Integrating health and economic benefit analysis in air quality management in Mexico City

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August 6, 2020

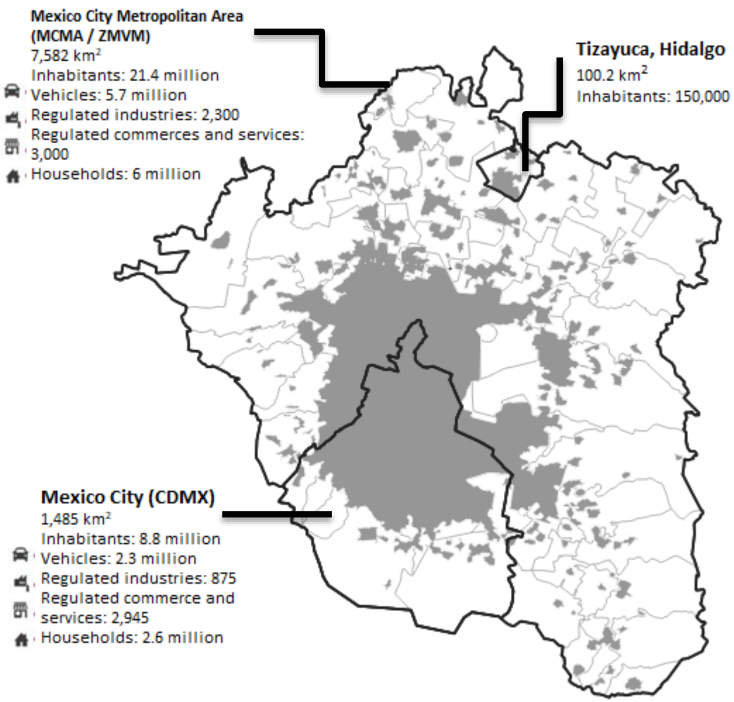
GOBIERNO DE LA CIUDAD DE MÉXICO

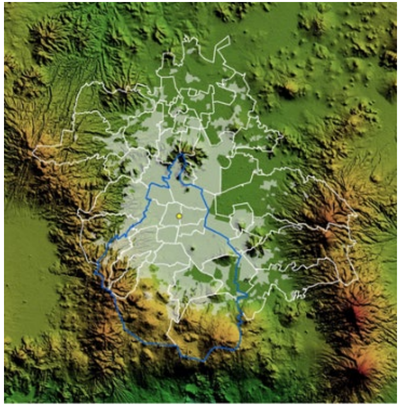
CIUDAD INNOVADORA Y DE DERECHOS

Outline

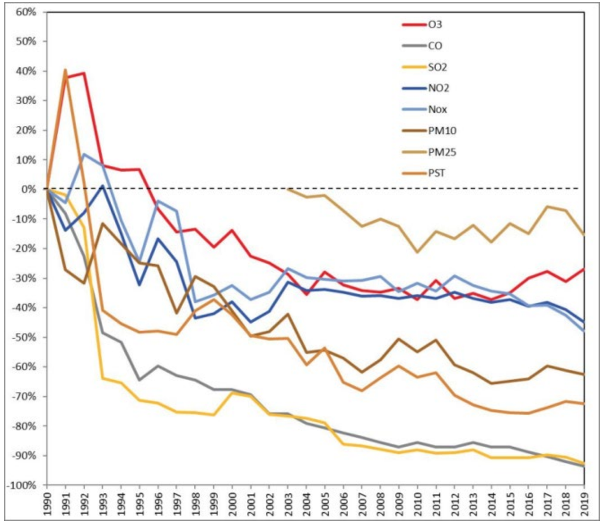
1. Context: The Mexico City Metropolitan Area (MCMA)
2. Integrating health in air quality management in the MCMA
3. Health and economic benefit analysis in the MCMA
4. Examples of HIA in the MCMA
5. Recommendations for other cities

1. Context – The Mexico City Metropolitan Area (MCMA)





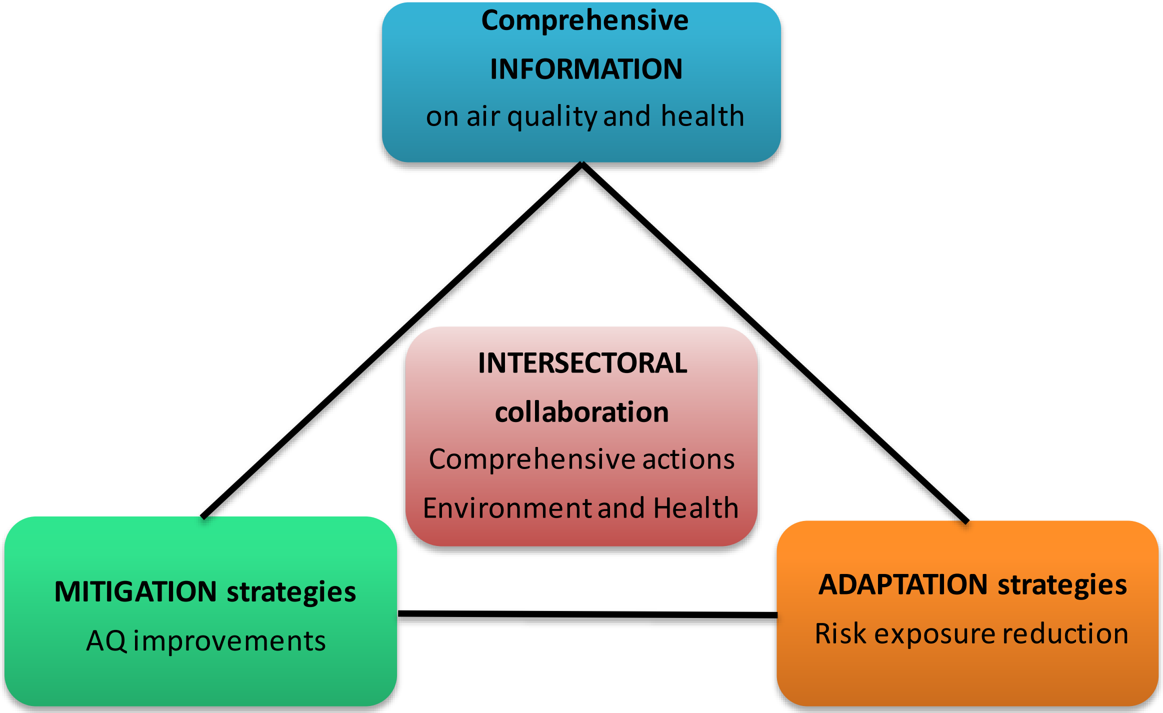
1990 – 2019 trend



MCMA (2018)

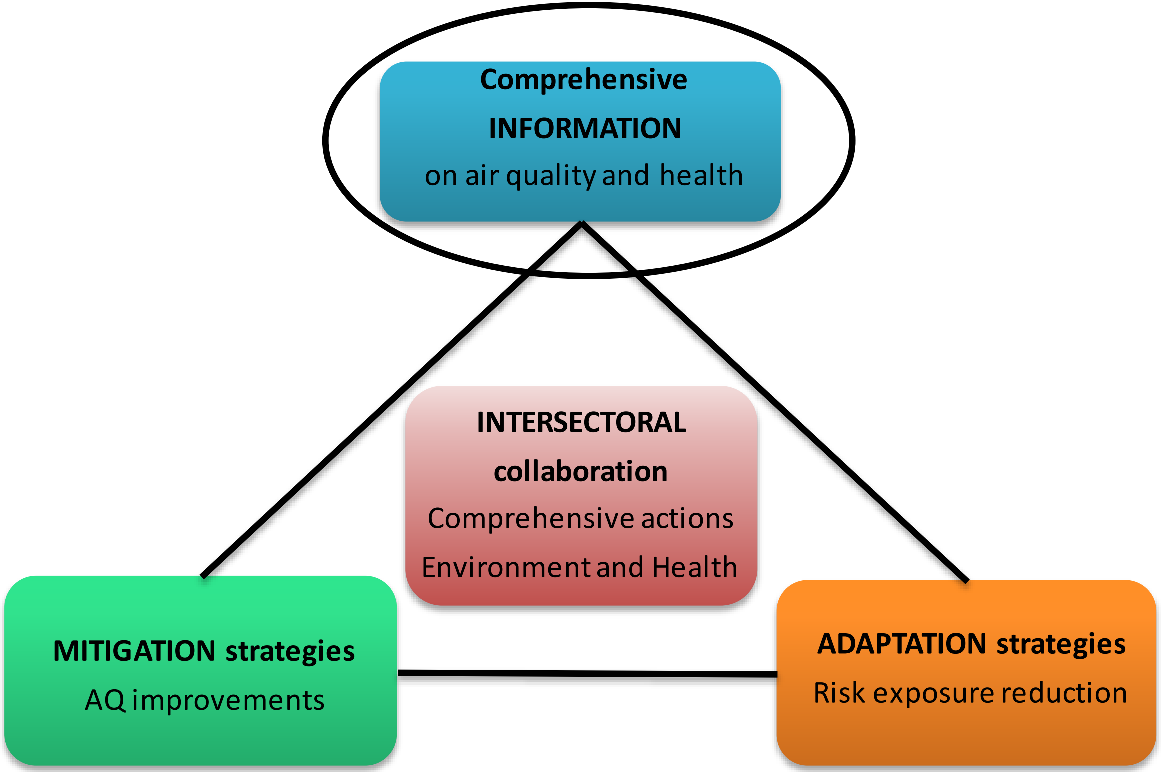
Pollutant	Averaging Metric	2018	WHO AQG	MEX AQS	Units
$PM_{2.5}$	Annual mean	27.7	10	12	mg/m^3
$PM_{2.5}$	24 h mean	70	25	45	mg/m^3
O_3	8 h max	120	50	70	ppb

2. Integrating HEALTH in AQ management in Mexico City



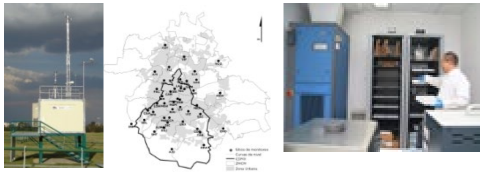
2. Integrating HEALTH in AQ management in Mexico City

INFORMATION

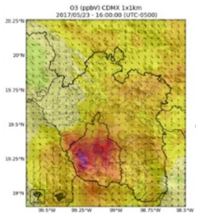


National AQ standards and WHO AQ guidelines

AQ monitoring

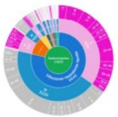


AQ modeling & scenarios



Health impact assesment (HIA)

Epidemiological surveillance system



Research

2. Integrating HEALTH in AQ management in Mexico City

MITIGATION

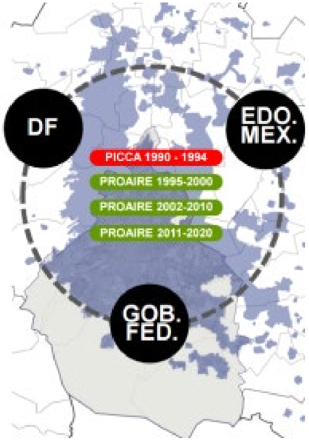
Comprehensive INFORMATION
on air quality and health

INTERSECTORAL collaboration
Comprehensive actions
Environment and Health

MITIGATION strategies
AQ improvements

ADAPTATION strategies
Risk exposure reduction

Air quality improvement programs (ProAire) and emission inventories

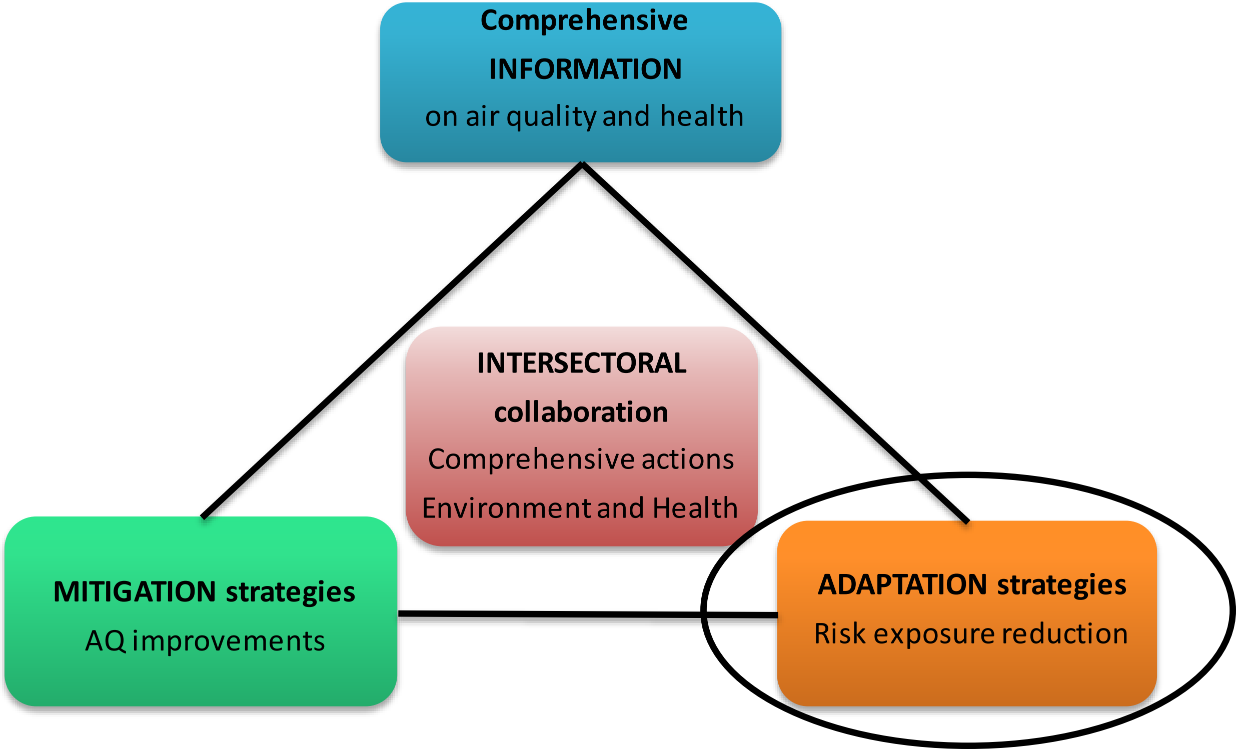


Health impact assesment (HIA)

BenMAP

2. Integrating HEALTH in AQ management in Mexico City

ADAPTATION

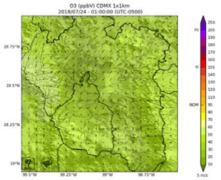


Protocolo for air pollution episodes

Early warning system for wildfires

Low cost sensor network
Hot spots & microenvironmens

Air quality forecast



Communication and engagement strategy

AQ app - push notifications

www.aire.cdmx.gob.mx

@Aire_CDMX

Engage health care providers

AQ flag program in schools

US EPA 2019

IRPS

BenMAP

Translate and communicate HIA results

2. Integrating HEALTH in AQ management in Mexico City

INTERSECTORAL COLLABORATION

Comprehensive INFORMATION
on air quality and health

INTERSECTORAL collaboration
Comprehensive actions
Environment and Health

MITIGATION strategies
AQ improvements

ADAPTATION strategies
Risk exposure reduction

HEALTH IN ALL POLICIES

Multi-stakeholder Technical Advisory Group on Air Pollution for Mexico City

Translate and communicate HIA results

BenMAP

Best practices

Capacity buidling

GOBIERNO DE LA CIUDAD DE MÉXICO
SECRETARÍA DE SALUD
Instituto Nacional de Salud Pública
Berlin
INER
CIDE
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
PAHO
Pan American Health Organization
World Health Organization
C40 CITIES
EDF ENVIRONMENTAL DEFENSE FUND
Finding the ways that work
WORLD ATHLETICS

3. Benefit analysis of AQ improvements in the MCMA using the BenMAP-CE software

Main goal

Integrate health impact assessment into AQ management in Mexico City as a key tool to guide policy design, implementation and evalution.

Estimating health and economic benefits of AQ improvements

The process

1. What specific policy **questions** would be useful to answer?
2. What are the **steps** to calculate health impacts?
3. What **data** is needed to estimate benefits?
4. Which **institutions** could **participate** to strengthen the project?
5. Which are the potential data **sources** and how to **process** data inputs?
6. Which **options** to select when **running the analyses** in BenMAP?
7. How to be **transparent** and allow analysis **replicability**?
8. How to **translate and communicate results** to key stakeholders?
9. Which **future analyses** should we consider?
10. How to **integrate health impact analysis in AQ management**?

Estimating health and economic benefits of AQ improvements
Policy questions

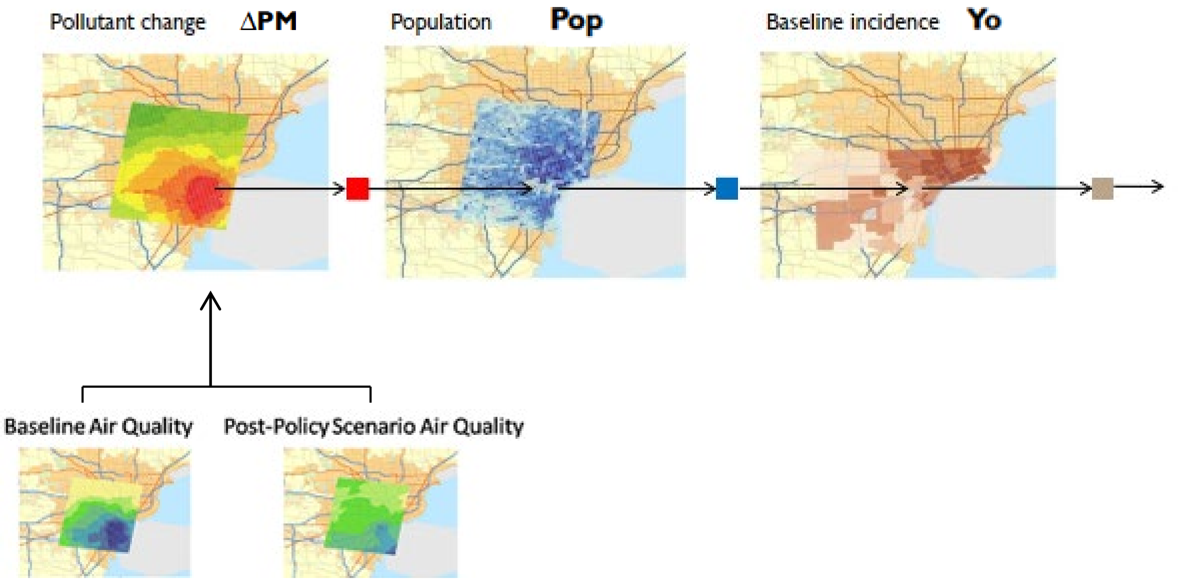
1. What are the **current** health and economic effects of air pollution in the MCMA?
2. How have changes in air pollution **contributed** to changes in health outcomes in the MCMA (**ProAire 2010-2020**)?
3. What are the health and economic benefits of attaining the national **AQ standards, the WHO AQG** and a **15% reduction** in air pollution in the MCMA?
4. What are the health and economic benefits in 2024 and 2030 of implementing the **next ProAire** (2021-2022)?

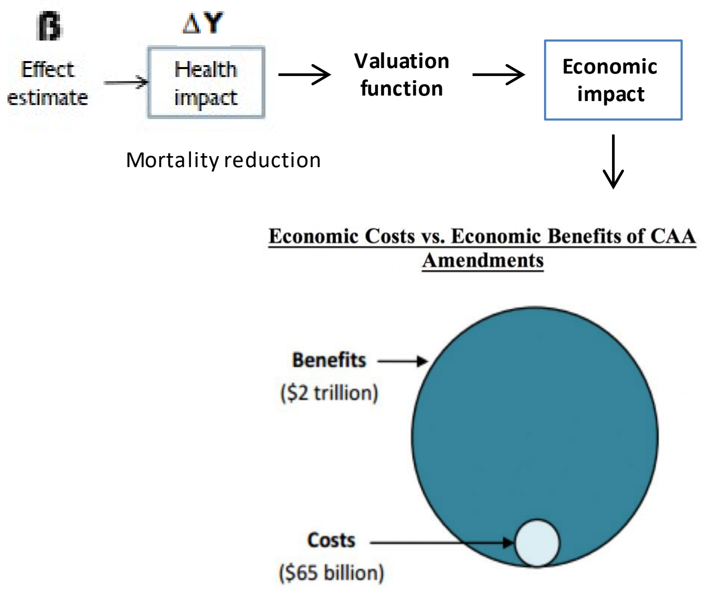
Main focus on **PM2.5 and ozone**

Estimating health and economic benefits of AQ improvements

Steps to calculate health and economic impacts

$$\Delta Y = Yo\,(1 - e^{-\beta \Delta PM}) * Pop$$

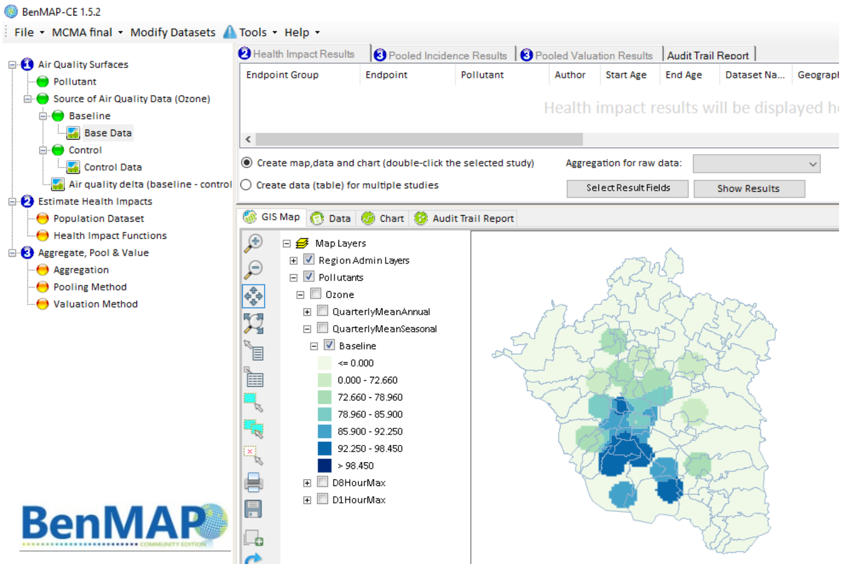




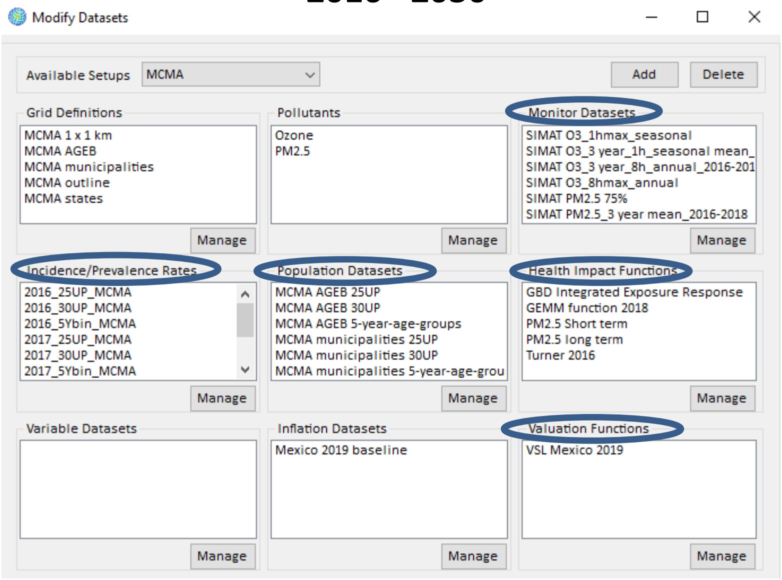
US EPA 2019

Estimating health and economic benefits of AQ improvements

Data inputs



2016 - 2030



Aim for the **finest resolution and disaggregation possible.**

Develop a setup for Mexico City with data for several years.

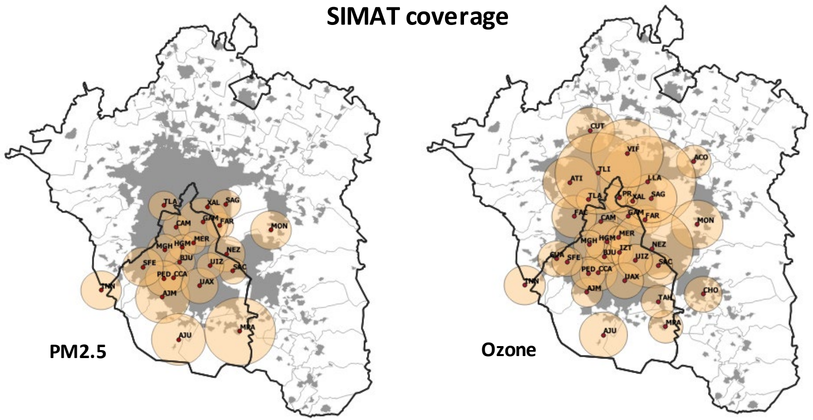
a. Pollutant change /AQ data

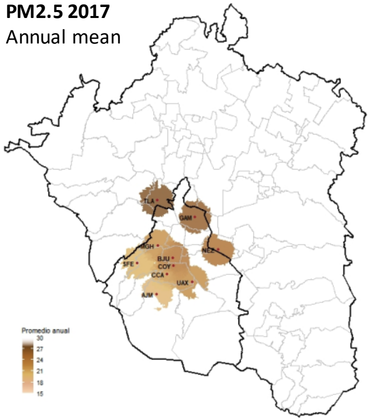
MONITOR DATA

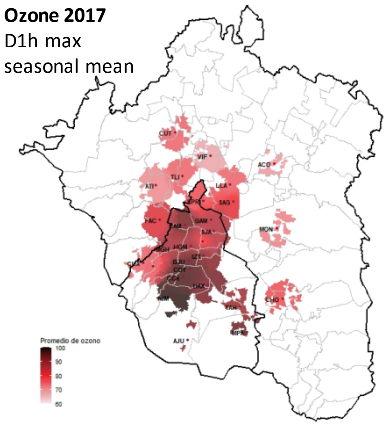
- **Years**: 2016 to 2019, 2016-2018
- **Source**: SEDEMA´s AQM network (SIMAT)
- **Sufficiency criteria**: 75% valid data
- **Datasets**: daily data for **PM2.5** (24 h mean) and **ozone** (1 and 8 h max)
- **Coverage**: varies by station
- **Counterfactual scenario:** Background concentration / NOM/ WHO AQG

Decisions within BenMAP

- **Grid definition:** AGEB (Basic geostatistical area) or 1 x 1 km.
- **Interpolation methods**: Voronoi neighbour averaging (VNA) + inverse distance squared weighted (IDW^2).
- **Maximum neighbour distance:** 5 km for PM2.5 and 5.5 km for ozone.



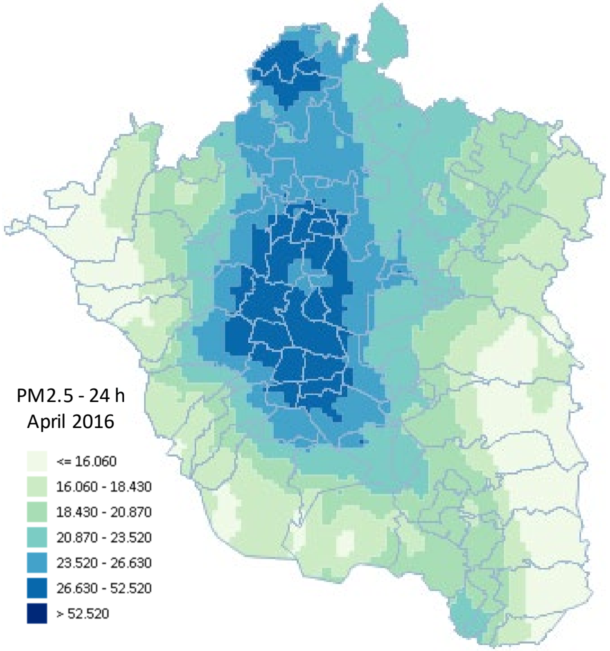




a. Pollutant change /AQ data

MODEL DATA

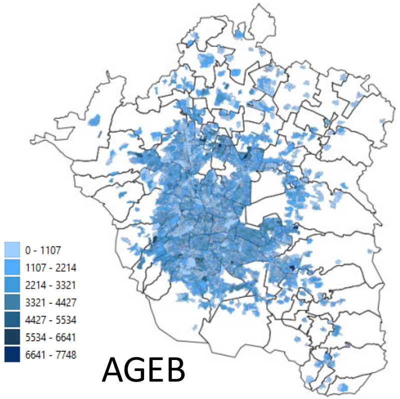
- **Resolution:** 1 x 1 km
- **Coverage**: the whole of the MCMA
- **Datasets**: daily data
  - **PM2.5:** 24 h mean
  - **Ozone:** 1 and 8 h max
- **Periods**: several scenarios for:
  - April 2016 (current ProAire)
  - 4 weeks in 2016 for the next ProAire (**assumption**: representative of the year)
  - ...
- **Source**: SEDEMA

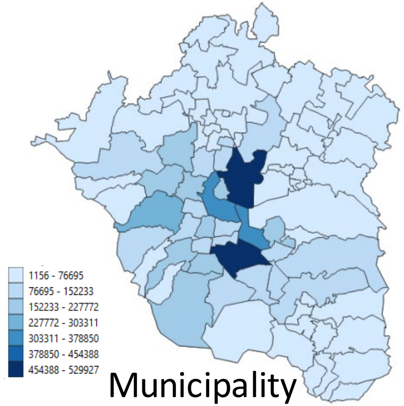


b. Population data

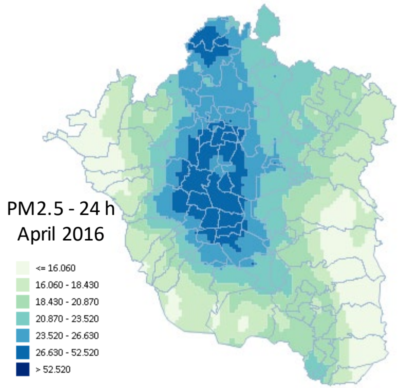
- **Years**: 2016-2018, 2024 and 2030.
- **Age groups:** 0-0, 1-4, 5-9…65+.
- **Sources**:
  - The National Institute of Statistics and Geography´s (INEGI) **2010 Census (AGEB).**
  - The National Population Council´s (CONAPO) **population projections 2015-2030** (municipality).
- **Resolution**:
  - Basic geostatistical area (**AGEB**) level.
  - Municipality level.
- **Combining datasets** for achieveing the finest resolution.

Population



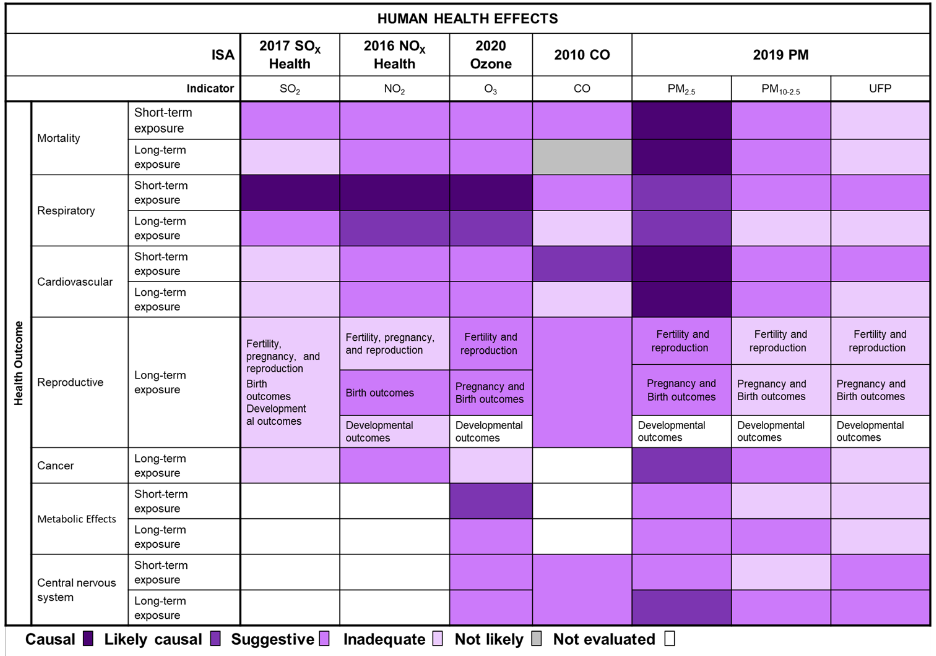


Air quality



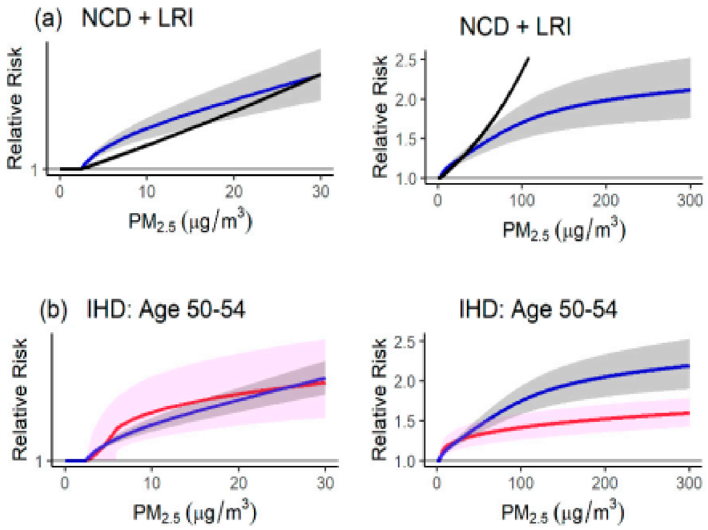
c. Baseline incidence

- **Years**: 2016-2018, 2020, 2024 and 2030.
- **Resolution**: municipality level.
- All-**cause,** non-accidental and cause-specific **mortality** :
  - Ischaemic heart disease
  - Stroke
  - COPD
  - Lung cancer
  - Lower respiratory infections
- **Age groups**: 0-0, 1-4, 5-14, 15-24, 25-34, 35-44, 45-54, 55-64 and 65+.
- **Sources**: INEGI (observed mortality) and CONAPO (mortality projections).
- Projected to achieve a **finer disaggregation**: cause-specific mortality.



Luben T (2020)

d. Effect estimates



Relative risk by PM2.5 concentrations below 30 μg/m3 (left side) and over the global concentration range (right side): Adapted from Burnett et al (2020)

Black: Log-linear
Red: Integrated exposure response model (IER)
Blue: Global exposure mortality model (GEMM)

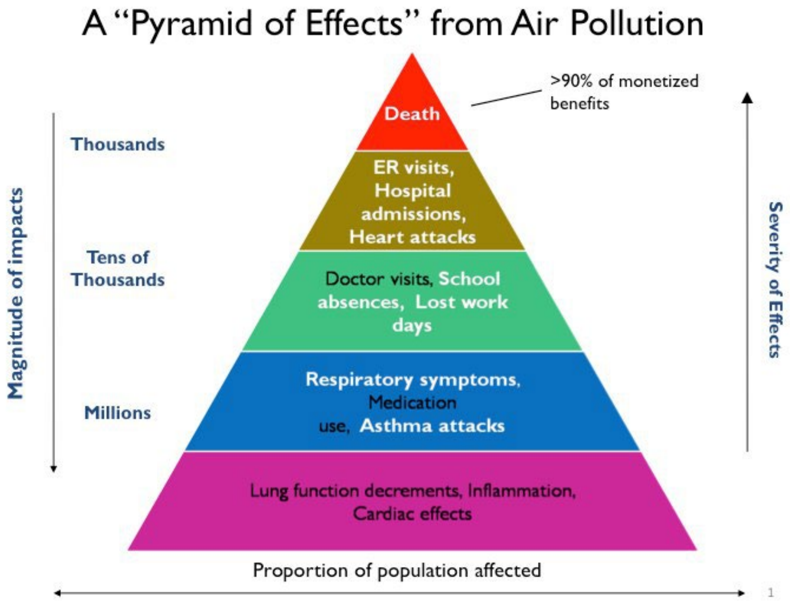
Health impact functions for causes of death linked to CHRONIC exposure to air pollutants

Air pollutant	Cause	Author and type of study	Risk ratio per 10 μg/m3 of PM2.5 or 10 ppb of O3	Age group
PM2.5	All-cause	Chen & Hoek (2020) Meta-analysis	1.08 (1.06–1.09)	0-99
	Ischemic heart disease (IHD)		1.16 (1.10–1.21)	
	Stroke		1.11 (1.04–1.18)	
	Chronic obstructive pulmonary disease (COPD)		1.11 (1.05–1.17)	
	Lung cancer (LC)		1.12 (1.07–1.16)	
	Lower respiratory infections		1.16 (1.01–1.34)	
	Non-Accidental and IHD, stroke, COPD, LC, LRI	Burnett et al (2018) Glonal exposure mortality model (GEMM)	Non-linear	25+
	IHD, stroke, COPD, LC, LRI	Cohen et al (2017) Integrated exposure response model (IER)	Non-linear	30+
Ozone	Respiratory / COPD	Jerret et al (2009) Cohort study in the US	1.029 (1.010-1.048) Daily 1 h max - Seasonal mean	30+
		Turner et al (2016) Cohort study in the US	1.12 (1.08 – 1.16) Daily 8 h max - Seasonal mean	30+

Health impact functions for causes of death linked to ACUTE exposure to air pollutants

Air pollutant	Cause	Author and type of study	Percentage change per 10 μg/m3 of PM2.5 or 5 ppb of O3	Age group
PM2.5 (24 h mean)	All-cause (non-external)	Liu et al (2019) Multi-city time series study	499 cities: 0.68 (0.59 to 0.77) Mexico: 1.29 (0.21 to 2.39)	All ages
	Cardiovascular disease		499 cities: 0.55 (0.45 to 0.66)	
	Respiratory disease		499 cities: 0.74 (0.53 to 0.95)	
Ozone (8 h max)	All-cause mortality	Orellano et al (2020) Meta-analysis	0.43 (0.34–0.52).	All ages
	All-cause mortality	Di et al (2017) Cohort study in the US	0.28 (0.21-0.31)	All ages
	Cardiopulmonary disease	Romieu et al (2013) Multi-city time series study Values for Mexico City:	0.12 (0.01 to 0.22)	≥65
	Cardiovascular disease		0.15 (0.03 to 0.27)	
	Stroke		0.28 (0.03 to 0.53)	
	Total mortality (natural and non-external)	Vicedo-Cabrera et al (2020) Multi-location time series study	406 cities: 0.18 (0.12 to 0.24)	All ages

e. Economic valuation – Value of statistical life

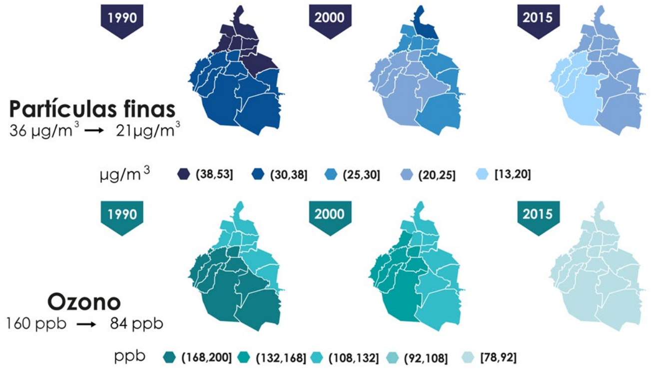


US EPA 2019

Mexico

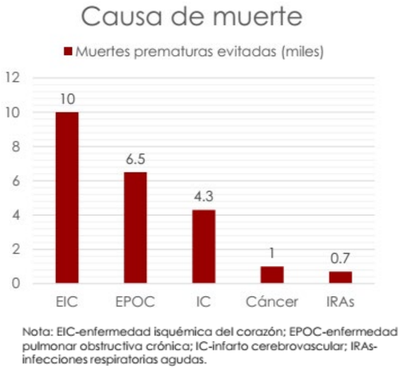
Original country	Original VSL in USD	Year	Source	VSL in 2019 (USD PPP) if elasticity is 1:
USA	6,300,000	2007	Viscusi (2004)	3,062,307
USA	9,300,000	2014	US DHHS (2016)	3,712,151
OECD	3,000,000	2005	OECD (2012)	2,245,057
OECD	3,830,000	2011	OECD (2012)	2,414,191
Varios	5400000	2000	Kochi et al. (2006)	3,684,591
Brazil (Sao Paulo)	1,306,941	2003	Ariagoni et al. (2009)	1,414,987
Chile	4,625,958	2006	Parada et al. (2013)	8,030,108
México	227,947 USD PPP	2010	De Lima (2019)	322,642
México	325,000 USD PPP	2002	Hammitt & Ibarraran (2006)	650,358

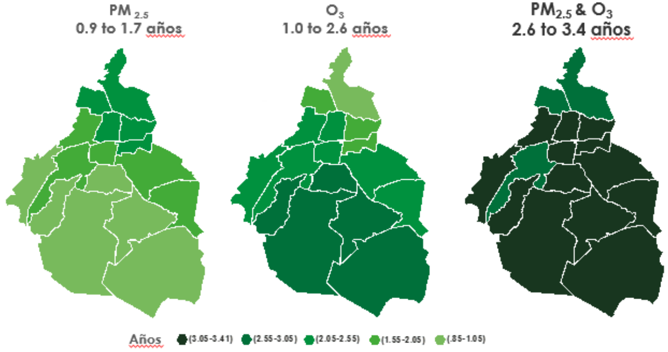
4. Examples of HIA in Mexico City and the MCMA



Harvard – SEDEMA (2018)

AQ improvements in **Mexico City** in the period from 1990 to 2015 avoided 22 thousand premature deaths (PM2.5: 18,000; Ozone: 4,000) and led to an increase in life expectancy of 3.2 years.





However, 7,700 premature deaths occur every year due to air pollution in the **Mexico City Metropolitan Area (MCMA)** with a cost of 12,699 million USD.

Trejo et al (2018)

5. Recommendations for other cities

- Develop HIA to inform decision making.
- **Start with a general/basic analysis** and then go further in your analysis.
- Reach to and **collaborate** with local, national and international **institutions**.
- Work hand-in-hand with the **AQ monitoring/ modeling / data analysis team** at your institution, especially when developing complex and multiple datasets.
- **Document your analysis** to ensure transparency and allow replicability.
- **Translate and communicate results** to citizens and decision-makers.

Special thanks

Data scientists:

Alberto Aguilar and Alejandro Ruiz

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Thank you

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