Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Environmental Research 188 (2020) 109775

Contents lists available at ScienceDirect

Environmental Research

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

Commercial exchanges instead of air pollution as possible origin of COVID-19 initial diffusion phase in Italy: More efforts are necessary to address interdisciplinary research

Elza Bontempi

INSTM and Chemistry for Technologies, University of Brescia, Via Branze 38, 25123, Brescia, Italy

A B S T R A C T

This communication aims to advocate a more coordinate activity mainly between medical and environmental scientists to clarify some confusing information related to airborne diffusion mechanisms of COVID-19. In this frame it is suggested that parameters other than environmental pollution (accounting for pollution-to-human transmission mechanisms), as for example parameters involving commercial exchanges (accounting for human-to-human transmission mechanisms), should be considered to better justify the difference in the initial diffusion of virus in Italy.

1. Introduction

At the end of 2019, COVID-19 infections were found, for the first time, in Wuhan (China). At the end of February 2020, the first infection case was reported in Northern Italy (Lombardy), opening an unexpected sanitary crisis in Europe.

During the continuous diffusion of the virus in Lombardy, the not complete knowledge of some aspects of infection spread (for example the virus transmission due to no-symptom patients), has alimented several debates and conflicting information about COVID-19 airborne diffusion (Zhiqiang Zhai, 2020), making evident the need of more dialogue between different disciplines.

In particular, due to several episodes of air pollution observed in the past in China (Wang et al., 1970) and in Northern Italy, especially in the Po valley (Perrino et al., 2014), a correlation between airborne particulate matter (PM) concentration and the reported infection cases was proposed by a position paper (Position paper). Based on this work, several newspapers and some research articles (Frontera et al., 2020), (Sterpetti, 2020) were published reporting the possibility that airborne PM acts as a carrier in COVID-19 diffusion (pollution-to-human transmission).

However, the potential influence of PM in virus diffusion was proposed as exploratory evidence of potential risks, but never demonstrated so far (Qin et al., 2020). In particular, few knowledges are still available about interaction of virus and PM.

On the contrary, it is well documented that the exposure to high PM concentrations can produce cardiovascular diseases, pulmonary oxidative stress and inflammation (Hadei and Naddafi, 2020). This situation can aggravate the health conditions of the infected subjects, due to the pneumonia often associated with COVID-19.

Concerning COVID-19 diffusion in the air, some recent published papers support the idea that the airborne transmission is a mechanism of virus diffusion. Moreover, these works concern the small respiratory droplets with viral content, that are generated by infected people (Morawska and Cao, 2020), and that can be transported by air current (human-to-human transmission). Indeed, this eventuality primarily concerns indoor situations, then different boundary conditions in comparison to transport that may be realized by outdoor PM. The lack of a clear definition of the COVID-19 possibility to be transported by the air has alimented several discussions and different opinions, mainly depending on the experts' background.

The aim of this letter is to highlight some limitations due to the deficiency in interdisciplinary activities focalized to study COVID-19 diffusion. This work would demonstrate the need of more interdisciplinary collaborations in reporting and interpreting the available data, and the possibility that other parameters, different to those already proposed, should be considered.

The next paragraph is devoted to expanding and discussing the examples cited in the introduction. The third part of this communication aims to propose a different point of view, considering also economic/commercial factors and suggesting some actions addressed to promote more efficacy in collaborations.

2. Theoretical framework: some limitations of available studies may be due to the lack of suitable interdisciplinary research

The need to increase the collaboration concerning COVID-19 infection, between different interdisciplinary areas, can be highlighted by

E-mail address: elza.bontempi@unibs.it.

https://doi.org/10.1016/j.envres.2020.109775
Received 22 April 2020; Received in revised form 1 June 2020; Accepted 3 June 2020
Available online 13 June 2020
0013-9351/

the lack of a suitable and shared terminology.

For example, the definition of airborne has a different meaning for medical and environmental scientists, with the consequence to make often confused the definition of airborne virus transmission. When public health officials discuss about airborne transmission, they specifically mean that virus is transported in aerosol respiratory droplets (generated indoor by infected people) smaller than 5 μm in diameter (https://www.who.int/). Compared to respiratory droplets of largest dimensions, bioaerosols are expected to be able to travel meters (Morawska and Cao, 2020). Then, this concerns possible infection mechanisms mainly occurring indoor (human-to-human transmission).

On the other side, airborne has a different definition for scientist working in other scientific areas, such as atmospheric topics. Indeed, in the air pollution studies, airborne generally refers to outdoor pollution, as for example, research concerning PM. In addition, bioaerosols consist of particles generated in biological processes, then they can consist of flowers, trees, carbohydrates, proteins, grass, lipids, DNA, RNA, fungi, bacteria, viruses, and so on (Hyde and Mahalov, 2020), that are only a limited part of PM, that usually contains large amount of inorganic components. The recent works suggesting virus diffusion in Northern Italy, concerning PM acting as a carrier, is an example of a possible mechanism concerning an outdoor virus diffusion possibility (pollution-to-human transmission), that need further investigations. The possibility that the virus can attach for example to PM, which may modify the aerodynamic characteristics of these particles (Prather et al., 2020), and increase the virus dispersion should be copuled with studies investigating the COVID-19 infectivity, also depending on its dilution (the virus may be represent in insufficient amounts to produce infection) (National Academies of Sciences, 2020).

This different meaning of airborne can lead to an incorrect understanding of the virologists assertions. For example, confusion arising from the perception that the virus airborne diffusion can be promoted by outdoor sources (as for example PM), may induce the populate to suppose that outdoor is a dangerous environment, with the possible contradictory consequence of a limitation of the indoor ventilation. However, indoor ventilation is strongly recommended by medical experts as an effective way to reduce indoor virus concentration.

Therefore, I think that the assertion that COVID-19 virus travels in the air must be better defined, investigated, clarified, and illustrated.

Another example that highlights the need of more interdisciplinary collaborations concerns the choice of the most suitable parameters for a comprehensive vision of the virus spread possibilities.

From the reported examples of virus diffusion mechanisms (human-to-human transmission and pollution-to-human transmission), it is evident that we have different variables that can contribute to virus diffusion, and that they are dependent on indoor and/or outdoor selected boundary conditions. The interpretation of simple correlations (for example between PM concentration and detected infections cases), that can be established between two time series (with a recognized variability also in the time of contagious diffusion, i.e. generally 7–14 days, that represents another variable), does not necessarily indicate a cause-effect relationship, due to the complexity of the system and the reduced variables number that are considered (Coccia, 2020). For example, despite several works justified in air pollution (due for example to PM_{10} concentration) the difference occurring in COVID-19 diffusion in Italy, a recent paper shows that the events of high PM concentrations in Northern Italy occurred in cities that had a limited number of infected people (such as Torino, Alessandria, and Asti) (Bontempi, 2020). This example reveals that great attention must be also devoted, in comparing data and trends when a reference system (or a comparison with other situations, such as other geographical locations, situated in the proximity) is not available. Indeed, despite several correlations with air pollution and COVID-19 diffusion have been proposed, few papers have analyzed the situation in reference areas (located in proximity), where even if in conditions of high pollution, the virus spread resulted limited (Zhu et al., 2020) (Bontempi, 2020).

Moreover, it is fundamental to remember that concerns must be devoted to air pollution for its recognized influence on respiratory problems that may exacerbate the COVID-19 symptoms (Orellano et al., 2017) (Hoek et al., 2013) (Carugno et al., 2018) (Zhu et al., 2020). As a result, it is possible that air pollution can play a significant role in factors determining the mortality of infected people. Then a correlation is expected between environmental factors and COVID-19 deaths, that will be verified in future, when more comprehensive data will be available (as for example solid statistics about virus real diffusion).

3. Method and sources of this work: new parameters should be considered in future studies related to COVID-19

Political authorities are looking, with the scientists support, to understand all the parameters that may be connected with virus diffusion and expansion not only to better manage the current sanitary crisis, but also to avoid possible similar critical situations in the next future. Several authors have already proposed some strategies to prevent future epidemic, connected for example with wildlife market and environmental pollution (Coccia, 2020), but probably the already available suggestions must be improved considering other indicators.

For this aim the basic of COVID-19 diffusion dynamics must be investigated with high attention. As already mentioned, in Italy, to justify the high incidence of infection cases detected in Lombardy the first days of March 2020, the most diffused theories concerned the environmental conditions in Northern Italy. In particular, among the different hypotheses, air pollution, coupled with the casualty, and the classical mechanisms of social interactions was generally supposed to be the first reason able to justify a contamination level that was not homogeneous in all the territory, then promoting difference in population susceptibility to COVID-19 (Coccia, 2020) (Position paper).

However, a more exhaustive and comprehensive approach to the problem can be achieved by considering other parameters, that may be not strictly related to sanitary implications (i.e. not strictly related to environmental pollution).

In my opinion, for example, it would be also interesting to investigate the financial relationships of different parts of Italy with China, that wasn't considered before in COVID-19 literature, dealing with the contagious origin. Northern Italy is the core of Italy economy with several international exchanges. In Brescia (Lombardy), for example, there are a lot of industries with associated partners located in China, and active workers transfer. Indeed, the hypothesis that the economical/commercial factor may be one of the origins of Italy different contagious map was supposed, but still not evaluated by reporting and analyzing suitable data. To quantify the interchange occurring between Italy and China, I have considered the trade data, available online by ISTAT (the Italian Institute of Statistic, https://www.istat.it/en/) between Italy reported aggregated areas and East Asia (that considers China, Mongolia, South Korea, North Korea, and Japan). ISTAT provide data that are aggregated considering different Italian Regions. Data are aggregated also for foreign commercial areas (then for China it is necessary to consider East Asia Countries). Anyway EUROSTAT (https://ec.europa.eu/eurostat/home?) shows that among East Asia Countries, China contribution is about 75% for export and about 87% for import in Italy. Then, these data can be considered a quite good picture of economical relationships occurring between different Italian areas and China.

Fig. 1 reports trade data provided by ISTAT, concerning import and export of Italian aggregated areas with East Asia in 2018 (data about 2019 are still not complete, but they confirm the reported trend). Fig. 2 shows data of detected infections case on March 10, 2020 (http://www.protezionecivile.gov.it/) in Italy (at the beginning of contagious reported diffusion), aggregated in the same way provided by ISTAT, to make possible the direct comparison with Fig. 1.

Fig. 1 (a, b) clearly shows the existence of strong commercial/economical relationships between China and Northern Italy.

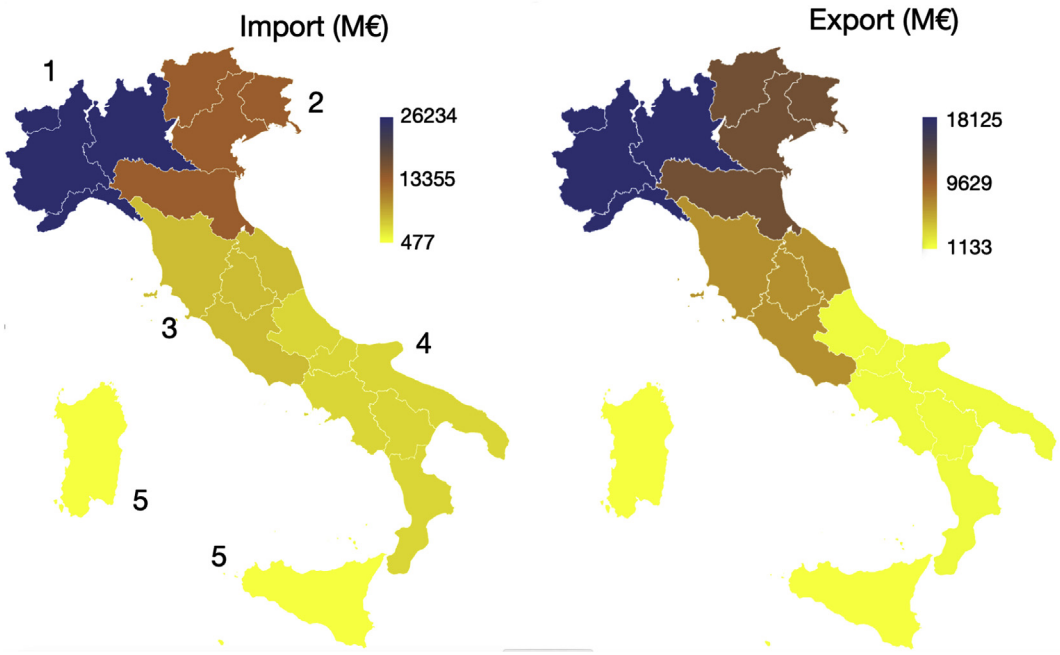

Fig. 1. Trade import (a) and export (b) data provided by ISTAT, concerning Italian regions with East Asia in 2018. Geographical classification of Italy, provided by ISTAT is: (1) North-West, (2) North-East, (3) Centre, (4) South, (5) Islands.

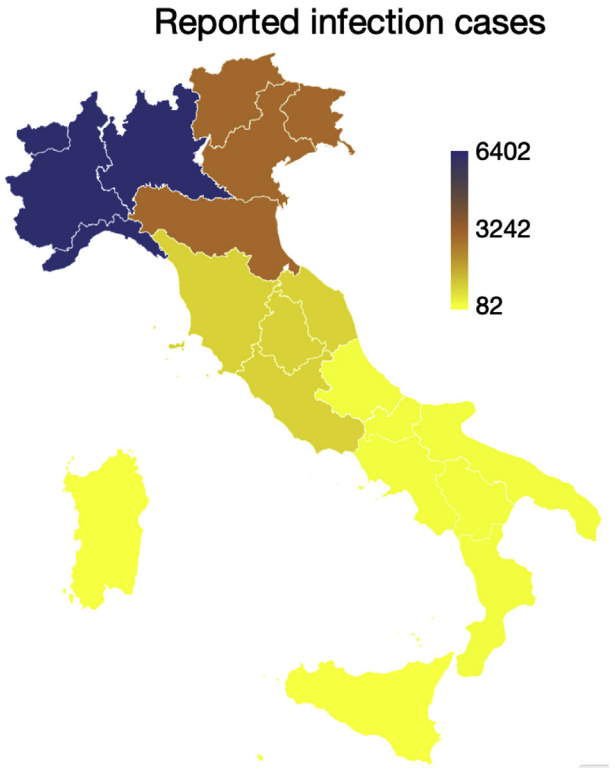

Fig. 2. Global reported infection cases detected at the beginning of the sanitary crisis (March 10, 2020), in all the Italy, reported in accord with the geographical areas provided by ISTAT for trade data (see Fig. 1).

It is very interesting to highlight that the image reported in Fig. 2 is very similar to those shown in Fig. 1, strongly suggesting a possible correlation. In particular, I quantified the correlation between the infection cases (shown in Fig. 2) and the trade import and export data (shown in Fig. 1) using the Pearson Correlation Coefficient: it resulted 0.99 considering infection cases versus import data, and 0.97 considering infection cases versus export data. This coupled with the consideration that Lombardy is the most populated Italian region, strongly supports the idea that economic/commercial relationships may be considered the most probable factor contributing to the initial phase of diffusion of the infection in Northern Italy. Commercial relationships can be a useful parameter representing mobility patterns across the investigated areas. In particular, it is probable that a suitable measure of human-to-human initial virus diffusion mechanisms could be found in Italy-China trade (external mobility). Obviously other factors may contributed to affect the transmission dynamics and accelerate the COVID-19 spread (such as people internal mobility, environmental conditions (Coccia, 2020), the possibility of virus interaction with the environment (Groulx et al., 2018), and so on), but economical/commercial factor (human-to-human transmission) seems apparently to be the most plausible reason able to justify the initial phase of diffusion.

It is also important to highlight that, despite the first detected cases of COVID-19 infections were reported at the end of February 2020, researchers suggest the virus probably circulated in Italy at least one month before (probably in January 2020), promoting its undetected diffusion. This may justify the detection of virus infections in all the Italian regions at the beginning of the sanitary crisis, with a geographical diffusion similar to the China commercial trade map. Based on these preliminary results other works are in progress to investigate in detail the existence of these correlations at regional levels (Bontempi et al., 2020).

In conclusion, it is important to highlight that a lesson derived from the different proposed mechanisms of virus diffusion concerns the need to promote interdisciplinary research activities, able to analyze the problem from different points of view. The research areas must include not only medical, epidemiologist, and environmental specialists, but also engineering, political, economic, social, and demographic sectors. Indeed, parameters that may be not evident to some experts can result clearer and more justified to researchers of other disciplines. Then, in my opinion, it is extremely important to begin a new methodological approach, that may start in clarifying the context and define a clear and recognized terminology specifically addressed to the COVID-19, select the fundamental parameters to investigate, and promote interdisciplinary international research activities. This goal can be obtained

also with the support of political authorities, that often select their scientific committees specifically devoted to COVID-19, involving only medical and epidemiology specialists. This will allow not only to better address all the research efforts, but also to contribute to disseminate suitable messages and information to non-specialists, such as population and policymakers.

Author contribution

This paper was conceived and written by only one author.

Declaration of competing interest

The author declares that she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

Bontempi, E., 2020. First data analysis about possible COVID-19 virus airborne diffusion due to air particulate matter (PM): the case of Lombardy. Italy) Environmental Research 186, 109639. https://doi.org/10.1016/j.envres.2020.109639.

Bontempi, E, Vergalli, S, Squazzoni, F, 2020. Understanding COVID-19 diffusion requires an interdisciplinary, multi-dimensional approach. Environ. Res. 188, 109814. https://doi.org/10.1016/j.envres.2020.109814.

Carugno, M., Dentali, F., Mathieu, G., Fontanella, A., Mariani, J., Bordini, L., Milani, G.P., Consonni, D., Bonzini, M., Bollati, V., Pesatori, A.C., 2018. PM10 exposure is associated with increased hospitalizations for respiratory syncytial virus bronchiolitis among infants in Lombardy, Italy. Environ. Res. 166, 452–457. https://doi.org/10.1016/j.envres.2018.06.016. 2018.

Coccia, M., 2020. Factors determining the diffusion of COVID-19 and suggested strategy to prevent future accelerated viral infectivity similar to COVID. Sci. Total Environ. 729, 138474. https://doi.org/10.1016/j.scitotenv.2020.138474.

Frontera, A., Martin, C., Vlachos, K., Sgubin, G., 2020. Regional air pollution persistence links to covid19 infection zoning. J. Infect. 187, 109650. https://doi.org/10.1016/j.jinf.2020.03.045.

Groulx, N., Urch, B., Duchaine, C., Mubareka, S., Scott, J.A., 2018. The Pollution Particulate Concentrator (PoPCon): a platform to investigate the effects of particulate air pollutants on viral infectivity. Sci. Total Environ. 628–629, 1101–1107. https://doi.org/10.1016/j.scitotenv.2018.02.118.

Hadei, M., Naddafi, K., 2020. Cardiovascular effects of airborne particulate matter: a review of rodent model studies. Chemosphere 242https://doi.org/10.1016/j.chemosphere.2019.125204. Article number 125204.

Hoek, G., Krishnan, R.M., Beelen, R., Peters, A., Ostro, B., Brunekreef, B., Kaufman, J.D., 2013. Long-term air pollution exposure and cardiorespiratory mortality: a review. Environ. Health 12 (1), 43. https://doi.org/10.1186/1476-069X-12-43.

Hyde, P., Mahalov, A., 2020. Contribution of bioaerosols to airborne particulate matter. J. Air Waste Manag. Assoc. 70 (1–2), 71–77. https://doi.org/10.1080/10962247.2019.1629360.

Morawska, L., Cao, J., 2020. Airborne transmission of SARS-CoV-2: the world should face the reality. Environ. Int. 139, 105730. https://doi.org/10.1016/j.envint.2020.105730.

National Academies of Sciences, 2020. Engineering, and medicine. Rapid Expert Consultation on the Possibility of Bioaerosol Spread of SARS-CoV-2 for the COVID-19 Pandemic (April 1, 2020). The National Academies Press, Washington, DC. https://doi.org/10.17226/25769.

Orellano, P., Quaranta, N., Reynoso, J., Balbi, B., Vasquez, J., 2017. Effect of Outdoor Air Pollution on Asthma Exacerbations in Children and Adults: Systematic Review and Multilevel Meta-Analysis PloS One, vol. 12, e0174050. https://doi.org/10.1371/journal.pone.0174050. 3.

Perrino, C., Catrambone, M., Dalla Torre, S., Rantica, E., Sargolini, T., Canepari, S., 2014. Seasonal variations in the chemical composition of particulate matter: a case study in the Po Valley. Part I: macro-components and mass closure. Environ. Sci. Pollut. Res. 21, 3999–4009. https://doi.org/10.1007/s11356-013-2067-1.

Position paper. https://www.actu-environnement.com/media/pdf/news-35178-covid-19.pdf.

Prather, K.A., Wang, C.C., Schooley, R.T., 2020. Reducing transmission of SARS-CoV-2. Science 27, eabc6197. https://doi.org/10.1126/science.abc6197.

Qin, N., Liang, P., Wu, C., Wang, G., Xu, Q., Xiong, X., Wang, T., Zolfo, M., Segata, N., Qin, H., Knight, R., Gilbert, J.A., Zhu, T.F., 2020. Genome Biology Longitudinal survey of microbiome associated with particulate matter in a megacity. Genome Biol. 21, 55. https://doi.org/10.1186/s13059-020-01964-x.

Sterpetti, A.V., 2020. Lessons learned during the COVID-19 virus pandemic. J. Am. Coll. Surg. 230 (6), 1092–1093. https://doi.org/10.1016/j.jamcollsurg.2020.03.018.

Wang, H., Dwyer Lindgren, L., Lofgren, K.T., Rajaratnam, J.K., Marcus, J.R., Levin-Rector, A., Levitz, C.E., Lopez, A.D., Murray, C.J.L., 2012. Age-specific and sex-specific mortality in 187 countries. 1970-2010: a systematic analysis for the Global Burden of Disease Study 2010 Lancet 380, 2071–2094. https://doi.org/10.1016/S0140-6736(12)61719-X.

Zhiqiang Zhai, J., 2020. Facial Mask: A Necessity to Beat COVID-19, Building and Environment. vol. 175. pp. 106827. https://doi.org/10.1016/j.buildenv.2020.106827.

Zhu, Y., Xie, J., Huang, F., Cao, L., 2020. Association between short-term exposure to air pollution and COVID-19 infection: evidence from China. Sci. Total Environ. 138704. https://doi.org/10.1016/j.scitotenv.2020.138704.