



Utilizzo di modelli *single-* e *two-pollutant* nella valutazione di impatto dell'inquinamento atmosferico: un caso studio su Bari utilizzando funzioni esposizione-risposta aggiornate al 2024

Orazio Valerio Giannico, MD
Struttura Complessa di Statistica ed Epidemiologia, ASL Taranto
Area Epidemiologia e Care Intelligence, ARESS Puglia

Orazio Valerio Giannico, Anna Maria Nannavecchia, Massimo Stafoggia, Lucia Bisceglia

Il problema del double counting

- Sono state proposte varie soluzioni per evitare il problema del “double counting” nell’health impact assessment (HIA) di più inquinanti
- Un possibile approccio consiste nell'utilizzare le ERF di modelli single-pollutant e selezionare solo la stima più alta come rappresentativa della miscela
- Un approccio alternativo consiste nel calcolare gli impatti congiunti utilizzando l'ERF da modelli multi-pollutant



ERF single-pollutant

PM_{2.5} and all-cause mortality

RR: 1.095 (95%CI 1.064;1.127) for 10 µg/m³

NO₂ and all-cause mortality

RR: 1.05 (95%CI 1.03;1.07) for 10 µg/m³



Long-Term Exposure to Particulate Matter and Mortality: An Update of the WHO Global Air Quality Guidelines Systematic Review and Meta-Analysis

Pablo Orellano^{1*}, María-Iosifina Kasdagli², Román Pérez Velasco³ and Evangelia Samoli²

¹Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Universidad Tecnológica Nacional, Facultad Regional San Nicolás, San Nicolás, Argentina, ²Department of Hygiene, Epidemiology and Medical Statistics, Medical School, National and Kapodistrian University of Athens, Athens, Greece, ³World Health Organization (WHO) Regional Office for Europe, European Centre for Environment and Health, Bonn, Germany



Long-Term Exposure to Nitrogen Dioxide and Ozone and Mortality: Update of the WHO Air Quality Guidelines Systematic Review and Meta-Analysis

María-Iosifina Kasdagli¹, Pablo Orellano², Román Pérez Velasco³ and Evangelia Samoli^{1*}

¹Department of Hygiene, Epidemiology and Medical Statistics, Medical School, National and Kapodistrian University of Athens, Athens, Greece, ²Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Universidad Tecnológica Nacional, Facultad Regional San Nicolás, San Nicolás, Argentina, ³World Health Organization (WHO) Regional Office for Europe, European Centre for Environment and Health, Bonn, Germany

ERF two-pollutant

PM_{2.5} and all-cause mortality

RR: 1.071 (95%CI 1.028-1.117) for 10 µg/m³

NO₂ and all-cause mortality

RR: 1.024 (95%CI 1.000-1.049) for 10 µg/m³



ELSEVIER



Single- and two-pollutant concentration-response functions for PM_{2.5} and NO₂ for quantifying mortality burden in health impact assessments

Xuan Chen^{a,*}, Ulrike Gehring^a, Georgia M.C. Dyer^{b,c,d}, Sasha Khomenko^{b,c,d}, Kees de Hoogh^{e,f}, Cathryn Tonne^{b,c,d}, Lambert Tatah^g, Roel Vermeulen^{a,h}, Haneen Khreis^g, Mark Nieuwenhuijsen^{b,c,d}, Gerard Hoek^a

^a Institute for Risk Assessment Sciences (IRAS), Utrecht University, Utrecht, the Netherlands

^b Barcelona Institute for Global Health (ISGlobal), Doctor Aiguader 88, 08003, Barcelona, Spain

^c Universitat Pompeu Fabra (UPF), Doctor Aiguader 88, 08003, Barcelona, Spain

^d CIBER Epidemiología y Salud Pública (CIBERESP), Melchor Fernández Almagro, 3-5, 28029, Madrid, Spain

^e Swiss Tropical and Public Health Institute, Allschwil, Switzerland

^f University of Basel, Basel, Switzerland

^g MRC Epidemiology Unit, School of Clinical Medicine, University of Cambridge, Cambridge, UK

^h Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, Utrecht University, Utrecht, the Netherlands

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ABSTRACT

Objective: Health Impact Assessments (HIAs) for air pollutant mixtures are challenging because risk estimates are primarily derived from single-pollutant models. Combining risk estimates from multiple pollutants requires new approaches, as a simple addition of single pollutant risk estimates from correlated air pollutants may result in double counting. We investigated approaches applying concentration-response functions (CRFs) from single- and two-pollutant models in HIAs, focusing on long-term exposure to particulate matter with a diameter less than 2.5 µm (PM_{2.5}) and nitrogen dioxide (NO₂) and their associations with all-cause mortality.

Methods: A systematic literature search of MEDLINE and EMBASE identified cohort studies employing single- and two-pollutant models of long-term exposure to PM_{2.5} and NO₂ with all-cause mortality. Pooled CRFs were calculated through random-effects meta-analyses of risk estimates from single- and two-pollutant models. Coefficient differences were calculated by comparing single- and two-pollutant model estimates. Four approaches to estimating population-attributable fractions (PAFs) were compared: PM_{2.5} or NO₂ single-pollutant models to represent the mixture, the sum of single-pollutant models, the sum of two-pollutant models and the sum of single-pollutant models from a larger body of evidence adjusted by coefficient difference.

Results: Seventeen papers reported both single and two-pollutant estimates. Pooled hazard ratios (HRs) for mortality from single- and two-pollutant models were 1.053 (95% confidence interval: 1.034–1.071) and 1.035 (1.014–1.057), respectively, for a 5 µg/m³ increase in PM_{2.5}. HRs for a 10 µg/m³ increase in NO₂ were 1.032 (1.014–1.049) and 1.024 (1.000–1.049) for single- and two-pollutant models, respectively. The average coefficient difference between single- and two-pollutant models was 0.017 for PM_{2.5} and 0.007 for NO₂. Combined PAFs for the PM_{2.5}-NO₂ mixture using joint HRs from single- and two-pollutant model CRFs were 0.09 and 0.06, respectively.

Conclusion: Utilizing CRFs from two-pollutant models or applying the coefficient difference to a more extensive evidence base seems to mitigate the potential overestimation of mixture health impacts from adding single-pollutant CRFs.

Obiettivi

Testare nella città di **Bari** le **ultime ERF** da modelli **single-pollutant** e **two-pollutant** per **quantificare e confrontare gli impatti sulla mortalità di PM_{2,5} ed NO₂** utilizzando come controfattuale le linee guida **OMS 2021**





Disegno, analisi e strumenti

QGIS version 3.24 e R version 4.2.2

Anni 2013,2014,2015

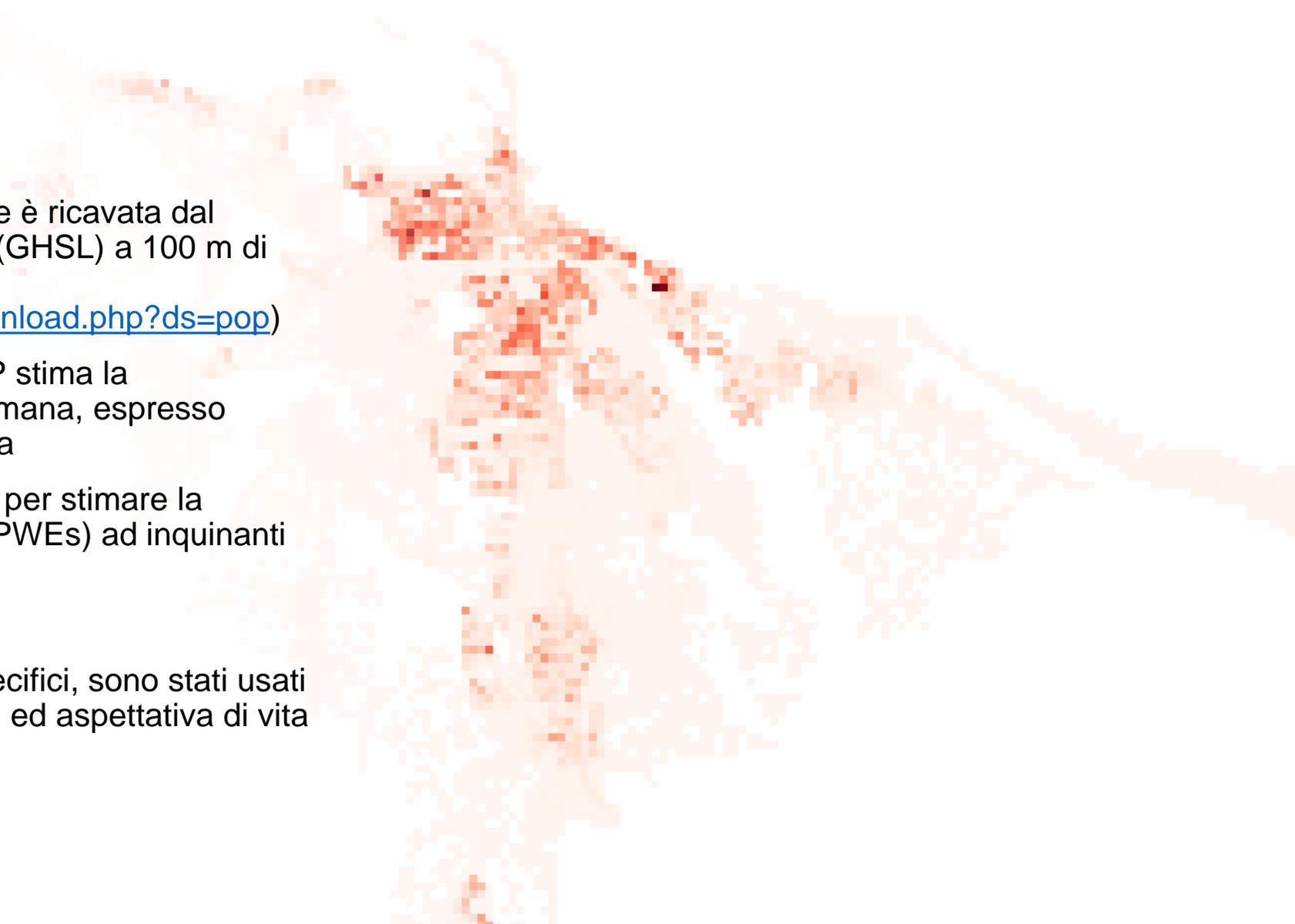
Area in studio: città di Bari

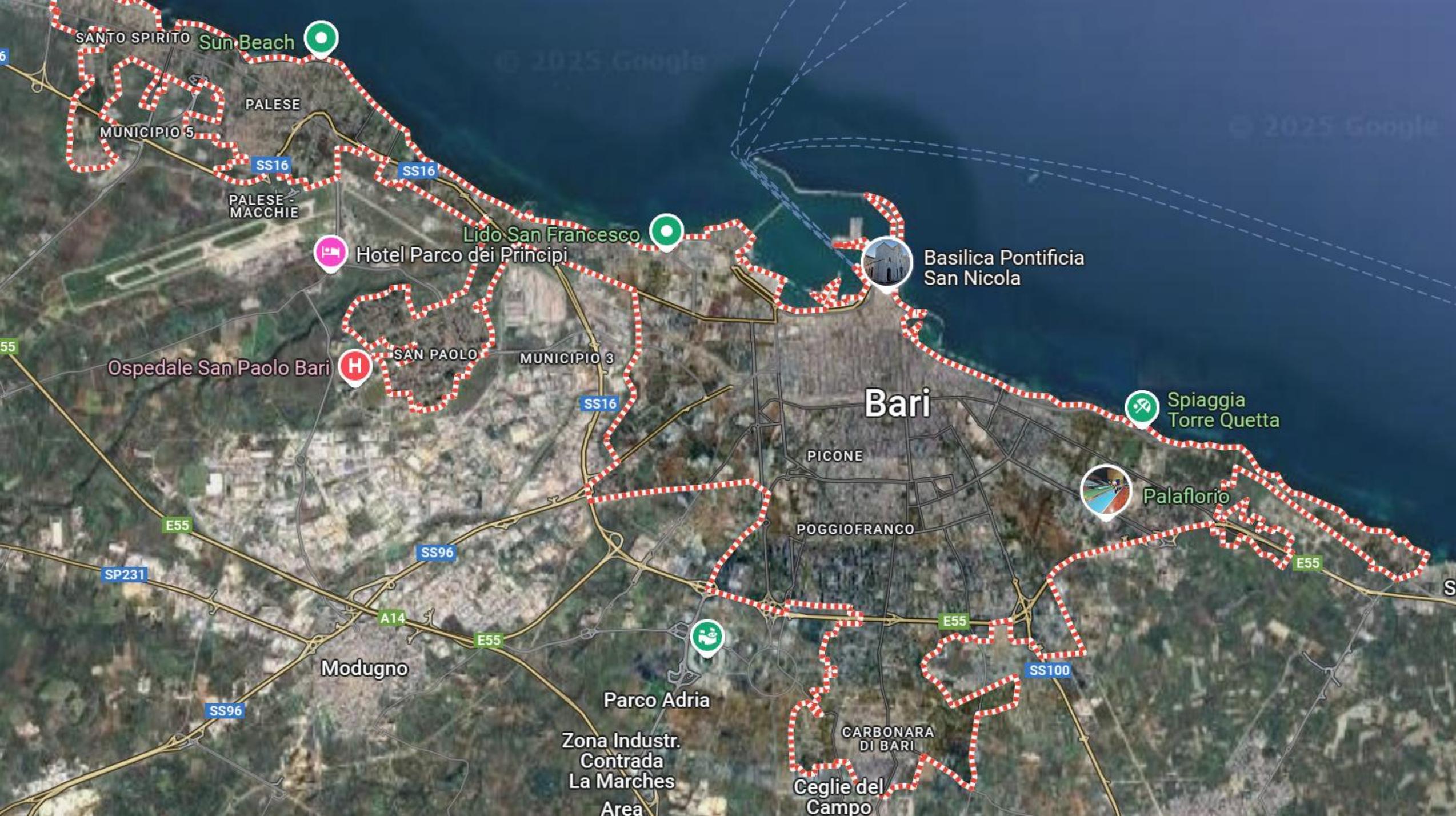
265.200 abitanti (≥ 20 anni)

Population weighted exposures (PWE) è stata calcolata usando il Global Human Settlement Layer Population del 2015 (risoluzione 100 metri)

Popolazione e mortalità

- La distribuzione della popolazione è ricavata dal Global Human Settlement Layer (GHSL) a 100 m di risoluzione (<https://ghsl.jrc.ec.europa.eu/download.php?ds=pop>)
- Questo raster spaziale GHS-POP stima la distribuzione della popolazione umana, espresso come numero di persone per cella
- GHS-POP 2015 è stata utilizzata per stimare la population weighted exposures (PWEs) ad inquinanti atmosferici
- Per il calcolo degli impatti età-specifici, sono stati usati i dati ISTAT di mortalità (comune) ed aspettativa di vita (provincia)





SANTO SPIRITO Sun Beach

PALESE

MUNICIPIO 5

PALESE MACCHIE

Lido San Francesco

Hotel Parco dei Principi

Basilica Pontificia San Nicola

Ospedale San Paolo Bari

SAN PAOLO

MUNICIPIO 3

Bari

Spiaggia Torre Quetta

Palaflorio

PICONE

POGGIOFRANCO

Modugno

Parco Adria

Zona Industr. Contrada La Marches Area

CARBONARA DI BARI

Ceglie del Campo

SS16

SS16

SS16

SS96

SP231

E55

A14

E55

SS96

E55

SS100

E55

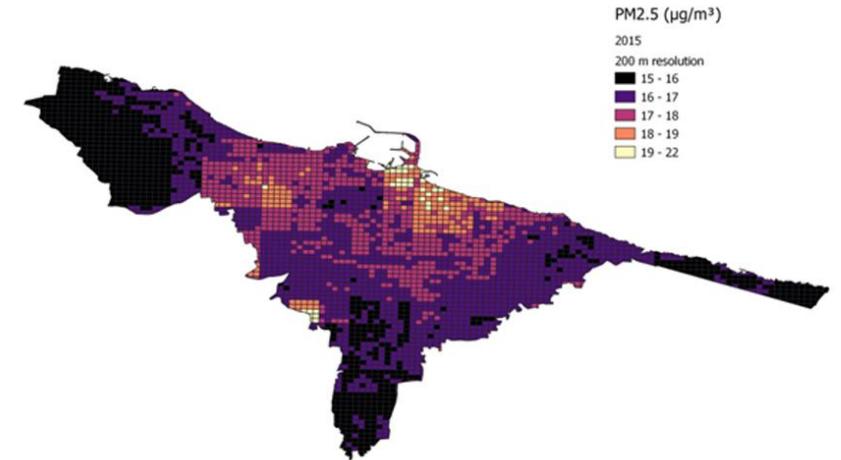
Esposizione

Baseline: Modello Random Forest 200m
Medie annuali

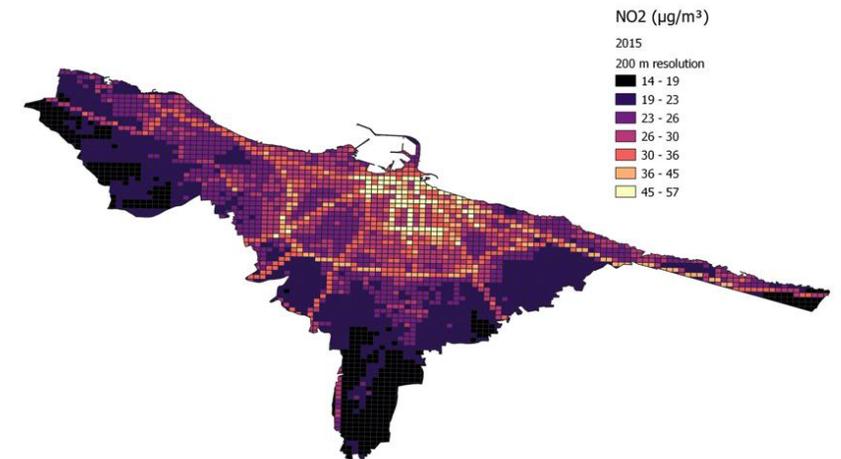
Controfattuale: WHO AQG 2021 annual

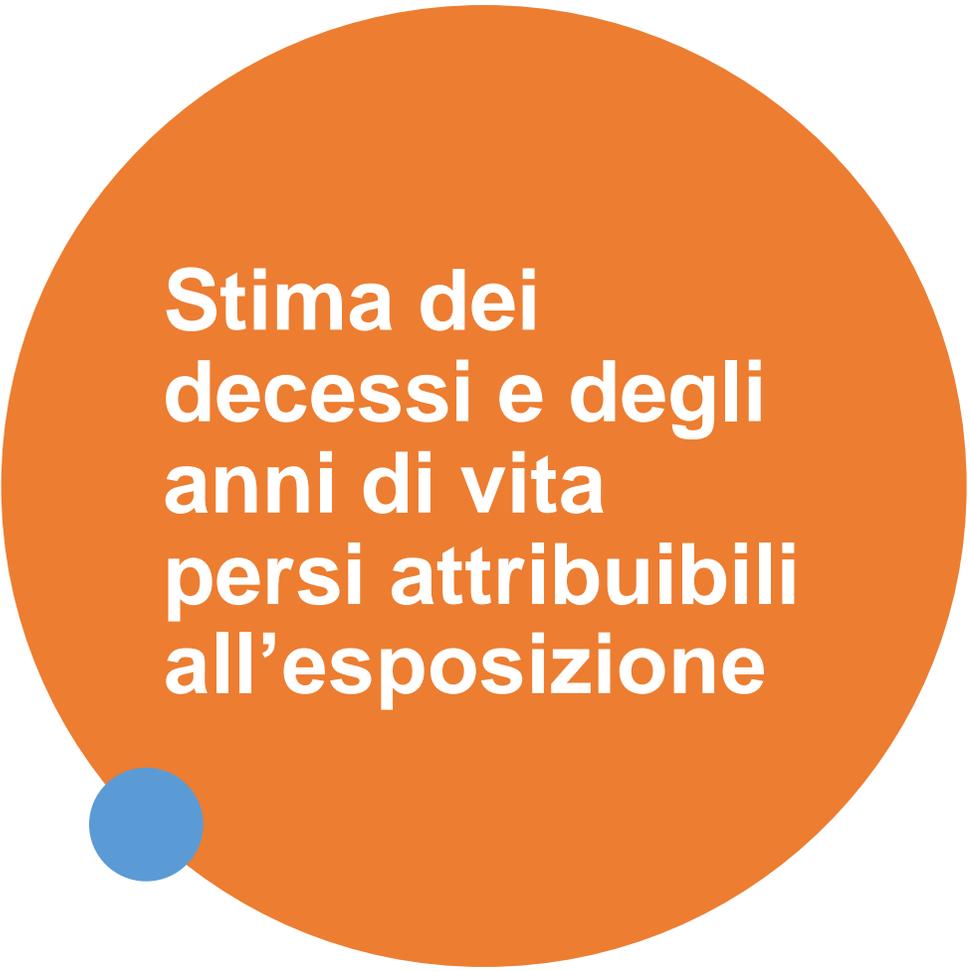
- PM2.5: 5 $\mu\text{g}/\text{m}^3$
- NO2: 10 $\mu\text{g}/\text{m}^3$

a



b





Stima dei decessi e degli anni di vita persi attribuibili all'esposizione

Δ = esposizione baseline (PWE) meno esposizione controfattuale (WHO21)

AD: attributable deaths, AF: attributable fraction, BD: baseline deaths, BYLL: baseline years of life lost, LE: life expectancy,

$$RR_{x1} = \exp\left[\frac{\ln(RR_{10})}{10} * \Delta\right]$$

...

$$RR_{joint} = RR_{x1} * RR_{x2}$$

$$AF = (RR - 1) / RR$$

$$AD = AF * BD$$

$$AYLL = AF * BYLL = AF * BD * LE = AD * LE$$

Risultati single-pollutant

Year	Pollutant	PWE	CE	Attributable fraction (95% CI) [%]	Preventable or attributable deaths (95% CI)			
					20–59 years	60–79 years	≥ 80 years	≥ 20 years
2013	PM _{2.5} , annual (200m) [µg/m ³]	16.13	5	9.6 (6.7;12.5)	25 (17;33)	101 (70;131)	172 (120;224)	298 (207;388)
	NO ₂ , annual (200m) [µg/m ³]	31.93	10	10.1 (6.3;13.8)	27 (16;36)	106 (66;145)	182 (113;248)	315 (195;429)
2014	PM _{2.5} , annual (200m) [µg/m ³]	14.42	5	8.2 (5.7;10.7)	20 (14;26)	82 (57;107)	156 (108;203)	258 (179;336)
	NO ₂ , annual (200m) [µg/m ³]	30.37	10	9.5 (5.8;12.9)	23 (14;31)	95 (58;129)	181 (112;246)	299 (184;406)
2015	PM _{2.5} , annual (200m) [µg/m ³]	17.63	5	10.8 (7.5;14)	27 (19;35)	110 (77;143)	224 (156;290)	361 (252;468)
	NO ₂ , annual (200m) [µg/m ³]	33.89	10	11.0 (6.8;14.9)	28 (17;38)	112 (69;152)	228 (141;309)	368 (227;499)
Year	Pollutant	PWE	CE	Attributable fraction (95% CI) [%]	Preventable or attributable years of life lost (95% CI)			
					20–59 years	60–79 years	≥ 80 years	≥ 20 years
2013	PM _{2.5} , annual (200m) [µg/m ³]	16.13	5	9.6 (6.7;12.5)	883 (613;1,145)	1,579 (1,096;2,048)	1,034 (718;1,341)	3,496 (2,427;4,534)
	NO ₂ , annual (200m) [µg/m ³]	31.93	10	10.1 (6.3;13.8)	933 (577;1,267)	1,668 (1,032;2,266)	1,092 (675;1,484)	3,693 (2,284;5,017)
2014	PM _{2.5} , annual (200m) [µg/m ³]	14.42	5	8.2 (5.7;10.7)	704 (488;915)	1,258 (871;1,635)	865 (600;1,125)	2,827 (1,959;3,675)
	NO ₂ , annual (200m) [µg/m ³]	30.37	10	9.5 (5.8;12.9)	812 (502;1,106)	1,452 (897;1,976)	999 (617;1,360)	3,263 (2,016;4,442)
2015	PM _{2.5} , annual (200m) [µg/m ³]	17.63	5	10.8 (7.5;14)	953 (663;1,233)	1,690 (1,176;2,187)	1,220 (849;1,578)	3,863 (2,688;4,998)
	NO ₂ , annual (200m) [µg/m ³]	33.89	10	11.0 (6.8;14.9)	968 (600;1,313)	1,716 (1,064;2,328)	1,239 (768;1,680)	3,923 (2,432;5,321)

Risultati two-pollutant

Year	Pollutant	PWE	CE	Attributable fraction (95% CI) [%]	Attributable deaths (95% CI)			
					20–59 years	60–79 years	≥ 80 years	≥ 20 years
2013	PM _{2.5} , annual (200m) [µg/m ³]	16.13	5	12.0 (3.0;20.4)	32 (8;53)	126 (32;214)	216 (54;366)	374 (94;633)
	NO ₂ , annual (200m) [µg/m ³]	31.93	10					
2014	PM _{2.5} , annual (200m) [µg/m ³]	14.42	5	10.7 (2.6;18.3)	26 (6;44)	107 (26;183)	204 (49;349)	337 (81;576)
	NO ₂ , annual (200m) [µg/m ³]	30.37	10					
2015	PM _{2.5} , annual (200m) [µg/m ³]	17.63	5	13.4 (3.4;22.4)	34 (9;57)	136 (35;229)	276 (71;464)	446 (115;750)
	NO ₂ , annual (200m) [µg/m ³]	33.89	10					
Year	Pollutant	PWE	CE	Attributable fraction (95%CI) [%]	Attributable years of life lost (95%CI)			
					20–59 years	60–79 years	≥ 80 years	≥ 20 years
2013	PM _{2.5} , annual (200m) [µg/m ³]	16.13	5	12.0 (3.0;20.4)	1,107 (278;1,874)	1,980 (497;3,351)	1,296 (326;2,194)	4,383 (1,101;7,419)
	NO ₂ , annual (200m) [µg/m ³]	31.93	10					
2014	PM _{2.5} , annual (200m) [µg/m ³]	14.42	5	10.7 (2.6;18.3)	917 (221;1,568)	1,639 (394;2,803)	1,128 (271;1,929)	3,684 (886;6,300)
	NO ₂ , annual (200m) [µg/m ³]	30.37	10					
2015	PM _{2.5} , annual (200m) [µg/m ³]	17.63	5	13.4 (3.4;22.4)	1,174 (302;1,973)	2,083 (535;3,500)	1,503 (386;2,526)	4,760 (1,223;7,999)
	NO ₂ , annual (200m) [µg/m ³]	33.89	10					

Conclusioni



- Le stime per il PM_{2,5} o l'NO₂ da modelli *single-pollutant* utilizzate come rappresentative della miscela potrebbero portare a una sottostima degli impatti (NO₂, AF:11%)
- D'altro canto, usare entrambe le stime *single pollutant* porterebbe probabilmente ad una sovrastima dell'effetto
- Le stime congiunte dei modelli *two-pollutant* rappresentano, a livello teorico, la scelta più adatta (PM_{2.5}+NO₂, AF:13.4%)
- Tuttavia, l'affidabilità degli ERF *two-pollutant* si basa ancora su un numero di studi inferiore rispetto alle stime corrispondenti dei modelli *single-pollutant*

Grazie per l'attenzione

