BIGEPI
BIG data per la valutazione degli Effetti sanitari dell'inquinamento atmosferico nella Popolazione Italiana

Il Progetto INAIL-BEEP: sintesi delle pubblicazioni

Midterm workshop
5 Novembre 2021

Claudio Gariazzo, Massimo Stafoggia, Giovanni Viegi

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BIG data per la valutazione degli Effetti sanitari dell'inquinamento atmosferico nella Popolazione Italiana

Claudio Gariazzo

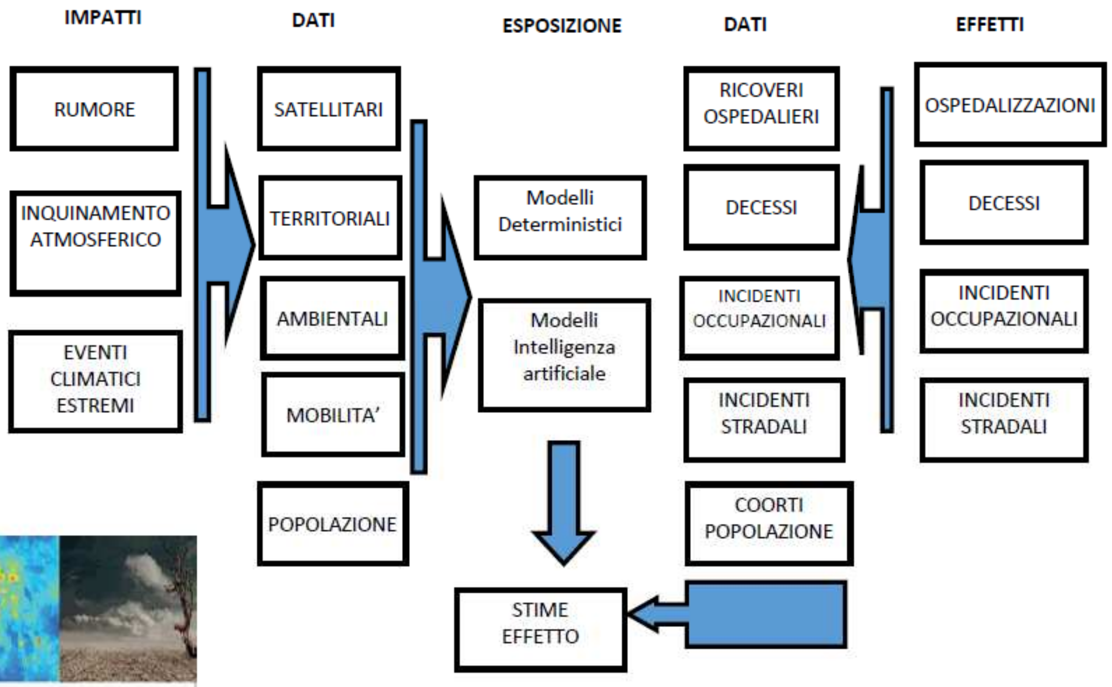
INAIL

Bigdata in Epidemiologia ambiEntale ed occuPazionale

Il progetto sfrutta la potenzialità e la connettività dei **Big data** relativi a :

- uso del territorio
- dati satellitari
- dati telefonia mobile
- stima dei modelli
- mortalità e ospedalizzazione
- incidenti sul lavoro
- incidenti stradali.

5. LAYOUT CONCETTUALE DEL PROGETTO



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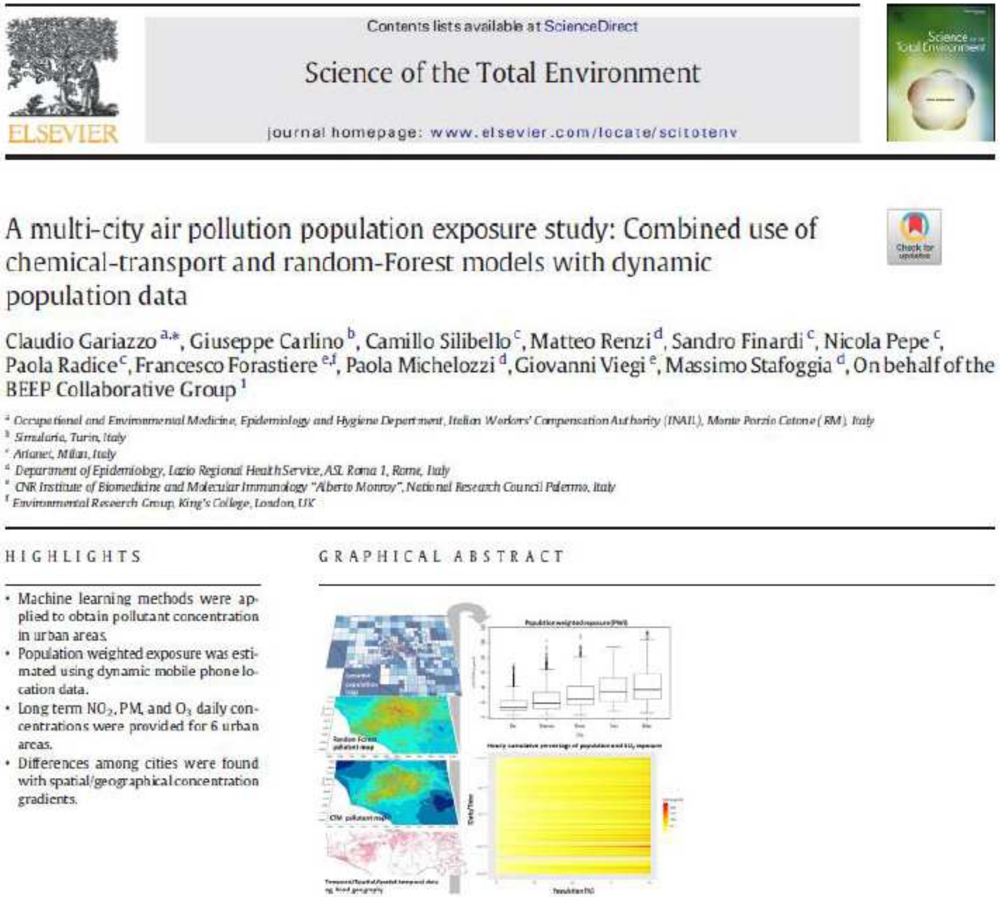
Exposure – High resolution maps of urban exposure



Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

A multi-city air pollution population exposure study: Combined use of chemical-transport and random-Forest models with dynamic population data

Claudio Gariazzo [a,*], Giuseppe Carlino [b], Camillo Silibello [c], Matteo Renzi [d], Sandro Finardi [c], Nicola Pepe [c], Paola Radice [c], Francesco Forastiere [e,f], Paola Michelozzi [d], Giovanni Viegi [e], Massimo Stafoggia [d], On behalf of the BEEP Collaborative Group [1]

[a] Occupational and Environmental Medicine, Epidemiology and Hygiene Department, Italian Workers' Compensation Authority (INAIL), Monte Porzio Catone (RM), Italy
[b] Simularia, Turin, Italy
[c] Arianet, Milan, Italy
[d] Department of Epidemiology, Lazio Regional Health Service, ASL Roma 1, Rome, Italy
[e] CNR Institute of Biomedicine and Molecular Immunology "Alberto Monroy", National Research Council Palermo, Italy
[f] Environmental Research Group, King's College, London, UK

HIGHLIGHTS

- Machine learning methods were applied to obtain pollutant concentration in urban areas.
- Population weighted exposure was estimated using dynamic mobile phone location data.
- Long term NO_2, PM and O_3 daily concentrations were provided for 6 urban areas.
- Differences among cities were found with spatial/geographical concentration gradients.

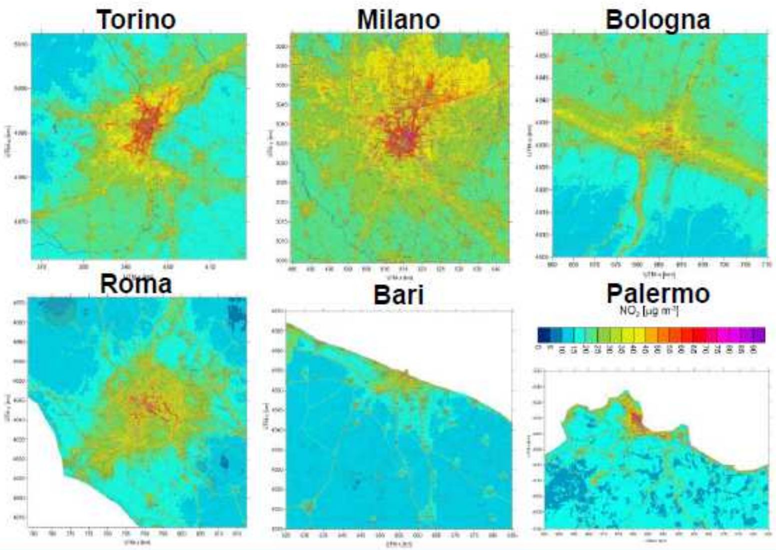
GRAPHICAL ABSTRACT

Materiali and metodi:

- Metodi di Machine Learning alimentati da:
    - dati da modelli di dispersione a 1 km
    - Variabili spazio-temporali (pop; traffico; sup. impervie)
    - Misure rete di monitoraggio urbane
- Dati mobilità della popolazione

Risultati:

- Mappe giornaliere di PM_{10}, $PM_{2.5}$, NO_2 e O_3 a 200m per le città di Torino, Milano, Bologna, Roma, Bari e Palermo per gli anni 2013-2015
- Esposizione dinamica della popolazione



Exposure: High resolution maps of air pollutants of Italy

Bigdata in Epidemiologia ambiEntale ed occuPazionale

Air Quality, Atmosphere & Health
https://doi.org/10.1007/s11869-021-00981-4

Spatial-temporal prediction of ambient nitrogen dioxide and ozone levels over Italy using a Random Forest model for population exposure assessment

Camillo Silibello[1] · Giuseppe Carlino[2] · Massimo Stafoggia[3] · Claudio Gariazzo[4] · Sandro Finardi[1] · Nicola Pepe[1] · Paola Radice[1] · Francesco Forastiere[5,6] · Giovanni Viegi[5,7]

Received: 21 October 2020 / Accepted: 6 January 2021

Abstract
We developed an integrated approach coupling a chemical transport model (CTM) with machine learning (ML) techniques to produce high spatial resolution NO_2 and O_3 daily concentration fields over Italy. Three years (2013–2015) simulations, at a spatial resolution of 5 km, performed by the Flexible Air quality Regional Model (FARM) were used as predictors, together with other spatial-temporal data, such as population, land-use, surface greenness and road networks, by a ML Random Forest (ML-RF) algorithm to produce daily concentrations at higher resolution (1 km) over the national territory. The evaluation of the adopted integrated approach was based on NO_2 and O_3 observations available from 530 and 293 monitoring stations across Italy, respectively. A good performance for NO_2 and excellent results for O_3 were obtained from the application of the CTM; as for NO_2, the levels at urban traffic stations were not captured by the simulations due to the adopted horizontal resolution and related emissions uncertainties. Performance improvements were achieved with ML-RF predictions, reducing NO_2 underestimation (near zero fractional bias results) and better capturing spatial contrasts. The results obtained in this work were used to support the national exposure assessment and environmental epidemiology studies planned in the BEEP (Big data in Environmental and occupational Epidemiology) project and confirm the potential of machine learning methods to adequately predict air pollutant levels at high spatial and temporal resolutions.

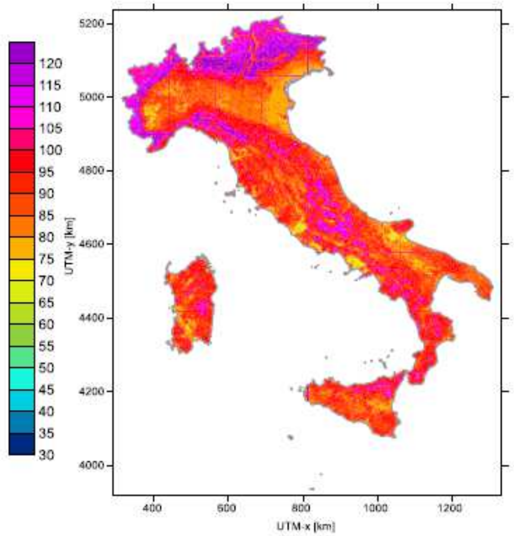
Keywords Chemical transport model · FARM · WRF · Machine learning · Random Forest · Nitrogen dioxide · Ozone

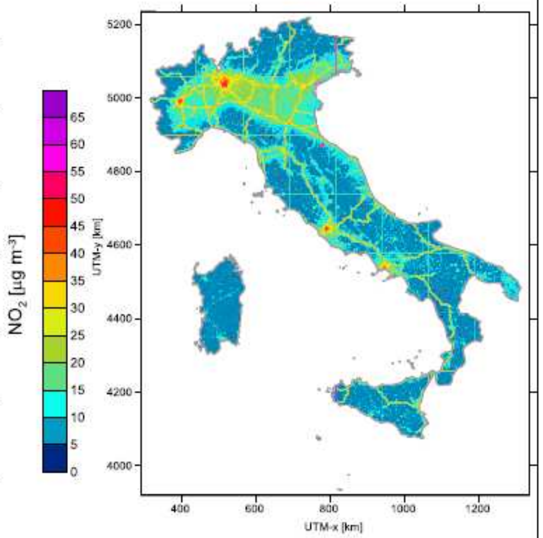
Materiali and metodi:

- Metodi di Machine Learning alimentati da:
  - dati da modelli di dispersione a scala nazionale a 5 km
  - Variabili spazio-temporali (pop; landuse; sup. impervie)
  - Misure rete di monitoraggio urbane

Risultati:

- Mappe giornaliere di NO_2 e O_3 a 1km per l'intero territorio nazionale per gli anni 2013-2015





INAIL

Exposure: Street level PM_{10} and NO_2 exposure in Rome

Atmospheric Environment 264 (2021) 118656

Contents lists available at ScienceDirect

Atmospheric Environment

journal homepage: www.elsevier.com/locate/atmosenv

ELSEVIER

A microscale hybrid modelling system to assess the air quality over a large portion of a large European city

Daniela Barbero[a,b,*], Gianni Tinarelli[a], Camillo Silibello[a], Alessandro Nanni[a], Claudio Gariazzo[c], Massimo Stafoggia[d], Giovanni Viegi[e], on behalf of theBEEP Collaborative Group

[a] ARIANET Srl, Via Gilino 9, Milano, Italy
[b] Politecnico di Milano, Piazza Leonardo da Vinci 32, Milano, Italy
[c] Occupational and Environmental Medicine, Epidemiology and Hygiene Department, Italian Workers' Compensation Authority (INAIL), Monte Porzio Catone (RM), Italy
[d] Department of Epidemiology, Lazio Regional Health Service, ASL Roma 1, Rome, Italy
[e] CNR - Istituto per la Ricerca e l'Innovazione Biomedica (CNR-IRIB), Palermo, Italy

HIGHLIGHTS

- Hybrid modelling approach to model air pollutant dispersion in an urban environment.
- Long-term simulations over extended urban areas at building-resolving scale.
- Combining micro-scale Lagrangian Particle Dispersion Model and Chemical Transport Model.
- Innovative time-saving kernel method to compute concentrations at micro-scale.
- Supporting advanced high-quality exposure assessment epidemiology studies.

ARTICLE INFO

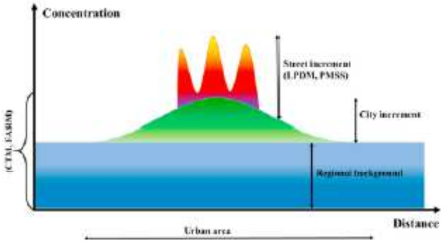
Keywords:
Urban air pollution dispersion
Air quality modelling
Micro-scale
Multi-model approach
PMSS (Parallel Micro Swift Spray)

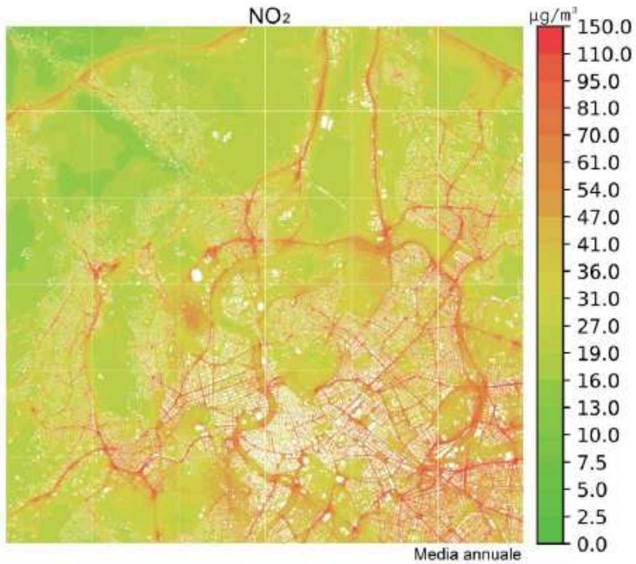
ABSTRACT

The role of atmospheric dispersion models is becoming increasingly relevant to assess air pollution urban population exposure for epidemiological studies. Estimating urban air quality is challenging, because of the intrinsic characteristics of cities atmospheric structure, such as high density of primary emissions and presence of local dispersion processes, that produce strong concentration gradients. Therefore, very high spatial resolution simulations may often be required to improve the accuracy of estimations.

Materiali and metodi:

- Modello di dispersione urbano per contributi regionali e locali
- Modello lagrangiano a particelle con trattamento effetto degli edifici per stime di esposizione a microscala
- **Risultati:**
  - Mappe orarie di NO_2 e PM_{10} a 4 m per una porzione di Roma (12x12 km) per l'anno 2015.





INAIL

Occupational effects of extreme temperatures

Environment International 133 (2019) 105176

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Nationwide epidemiological study for estimating the effect of extreme outdoor temperature on occupational injuries in Italy

Alessandro Marinaccio[a,*], Matteo Scortichini[b], Claudio Gariazzo[a], Antonio Leva[a], Michela Bonafede[a], Francesca K. de' Donato[b], Massimo Stafoggia[b], Giovanni Viegi[c], Paola Michelozzi[b], BEEP Collaborative Group (Ancona Carla, Angelini Paola, Argentini Stefania, Baldacci Sandra, Bisceglia Lucia, Bonomo Sergio, Bonvicini Laura, Broccoli Serena, Brusasca Giuseppe, Bucci Simone, Calori Giuseppe, Carlino Giuseppe, Cernigliaro Achille, Chieti Antonio, Fasola Salvatore, Finardi Sandro, Forastiere Francesco, Galassi Claudia, Giorgi Rossi Paolo, La Grutta Stefania, Licitra Gaetano, Maio Sara, Migliore Enrica, Moro Antonino, Nanni Alessandro, Ottone Marta, Pepe Nicola, Radice Paola, Ranzi Andrea, Renzi Matteo, Scondotto Salvatore, Silibello Camillo, Sozzi Roberto, Tinarelli Gianni, Uboldi Francesco)

[a] Occupational and Environmental Medicine, Epidemiology and Hygiene Department, Italian Workers' Compensation Authority (INAIL), Roma, Italy
[b] Department of Epidemiology, Lazio Regional Health Service, ASL Roma 1, Rome, Italy
[c] Italian National Research Council (CNR), Institute of Biomedical Research and Innovation (IRIB) (previously Institute of Biomedicine and Molecular Epidemiology "Alberto Monroy"), Palermo, Italy

ARTICLE INFO

Handling Editor: Zorana Jovanovic Andersen

Keywords:
Climate change
Extreme outdoor air temperature
Occupational injuries
Heat impacts
Cold impacts
Case-crossover study

ABSTRACT

Background: Despite the relevance for occupational safety policies, the health effects of temperature on occupational injuries have been scarcely investigated. A nationwide epidemiological study was carried out to estimate the risk of injuries for workers exposed to extreme temperature and identify economic sectors and jobs most at risk.

Materials and methods: The daily time series of work-related injuries in the industrial and services sector from the Italian national workers' compensation authority (INAIL) were collected for each of the 8090 Italian municipalities in the period 2006–2010. Daily air temperatures with a 1 × 1 km resolution derived from satellite land surface temperature data using mixed regression models were included. Distributed lag non-linear models (DLNM) were used to estimate the association between daily mean air temperature and injuries at municipal

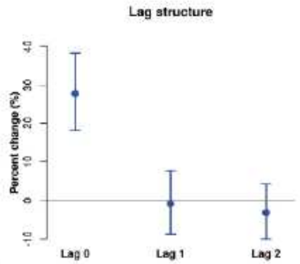
Materiali and metodi:

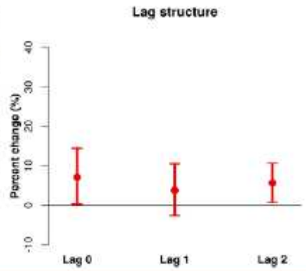
- Temperature giornaliere a 1km su Italia dal 2006-2010
- Incidenti sul lavoro giornalieri occorsi in Italia dal 2006-2010
- Modello statistico di analisi serie temporali con trattamento ad effetti a lag distribuito non lineare

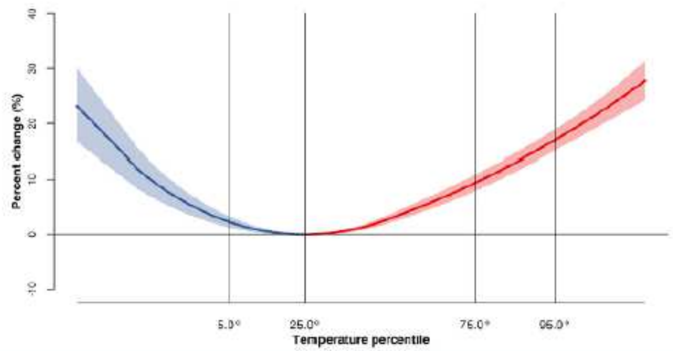
Obiettivi: Verificare l'esistenza di una associazione tra temperature estreme e incidenti sul lavoro

Risultati:

- Effetti significativi per temperature calde (RR=1.17) e fredde (RR=1.23)
- 5211 incidenti/anno attribuibili a temperature estreme (>75° e <25° percentile)
- Rischio maggiore per maschi e occupati in aziende medio-piccole







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BIG data per la valutazione degli Effetti sanitari dell'inquinamento atmosferico nella Popolazione Italiana

Massimo Stafoggia

Dipartimento di Epidemiologia SSR Lazio / ASL Roma 1

Modelli Random Forest per la stima del PM in Italia

Environment International 124 (2019) 170–179

Contents lists available at ScienceDirect

Environment International

journal homepage: www.elsevier.com/locate/envint

Estimation of daily PM_{10} and $PM_{2.5}$ concentrations in Italy, 2013–2015, using a spatiotemporal land-use random-forest model

Massimo Stafoggia[a,b,*], Tom Bellander[b], Simone Bucci[a], Marina Davoli[a], Kees de Hoogh[c,d], Francesca de' Donato[a], Claudio Gariazzo[e], Alexei Lyapustin[f], Paola Michelozzi[a], Matteo Renzi[a], Matteo Scortichini[a], Alexandra Shtein[g], Giovanni Viegi[h], Itai Kloog[g], Joel Schwartz[i]

[a] Department of Epidemiology, Lazio Regional Health Service/ASL Roma 1, Via C. Colombo 112, 00147 Rome, Italy
[b] Karolinska Institutet, Institute of Environmental Medicine, Stockholm, Sweden
[c] Swiss Tropical and Public Health Institute, Basel, Switzerland
[d] University of Basel, Basel, Switzerland
[e] INAIL, Department of Occupational & Environmental Medicine, Monteporzio Catone, Italy
[f] National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC), Greenbelt, MD, USA
[g] Department of Geography and Environmental Development, Ben-Gurion University of the Negev, Beer Sheva, Israel
[h] Institute of Biomedicine and Molecular Immunology "Alberto Monroy", National Research Council, Palermo, Italy
[i] Department of Environmental Health, Harvard T. H. Chan School of Public Health, Cambridge, MA, USA

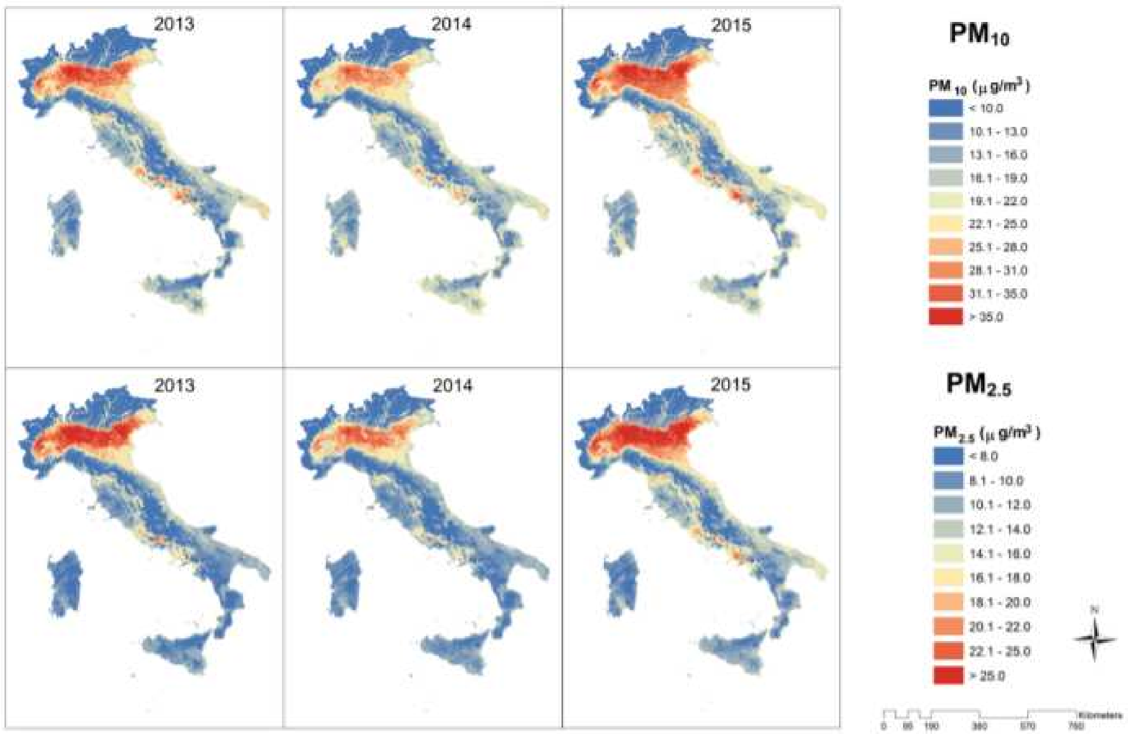


Fig. 2. Predicted PM_{10} (top) and $PM_{2.5}$ (bottom) concentrations from stage 4 model: annual means, 2013–2015.

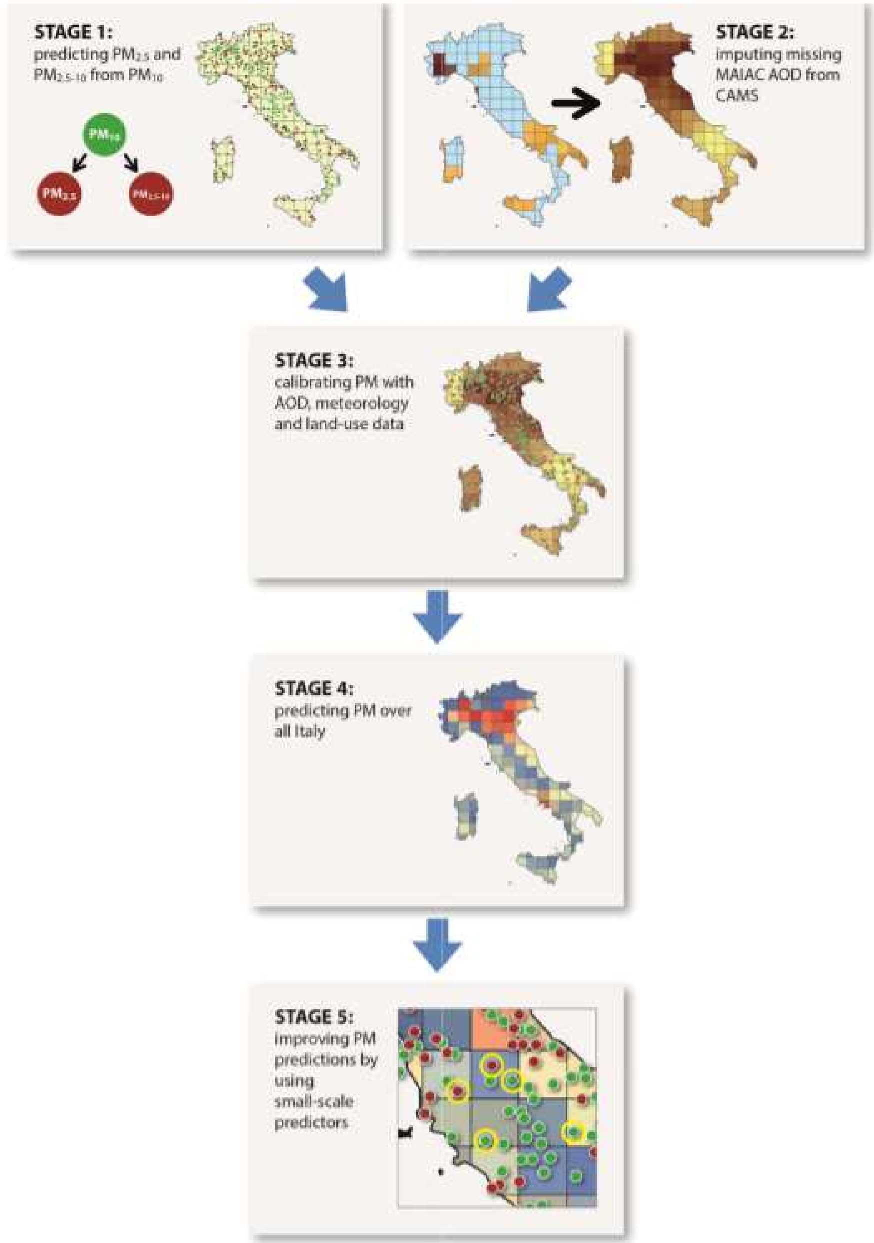


Fig. 1. Graphical representation of the five stage process.

Modelli «ensemble» per la stima del PM in Italia

Environmental Science & Technology

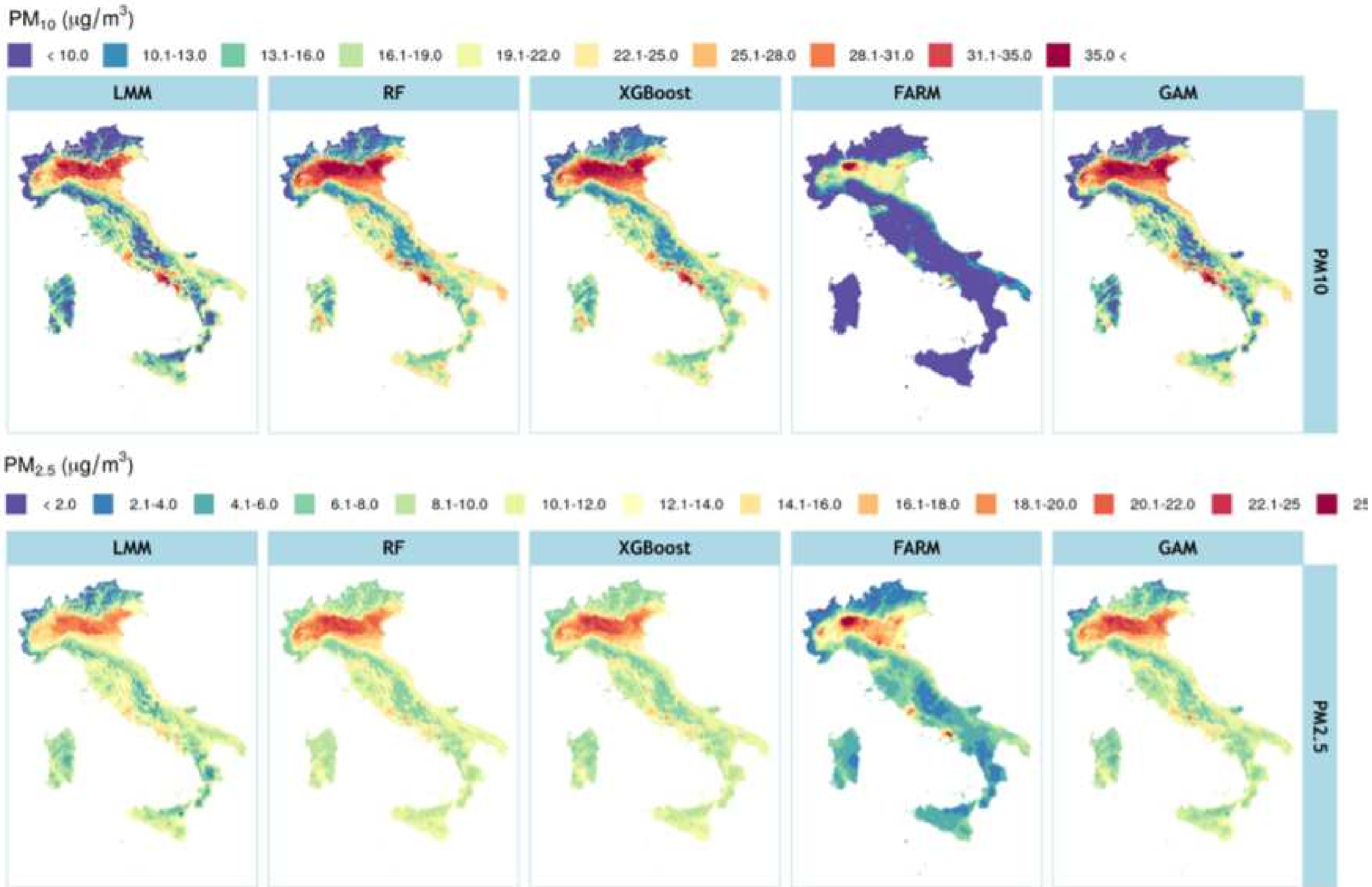
Article

Cite This: *Environ. Sci. Technol.* 2020, 54, 120–128

pubs.acs.org/est

Estimating Daily $PM_{2.5}$ and PM_{10} over Italy Using an Ensemble Model

Alexandra Shtein,[*,†] Itai Kloog,[†] Joel Schwartz,[‡] Camillo Silibello,[§] Paola Michelozzi,[∥] Claudio Gariazzo,[⊥] Giovanni Viegi,[#] Francesco Forastiere,[#,○] Arnon Karnieli,[¶] Allan C. Just,[∇] and Massimo Stafoggia[∥,◆]



Effetti acuti del PM sui ricoveri CVD in Italia

ESC European Society of Cardiology
European Journal of Preventive Cardiology
doi:10.1093/eurjpc/zwaa084
FULL RESEARCH PAP
Cardiovascular dise

Short-term effects of particulate matter on cardiovascular morbidity in Italy: a national analysis

Massimo Stafoggia [1,2]*, Matteo Renzi[1], Francesco Forastiere[3,4], Petter Ljungman [2,5], Marina Davoli[1], Francesca de' Donato[1], Claudio Gariazzo[6], Paola Michelozzi[1], Matteo Scortichini[1], Angelo Solimini[7], Giovanni Viegi [3,8], and Tom Bellander [2,9] on behalf of the BEEP Collaborative Group

Table 2 Association[a] between PM and cardiovascular admissions

Disease (ICD-9 code)	Lag (days)	PM_{10} % IR	PM_{10} 95% CI		$PM_{2.5}$ % IR	$PM_{2.5}$ 95% CI	
Total cardiovascular diseases (ICD-9: 390–459)	0	**0.45**	**0.32**	**0.57**	**0.65**	**0.46**	**0.84**
	0–1	**0.42**	**0.27**	**0.57**	**0.64**	**0.42**	**0.85**
	2–5	**0.37**	**0.15**	**0.59**	**0.81**	**0.49**	**1.13**
	0–5	**0.55**	**0.32**	**0.77**	**0.97**	**0.67**	**1.27**
Cardiac diseases (ICD-9: 390-429)	0	**0.55**	**0.38**	**0.71**	**0.77**	**0.53**	**1.01**
	0–1	**0.58**	**0.40**	**0.77**	**0.86**	**0.60**	**1.13**
	2–5	**0.57**	**0.29**	**0.85**	**1.12**	**0.76**	**1.49**
	0–5	**0.79**	**0.52**	**1.07**	**1.32**	**0.97**	**1.68**
Ischaemic heart diseases (ICD-9: 410–414)	0	**0.62**	**0.13**	**1.11**	**0.88**	**0.15**	**1.61**
	0–1	**0.52**	**0.22**	**0.81**	**0.98**	**0.22**	**1.74**
	2–5	0.18	-0.26	0.63	**0.60**	**0.06**	**1.14**
	0–5	**0.43**	**0.01**	**0.85**	**0.84**	**0.29**	**1.39**
Atrial fibrillation (ICD-9: 427.31)	0	**0.78**	**0.07**	**1.49**	0.96	-0.03	1.96
	0–1	0.79	-0.05	1.65	**1.25**	**0.26**	**2.26**
	2–5	0.73	-0.13	1.60	1.07	-0.15	2.30
	0–5	**1.03**	**0.10**	**1.97**	**1.44**	**0.15**	**2.74**
Heart failure (ICD-9: 428)	0	**1.04**	**0.75**	**1.32**	**1.46**	**1.04**	**1.88**
	0–1	**1.15**	**0.82**	**1.48**	**1.74**	**1.23**	**2.24**
	2–5	**1.32**	**0.96**	**1.69**	**2.16**	**1.69**	**2.63**
	0–5	**1.70**	**1.28**	**2.13**	**2.66**	**2.09**	**3.23**

Table 1 Description of the study population

Study population	N	%	Rate (per 1000)
Disease group (ICD-9 code)			
Total cardiovascular diseases (390–459)	2 154 810	100.0	12.1
Cardiac diseases (390–429)	1 470 370	68.2	8.2
Hypertension (401–405)	72 391	3.4	0.4
Ischaemic heart diseases (410–414)	511 027	23.7	2.9
Myocardial infarction (410)	321 768	14.9	1.8
Arrhythmias (427)	200 207	9.3	1.1
Atrial fibrillation (427.31)	101 491	4.7	0.6
Heart failure (428)	471 042	21.9	2.6
Cerebrovascular diseases (430–438)	542 671	25.2	3.0
Haemorrhagic stroke (431)	57 223	2.7	0.3
Ischaemic stroke (433–435)	329 702	15.3	1.8
Age group (years)			
0–64	476 936	22.1	3.3
65–74	456 683	21.2	25.2
75–84	726 284	33.7	55.1
85+	494 907	23.0	108.6
Sex			
Males	1 169 789	54.3	13.5
Females	985 021	45.7	10.7
Degree of urbanization of the municipality of residence			
Very low or low	286 602	13.3	13.7
Medium	262 437	12.2	12.4
High	429 963	20.0	12.1
Very high	1 175 808	54.6	11.7

ICD-9, International Classification of Diseases, 9th revision.

Effetti cronici dell'inquinamento stimato a diverse risoluzioni

Environmental Research 192 (2021) 110351

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Impact of different exposure models and spatial resolution on the long-term effects of air pollution

Claudio Gariazzo[a,*], Giuseppe Carlino[b], Camillo Silibello[c], Gianni Tinarelli[c], Matteo Renzi[d], Sandro Finardi[c], Nicola Pepe[c], Daniela Barbero[c], Paola Radice[c], Alessandro Marinaccio[a], Francesco Forastiere[e,f], Paola Michelozzi[d], Giovanni Viegi[e,g], Massimo Stafoggia[d], on behalf of theBEEP Collaborative Group

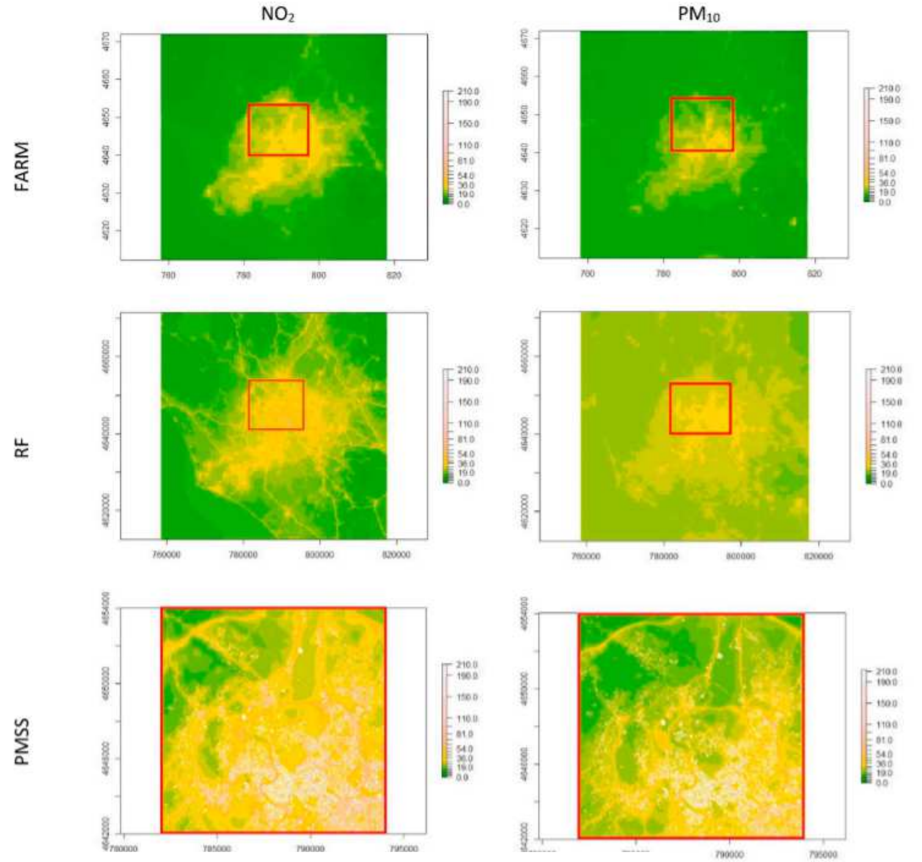


Table 5
Adjusted HRs (95% CI) for increments corresponding to interquartile ranges (IQRs) for natural, cardiovascular, and respiratory mortality according to different exposure models, Rome 2001–2015.

Pollutant	Model	n. data	IQR	Natural (n = 98,480) HR[a] (95% CI)	Cardiovascular (n = 39,393) HR[a] (95% CI)	Respiratory (n = 6,558) HR[a] (95% CI)
NO_2	PMSS_4m	416,766	16.7	1.013 (1.004,1.022)	1.028 (1.014,1.042)	1.014 (0.980,1.050)
	PMSS_12m	480,197	16.4	1.012 (1.004,1.021)	1.029 (1.016,1.043)	1.006 (0.973,1.039)
	PMSS_24m	482,259	16.5	1.013 (1.004,1.022)	1.030 (1.016,1.044)	1.004 (0.970,1.039)
	PMSS_52m	482,259	16.0	1.015 (1.005,1.024)	1.033 (1.018,1.048)	1.004 (0.969,1.041)
	PMSS_100m	482,259	15.8	1.017 (1.007,1.027)	1.037 (1.021,1.053)	1.016 (0.977,1.056)
	PMSS_200m	482,259	14.9	1.018 (1.007,1.028)	1.037 (1.020,1.055)	1.016 (0.975,1.059)
	RF_200m	482,259	14.4	1.016 (1.005,1.027)	1.022 (1.005,1.039)	1.002 (0.962,1.044)
	FARM_1km	482,259	5.1	1.018 (1.008,1.028)	1.042 (1.025,1.058)	1.014 (0.975,1.054)
PM_{10}	PMSS_4m	416,766	13.1	1.013 (1.004,1.022)	1.027 (1.013,1.041)	1.007 (0.973,1.041)
	PMSS_12m	480,197	13.2	1.012 (1.004,1.021)	1.029 (1.015,1.042)	0.999 (0.966,1.032)
	PMSS_24m	482,259	13.5	1.013 (1.004,1.022)	1.029 (1.015,1.043)	0.996 (0.963,1.032)
	PMSS_52m	482,259	13.6	1.015 (1.005,1.025)	1.034 (1.018,1.049)	0.996 (0.959,1.034)
	PMSS_100m	482,259	13.6	1.018 (1.007,1.029)	1.039 (1.022,1.057)	1.007 (0.966,1.050)
	PMSS_200m	482,259	13.1	1.020 (1.008,1.031)	1.042 (1.024,1.061)	1.009 (0.965,1.055)
	RF_200m	482,259	2.5	1.010 (1.000,1.020)	1.028 (1.012,1.044)	1.011 (0.973,1.052)
	FARM_1km	482,259	6.8	1.017 (1.007,1.026)	1.041 (1.025,1.057)	1.007 (0.970,1.046)

[a] Adjusted for sex, marital status, place of birth, education, occupation, and area-based socioeconomic position.

BIGEPI

BIG data per la valutazione degli Effetti sanitari dell'inquinamento atmosferico nella Popolazione Italiana

Giovanni Viegi

Ex Direttore, Istituto di Biomedicina e Immunologia Molecolare CNR, Palermo

Associato di ricerca senior, Istituto per la Ricerca e l'Innovazione Biomedica CNR, Palermo, ed Istituto di Fisiologia Clinica CNR, Pisa

2006-07 Past President, European Respiratory Society (ERS)

2017-2022 Planning Group Member, Global Alliance against chronic Respiratory Diseases (GARD)

INAIL – Istituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro
IRIB CNR – Istituto per la Ricerca e l'Innovazione Biomedica, Consiglio Nazionale delle Ricerche
D/EP/Lazio – Dipartimento di Epidemiologia, Servizio Sanitario Regionale, Regione Lazio
Epidemiologia Piemonte
arpae – agenzia prevenzione ambiente energia emilia-romagna
AReSS – Agenzia Regionale per la Salute ed il Sociale Puglia
Regione Sicilia
Università di Verona – Dipartimento di Diagnostica e Sanità Pubblica

Effects of Particulate Matter on the Incidence of Respiratory Diseases in the Pisan Longitudinal Study

Salvatore Fasola [1,*], Sara Maio [2], Sandra Baldacci [2], Stefania La Grutta [1], Giuliana Ferrante [3], Francesco Forastiere [1], Massimo Stafoggia [4], Claudio Gariazzo [5], Giovanni Viegi [1,2] and on behalf of the BEEP Collaborative Group [†]

Abstract: The current study aimed at assessing the effects of exposure to Particulate Matter (PM) on the incidence of respiratory diseases in a sub-sample of participants in the longitudinal analytical epidemiological study in Pisa, Italy. Three hundred and five subjects living at the same address from 1991 to 2011 were included. Individual risk factors recorded during the 1991 survey were considered, and new cases of respiratory diseases were ascertained until 2011. Average PM_{10} and $PM_{2.5}$ exposures (μg/m^3, year 2011) were estimated at the residential address (1-km^2 resolution) through a random forest machine learning approach, using a combination of satellite data and land use variables. Multivariable logistic regression with Firth's correction was applied. The median (25th–75th percentile) exposure levels were 30.1 μg/m^3 (29.9–30.7 μg/m^3) for PM_{10} and 19.3 μg/m^3 (18.9–19.4 μg/m^3) for $PM_{2.5}$. Incidences of rhinitis and chronic phlegm were associated with increasing $PM_{2.5}$: OR = 2.25 (95% CI: 1.07, 4.98) per unit increase (p.u.i.) and OR = 4.17 (1.12, 18.71) p.u.i., respectively. Incidence of chronic obstructive pulmonary disease was associated with PM_{10}: OR = 2.96 (1.50, 7.15) p.u.i. These results provide new insights into the long-term respiratory health effects of PM air pollution.

Table 2. Associations (odds ratio, OR, and 95% confidence intervals (CI)) between risk factors ascertained during the first survey (1991–1993) and cumulative incidences of asthma, rhinitis, Chronic Obstructive Pulmonary Disease (COPD) and chronic phlegm ascertained at the second survey (2009–2011), from multivariable logistic regression models with Firth's correction.

	Asthma	Rhinitis	COPD	Chronic Phlegm
Cumulative incidence:	4/284 (1.4%)	90/264 (34.1%)	29/282 (10.3%)	16/262 (6.1%)
Independent variables:	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
PM_{10} (1 $\mu g/m^3$ increase) [1]	- [2]	- [2]	**2.96 (1.50–7.15)**	- [2]
$PM_{2.5}$ (1 $\mu g/m^3$ increase) [1]	- [2]	**2.25 (1.07–4.98)**	- [2]	**4.17 (1.12–18.71)**
Age, years (10-year increase)	- [2]	- [2]	**1.87 (1.29–3.02)**	- [2]
Male gender	- [2]	- [2]	- [2]	- [2]
Smoker (ref = non-smoker)	**12.96 (1.25–∞)**	- [2]	**2.99 (1.08–9.39)**	- [2]
Ex-smoker (ref = non-smoker)	4.86 (0.27–∞)	- [2]	1.67 (0.60–4.89)	- [2]
Occupational exposure	- [2]	- [2]	1.91 (0.83–4.79)	**5.41 (1.88–21.79)**

[1] Estimated exposure levels at the residential address for the year 2011, 1 km^2 resolution. [2] Variables excluded by the stepwise selection procedure. Significant odds ratios are reported in bold.

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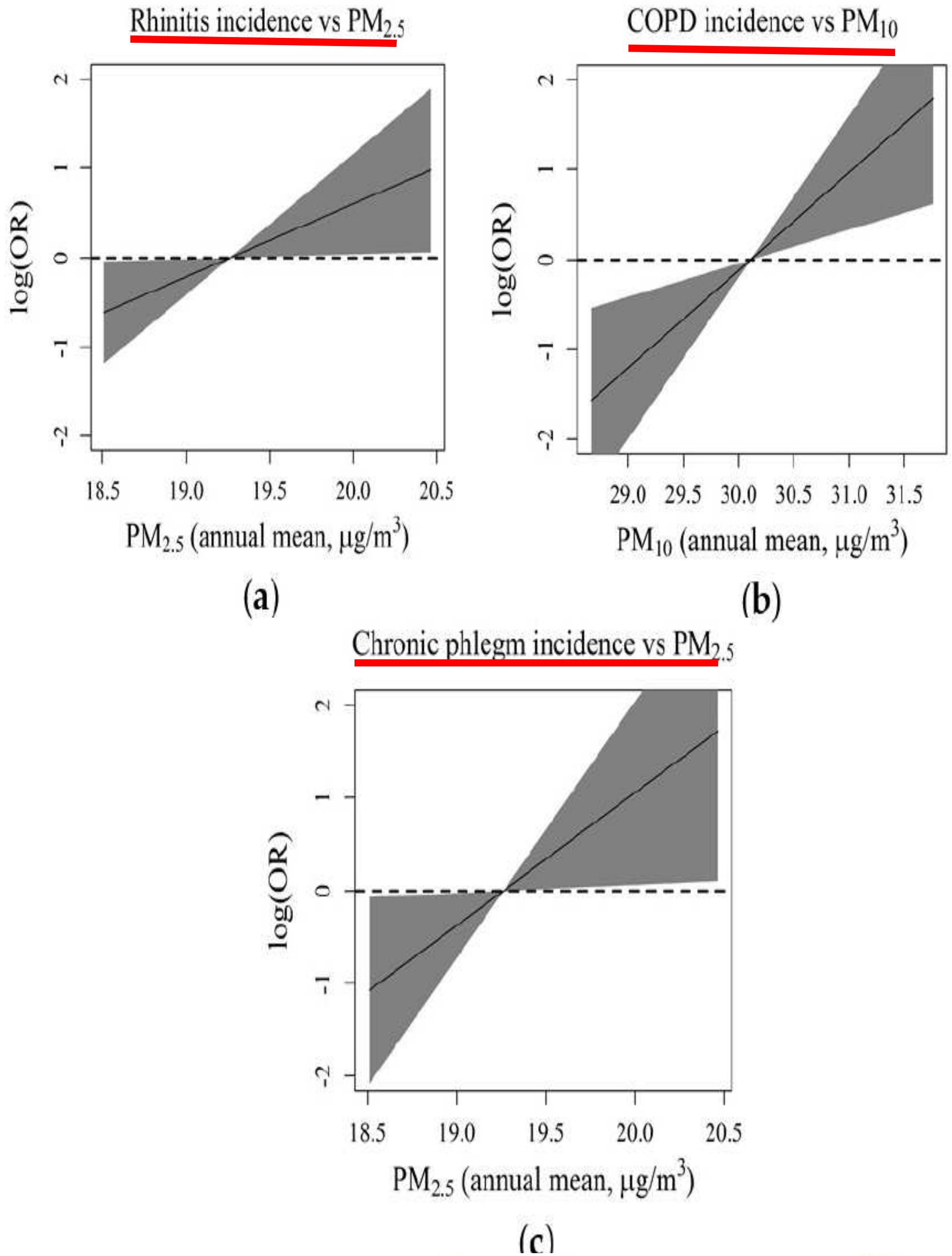

Figure 2. Exposure-response functions: (**a**) $PM_{2.5}$ vs. rhinitis incidence; (**b**) PM_{10} vs. COPD incidence; (**c**) $PM_{2.5}$ vs. of chronic phlegm incidence. The log-ORs were calculated assuming the median annual concentrations of PM as the reference (30.1 µg/m^3 for PM_{10} and 19.3 µg/m^3 for $PM_{2.5}$).

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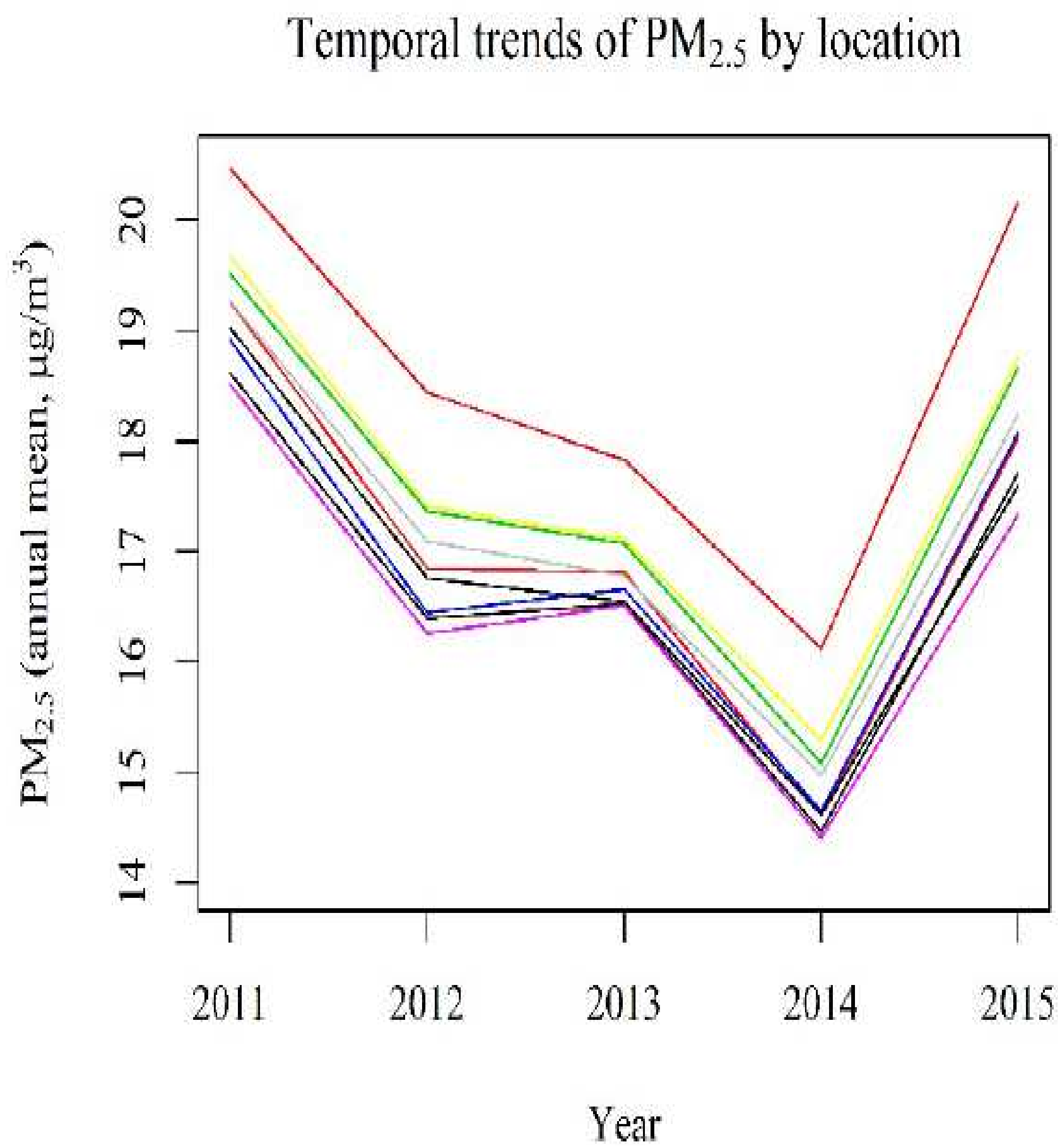

Figure 3. Observed temporal trends for the annual mean concentrations of PM from 2011 to 2015, in 10 randomly selected residential locations.

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Short-Term Effects of Air Pollution on Cardiovascular Hospitalizations in the Pisan Longitudinal Study

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Salvatore Fasola [1,*,†], Sara Maio [2,†], Sandra Baldacci [2], Stefania La Grutta [1], Giuliana Ferrante [3], Francesco Forastiere [1], Massimo Stafoggia [4], Claudio Gariazzo [5], Camillo Silibello [6], Giuseppe Carlino [7], Giovanni Viegi [1,2] and on behalf of the BEEP Collaborative Group [‡]

Abstract: Air pollution effects on cardiovascular hospitalizations in small urban/suburban areas have been scantly investigated. Such effects were assessed among the participants in the analytical epidemiological survey carried out in Pisa and Cascina, Tuscany, Italy (2009–2011). Cardiovascular hospitalizations from 1585 subjects were followed up (2011–2015). Daily mean pollutant concentrations were estimated through random forests at 1 km (particulate matter: PM_{10}, 2011–2015; $PM_{2.5}$, 2013–2015) and 200 m (PM_{10}, $PM_{2.5}$, NO_2, O_3, 2013–2015) resolutions. Exposure effects were estimated using the case-crossover design and conditional logistic regression (odds ratio—OR—and 95% confidence interval—CI—for 10 $\mu g/m^3$ increase; lag 0–6). During the period 2011–2015 (137 hospitalizations), a significant effect at lag 0 was observed for PM_{10} (OR = 1.137, CI: 1.023–1.264) at 1 km resolution. During the period 2013–2015 (69 hospitalizations), significant effects at lag 0 were observed for PM_{10} (OR = 1.268, CI: 1.085–1.483) and $PM_{2.5}$ (OR = 1.273, CI: 1.053–1.540) at 1 km resolution, as well as for PM_{10} (OR = 1.365, CI: 1.103–1.690), $PM_{2.5}$ (OR = 1.264, CI: 1.006–1.589) and NO_2 (OR = 1.477, CI: 1.058–2.061) at 200 m resolution; significant effects were observed up to lag 2. Larger ORs were observed in males and in subjects reporting pre-existent cardiovascular/respiratory diseases. Combining analytical and routine epidemiological data with high-resolution pollutant estimates provides new insights on acute cardiovascular effects in the general population and in potentially susceptible subgroups living in small urban/suburban areas.

Table 4. Acute effects of estimated pollution levels on the risk of cardiovascular hospitalizations: odds ratios (10 μg/m^3 increase) and 95% confidence intervals through the conditional logistic regression models.

Lags	2011–2015 n = 137	2013–2015 n = 69					
	PM_{10}, 1 km	PM_{10}, 1 km	$PM_{2.5}$, 1 km	PM_{10}, 200 m	$PM_{2.5}$, 200 m	NO_2, 200 m	O_3, 200 m
Lag 0	1.137 (1.023, 1.264)	1.268 (1.085, 1.483)	1.273 (1.053, 1.540)	1.365 (1.103, 1.690)	1.264 (1.006, 1.589)	1.477 (1.058, 2.061)	0.896 (0.710, 1.130)
Lag 1	1.099 (1.017, 1.188)	1.190 (1.063, 1.332)	1.197 (1.045, 1.372)	1.255 (1.078, 1.461)	1.193 (1.015, 1.401)	1.313 (1.040, 1.658)	0.930 (0.794, 1.089)
Lag 2	1.062 (1.006, 1.121)	1.116 (1.036, 1.203)	1.126 (1.029, 1.231)	1.154 (1.049, 1.270)	1.125 (1.016, 1.245)	1.167 (1.012, 1.346)	0.965 (0.885, 1.054)
Lag 3	1.027 (0.984, 1.071)	1.047 (0.990, 1.108)	1.059 (0.989, 1.133)	1.061 (0.998, 1.129)	1.061 (0.989, 1.139)	1.038 (0.947, 1.137)	1.002 (0.961, 1.046)
Lag 4	0.992 (0.942, 1.044)	0.982 (0.913, 1.058)	0.995 (0.908, 1.091)	0.976 (0.897, 1.061)	1.001 (0.905, 1.107)	0.922 (0.804, 1.058)	1.041 (0.954, 1.135)
Lag 5	0.959 (0.890, 1.033)	0.922 (0.825, 1.030)	0.936 (0.815, 1.075)	0.897 (0.782, 1.029)	0.945 (0.805, 1.109)	0.820 (0.654, 1.029)	1.081 (0.923, 1.265)
Lag 6	0.927 (0.837, 1.026)	0.865 (0.741, 1.009)	0.880 (0.726, 1.068)	0.825 (0.677, 1.006)	0.891 (0.710, 1.118)	0.729 (0.526, 1.011)	1.122 (0.890, 1.415)

Significant effects (1 not included in the confidence interval) are in bold.

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A nationwide study of air pollution from particulate matter and daily hospitalizations for respiratory diseases in Italy

Matteo Renzi [a], Matteo Scortichini [a], Francesco Forastiere [b, e], Francesca de' Donato [a], Paola Michelozzi [a], Marina Davoli [a], Claudio Gariazzo [c], Giovanni Viegi [b, d], Massimo Stafoggia [a], BEEP collaborative Group, Carla Ancona [f], Simone Bucci [f], Francesca de' Donato [f], Paola Michelozzi [f], Matteo Renzi [f], Matteo Scortichini [f], Massimo Stafoggia [f], Michela Bonafede [g] … Giuseppe Carlino [s]

Abstract

Background/aim

The relationship between air pollution and respiratory morbidity has been widely addressed in urban and metropolitan areas but little is known about the effects in non-urban settings. Our aim was to assess the short-term effects of PM10 and PM2.5 on respiratory admissions in the whole country of Italy during 2006–2015.

Methods

We estimated daily PM concentrations at the municipality level using satellite data and spatiotemporal predictors. We collected daily counts of respiratory hospital admissions for each Italian municipality. We considered five different outcomes: all respiratory diseases, asthma, chronic obstructive pulmonary disease (COPD), lower and upper respiratory tract infections (LRTI and URTI). Meta-analysis of province-specific estimates obtained by time-series models, adjusting for temperature, humidity and other confounders, was applied to extrapolate national estimates for each outcome. At last, we tested for effect modification by sex, age, period, and urbanization score. Analyses for $PM_{2.5}$ were restricted to 2013–2015 cause the goodness of fit of exposure estimation.

Results

A total of 4,154,887 respiratory admission were registered during 2006–2015, of which 29% for LRTI, 12% for COPD, 6% for URTI, and 3% for asthma. Daily mean PM_{10} and $PM_{2.5}$ concentrations over the study period were 23.3 and 17 $\mu g/m^3$, respectively. For each 10 $\mu g/m^3$ increases in PM_{10} and $PM_{2.5}$ at lag 0–5 days, we found excess risks of total respiratory diseases equal to 1.20% (95% confidence intervals, 0.92, 1.49) and 1.22% (0.76, 1.68), respectively. The effects for the specific diseases were similar, with the strongest ones for asthma and COPD. Higher effects were found in the elderly and in less urbanized areas.

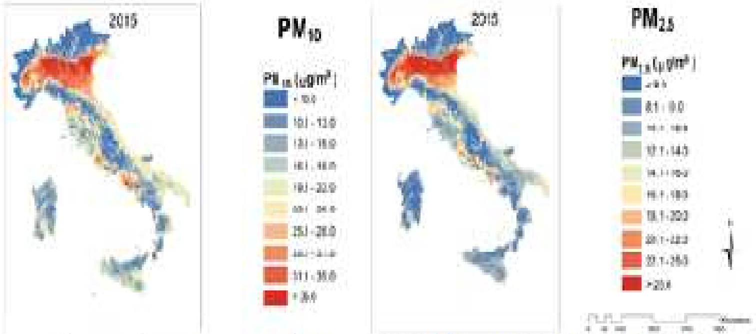
Conclusions

Short-term exposure to PM is harmful for the respiratory system throughout an entire country, especially in elderly patients. Strong effects can be found also in less urbanized areas.

Graphical abstract

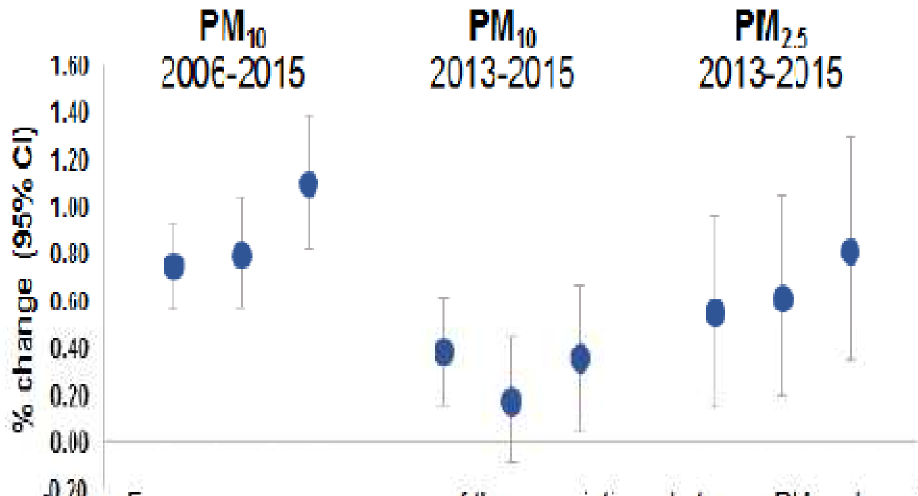
A nationwide study of air pollution and daily hospitalizations for respiratory diseases in Italy

- Machine-learning approach to estimate PM exposure
- National health data database
- Sensitivity analyses (subgroup outcomes, effect modification, exposure-response curves)

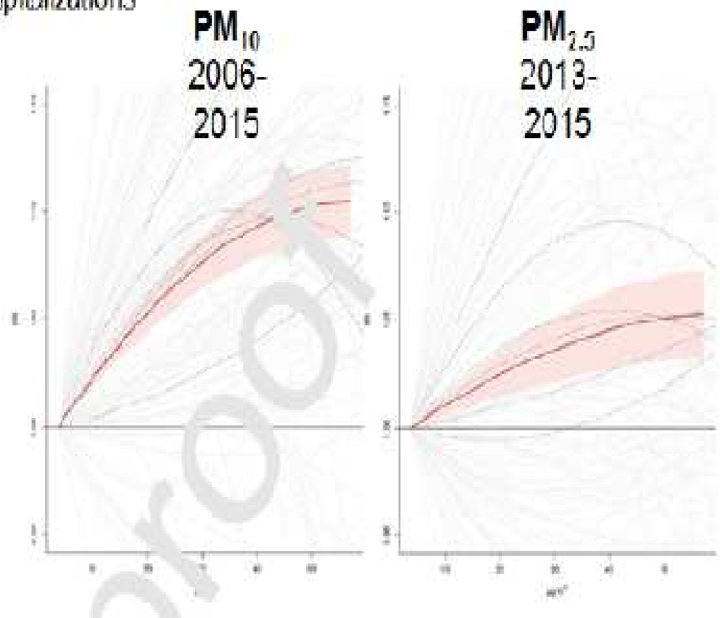


Annual concentrations of PM10 and PM2.5 in Italy

Association with total respiratory hospitalizations



Exposure-response curves of the associations between PM and respiratory hospitalizations



Conclusions:
In this study we provided evidence of harmful effect of PM_{10} and $PM_{2.5}$ on respiratory hospitalizations in Italy during 2006-2015 and we reported a positive association for a subgroup of respiratory outcomes such as asthma, COPD and LRTI. Low-level effects were detected.