

On the Short-term Impact of Pollution: The Effect of PM 2.5 on Emergency Room Visits

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Introduction

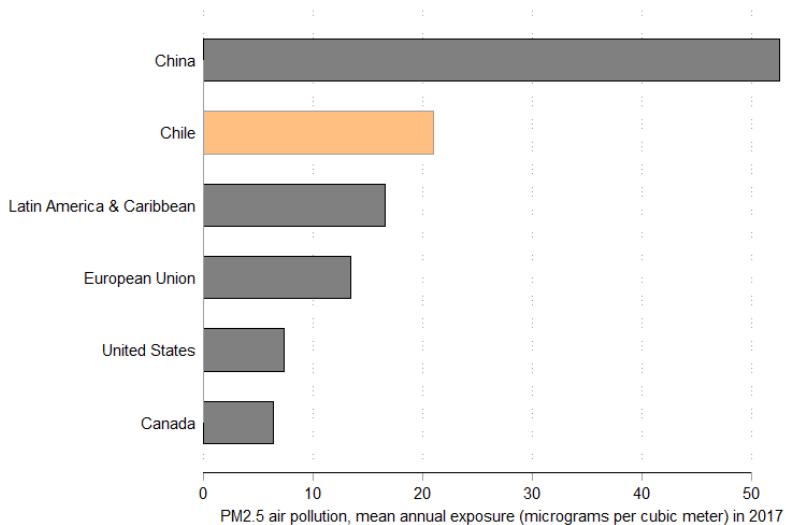
Air pollution and fine particulate matter (PM 2.5)

- Air pollution is a public policy concern because it can have negative effects on human health.
- An important source of air pollution is **fine particulate matter** (PM 2.5)
 - Tiny particles with diameters smaller than 2.5 microns.
 - They come from outdoor sources (vehicle exhausts, burning of fuels, and forest and grass fires) and indoor sources (tobacco smoke, cooking, and operating fireplaces)
 - They can get deep into the lungs or into the bloodstream causing a variety of health problems such as decreased lung function, aggravated asthma, irregular heartbeat, etc.

Effects of exposure to PM 2.5 on health

- Recent evidence of negative effects of exposure to PM 2.5 on health in developed countries
 - Deryugina et al. (AER, 2019), Ward (CJE, 2019), and Godzinski and Castillo (JEEM, 2021).
- There is scarce evidence, however, for developing countries that have higher levels of air pollution

PM 2.5 air pollution in selected countries and regions



This paper

- We study the effect of PM 2.5 exposure on Emergency Room (ER) visits in Chile.
- Identification strategy: IV estimation using wind speed and direction.
- We present results for different age groups: < 1 , 1-4, 5-14, 15-64, 65+.
- We also study heterogeneous effects by different sources of emissions: residential burning of wood.

Contributions

- Chile → higher level of pollution than most developed countries.
 1. Other papers focus on USA or Canada → average $< 10 \mu\text{g}/\text{m}^3$
 2. Chile → average $25 \mu\text{g}/\text{m}^3$ (above $10 \mu\text{g}/\text{m}^3$ considered not safe (WHO))
- This can explain why our findings differ from previous papers
 1. We find a larger effect than Deryugina et al. (AER, 2019) for the US.
 2. We find significant effects not only on children or the elderly but also in the middle age population.
- Unit of analysis is hospital → reduce measurement error
- Exploit geographical variation to study the effect of PM 2.5 from residential wood burning emissions.

Literature review

- Effect of PM 2.5 on health outcomes for developed countries.
 - Deryugina et al. (AER, 2019) for US, Ward (CJE, 2019) for Canada, and Godzinski and Castillo (JEEM, 2021) for France.

→ We estimate the effect for a country with higher levels of air pollution
- Effect of PM 2.5 on health outcomes for developing countries.
 - Gong et al. (WP, 2019) estimates the causal impact of long-term exposure to PM 2.5 on mortality in China.

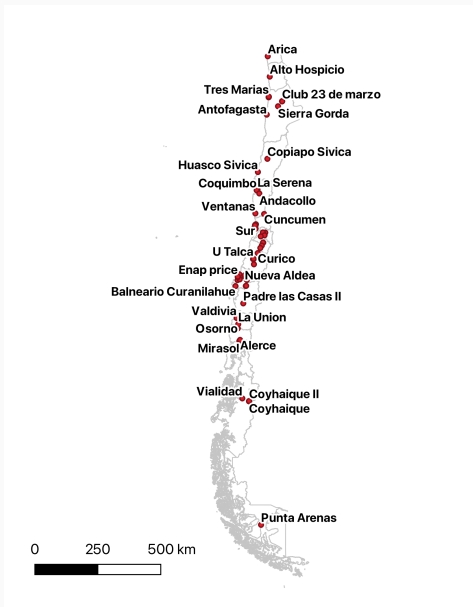
→ We estimate the short-term effect and use a different identification strategy
- Effect of air pollution on health outcomes in Chile
 - Mullins and Bharadwaj (AJAE, 2015), Bharadwaj et al. (JAERE, 2017), Rivera et al. (WP, 2021), and Ruiz-Tagle (WP, 2019)

→ They focus on different pollutants, use data only for Santiago, or rely on a different identification strategy

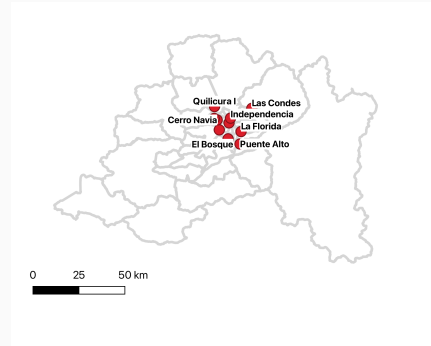
Data

Data: Air pollution

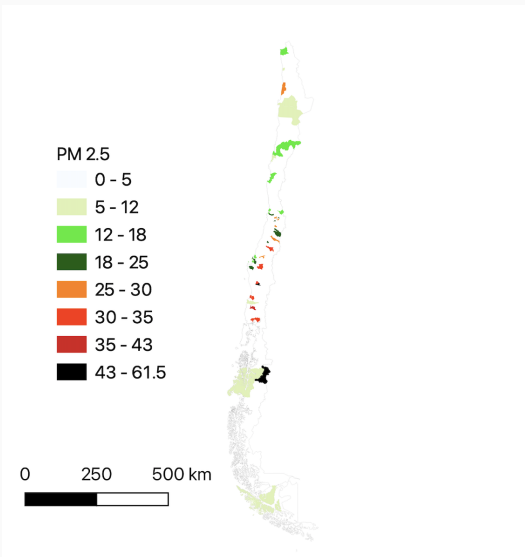
- **Source:** Air Quality National Information System (SINCA) of the Ministry of Environmental Affairs in Chile.
- **Variables:**
 - PM 2.5 (in $\mu g/m^3$),
 - O_3 (in parts per billion),
 - CO (in parts per billion).
 - Wind speed and direction.
- **Sample**
 - Period: 2013–2019.
 - 75 monitors.
 - Daily



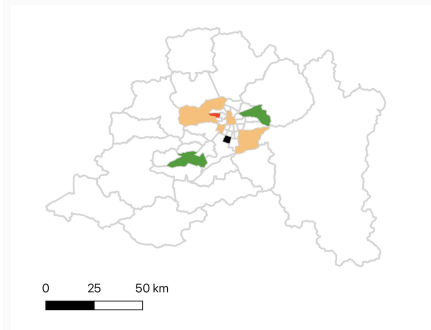
(a) Monitors's locations



(b) Monitors'locations in Santiago Metropolitan Area



(a) Average PM 2.5, 2013-2019: All municipalities



(b) Average PM 2.5, 2013-2019:
Municipalities in Santiago Metropolitan
Area

Data: Emergency department visits (ER visits)

- **Source:** Departamento de Estadísticas e Información de Salud (DEIS), Ministry of Health, Chile.
- **Variables:**
 - Number of ER visits by cause, age group, and hospital
 - Causes: respiratory, circulatory, external causes (traffic accidents and other external causes), and other causes.
 - Age groups: 0-1 year, 1-4 years, 5-14 years, 15-64 years, and older than 65 years.
- **Sample**
 - Period: 2008–2019.
 - By age group at the hospital level.
 - Daily

Data: Atmospheric conditions

- **Source:** Center for Climate and Resilience Research.
- **Variables:**
 - Minimum and maximum temperatures
 - Precipitation
- **Sample**
 - Period: 2013–2019.
 - Daily

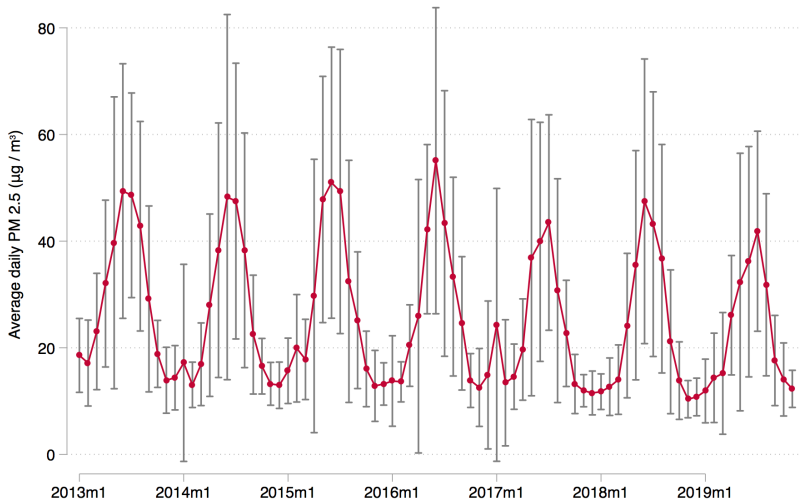
Dataset construction

- Unit of observation: hospitals located within a 5 km radius from a monitor.
- Match each hospital to the closest monitor and weather station to add air pollution and weather variables to the ER data in the hospital.
 - More accurate measurement of air pollution near the hospital.
 - If individuals do not travel long distances for ER visits, then we also have a more accurate measurement of pollution exposure.

▸ N of monitors and hospitals

▸ Summary stats

Evolution of PM 2.5 concentration, daily average



Evolution of respiratory ER visits, daily average



Empirical strategy

Estimating equation

$$Y_{hadmy} = \beta_0 + \beta_1 PM2.5_{hdmy} + X'_{hdmy}\gamma + \alpha_a + \alpha_{hmy} + \alpha_{dmy} + \epsilon_{hadmy}, \quad (1)$$

where

- Y_{hadmy} is the logarithm of ER visits for age group a in hospital h on day d in month m and year y ,
- $PM2.5_{hdmy}$ is the fine particulate level in hospital h on dmy ,
- X_{hdmy} are weather variables in hospital h on dmy
- α_a is an age-group FE, and α_{hmy} is a hospital-month-year FE, and α_{dmy} is a day-month-year FE.

Threats to identification

- **Sorting of individual** and **Seasonal factors** → we rely on variation within hospital-year-month cell
- **Common daily shocks across hospitals** → we control by day-month-year FE
- **Measurement error** in exposure to air pollution
 - We rely on a more accurate measure of air pollution at the hospital level
 - We instrument PM 2.5 using wind speed and direction
 - Wind instruments also deal with other endogeneity concerns like omitted variable bias

Wind instrument

- We follow Ward (2015) and Deryugina et al. (2019)) and use wind direction and velocity to instrument the level of PM 2.5.
- **Exclusion restriction**: instrument is unlikely to have a direct effect on ER visits
- **Relevance condition**: level of fine particulates depends on weather conditions such as wind

First stage

$$\begin{aligned} PM2.5_{hdmy} = & \sum_{b=0}^2 \pi_{1,b} \text{wind direction}_{hdmy}^b + \pi_2 \text{wind speed}_{hdmy} \\ & \sum_{b=0}^2 \pi_{3,b} \text{wind direction}_{hdmy}^b \times \text{wind speed}_{hdmy} \\ & + X'_{hdmy} \theta + \alpha_a + \alpha_{hmy} + \alpha_{dmy} + \epsilon_{hadmy}, \end{aligned}$$

where

- wind speed_{hdmy} is the average daily wind speed, and
- $\text{wind direction}_{hdmy}^b$ is equal to 1 if the average daily wind direction falls in the interval $[90b, 90b + 90]$ and 0 otherwise.

Results

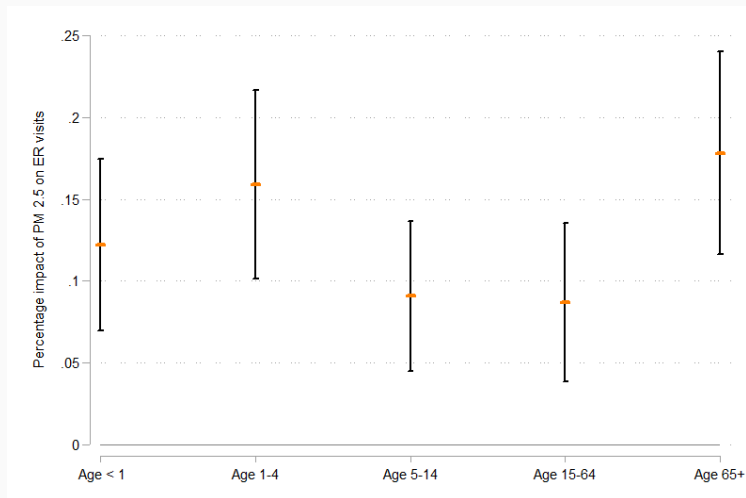
Effect of PM 2.5 on (log) respiratory ER visits

	OLS		IV/2SLS	
	(1)	(2)	(3)	(4)
PM 2.5, same day ($\mu\text{g} / \text{m}^3$)	0.0003** [0.0001]	0.0003*** [0.0000]	0.0014*** [0.0004]	0.0013*** [0.0002]
Hospital-Year FE	Yes	No	Yes	No
Hospital-Month-Year FE	No	Yes	No	Yes
F stat PM 2.5 (weak inst.)			16.0	24.5
p-value PM 2.5 (weak inst.)			0.000	0.000
Mean DV	8.089	8.089	8.089	8.089
Observations	1,756,720	1,756,720	1,756,720	1,756,720

Effect of PM 2.5 on (log) respiratory ER visits by age group

	(1) < 1	(2) 1-4	(3) 5-14	(4) 15-64	(5) 65 +
PM 2.5, same day ($\mu g / m^3$)	0.0012*** [0.0003]	0.0016*** [0.0003]	0.0009*** [0.0002]	0.0009*** [0.0002]	0.0018*** [0.0003]
Mean DV	3.492	9.392	8.116	16.500	2.947
Observations	351,325	351,325	351,325	351,325	351,325

Effect of PM 2.5 on (log) respiratory ER visits by age group



- An increase of $1 \mu\text{g}/\text{m}^3$ in daily PM 2.5 exposure increases ER visits in 0.13%, on average.
- **This effect is important:** an increase in 1 SD in daily PM 2.5 exposure increases ER visits in 3.1%, on average.
- This effect is positive and significant for **all age groups**.
- **Comparison with previous work**
 - Deryugina et al. (2019) finds that $1 \mu\text{g}/\text{m}^3$ in daily PM 2.5 exposure increases ER visits in **0.068%** for the age group 65+ in US.
 - We find that $1 \mu\text{g}/\text{m}^3$ in daily PM 2.5 exposure increases ER visits in **0.180%** for the age group 65+ in Chile.

- Air pollution alerts. [▶ Table](#)
- Falsification tests using external causes. [▶ Table](#)
- Balance panel of monitors and hospitals. [▶ Table](#)
- Leads/lags of PM 2.5.
- Multiple pollutants.
- Flexible controls in weather variables.

Conclusion

- We find a positive impact of PM 2.5 on ER visits (on the same day).
- This effect is positive and significant for all age groups, and larger than comparable estimates for US, a country with lower levels of air pollution.

Thank you

Appendix

Number of monitors and hospitals by year

Year	Number of Monitors	Number of Hospitals
2013	58	196
2014	59	201
2015	66	221
2016	69	249
2017	74	259
2018	73	265
2019	75	267

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Summary statistics: Pollution

Variables	Mean	s.d.
PM 2.5 ($\mu g / m^3$)	25.66	24.12
Good (0-12)	0.289	0.453
Moderate (12.1-35.4)	0.496	0.500
Unhealthy sensit. (35.5-55.4)	0.123	0.329
Unhealthy (55.5-150.4)	0.087	0.282
Very unhealthy (150.5-250.4)	0.004	0.063
Hazardous (250.5+)	0.001	0.023
CO (parts per billion)	0.72	0.62
Ozone (parts per billion)	13.05	7.47
Alert	0.094	0.292

Summary statistics: ER visits

Variables	Mean	s.d.
Total	26.38	35.52
Respiratory	7.89	9.51
Acute respiratory (J00-J21)	6.70	8.42
Chronic respiratory (J40-J46)	0.44	1.23
Circulatory	0.55	1.71
External causes	3.13	9.04

Summary statistics: Weather

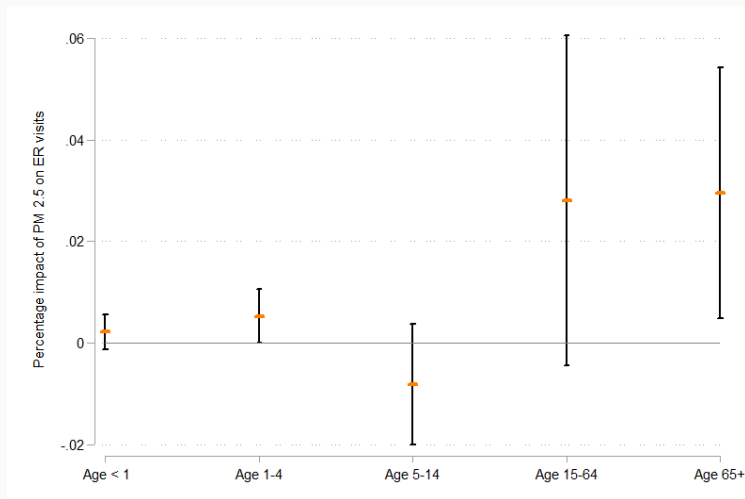
Variables	Mean	s.d.
Max. Daily Temp. (Celsius)	20.67	6.64
Min. Daily Temp. (Celsius)	8.91	4.79
Daily precipitation (mm)	0.80	45.28
Wind Speed (km/hour)	1.52	0.83
Observations	2,396,905	

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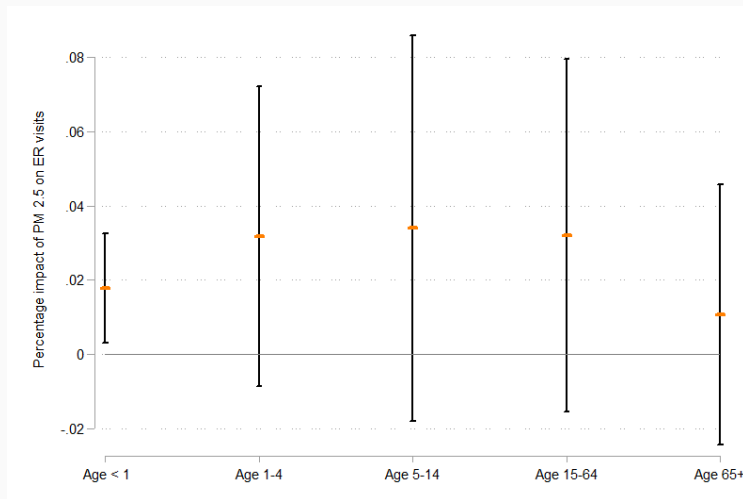
Air pollution alerts

	OLS		IV/2SLS	
	(1)	(2)	(3)	(4)
PM 2.5, same day ($\mu g / m^3$)	0.0003*** [0.0000]	0.0006*** [0.0001]	0.0013*** [0.0002]	0.0019*** [0.0004]
Alert		-0.0100* [0.0052]		-0.0562*** [0.0149]
PM 2.5 $\times$ Alert		-0.0005*** [0.0001]		-0.0014*** [0.0005]
F stat PM 2.5 (weak inst.)			24.5	23.1
p-value PM 2.5 (weak inst.)			0.000	0.000
F stat PM 2.5 $\times$ Alert (weak inst.)				26.6
p-value PM 2.5 $\times$ Alert (weak inst.)				0.000
Mean DV	8.038	8.038	8.038	8.038
Observations	1,756,720	1,756,720	1,756,720	1,756,720

Effect of PM 2.5 on (log) ER visits due to circulatory problems



Effect of PM 2.5 on (log) ER visits due to External causes



Balance panel of monitors

	OLS		IV/2SLS	
	(1)	(2)	(3)	(4)
PM 2.5, same day ($\mu\text{g} / \text{m}^3$)	0.0002 [0.0001]	0.0003*** [0.0001]	0.0013** [0.0005]	0.0012*** [0.0002]
Hospital-Year FE	Yes	No	Yes	No
Hospital-Month-Year FE	No	Yes	No	Yes
F stat PM 2.5 (weak inst.)			18.7	23.0
p-value PM 2.5 (weak inst.)			0.000	0.000
Mean DV	8.067	8.067	8.067	8.067
Observations	1,435,245	1,435,245	1,435,245	1,435,245