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SARS-CoV-2 and other main pathogenic microorganisms in the environment: Situation in Galicia and Spain

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ABSTRACT

In the context of the current COVID-19 pandemic, and mostly taking a broad perspective, it is clearly relevant to study environmental factors that could affect eventual future outbreaks due to coronaviruses and/or other pathogenic microorganisms. In view of that, the authors of this manuscript review the situation of SARS-CoV-2 and other main pathogenic microorganisms in the environment, focusing on Galicia and Spain. Overall, in addition to showing local data, it is put in evidence that, summed to all efforts being carried out to treat/control this and any other eventual future epidemic diseases, both at local and global levels, a deep attention should be paid to ecological/environmental aspects that have effects on the planet, its ecosystems and their relations/associations with the probability of spreading of eventual future pandemics.

1. Introduction

Pathogenic microorganisms cause many different diseases all over the world. With the current pandemic situation hitting, and not fully evaluated, it could be of value to compare available data corresponding to COVID-19 with that from previous years regarding infectious diseases. In this regard, taking into account that, time to time (with lapse of few years), the Institute for Health Metrics and Evaluation (IHME) publishes new updated versions of the Global Burden Disease study (GBD), Hessling et al. (2017) commented on data referred to a 2015 version, considered as a detailed and broad study on the matter. At that time, total yearly casualties due to pathogens were as follows: Lower respiratory infections (caused by a variety of microbes) 2,736,700; Diarrhea (also caused by a variety of microbes) 1,312,100; AIDS (by HIV) 1,192,600; Tuberculosis (by *Mycobacterium tuberculosis*) 1,112,600; Malaria (by *Plasmodium falciparum* and *P. vivax*) 730,500; Meningitis (by various microbes) 379,200; Liver cancer due to hepatitis B virus 263,100. Then, there were other individual diseases with casualty numbers lower than 200,000, and a pool called "Other infectious diseases" reaching 119,600 casualties.

Recently, new publications have commented on the last version of the GBD study. In one of them, Vos et al. (2020) reported that, in 2019, six infectious diseases were within the first ones causing disability-adjusted life-years in children younger than ten years, being specifically: lower respiratory infections, diarrheal diseases, malaria, meningitis, whooping cough, and congenital syphilis.

Any case, bearing in mind that, as per the World Health Organization (WHO, 2021), the total number of casualties due to COVID-19 taking place in the world during 2020 were 1,801,095 (for a total of 82,386,766 infected people by December 31, 2020), it is clear that the relevance of this pandemic is really high among transmissible diseases.

Regarding specifically to Spain, WHO (2021) indicated that there were 1,949,912 COVID-19 cases by December 31, 2020, with a total of 53,225 deaths associated to the disease at that date. The latest data showed by WHO (2021) on March 14, 2021, indicate that the numbers for Spain are 3,183,704 cases, with 72,258 deaths associated. This means a percentage of 2.69 for Spain referred to the total number of cases for the whole world (118,261,985), and 2.75% of the total number of deaths in a world basis (2,624,681). These scores can be seen as very relevant, especially bearing in mind that the population of Spain is equivalent to the 0.60% of the whole world (Worldometer, 2021).

Data on Galicia (provided by Johns Hopkins University CSSE, 2021) indicate that the number of cases were 60,590 by December 31, 2020, with a total of 1371 deaths associated to the disease. On March 14, 2021,

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the numbers are: total cases 113,753, and 2266 deaths, representing 3.57% of total cases, and 3.14% of deaths referred to the whole Spain. The population of Galicia is 2,701,819 people, meaning 5.69% referred to the whole Spain (47,450,795 people), as per INE (2021a,b). In addition, the behavior of the disease in Galicia has shown a certain delay and other differences as compared to other geographic areas in Spain and Portugal, making of interest to carry out individualized studies and estimations (Ndaïrou et al., 2021).

Other data to contextualize Spain and Galicia in the world are the following. In 2019, the Gross Domestic Product (GDP) per capita was 27,970 euro for the European Union, and 25,200 for Spain, as per Eurostat (2021). With some difference, the Spanish National Institute of Statistics (INE) indicates that during 2019 it was 26,426 euro for Spain, and 23,873 for Galicia (INE, 2021a,b).

In addition, Fig. 1 shows the geographical placements of Galicia and Spain in Europe.

With all this in mind, and with the specific objective of focusing on environmental aspects, in this manuscript the authors take into consideration the fact that shedding of pathogenic microorganisms (including SARS-CoV-2) through excreta causes that these microbes can reach wastewater, watercourses, soils, and plants, in some cases with the added risk of generation of aerosols at specific points (for instance, at wastewater treatment plants before treatment of raw influents). But, in addition, another very relevant concern, also related to shedding of excreta, is due to the spreading into environmental compartments of drugs used to treat microbial infections. Specifically, environmental pollution due to antibiotics, and subsequent antibiotic resistance, are considered real threats for humans, mostly for the coming decades. In fact, Strathdee et al. (2020) indicate that bacterial infections not correctly solved due to antimicrobial resistance are considered to cause at least 700,000 deaths per year globally, with ten-million casualties per year expected by 2050. This hazard for humankind is promoted by the spreading of antibiotic residues contained in wastewater and sewage sludge, as well as in animal manures and slurries. Similarly, the spreading of virucidal substances and other drugs in the environment could be seen as a potential risk for human and environmental health.

2. Current situation regarding environmental aspects of SARS-CoV-2 and other pathogenic microorganisms in Galicia and Spain

Starting with environmental pollution related to the spreading of substances used to treat infections caused by bacteria, our team of research has carried out different works in Galicia dealing with antibiotics in the environment. In this regard, we have published some papers focused on the characterization of the situation, such as Conde-Cid et al. (2018, 2020a), while other dealt with retention/release of antibiotics on/from Galician soils, such as those by Conde-Cid et al. (2019, 2020b, 2020c, 2021a), and Álvarez-Esmorís et al. (2020).

Other papers focused on the assessment of alternatives to retain/remove these emerging pollutants affecting to environmental compartments, mainly based on the use of bio-adsorbent materials (as previously done for a variety of inorganic and organic pollutants, i.e. Anastopoulos et al., 2020; Núñez-Delgado et al., 2015; Peña-Rodríguez et al., 2013; Seco-Reigosa et al., 2013). Some of these publications are those by Conde-Cid et al. (2020d, 2020e, 2020f, 2020g), Cela-Dablanca et al. (2021), and Santás-Miguel et al. (2020, 2021).

Other researchers have published on this subject, describing the situation in Europe, such as Rodriguez-Mozaz et al. (2020), who indicate that Portugal, Spain and Ireland showed the highest levels of antibiotics in final effluents from wastewater treatment plants, making clear the importance of this issue at local and overall levels.

Furthermore, it should be noted that residues of antiviral drugs, especially those associated to the treatment of COVID-19, have been increasingly detected in wastewater and different environmental compartments (Race et al., 2020). In this regard, resistance to antiviral drugs could also grow up due to the increased use of this kind of molecules promoted by the pandemic situation (Kumar et al., 2020; Lopes-da-Silva et al., 2021; Matthew et al., 2021).

To date, some relevant research works have been carried out dealing with residues of these molecules that reach different environmental compartments, this taking place by means of wastewater or other materials being disposed or spread contained in a variety of liquids or solid wastes, as those used as organic fertilizers (Akenga et al., 2021; Kumar et al., 2021; Nannou et al., 2020).

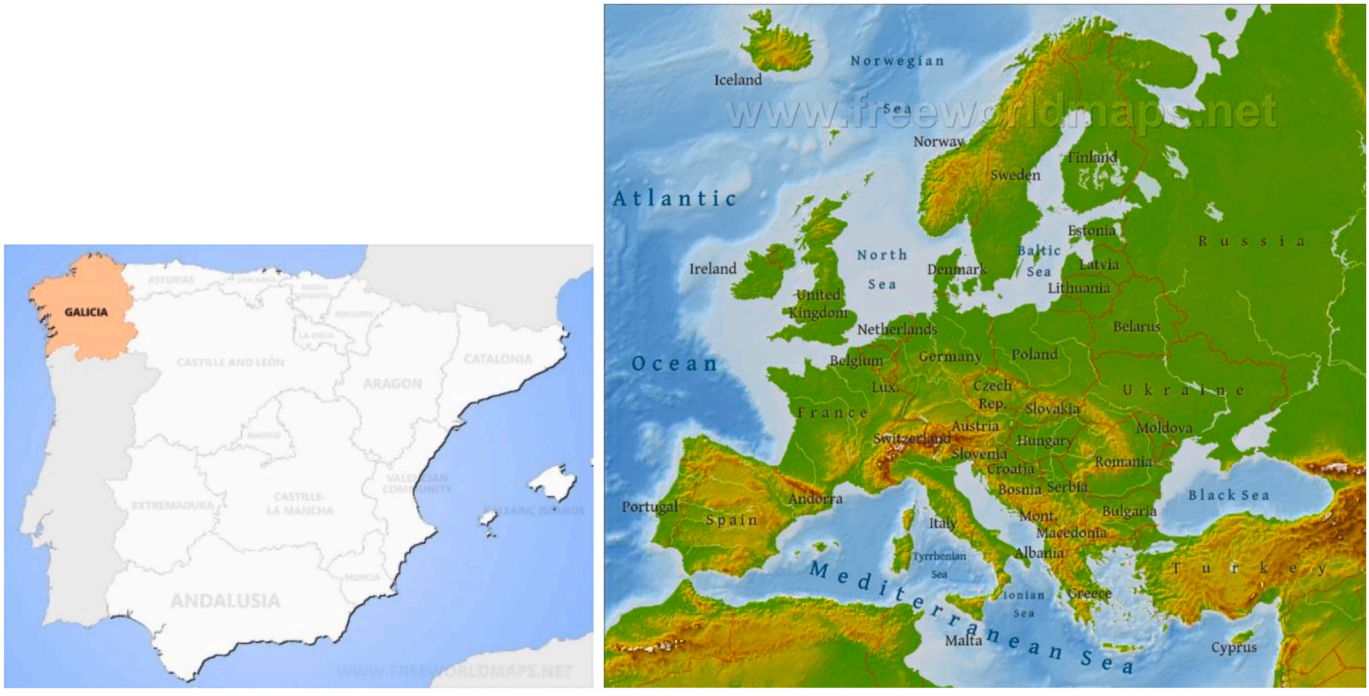

Fig. 1. Map of Galicia showing its placement into the Iberian Peninsula, above Portugal and besides other Autonomous Communities in Spain, and map of Spain, besides Portugal, Andorra, France and other countries in Europe.

Regarding SARS-CoV-2, different research papers have been published studying this virus in the environment, some of them focusing on the situation in Galicia and Spain. Table 1 shows selected publications in this regard.

Our research team has published papers dealing with the situation in specific environmental compartments, as well as with the whole environment. Specifically, a paper by Núñez-Delgado (2020a) showed an overall view as regards the SARS-CoV-2 coronavirus in the environment, whereas Núñez-Delgado (2020b) published the first research paper on SARS-CoV-2 in soils. This publication was complemented with subsequent papers including details and proposals on the study of SARS-CoV-2 in whole soils (Conde-Cid et al., 2020g), and in liquid samples from soils (Conde-Cid et al., 2021b).

In addition, one of the members of the research team has collaborated in a paper previously commented, which dealt with potential impacts of the virus and related therapeutic drugs on aquatic compartments (Race et al., 2020), and has edited special issues on the subject, with two of them already completed (Núñez-Delgado, 2020c; Núñez-Delgado et al., 2021). Also, some of the members of the team are editing a book on the matter, as well as preparing chapters and further publications dealing with epidemic microorganisms in the environment, with special focus on Galicia and Spain.

Other authors have published on SARS-CoV-2 in the environment in Spain. Some of these papers focused on wastewater, as the ones by Fernández et al. (2020), Randazzo et al. (2020a, b), Chavarria et al. (2021), Forés et al. (2021), and Pérez et al. (2021), whereas some other explored atmospheric condition, such as that by Fernández et al. (2021) and Sanchez et al. (2021).

To be remarked that we do not include references corresponding to not-peer-reviewed preprints, but just to peer-reviewed papers. Maybe, some manuscript dealing with SARS-CoV-2 in the environment in Galicia and Spain, currently under review, or published as preprints but needing more research to be accepted in peer-reviewed journals, could give further interesting data in the future. However, at the current moment, some problems, such as data availability or data heterogeneity, could be affecting to investigations under development, or being carried out, as well as to the design of eventual future studies dealing with these research topics.

3. Perspectives and needs regarding future research on this matter

In view of the current situation, with many high-quality researches being published and/or being performed as regards the detection and characterization of SARS-CoV-2 in humans, other living beings, and the environment, as well as focusing on the treatment/prevention of the COVID-19 disease, the authors of this piece think that additional research would be needed on the following aspects.

-Further and extended research would be carried out dealing with the detection/quantification of SARS-CoV-2 in wastewater from increasing number of cities/towns, as early warning tool, taking into account the precepts of wastewater-based epidemiology (WBE), which could be progressively adapted/improved for the current pandemic, as different research teams are doing around the world.

-New research could be programmed/started focusing on the detection/quantification of SARS-CoV-2 in various environmental compartments. Although previous research has been carried out to detect/quantify the virus in various kinds of materials/surfaces, and it is considered that most care must be paid to the spreading of SARS-CoV-2 through aerosols, it should be noted that mutations are taking place, and they could affect not only to human-to-human transmissibility, but also (mostly thinking on eventual future mutations) to between-animal-species transmissions, and/or to facilitating easier/increased transmission through the fecal-oral route, or affecting/modifying the current characteristics of aerosol transmission or solid/liquid-surface mediated transmissions.

Table 1
Some of the main research papers published in Galicia and Spain regarding SARS-CoV-2 in the environment.

Medium	Geographic area	Reference
Overall environment	Galicia, Spain	Núñez-Delgado (2020a)
Soils	Galicia, Spain	Núñez-Delgado (2020b)
Soils	Galicia, Spain	Conde-Cid et al. (2020f)
Soils	Galicia, Spain	Conde-Cid et al. (2021b)
Wastewater	Spain	Fernández et al. (2020)
Wastewater	Spain	Randazzo et al. (2020a)
Wastewater	Spain	Randazzo et al. (2020b)
Wastewater	Spain	Chavarria et al. (2021)
Wastewater	Spain	Forés et al. (2021)
Wastewater	Spain	Pérez et al. (2021)
Atmosphere	Spain	Fernández et al. (2021)
Atmosphere	Spain	Sanchez et al. (2021)

-Further basic research should focus on overall ecological conditions favoring the eventual future spreading of pandemics. Previous research has warning about it, and it is clear that some anthropogenic activities affecting the environment have global relevance in this regard, as they can result in highly increased probabilities of animal-to-human transmission of pathogenic microorganisms that up to now had been restricted to natural habitats, when they had suffered low anthropogenic pressure and modification. In view of that, additional research should be carried out to clearly define global and local actions to be taken in order to avoid/minimize environmental modifications that increase the probability of favoring new pandemics due to coronaviruses, other viruses or any other pathogenic microorganisms.

Credit author statement

All authors have contributed to this manuscript.

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.

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