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Frontiers in Computational Physics

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Dipartimento di Fisica Università di Bari "Aldo Moro", INFN Sezione di Bari

A Novel Methodology for Epidemic Risk Assessment:

The Case of COVID-19 Outbreak in Italy

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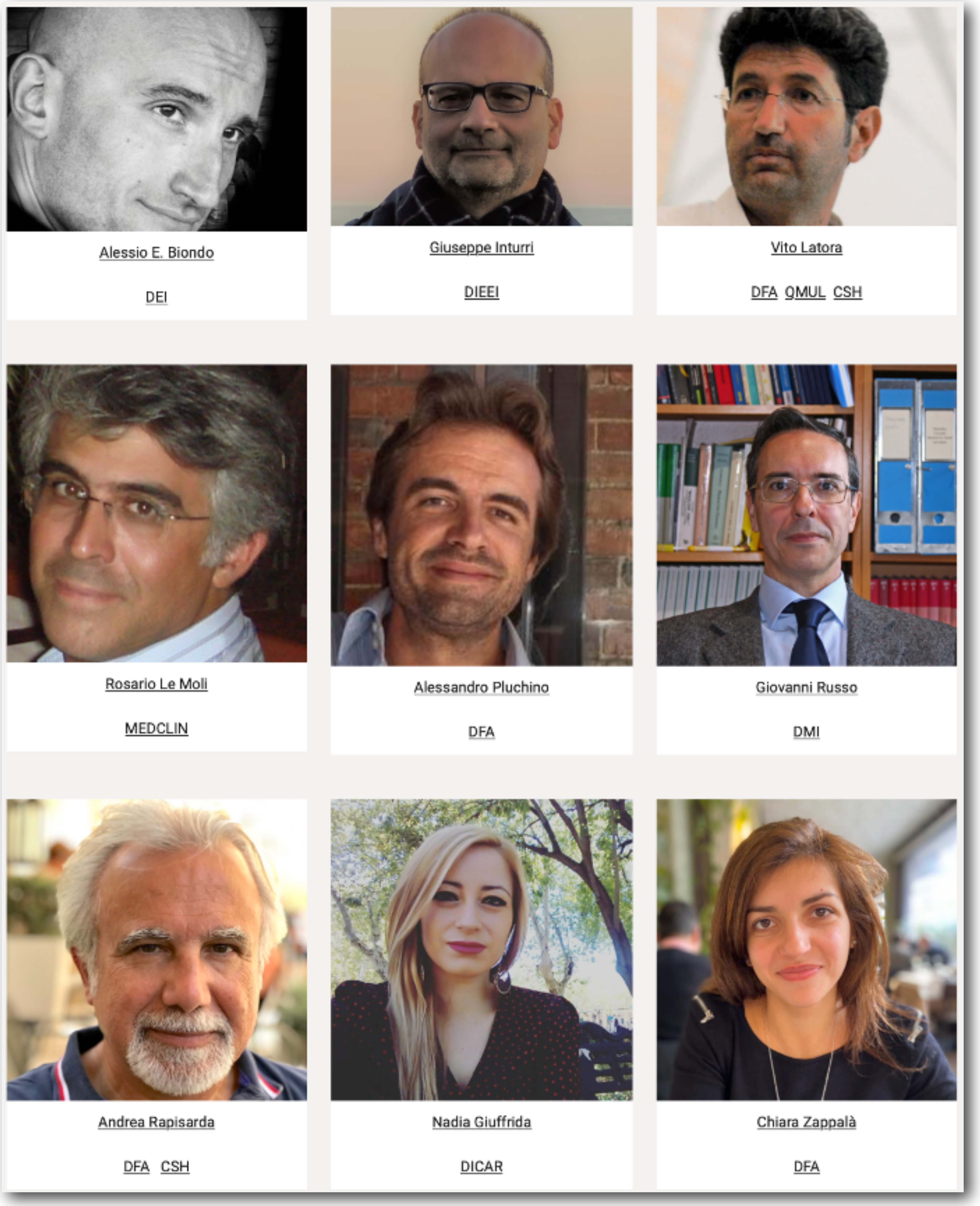
Bari December 20, 2022

The paper

In collaboration with



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A novel methodology for epidemic risk assessment of COVID-19 outbreak

A. Pluchino[1]✉, A. E. Biondo[2], N. Giuffrida[3], G. Inturri[4], V. Latora[1,5,6,7], R. Le Moli[8], A. Rapisarda[1,5], G. Russo[9] & C. Zappalà[1]

We propose a novel data-driven framework for assessing the *a-priori* epidemic risk of a geographical area and for identifying high-risk areas within a country. Our risk index is evaluated as a function of three different components: the hazard of the disease, the exposure of the area and the vulnerability of its inhabitants. As an application, we discuss the case of COVID-19 outbreak in Italy. We characterize each of the twenty Italian regions by using available historical data on air pollution, human mobility, winter temperature, housing concentration, health care density, population size and age. We find that the epidemic risk is higher in some of the Northern regions with respect to Central and Southern Italy. The corresponding risk index shows correlations with the available official data on the number of infected individuals, patients in intensive care and deceased patients, and can help explaining why

Scientific Reports | (2021) 11:5304 | https://doi.org/10.1038/s41598-021-82310-4 nature portfolio 1

Covid-19 pandemic waves in Italy since 2020

Covid-19 outbreak: comparison among different countries since 2020

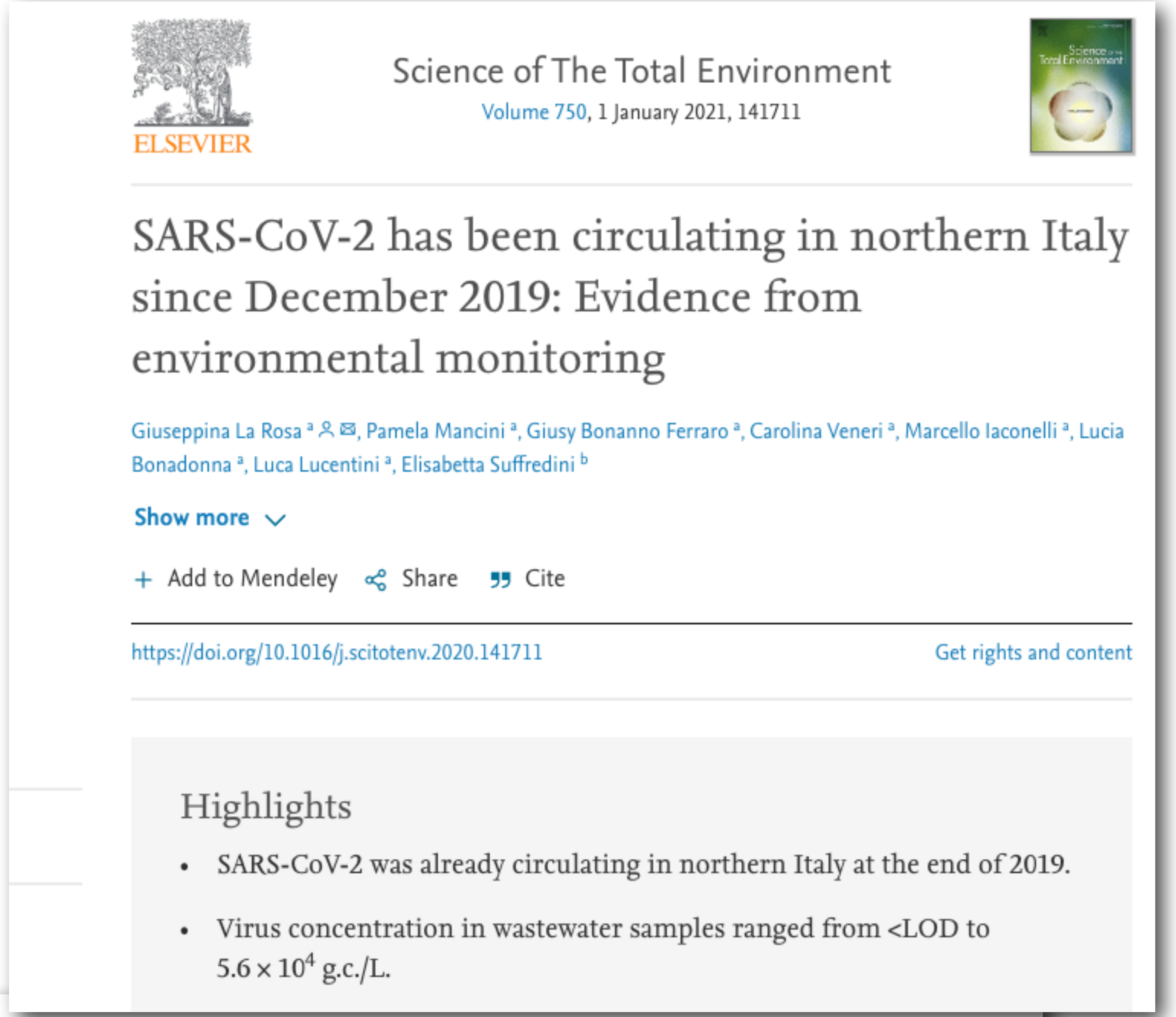
	Deceased (5.7.22)	Deceased (31.12.20)	Population	% of deaths (5.7.22) after vaccination	Complete Vaccination	% of deaths (31.12.20) before vaccination
Italy	168,969	74,159	60,260,000	0.28%	79.4%	0.12%
France	151,056	64,758	65,580,000	0.23%	78.5%	0.10%
Germany	141,862	33,071	83,880,000	0.17%	75.5%	0.04%
Spain	108,731	50,837	46,720,000	0.23%	86.8%	0.11%
Greece	30,422	4838	10,320,000	0.29%	73.6%	0.05%
Sweden	19,144	8,727	10,220,000	0.19%	75.3%	0.085%
Bulgaria	37,266	7,576	6,840,000	0.54%	30.1%	0.11%
UK	181,398	73,621	68,500,00	0.26%	73.6%	0.11%
USA	1,020,816	349,938	334,810,000	0.30%	67.0%	0.10%

Italy (with 169,000 deceased people for a population of 60,000,000 of inhabitants) has been one of the European countries where Covid-19 has had the strongest impact (since the beginning), although the high percentage of complete vaccination with 3 doses

Data from John Hopkins University and Our World data, updated on July 5, 2022

Covid-19 outbreak in Italy, how it started…

First official patient was found at the end of February 2020, but new data (from wastewater data and blood samples or other sources) indicate that the virus was already circulating in Italy and Europe since the end of 2019


Science of The Total Environment
Volume 750, 1 January 2021, 141711

SARS-CoV-2 has been circulating in northern Italy since December 2019: Evidence from environmental monitoring

Giuseppina La Rosa[a], Pamela Mancini[a], Giusy Bonanno Ferraro[a], Carolina Veneri[a], Marcello Iaconelli[a], Lucia Bonadonna[a], Luca Lucentini[a], Elisabetta Suffredini[b]

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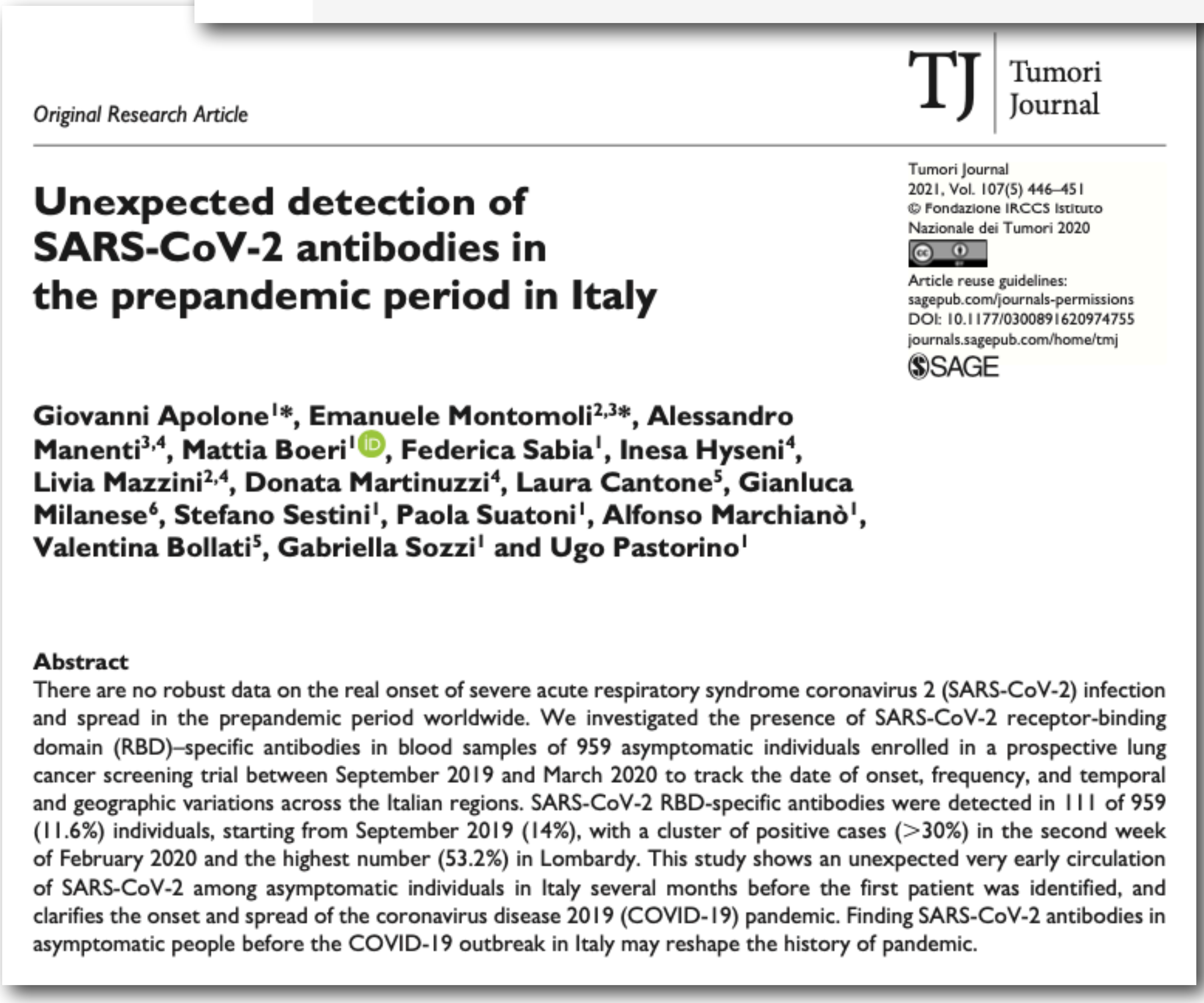
Highlights

- SARS-CoV-2 was already circulating in northern Italy at the end of 2019.
- Virus concentration in wastewater samples ranged from <LOD to 5.6×10^4 g.c./L.


Original Research Article

Tumori Journal

Tumori Journal
2021, Vol. 107(5) 446–451
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DOI: 10.1177/0300891620974755
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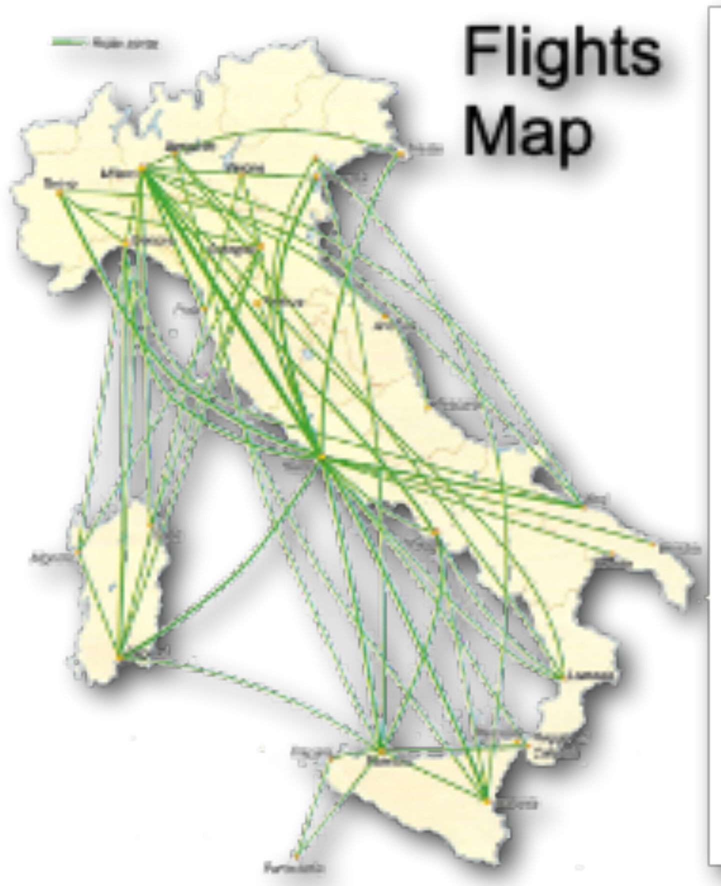
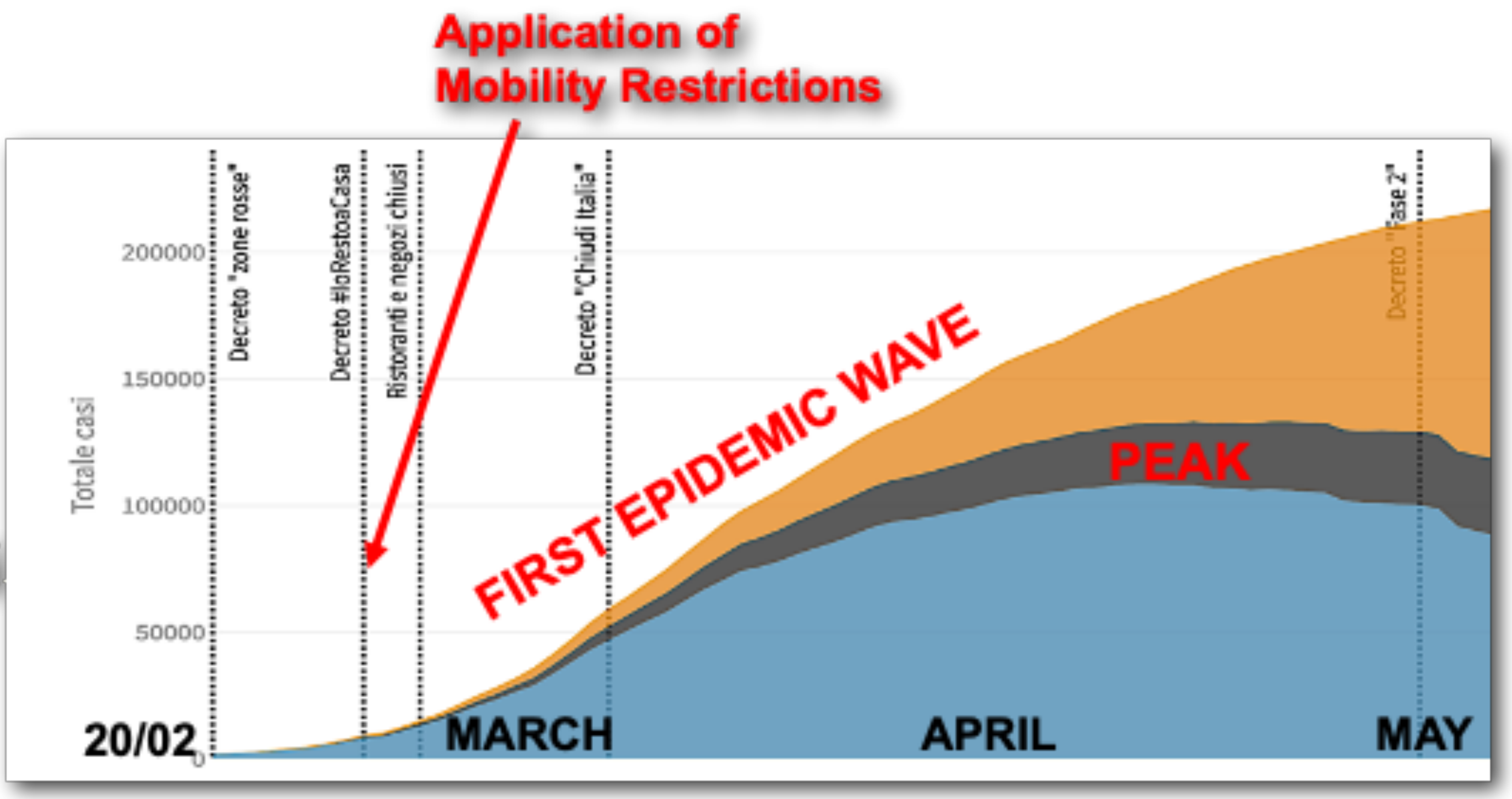
SAGE

Unexpected detection of SARS-CoV-2 antibodies in the prepandemic period in Italy

Giovanni Apolone[1]*, Emanuele Montomoli[2,3]*, Alessandro Manenti[3,4], Mattia Boeri[1], Federica Sabia[1], Inesa Hyseni[4], Livia Mazzini[2,4], Donata Martinuzzi[4], Laura Cantone[5], Gianluca Milanese[6], Stefano Sestini[1], Paola Suatoni[1], Alfonso Marchianò[1], Valentina Bollati[5], Gabriella Sozzi[1] and Ugo Pastorino[1]

Abstract
There are no robust data on the real onset of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection and spread in the prepandemic period worldwide. We investigated the presence of SARS-CoV-2 receptor-binding domain (RBD)–specific antibodies in blood samples of 959 asymptomatic individuals enrolled in a prospective lung cancer screening trial between September 2019 and March 2020 to track the date of onset, frequency, and temporal and geographic variations across the Italian regions. SARS-CoV-2 RBD-specific antibodies were detected in 111 of 959 (11.6%) individuals, starting from September 2019 (14%), with a cluster of positive cases (>30%) in the second week of February 2020 and the highest number (53.2%) in Lombardy. This study shows an unexpected very early circulation of SARS-CoV-2 among asymptomatic individuals in Italy several months before the first patient was identified, and clarifies the onset and spread of the coronavirus disease 2019 (COVID-19) pandemic. Finding SARS-CoV-2 antibodies in asymptomatic people before the COVID-19 outbreak in Italy may reshape the history of pandemic.





Impact of Covid-19 in Italy

Since the beginning COVID-19 has had a different impact (in terms of deceased people and ICU) in the north, the center and the south of Italy.

The northern part of Italy has been the one where the pandemic has had the most dramatic impact

But the virus was already circulating for months all over, so WHY the north of Italy has had the highest impact?

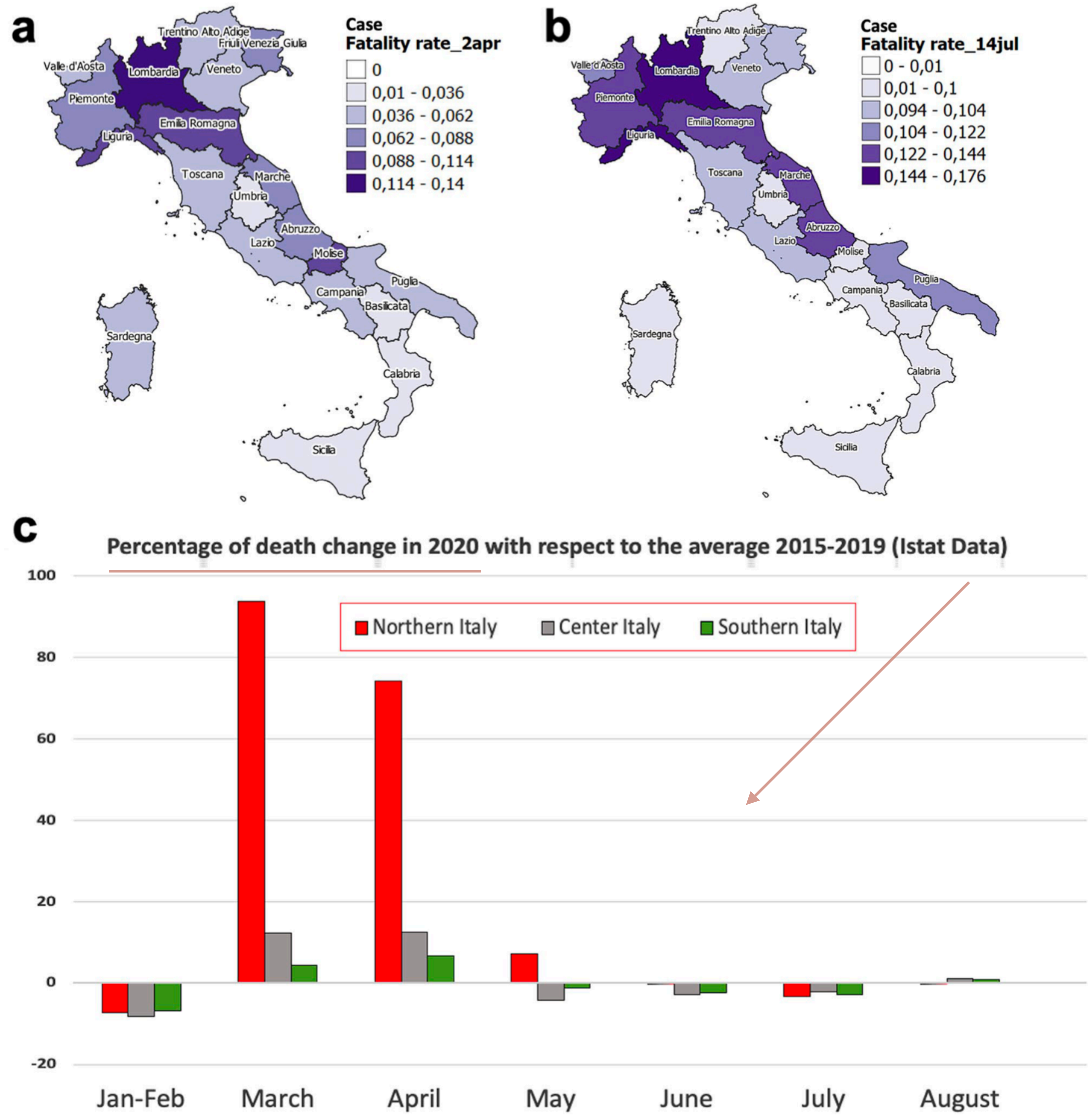


Figure 1. (a) Color geographic maps of the apparent case fatality rate in the various regions on April 2, 2020 and on July 14, 2020 (b), data released by the Italian Ministry of Health[4]. Maps were realized with QGIS 3.10 (https://qgis.org/en/site/). (c) Percentage of deaths change in 2020 with respect to the average taken in the period 2015–2019 (ISTAT[22]).

Pollution and Covid-19 mortality

Several papers relating pollution and respiratory diseases already for SARS

Environmental Health: A Global Access Science Source

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Research

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Air pollution and case fatality of SARS in the People's Republic of China: an ecologic study

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Accepted: 20 November 2003

Correlation among Pollution and Covid-19 mortality

SCIENCE ADVANCES | RESEARCH ARTICLE

CORONAVIRUS

Air pollution and COVID-19 mortality in the United States: Strengths and limitations of an ecological regression analysis

X. Wu[1]*, R. C. Nethery[1]*, M. B. Sabath[1], D. Braun[1,2], F. Dominici[1]†

Assessing whether long-term exposure to air pollution increases the severity of COVID-19 health outcomes, including death, is an important public health objective. Limitations in COVID-19 data availability and quality remain obstacles to conducting conclusive studies on this topic. At present, publicly available COVID-19 outcome data for representative populations are available only as area-level counts. Therefore, studies of long-term exposure to air pollution and COVID-19 outcomes using these data must use an ecological regression analysis, which precludes controlling for individual-level COVID-19 risk factors. We describe these challenges in the context of one of the first preliminary investigations of this question in the United States, where we found that higher historical $PM_{2.5}$ exposures are positively associated with higher county-level COVID-19 mortality rates after accounting for many area-level confounders. Motivated by this study, we lay the groundwork for future research on this important topic, describe the challenges, and outline promising directions and opportunities.

Wu *et al.*, *Sci. Adv.* 2020; **6** : eabd4049 4 November 2020

International Journal of *Environmental Research and Public Health*

MDPI

Article

Air Pollution Is Associated with COVID-19 Incidence and Mortality in Vienna, Austria

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Received: 13 October 2020; Accepted: 9 December 2020; Published: 11 December 2020

check for updates

Abstract: We determined the impact of air pollution on COVID-19-related mortality and reported-case incidence, analyzing the correlation of infection case numbers and outcomes with previous-year air pollution data from the populations of 23 Viennese districts. Time at risk started in a district when the first COVID-19 case was diagnosed. High exposure levels were defined as living in a district with an average (year 2019) concentration of nitrogen dioxide (NO_2) and/or particulate matter (PM10) higher than the upper quartile (30 and 20 $\mu g/m^3$, respectively) of all districts. The total population of the individual districts was followed until diagnosis of or death from COVID-19, or until 21 April 2020, whichever came first. Cox proportional hazard regression was performed after controlling for percentage of population aged 65 and more, percentage of foreigners and of persons with a university degree, unemployment rate, and population density. PM10 and NO_2 were significantly and positively associated with the risk of a COVID-19 diagnosis (hazard ratio (HR) = 1.44 and 1.16, respectively). NO_2 was also significantly associated with death from COVID-19 (HR = 1.72). Even within a single city, higher levels of air pollution are associated with an adverse impact on COVID-19 risk.

Initial evidence of higher morbidity and mortality due to SARS-CoV-2 in regions with lower air quality

Riccardo Pansini[1,2,3] & Davide Fornacca[1,4]

1 Institute of Eastern-Himalaya Biodiversity Research, Dali University, Yunnan, China
2 Behavioral and Experimental Economics Research Center, Statistic and Mathematics College, Yunnan University of Finance and Economics, Kunming, China
3 Department of Economics and Finance, Global Research Unit, City University of Hong Kong
4 Institute for Environmental Sciences, University of Geneva, Switzerland
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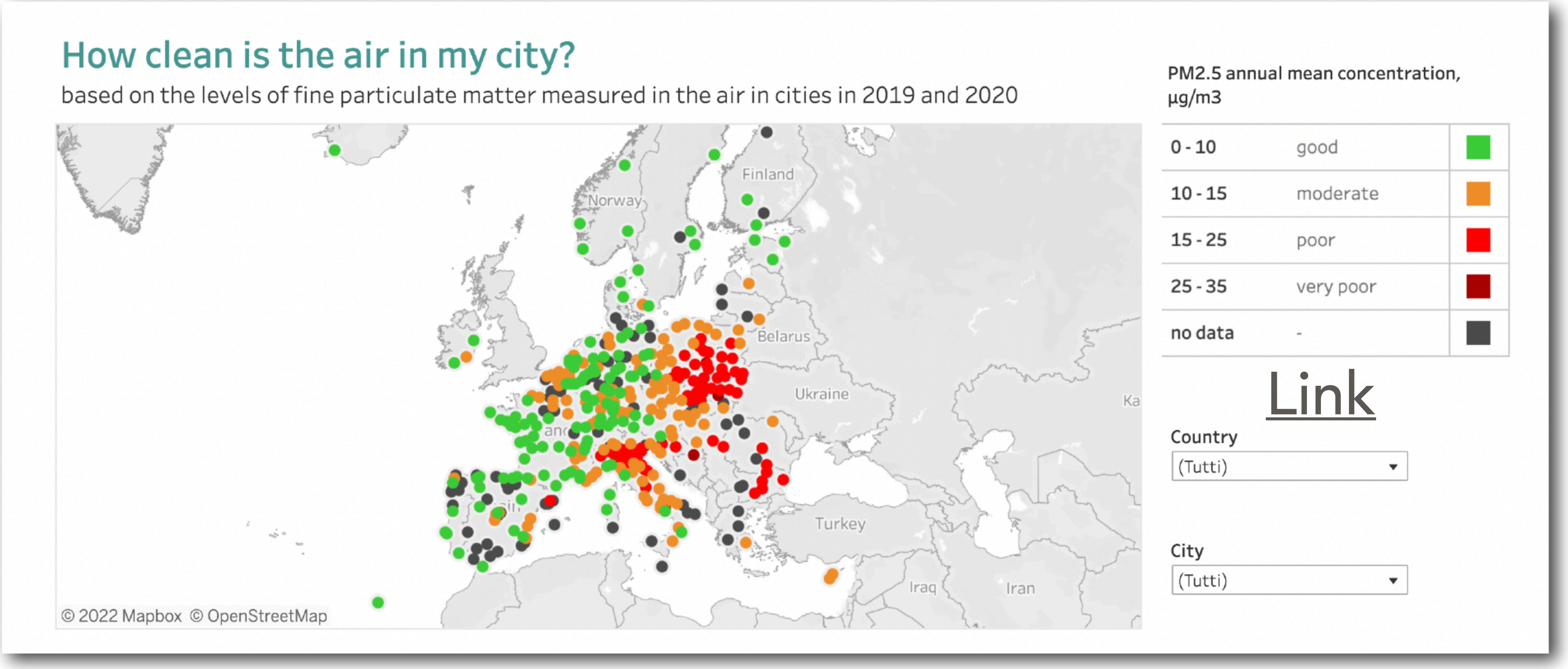
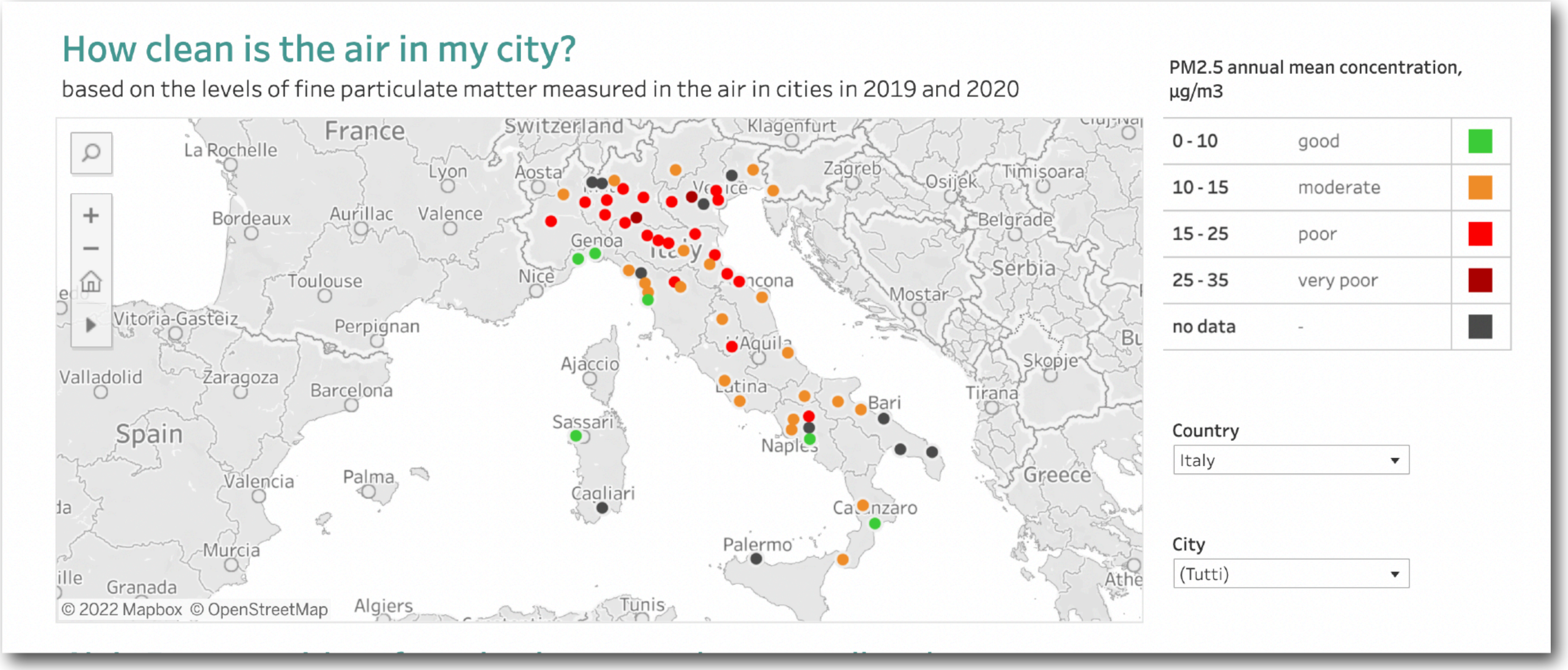
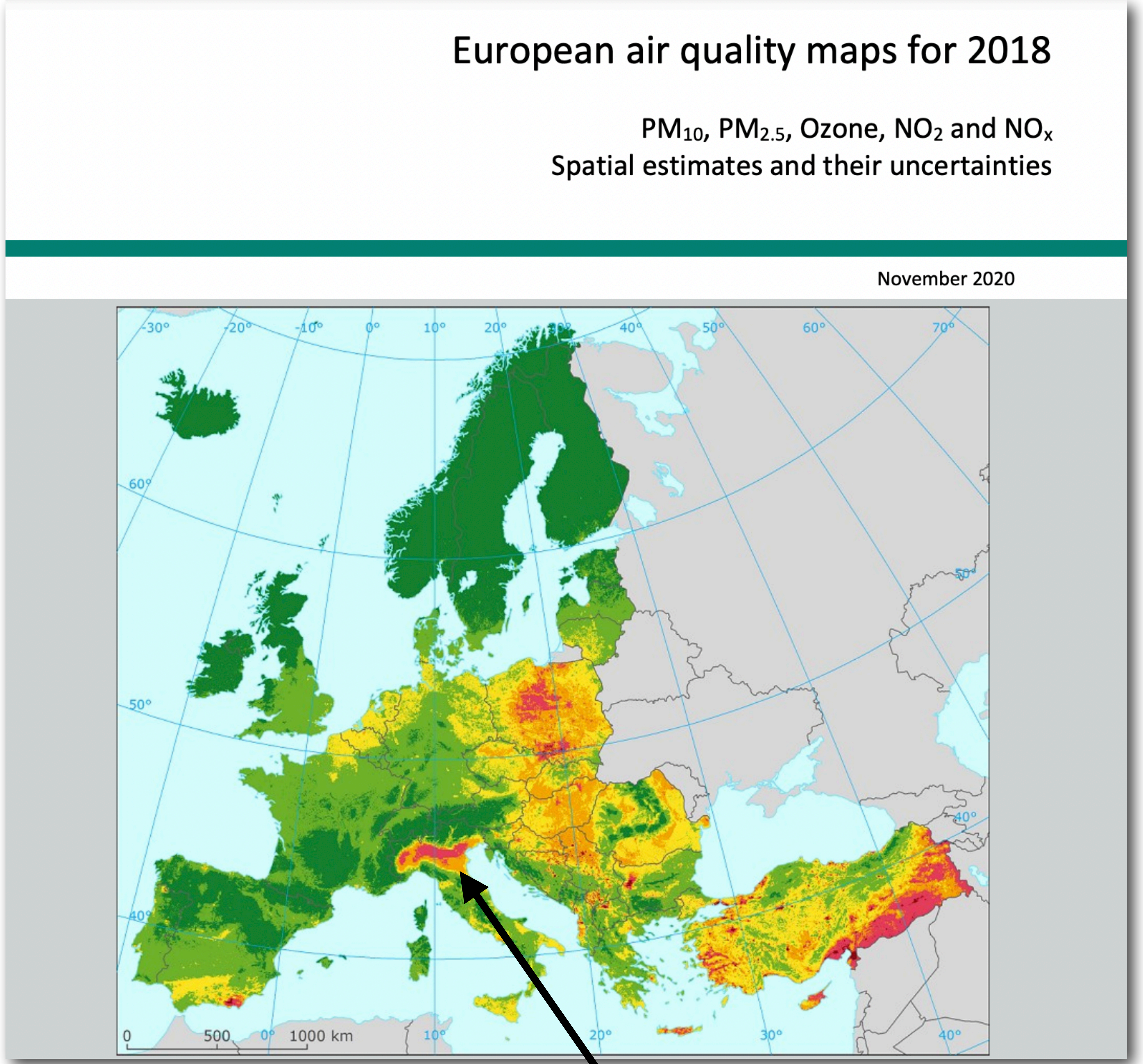
Abstract – COVID-19 has spread from China to the rest of the world in a span of just over three months, escalating into a pandemic that poses several humanitarian as well as scientific challenges. We here investigated the geographical expansion of the infection and correlate it with the annual indexes of air quality observed from the Sentinel-5 satellite orbiting around China, Italy and the U.S.A. Controlling for population size, we find more viral infections in those areas afflicted by Carbon Monoxide (CO) and Nitrogen Dioxide (NO_2). Higher mortality was also correlated with poor air quality, namely with high PM2.5, CO and NO_2 values. In Italy, the correspondence between poor air quality and SARS-CoV-2 appearance and induced mortality was the starkest. Similar to smoking, people living in polluted areas are more vulnerable to SARS-CoV-2 infections and induced mortality. This further suggests the detrimental impact of climate change on the prevention of epidemics.

Keywords: air pollution; COVID-19; coronavirus; virulence; Sentinel-5.

Most polluted areas in Europe





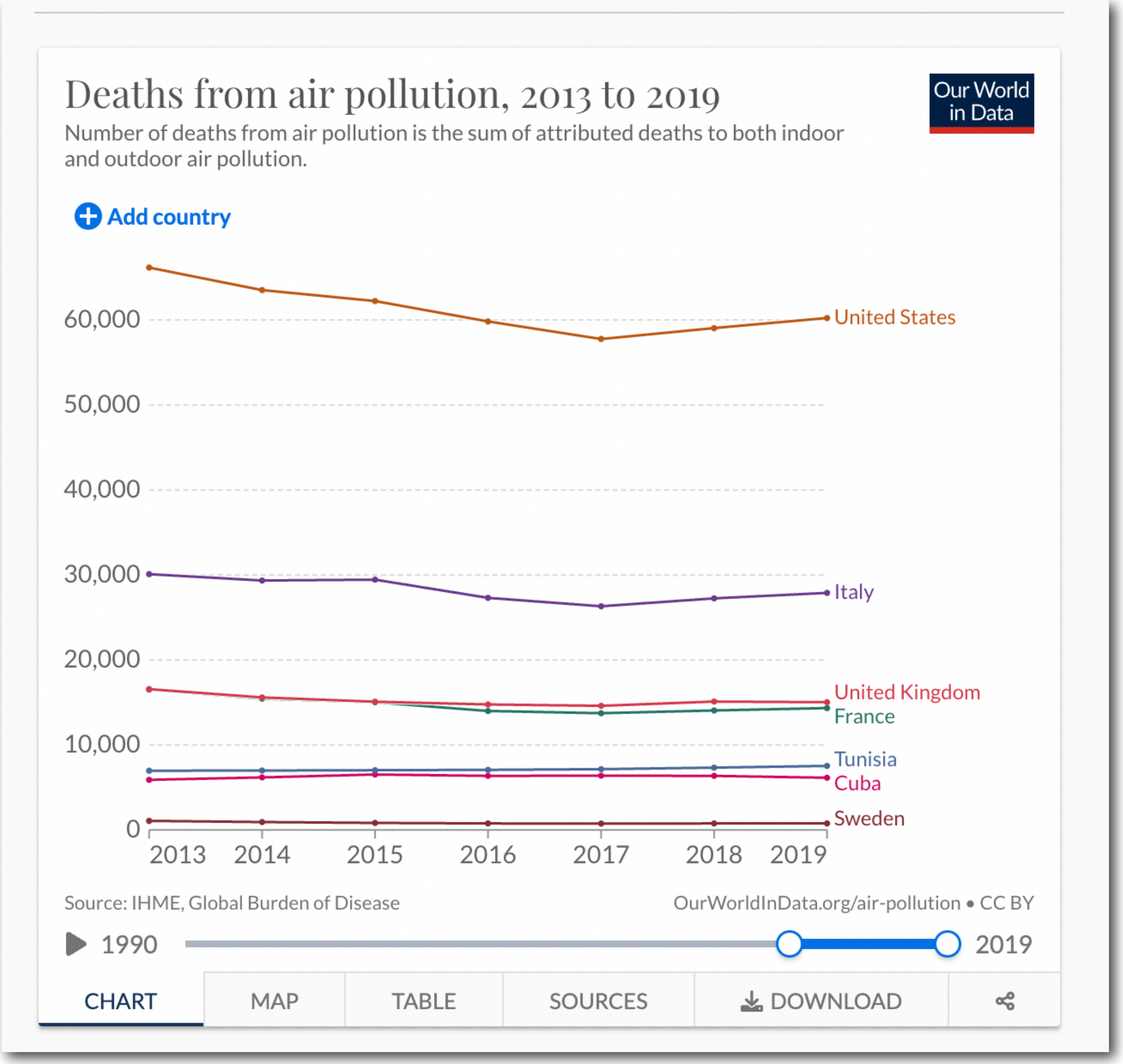


Pianura Padana, in the North of Italy is one of the most polluted areas in Europe… could this explain the different impact?

Data on deaths caused by air pollution

Around 30000 deaths per year for air pollution in Italy
i.e.

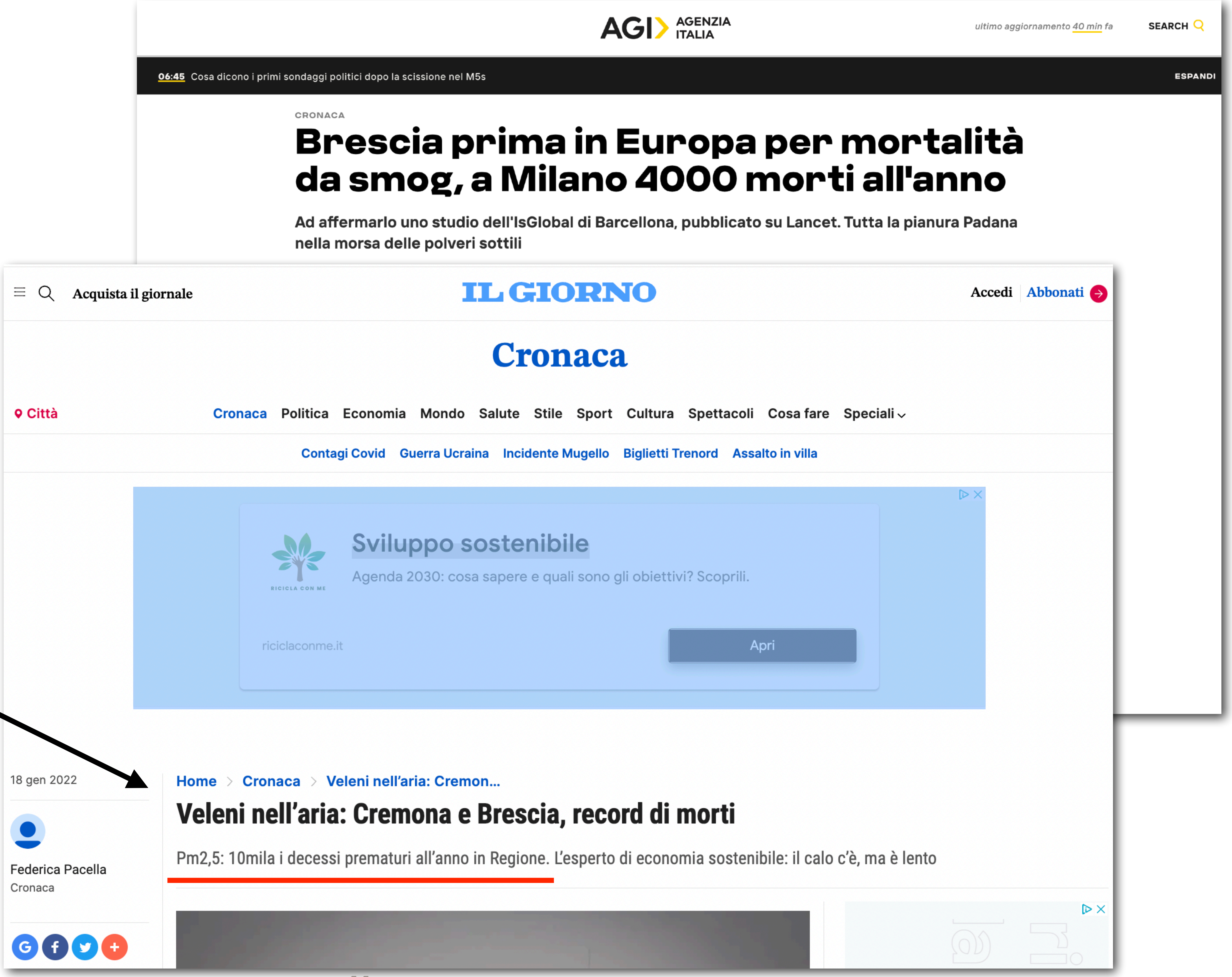
2019	
United States	60,229
Italy	27,902
United Kingdom	15,026
France	14,334
Tunisia	7,530
Cuba	6,144
Sweden	758



Link

Data on the deaths for air pollution

There are around 30000 deaths per year for air pollution in Italy, and around 1/3 (10000) of these deaths are just in Lombardy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06:45 Cosa dicono i primi sondaggi politici dopo la scissione nel M5s ESPANDI

CRONACA

Brescia prima in Europa per mortalità da smog, a Milano 4000 morti all'anno

Ad affermarlo uno studio dell'IsGlobal di Barcellona, pubblicato su Lancet. Tutta la pianura Padana nella morsa delle polveri sottili

Acquista il giornale IL GIORNO Accedi Abbonati

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Città Cronaca Politica Economia Mondo Salute Stile Sport Cultura Spettacoli Cosa fare Speciali

Contagi Covid Guerra Ucraina Incidente Mugello Biglietti Trenord Assalto in villa

Sviluppo sostenibile

Agenda 2030: cosa sapere e quali sono gli obiettivi? Scoprili.

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Veleni nell'aria: Cremona e Brescia, record di morti

Pm2,5: 10mila i decessi prematuri all'anno in Regione. L'esperto di economia sostenibile: il calo c'è, ma è lento

But pollution was likely only one risk factor for explaining the dramatic impact that Covid-19 has had in the north of Italy with respect to the rest of the country

So we considered also other probable risk indicators according to the published literature on Covid-19

RISK INDICATORS that we considered for Covid-19

Historical data taken from public repositories concerning territorial or environmental factors which are unevenly distributed among the regions.

Indicator	Mobility index	Housing concentration	Healthcare density	Pollution	Temperature	Age of population	Population
Data source	www.urbanindex.it	www.urbanindex.it	www.dati.salute.gov.it	www.who.int/airpollution/data/cities/en	www.politicheagricole.it	www.istat.it/it/archivio/104317	www.istat.it/it/archivio/104317
Definition	Ratio between commuting flows and employed population	Ratio between the number of "non detached houses" and the total number of houses	Number of hospital beds per 10.000 inhabitants	Annual average of PM10 daily mean concentration	Average winter daily mean temperature (from 12/2016 to 04/2017)	Ratio between over 60 population and total population	Total residents living in the region
Region	Dimensionless	Dimensionless	# beds/inhab. ('0000)	mg/m^3	°C	Dimensionless	Inhabitans
Abruzzo	0.752	0.871	33.8	24.3	5.4	0.281	1.307.309
Basilicata	0.738	0.869	32.2	18.7	8.4	0.267	578.036
Calabria	0.775	0.917	29.6	22.9	10.5	0.252	1.959.050
Campania	0.762	0.863	31.2	31.1	8.5	0.222	5.766.810
Emilia-Romagna	0.823	0.851	40.1	24.8	5.7	0.293	4.342.135
Friuli-Venezia Giulia	0.823	0.952	35.7	21.9	4.0	0.308	1.218.985
Lazio	0.793	0.834	37.8	25.3	7.7	0.265	5.502.886
Liguria	0.788	0.903	36.4	20.7	6.8	0.344	1.570.694
Lombardia	0.844	0.961	38.9	29.5	3.6	0.271	9.704.151
Marche	0.801	0.795	33.9	23.9	6.6	0.292	1.541.319
Molise	0.735	0.871	39.2	18.9	7.1	0.287	313.660
Piemonte	0.799	0.862	38.1	26.3	2.5	0.303	4.363.916
Puglia	0.767	0.950	31.0	23.2	9.6	0.253	4.052.566
Sardegna	0.767	0.962	35.3	22.4	10.7	0.266	1.639.362
Sicilia	0.794	0.942	31.6	21.7	11.9	0.250	5.002.904
Toscana	0.815	0.857	32.7	22.7	7.2	0.306	3.672.202
Trentino-Alto Adige	0.807	0.888	40.8	18.1	−1.0	0.247	1.029.475
Umbria	0.795	0.805	37.0	22.2	6.4	0.303	884.268
Valle d'Aosta	0.805	0.919	38.6	21.4	−2.3	0.279	126.806
Veneto	0.838	0.884	36.1	27.6	4.3	0.268	4.857.210

Table 1. The risk indicators original data are reported for each Italian region, together with their sources.

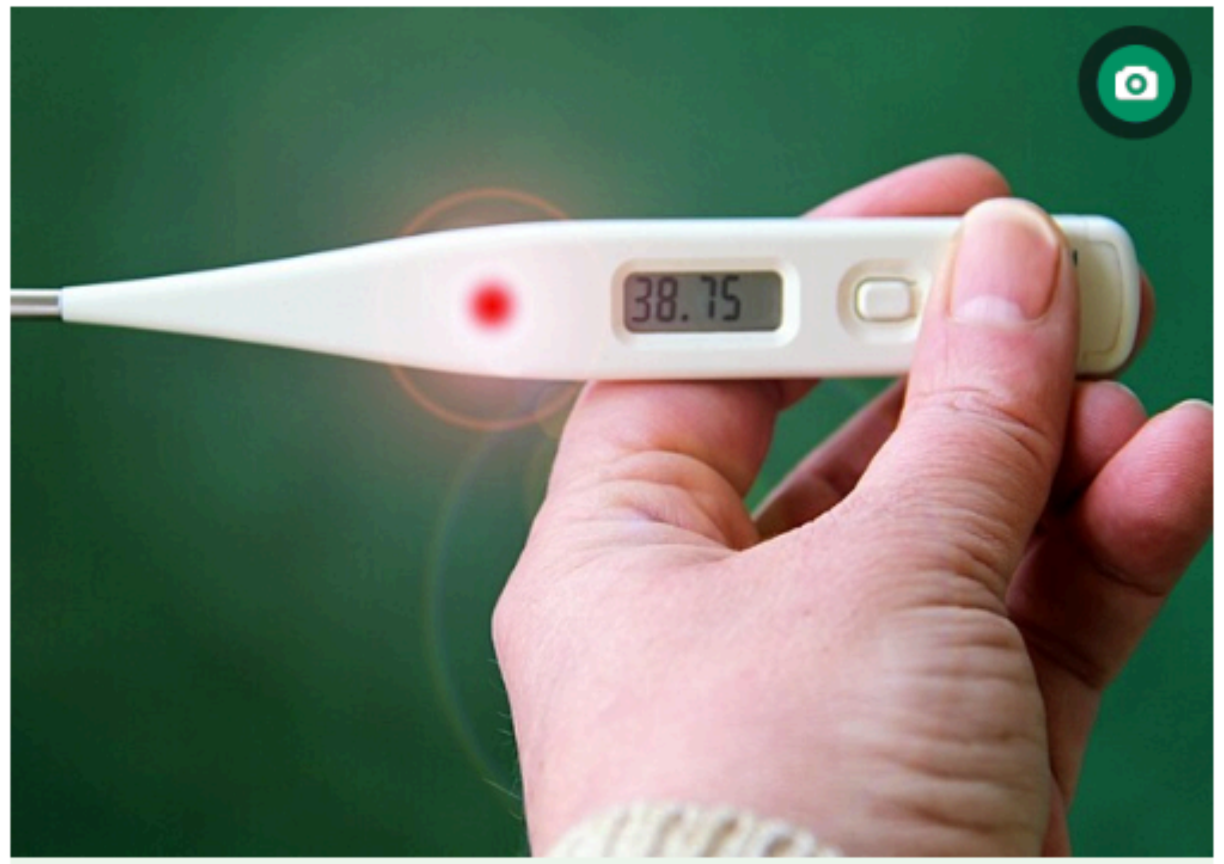
Temperature as a RISK INDICATOR for Covid-19

Cold temperature is a risk factor as confirmed by a recent study

ANSA S&T › Biotech

Il freddo sopprime la prima linea di difese immunitarie nel naso

Redazione ANSA 06 dicembre 2022 16:07



Il freddo sopprime la prima linea di difese immunitarie che vengono messe in atto nel naso, la principale via d'ingresso nel nostro corpo dei virus che infettano le vie aeree (free via pixabay) - RIPRODUZIONE RISERVATA

CLICCA PER INGRANDIRE

DALLA HOME

Si è scoperto perché raffreddore, influenza e Covid-19 colpiscono di più nella stagione invernale.

Non c'entra, come si pensava, il fatto che in inverno le persone passano più tempo al chiuso, ma la causa sono proprio le basse temperature: il freddo sopprime la prima linea delle difese immunitarie che vengono messe in atto nel naso, la principale via d'ingresso nel nostro corpo dei virus che infettano le vie aeree.

Lo ha dimostrato, pubblicando i risultati su The Journal of Allergy and Clinical Immunology, il gruppo di ricerca guidato dall'ospedale specializzato in malattie di occhi e orecchie della statunitense Harvard Medical School, che ha lavorato in collaborazione con la Northwestern University. La scoperta apre a soluzioni terapeutiche che nascondano questo punto debole, come spray nasali che rinforzino le difese immunitarie indebolite.

The Journal of Allergy and Clinical Immunology

FULL LENGTH ARTICLE | ARTICLES IN PRESS

Cold exposure impairs extracellular vesicle swarm–mediated nasal antiviral immunity

Di Huang, PhD • Maie S. Taha, PhD • Angela L. Nocera, PhD • Alan D. Workman, MD • Mansoor M. Amiji, PhD • Benjamin S. Bleier, MD

Published: December 06, 2022 • DOI: https://doi.org/10.1016/j.jaci.2022.09.037

Graphical abstract

Key words

References

References

Article Info

Related Articles

Background

The human upper respiratory tract is the first site of contact for inhaled respiratory viruses and elaborates an array of innate immune responses. Seasonal variation in respiratory viral infections and the importance of ambient temperature in modulating immune responses to infections have been well recognized; however, the underlying biological mechanisms remain understudied.

Objective

We investigated the role of nasal epithelium-derived extracellular vesicles (EVs) in innate Toll-like receptor 3 (TLR3)-dependent antiviral immunity.

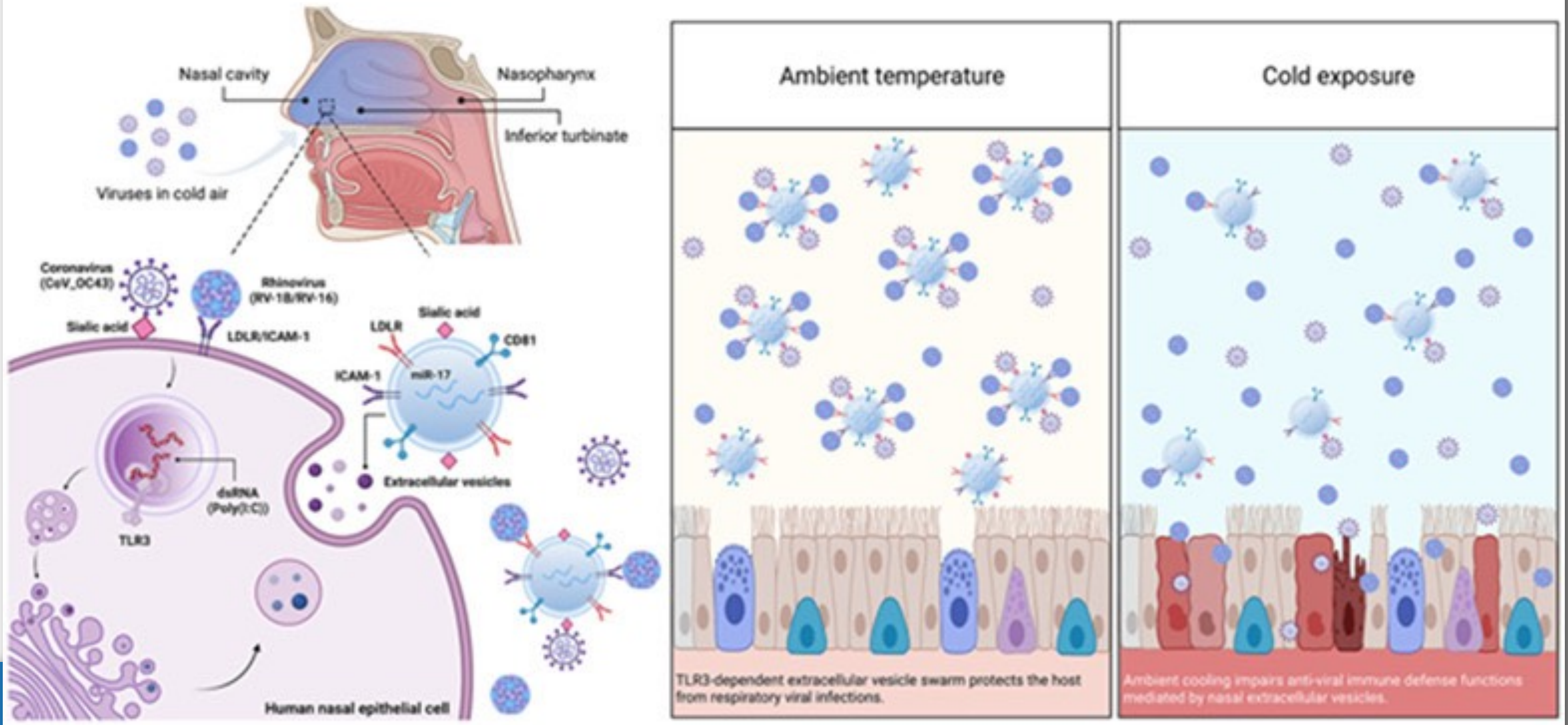
Methods

We evaluated the secretion and composition of nasal epithelial EVs after TLR3 stimulation in human autologous cells and fresh human nasal mucosal surgical specimens. We also explored the antiviral activity and mechanisms of TLR3-stimulated EVs against respiratory viruses as well as the effect of cool ambient temperature on TLR3-dependent antiviral immunity.

Results

We found that polyinosinic:polycytidylic acid, aka poly(I:C), exposure induced a swarm-like increase in the secretion of nasal epithelial EVs via the TLR3 signaling. EVs participated in TLR3-dependent antiviral immunity, protecting the host from viral infections through both EV-mediated functional delivery of miR-17 and direct virion neutralization after binding to virus ligands via surface receptors, including LDLR and ICAM-1. These potent antiviral immune defense functions mediated by TLR3-stimulated EVs were impaired by cold exposure via a decrease in total EV secretion as well as diminished microRNA packaging and antiviral binding affinity of individual EV.

Cold Exposure Impairs Extracellular Vesicle Swarm Mediated Nasal Anti-Viral Immunity



All of experiments described in this article including TLR3 stimulation by poly(I:C) and cold exposure were performed *in vitro* on primary human nasal epithelial cells and turbinate tissue explants.

Abbreviations: CD81, Cluster of differentiation 81; dsRNA, Double-stranded RNA; ICAM-1, Intercellular adhesion molecule 1; LDLR, Low-density lipoprotein receptor; miR, MicroRNAs; Poly(I:C), Polyinosinic-polycytidylic acid; TLR3, Toll-like receptor 3

Created with BioRender.com.

COLD TEMPERATURE SUPPRESS THE FIRST LINE OF IMMUNE DEFENSES THAT ARE PUT IN PLACE IN OUR NOSE, WHICH REPRESENTS THE MAIN ENTRY ROUTE FOR AERIAL VIRUSES

The seven risk indicators under consideration are named below, together with their reference interval:

Population: $X_0 \in [126806, 9704151]$

Mobility index: $X_1 \in [0.74, 0.84]$

Housing concentration: $X_2 \in [0.80, 0.96]$

Healthcare density: $X_3 \in [29.6, 40.80]$

Air Pollution: $X_4 \in [18.09, 31.07]$

Average Winter Temperature: $X_5 \in [\text{-}2.29, 11.92]$

Age of Population (fraction of over-60 individuals): $X_6 \in [0.22, 0.34]$

These variables are suitably normalized between 0 and 1 as:

$$x_0 = \frac{X_0}{\max(X_0)} \quad ; \quad x_i = \frac{X_i - \min(X_i)}{\max(X_i) - \min(X_i)}, \quad i = 1,2,3,4,6, \quad x_5 = \frac{\max(X_5) - X_5}{\max(X_5) - \min(X_5)}$$

Very small pairwise correlations among normalized indicators

	Mobility index	Housing concentration	Healthcare density	Air Pollution	Inverted temperature	Over60 concentration
Mobility index	1.0000	0.0820	0.4064	0.3505	0.4640	0.2337
Housing concentration	0.0820	1.0000	-0.1356	-0.0510	-0.0737	-0.2119
Healthcare density	0.4064	-0.1356	1.0000	-0.0935	0.6998	0.3389
Air Pollution	0.3505	-0.0510	-0.0935	1.0000	-0.0405	-0.2527
Inverted temperature	0.4640	-0.0737	0.6998	-0.0405	1.0000	0.2183
Over 60 concentration	0.2337	-0.2119	0.3389	-0.2527	0.2183	1.0000

Table M2.1: Pearson correlation coefficients among the indicators $x_1, \ldots, x_6$

The Crichton Risk Triangle

Crichton D. , 1999, The Risk Triangle. Natural disaster management: a presentation to commemorate the International Decade for Natural Disaster Reduction (IDNDR), 1990-2000Ingleton J: Tudor Rose; 1999

HAZARD is related to the potential of an event to cause damage (in this case the probability of an epidemic spreading)

EXPOSURE is a measure of the resources exposed to the potential damage (the number of people present in a certain region)

VULNERABILITY is the aptitude to be damaged once exposed to the harmful event (the probability that, once infected, one becomes ill, is hospitalized and eventually dies).

Risk Index = E * H * V

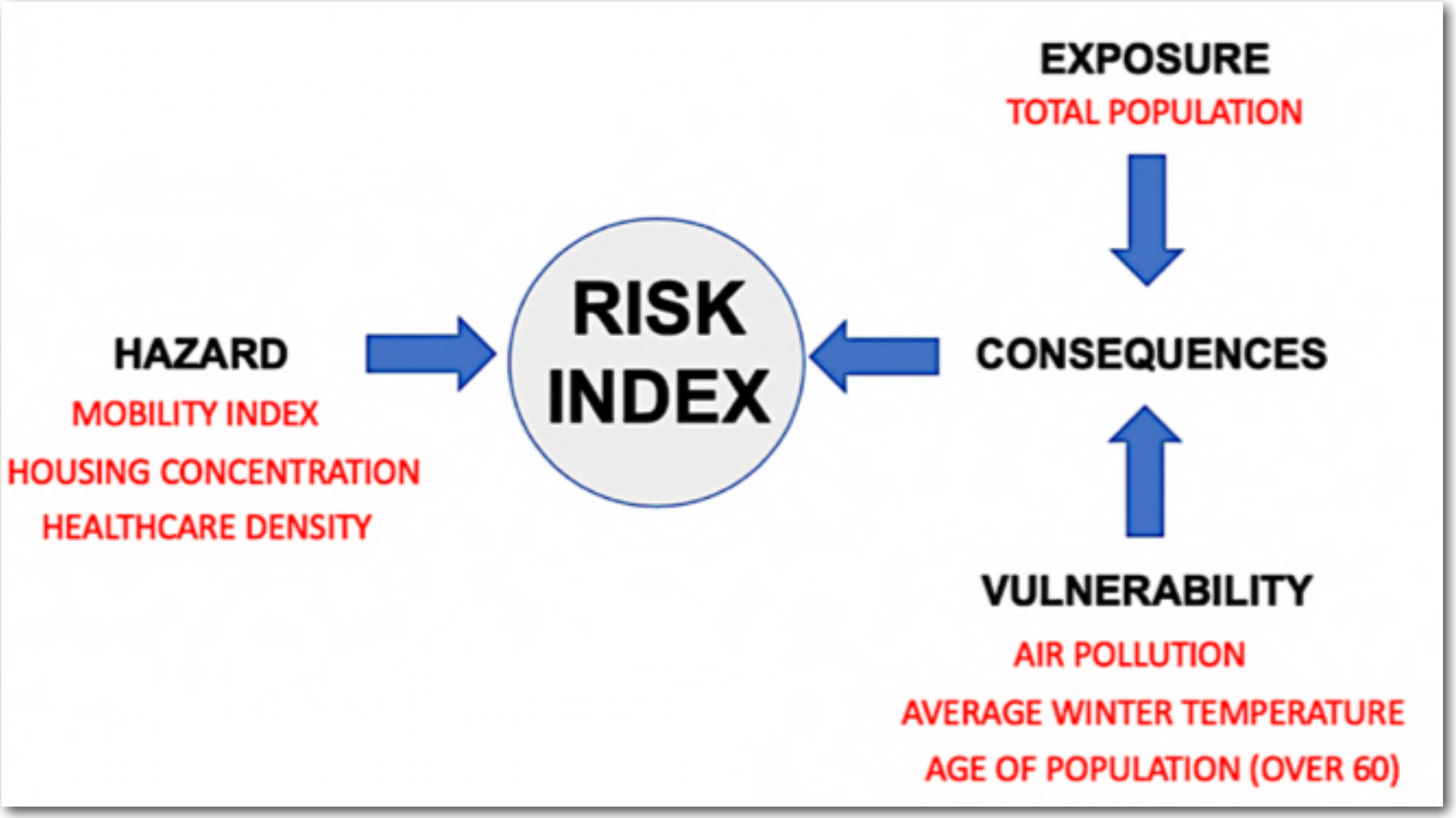
$$E = x_0,$$

$$H = \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3$$

$$V = \alpha_4 x_4 + \alpha_5 x_5 + \alpha_6 x_6$$

$$\alpha_1 + \alpha_2 + \alpha_3 = 1,$$

$$\alpha_4 + \alpha_5 + \alpha_6 = 1.$$



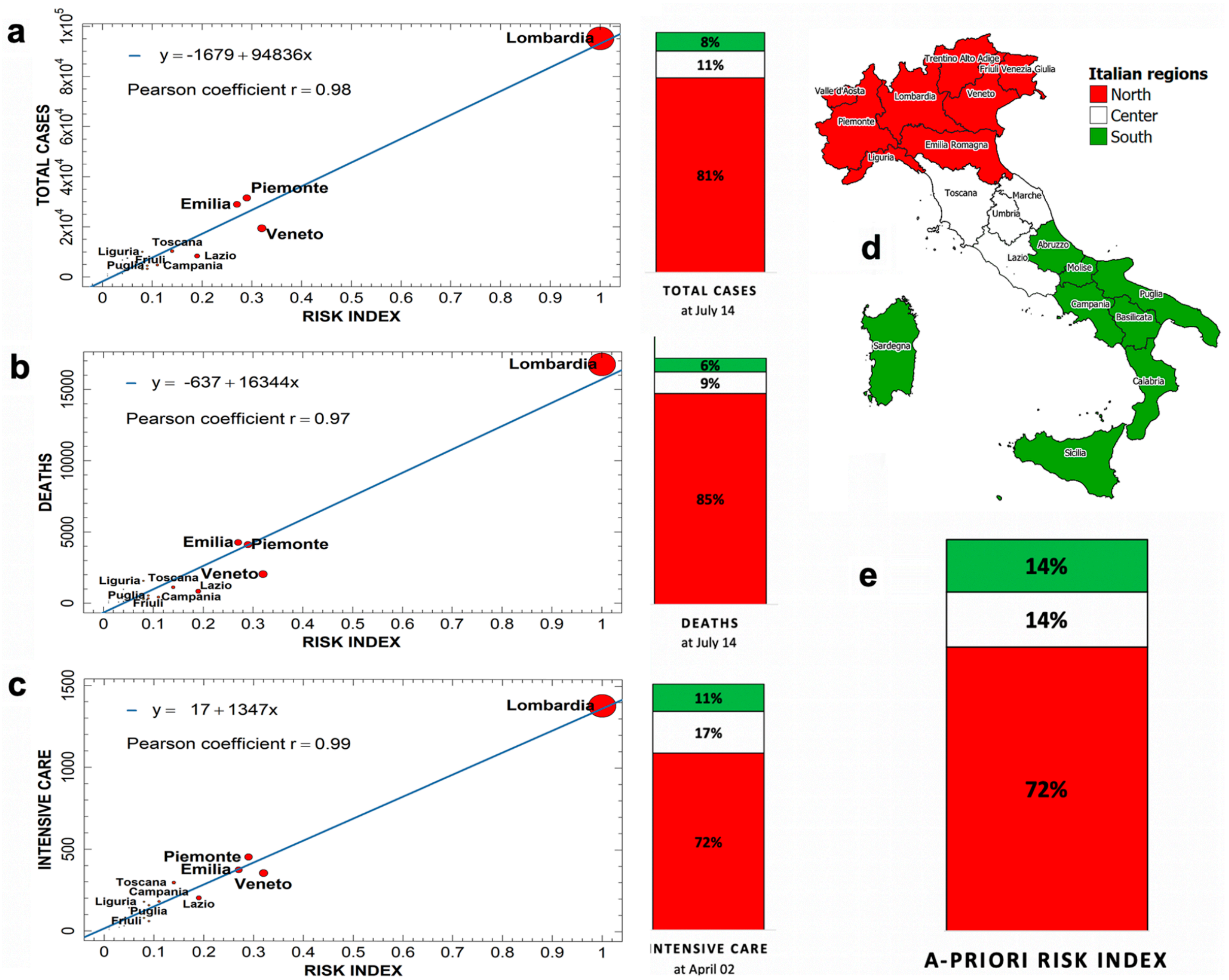
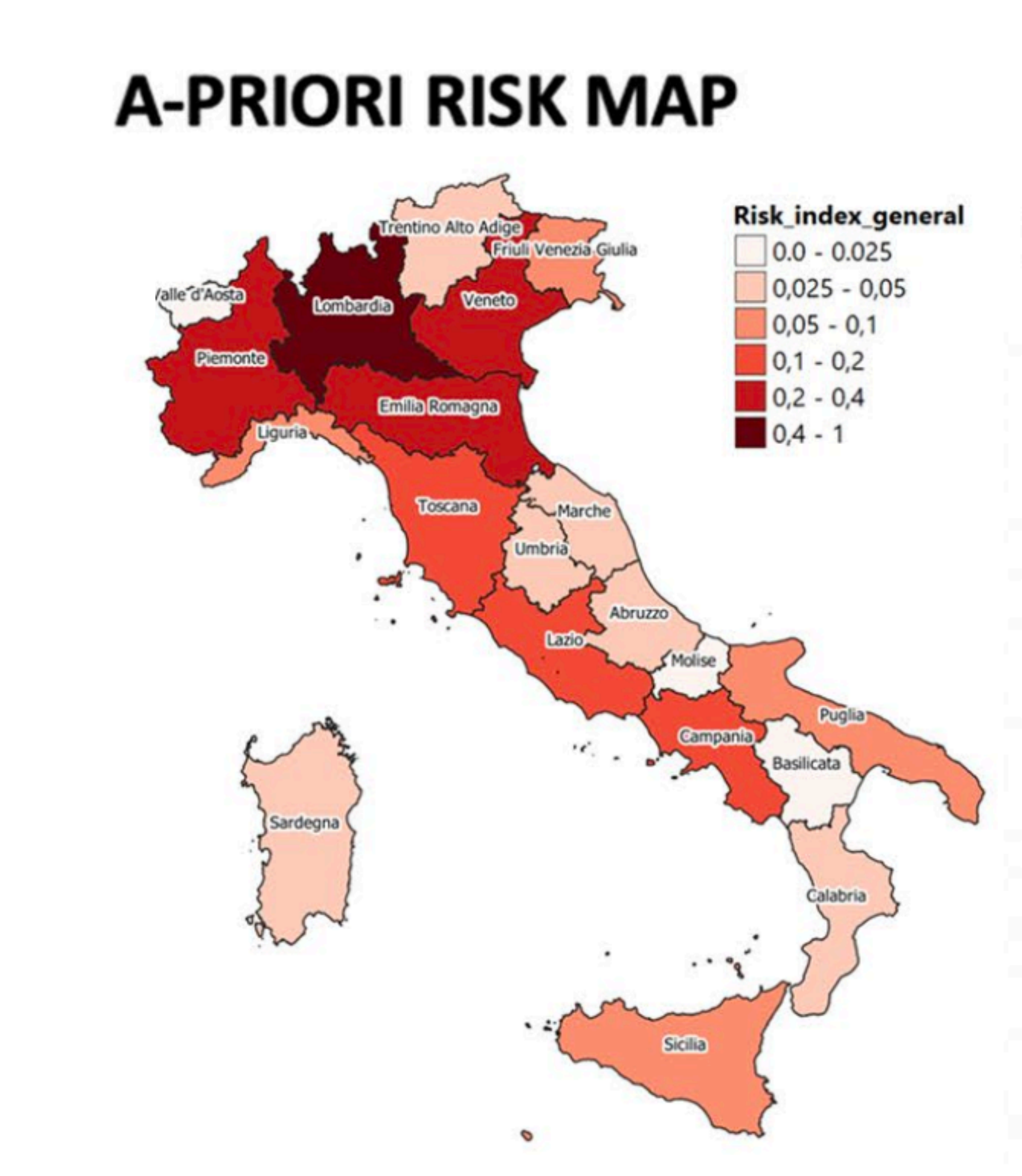


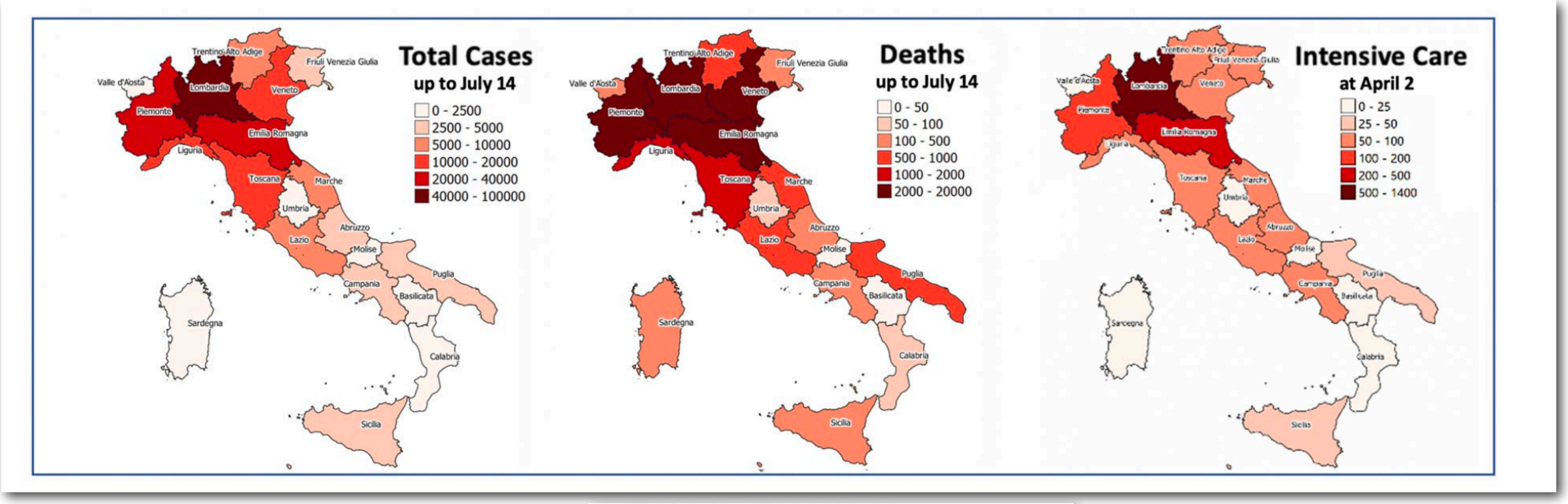
Figure 4. The three main impact indicators for COVID-19—the total number of cases (**a**) and the total number of deaths (**b**) cumulated up to July 14, 2020[4], and the intensive care occupancy (c) at April 2, 2020[4]—are reported as function of the *a-priori* risk index for all the Italian regions. The size of the points is proportional to the risk index score. A linear regression has been performed for each plot. The Pearson correlation coefficients are very good, always greater or equal than 0.97. The corresponding percentages of damages, aggregated for the three Italian macro-regions (North, Center and South (**d**)) are also reported to the right and can be compared with the percentages of cumulated *a-priori* risk (**e**). It is clear that our *a-priori* risk index is able to explain the anomalous damage discrepancies between these different parts of Italy. Maps were realized with QGIS 3.10 (https://qgis.org/en/site/).

Risk Index Vs Pandemic Data

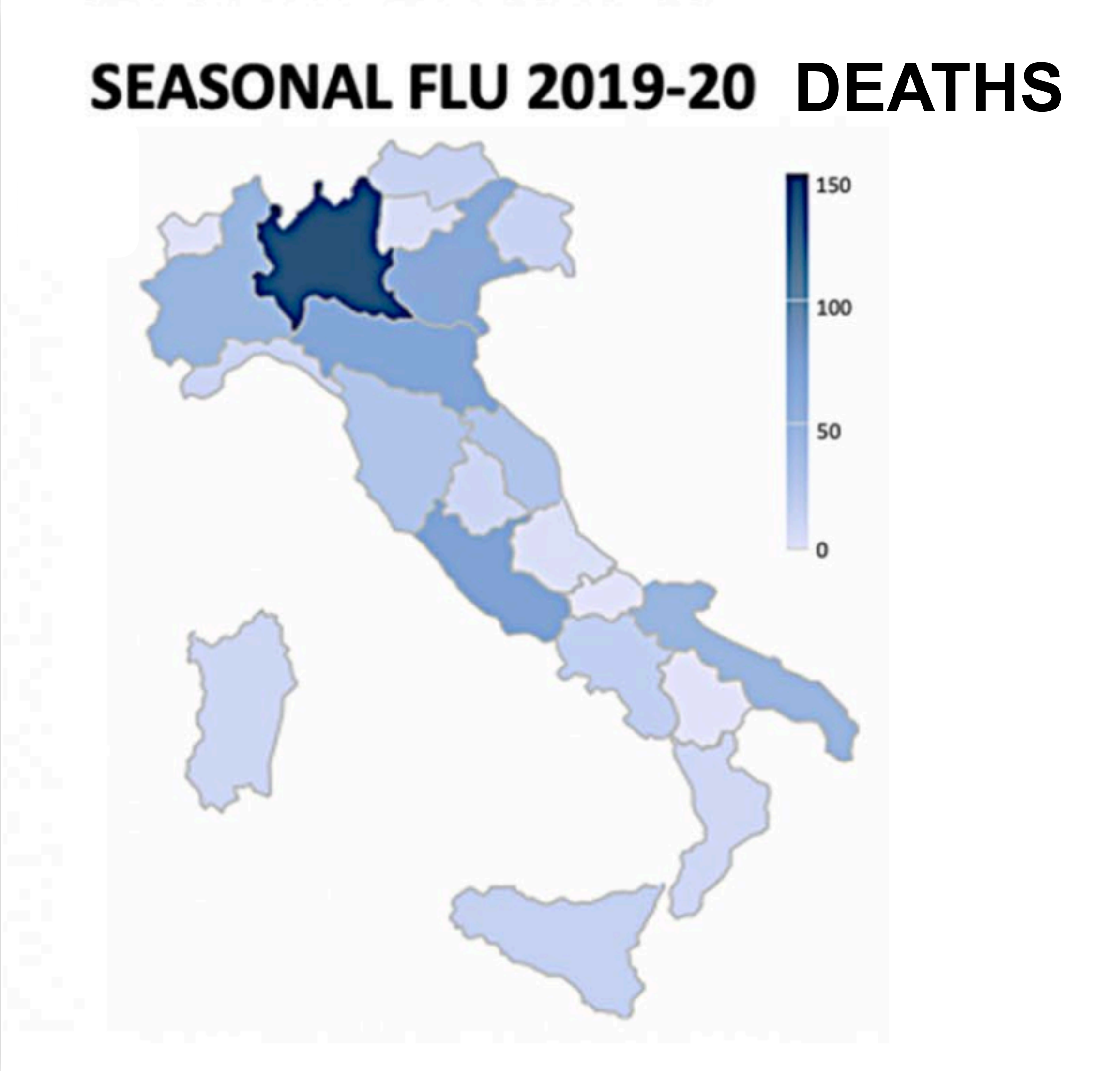
#	Ranking	A-priori Risk Index	Total Cases		Deaths		Intensive Care	
			02/04/20	14/07/20	02/04/20	14/07/20	02/04/20	14/07/20
1	Lombardia	1,00	46065	95173	7960	16760	1351	27
2	Veneto	0,32	10111	19420	532	2041	345	2
3	Piemonte	0,29	10353	31507	983	4115	453	9
4	Emilia Romagna	0,27	15333	28971	1811	4271	366	9
5	Lazio	0,19	3433	8356	185	846	181	10
6	Toscana	0,14	5273	10330	268	1125	295	2
7	Campania	0,11	2456	4779	167	432	120	1
8	Puglia	0,09	2077	4541	273	547	118	0
9	Friuli Venezia Giulia	0,09	1799	3338	129	345	60	0
10	Liguria	0,08	3782	10038	488	1561	172	0
11	Sicilia	0,08	1791	3115	93	283	73	0
12	Trentino Alto Adige	0,05	3482	7555	187	697	138	0
13	Marche	0,04	4098	6805	503	987	164	0
14	Abruzzo	0,04	1497	3328	133	467	75	0
15	Sardegna	0,04	794	1374	40	134	24	0
16	Calabria	0,03	691	1216	41	97	19	0
17	Umbria	0,03	1128	1450	38	80	47	0
18	Valle d'Aosta	0,01	668	1196	63	146	25	0
19	Molise	0,01	165	446	11	23	8	0
20	Basilicata	0,01	246	406	10	27	19	0

Comparison with COVID-19 pandemic data (up to July 14, 2020)

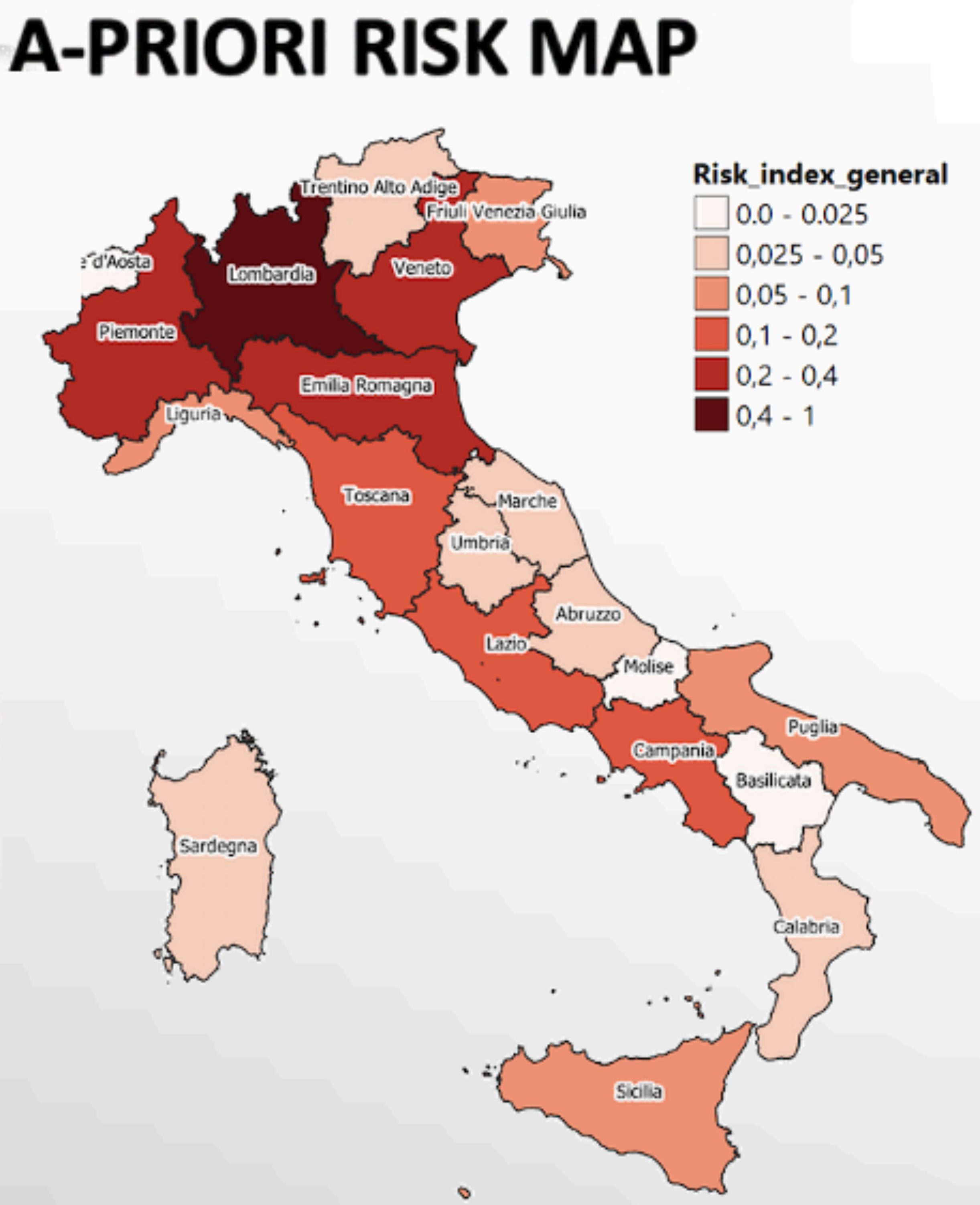


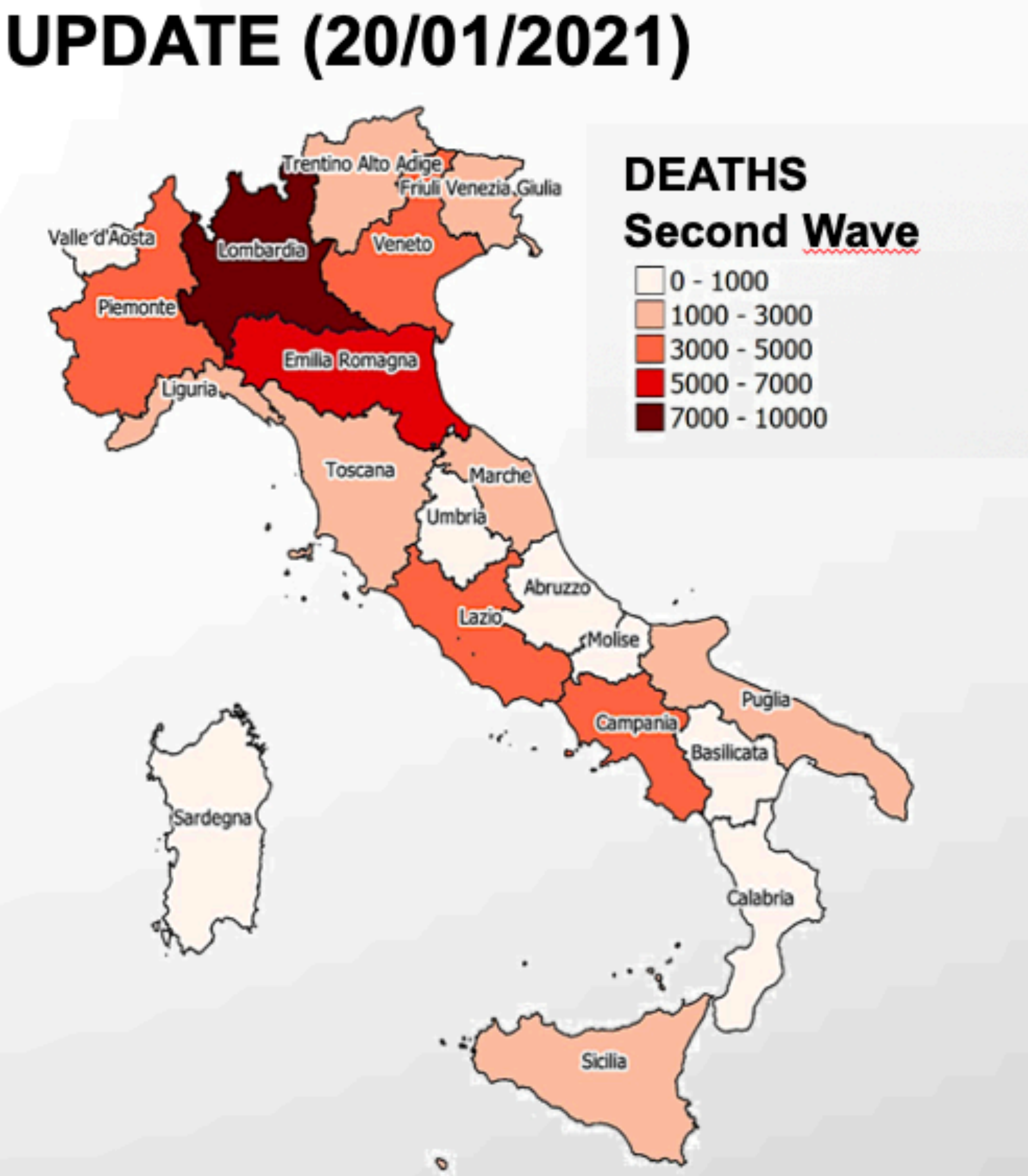


Our a-priori risk index compares well with Covid-19 pandemic data, but also with seasonal influenza data



Risk Index: comparison with data of second wave

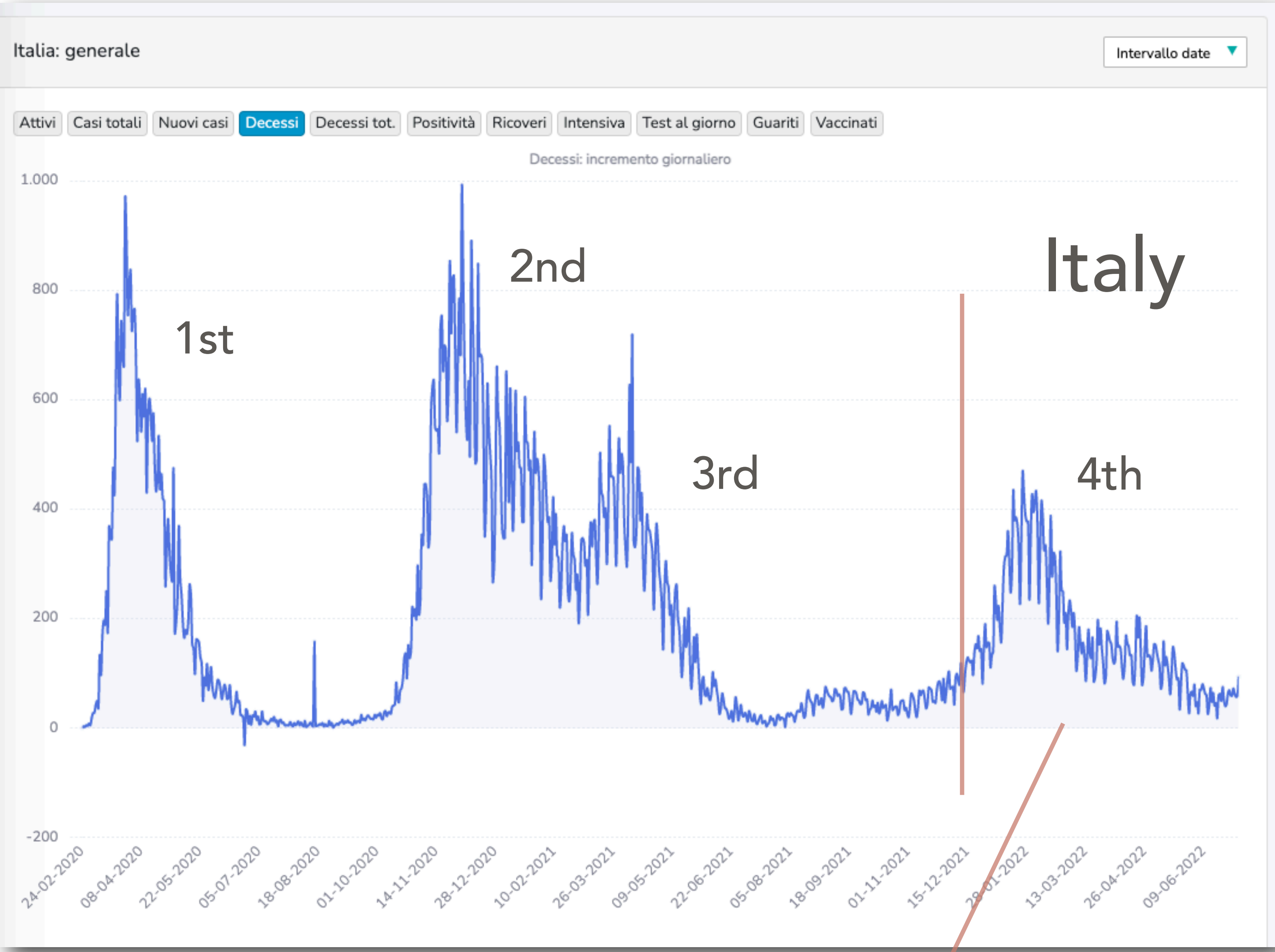


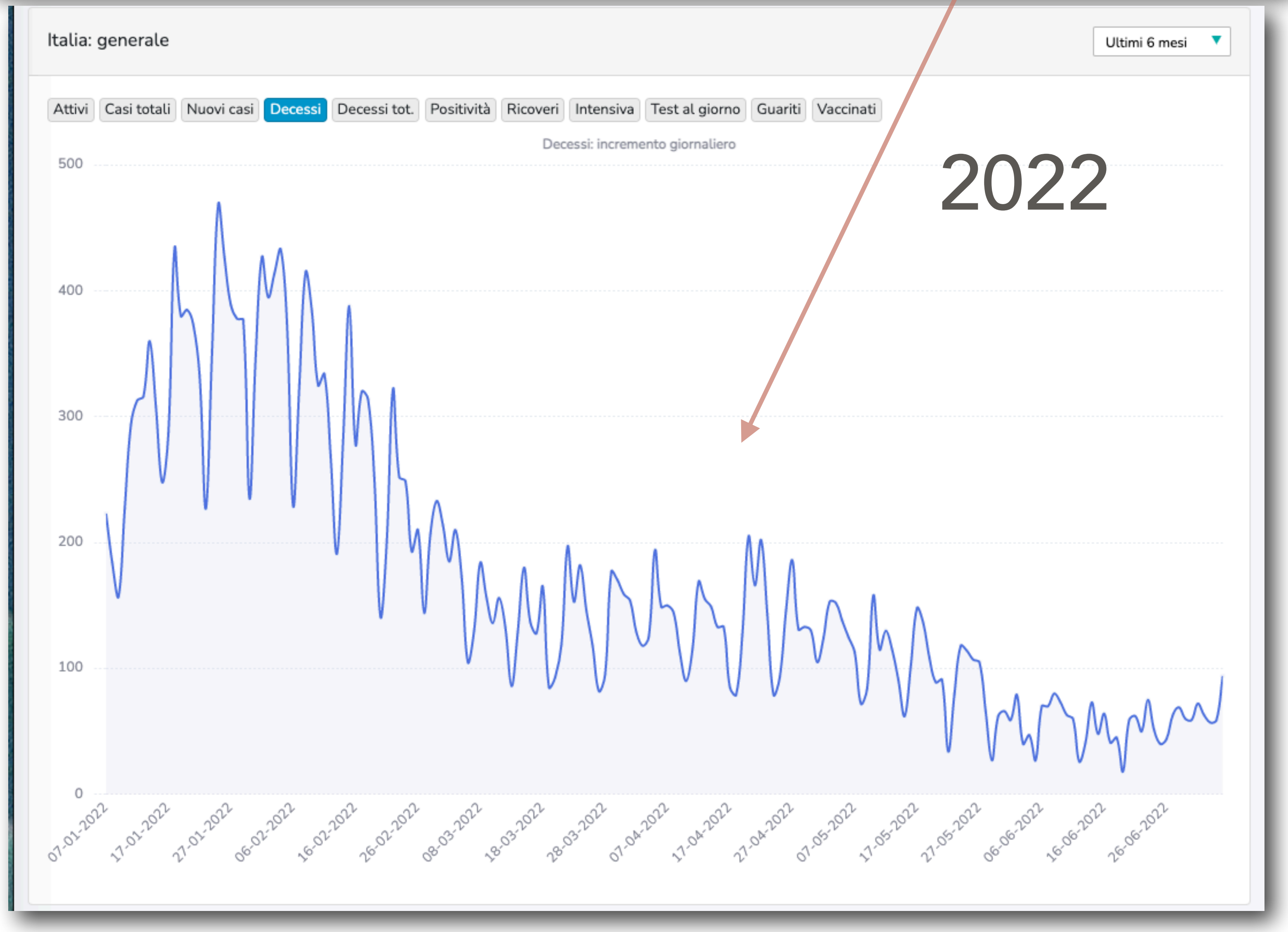


Robustness of the a-priori Risk index

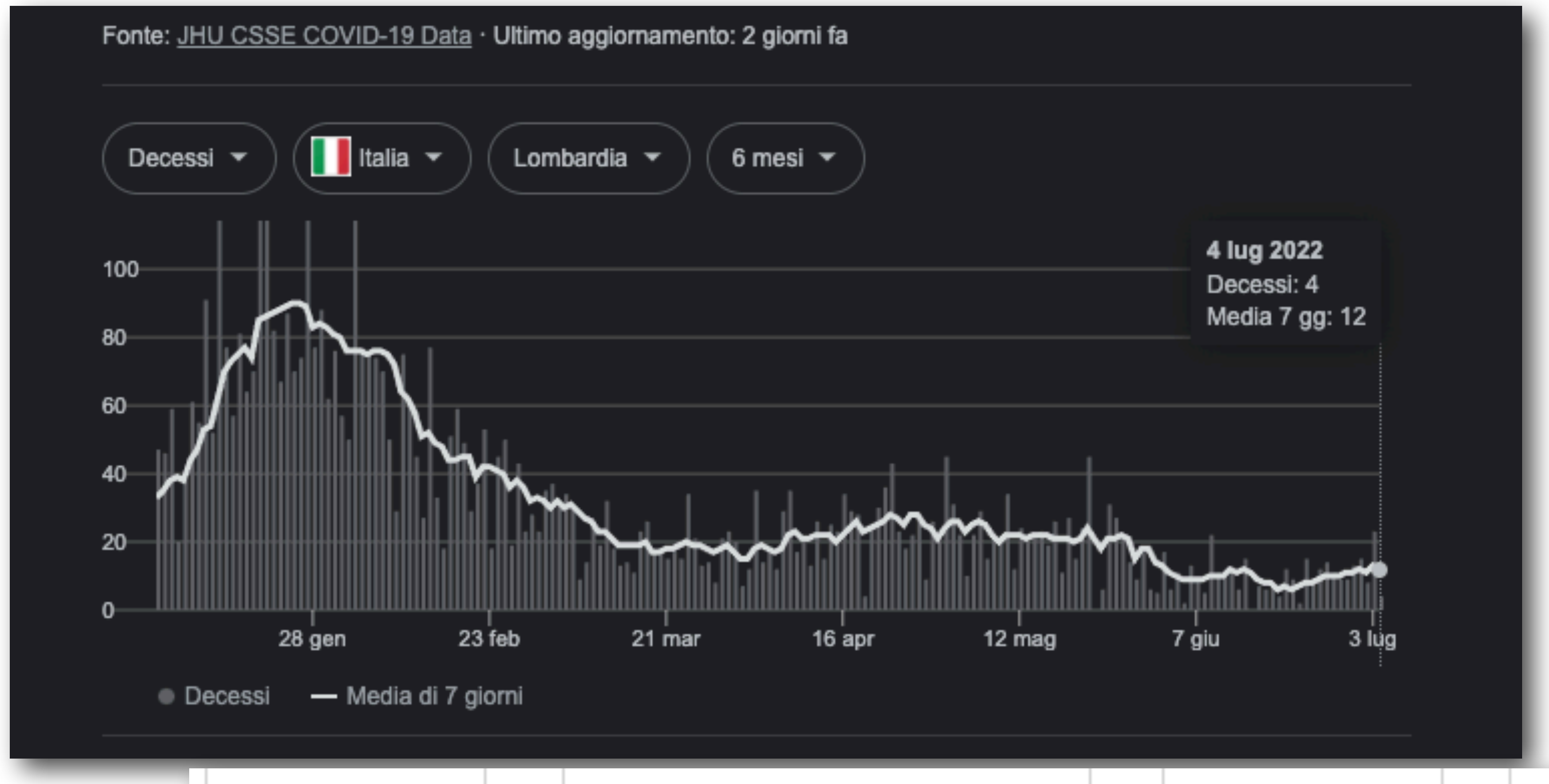
ISS official data						Our predictions - Scientific Reports (May 2020)	
	3rd wave	2nd wave	1st wave	Difference of deaths 2nd wave - 1st wave	Difference of deaths 3rd wave - 2nd wave		
Region	*Deaths 11-4-21*	*Deaths 20-1-21*	*Deaths 14-7-20*			*Region*	*a-priori risk*
Lombardia	31753	26405	16760	9645	5348	Lombardia	1
Emilia-Romagna	12380	8935	4271	4664	3445	Veneto	0,32
Piemonte	10660	8496	4115	4381	2164	Piemonte	0,29
Veneto	10941	8256	2041	6215	2685	Emilia-Romagna	0,27
Lazio	7033	4535	846	3689	2498	Lazio	0,19
Toscana	5662	4038	1125	2913	1624	Toscana	0,14
Campania	5774	3471	432	3039	2303	Campania	0,11
Liguria	4003	3169	1561	1608	834	Puglia	0,09
Sicilia	5038	3101	283	2818	1937	Friuli VG	0,09
Puglia	5189	2917	547	2370	2272	Liguria	0,08
Friuli VG	3506	2157	345	1812	1349	Sicilia	0,08
Trentino Alto Adige	2461	1909	697	1212	552	Trentino Alto Adige	0,05
Marche	2771	1825	503	1322	946	Marche	0,04
Abruzzo	2243	1349	467	882	894	Abruzzo	0,04
Sardegna	1265	920	134	786	345	Sardegna	0,04
Umbria	1296	714	80	634	582	Calabria	0,03
Calabria	903	543	97	446	360	Umbria	0,03
Valle d'Aosta	436	399	146	253	37	Valle d'Aosta	0,01
Basilicata	484	302	27	275	182	Molise	0,01
Molise	456	240	23	217	216	Basilicata	0,01

COMPARISON OF THE SITUATION FOR THE PERIOD JANUARY-JUNE 2022 AND EFFECT OF VACCINATIONS





Lombardia 2022 Sicilia



Region	Deceased Jan-June2022	Ratio	Vaccinated (up to 3rd dose)	A-priori risk	Population
Lombardia	5791	1	85%	1	1
Veneto	2437	0.42	82%	0.32	0.45
Lazio	2227	0.38	85%	0.19	0.57
Sicilia	3731	0.64	78%	0.08	0.52
Umbria	380	0.07	84%	0.03	0.17

Vaccinations have strongly reduced the deaths due to Covid-19 mitigating the higher priori-risk of Lombardia with respect to other Italian regions !

More deaths than expected in Sicily due to a lower percentage of vaccinations !

Conclusions

There seem to be several structural and environmental regional co-factors which should be taken into account in order estimate in a realistic way the epidemic risk and decide the most effective restrictions to contain epidemic waves like that of Covid-19.

The a-priori risk index is an efficient way to consider them.

Official Total Deaths due to Covid-19 (updated on 05/07/22)

Italy	169,000	(60,000,000 inhabitants)	
Lombardy	40,879	(10,000,000 inhabitants)	24.2 % of the all country
Sicily	11,231	(5,000,000 inhabitants)	6.6 % of the all country
Cuba	8,529	(11,300,000 inhabitants)	

Source Our world in data

This method could be extended (considering for example also other cofactors of genetic origin) and tested also for other countries if data were available

Thanks for your attention !