The Environment and Lung Health in Children

Salman Mroueh, MD

Department of Pediatrics and Adolescent Medicine

1866 AUB American University of Beirut الجامعة الأميركية في بيروت

Outline

- Definition
- Why are children more vulnerable
- Acute effects of air pollution
- Chronic effects of air pollution
- Smoking and health


0%
PHARMACIE
Anvers
Roger Zougheib
Specialiste – Mercedes
03-413324

Environment

- Air, water, minerals, organisms and all other external factors surrounding and affecting the organism at any time

Why are children more vulnerable?

- Children are exposed to a higher burden of airborne pollutants because of their greater ventilatory rate
- Their breathing zone is lower than that of adults so they are more exposed to heavier pollutants that tend to concentrate at lower air levels
- They spend more time outdoors, engaged in physical activity
- They are also exposed at a vulnerable stage, when the immune and metabolic systems are less mature and the lungs are rapidly developing
- They are more likely to suffer the long term effects of exposures

“Criteria” air pollutants

- Ozone
- Carbon monoxide
- Nitrogen oxides
- Sulfur dioxide
- Particulate matter


Fiaa - Koura

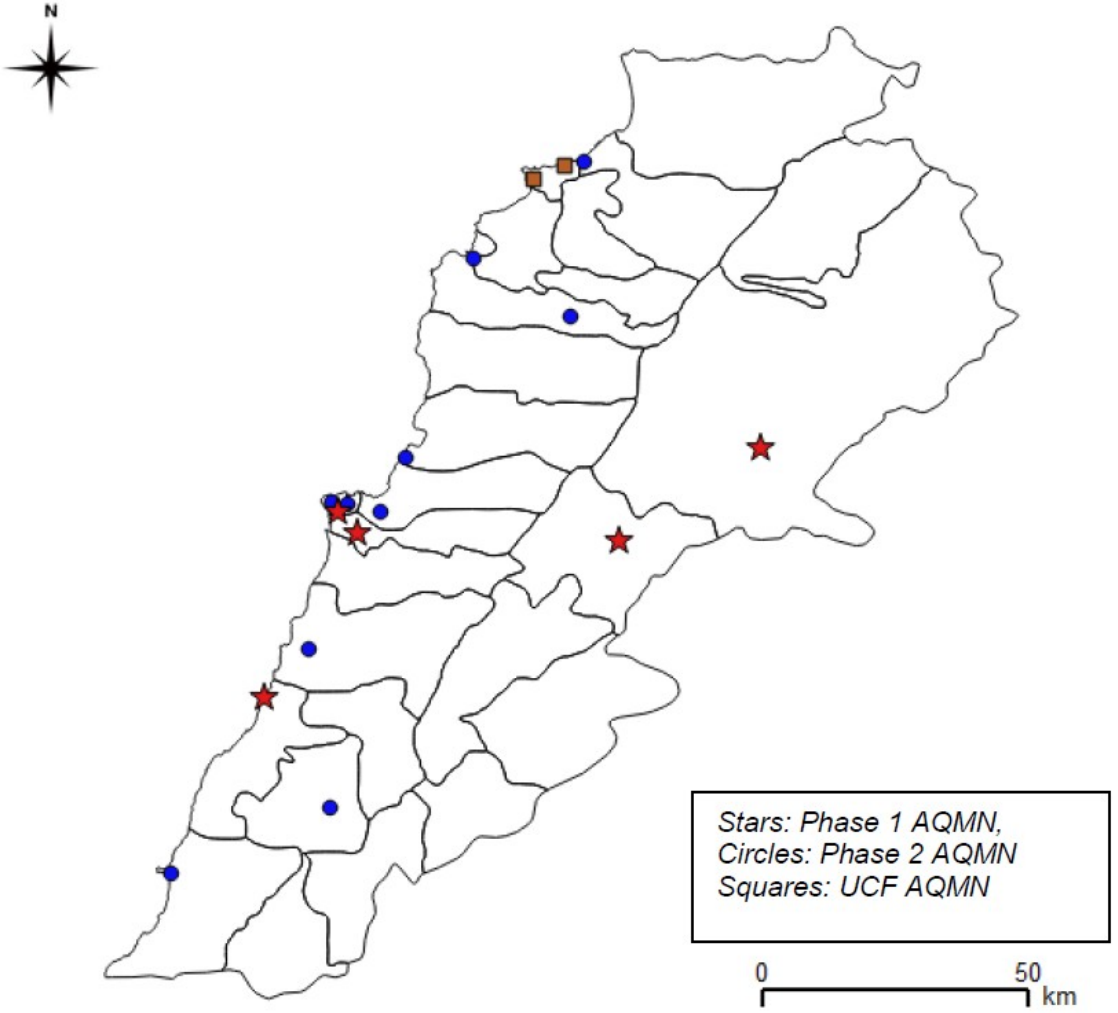

Deir Ammar - North


Imane High School - Barja


LAU - Beirut


Teir Debba - Tyre


Barouk Reserve


N
Stars: Phase 1 AQMN,
Circles: Phase 2 AQMN
Squares: UCF AQMN
0
50
km

NO_2 annual values over Greater Beirut

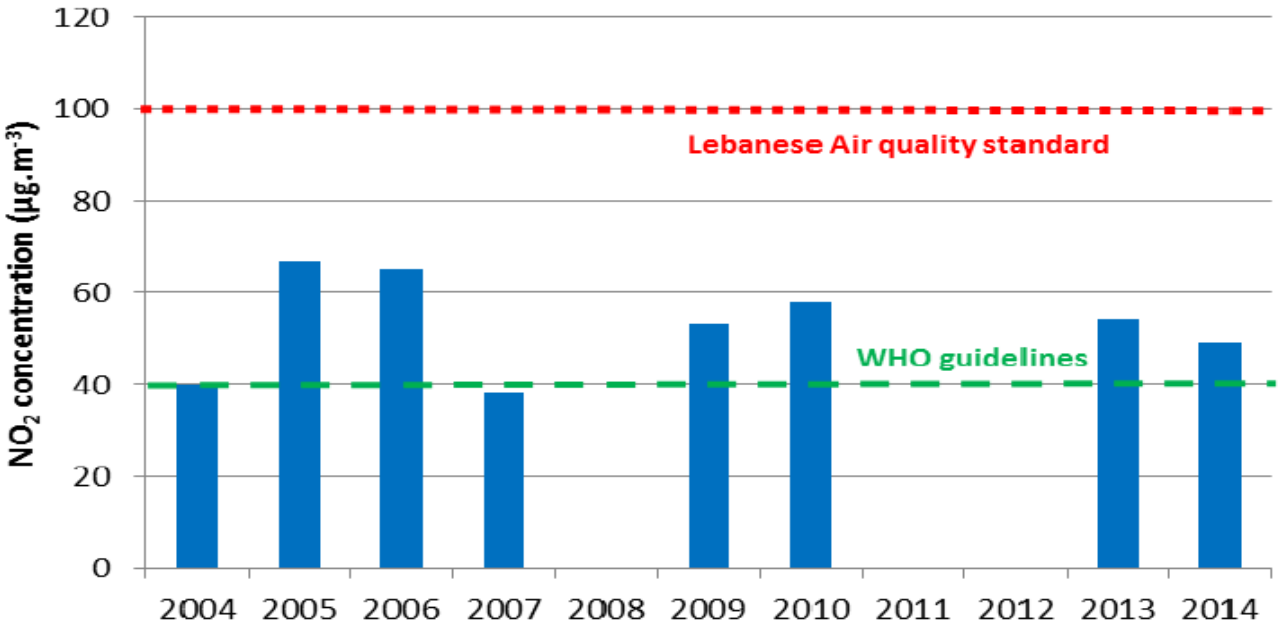


Figure 3: NO_2 annual values over Greater Beirut Area[10].

Lebanese MoE, 2017

PM annual values over Greater Beirut

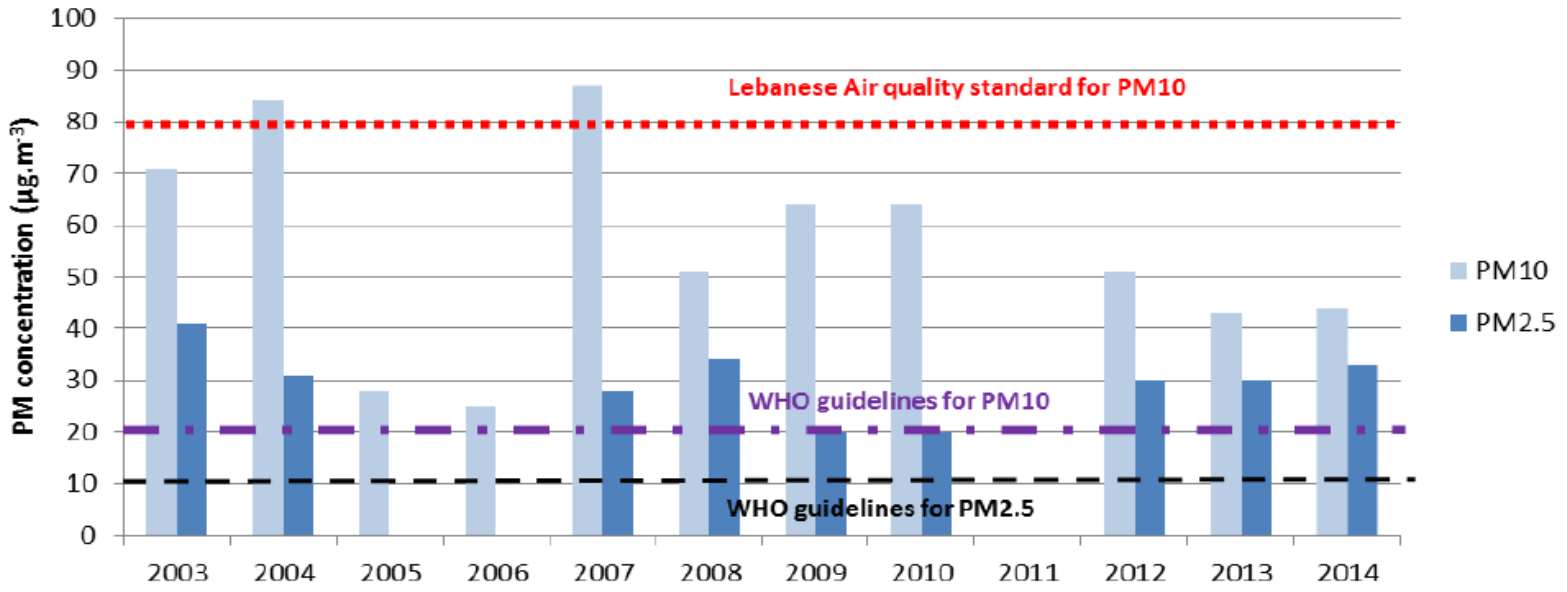


Figure 4: PM annual values over Greater Beirut area[11]

Lebanese MoE, 2017

Ozone

- Results from a photochemical reaction between UV light and chemical precursors (volatile hydrocarbons, nitrogen and sulfur oxides…)
- Abounds in sunny areas, during specific seasons and times of the day
- Induces irritation and injury in the respiratory epithelium through generation of free radicals

The “summer camp” studies

- Ozone causes a dose-dependant drop in pulmonary functions (FEV_1) in healthy children

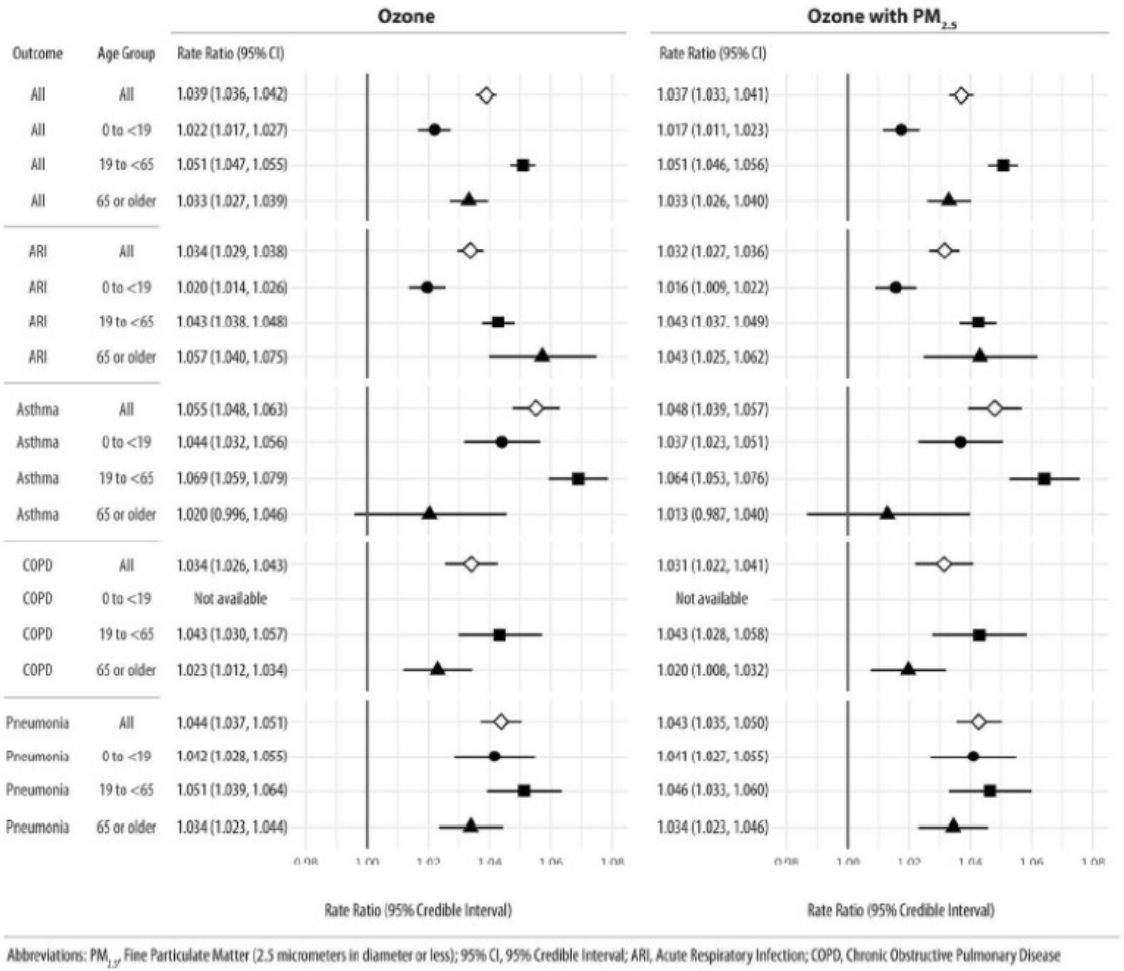
Kinney PL et al, *Environ Health Perspect 1996*

Ozone exposure and pulmonary function

Days	Change in PEF (L/min)	95% CI	*P*–value
Lag 0	–3.67	–4.73, –2.61	< 0.01
Lag 1	–1.29	–2.24, –0.33	< 0.01
Lag 2	1.47	0.52, 2.41	< 0.01
Lag 3	0.59	–0.33, 1.50	NS

Kurai et al, *J Med Invest. 2018*

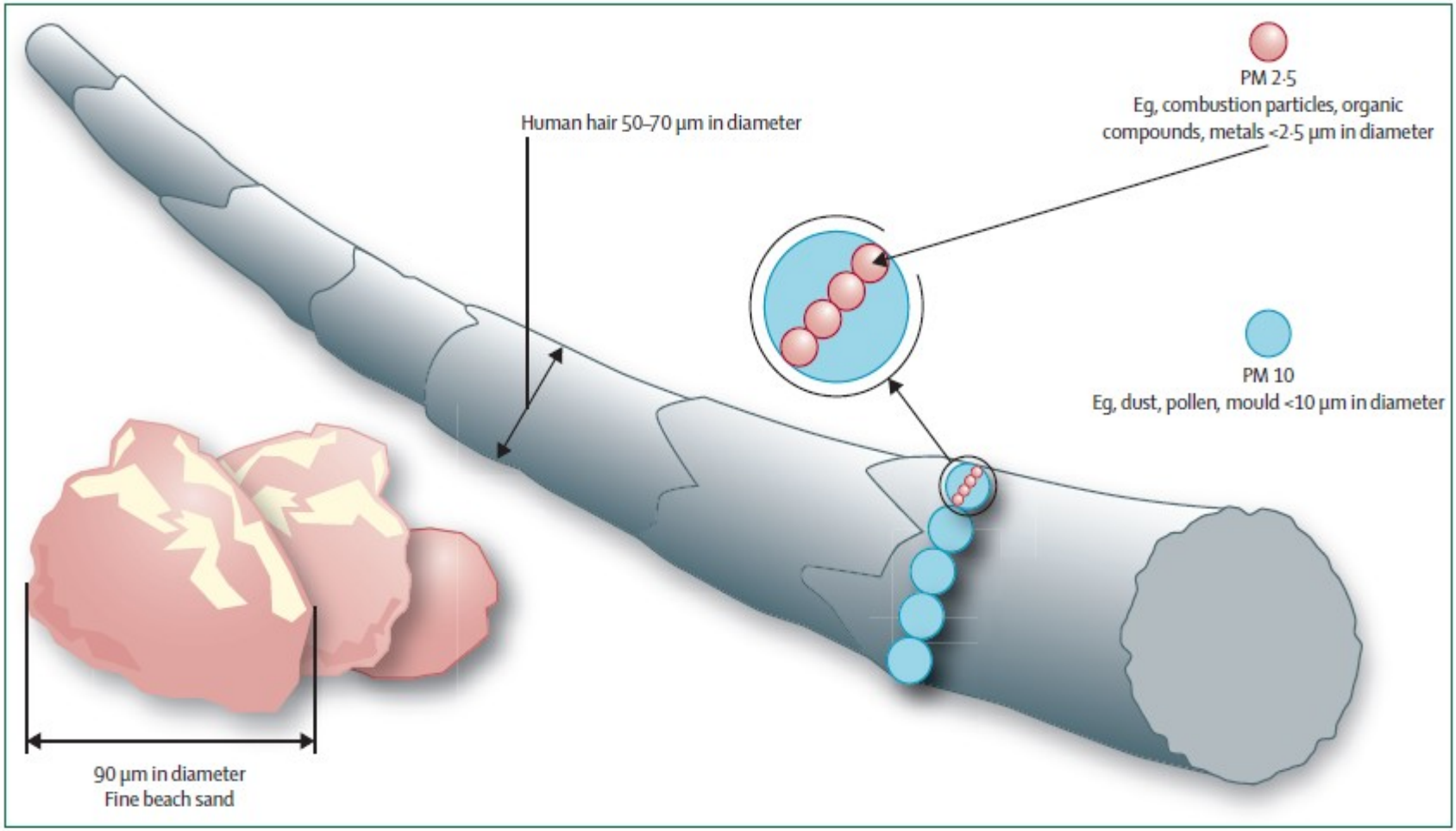
ER visits with increased ozone concentration



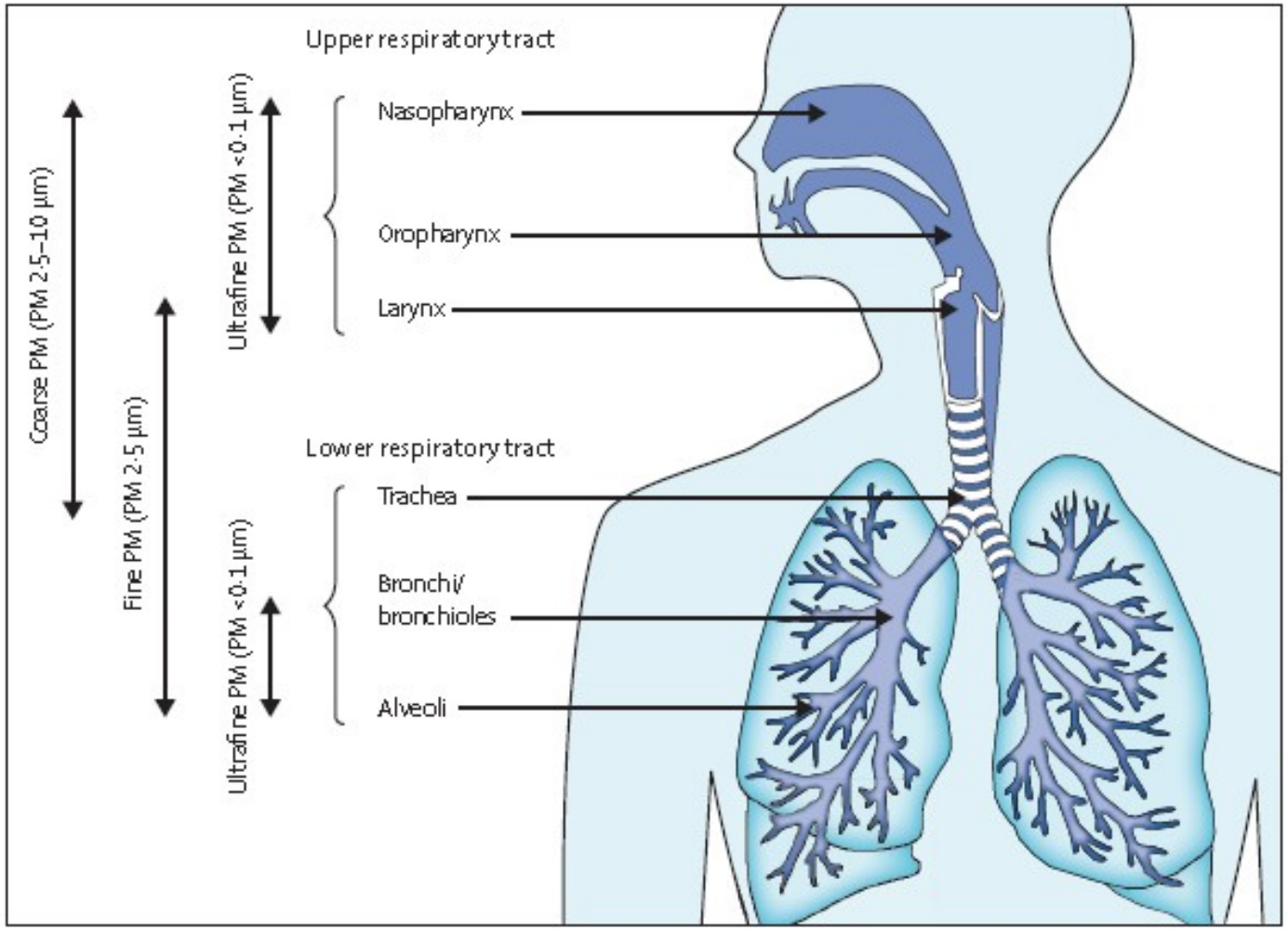
Strosnider et al, *AJRCCM 2019*

Particulate matter

- Suspended particles: fine solids, aerosols, soil dust, road dust, soot, ash, molds, pollens…
- Generated from factories, mines and quarries, construction activity, dust storms, volcanoes, refuse burning, vehicular exhaust…
- Designated as PM_{10} or $PM_{2.5}$, depending on the size in micrometers

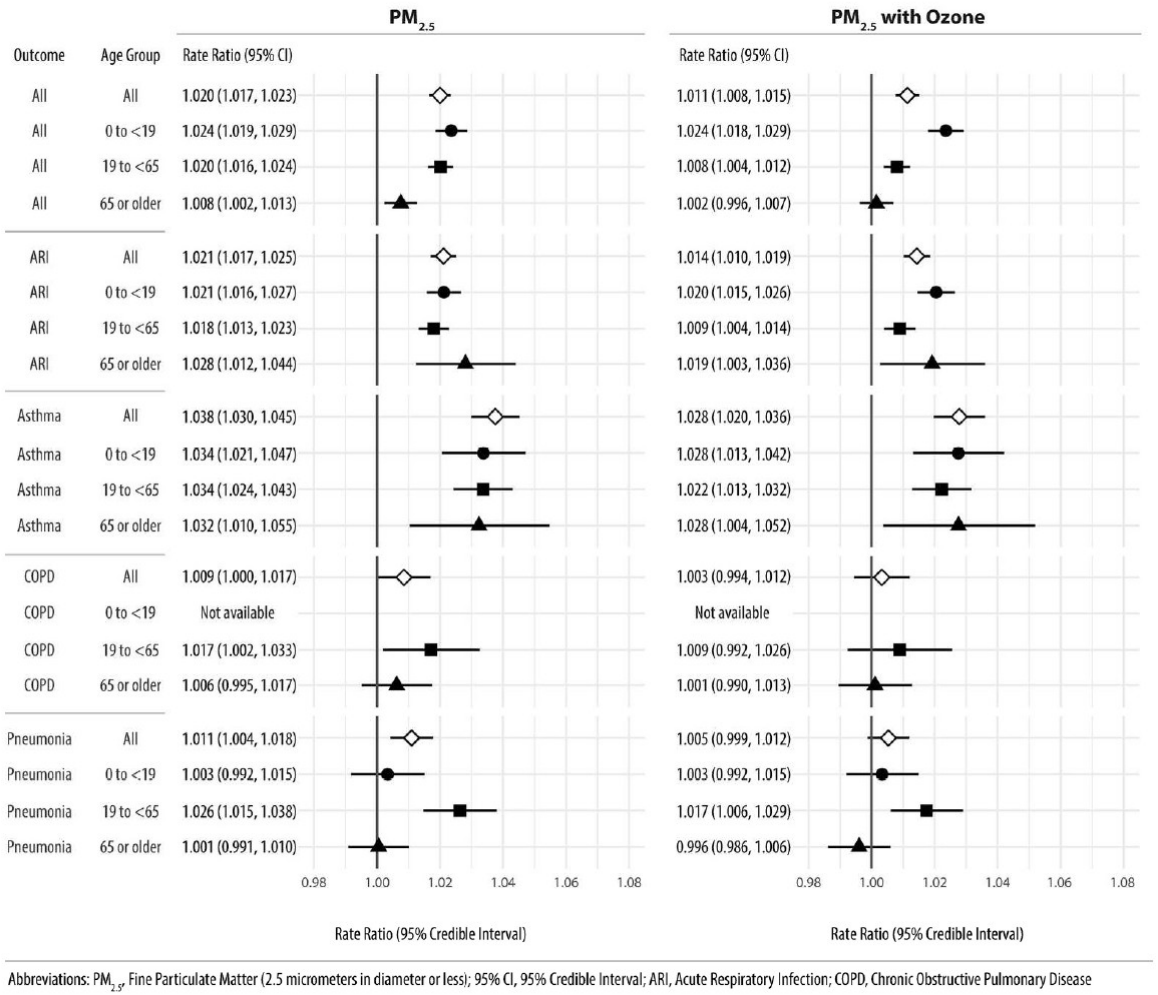

PM 2·5
Eg, combustion particles, organic compounds, metals <2·5 µm in diameter
Human hair 50–70 µm in diameter
PM 10
Eg, dust, pollen, mould <10 µm in diameter
90 µm in diameter
Fine beach sand

Size matters



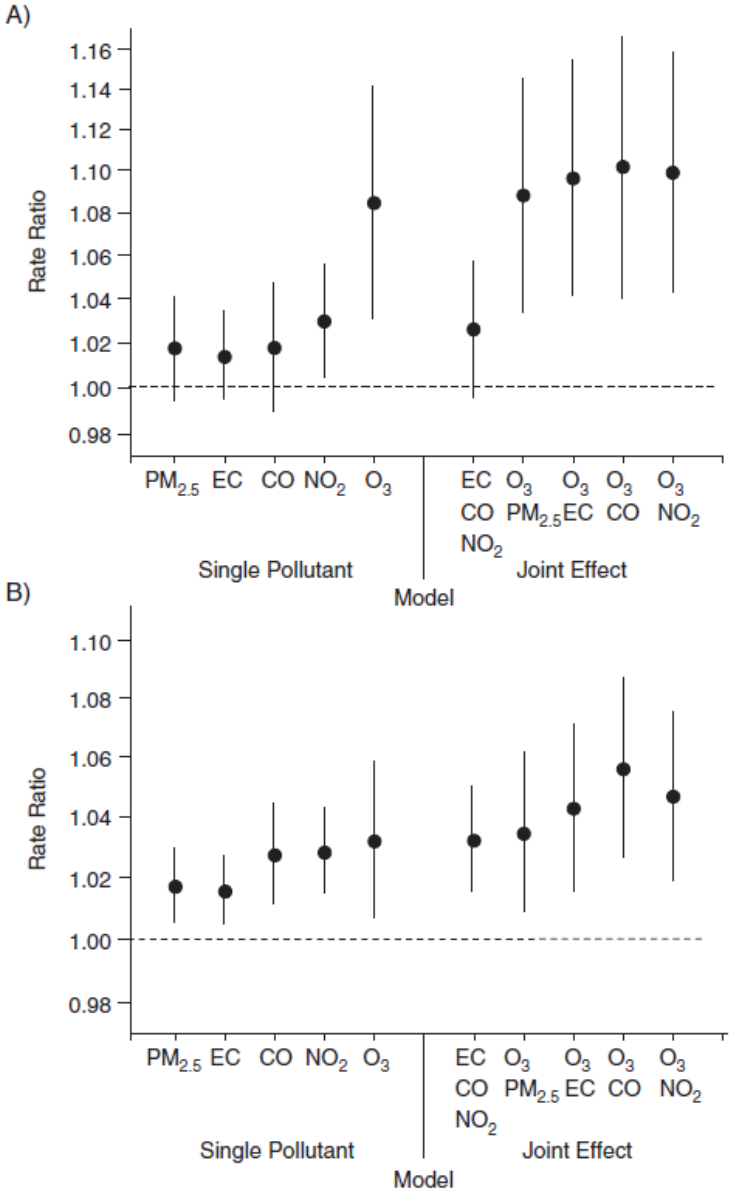
- Associated with increased airway inflammation and decreased immune responses to both viral and bacterial infections
- Promotes TH2 response by inhibiting production of INF-gamma (Guarneri and Balmes, 2014)

ER visits with increased $PM_{2.5}$ concentration



Abbreviations: $PM_{2.5}$, Fine Particulate Matter (2.5 micrometers in diameter or less); 95% CI, 95% Credible Interval; ARI, Acute Respiratory Infection; COPD, Chronic Obstructive Pulmonary Disease

Strosnider et al, *AJRCCM 2019*



Darrow et al. *Am J Epidemiol 2014*

Beijing Olympics 2008

- Outpatient visits for asthma decreased by 41.6% during the Olympic games
- Exhaled NO was lower in schoolchildren during the Olympic games

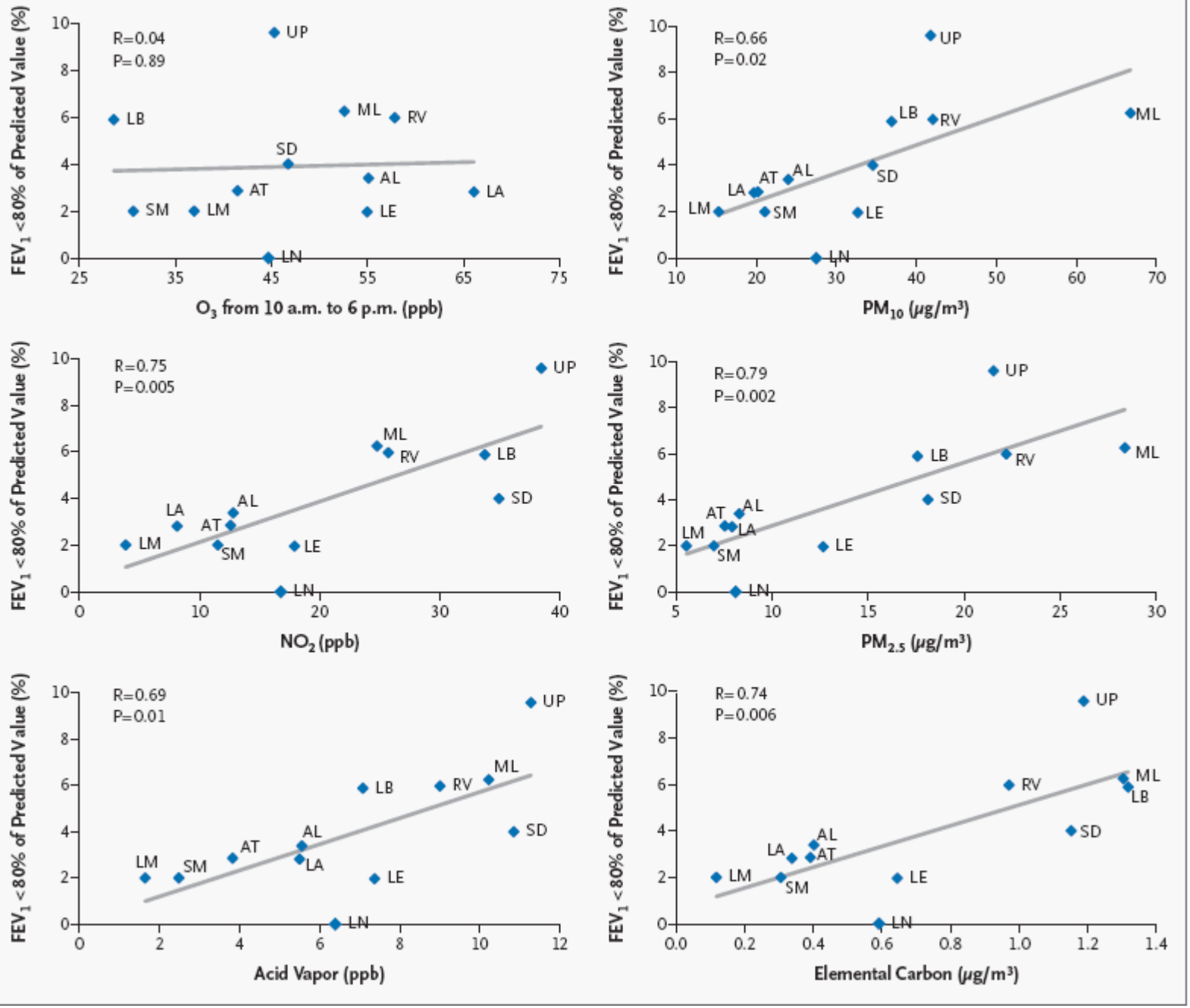
Li et al, *Sci Total Environ. 2010*
Lin et al, *Environ Health Perspect. 2011*

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 SEPTEMBER 9, 2004 VOL. 351 NO. 11

The Effect of Air Pollution on Lung Development from 10 to 18 Years of Age

W. James Gauderman, Ph.D., Edward Avol, M.S., Frank Gilliland, M.D., Ph.D., Hita Vora, M.S., Duncan Thomas, Ph.D., Kiros Berhane, Ph.D., Rob McConnell, M.D., Nino Kuenzli, M.D., Fred Lurmann, M.S., Edward Rappaport, M.S., Helene Margolis, Ph.D., David Bates, M.D., and John Peters, M.D.


R=0.04
P=0.89
FEV1 <80% of Predicted Value (%)
O3 from 10 a.m. to 6 p.m. (ppb)
UP
ML
RV
LB
SD
AL
AT
LA
SM
LM
LE
LN
R=0.66
P=0.02
PM10 (μg/m3)
R=0.75
P=0.005
NO2 (ppb)
R=0.79
P=0.002
PM2.5 (μg/m3)
R=0.69
P=0.01
Acid Vapor (ppb)
R=0.74
P=0.006
Elemental Carbon (μg/m3)

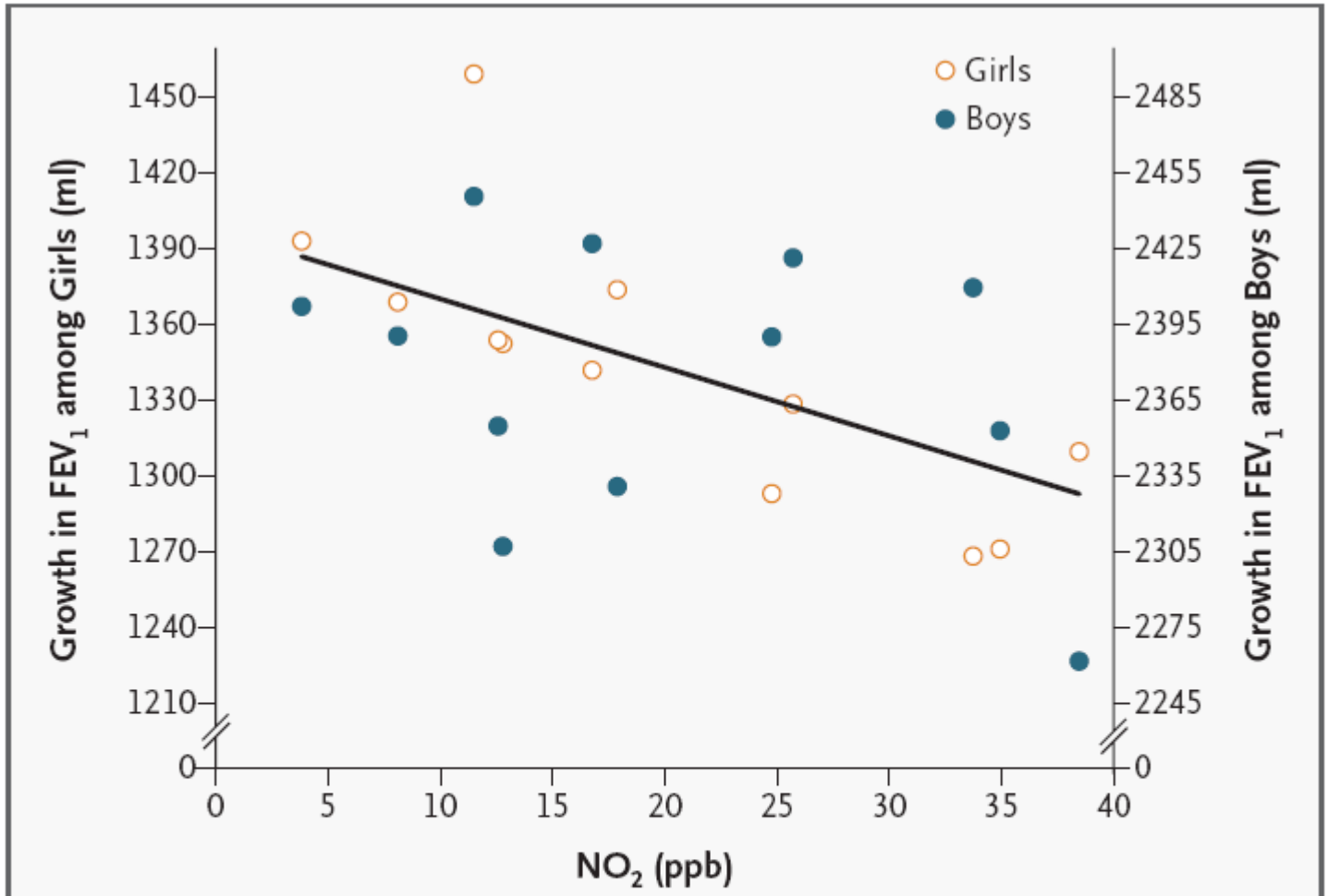
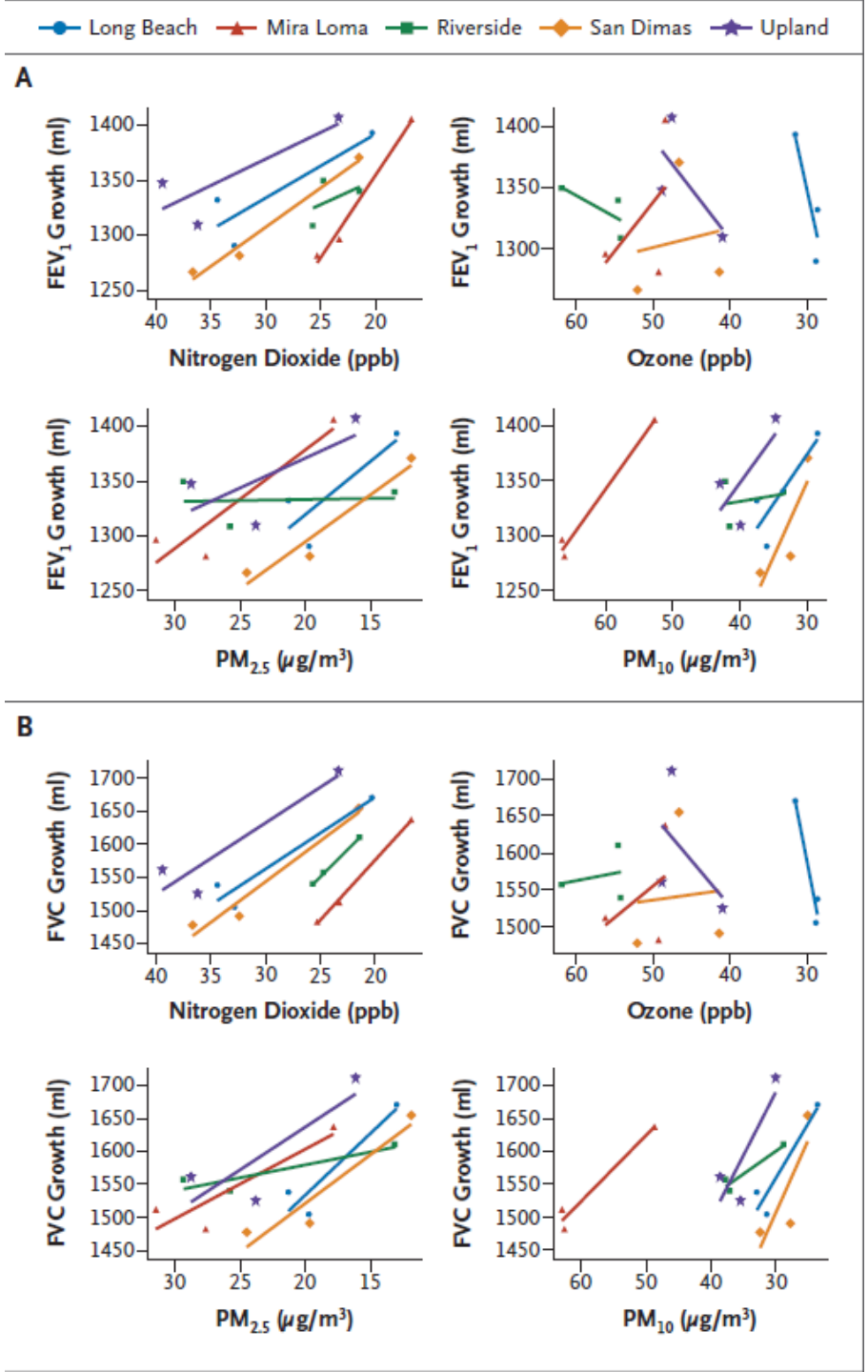


Figure 2. Community-Specific Average Growth in FEV_1 among Girls and Boys During the Eight-Year Period from 1993 to 2001 Plotted against Average Nitrogen Dioxide (NO_2) Levels from 1994 through 2000.

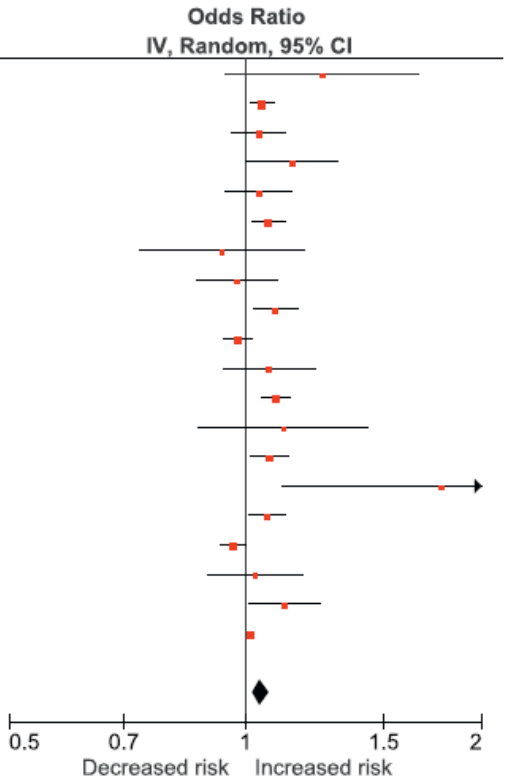


Gauderman et al, *NEJM 2015*

Traffic-related pollution and asthma: NO_2

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Carlsten et al. 2010 - at 7 y.o.	0.2253	0.1448	0.6%	1.25 [0.94, 1.66]
Clark et al. 2010 LUR - at mean age of 4 y.o.	0.0489	0.0171	9.5%	1.05 [1.02, 1.09]
Dell et al. 2014 LUR - 5 to 9 y.o.	0.039	0.04	5.0%	1.04 [0.96, 1.12]
Deng et al. 2016 - 3 to 6 y.o.	0.1374	0.0689	2.4%	1.15 [1.00, 1.31]
Gehring et al. 2015 b - BAMSE birth to 16 y.o.	0.0397	0.0498	3.8%	1.04 [0.94, 1.15]
Gehring et al. 2015 b - PIAMA birth to 14 y.o.	0.0665	0.0246	7.8%	1.07 [1.02, 1.12]
Gehring et al. 2015b - GINI&LISA North birth to 15	-0.0679	0.1235	0.8%	0.93 [0.73, 1.19]
Gehring et al. 2015b - GINI&LISA South birth to 15	-0.0252	0.0602	2.9%	0.98 [0.87, 1.10]
Jerret et al. 2008 - 10 to 18 y.o.	0.0874	0.033	6.1%	1.09 [1.02, 1.16]
Kim et al. 2016 - 6 to 7 y.o.	-0.0214	0.0219	8.4%	0.98 [0.94, 1.02]
Krämer et al. 2009 - 4 to 6 y.o.	0.0698	0.069	2.3%	1.07 [0.94, 1.23]
Liu et al. 2016 - 4 to 6 years old	0.0877	0.0215	8.5%	1.09 [1.05, 1.14]
MacIntyre et al. 2014 - CAPPS&SAGE only birth to 8	0.1111	0.1268	0.8%	1.12 [0.87, 1.43]
McConnell et al. 2010 - 4th to 6th grade	0.0698	0.0281	7.1%	1.07 [1.01, 1.13]
Mölter et al. 2014 b - MAAS only birth to 8 y.o.	0.574	0.2374	0.2%	1.78 [1.11, 2.83]
Nishimura et al. 2013 - 8 to 21 y.o.	0.0632	0.0269	7.3%	1.07 [1.01, 1.12]
Oftedal et al. 2009 - birth to 10 y.o.	-0.0359	0.0196	8.9%	0.96 [0.93, 1.00]
Ranzi et al. 2014 - birth to 7 y.o.	0.0289	0.0701	2.3%	1.03 [0.90, 1.18]
Shima et al. 2002 - 6 to 12 y.o.	0.1136	0.0534	3.5%	1.12 [1.01, 1.24]
Tétreault et al. 2016 - birth to 12 y.o.	0.0153	0.0048	11.6%	1.02 [1.01, 1.03]
Total (95% CI)			**100.0%**	**1.05 [1.02, 1.07]**

Heterogeneity: Tau² = 0.00; Chi² = 54.38, df = 19 (P < 0.0001); I² = 65%
Test for overall effect: Z = 3.76 (P = 0.0002)



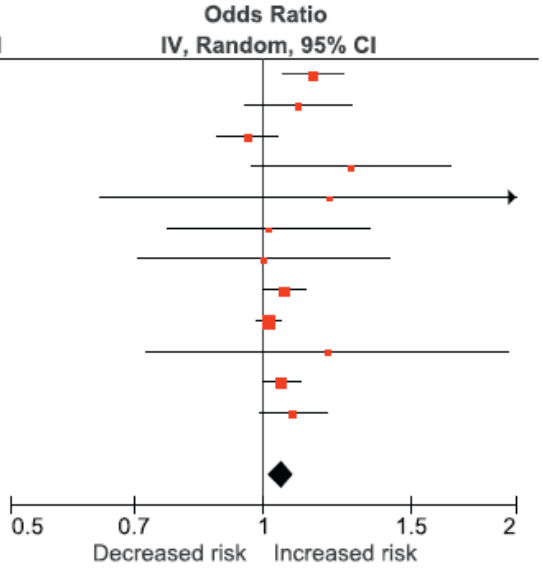
Khreis et al *Environment International 2017*

Traffic-related pollution and asthma: PM_{10}

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Clark et al. 2010 IDW - at mean age of 4 y.o.	0.1353	0.0427	10.7%	1.14 [1.05, 1.24]
Deng et al. 2016 - 3 to 6 y.o.	0.0963	0.0746	4.4%	1.10 [0.95, 1.27]
Gehring et al. 2015 b - BAMSE birth to 16 y.o.	-0.0441	0.0424	10.8%	0.96 [0.88, 1.04]
Gehring et al. 2015 b - PIAMA birth to 14 y.o.	0.2394	0.1391	1.4%	1.27 [0.97, 1.67]
Gehring et al. 2015b - GINI&LISA North birth to 15	0.1804	0.3223	0.3%	1.20 [0.64, 2.25]
Gehring et al. 2015b - GINI&LISA South birth to 15	0.0147	0.1419	1.3%	1.01 [0.77, 1.34]
Kim et al. 2016 - 6-7 y.o.	0	0.1777	0.9%	1.00 [0.71, 1.42]
Liu et al. 2016 - 4 to 6 y.o.	0.057	0.0307	16.2%	1.06 [1.00, 1.12]
McConnell et al. 2010 - 1st to 4th grade	0.0137	0.0174	25.7%	1.01 [0.98, 1.05]
Mölter et al. 2014 b - MAAS only birth to 8 y.o.	0.1759	0.2539	0.4%	1.19 [0.72, 1.96]
Nishimura et al. 2013 - 8 to 21 y.o.	0.0489	0.0262	19.0%	1.05 [1.00, 1.11]
Shima et al. 2002 - 6 to 12 y.o.	0.0809	0.0481	9.0%	1.08 [0.99, 1.19]
Total (95% CI)			**100.0%**	**1.05 [1.02, 1.08]**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 15.51$, df = 11 (P = 0.16); $I^2 = 29\%$

Test for overall effect: Z = 2.87 (P = 0.004)

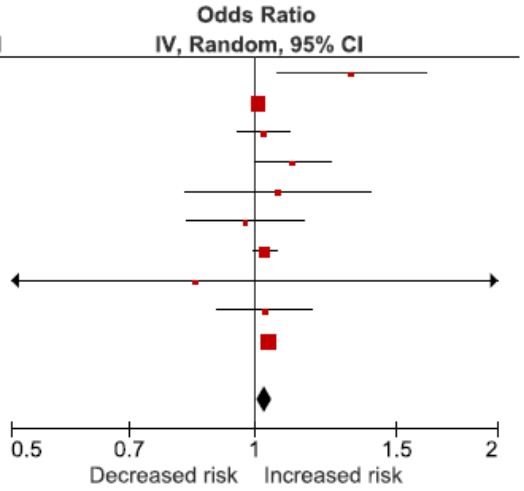


Khreis et al *Environment International 2017*

Traffic-related pollution and asthma: $PM_{2.5}$

Study or Subgroup	log[Odds Ratio]	SE	Weight	Odds Ratio IV, Random, 95% CI
Carlsten et al. 2010 - at 7 y.o.	0.276	0.1082	0.9%	1.32 [1.07, 1.63]
Clark et al. 2010 LUR - at mean age of 4 y.o.	0.01	0.0101	32.7%	1.01 [0.99, 1.03]
Gehring et al. 2015 b - BAMSE birth to 16 y.o.	0.0259	0.0385	6.2%	1.03 [0.95, 1.11]
Gehring et al. 2015 b - PIAMA birth to 14 y.o.	0.1093	0.0546	3.3%	1.12 [1.00, 1.24]
Gehring et al. 2015b - GINI&LISA North birth to 15	0.066	0.1352	0.6%	1.07 [0.82, 1.39]
Gehring et al. 2015b - GINI&LISA South birth to 15	-0.0266	0.0861	1.4%	0.97 [0.82, 1.15]
McConnell et al. 2010 - 1st to 4th grade	0.0291	0.0177	19.8%	1.03 [0.99, 1.07]
Mölter et al. 2014 b - MAAS only birth to 8 y.o.	-0.1688	0.8068	0.0%	0.84 [0.17, 4.11]
Nishimura et al. 2013 - 8 to 21 y.o.	0.0296	0.0691	2.1%	1.03 [0.90, 1.18]
Tétreault et al. 2016 - birth to 12 y.o.	0.0396	0.0099	33.1%	1.04 [1.02, 1.06]
Total (95% CI)			**100.0%**	**1.03 [1.01, 1.05]**

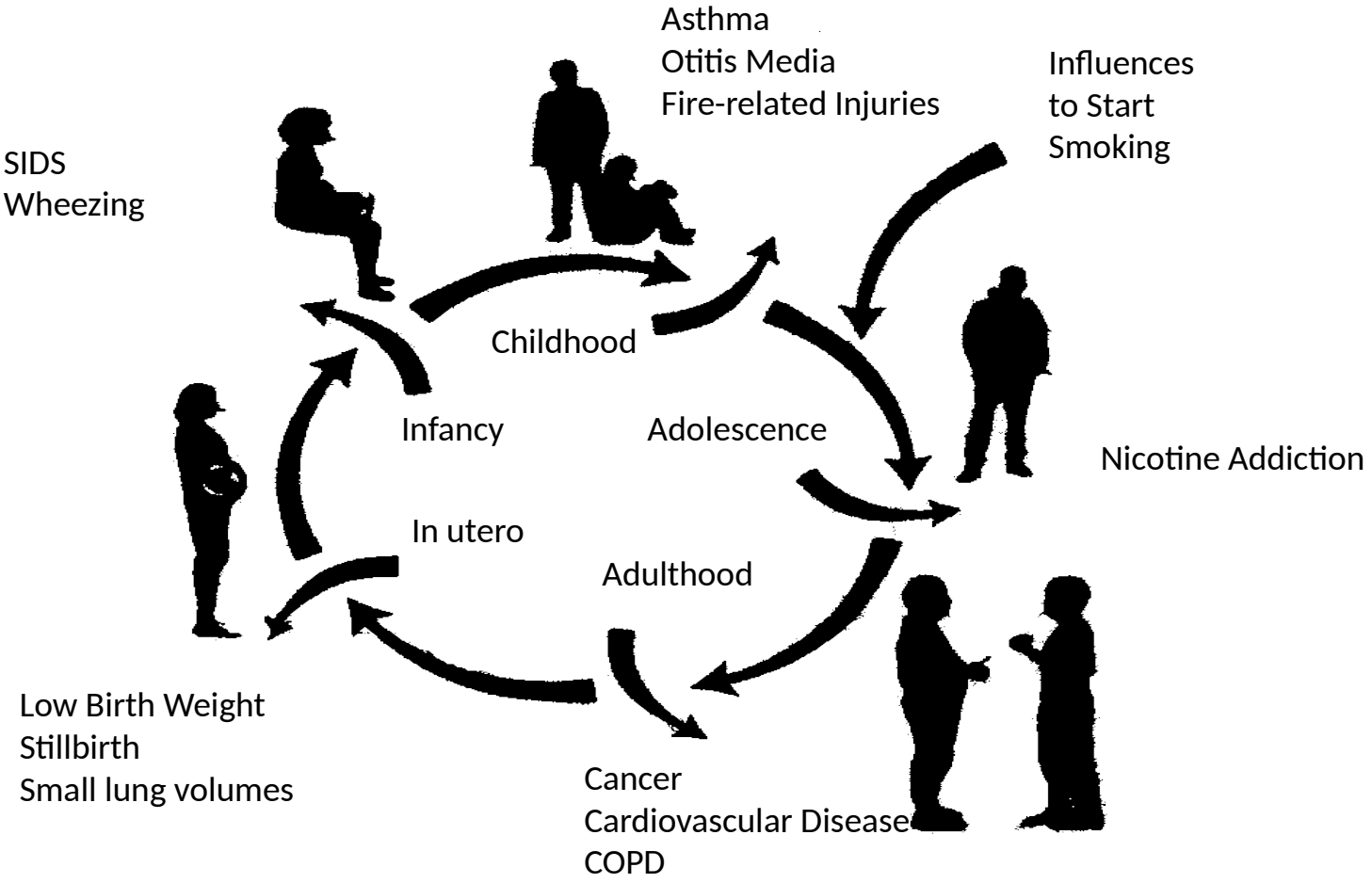
Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 12.56$, df = 9 (P = 0.18); $I^2 = 28\%$
Test for overall effect: Z = 2.96 (P = 0.003)



Khreis et al *Environment International 2017*

Smoking and Health

Life cycle of the health effects of smoking



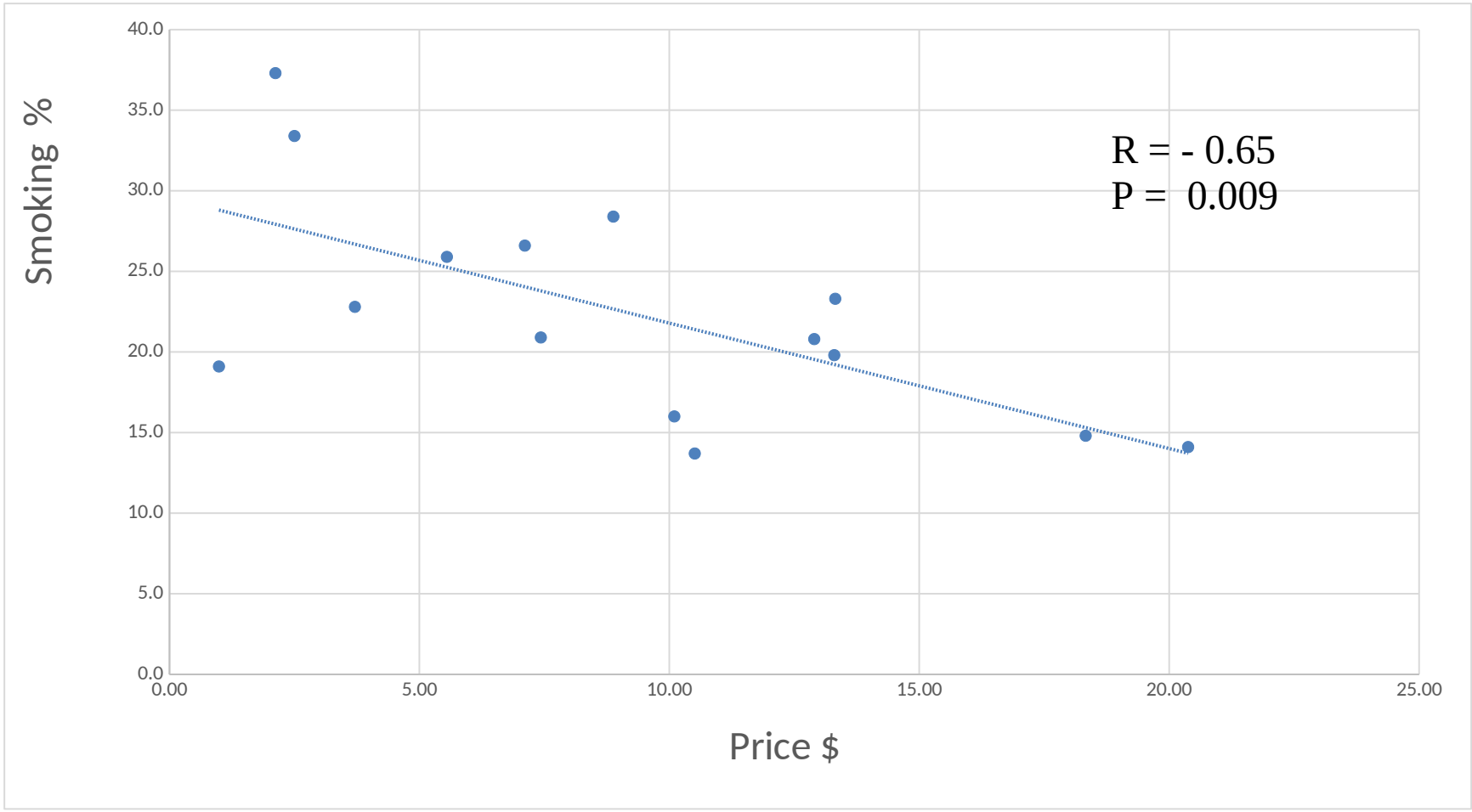
Adapted from Aligne, 1997

The Price of a Pack of Cigarettes around the World

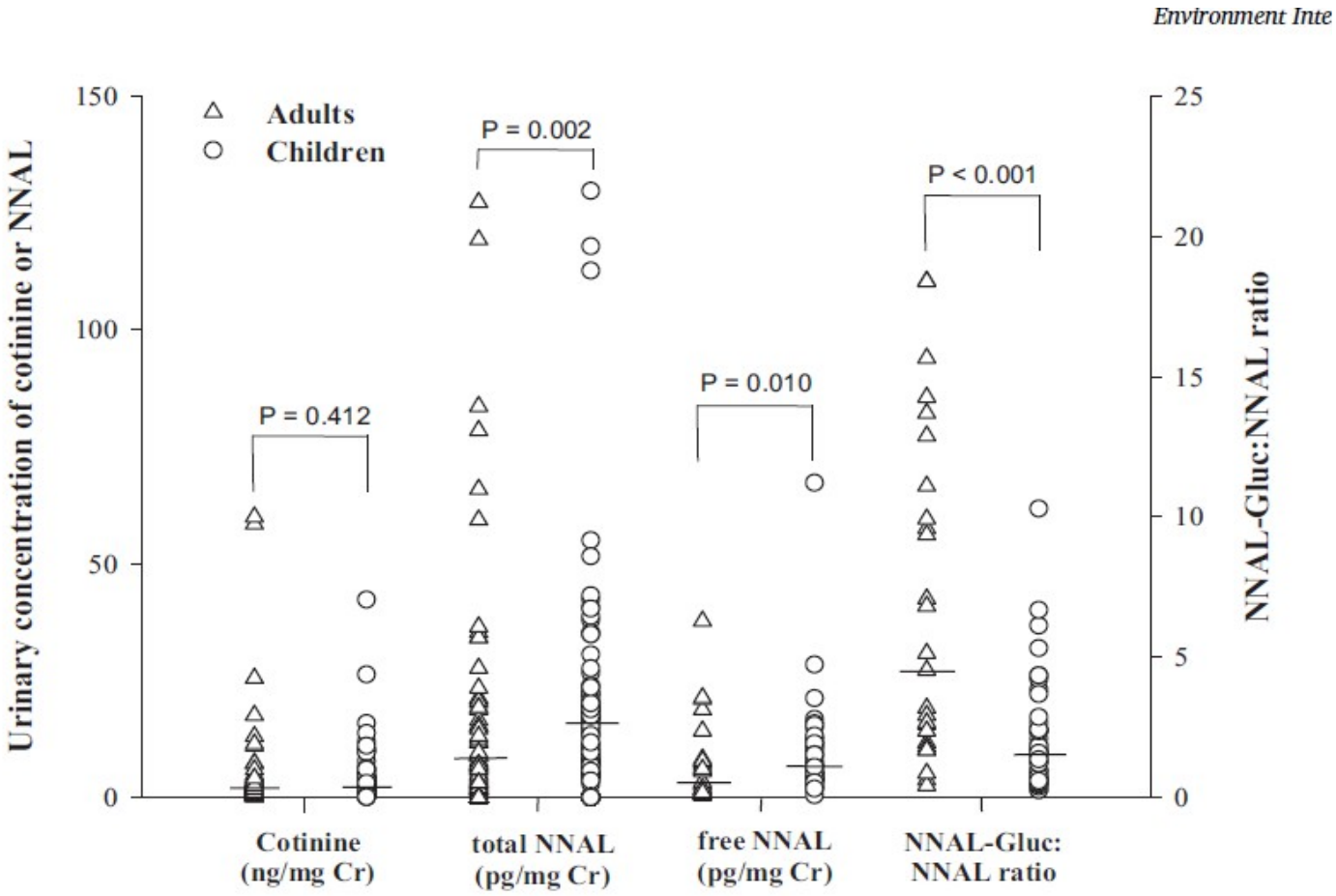
Selling price for a 20 pack of Marlboro cigarettes in selected countries (Aug 2019)

 Source: numbeo.com

statista


Smoking %
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0.00
5.00
10.00
15.00
20.00
25.00
Price $
R = - 0.65
P = 0.009

Cotinine and nitrosamines after ETS exposure



Chao et al, *Environ Int 2018*

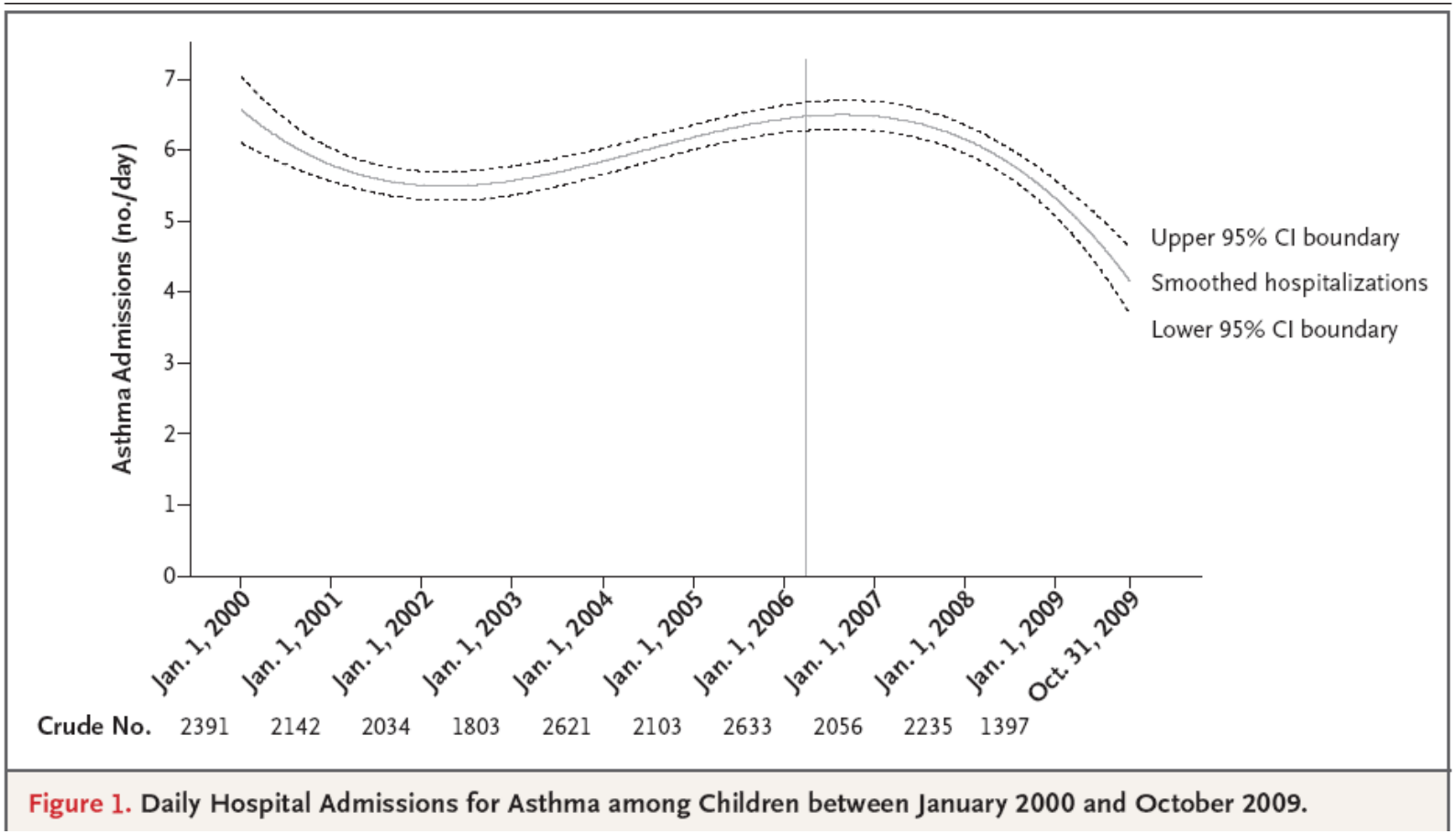


Figure 1. Daily Hospital Admissions for Asthma among Children between January 2000 and October 2009.

Mackay et al, *NEJM 2010*

Table 3. Association between smoke-free legislation and changes in child health outcomes

Outcome	*Effect size (95% CI)*	*Study type*	*Location(s)*	*Legislation comprehensive?*
Perinatal outcomes				
Stillbirth	−7.8% (−11.8 to −3.5); ref. 45	ITS	England	Yes
	−1% (−9 to 8)/−3% (−12 to 6); ref. 24	ITS	Netherlands	No
Low birthweight	−1.7% (−5.1 to 1.6); ref. 58	MA	Belgium, Norway, Scotland, USA	Mixed
Very low birthweight	−35.4% (−111.1 to 40.3); ref. 58	MA	Norway, USA	No
Preterm birth	−10.4% (−18.8 to −2.0); ref. 58	MA	Belgium, Norway, Scotland, USA	Mixed
Very preterm birth	−17.4% (−26.9 to −6.7); ref. 42	ITS	Scotland	Yes
	−2.3%[a] (−3.7 to −0.9); ref. 59	ITS	Quebec, Canada	Yes
	−6% (−14 to 3)/−11% (−19 to −3); ref. 24	ITS	Netherlands	No
SGA	−1.4% (−3.2 to 0.4); ref. 58	MA	Belgium, Ireland, Scotland	Mixed
Very SGA	−5.3% (−5.4 to −5.2); ref. 58	MA	Ireland, Scotland	Yes
Congenital anomalies	1% (−6 to 8)/−2% (−9 to 6); ref. 24	ITS	Netherlands	No
	−0.03%[a] (−4.0 to 3.9); ref. 41	CITS	Norway	No
Neonatal mortality	−7.6% (−11.7 to −3.4); ref. 45	ITS	England	Yes
	−3% (−16 to 12)/−12% (−24 to 2); ref. 24	ITS	Netherlands	No
Childhood outcomes				
Infant mortality	−6.3% (−9.6 to −2.9); ref. 45	ITS	England	Yes
Sudden infant death syndrome	1.8% (−8.4 to 13.2); ref. 45	ITS	England	Yes
Asthma hospital attendance	−10.1% (−15.2 to −5.0); ref. 58	MA	Canada, England, USA	Mixed
RTI hospital admissions	−3.5% (−4.5 to −2.3); ref. 60	ITS	England	Yes
Lower RTI hospital admissions	−13.8% (−15.6 to −12.0); ref. 60	ITS	England	Yes
	−33.5% (−36.4 to −30.5); ref. 61	ITS	Hong Kong	Yes
Lower RTI emergency department visits	−8% (−13 to −4%); ref. 62	CITS	USA	Mixed

Faber et al *NPJ Prim Care Respir Med 2016*

Conclusion

- Exposure to air pollution results in short and long term deleterious effects on lung health in children

Critical roles of health professionals

- Do research and publish
  - Detect sentinel cases
  - Inspire community-based interventions
- Educate patients, families, colleagues and students
- Advocate
- Provide good role model