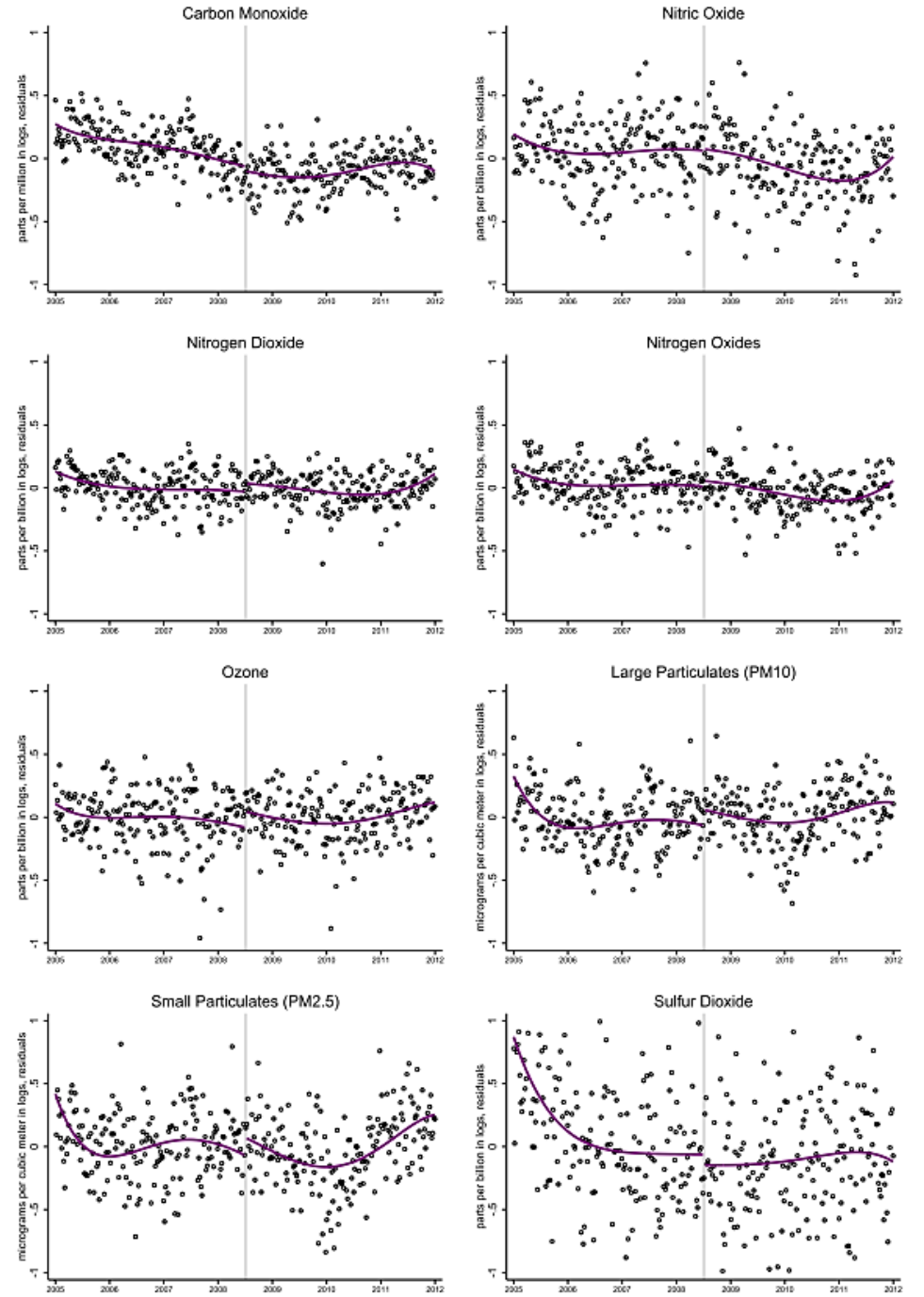


Figure 1. Mean Daily Air Pollution on Saturdays in Mexico City.

We did not…

- Look at effects of other pathways, comparable to – or with larger impact than - air pollution e.g. physical inactivity, motor vehicle crashes (Mueller et al., 2015)
- But if you do → land-use and behavioural policies are very promising!
  - 50-70% statistically significant reduction in injuries in London Low Traffic Neighbourhoods (LTN) (Laverty et al, 2021; Goodman et al., 2021)
  - Physical activity from walking + cycling increased by 2 hours/week in LTN residents after 2 years (Aldred and Goodman, 2021)
  - Modest (5.7-8.9%) NO_2 reduction effect (Yang et al., 2022)

Land-use – 77

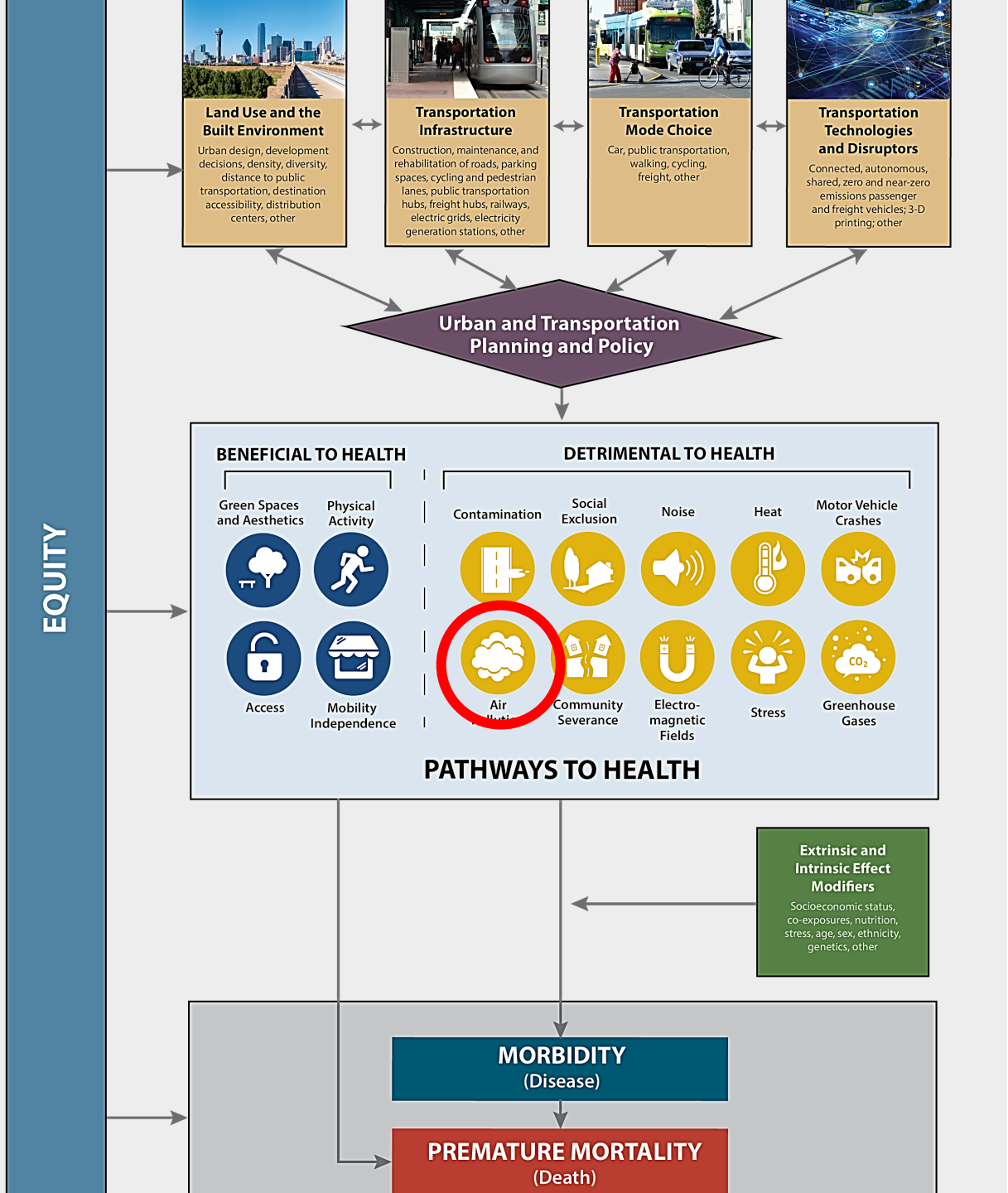
- Development density and mix
- Transit oriented development
- Parking expansion

Behavioural – 116

- Public transport mode shift and promotion
- Active transportation mode shift and promotion
- Flexible working arrangements and ride sharing

Summary

- Created an open access database + tool for researchers, practitioners and policy makers
- Address some of the principal weaknesses in policy generation and selection: e.g. over-reliance on preconceived ideas; a lack of awareness of range of measures available; and their effectiveness, no systemized evidence base
- Limited by:
  - Recency of studies included, up to 2020
  - Potential publication bias
  - Concentration of evidence in high income countries and on certain categories
  - Most studies assess traffic emissions and not exposures and health impacts
  - Some studies lump and simultaneously study ≥ 2 policies in one scenario
  - Not assessing other pathways (each can be a SEM of its own!)



Glazener et al., 2021

Thank you!

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