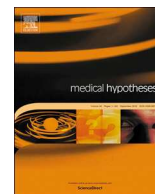




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Letter to Editors

Correlation between atmospheric particulate matter and antibiotic resistance: A hypothesis



Dear Editors,

the Italian National Health System, universally recognized as one of the best in the world also by recent studies [1], has faced two important health threats in recent years, in addition to the current SARS-CoV-2 epidemic: Italy is in first place in Europe both for premature deaths due to exposure to PM_{2.5} fine particulate matter (58,600 deaths in 2016) [2] and for the number of deaths due to infections caused by antibiotic-resistant bacteria (over 10,700 in 2015, 1/3 out of the total of the European Union) [3], with the latter data confirmed not only by the high quantity of prescriptions of these drugs for medical use [4], but also and above all by the large percentage of sales for veterinary applications and zootechnics [5].

Therefore, a question arises: could there be a connection between these two apparently so different phenomena? Indeed, a hypothesis could be advanced, moving from the epidemiological data to a biochemical explanation. PM_{2.5} or lower particles could adsorb fragments of nuclear or plasmid DNA [6] from the environmental resistome or from bacteria (not only pathogenic) that are dead but resistant or multiresistant (both environmental and hospital), therefore containing Antibiotic Resistance Genes (ARGs), and disseminate them everywhere through the wind or other atmospheric manifestations.

These DNA fragments could later penetrate, using PM_{2.5} or lower particles as carriers (also biocompatible), into other bacteria (also of different genres) which could exploit them evolutionarily to obtain new characteristics of resistance, integrating these genes in their nuclear genome or in their plasmids (therefore transferring them to other germs by conjugation, a mode already favored by PM_{2.5} particles [7]) with a mechanism similar to bacterial transformation or biolistic method, widely used in research laboratories.

In this way, high concentrations of atmospheric particulate matter, already a cause of death in itself, could passively and actively favor the propagation of the phenomenon of antibiotic resistance, with its burden of disease. With this in mind, health costs of air pollution should be

reviewed, also adding the possible share of costs due to hospitalizations for infectious diseases from antibiotic-resistant germs.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- [1] GBD 2017 Italy Collaborators. Italy's health performance, 1990-2017: findings from the Global Burden of Disease Study 2017. *Lancet Public Health* 2019, 4(12):e645-e657.
- [2] EEA. Air Quality in Europe - 2019 Report; No 10/2019; European Environment Agency: Copenhagen, Denmark, 2019.
- [3] Cassini A, Högberg LD, Plachouras D, Quattrocchi A, Hoxha A, Simonsen GS, et al. Attributable deaths and disability-adjusted life-years caused by infections with antibiotic-resistant bacteria in the EU and the European Economic Area in 2015: a population-level modelling analysis. *Lancet Infect Dis* 2019;19(1):56-66.
- [4] ECDC. Antimicrobial consumption in the EU/EEA, Annual epidemiological report for 2018. European Centre for Disease Prevention and Control: Stockholm, Sweden, 2019.
- [5] EMA. Sales of veterinary antimicrobial agents in 31 European countries in 2017; EMA/294674/2019; European Medicines Agency: Amsterdam, The Netherlands, 2019.
- [6] McEachran AD, Blackwell BR, Hanson JD, Wooten KJ, Mayer GD, Cox SB, et al. Antibiotics, bacteria, and antibiotic resistance genes: aerial transport from cattle feed yards via particulate matter. *Environ Health Perspect* 2015;123(4):337-43.
- [7] Xie S, Gu AZ, Cen T, Li D, Chen J. The effect and mechanism of urban fine particulate matter (PM_{2.5}) on horizontal transfer of plasmid-mediated antimicrobial resistance genes. *Sci Total Environ* 2019;683:116-23.

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