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EDITORIALE

Covid-19 and air pollution: communicating the results of geographic correlation studies

Covid-19 e inquinamento atmosferico: comunicare i risultati di studi di correlazione geografica

The Covid-19 pandemic has conveyed a great deal of interest in epidemiology, which has received unprecedented attention within the scientific community, as well as from the media and from decision makers. Some of the many scientific articles regarding the SARS-CoV-2 outbreak published or released in pre-print mode examined the relationship between air pollution and Covid-19 cases or deaths. They received ample media coverage, attracted public attention, and raised a debate that will presumably continue.

The community of environmental epidemiologists was positively surprised by this remarkable interest, but some concerns arose from the interpretations of the results, which were not consistent with the study design. This text intends to propose some reflections regarding the messages emerged from a limited number of epidemiological studies, chosen as an example to underline the reasons for the great interest and the wide media coverage.

The storm of news and information around the virus outbreak has been appropriately defined as *infodemia* by the World Health Organization (WHO),[1] envisaging the negative social impacts of misinformation and disinformation, and the alarm was endorsed and amplified by the European Commission.[2] As a consequence, the debate about Covid-19 and communication is one of the topic of this unforgettable beginning of the year 2020. Traditional and social media have been searching for attractive stories and revelations linked to the epidemic, the general public was relentlessly looking for news, and there was a relevant attention for the information originated from the scientific world.

In this tumultuous situation, two main aspects should be considered. **First**, the scientific research has the power to prompt strong emotional reactions, affecting the comprehension of the content, strongly depending on the form of presentation, among other factors.[3] **Second**, even if in Italy the respect towards science is well established, the health literacy and the numeracy ability of the population are generally limited; it implies an inadequate competence in scrutinizing and evaluating scientific information.[4]

In the case of Covid-19 outbreak, the information regarding a connection between environmental pollution and the novel Coronavirus emerged as a new strand of interest more than one month after the declaration of the national emergency in Italy, immediately attracting everybody's attention, generating the possibility to build a new frame with a novel 'enemy' to blame, co-responsible for the outbreak, already known and identified as bad and dangerous.[5] The responsible for this framing cannot be sharply identified; it is a combination of facts and actors in the communication arena.[6] To date, epidemiological studies on air pollution and Covid-19 have multiplied, mainly on long-term effects and mortality, all with a geographical or ecological correlation design.

By observing the maps of the concentration of atmospheric pollutants and analysing spatiotemporal distribution of the number of Covid-19 deaths and positive subjects by province or county, the first question that arises is whether and how much these two phenomena can be connected. Of course, there is nothing wrong with asking this question, but it should be well known and declared in advance that a correlation should not represent a proof of a causal link.

> The strong implications, in terms of risk communication and governance, of this kind of result reporting are often underestimated

This concept is clearly formalized in epidemiology and well understood by epidemiologists,[7] but it cannot be taken for granted that other professionals, decision makers, citizens, and the media are aware of its impications. Furthermore, the question of how many other variables may be involved in the postulated correlation between air pollutants and disease appears crucial, as well as what is considered as the main determinant of the disease. Here, the difference between communicable and non-communicable diseases is fundamental. Despite the simplicity of reasoning and the analysis concerning the correlation, the risks of oversimplification of the conceptual model – including the trap of the nonsense correlation – should be taken into consideration.(*)

Considering the information disseminated by media and non-professional subjects, it is not surprising that the results of the correlation studies on air pollution and Covid-19 are not interpreted as a simple association, but as a cause-effect relationship, that is certainly a more captivating notion. This distorted interpretation of the results can depend upon many interacting factors: the lack of attention to the limits stated in the scientific articles, the veiled or ambiguous statements of the authors, the need of the media to simplify and amplify the news to capture public attention.

HOW THE RESEARCHERS REPORTED THEIR RESULTS

1. A position paper[8] recently published in Italy is a particularly useful example to deepen the reflection on scientific implications and health literacy. It is a rough correlation study (see the Summary Table S1 in the on-line supplementary material). The conclusion regarding the high correlation between positive Covid-19 cases and PM10 was presented as follows: «*the specificity of an increase in the number of cases of contagion that affected some areas of Northern Italy in particular could be linked to the conditions of pollution by atmospheric particulate matter which carried out a carrier and boost action*». The results have been interpreted and amplified by the media in the direction of causation, and the use of the conditional verb appeared to be negligible.

It is important to note that no attention was given – even in the discussion that followed – to the role of fundamental variables not considered in the analytical model, such as the presence of specific epidemic outbreaks, retirement and nursing homes, risky work activities for social contacts, the measures undertaken to control the infection, etc.

The study had widespread media coverage, and also prompted scientific interventions by Italian researchers focused on how to interpret the reported correlations.[9-11]

2. A subsequent study on short term exposure in 120 Chinese towns allows further reflections[12] (see Summary Table S1).

In the discussion, after giving recommendations, the authors declare: «*Our study has several limitations. First, we only focused on the association between air pollutants and Covid-19 confirmed cases and not the causal effect of air pollution on Covid-19 infection. Second, our data did not include gender- or age-specific confirmed cases, so we could not conduct subgroup analyses. Third, our findings were not globally representative since cities of other countries were not included in this study. Future studies are needed to overcome these limitations*».

In the conclusions, those limits, although substantial, did not find any space, indeed the statement is surprisingly assertive: «*Short-term exposure to higher concentrations of PM2.5, PM10, CO, NO_2 and O_3 is associated with an increased risk of Covid-19 infection*».

3. Another geographic correlation study on the relationship between long-term exposure to NO_2 and Coronavirus fatality was recently published[13] (see Summary Table S1).

Despite the simplification of the design, the conclusion is quite strong toward a direct relationship between exposure to air pollution and Covid-19 mortality: «*These results indicate that the long-term exposure to this pollutant may be one of the most important contributors to fatality caused by the Covid-19 virus in these regions and maybe across the whole world*».

4. A nationwide ecological study by a research team from Harvard University used county-level data on Covid-19 deaths and on the long-term average exposure to PM2.5[14] (see Summary Table S1).

The results has been highly quoted by the media, often as a confirmation of a causal link, although in the paragraph about limitations the authors wrote: «*Due to the potential for ecologic bias, our results should be interpreted in the context of this design and should not be used to make individual-level inferential statements. Also, unmeasured confounding bias is a threat to the validity of our conclusions*».

5. A recent study from another research group from Harvard University included information variables of Covid-19 previously not considered to estimate the association between long-term county-level exposures to NO_2, PM2.5, and O_3 and county-level Covid-19 case-fatality and mortality rates in the US[15] (see Summary Table S1).

The authors' conclusion is in favour of an increase in the susceptibility to severe outcomes of Covid-19, regardless of the long-term exposure of PM2.5 and O_3, and the recommendation is to support specific public health actions to protect people living in regions with high levels of NO_2, also aimed to reduce the population risk of Covid-19 deaths.

It should be noted that in this latest paper the role of pollution is clearly related to the susceptibility to getting sick.

The strong implications, in terms of risk communication and governance, of these kind of reporting often seem underestimated, even if the limitations should be well known.[7]

REFLECTIONS AND IMPLICATIONS

The role of air pollutants on the spread of the current pandemic evolves along a **complex relationship chain.** Air pollutants as risk factors for respiratory tract infections, the transport of microorganisms, the ability to make pathogens more invasive for humans, to influence their immunological structure, up to affect individual sensitivity to pathogens and expanding the portion of susceptible to SARS-CoV-2 action constitute a challenge for defining the rationale and design of epidemiological studies before their execution.

Fragments of this chain can be identified, but there is an overall simplification. About the **possible permanence of SARS-CoV-2 in aerosol**, the mention of the article by van Doremalen[16] proposed by Zhu et al. is not enough,[12] without presenting the potential and limits of the available tests. In particular, it should be said that it is a laboratory study (artificially produced bioaerosol) and that key aspects remain to be clarified, such as the effects of weather conditions and the decay time and entity of the viral load. In this regard, the document by Baldini et al.[17] and the study by Contini and Costabile[10] offer an advanced view on the role of airborne particulate matter and on the in-

teraction between air pollutants and respiratory infections. Furthermore, **lockdown measures** lower the levels of air pollution so the notification rate can decrease, creating a favourable condition for spurious correlation.[18]

About the confounding issue, in spite of a general wealth of confounders and sensitivity analyses done by three studies (Zhu et al.,[12] Whu et al.,[14] Liang et al.[15]), it seems that the centrality of the **Covid-19 definition** has not been fully addressed. In fact, positive cases and deaths represent only a proxy for the incidence of infection, which determines a multitude of asymptomatic and paucisymptomatic cases.[19]

In addition to the intrinsic limitations of geographic correlation studies, the definition of the observation context, to be addressed a priori should not be underestimated. In epidemiology, the theme of the hyperconcentration of the **observation context** by the observer has been brilliantly explained with the expression 'Texan sharpshooter'.[20,21(**)]

Undoubtedly, the image of maps with dark spots of pollution and of Covid-19 infections or death cases in overlapping areas, as in Northern Italy, represents a 'fatal' attraction to correlate the two phenomena. The environmental and diseases data are available or can be found, the analytical method is easy and handy, and the game is done. In this context, insisting on doing correlation studies, when the research question regarding potential causal relationships has been already posed (hypothesis), does not produce significant steps towards verifying that hypothesis.

On the relationship between exposure to air pollution and Covid-19, the question to answer may be: «Can the exposure to air pollution, both chronic and acute, have an effect on the probability of infection, the appearance of symptoms, and the course of the Covid-19 caused by SARS-CoV-2?».[22] To answer such a complex question, studies based on individual data on the determinants of Covid-19 are required and are to be followed over time using reliable information on the spread of SARS-CoV-2, the evolution and comorbidities of Covid-19, on the main factors that can act as confounders or effect modifiers, including exposure to pollution, both in the previous phases and during the epidemic.

A study with these characteristics (EpiCovAir National Project) is being activated in Italy by a collaboration agreement between the National Institute of Health (ISS), the National System for the Environmental Protection (SNPA), and the Italian Network on Environmental and Health (RIAS).

This design is certainly more challenging than the correlation one, but it is available in the epidemiology toolbox. To do this, a multi and interdisciplinary approach is needed, a recognised but seldom practiced requirement. In this regard, the metaphor of Kant's Cyclops seems to be appropriate: «The Cyclops is a selfish of science, and would need an additional eye to be able to see its object from the point of view of other men.

The knowledge that mulls over, those whose contents can be remembered and which therefore take root without the acquired being tested, are the reason for the existence of the Cyclops. The world of sciences (theology, jurisprudence, medicine, and geometry) is full of these beings and for each science there is the need to manufacture an additional second eye».[23]

REFLECTION ON COMMUNICATION

The broad interest from the public and the simplicity of use of the ecological studies may have played a significant role in their proliferation. The correlation analyses were developed with reference to the Italian Po Valley, recognized as one of the most polluted areas in Europe.[24]

The debate had a wide echo in the traditional media,[25] framing the news around air pollution, a well known enemy, and around the simple cause-effect correlation.[7] It is interesting to notice is that also the scientific debate was captured by the communication road roller, showing the different views as conflicts.[26,27]

The communication issue during the *infodemia* is profoundly linked to the trust in science and in its application, but there is a high risk that it will be misused. The differences between the logical process of science and the practice of policy decisions are so deep that the continuous appeal of decision makers to science appears as an ultimate lifebuoy. Scientists and experts are not really interchangeable: scientists decide subjects and questions to investigate, while experts are called by policy makers to apply knowledge and judgment to a specific issue, often outside the specific competence. There is always a tension and a potential discrepancy in case of decisions with strong political and social implications. If the expert is solicited beyond what he considers legitimate, he can take refuge back in the role of scientist, claiming that science is uncertain. For all these reasons, the responsibility of properly use science for decisions in the present phase is of the utmost importance.[28]

CONCLUSIONS AND OPTIONS

Limits regarding pollution data, with the problem of choosing the geographic scale, data on Covid-19, often incomplete or even inadequate, and conclusions such as «the results must be used with great caution» leave unsatisfied.

The limitations mentioned by the authors of the papers here discussed, although generally clear, are fraught with underweight consequences. A deeper consideration should be dedicated not only to the intrinsic limit of the ecological design, on the causal determinant of the epidemic, on the confounding or modifying factors, but also to the strategy for communicating the results, especially during a pandemic crisis. Little or no attention is given to the reverberations of those limitations, especially with reference to the usability of the results. On the contrary, the consequences should be taken into serious consideration in terms of practical and ethical implications for science communication and decision-making.[29]

To study patterns of spread of infectious disease and environmental interactions, the epidemiology of communicable diseases and environmental epidemiology should go hand in hand. The potentials and the limits of the adopted design and of the used data should be clearly stated in the conclusions.

Researchers are challenged in fact by informing and support-

ing authorities on acquired knowledge and practical implications, and by sharing the results within and outside the scientific community. In the current difficult context, researchers should reflect about science and be aware of risks and opportunities of disseminating results in a fair modality. Also the importance of understanding risk perceptions in these unprecedented times should not be disregarded to improve health risk communication, build trust, and contribute to a collaborating governance.[30]

Discussing the possibility to calculate how many additional Covid-19 cases and deaths will be attributable to air pollution, the Director of Public Health at the World Health Organization, Dr. María Neira, told the Guardian: «But whatever the research concludes in the end, the most important issue is that we need to make sure that after Covid-19 the recovery will be a healthy recovery, because we want to reduce vulnerability».[31]

In addition to the persuasive evidence already available on the causal relationship between air pollution and health,[32] research is called upon providing evidence on how and how much air pollution increases the susceptibility of vulnerable subjects or acts as effect modifier towards Covid-19. The type of study and the communication strategy must be able to face the challenge for strengthening preventive actions and for countering any unacceptable weakening of environmental protection.

Conflicts of interest: none declared.

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NOTES

(*) Nonsense correlation. A meaningless correlation between two variable. Nonsense correlations occur when social, economic, or techonological changes have the same trend over time as incidence or mortality rates. An example is correlation between the birth rate and the density of storks in parts of Holland and Germany. See also Confounding; Ecological Fallacy (Last JM, A Dictionary of Epidemiology, II ed, Oxford University Press, New York 1988; p 31).

(**) The sharpshooter shoots at random on a barn door, then draws a circle centred on the bullet hole: obviously he hits the centre. He is asked to shoot again and the new holes will be positioned around the first one according with the precision and accuracy of the sharpshooter. This metaphor is particularly effective in clarifying the situation happening when a procedure is adopted focusing on a set of data apparently arranged in a non-random way, the objective is designed on the basis of data, thus defining the phenomenon after observing their significance or plausibility, instead of starting from the formulation of a hypothesis aimed at explaining a certain phenomenon.