Pollution atmosphérique et COVID-19.

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Co-Directrice Institut Desbrest d'Epidémiologie et Santé Publique (IDESP),
INSERM et Université de Montpellier

FERS

IDESP

Inserm

COI

- ERS Ethics and Integrity Committee (Member)
- IRD Ethics Committee (President)
- EAACI ROC
- AAAAI Environmental Exposures and Respiratory Health Committee
- ATS Health Policy Committee
- Société de Pneumologie de Langue Française: GT PAPPEI
- SFA Scientific Committee (Member)
- CSTB Scientific Committee (Member)
- RNSA Scientific Committee (Member)
- Météo France (Commission Santé)

Pollution atmosphérique et COVID-19

- **SARS-CoV2 et COVID-19 sont-ils significativement associés à la pollution atmosphérique?**

- **Cette association (si elle existe) est-elle fallacieuse ?**

Pour répondre

  - Etudes expérimentales
  - Etudes épidémiologiques (écologiques et individuelles)
  - Etudes d'intervention

- **Quels mécanismes?**
- **Perspectives**

COVID-19 KEY FACTS

Monde entier

Nombre total de cas
521 474 937
Signalés hier : **+347 476**

Nouveaux cas (sur les 14 derniers jours)
2–15 mai : **+ 7 667 720**

Décès
6 263 967
Signalés hier : **+625**

Nombre total de doses administrées
11 704 901 584
Signalés hier : **+4 094 364**

Nouvelles doses administrées (14 jours)
2–15 mai : **+ 89 893 895**

Personnes complètement vaccinées
4 696 040 351
% de la population : **60,4 %**

"Nombre total de doses administrées" indique le nombre de doses de vaccin administrées. Plusieurs doses étant nécessaires pour certains vaccins, le nombre de personnes vaccinées est probablement moins élevé. "Personnes complètement vaccinées" indique combien de personnes ont reçu le nombre total de doses d'un vaccin COVID-19.

Mise à jour hier • À propos des données sur les cas • À propos des données sur la vaccination • Source: Our World in Data

Evolution

- Variants?
- Saisons?
- Susceptibilité
- Harvesting

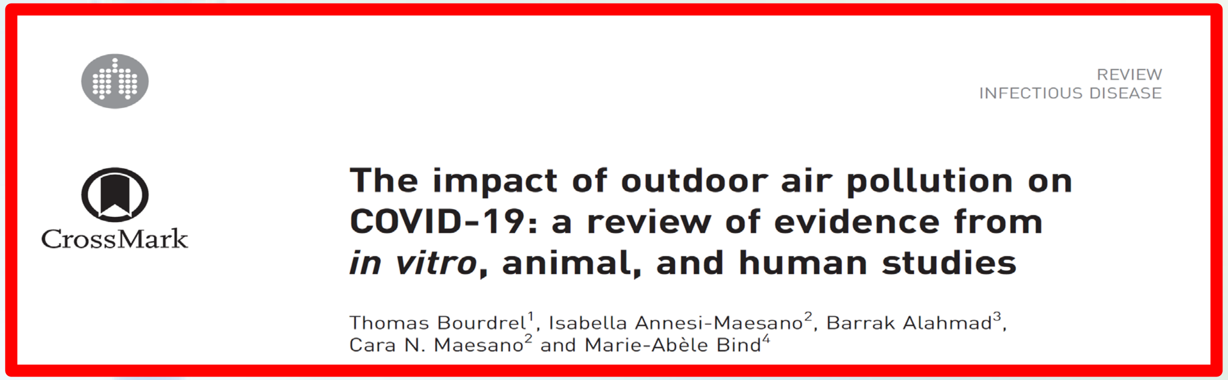
https://news.google.com/covid19/map?hl=en-US&mid=%2Fm%2F02j71&gl=US&ceid=US%3Aen&state=1

La pollution atmosphérique liée à plusieurs viroses respiratoires

- Grippe aviaire : Relation exponentielle avec les niveaux de PM10 et PM2.5 (µg/m3) (le virus s'est propagé sur de longues distances grâce aux tempêtes de poussière asiatiques) (Chen, EHP 2010).
- Grippe : L'exposition à long terme à la pollution atmosphérique est liée à une mortalité accrue (Pope, Circulation 2004).
- VRS : relations et niveaux de PM10 et PM2,5 chez les enfants (Ye, Environ Science and Pollution Research 2016)
- Tuberculose : relation avec les PM2,5 (suppression des mécanismes de défense immunitaire) (Popovic, Env Res 2019)
- Rougeole : le nombre de cas de rougeole dans 21 villes chinoises au cours de la période 2013-2014 a varié en fonction des concentrations de PM2,5 (Chen, Env Res 2017)
- SRAS-CoV-1 : Pendant le SRAS de 2002, les patients provenant des endroits où les niveaux de pollution atmosphérique étaient les plus élevés avaient deux fois plus de risques de mourir du SRAS que les autres (Cui, Env Health 2003)

- SARS-COV-2 et COVID **????**

Il existe actuellement environ 1 500 études sur *PubMed* et 200 sur *medRxiv* (*med-archive*) sur le thème des liens entre pollution et SARS-CoV-2 ou COVID

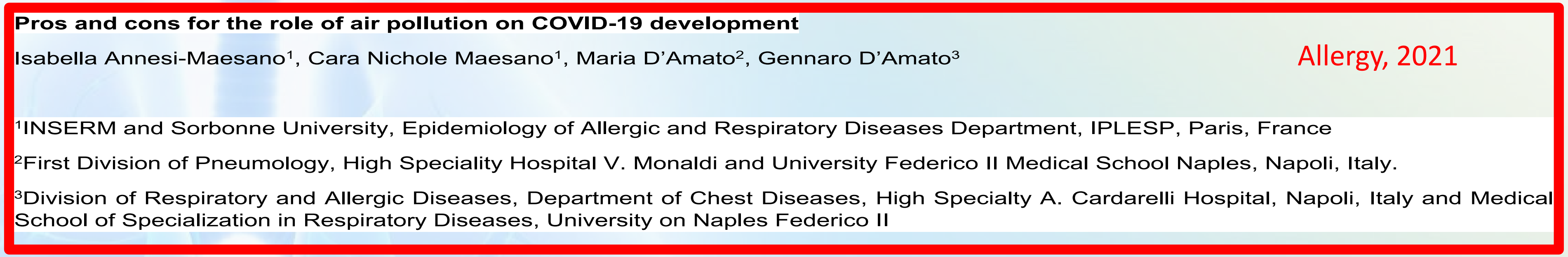


REVIEW
INFECTIOUS DISEASE

CrossMark

The impact of outdoor air pollution on COVID-19: a review of evidence from *in vitro*, animal, and human studies

Thomas Bourdrel[1], Isabella Annesi-Maesano[2], Barrak Alahmad[3], Cara N. Maesano[2] and Marie-Abèle Bind[4]



Pros and cons for the role of air pollution on COVID-19 development

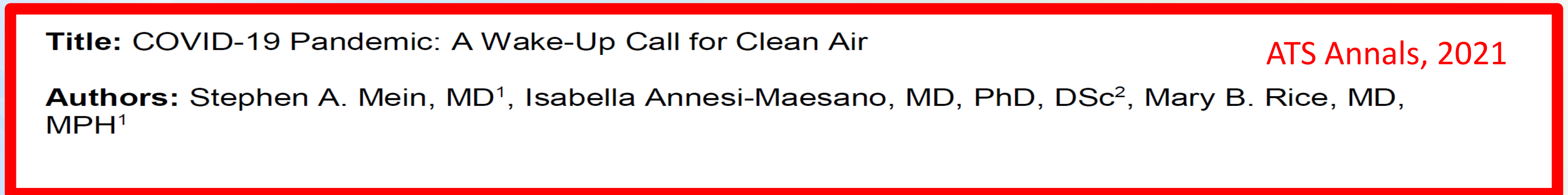
Isabella Annesi-Maesano[1], Cara Nichole Maesano[1], Maria D'Amato[2], Gennaro D'Amato[3]

Allergy, 2021

[1]INSERM and Sorbonne University, Epidemiology of Allergic and Respiratory Diseases Department, IPLESP, Paris, France

[2]First Division of Pneumology, High Speciality Hospital V. Monaldi and University Federico II Medical School Naples, Napoli, Italy.

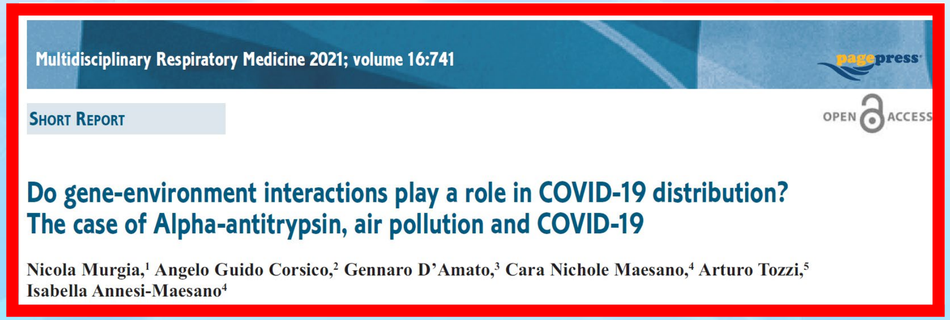
[3]Division of Respiratory and Allergic Diseases, Department of Chest Diseases, High Specialty A. Cardarelli Hospital, Napoli, Italy and Medical School of Specialization in Respiratory Diseases, University on Naples Federico II



Title: COVID-19 Pandemic: A Wake-Up Call for Clean Air

ATS Annals, 2021

Authors: Stephen A. Mein, MD[1], Isabella Annesi-Maesano, MD, PhD, DSc[2], Mary B. Rice, MD, MPH[1]



Multidisciplinary Respiratory Medicine 2021; volume 16:741

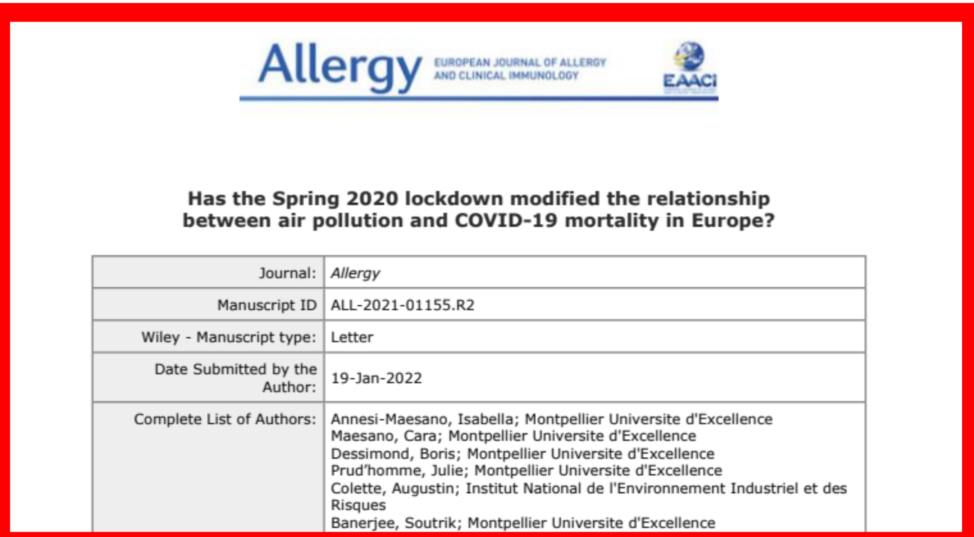
pagepress

SHORT REPORT

OPEN ACCESS

Do gene-environment interactions play a role in COVID-19 distribution? The case of Alpha-antitrypsin, air pollution and COVID-19

Nicola Murgia,[1] Angelo Guido Corsico,[2] Gennaro D'Amato,[3] Cara Nichole Maesano,[4] Arturo Tozzi,[5] Isabella Annesi-Maesano[4]



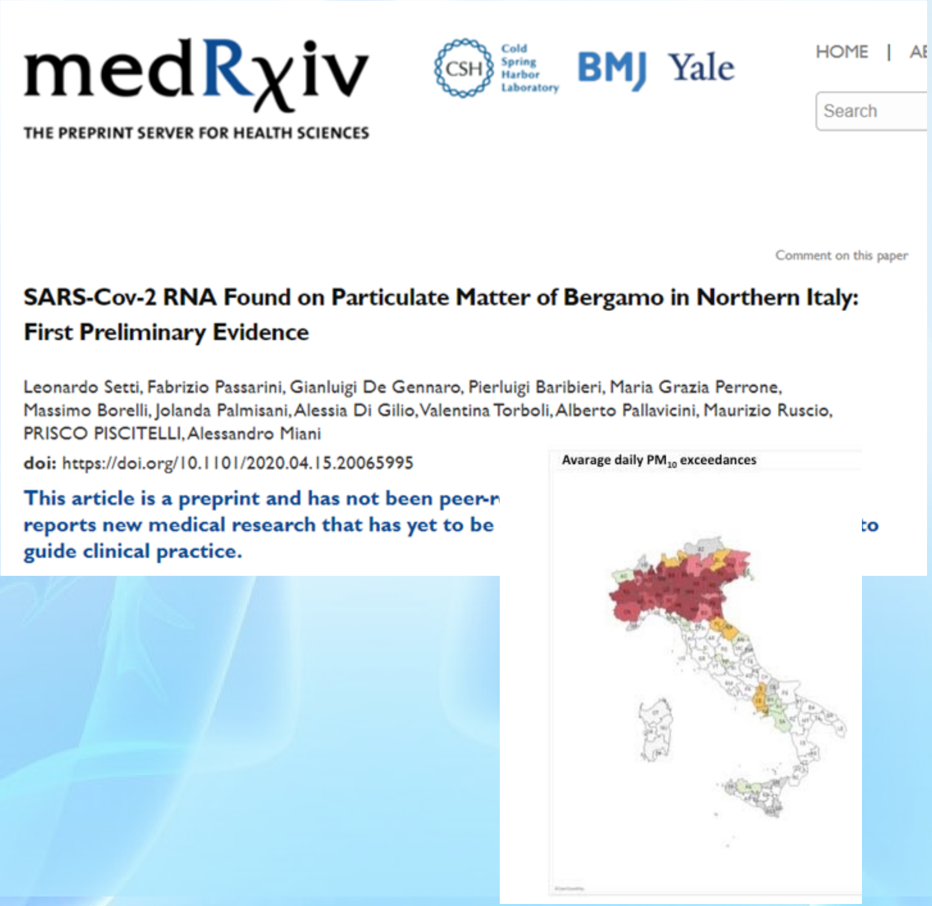
Allergy EUROPEAN JOURNAL OF ALLERGY AND CLINICAL IMMUNOLOGY

EAACI

Has the Spring 2020 lockdown modified the relationship between air pollution and COVID-19 mortality in Europe?

Journal:	*Allergy*
Manuscript ID	ALL-2021-01155.R2
Wiley - Manuscript type:	Letter
Date Submitted by the Author:	19-Jan-2022
Complete List of Authors:	Annesi-Maesano, Isabella; Montpellier Universite d'Excellence Maesano, Cara; Montpellier Universite d'Excellence Dessimond, Boris; Montpellier Universite d'Excellence Prud'homme, Julie; Montpellier Universite d'Excellence Colette, Augustin; Institut National de l'Environnement Industriel et des Risques Banerjee, Soutrik; Montpellier Universite d'Excellence

La pollution atmosphérique a été associée aux cas et aux décès de COVID-19 déjà en 2019

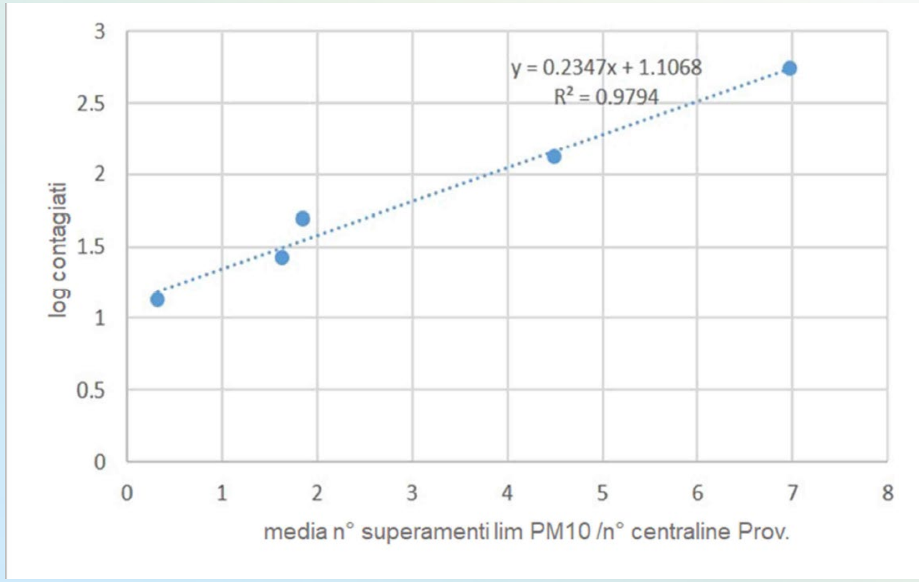


SARS-Cov-2 RNA Found on Particulate Matter of Bergamo in Northern Italy: First Preliminary Evidence

Leonardo Setti, Fabrizio Passarini, Gianluigi De Gennaro, Pierluigi Baribieri, Maria Grazia Perrone, Massimo Borelli, Jolanda Palmisani, Alessia Di Gilio, Valentina Torboli, Alberto Pallavicini, Maurizio Ruscio, PRISCO PISCITELLI, Alessandro Miani

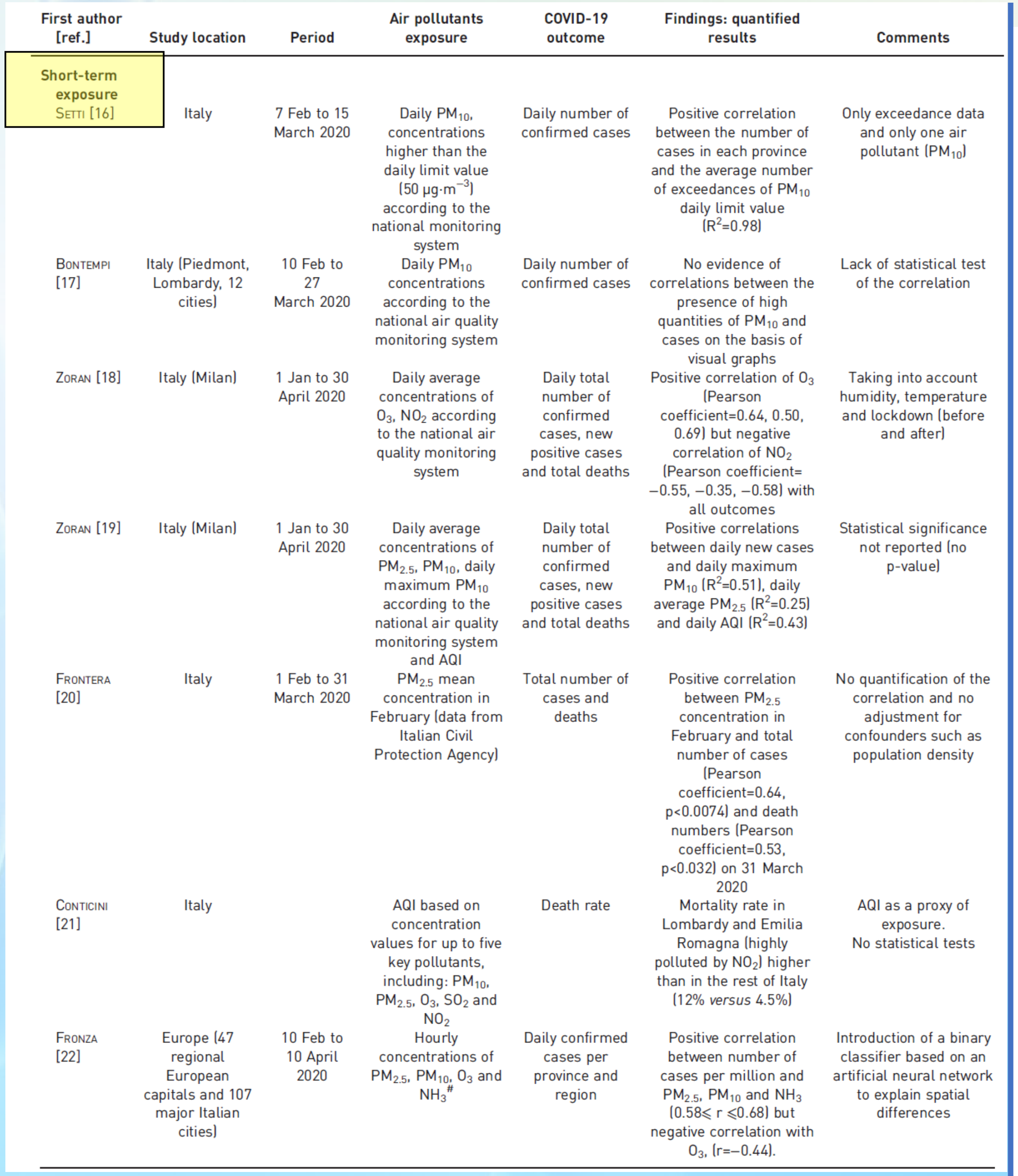
doi: https://doi.org/10.1101/2020.04.15.20065995

This article is a preprint and has not been peer-r reports new medical research that has yet to be to guide clinical practice.

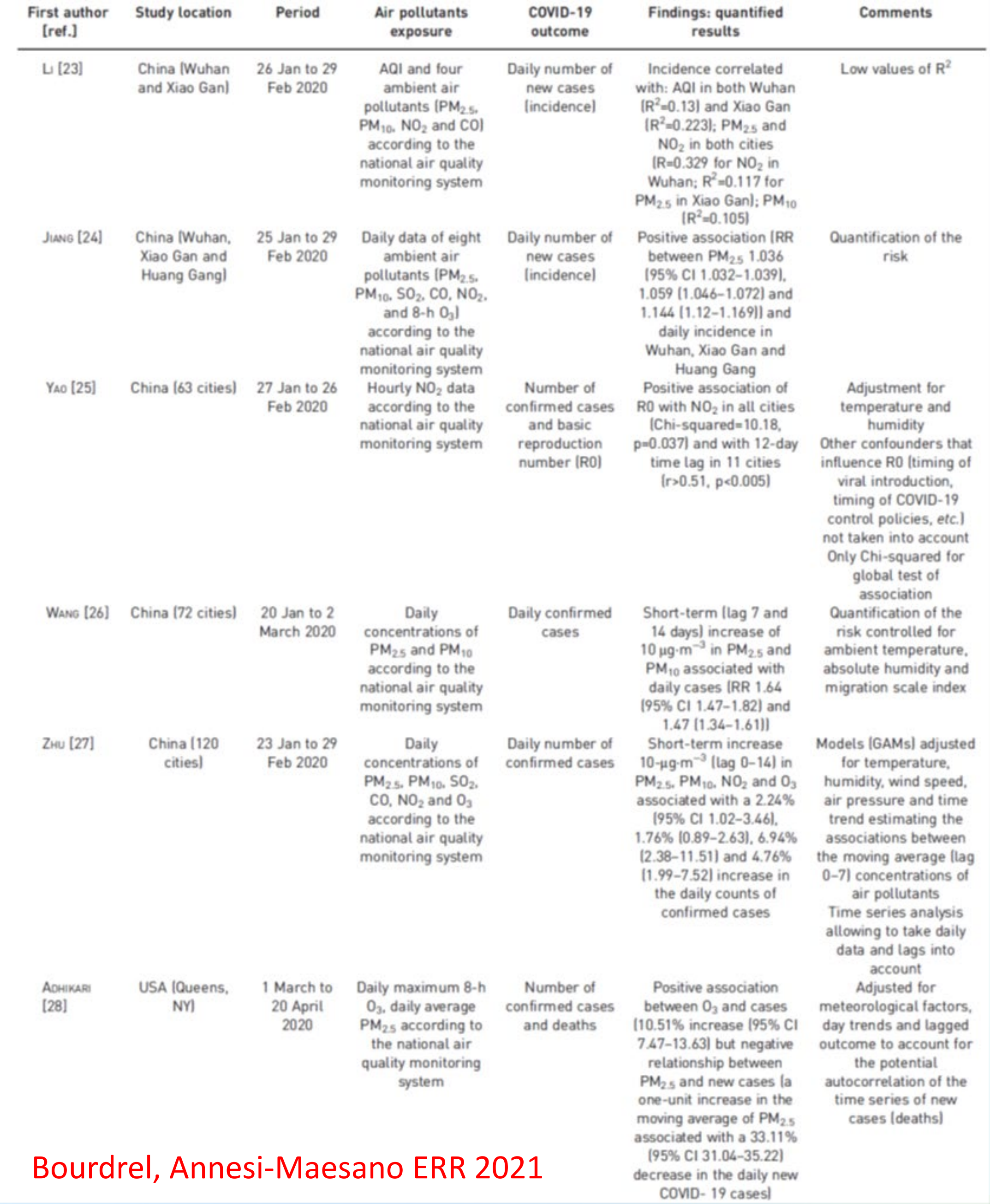


Les dépassements de la valeur limite quotidienne des PM_{10} semblent être un prédicteur significatif ($p < 0{,}001$) de l'infection par SARS-CoV2 dans les analyses univariées. Les provinces les moins polluées présentaient une médiane de 0,03 cas d'infection sur 1000 habitants, tandis que les provinces les plus polluées présentaient une médiane de 0,26 cas sur 1000 habitants.

Short-Term Effects



First author [ref.]	Study location	Period	Air pollutants exposure	COVID-19 outcome	Findings: quantified results	Comments
Short-term exposure						
Setti [16]	Italy	7 Feb to 15 March 2020	Daily PM_{10}, concentrations higher than the daily limit value ($50\ \mu g \cdot m^{-3}$) according to the national monitoring system	Daily number of confirmed cases	Positive correlation between the number of cases in each province and the average number of exceedances of PM_{10} daily limit value ($R^2=0.98$)	Only exceedance data and only one air pollutant (PM_{10})
Bontempi [17]	Italy (Piedmont, Lombardy, 12 cities)	10 Feb to 27 March 2020	Daily PM_{10} concentrations according to the national air quality monitoring system	Daily number of confirmed cases	No evidence of correlations between the presence of high quantities of PM_{10} and cases on the basis of visual graphs	Lack of statistical test of the correlation
Zoran [18]	Italy (Milan)	1 Jan to 30 April 2020	Daily average concentrations of O_3, NO_2 according to the national air quality monitoring system	Daily total number of confirmed cases, new positive cases and total deaths	Positive correlation of O_3 (Pearson coefficient=0.64, 0.50, 0.69) but negative correlation of NO_2 (Pearson coefficient= −0.55, −0.35, −0.58) with all outcomes	Taking into account humidity, temperature and lockdown (before and after)
Zoran [19]	Italy (Milan)	1 Jan to 30 April 2020	Daily average concentrations of $PM_{2.5}$, PM_{10}, daily maximum PM_{10} according to the national air quality monitoring system and AQI	Daily total number of confirmed cases, new positive cases and total deaths	Positive correlations between daily new cases and daily maximum PM_{10} ($R^2=0.51$), daily average $PM_{2.5}$ ($R^2=0.25$) and daily AQI ($R^2=0.43$)	Statistical significance not reported (no p-value)
Frontera [20]	Italy	1 Feb to 31 March 2020	$PM_{2.5}$ mean concentration in February (data from Italian Civil Protection Agency)	Total number of cases and deaths	Positive correlation between $PM_{2.5}$ concentration in February and total number of cases (Pearson coefficient=0.64, $p<0.0074$) and death numbers (Pearson coefficient=0.53, $p<0.032$) on 31 March 2020	No quantification of the correlation and no adjustment for confounders such as population density
Conticini [21]	Italy		AQI based on concentration values for up to five key pollutants, including: PM_{10}, $PM_{2.5}$, O_3, SO_2 and NO_2	Death rate	Mortality rate in Lombardy and Emilia Romagna (highly polluted by NO_2) higher than in the rest of Italy (12% *versus* 4.5%)	AQI as a proxy of exposure. No statistical tests
Fronza [22]	Europe (47 regional European capitals and 107 major Italian cities)	10 Feb to 10 April 2020	Hourly concentrations of $PM_{2.5}$, PM_{10}, O_3 and $NH_3^{\#}$	Daily confirmed cases per province and region	Positive correlation between number of cases per million and $PM_{2.5}$, PM_{10} and NH_3 ($0.58 \leqslant r \leqslant 0.68$) but negative correlation with O_3, ($r=-0.44$).	Introduction of a binary classifier based on an artificial neural network to explain spatial differences



First author [ref.]	Study location	Period	Air pollutants exposure	COVID-19 outcome	Findings: quantified results	Comments
Li [23]	China (Wuhan and Xiao Gan)	26 Jan to 29 Feb 2020	AQI and four ambient air pollutants ($PM_{2.5}$, PM_{10}, NO_2 and CO) according to the national air quality monitoring system	Daily number of new cases (incidence)	Incidence correlated with: AQI in both Wuhan ($R^2=0.13$) and Xiao Gan ($R^2=0.223$); $PM_{2.5}$ and NO_2 in both cities ($R=0.329$ for NO_2 in Wuhan; $R^2=0.117$ for $PM_{2.5}$ in Xiao Gan); PM_{10} ($R^2=0.105$)	Low values of R^2
Jiang [24]	China (Wuhan, Xiao Gan and Huang Gang)	25 Jan to 29 Feb 2020	Daily data of eight ambient air pollutants ($PM_{2.5}$, PM_{10}, SO_2, CO, NO_2, and 8-h O_3) according to the national air quality monitoring system	Daily number of new cases (incidence)	Positive association (RR between $PM_{2.5}$ 1.036 (95% CI 1.032–1.039), 1.059 (1.046–1.072) and 1.144 (1.12–1.169)) and daily incidence in Wuhan, Xiao Gan and Huang Gang	Quantification of the risk
Yao [25]	China (63 cities)	27 Jan to 26 Feb 2020	Hourly NO_2 data according to the national air quality monitoring system	Number of confirmed cases and basic reproduction number (R0)	Positive association of R0 with NO_2 in all cities (Chi-squared=10.18, $p=0.037$) and with 12-day time lag in 11 cities ($r>0.51$, $p<0.005$)	Adjustment for temperature and humidity Other confounders that influence R0 (timing of viral introduction, timing of COVID-19 control policies, *etc.*) not taken into account Only Chi-squared for global test of association
Wang [26]	China (72 cities)	20 Jan to 2 March 2020	Daily concentrations of $PM_{2.5}$ and PM_{10} according to the national air quality monitoring system	Daily confirmed cases	Short-term (lag 7 and 14 days) increase of $10\ \mu g \cdot m^{-3}$ in $PM_{2.5}$ and PM_{10} associated with daily cases (RR 1.64 (95% CI 1.47–1.82) and 1.47 (1.34–1.61))	Quantification of the risk controlled for ambient temperature, absolute humidity and migration scale index
Zhu [27]	China (120 cities)	23 Jan to 29 Feb 2020	Daily concentrations of $PM_{2.5}$, PM_{10}, SO_2, CO, NO_2 and O_3 according to the national air quality monitoring system	Daily number of confirmed cases	Short-term increase $10\text{-}\mu g \cdot m^{-3}$ (lag 0–14) in $PM_{2.5}$, PM_{10}, NO_2 and O_3 associated with a 2.24% (95% CI 1.02–3.46), 1.76% (0.89–2.63), 6.94% (2.38–11.51) and 4.76% (1.99–7.52) increase in the daily counts of confirmed cases	Models (GAMs) adjusted for temperature, humidity, wind speed, air pressure and time trend estimating the associations between the moving average (lag 0–7) concentrations of air pollutants Time series analysis allowing to take daily data and lags into account
Adhikari [28]	USA (Queens, NY)	1 March to 20 April 2020	Daily maximum 8-h O_3, daily average $PM_{2.5}$ according to the national air quality monitoring system	Number of confirmed cases and deaths	Positive association between O_3 and cases (10.51% increase (95% CI 7.47–13.63) but negative relationship between $PM_{2.5}$ and new cases (a one-unit increase in the moving average of $PM_{2.5}$ associated with a 33.11% (95% CI 31.04–35.22) decrease in the daily new COVID- 19 cases)	Adjusted for meteorological factors, day trends and lagged outcome to account for the potential autocorrelation of the time series of new cases (deaths)

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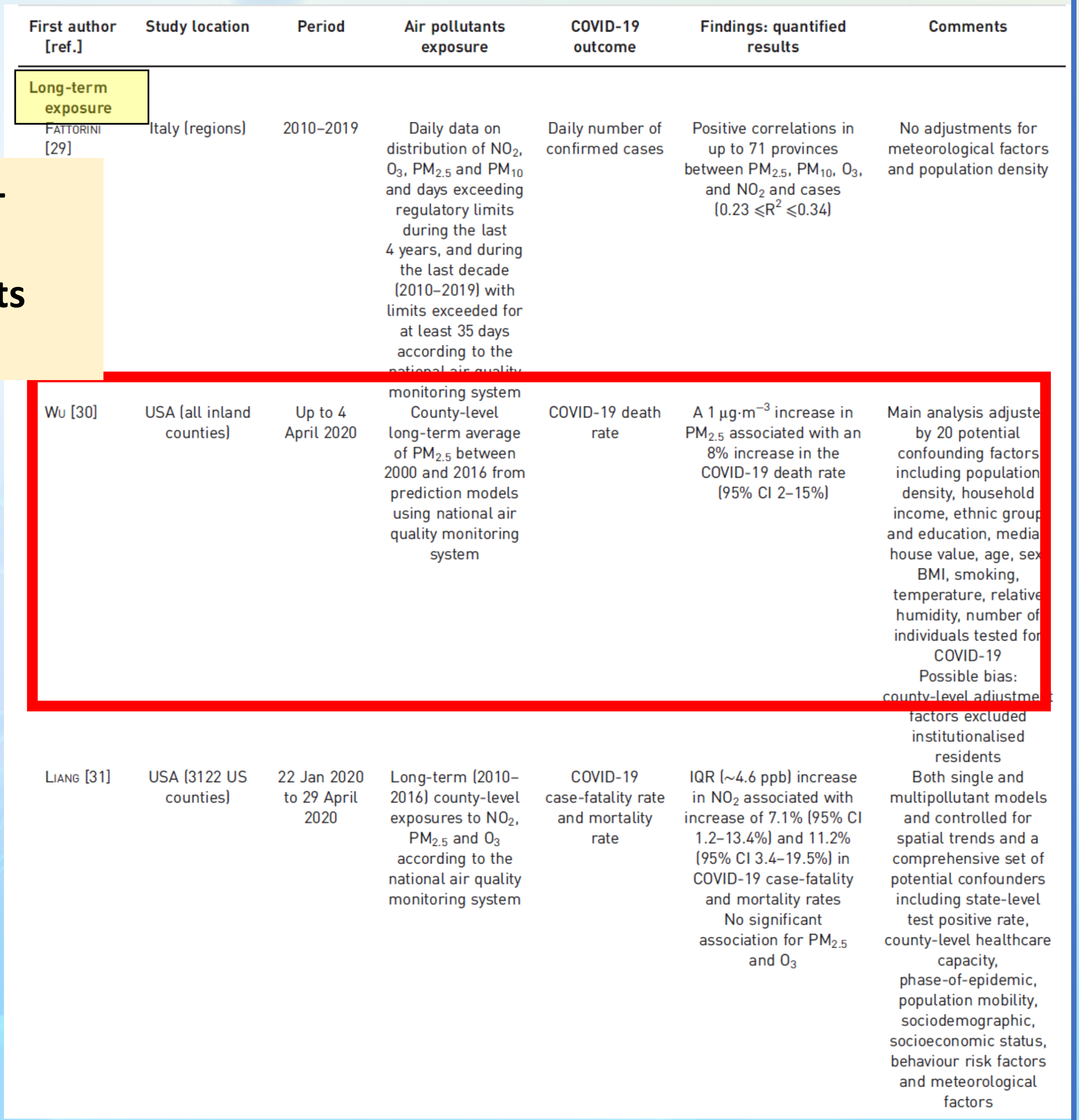
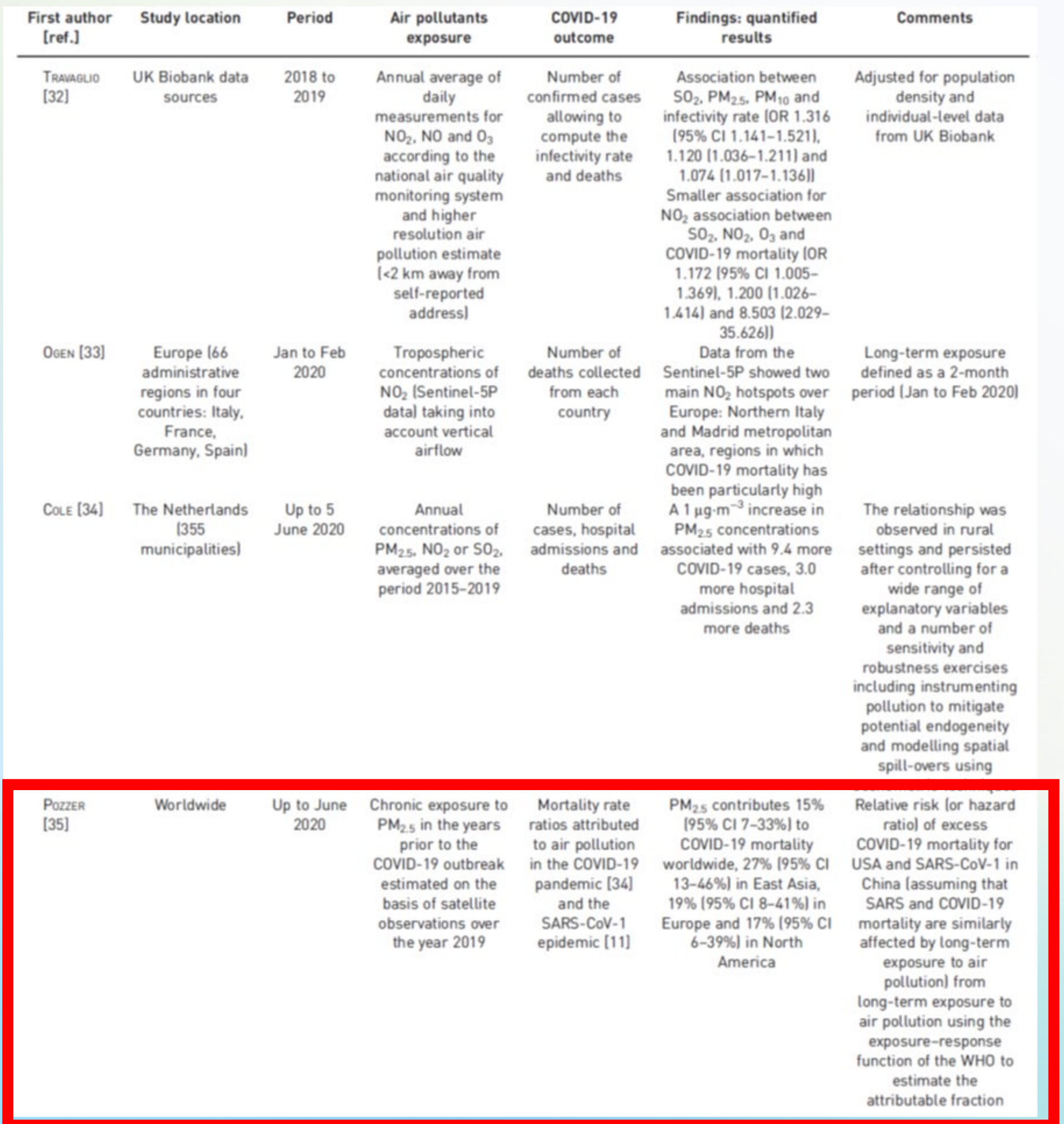
Long-Term Effects



First author [ref.]	Study location	Period	Air pollutants exposure	COVID-19 outcome	Findings: quantified results	Comments
Long-term exposure						
Fattorini [29]	Italy (regions)	2010–2019	Daily data on distribution of NO_2, O_3, $PM_{2.5}$ and PM_{10} and days exceeding regulatory limits during the last 4 years, and during the last decade (2010–2019) with limits exceeded for at least 35 days according to the national air quality monitoring system	Daily number of confirmed cases	Positive correlations in up to 71 provinces between $PM_{2.5}$, PM_{10}, O_3, and NO_2 and cases ($0.23 \leqslant R^2 \leqslant 0.34$)	No adjustments for meteorological factors and population density
Wu [30]	USA (all inland counties)	Up to 4 April 2020	County-level long-term average of $PM_{2.5}$ between 2000 and 2016 from prediction models using national air quality monitoring system	COVID-19 death rate	A 1 $\mu g \cdot m^{-3}$ increase in $PM_{2.5}$ associated with an 8% increase in the COVID-19 death rate (95% CI 2–15%)	Main analysis adjuste by 20 potential confounding factors including population density, household income, ethnic group and education, media house value, age, sex BMI, smoking, temperature, relative humidity, number of individuals tested for COVID-19 Possible bias: county-level adjustme factors excluded institutionalised residents
Liang [31]	USA (3122 US counties)	22 Jan 2020 to 29 April 2020	Long-term (2010–2016) county-level exposures to NO_2, $PM_{2.5}$ and O_3 according to the national air quality monitoring system	COVID-19 case-fatality rate and mortality rate	IQR (~4.6 ppb) increase in NO_2 associated with increase of 7.1% (95% CI 1.2–13.4%) and 11.2% (95% CI 3.4–19.5%) in COVID-19 case-fatality and mortality rates No significant association for $PM_{2.5}$ and O_3	Both single and multipollutant models and controlled for spatial trends and a comprehensive set of potential confounders including state-level test positive rate, county-level healthcare capacity, phase-of-epidemic, population mobility, sociodemographic, socioeconomic status, behaviour risk factors and meteorological factors



First author [ref.]	Study location	Period	Air pollutants exposure	COVID-19 outcome	Findings: quantified results	Comments
Travaglio [32]	UK Biobank data sources	2018 to 2019	Annual average of daily measurements for NO_2, NO and O_3 according to the national air quality monitoring system and higher resolution air pollution estimate (<2 km away from self-reported address)	Number of confirmed cases allowing to compute the infectivity rate and deaths	Association between SO_2, $PM_{2.5}$, PM_{10} and infectivity rate (OR 1.316 (95% CI 1.141–1.521), 1.120 (1.036–1.211) and 1.074 (1.017–1.136)) Smaller association for NO_2 association between SO_2, NO_2, O_3 and COVID-19 mortality (OR 1.172 (95% CI 1.005–1.369), 1.200 (1.026–1.414) and 8.503 (2.029–35.626))	Adjusted for population density and individual-level data from UK Biobank
Ogen [33]	Europe (66 administrative regions in four countries: Italy, France, Germany, Spain)	Jan to Feb 2020	Tropospheric concentrations of NO_2 (Sentinel-5P data) taking into account vertical airflow	Number of deaths collected from each country	Data from the Sentinel-5P showed two main NO_2 hotspots over Europe: Northern Italy and Madrid metropolitan area, regions in which COVID-19 mortality has been particularly high	Long-term exposure defined as a 2-month period (Jan to Feb 2020)
Cole [34]	The Netherlands (355 municipalities)	Up to 5 June 2020	Annual concentrations of $PM_{2.5}$, NO_2 or SO_2, averaged over the period 2015–2019	Number of cases, hospital admissions and deaths	A 1 $\mu g \cdot m^{-3}$ increase in $PM_{2.5}$ concentrations associated with 9.4 more COVID-19 cases, 3.0 more hospital admissions and 2.3 more deaths	The relationship was observed in rural settings and persisted after controlling for a wide range of explanatory variables and a number of sensitivity and robustness exercises including instrumenting pollution to mitigate potential endogeneity and modelling spatial spill-overs using
Pozzer [35]	Worldwide	Up to June 2020	Chronic exposure to $PM_{2.5}$ in the years prior to the COVID-19 outbreak estimated on the basis of satellite observations over the year 2019	Mortality rate ratios attributed to air pollution in the COVID-19 pandemic [34] and the SARS-CoV-1 epidemic [11]	$PM_{2.5}$ contributes 15% (95% CI 7–33%) to COVID-19 mortality worldwide, 27% (95% CI 13–46%) in East Asia, 19% (95% CI 8–41%) in Europe and 17% (95% CI 6–39%) in North America	Relative risk (or hazard ratio) of excess COVID-19 mortality for USA and SARS-CoV-1 in China (assuming that SARS and COVID-19 mortality are similarly affected by long-term exposure to air pollution) from long-term exposure to air pollution using the exposure–response function of the WHO to estimate the attributable fraction

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EDITOR'S CHOICE

Regional and global contributions of air pollution to risk of death from COVID-19

Andrea Pozzer, Francesca Dominici, Andy Haines, Christian Witt, Thomas Münzel ✉, Jos Lelieveld ✉

Cardiovascular Research, Volume 116, Issue 14, 1 December 2020, Pages 2247–2253, https://doi.org/10.1093/cvr/cvaa288

Published: 26 October 2020 **Article history** ▾

Region/Population (million)	COVID-19 MORTALITY FRACTION ATTRIBUTED TO AIR POLLUTION (%)	
	Fossil fuel-related emissions	**All anthropogenic emissions**
Europe (628)	13 (6–33)*	19 (8–41)
Africa (1345)	2 (1–19)	7 (3–25)
West Asia (627)	6 (3–25)	8 (4–27)
South Asia (2565)	7 (3–22)	15 (8–31)
East Asia (1685)	15 (8–32)	27 (13–46)
North America (525)	14 (6–36)	17 (6–39)
South America (547)	3 (1–23)	9 (4–30)
Oceania (28)	1 (0–20)	3 (1–23)
World (7950)	8 (4–25)	15 (7–33)

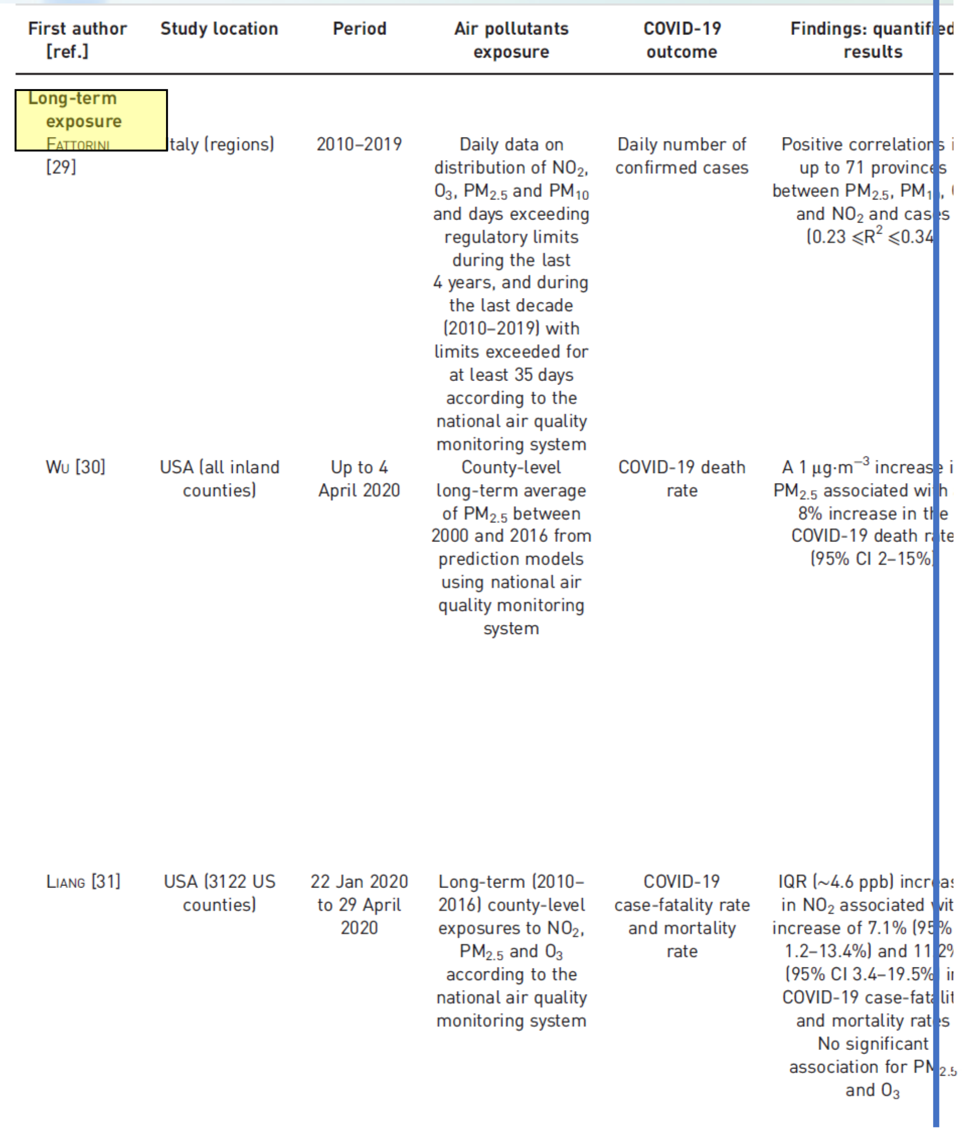
*The 95% confidence levels are given in parentheses.

La pollution atmosphérique contribue à 18 % des décès dus à la COVID-19

Pollution de l’air et COVID

Short-Term Effects

Données individuelles (vs.données écologiques)



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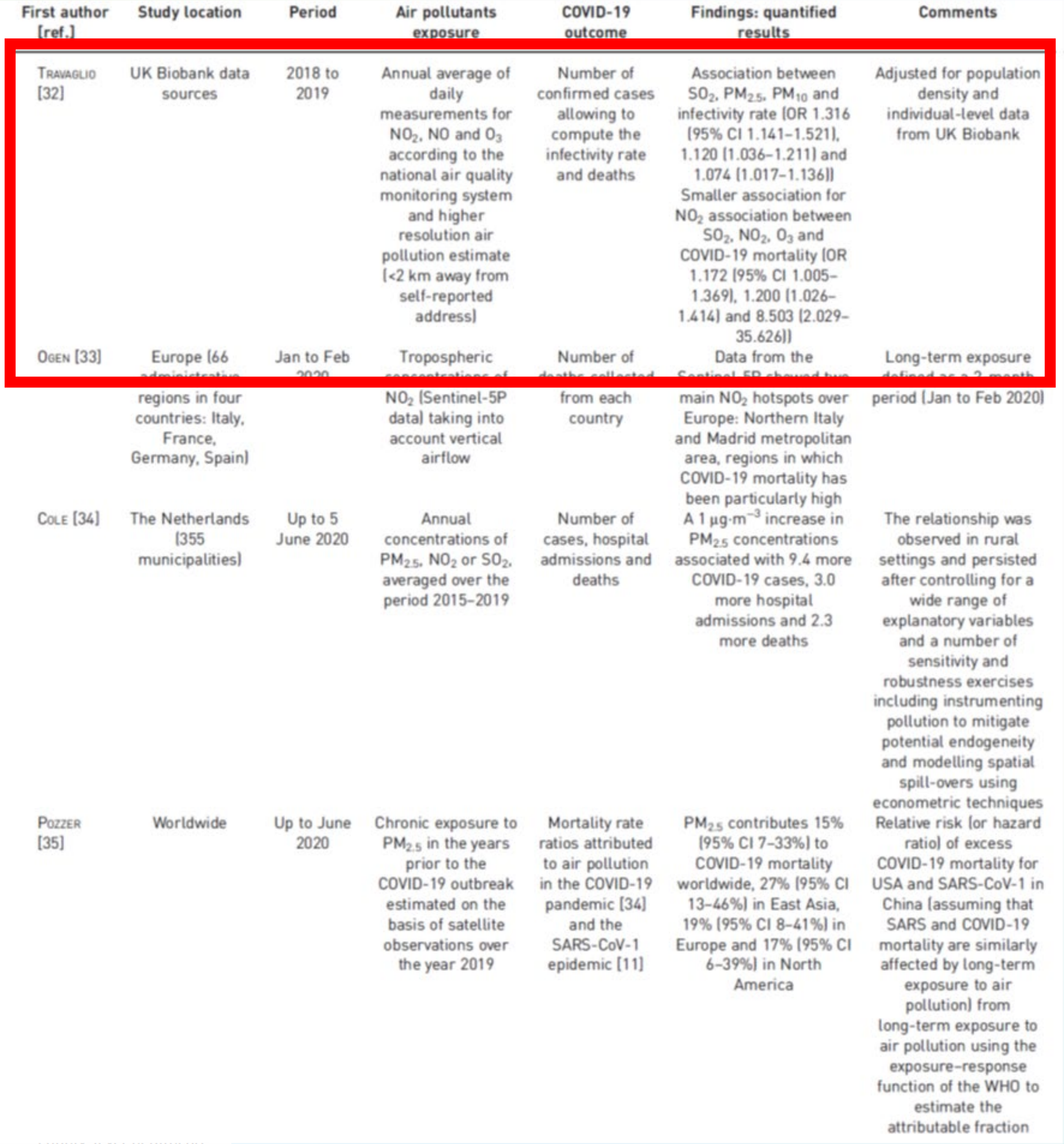

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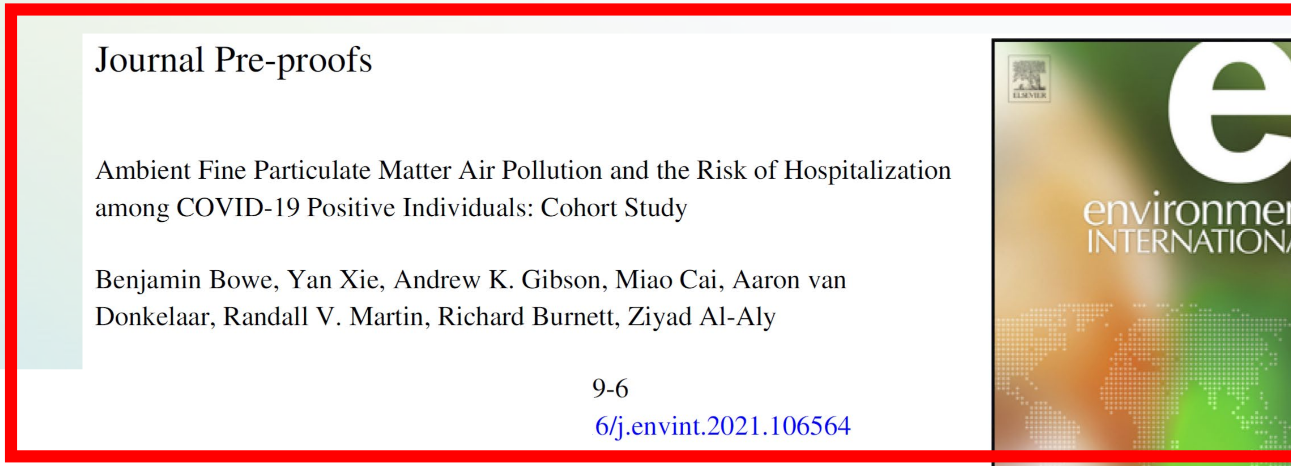
Ogen [33]	Europe (66 administrative regions in four countries: Italy, France, Germany, Spain)	Jan to Feb 2020	Tropospheric concentrations of NO_2 (Sentinel-5P data) taking into account vertical airflow	Number of deaths collected from each country	Data from the Sentinel-5P showed two main NO_2 hotspots over Europe: Northern Italy and Madrid metropolitan area, regions in which COVID-19 mortality has been particularly high	Long-term exposure defined as a 2-month period (Jan to Feb 2020)
Cole [34]	The Netherlands (355 municipalities)	Up to 5 June 2020	Annual concentrations of $PM_{2.5}$, NO_2 or SO_2, averaged over the period 2015–2019	Number of cases, hospital admissions and deaths	A 1 $\mu g \cdot m^{-3}$ increase in $PM_{2.5}$ concentrations associated with 9.4 more COVID-19 cases, 3.0 more hospital admissions and 2.3 more deaths	The relationship was observed in rural settings and persisted after controlling for a wide range of explanatory variables and a number of sensitivity and robustness exercises including instrumenting pollution to mitigate potential endogeneity and modelling spatial spill-overs using econometric techniques
Pozzer [35]	Worldwide	Up to June 2020	Chronic exposure to $PM_{2.5}$ in the years prior to the COVID-19 outbreak estimated on the basis of satellite observations over the year 2019	Mortality rate ratios attributed to air pollution in the COVID-19 pandemic [34] and the SARS-CoV-1 epidemic [11]	$PM_{2.5}$ contributes 15% (95% CI 7–33%) to COVID-19 mortality worldwide, 27% (95% CI 13–46%) in East Asia, 19% (95% CI 8–41%) in Europe and 17% (95% CI 6–39%) in North America	Relative risk (or hazard ratio) of excess COVID-19 mortality for USA and SARS-CoV-1 in China (assuming that SARS and COVID-19 mortality are similarly affected by long-term exposure to air pollution) from long-term exposure to air pollution using the exposure–response function of the WHO to estimate the attributable fraction

capacity,
phase-of-epidemic,
population mobility,
sociodemographic,
socioeconomic status,

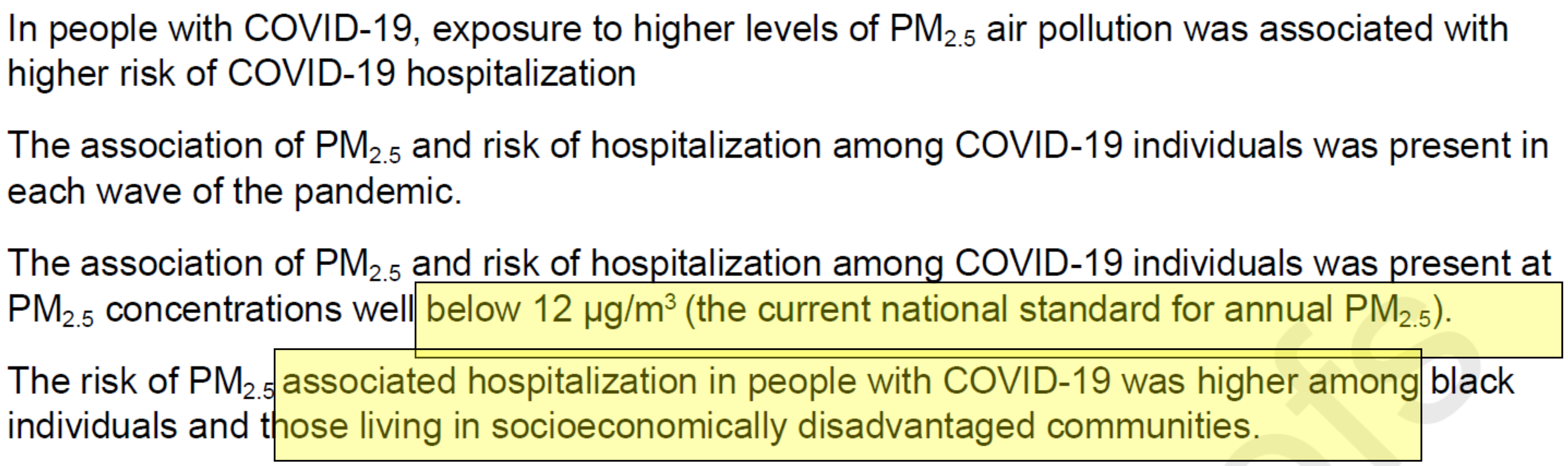

Journal Pre-proofs

Ambient Fine Particulate Matter Air Pollution and the Risk of Hospitalization among COVID-19 Positive Individuals: Cohort Study

Benjamin Bowe, Yan Xie, Andrew K. Gibson, Miao Cai, Aaron van Donkelaar, Randall V. Martin, Richard Burnett, Ziyad Al-Aly

9-6
6/j.envint.2021.106564

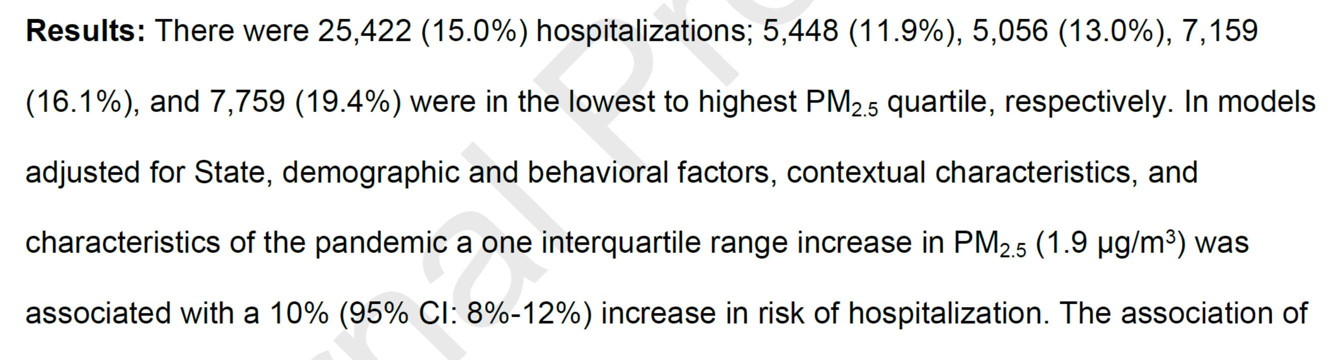
Highlights:


In people with COVID-19, exposure to higher levels of $PM_{2.5}$ air pollution was associated with higher risk of COVID-19 hospitalization

The association of $PM_{2.5}$ and risk of hospitalization among COVID-19 individuals was present in each wave of the pandemic.

The association of $PM_{2.5}$ and risk of hospitalization among COVID-19 individuals was present at $PM_{2.5}$ concentrations well below 12 µg/m³ (the current national standard for annual $PM_{2.5}$).

The risk of $PM_{2.5}$ associated hospitalization in people with COVID-19 was higher among black individuals and those living in socioeconomically disadvantaged communities.


Results: There were 25,422 (15.0%) hospitalizations; 5,448 (11.9%), 5,056 (13.0%), 7,159 (16.1%), and 7,759 (19.4%) were in the lowest to highest $PM_{2.5}$ quartile, respectively. In models adjusted for State, demographic and behavioral factors, contextual characteristics, and characteristics of the pandemic a one interquartile range increase in $PM_{2.5}$ (1.9 µg/m³) was associated with a 10% (95% CI: 8%-12%) increase in risk of hospitalization. The association of

Pourquoi faut-il être prudent ?

- Peu d’études longitudinales (vs. études transversales, séries temporelles)
- Missclassification de l’exposition (évaluation écologique de l'exposition et des résultats sanitaires)
- Mauvaise classification des événements de santé (sous-déclaration, PCR T...)
- Sélection des populations (biais)
- Méthodes statistiques
- Facteurs de confusion ou modificateurs
- Ajustement (R0), Etc.)…

Annesi-Maesano Allergy 2021

Pourquoi/comment la pollution de l'air pourrait-elle être liée à la COVID-19 ?

Pourquoi/comment la pollution de l'air pourrait-elle être liée à la COVID-19 ?

A. Effets directs de la pollution atmosphérique

B. Exposition accrue aux virus en cas de pollution atmosphérique

A. Effets directs de la pollution atmosphérique rélévants dans le COVID

A. Effets directs de la pollution atmosphérique rélévants dans le COVID

NO_2 PM

O_3

A. Effets directs de la pollution atmosphérique rélévants dans le COVID

NO_2 PM

O_3

i)

Altération de la perméabilité des voies respiratoires

- ↘ fonctionnement des cellules ciliées des voies respiratoires
- ↘ phagocytose des macrophages,
- ↘ défense immunitaire respiratoire

Risque accru de contagion et de COVID-19

Plusieurs études expérimentales confirment le lien entre SRAS-COV-2 et la pollution atmosphérique (perméabilité et système immunitaire)

Études humaines

- *Les macrophages du LBA étaient moins efficaces pour inactiver le virus de la grippe lorsque les individus étaient préalablement exposés au NO_2 par rapport à l'air ambiant dans une chambre (Frampton, Environ Res 1989Des concentrations élevées de $PM_{2,5}$ ont diminué les niveaux d'agglutinine salivaire (SAG) - l'une des principales protéines et peptides antimicrobiens (AMP) - chez les enfants (Zhang, Env Inter 2019)*

Études in vitro

- La pollution atmosphérique peut réduire l'activité antimicrobienne par la régulation à la baisse des AMP (par exemple, l'agglutinine salivaire et la protéine D du surfactant) dans le fluide des muqueuses respiratoires (Zhang, Chemosphere, 2019).
- Dans le fluide de la muqueuse épithéliale des voies respiratoires humaines, l'O_3 et les PM induisent un stress oxydatif et la formation d'espèces réactives de l'oxygène qui entraînent une déplétion des antioxydants et des surfactants (Lakey, Sci Rep, 2016).

Études sur les animaux

Chez les souris, l'exposition à l'O_3 et aux PM induit une phagocytose plus faible et une infectiosité plus facile (Bourdrel, 2021). Tr

A. Effets directs de la pollution atmosphérique rélévants dans le COVID

NO_2 PM

O_3

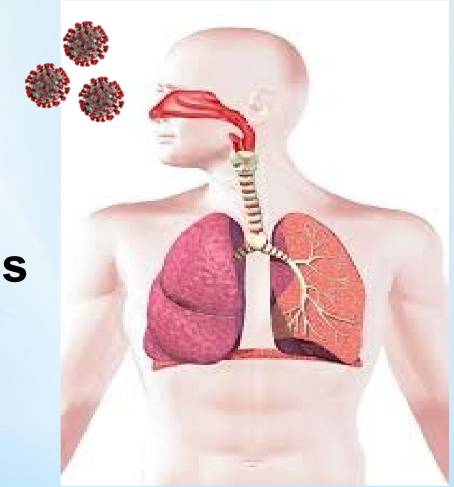
i)

Altération de la perméabilité des voies respiratoires**

**: ↘ fonctionnement des cellules ciliées des voies respiratoires

↘ phagocytose des macrophages,

↘ défense immunitaire respiratoire



Risque accru de contagion et de COVID-19

ii)

Effets sanitaires (surtout à long terme) de la pollution

- Maladies cardiovasculaires
- Maladies respiratoires
- Maladies métaboliques (diabète, surpoids…)
- Maladies neurodégénératives
- Maladies du rein
- Cancer
- …

Comorbidités du COVID 19

Même en considérant la vaccination

Long-term exposure to air pollution and COVID-19 incidence: a prospective study of residents in the city of Varese, Northern Italy

Giovanni Veronesi [1], Sara De Matteis [2,3] Giuseppe Calori,[4] Nicola Pepe,[4] Marco M Ferrario [1]

OEM 2022

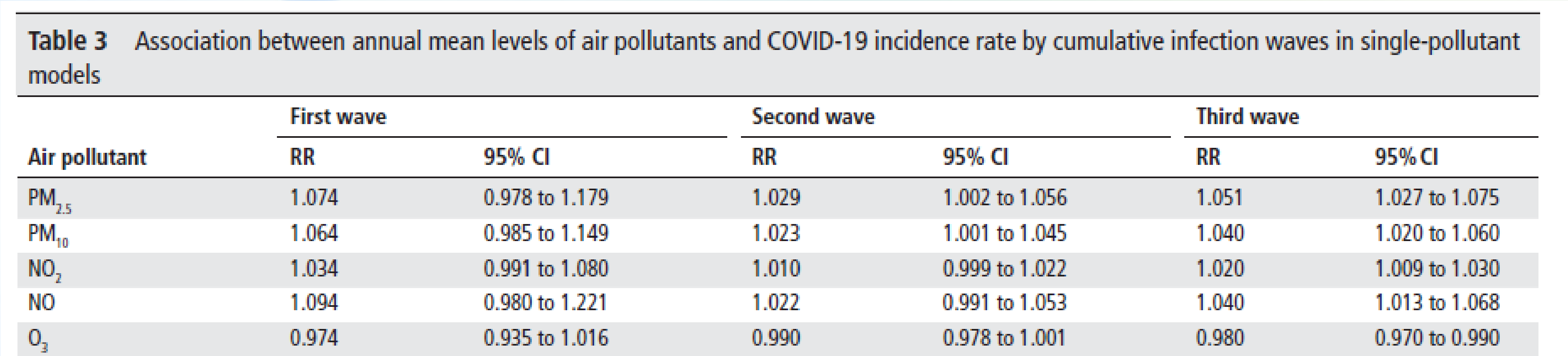
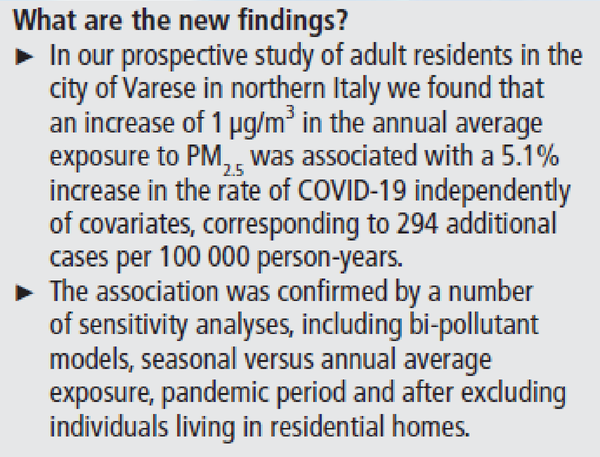


Table 3 Association between annual mean levels of air pollutants and COVID-19 incidence rate by cumulative infection waves in single-pollutant models

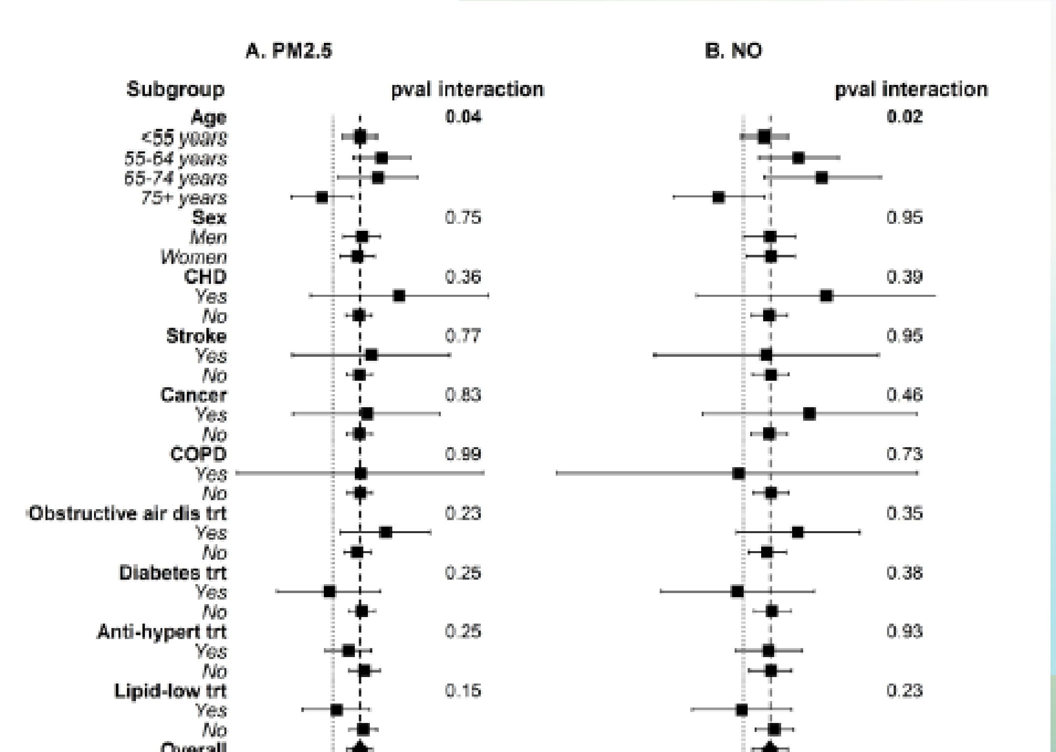
	First wave		Second wave		Third wave	
Air pollutant	**RR**	**95% CI**	**RR**	**95% CI**	**RR**	**95% CI**
$PM_{2.5}$	1.074	0.978 to 1.179	1.029	1.002 to 1.056	1.051	1.027 to 1.075
PM_{10}	1.064	0.985 to 1.149	1.023	1.001 to 1.045	1.040	1.020 to 1.060
NO_2	1.034	0.991 to 1.080	1.010	0.999 to 1.022	1.020	1.009 to 1.030
NO	1.094	0.980 to 1.221	1.022	0.991 to 1.053	1.040	1.013 to 1.068
O_3	0.974	0.935 to 1.016	0.990	0.978 to 1.001	0.980	0.970 to 0.990

Rate ratios (RR) per 1 µg/m^3 increase in the annual average exposure to each pollutant estimated from Poisson regression model. Covaria
residential care home, positive history of stroke, treatment for diabetes, antihypertensive treatment and treatment for obstructive airway
First wave from COVID-19 outbreak to 11 June 2020; second wave from COVID-19 outbreak to 31 December 2020; third wave from COVI
of observational period).

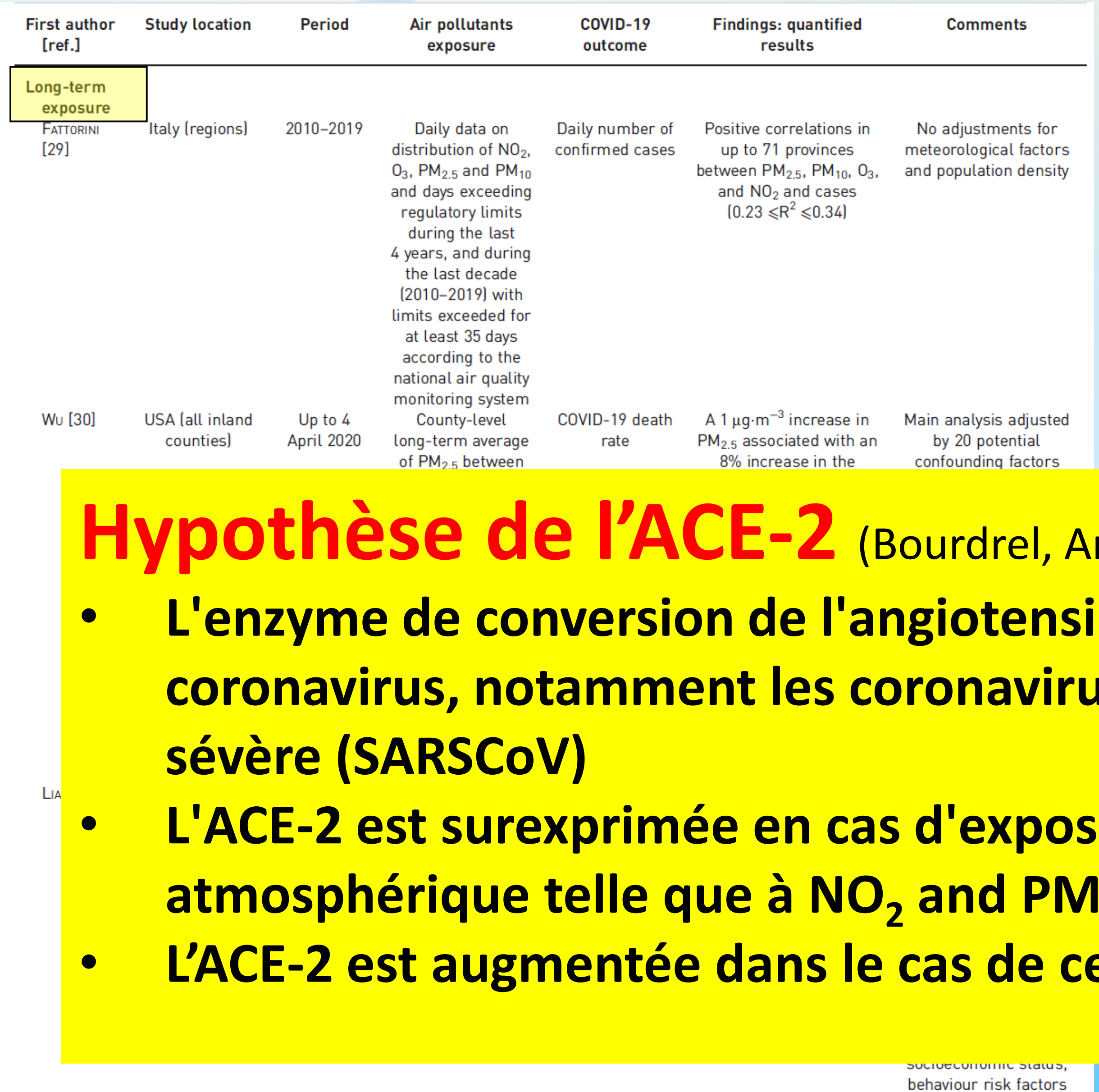


What are the new findings?

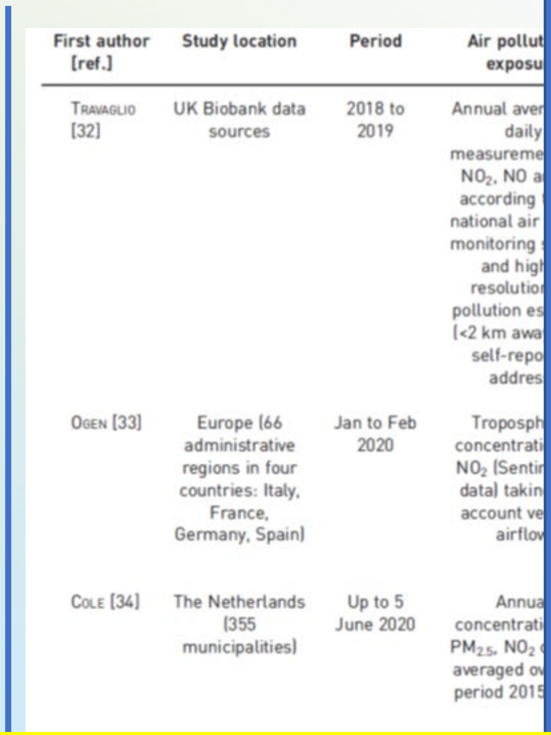
- In our prospective study of adult residents in the city of Varese in northern Italy we found that an increase of 1 µg/m^3 in the annual average exposure to $PM_{2.5}$ was associated with a 5.1% increase in the rate of COVID-19 independently of covariates, corresponding to 294 additional cases per 100 000 person-years.
- The association was confirmed by a number of sensitivity analyses, including bi-pollutant models, seasonal versus annual average exposure, pandemic period and after excluding individuals living in residential homes.



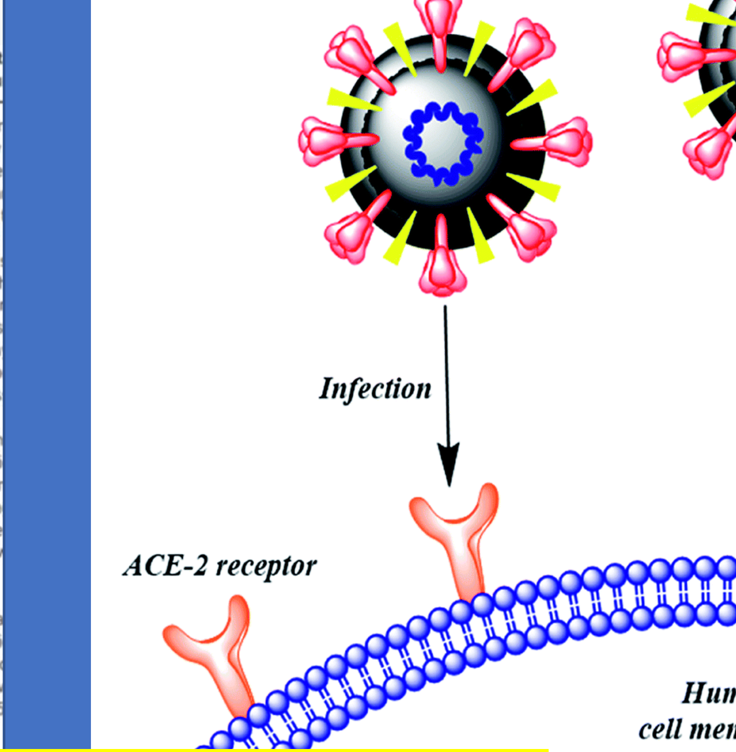
Mécanismes



First author [ref.]	Study location	Period	Air pollutants exposure	COVID-19 outcome	Findings: quantified results	Comments
Long-term exposure						
Fattorini [29]	Italy (regions)	2010–2019	Daily data on distribution of NO_2, O_3, $PM_{2.5}$ and PM_{10} and days exceeding regulatory limits during the last 4 years, and during the last decade (2010–2019) with limits exceeded for at least 35 days according to the national air quality monitoring system	Daily number of confirmed cases	Positive correlations in up to 71 provinces between $PM_{2.5}$, PM_{10}, O_3, and NO_2 and cases ($0.23 \leq R^2 \leq 0.34$)	No adjustments for meteorological factors and population density
Wu [30]	USA (all inland counties)	Up to 4 April 2020	County-level long-term average of $PM_{2.5}$ between	COVID-19 death rate	A 1 $\mu g \cdot m^{-3}$ increase in $PM_{2.5}$ associated with an 8% increase in the	Main analysis adjusted by 20 potential confounding factors
Lia						socioeconomic status, behaviour risk factors

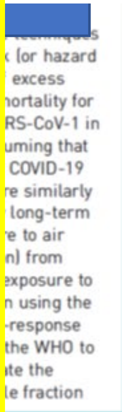


First author [ref.]	Study location	Period	Air pollut exposu
Travaglio [32]	UK Biobank data sources	2018 to 2019	Annual aver daily measureme NO_2, NO a according national air monitoring and high resolution pollution es (<2 km awa self-repo addres
Ogen [33]	Europe (66 administrative regions in four countries: Italy, France, Germany, Spain)	Jan to Feb 2020	Troposph concentrati NO_2 (Sentin data) takin account ve airflow
Cole [34]	The Netherlands (355 municipalities)	Up to 5 June 2020	Annua concentrati $PM_{2.5}$, NO_2 averaged ov period 2015



Hypothèse de l'ACE-2 (Bourdrel, Annesi-Maesano I, 2021)

- **L'enzyme de conversion de l'angiotensine-2 (ACE-2) est un récepteur pour les coronavirus, notamment les coronavirus 1 et 2 du syndrome respiratoire aigu sévère (SARSCoV)**
- **L'ACE-2 est surexprimée en cas d'exposition chronique à la pollution atmosphérique telle que à NO_2 and $PM_{2.5}$**
- **L'ACE-2 est augmentée dans le cas de certaines pathologies chroniques**



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B. Exposition accrues au SARS-CO-2

Clinical Infectious Diseases

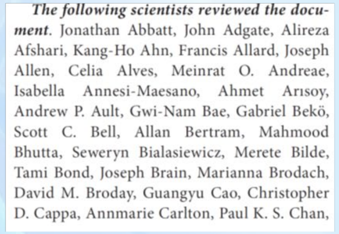
INVITED COMMENTARY

IDSA Infectious Diseases Society of America · hivma hiv medicine association · OXFORD

It Is Time to Address Airborne Transmission of Coronavirus Disease 2019 (COVID-19)

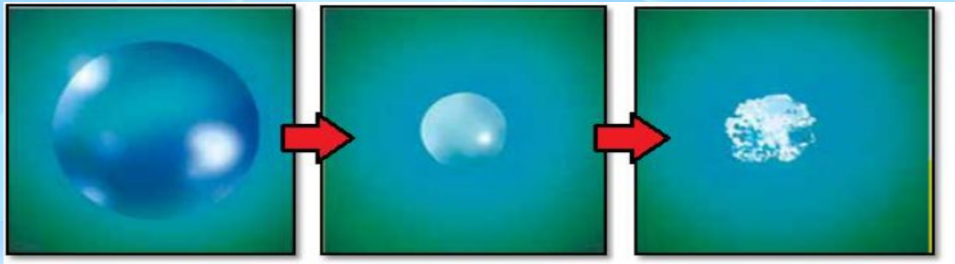
Lidia Morawska[1] and Donald K. Milton[2]

[1]International Laboratory for Air Quality and Heath, WHO Collaborating Centre, Queensland University of Technology, Brisbane, Australia, and [2]Institute for Applied Environmental Health, University of Maryland School of Public Health, College Park, Maryland, USA

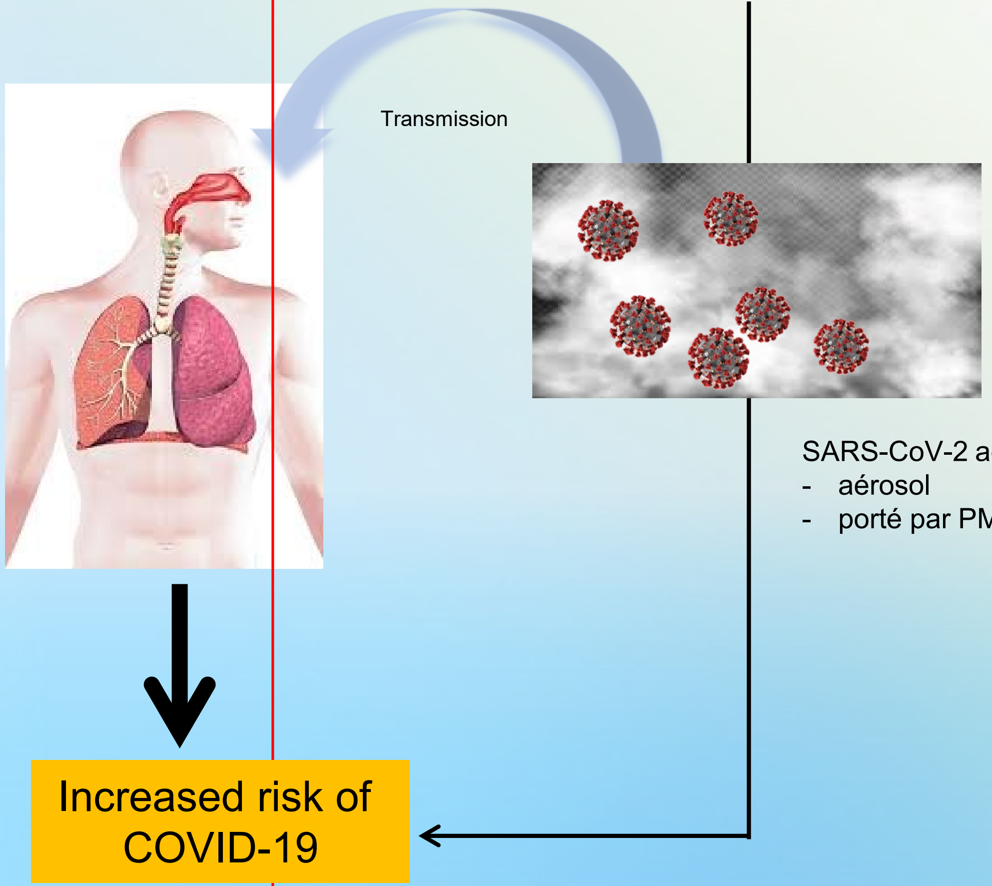


The following scientists reviewed the document. Jonathan Abbatt, John Adgate, Alireza Afshari, Kang-Ho Ahn, Francis Allard, Joseph Allen, Celia Alves, Meinrat O. Andreae, Isabella Annesi-Maesano, Ahmet Arısoy, Andrew P. Ault, Gwi-Nam Bae, Gabriel Bekö, Scott C. Bell, Allan Bertram, Mahmood Bhutta, Seweryn Bialasiewicz, Merete Bilde, Tami Bond, Joseph Brain, Marianna Brodach, David M. Broday, Guangyu Cao, Christopher D. Cappa, Annmarie Carlton, Paul K. S. Chan,

SARS-CoV-2
Goutellettes



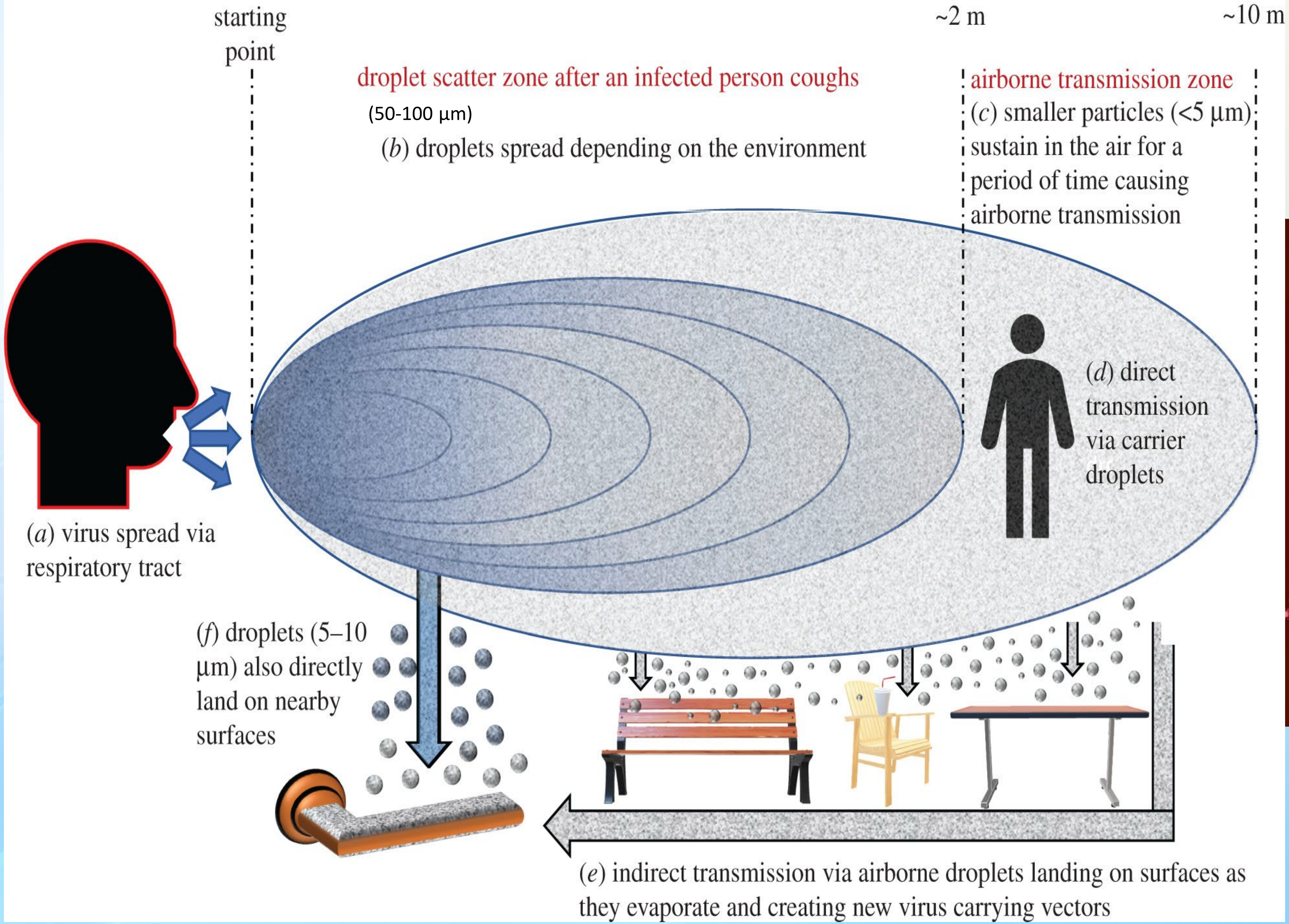
Risque accru d'exposition au SRAS-CoV-2 en suspension dans l'air dans les zones polluées



SARS-CoV-2 aéroporté:
- aérosol
- porté par PM

Increased risk of COVID-19

SARS CoV-2 transmissions



starting point

~2 m

~10 m

droplet scatter zone after an infected person coughs

(50-100 µm)

(*b*) droplets spread depending on the environment

airborne transmission zone

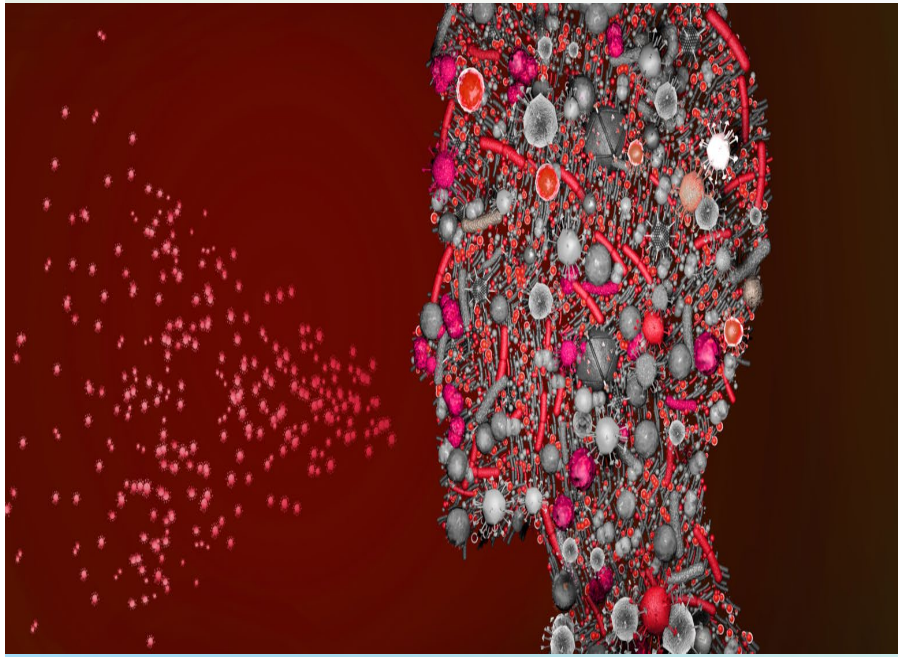
(*c*) smaller particles (<5 µm) sustain in the air for a period of time causing airborne transmission

(*d*) direct transmission via carrier droplets

(*a*) virus spread via respiratory tract

(*f*) droplets (5–10 µm) also directly land on nearby surfaces

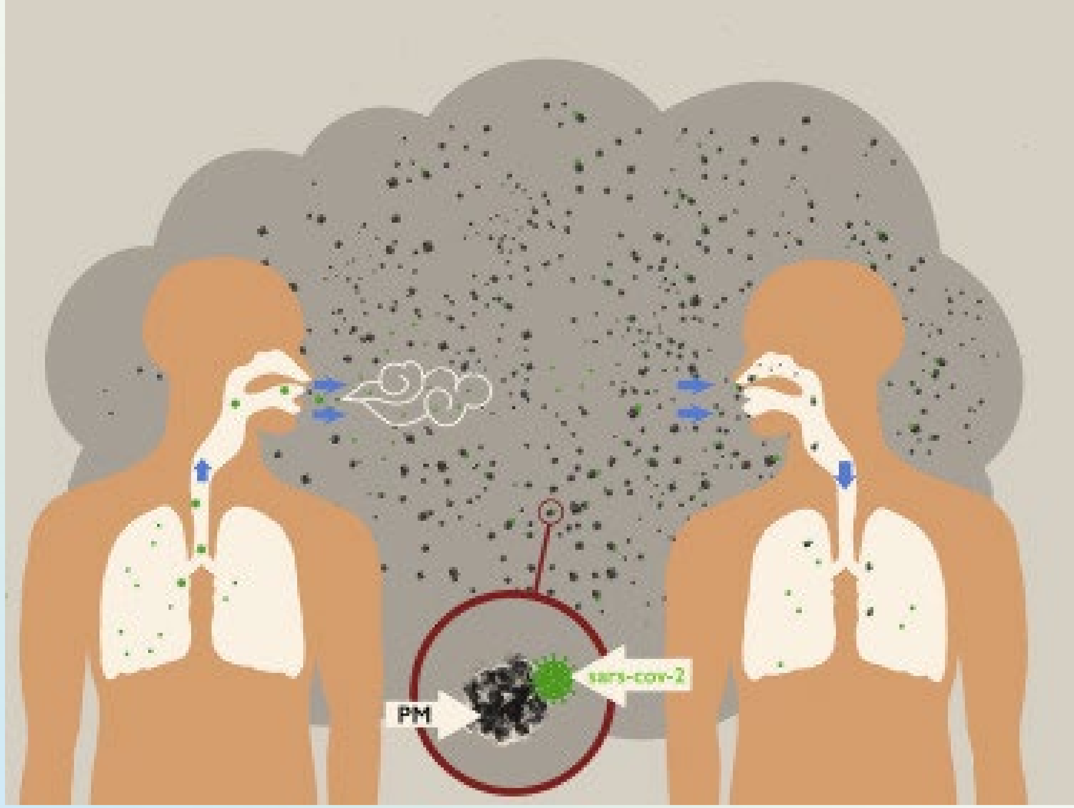
(*e*) indirect transmission via airborne droplets landing on surfaces as they evaporate and creating new virus carrying vectors

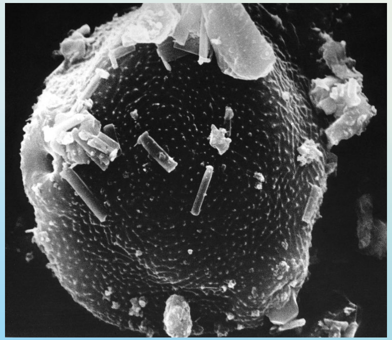


PM et microbes interagissent

PM$_{10}$ en tant que transporteur, vecteur

- Observé pour de nombreux contaminants chimiques et biologiques.
- Virus "collent" (avec un processus de coagulation) aux PM$_{10}$ capables de rester dans l'atmosphère pendant des heures, des jours ou des semaines, et qui peuvent se propager et être transportés même sur de longues distances





Amoatey et al., 2020; Carraturo et al., 2020;
Creager et al., 2017; Groulx et al., 2018; Sedlmaier et al., 2009,
Bontempi, 2020; Coccia, 2020; Zhang, 2020, Barakat, 2020.

Transporté par le vent parfois sur des milliers de kilomètres, par exemple du Sahara.

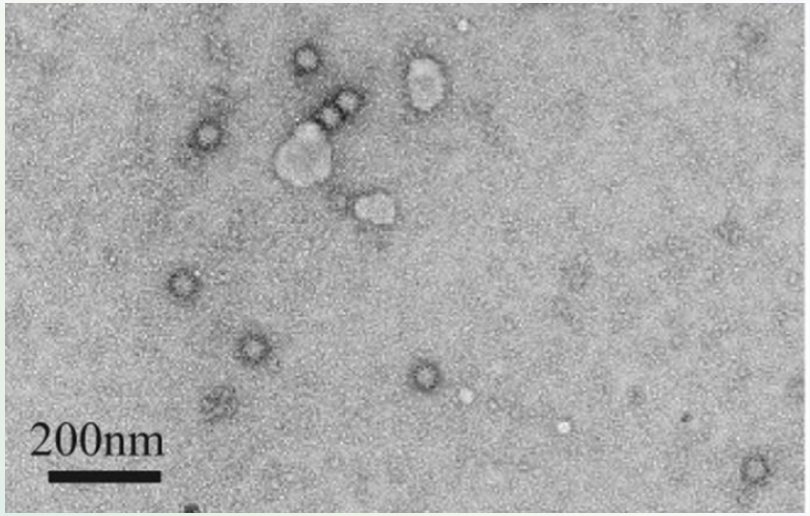
PM et SARS-CoV 2 interagissent

SARS-COV-2 dans aérosol

SARS-Cov-2 virus RNA dans aerosols prélevé:

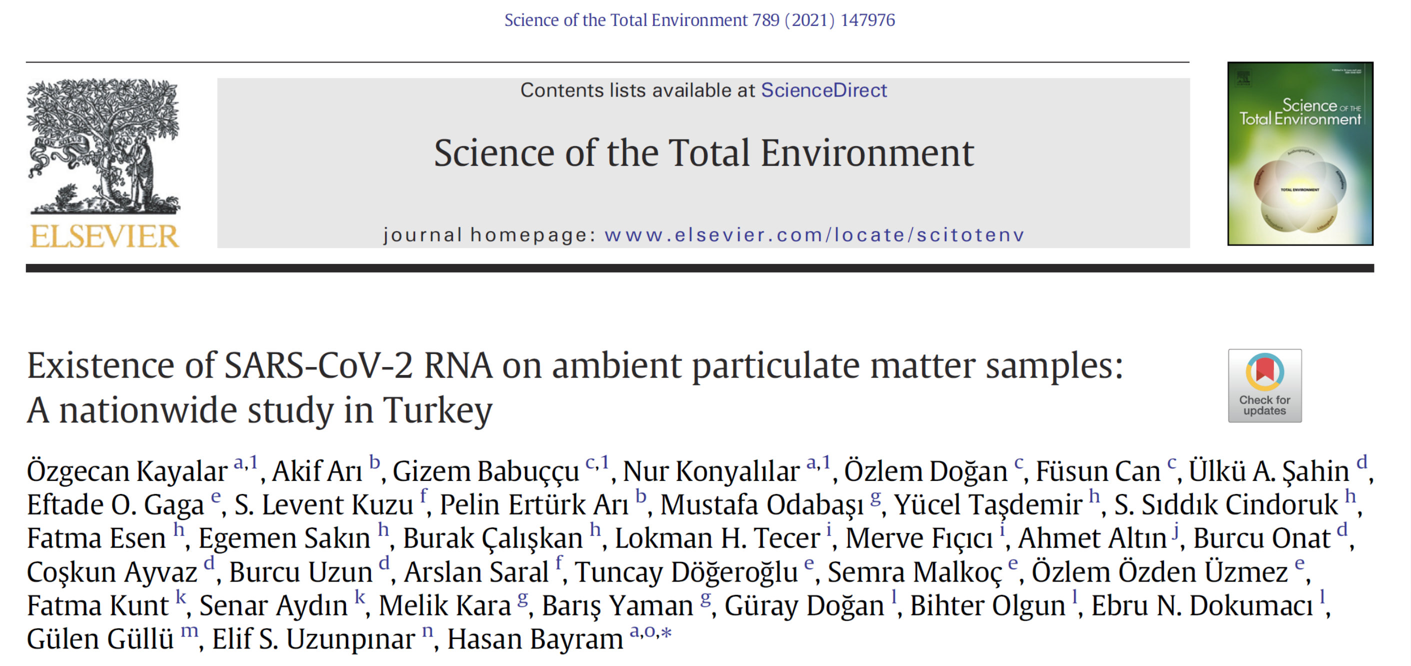
→ LABORATOIRE: Augmentation de l'ARN viral du SRAS-CoV-2 pendant la culture cellulaire du virus à partir de l'aérosol récupéré émis par les patients respirant ou parlant (Santarpia, 2020):
  - → Présence de virions infectieux et réplicatifs dans des échantillons d'aérosol de <1 µm à un niveau significatif ($p<0,05$).
  - → Présence de protéines virales et de virions intacts par western blot et microscopie électronique à transmission de ces échantillons.

→ VIE REELLE: Détection dans les échantillons d'air extérieur
  - → dans une étude où pollution élevée (Setti)
  - → mais pas dans une autre étude avec des faibles concentrations à Madrid, en Venitie et dans les Pouilles (Linillos-Pradillo, Chirizzi)
  - → Dans étude nationale turque



Lednicki, *Aerosol Air Qual. Res 2020*

→ Difficulté d'isoler le SRAS-CoV-2 lorsque plusieurs virus sont présents dans un échantillon d'essai



Science of the Total Environment 789 (2021) 147976

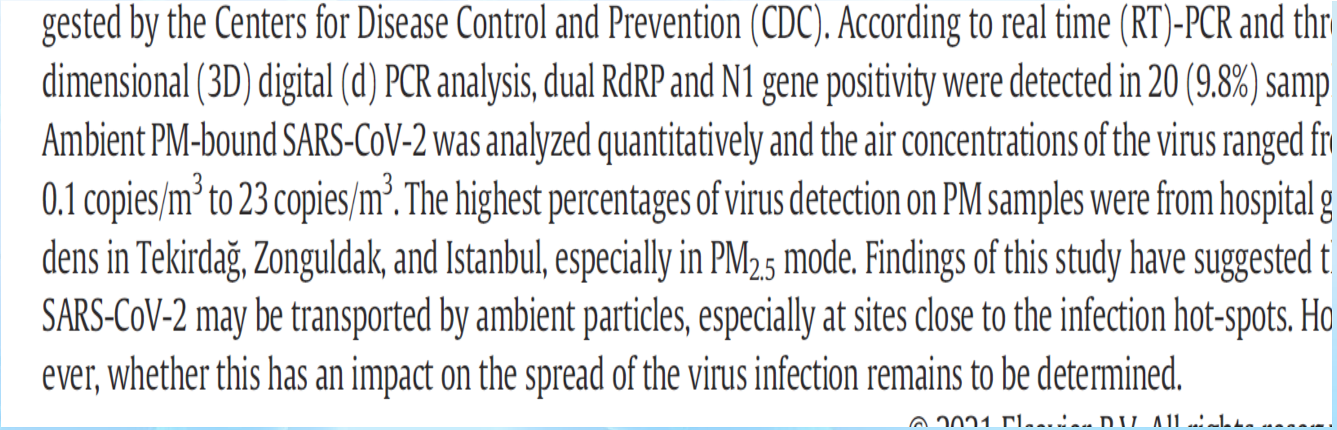
Contents lists available at ScienceDirect

Science of the Total Environment

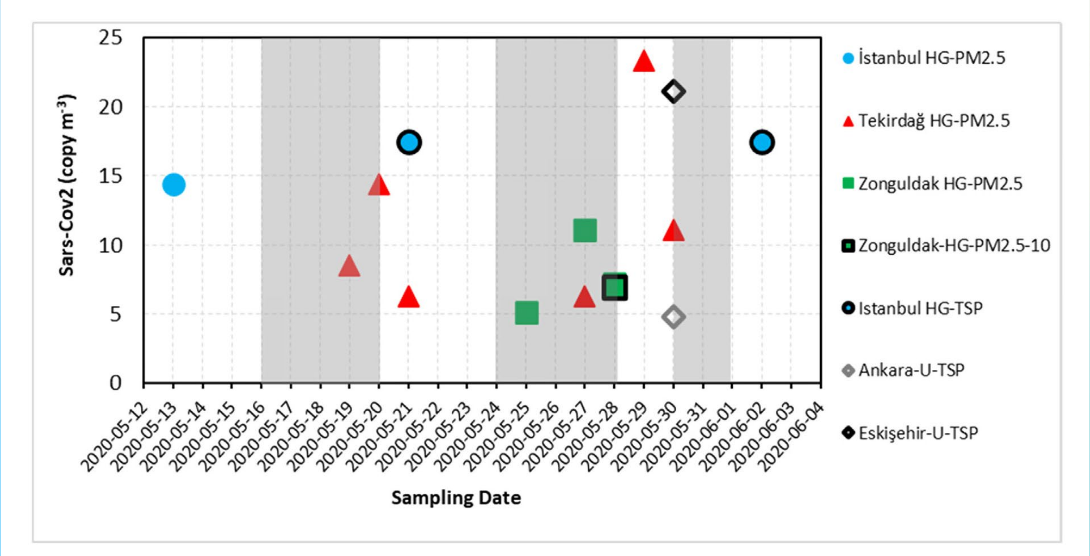
journal homepage: www.elsevier.com/locate/scitotenv

Existence of SARS-CoV-2 RNA on ambient particulate matter samples: A nationwide study in Turkey

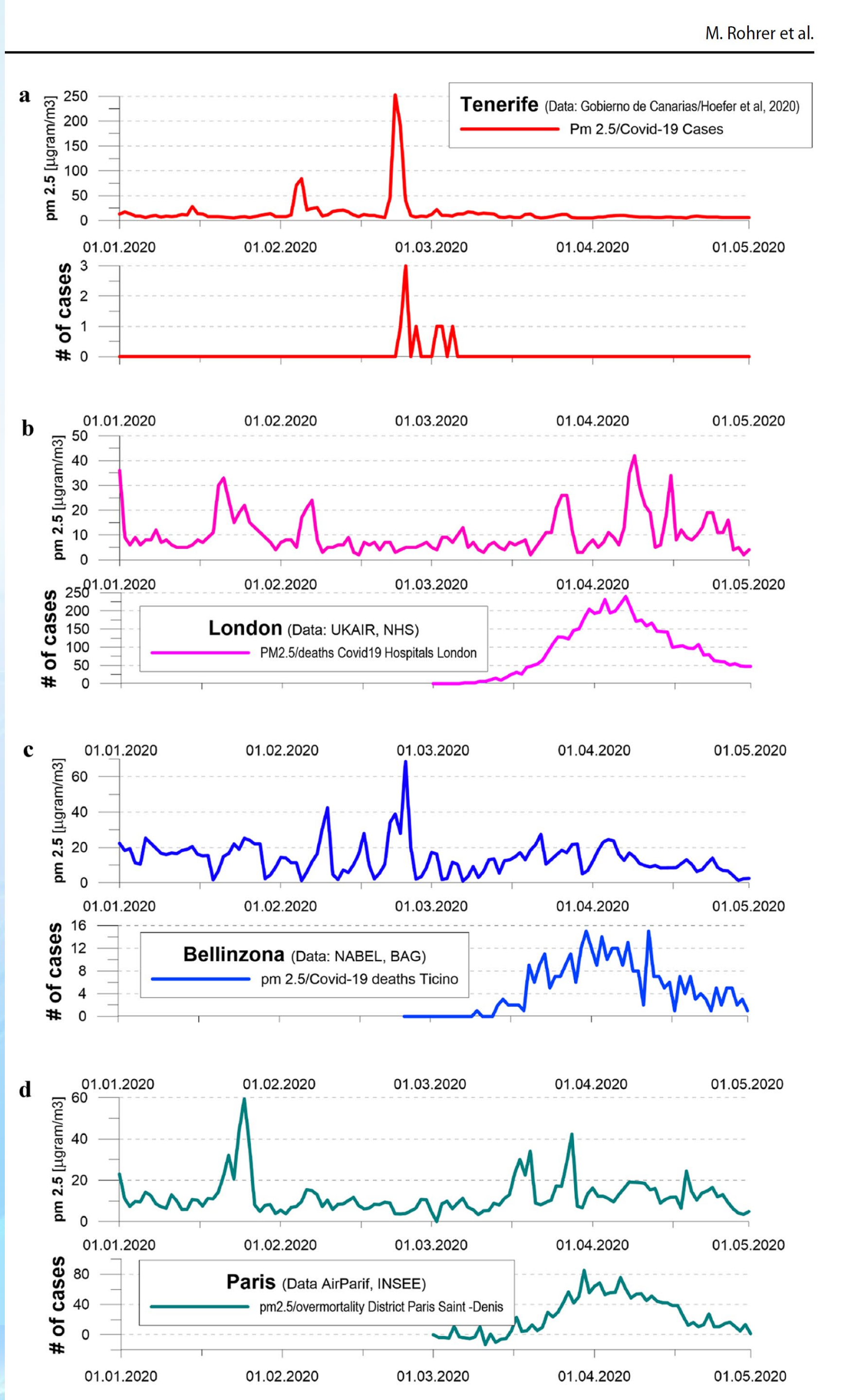
Özgecan Kayalar [a,1], Akif Arı [b], Gizem Babuççu [c,1], Nur Konyalılar [a,1], Özlem Doğan [c], Füsun Can [c], Ülkü A. Şahin [d], Eftade O. Gaga [e], S. Levent Kuzu [f], Pelin Ertürk Arı [b], Mustafa Odabaşı [g], Yücel Taşdemir [h], S. Sıddık Cindoruk [h], Fatma Esen [h], Egemen Sakın [h], Burak Çalışkan [h], Lokman H. Tecer [i], Merve Fıçıcı [i], Ahmet Altın [j], Burcu Onat [d], Coşkun Ayvaz [d], Burcu Uzun [d], Arslan Saral [f], Tuncay Döğeroğlu [e], Semra Malkoç [e], Özlem Özden Üzmez [e], Fatma Kunt [k], Senar Aydın [k], Melik Kara [g], Barış Yaman [g], Güray Doğan [l], Bihter Olgun [l], Ebru N. Dokumacı [l], Gülen Güllü [m], Elif S. Uzunpınar [n], Hasan Bayram [a,o,*]

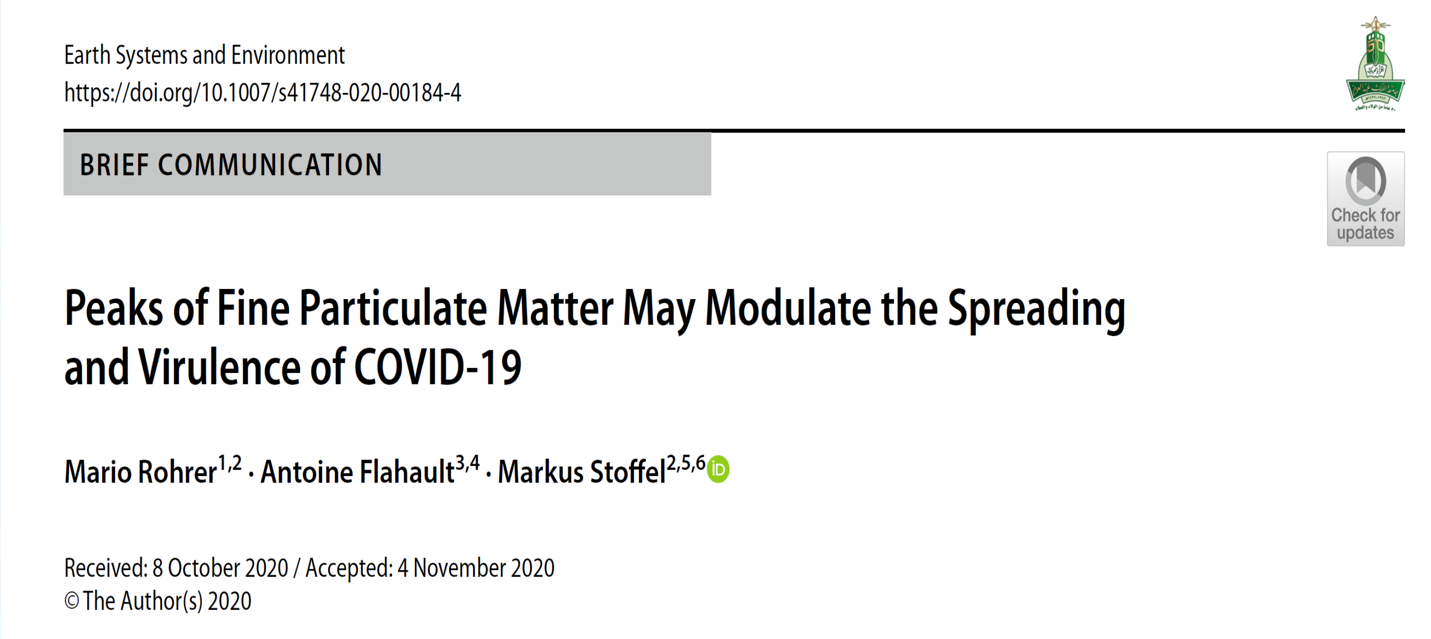


gested by the Centers for Disease Control and Prevention (CDC). According to real time (RT)-PCR and thr dimensional (3D) digital (d) PCR analysis, dual RdRP and N1 gene positivity were detected in 20 (9.8%) samp Ambient PM-bound SARS-CoV-2 was analyzed quantitatively and the air concentrations of the virus ranged fr 0.1 copies/m^3 to 23 copies/m^3. The highest percentages of virus detection on PM samples were from hospital g dens in Tekirdağ, Zonguldak, and Istanbul, especially in $PM_{2.5}$ mode. Findings of this study have suggested t SARS-CoV-2 may be transported by ambient particles, especially at sites close to the infection hot-spots. Ho ever, whether this has an impact on the spread of the virus infection remains to be determined.



Infectivity of the virus?
Necessary dose?





Earth Systems and Environment
https://doi.org/10.1007/s41748-020-00184-4

Check for updates

BRIEF COMMUNICATION

Peaks of Fine Particulate Matter May Modulate the Spreading and Virulence of COVID-19

Mario Rohrer[1,2] · Antoine Flahault[3,4] · Markus Stoffel[2,5,6]

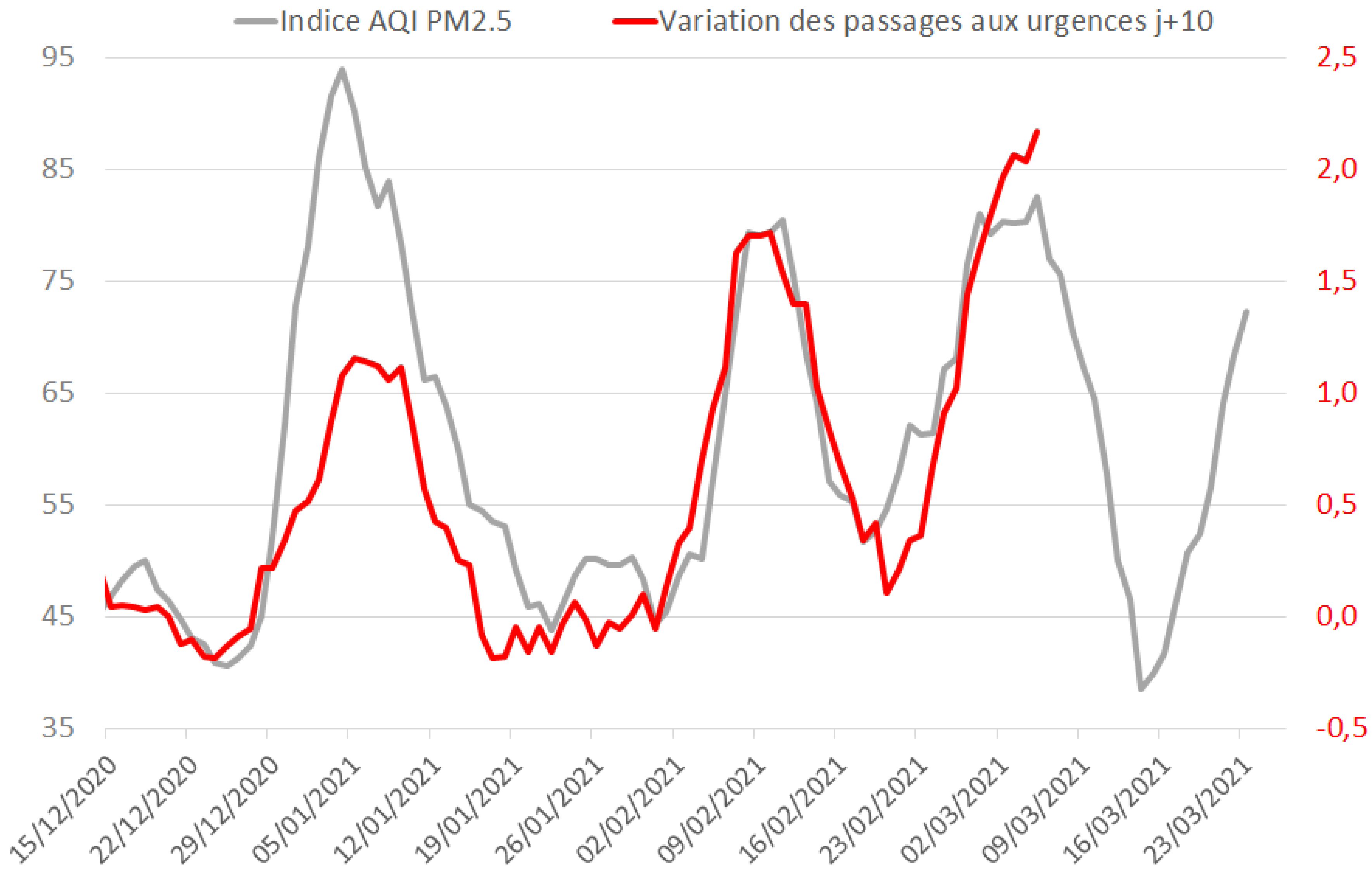
Received: 8 October 2020 / Accepted: 4 November 2020

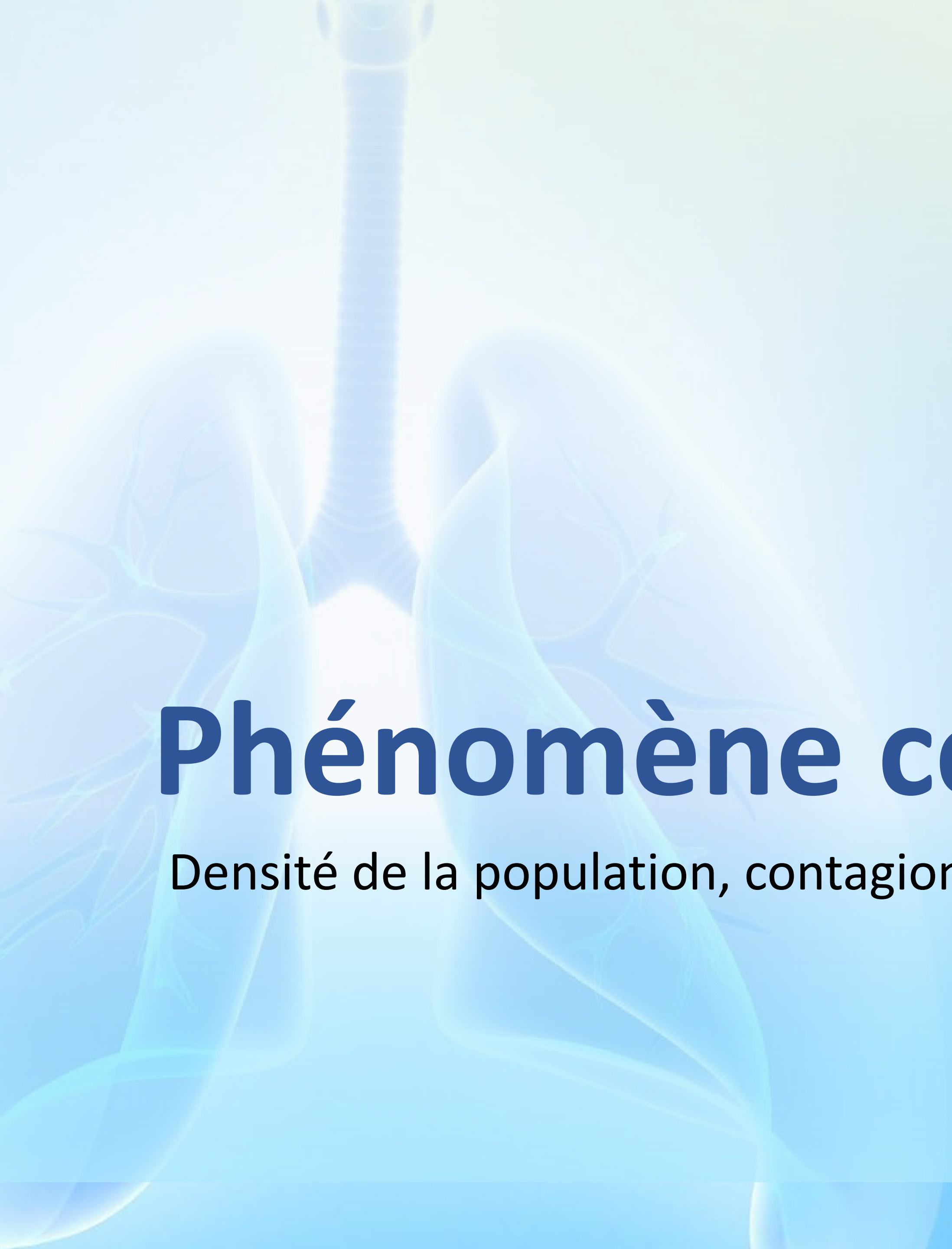
Un épisode de pollution aux particules fines est prévu ce mardi 9 mars.[© DANIEL JANIN / AFP]

Moins d'une semaine après le précédent épisode, un nouveau pic de pollution est prévu mardi 9 mars en Ile-de-France. Les particules fines sont suspectées de créer un cocktail dangereux avec le Covid.

Pollution PM 2.5 vs. Variation des passages aux urgences j+10

Paris





Phénomène complexe

Densité de la population, contagion, température, humidité…

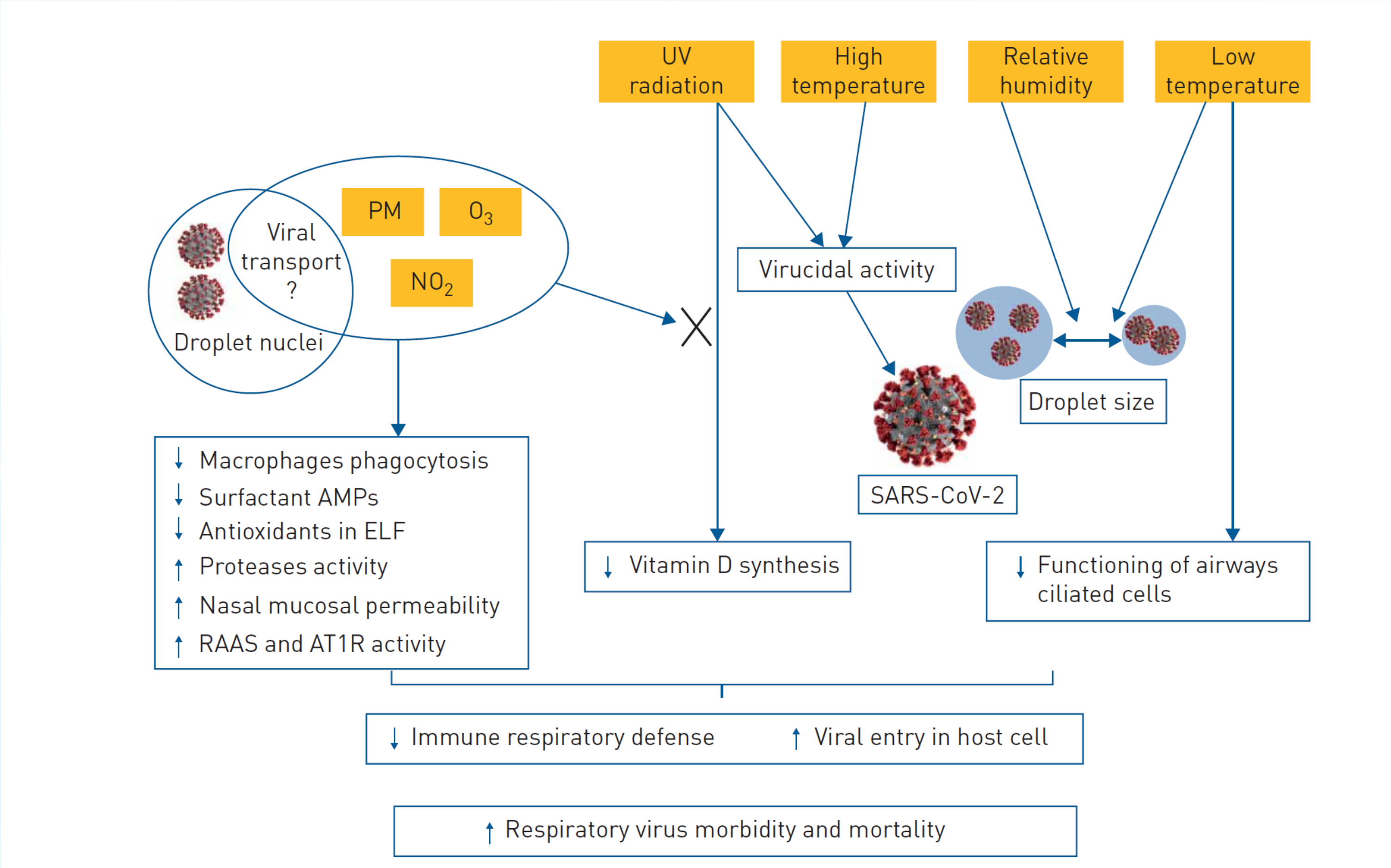
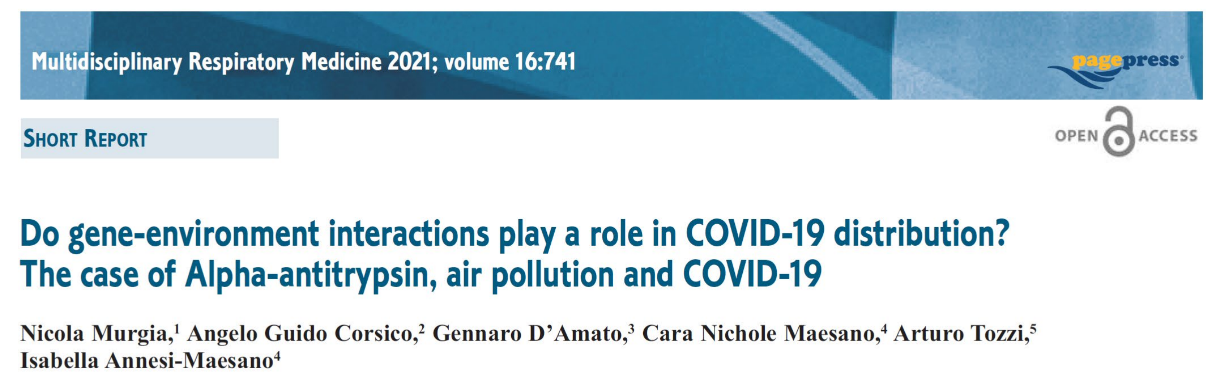


FIGURE 2 Air pollutants/virus interaction according to atmospheric conditions. Relative humidity plays a role in the desiccation or hydration of viral droplet and, thus, influences the size of the droplet and the persistence of respiratory viruses in the air. Solar ultraviolet (UV) radiations have *in vitro* antiviral activity and lead to an increase in vitamin D synthesis. Atmospheric air pollutants may lead to decreased UV penetration leading to reduced vitamin D synthesis. Temperature influences the size of the viral droplet. In addition, low temperatures decrease the functioning of airways ciliated cells, while high temperatures may have antiviral activity. Droplet nuclei refers to viral droplets ⩽5µm, it is also called viral airborne or viral aerosol. In addition to the common effect of air pollutants, which lead to a decrease in immune respiratory defence, particulate matter (PM) may be involved in respiratory virus transport. AMP: antimicrobial proteins and peptides; ELF: epithelial lining fluid; RASS: renin-angiotensin-aldosterone system; AT1R: angiotensin 2 receptor type 1.

Bourdrel, Annesi-Maesano, ERR 2020



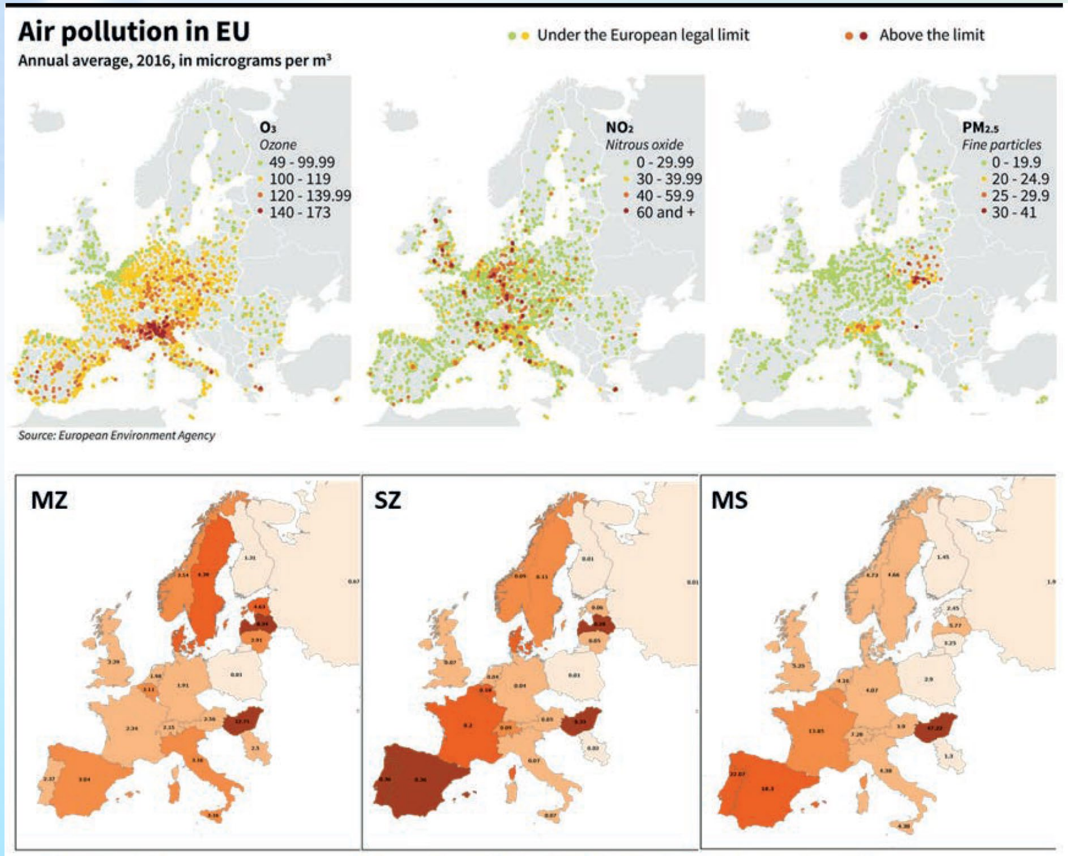
Multidisciplinary Respiratory Medicine 2021; volume 16:741

SHORT REPORT

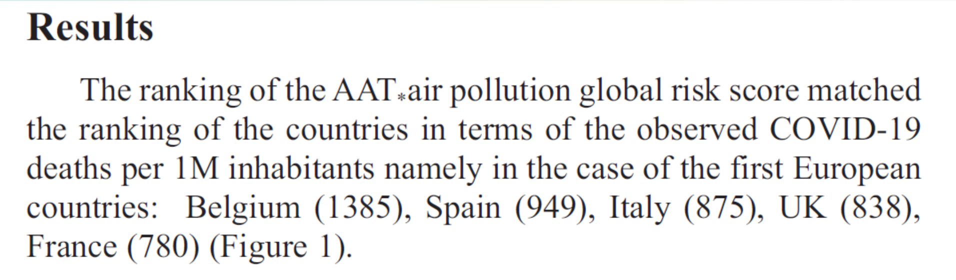
OPEN ACCESS

Do gene-environment interactions play a role in COVID-19 distribution? The case of Alpha-antitrypsin, air pollution and COVID-19

Nicola Murgia,[1] Angelo Guido Corsico,[2] Gennaro D'Amato,[3] Cara Nichole Maesano,[4] Arturo Tozzi,[5]
Isabella Annesi-Maesano[4]



AAT deficient genes combination (MS, SZ, MS) distribution in EU



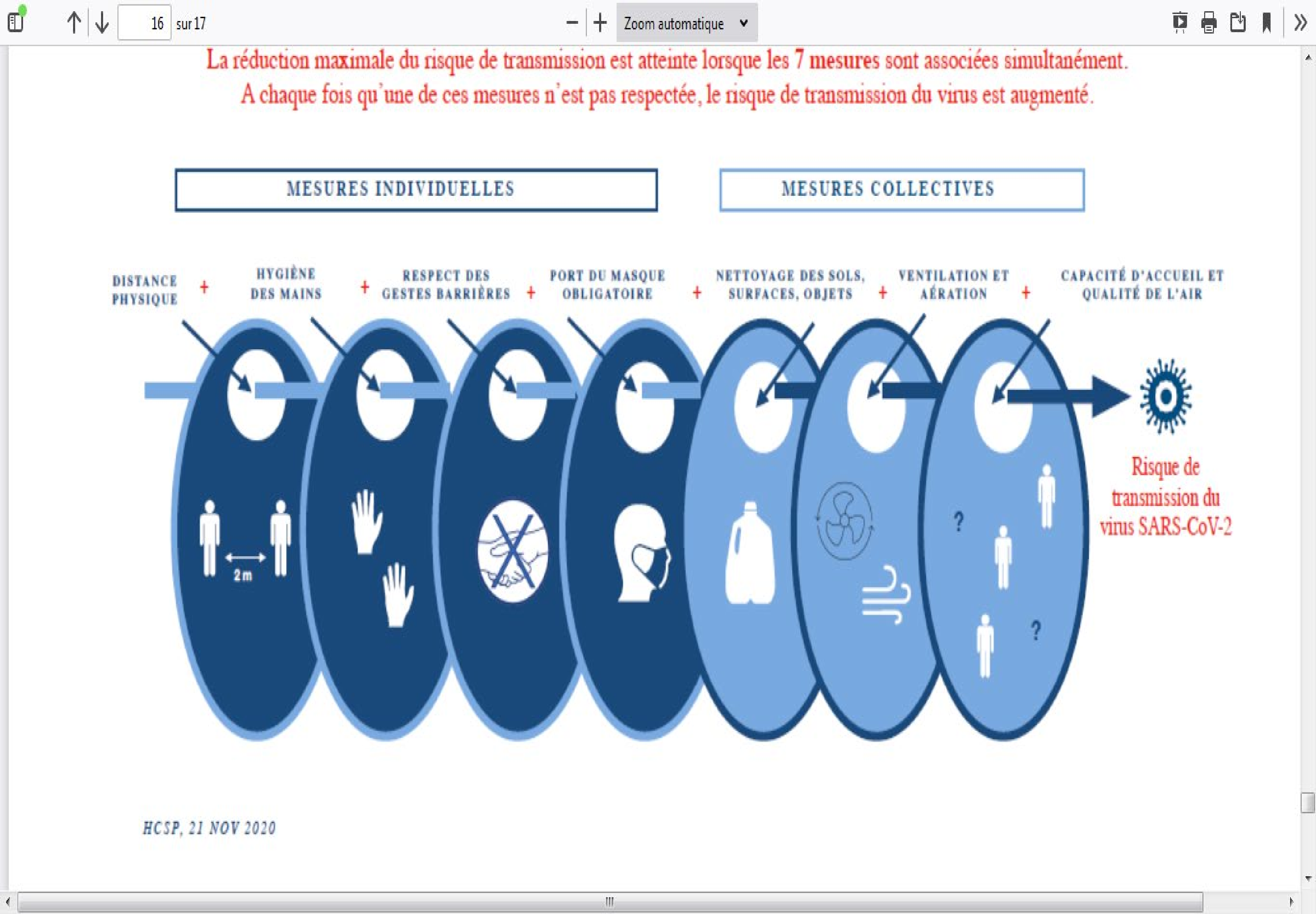
Results

The ranking of the AAT*air pollution global risk score matched the ranking of the countries in terms of the observed COVID-19 deaths per 1M inhabitants namely in the case of the first European countries: Belgium (1385), Spain (949), Italy (875), UK (838), France (780) (Figure 1).

QUIZ

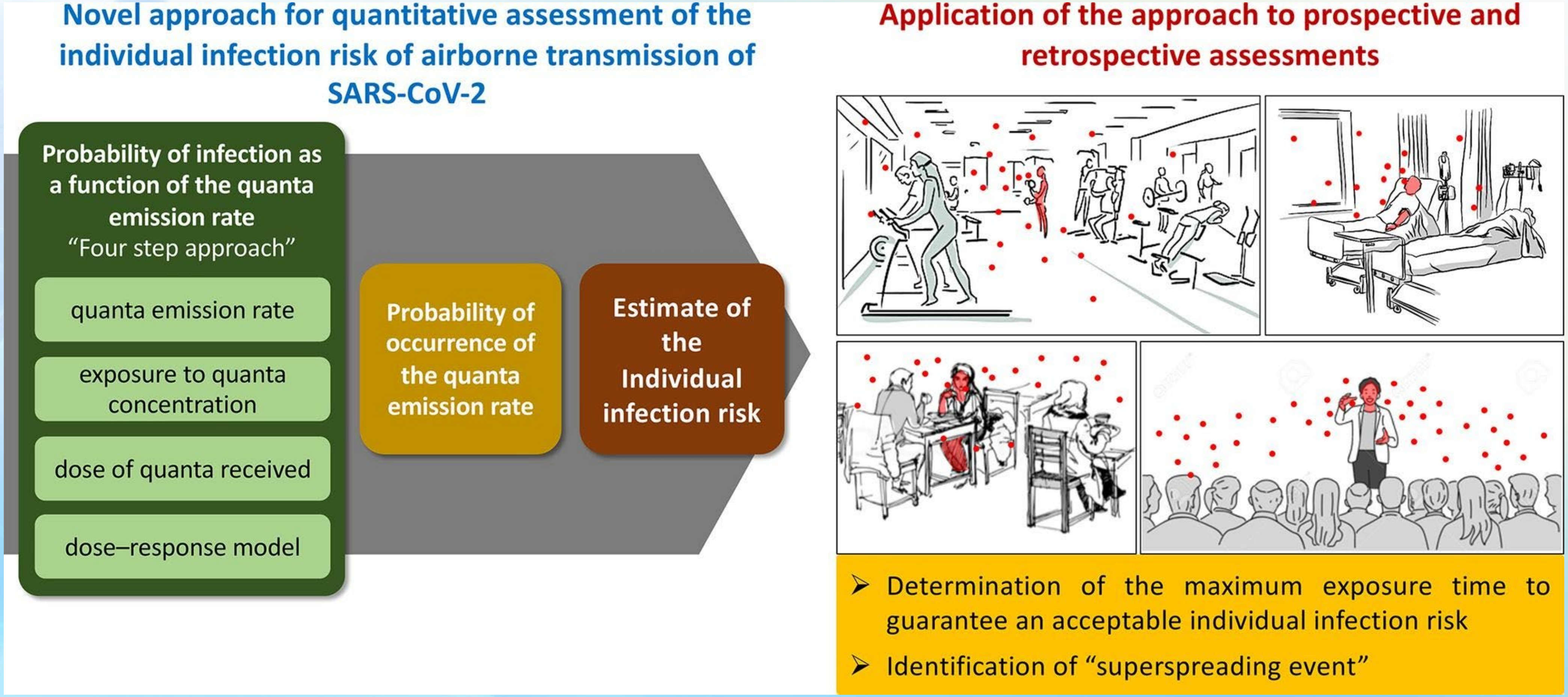
PRIORITE DE SANTE PUBLIQUE

1) Le COVID-19 est-il significativement associé à la pollution atmosphérique ?	OUI: grâce aux études écologiques, mais aussi par le biais de données individuelles (d’autres sont nécessaires pour confirmer et quantifier cette relation).
2) Le SARS-CoV-2 est-il aéroporté ?	OUI : il a été prouvé que la majorité des transmissions se produisent lorsque des personnes infectées crachent non seulement de grosses gouttelettes mais aussi de petites particules appelées aérosols lorsqu'elles toussent, parlent, chantent ou respirent.
3) La pollution atmosphérique est-elle au moins un cofacteur de l'infection par le SRAS-CoV-2 ?	OUI : par deux actions directes (baisse perméabilité des muqueuses et ACE-2)



La réduction maximale du risque de transmission est atteinte lorsque les 7 mesures sont associées simultanément.
A chaque fois qu'une de ces mesures n'est pas respectée, le risque de transmission du virus est augmenté.

HCSP, 21 NOV 2020



Novel approach for quantitative assessment of the individual infection risk of airborne transmission of SARS-CoV-2

Probability of infection as a function of the quanta emission rate
"Four step approach"

- quanta emission rate
- exposure to quanta concentration
- dose of quanta received
- dose–response model

Probability of occurrence of the quanta emission rate

Estimate of the Individual infection risk

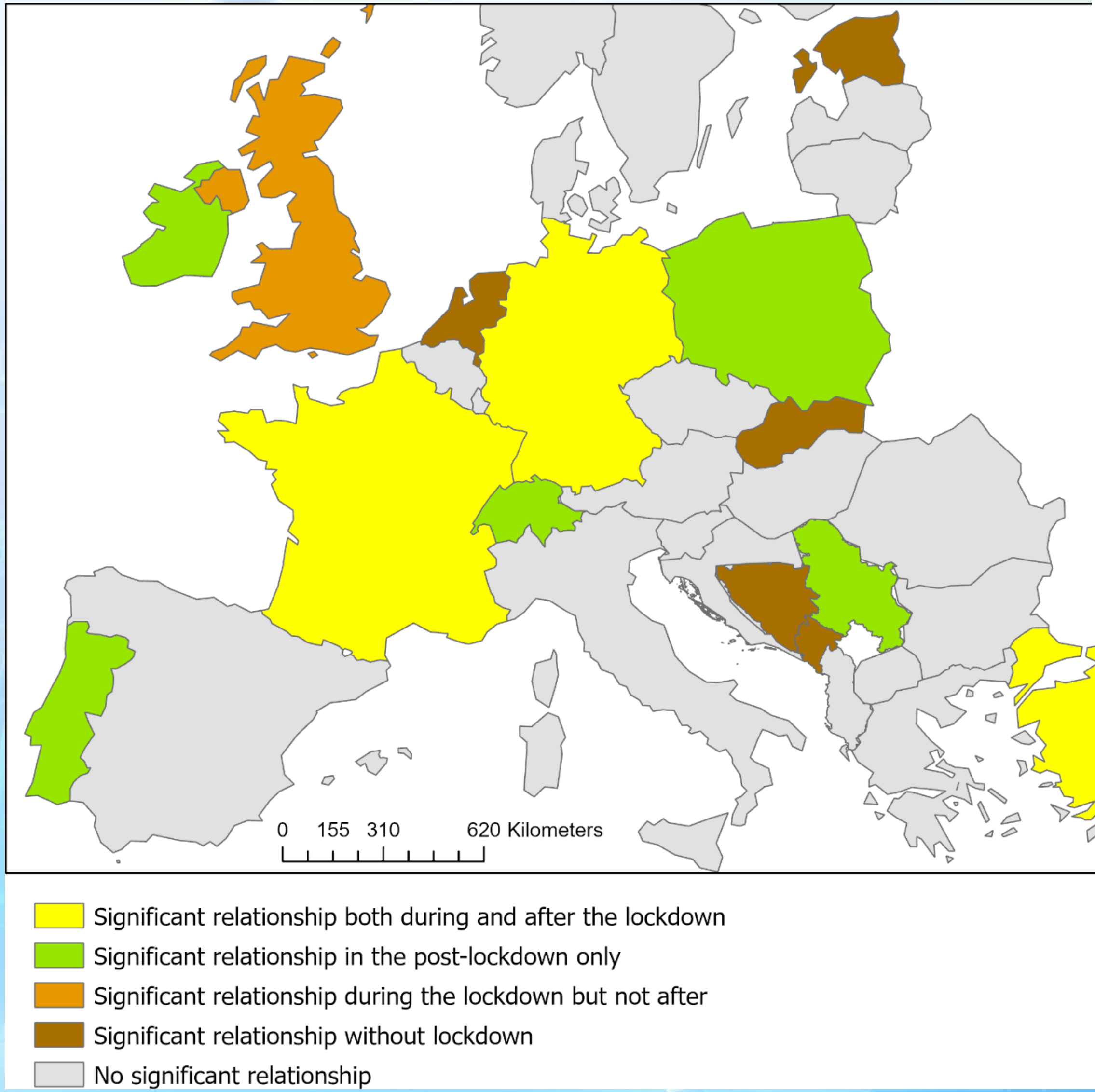
Application of the approach to prospective and retrospective assessments

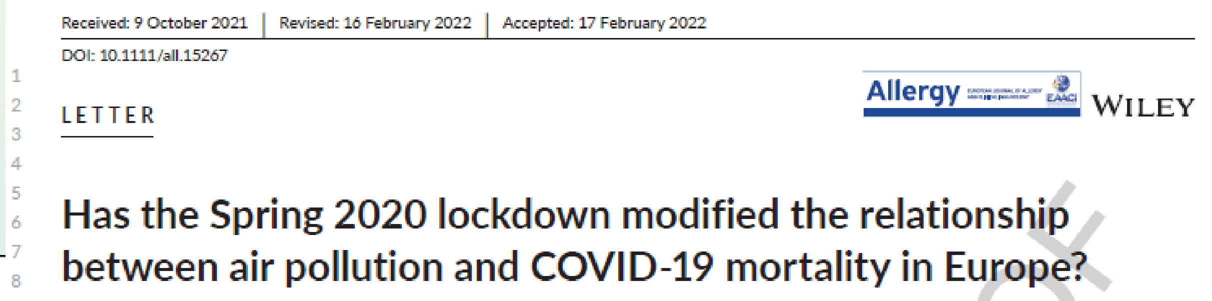
- ➢ Determination of the maximum exposure time to guarantee an acceptable individual infection risk
- ➢ Identification of "superspreading event"

Urging priority: Improve air quality

Declining air quality is a great risk to human health, as well as the environment and our society.

“A large body of evidence from almost all corners of the world demonstrates that it is possible to improve air quality and human health without compromising economic growth.”

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Allergy WILEY

LETTER

Has the Spring 2020 lockdown modified the relationship between air pollution and COVID-19 mortality in Europe?


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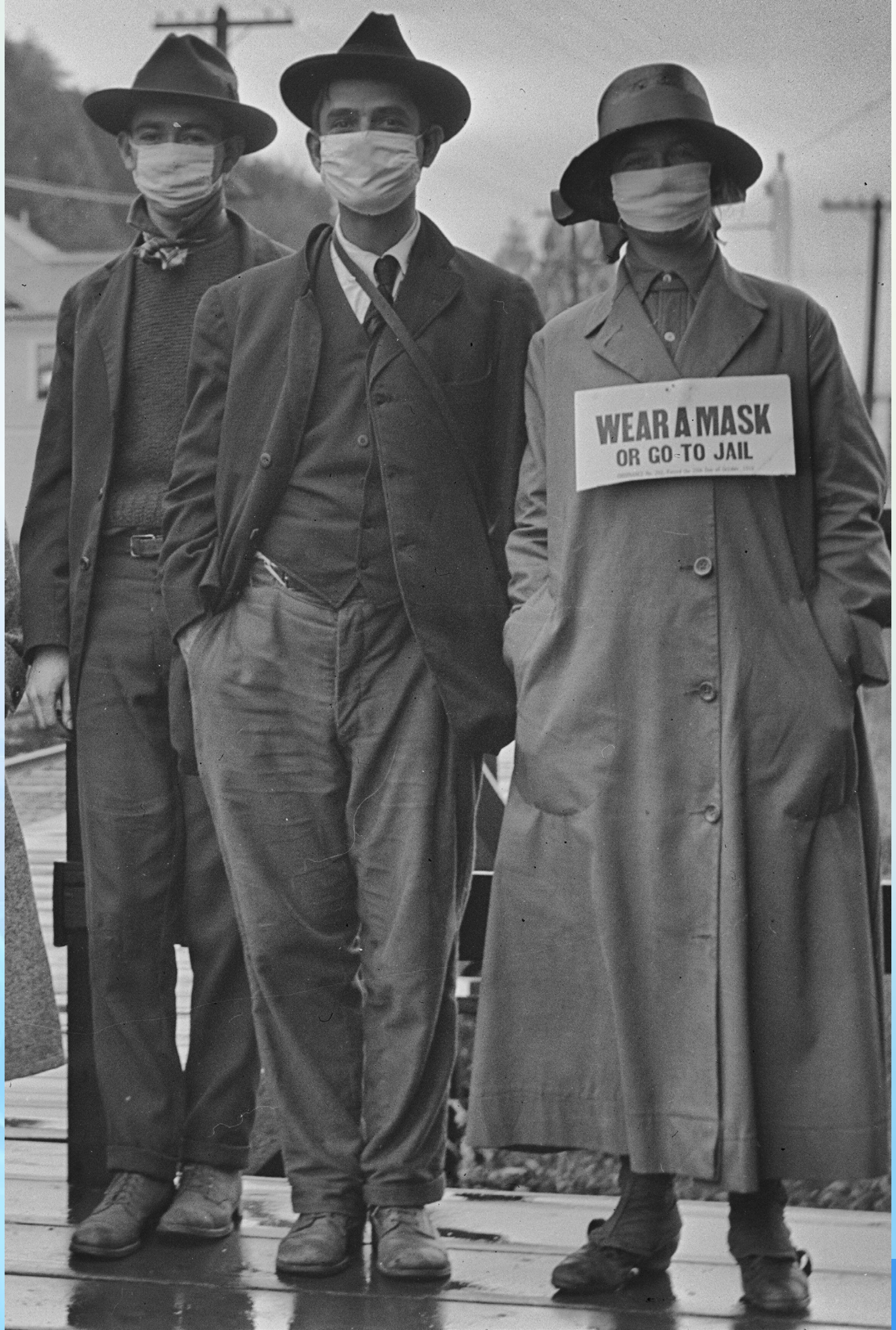
WEAR A MASK
OR GO TO JAIL

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MERCI POUR VOTRE ATTENTION