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## Air pollution and health prevention: A document of reflection

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## ABSTRACT

Ambient air quality, pollution and its implication on health is a topic of enormous importance that is normally dealt with by major specialists in their particular areas of interest. In general, it is not discussed from multidisciplinary approaches or with a language that can reach everyone. For this reason, the Health Sciences Foundation, from its prevention area, has formulated a series of questions to people with very varied competences in the area of ambient air quality in order to obtain a global panorama of the problem and its elements of measurement and control. The answers have been produced by specialists in each subject and have been subjected to a general discussion that has allowed conclusions to be reached

on each point. The subject was divided into three main blocks: external ambient air, internal ambient air, mainly in the workplace, and hospital ambient air and the consequences of its poor control. Along with the definitions of each area and the indicators of good and bad quality, some necessary solutions have been pointed out. We have tried to know the current legislation on this problem and the competences of the different administrations on it. Despite its enormous importance, ambient air quality and health is not usually a topic of frequent presence in the general media and we have asked about the causes of this. Finally, the paper addresses a series of reflections from the perspective of ethics and very particularly in the light of the events that the present pandemic raises. This work aims to provide objective data and opinions that will enable non-specialists in the field to gain a better understanding of this worrying reality.

**Keywords:** Ambient air, quality, public health, nosocomial infection, invasive aspergillosis, measurement systems, respiratory infections.

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## Calidad del aire ambiente y prevención de la salud: Un documento de reflexión

### RESUMEN

La calidad del aire ambiente y su implicación en la salud es un tema de enorme importancia que normalmente es tratado por grandes especialistas en sus particulares áreas de interés. En general, no es discutido desde enfoques multidisciplinares ni con un lenguaje que pueda llegar a todos. Por ese motivo, la Fundación de Ciencias de la Salud desde su área de prevención, ha formulado una serie de preguntas a personas con competencias muy variadas en el área de la calidad del aire ambiente para obtener un panorama global del problema y de sus elementos de medida y control. Las respuestas han sido producidas por especialistas en cada tema y han sido sometidas a una discusión general que ha permitido alcanzar conclusiones en cada punto. El tema ha sido dividido en tres grandes bloques: el aire ambiente externo, el aire ambiente interno, principalmente en el medio laboral, y el aire ambiente hospitalario y las consecuencias de su mal control. Junto con las definiciones de cada área y los indicadores de buena y mala calidad, se ha apuntado a algunas necesarias soluciones. Hemos tratado de conocer la legislación vigente sobre este problema y las competencias de las distintas administraciones sobre el mismo. Pese a su enorme importancia, la calidad del aire ambiente y la salud no suele ser un tema de frecuente presencia en los medios de comunicación generales y hemos preguntado sobre las causas de ello. Finalmente, el documento aborda una serie de reflexiones desde la perspectiva de la ética y muy particularmente a la luz de los acontecimientos que la presente pandemia plantea. Este trabajo pretende aportar datos objetivos y opinión que permitan a los no especialistas en el tema conocer mejor esta preocupante realidad.

**Palabras clave:** Aire ambiente, calidad, salud pública, infección nosocomial, aspergilosis invasora, sistemas de medición, infecciones respiratorias

### INTRODUCTION

Air quality is a subject of unquestionable interest for the population, for health authorities, for scientists and technicians involved in one way or another and, consequently, for the political world. However, its complexity, its multiple technical aspects and the different approaches to this subject from different fields mean that an overall view is often lacking. The quality of external ambient air does not necessarily follow the same parameters as in the working environment, and hospital air problems have specific consequences that are not always understood from outside the healthcare world.

Very often, experts in one of these aspects ignore the quality parameters and the consequences of their lack of control in areas other than their own.

For this reason, the Health Sciences Foundation, from its area of prevention, has motivated a multidisciplinary meeting so that different experts in some of the many facets of air

quality control, could answer questions, apparently elementary, but not always known by all, that would help to better understand this issue and its very serious implications for the health of all.

The different authors responded in writing to the questions posed to them, shared the information with the rest of the participants and conclusions were reached after the discussion of each topic.

The following document is the result of these activities and we have divided it into 3 thematic areas: ambient air in the community, ambient air in the workplace and ambient air in the hospital environment.

### FIRST BLOCK: AMBIENT AIR IN THE COMMUNITY

#### WHAT IS THE RELATIONSHIP BETWEEN OUTDOOR AIR POLLUTION, DISEASE AND MORTALITY?

##### Bernardino Alcázar Navarrete

Environmental pollution is a global threat that has high impacts on human health and ecosystems, with emissions and concentrations that have been progressively increasing in recent years around the world. Air pollution is currently considered the most important environmental risk factor for human health and is a leading cause of premature death and disease [1-3]. In Europe, air quality remains below the level considered optimal in many areas despite efforts to reduce emissions and air pollutants [4].

The effects of air pollution on human health include primarily premature deaths from cardiovascular disease, including ischemic heart disease and cerebrovascular disease, followed by deaths due to respiratory disease and lung cancer. In addition, both short- and long-term exposure to air pollution can lead to reduced lung function, increased individual susceptibility to respiratory infections, and aggravation of bronchial asthma. On the other hand, exposure to environmental pollutants is associated with negative impacts on fertility, pregnancy, newborns, and children.

Different studies have shown a consistent association between levels of environmental pollution and all-cause mortality and also specific mortality due to cardiovascular or respiratory disease, both in the short and in the medium and long term. In an international study involving more than 600 cities around the world, exposure to 10  $\mu\text{g}$  increases in mean suspended particulate matter (PM) concentrations [5] was associated in the short term with an increase in overall, cardiovascular and respiratory mortality. Similarly, increases of the same magnitude in mean daily PM were also associated with increases in overall, cardiovascular and respiratory mortality.

Air pollution is also associated with increases in long-term mortality in the European population. Within the ESCAPE (European Cohort Study for the Effects of Environmental Pollution) initiative, this effect was analyzed using data from

22 European cohorts, with an average follow-up of 13.9 years, showing an effect of PM on mortality (7% increased risk of death per 5  $\mu\text{g}/\text{mm}^3$ ). These effects were also observable if data were selected from participants with exposure levels below the thresholds recommended by the authorities [4].

In Spain, the most recent available data indicate that 15.3% of the Spanish urban population is exposed to levels of ozone ( $\text{O}_3$ ) above the EU recommended standard, 3.6% of the population is exposed to levels of nitrogen dioxide ( $\text{NO}_2$ ) above the recommended standard and 0.1% is exposed to excessive levels of PM. It is true that exposure to these environmental pollutants has undergone a progressive decrease in the last decade thanks to the efforts of different governments, but there is still work to be done.

According to the data consulted for 2018, estimates tell us that in Spain there were 23,000 premature deaths due to exposure to PM, 6,800 premature deaths attributable to  $\text{NO}_2$  and 1,800 deaths attributable to  $\text{O}_3$ , which would give us a total of 31,600 premature deaths attributable to environmental pollution in a year.

In addition to these data, environmental pollution, as previously mentioned, is responsible for the loss of years of life derived from its effects both in the short and long term. It was estimated for 2018 a loss of more than 350,000 years of life in the Spanish population attributable to environmental pollution, derived from 254,700 years of life lost due to PM, 75,400 years of life lost due to  $\text{NO}_2$  and 20,600 years of life lost due to  $\text{O}_3$ . In population-adjusted terms, these losses would be 573, 170 and 46 years of life/100,000 inhabitants for PM,  $\text{NO}_2$  and  $\text{O}_3$ , respectively.

## CONCLUSION:

**The impact of environmental pollution on the health of the population is indisputable, both in the short and long term, with increases in mortality due mainly to cardiovascular and respiratory causes, in addition to other health effects that can have repercussions on the quality and duration of life.**

## HOW DO WE DEFINE WHAT IS AN OUTDOOR AIR OF GOOD QUALITY? WHAT ARE THE CRITICAL PARAMETERS IN OUTDOOR AMBIENT AIR QUALITY CONTROL? WHAT MEASURES SHOULD BE TAKEN TO IMPROVE OUTDOOR AIR QUALITY?

### Xavier Querol Carceller

An air pollutant is any substance present in the air that may have harmful effects on human health, the environment or property of any nature. The increase in the concentration of atmospheric pollutants in outdoor ambient air (street, parks, industrial, rural, and remote areas) causes deterioration of air quality. This deterioration occurs at different scales. Thus, in cities, emissions of urban, industrial, and domestic pollutants have an impact on air quality in the same area where they are

emitted. On the other hand, cities and rural and remote areas can see their ambient air deteriorated by the transport of pollutants produced tens, hundreds or even thousands of kilometers away. Examples include tropospheric ozone, acid rain or incursions of Saharan dust masses. The critical WHO normative target pollutants are particulate matter ( $\text{PM}_{10}$  and  $\text{PM}_{2.5}$ ), nitrogen dioxide ( $\text{NO}_2$ ), tropospheric ozone ( $\text{O}_3$ ) and Benzo(a)pyrene (BaP). Any pollutant that has a WHO normative reference value should be kept below the reference values.

The latest study on "The global burden of disease", published in The Lancet, concludes that exposure to polluted air is the fourth leading risk factor for mortality on a global scale, behind high blood pressure, smoking and inadequate diet. This impact also has another associated economic effect, estimated by the World Bank at 4% of global GDP [5,6].

The European Environment Agency [7] quantifies the annual premature deaths in the European Union due to exposure to  $\text{PM}_{2.5}$  at 374,000, and recalls that in 1990 this impact reached one million. The same Agency states that 74% of the European population breathed outdoor air that exceeded the WHO guideline value for this pollutant. The maximum levels of  $\text{NO}_2$  are not complied with in some of our cities and the Agency estimates that 54,000 premature deaths per year are attributable to its impact on health. With regard to  $\text{O}_3$  levels, 70% of the Spanish territory does not comply with the normative target values for human health and 99% of the population of the Europe of -28 breathes outdoor air with concentrations above the WHO guideline level. Finally, BaP is highly carcinogenic, and its levels have increased with the use of agricultural, domestic and residential biomass burning.

In a typical Spanish city, road traffic contributes 70% of the  $\text{NO}_2$  breathed by its citizens. And within the traffic about 90% of this contribution is due to diesel vehicles, especially those prior to 2019. In the case of  $\text{PM}_{2.5}$ , road traffic is also responsible for 30% of the  $\text{PM}_{2.5}$  and  $\text{PM}_{10}$  we breathe, and not only because of exhaust pipes, but also because of brake and wheel wear. Industry can still contribute 20% of PM, construction sites 10%, ports 5%, .... In the case of BaP, the highest levels recorded in Spain are from rural areas with high domestic-residential and/or agricultural biomass burning. Finally,  $\text{O}_3$  is the most complex pollutant. It is secondary (not emitted by emission sources but formed in the atmosphere from reactions between  $\text{NO}_2$  and volatile organic compounds), so to reduce its levels it is necessary to act on its precursors, although knowing how to do this is still scientifically and politically complex. In addition, there are unregulated pollutants, such as ultra-fine particles (those smaller than 0.1 microns) and black carbon (the product of the imperfect combustion of fossil fuels or biomass), which have a high impact on health and, in the opinion of a large part of science, deserve to be regulated. In both cases their main source in urban areas is road traffic.

To improve air quality, the most environmentally advanced cities (Scandinavian, Swiss, Canadian, Australian) have for years implemented measures that have enabled them to record the lowest pollution levels in the urban world, but also in rural areas, where air quality problems can also occur. It is

important to note that air quality is a characteristic of a society, and that the most cultured and advanced societies have the best conditions in this regard.

In the case of  $\text{NO}_2$ , measures have focused on reducing the number of metropolitan vehicles circulating by means of [8]

- 1) well-developed, fast, economical and comfortable metropolitan and urban public transport;
- 2) reduction of the number of urban vehicles circulating through urban tolls and restriction of outdoor parking to residents only;
- 3) low emission zones that do not allow the circulation of the most polluting older vehicles and favor the most eco-efficient ones;
- 4) efficient logistics of urban distribution of goods and cabs (reducing the number of trips through intelligent logistics, night-time deliveries, hybridization and electrification of vehicles, ...); and
- 5) urban redesign to gain space for the vehicle in favor of green and pedestrian areas, and to separate traffic from hospitals, schools, primary care centers, geriatric centers, playgrounds, etc.)

For  $\text{PM}_{2.5}$ , these measures may be partially effective, but measures have also been taken on industrial emissions, ports, airports, construction-demolition and domestic and residential emissions. Thus, for both  $\text{PM}_{2.5}$  and BaP, low emission certification for biomass boilers and the use of certified biomass (natural origin, low humidity and ash) is mandatory [9].

For  $\text{O}_3$  the situation is more complex [10, 11], measures should be taken not only at the urban level but also at the regional, national and European levels, in terms of reducing emissions of precursors ( $\text{NO}_2$  from traffic, industry and electricity generation mainly) and volatile organic compounds (traffic and industry mainly, but also from the use of cleaning products, paints, resins, ...).

## CONCLUSION:

**The critical pollutants are suspended particulate matter ( $\text{PM}_{10}$ , and  $\text{PM}_{2.5}$ ), nitrogen dioxide ( $\text{NO}_2$ ), tropospheric ozone ( $\text{O}_3$ ) and Benzo(a)pyrene (BaP).**

**Control measures have focused on reducing the number of metropolitan vehicles circulating, but measures have also been taken on industrial emissions, ports, airports, construction-demolition and domestic and residential emissions.**

**HOW DOES AIR POLLUTION AFFECT MORE THAN JUST CARDIOVASCULAR AND RESPIRATORY DISEASES? IS THERE A RELATIONSHIP BETWEEN COVID-19 AND AIR POLLUTION? WHY IS NOISE POLLUTION NOT CONSIDERED AS PART OF AIR POLLUTION?**

Cristina Linares Gil

According to the World Health Organization (WHO), 90% of the world's population currently lives in areas where environmental pollution levels acceptable for health protection are exceeded [12]. Historically, air pollution has been linked to respiratory and cardiovascular health problems, but every day more and more studies are published on the impact on other organs. In 2013, the IARC (International Agency for Research on Cancer) classified air pollution as a major carcinogen [13] and in 2018 a review study was already published with data from different cohorts in Europe linking air pollution to breast cancer [14], especially with  $\text{NO}_2$ . Other studies [15] have also pointed out that there is an association between  $\text{PM}_{2.5}$  concentrations and mortality from cancer of any origin and especially in the upper digestive tract. Pollution is also related to endocrine diseases such as diabetes. The study by Alderete et al. [16] summarizes the scientific evidence that air pollution is a new risk factor for various metabolic dysfunctions and type 2 diabetes.

At the behavioral level, air pollution is also related to the risk of anxiety and depression. A study conducted in Barcelona, between 2013-2014, shows increased cases of depression and use of medications such as benzodiazepines and antidepressants as the levels of exposure to air pollutants increase [17]. Air pollution has also been linked to cognitive ability in adults. A review of studies linking air pollution and Parkinson's disease establishes that exposure to  $\text{NO}_2$ , CO and  $\text{O}_3$  may increase the risk of Parkinson's disease [18] and a study carried out in Madrid shows that hospital admissions for Alzheimer's disease increase in relation to  $\text{PM}_{2.5}$  concentrations [19].

Of particular importance is the impact of air pollution on children's health. There is growing evidence that exposure to air pollutants during periods of fetal life and infancy can have very long-term effects. Health impacts occur even at lower pollutant concentrations than in adults [20] because of the vulnerability of the accelerated cellular growth that occurs at this stage for the formation of the nervous, reproductive and endocrine systems [21] among others; as well as the fact that the physiological pathways are metabolically more immature and the mechanisms of elimination of exogenous compounds from the organism are also less developed and less effective. Exposure of children to  $\text{O}_3$  and PM is associated with an increased likelihood of bronchitis and other respiratory diseases in the postnatal stage, while intrauterine exposure to nitrogen dioxide and particulate matter has significant negative effects on fetal growth and anthropometric parameters at birth [22,23]. On the other hand, COVID-19 and the mobility limitations established to try to contain its spread during the period of confinement in Spain, have led to a decrease in pollutant emissions. This reduction has been of more than 50% in  $\text{NO}_2$  emissions and almost 20% in  $\text{PM}_{10}$  emission [24]. As to whether air pollution may be a risk factor in the transmission of the SARS-CoV-2 virus, two hypotheses are currently being considered, both of which are complementary:

a) It is being investigated whether the polluting particles themselves are capable of viably transporting the new virus, as has been demonstrated in previous studies with other ty-

pes of biological material: bacteria, viruses, fungi and pollen grains [25]. The explanation for this mechanism can be found in recent research according to which particulate matter may act as a vector for the spread of the disease [26-28]; places with higher concentrations of  $PM_{10}$  would be associated with regions with a higher number of COVID-19 cases. This same study, but more extended, has found traces of SARS-CoV-2 RNA in PM samples measured in both industrial and urban environments. The hypothesis is based on the fact that aerosol particles containing the virus of between 0.1 and  $1\mu m$  can travel farther when bound to pollutant particles of up to  $10\mu m$  as the resulting particle is larger and less dense than a respiratory droplet, so it could increase its residence time in the atmosphere.

b) The second hypothesis focuses on the increased cardio-respiratory vulnerability of people who are regularly exposed to high levels of pollution in cities. According to the WHO, 1 in 7 patients with COVID-19 suffer respiratory difficulties and other serious complications [29] and to date, factors associated with COVID-19 mortality include: advanced age (higher risk in >65 years) and the presence of comorbidities, including hypertension, diabetes, cardiovascular and cerebrovascular disease. Also documented in relation to this new disease are: vascular inflammation, myocarditis and cardiac arrhythmias.

Finally, it is important to note that air pollution includes both traditional chemical air pollution and pollen pollution as well as thermal, light, electromagnetic and, of course, noise pollution. Although when air pollution is almost always referred to as chemical pollution, in an urban environment and from the point of view of its impact on health, chemical pollution is just as important as noise pollution [30].

## CONCLUSION:

**Environmental pollution is a major carcinogen, is a risk factor for various metabolic dysfunctions such as type 2 diabetes, increases the risk of anxiety and depression, and influences fetal and neonatal health.**

**It was initially hypothesized that particulate matter could act as a viable transport vector for SARS-CoV-2, although recent research does not appear to support this hypothesis. It is important to note that air pollution includes both traditional chemical and pollen pollution as well as thermal, light, electromagnetic and noise pollution.**

## HOW IS THE DETECTOR NETWORK IN SPAIN? ARE THERE DIFFERENCES BY AUTONOMOUS COMMUNITIES? IS IT SUFFICIENT?

### Miguel Angel Gil Amigot

The Network of Environmental Pollutant Detectors in Spain is based on a system of monitoring stations equipped with sensors and automatic analyzers distributed in representative locations by zones affected by air quality. This zoning serves to group areas with similar characteristics or homogeneous

behavior in relation to air quality and environmental pollutant thresholds [31].

The determination of the different zones and the location of each control and monitoring station is the responsibility of the Autonomous Communities (CCAA). In addition to the network controlled by the Autonomous Communities, there are two other types of monitoring networks. On the one hand, the state network managed by the Spanish Meteorological Agency (AEMET), which is responsible for measuring air quality in remote rural environments and aims to obtain information on transboundary and background pollution in order to comply with current regulations [32]. On the other hand, the network of detectors controlled by local entities or municipalities is developed in order to monitor the main pollutants in certain locations.

In addition to the air quality homogeneity criteria, the air quality legislation, Royal Decree 102/2011 on air quality improvement, requires the Autonomous Regions to justify the division of the zones considering a certain population density and a common ecosystem in each one of them. As an example, the Autonomous Community of Aragon follows a methodology for zoning its territory [33]. On the one hand, the historical air quality data from the detector stations is studied, comparing the data from different stations, the meteorological factors of each area and the topography of the territory. Once the data for the territory has been obtained, measures are taken to ensure that the characteristics in terms of air quality and geography are the same in each area and to delimit as far as possible the areas where there is a high level of concentration (since the restrictions required by law are greater).

All the monitoring stations of the regional and local network in Spain measure the concentrations of gaseous pollutants ( $NO_2$ ,  $O_3$ ,  $CO...$ ) and particulate matter ( $PM_{2.5}$ ,  $PM_{10}$ ) in the air that are harmful to health and the environment. It is a monitoring network with more than 600 fixed measurement stations in which a wide variety of pollutants are recorded and controlled to estimate the risks and associate the effects on health resulting from exposure to various pollutants in each area of the Spanish territory [34-36].

Stations can be classified by type of area and by type of main pollutant influencing the site. In relation to the type of area, the station can be urban, if it is placed in areas that are continuously built-up; suburban, if it is in places where there is no continuous building and there are separations from lakes, forests, parks...; or rural, when it does not meet any of the previous criteria. On the other hand, in relation to the type of pollutant influencing the zone, it can be classified as a traffic station, if the main pollutant in the zone is vehicle emissions; industrial, when the emission comes from industry; or background, when no predominant emission is detected.

The reason why each zone is evaluated by means of a number of stations and a type of station determined by each Autonomous Community is justified by the impossibility of measuring air quality at all points of the territory. In line with this reasoning, it is true that the location of the monitoring and control stations in each area of Spain can be a determining factor

in the measurement of the levels of certain pollutants. That is to say, it is not the same to place a traffic station very close to one of the busiest and most congested roads in a large city where it is obvious that very high concentrations of pollutants will be registered (for example, NO<sub>2</sub> emissions from vehicles will be directly registered in these stations), than to build the station in a place further away from traffic and high congestion in that same city. Since there is no specific standard related to the exact location of station placement, it is very difficult to reflect the reality of variations in pollutant exposure levels.

Finally, it should be noted that although each Autonomous Community divides its territory into air quality assessment zones, in the end, Spanish legislation requires a series of criteria for the division of the zones. It is true that in the most populated and busiest cities in Spain, where the highest levels of pollution are detected, i.e. Madrid, Barcelona and Valencia, a greater number of control stations are concentrated and more rigorous action plans and protocols are developed to obtain the values allowed by law.

#### CONCLUSION:

The air quality monitoring network in the national territory is correctly distributed in cities and towns and it is sufficiently sophisticated for the detection of environmental pollutants. They send, in real-time, the results recorded for the preparation of evaluation reports and implementation of plans for the reduction of pollutants in the environment, although it is true, that there is room for improvement at least as far as unification of criteria is concerned.

#### WHAT DISEASES ARE DIRECTLY RELATED TO AIR POLLUTION?

##### Isabel Urrutia

Recent work indicates that the health impact attributable to air pollution is substantially higher than previously assumed, and estimates excess mortality attributed to air pollution at 790,000 deaths per year in Europe alone (Figure 1). Although air pollutants can damage virtually every organ in the human body, it is cardiovascular and respiratory diseases that cause the most deaths. It is estimated that around 500,000 lung cancer deaths and 1.6 million COPD deaths worldwide can be attributed to air pollution. In Spain, it is estimated that there are more than 5,000 deaths per year from ischemic heart disease, more than 2,000 from strokes, almost 3,000 from COPD, 1,216 from pulmonary neoplasms and more than 1,000 from lower respiratory tract infections that would not occur if we did not breathe polluted air.

COPD is characterized by persistent airflow limitation associated with chronic inflammation of the airways and lungs in response to exposure to particles and gases. Active smoking remains the main risk factor, but other factors are increasingly well known, such as occupational exposures, infections and

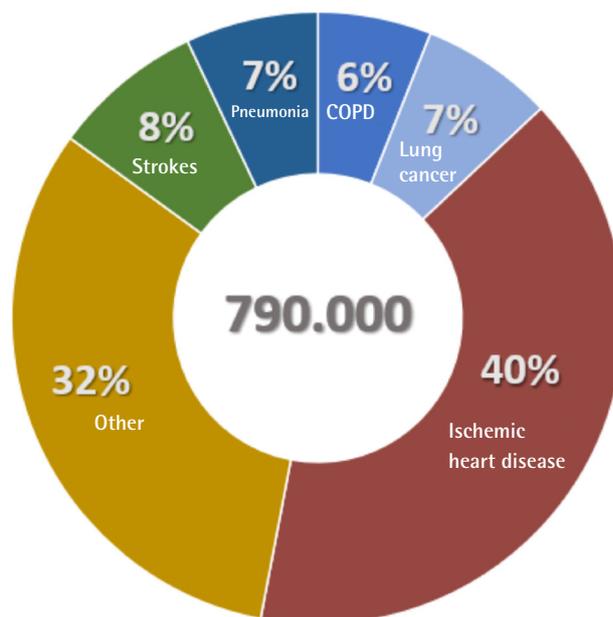


Figure 1 | Deaths per year in Europe due to air pollution

the role of air pollution. COPD is the fourth leading cause of death both in Spain and worldwide, and it is estimated that in the coming years it will climb one more place in this fateful ranking [37]. Worldwide prevalence is estimated at 11.7% with very high underdiagnosis rates that may exceed 70%.

COPD patients are more vulnerable to the effects of air pollution. The main mechanisms underlying the adverse health effects of environmental exposure to pollutants are related to oxidative stress and inflammation. Apart from the fact that particulate matter can move into the bloodstream and create vascular dysfunction with potential systemic effects that decompensate the frequent cardiovascular comorbidities of these patients, oxidative stress related to air pollutants can directly damage the airway epithelium and alter the immune response. At present, there is sufficient scientific evidence to consider environmental pollution as a direct cause of COPD. This is reflected in the favorable positioning of the main clinical practice guidelines for the management of COPD, both national and international [38-40]. Ambient concentrations of particulate matter (PM) and nitrogen dioxide (NO<sub>2</sub>) have been associated with an increased prevalence of COPD. For example, a higher year-round average PM<sub>2.5</sub> concentration has been associated with an increased prevalence of COPD with an adjusted odds ratio (OR) of 2.4 for concentrations between 35 and 75 µg/m<sup>3</sup> and 2.5 for concentrations above 75 µg/m<sup>3</sup>, respectively, compared with the lower limit of 35 µg/m<sup>3</sup>. However, this etiological role is even more evident if we consider indoor air pollution. We spend about 90% of our time indoors, so the atmosphere in these spaces is very important for our health. Some 3 billion people cook and heat their homes with open fires and stoves burning biomass (wood,

animal dung or agricultural waste) and charcoal. This practice occurs mainly in developing countries. Each year, more than 4 million people die prematurely from diseases attributable to household air pollution and COPD accounts for 20% of these deaths. Thus, environmental pollutants become the main cause of COPD in some regions of the world among certain population groups, such as women with limited economic resources in some areas of Southeast Asia.

Environmental pollution has also been recognized as a precipitating factor in COPD exacerbations, which accelerate the deterioration of respiratory function, contribute to increased mortality and significantly increase healthcare costs. In the case of the COVID pandemic, we know that SARS-CoV-2 is spread through the air by so-called Flugge droplets. Particles smaller than 5 $\mu$  can remain in the air even for hours and spread far away. Some authors have described that PM can both increase transmission distance and infectivity in the aerosol with a "booster" effect.

The impact that air pollution has on the extent and prognosis of COVID-19 remains to be elucidated. In a recent study conducted in China between January and February 2020 they observed a positive association between two-week PM<sub>2.5</sub>, PM<sub>10</sub>, NO<sub>2</sub> and O<sub>3</sub> levels and confirmed new cases of COVID-19. The authors observed that each 10g/m<sup>3</sup> (lag 0-14 days) increase in these pollutants was associated with an increase in new confirmed cases of 2.24%, 1.76%, 6.94%, and 4.76%, respectively.

Italy was another of the major victims of the beginning of this pandemic in Europe. Several Italian authors have stressed that the high spread of COVID in some areas of Northern Italy could be linked to environmental conditions. In addition, the suspended particles, composed of solid and liquid particles, allow the virus to float in the air for longer and over longer distances. In fact, the spread of SARS-CoV-2 infection is found to increase in areas with higher relative humidity while it decreases in warmer climates.

## CONCLUSION:

**Ambient air pollution is estimated to cause 790,000 deaths per year in Europe. In addition to cardiovascular diseases, the relationship between environmental pollution and Chronic Obstructive Pulmonary Disease is essential. There is also speculation about the relationship between environmental pollutants and a better vehiculation of SARS-CoV-2 particles over longer distances.**

## SECOND BLOCK: INDOOR AMBIENT AIR QUALITY IN THE WORKING ENVIRONMENT

**HOW DO WE DEFINE INDOOR ENVIRONMENTAL QUALITY? WHAT IS THE EFFECT OF AEROSOLS ON SARS-CoV-2 TRANSMISSION? WHAT MEASURES ARE MOST EFFECTIVE IN REDUCING AEROSOLS?**

Francisco Vargas Marcos

Indoor Environmental Quality (IQ) is defined in the UNE 171330:2008 Standard [41] as "Indoor environmental conditions, appropriate to the user and the activity, defined by the levels of chemical and microbiological contamination and by the values of physical factors". Without good IAC, the risk of numerous diseases such as COVID-19 increases. We spend between 80-90% of our time in indoor environments for work, home, education, sports or leisure. During the COVID-19 pandemic this percentage has risen and has highlighted the importance of living in healthier and safer enclosed spaces that prevent airborne transmission of SARS-CoV-2. Humans generate aerosols or bioaerosols that have been defined elsewhere [42]. It can be stated that SARS-CoV-2 is viable as an aerogenic pathogen continuously emitted with respiration. Its quantity increases when we suffer from respiratory diseases and when we force our voice when speaking, singing or shouting. For these reasons, the transmission of respiratory diseases inside poorly ventilated enclosed spaces can be up to 20 times higher than outdoor transmission. Since the beginning of the pandemic, numerous studies have been published that have observed an increase in the number of outbreaks of COVID-19 caused by aerosols carrying the virus in restaurants, gyms, boats, buses, choirs and other enclosed places with poor ventilation. Several experimental tests on fluid dynamics, aerosol physico-chemistry, permanence, SARS-CoV-2 viability, infective capacity (16 hours), have alerted to the importance of aerosol transmission and the need to apply prevention and control measures in closed, poorly ventilated and crowded spaces [43-46].

This evidence challenged the classical routes of transmission of respiratory diseases accepted by WHO and the scientific community. New knowledge on respiratory emission dynamics indicates that respiratory droplets can reach, under specific conditions, 7-8 meters. Their acceptance has important implications for improving respiratory protection mask design, social distancing recommendations, prevention strategies in air conditioning installations and other public health recommendations.

But to prevent airborne SARS-CoV-2 transmission, the first step was for health authorities, agencies and organizations to accept the published evidence on the role of aerosols in COVID-19 transmission, overcoming political fears of public reaction, the media, opinion polls and social networks. It is clear that there has been a delay in recognizing the impact of air on COVID-19 transmission and in making decisions on the most effective measures for implementation.

Legitimate and justified calls have been published to evaluate how the pandemic has been managed, to learn from mistakes, to provide the necessary resources for research, to improve epidemiological surveillance systems and public health services. However, it should be noted that it is common for too much time to elapse between the publication of solid evidence, its majority acceptance by the scientific community and finally its application by the competent authorities in Public Health or health professionals with respect to a preventive measure, drug, medical or surgical technique.

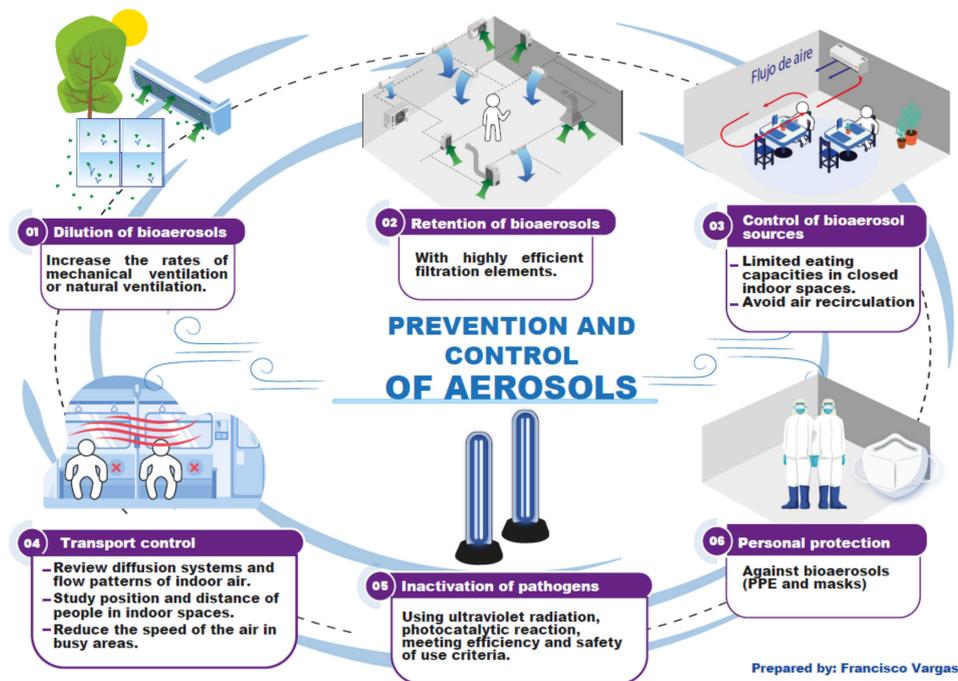


Figure 2 Prevention and control of pathogen transmission by aerosols.

One of the first articles published in our country calling for airway prevention measures was a review of scientific evidence on the transmission of SARS-CoV-2 by respiratory droplets, contaminated objects and aerosols [47]. This document served as the basis for the Ministry of Health to promote the drafting of a technical document containing the Recommendations for the operation and maintenance of air conditioning and ventilation systems to prevent the spread of SARS-CoV-2 [48].

The ECDC [49], WHO [50] and American CDC [51] have accepted the evidence of SARS-CoV-2 transmission via aerosols, proposed measures to reduce the risk of exposure to aerosols and described the role played by heating, ventilation and air conditioning systems. In the light of the new evidence, they admit the possibility that in certain indoor environments with many people who do not keep a safe distance, without facial protection, in closed and poorly ventilated spaces, airborne transmission combined with droplet (large) and contact transmission may occur.

Subsequently, the Spanish Ministry of Health published a technical document supported by experts and several SSCCs specialized in aerosols that recognizes the importance of airborne transmission and proposes prevention measures [52].

#### Summary of recommendations for the prevention of SARS-CoV-2 transmission by aerosols.

Preventive measures to avoid SARS-CoV-2 virus transmission should follow a combined strategy of protective measures,

so that the combined use of more than one measure achieves better protection. No single protective measure is 100% effective on its own in preventing transmission. At present, the scientific evidence on the effectiveness of each measure in relation to SARS-CoV-2 is still limited and must be weighed against the risks and feasibility associated with its implementation. Figure 2 summarizes the measures for the prevention of SARS-CoV-2 transmission.

#### 1. Dilution of bioaerosols.

- Increase ventilation rates with mechanical ventilation equipment or natural ventilation by opening windows.

#### 2. Retention of bioaerosols.

- Use of filtration elements with high filtration efficiency.

#### 3. Control of sources of bioaerosols.

- Reduce occupancy rates and time spent in the premises. Maintain interpersonal distance.
- Avoid recirculation of air in air conditioning equipment.
- Use of face masks in enclosed areas when social distancing measures cannot be applied.

#### 4. Control of bioaerosol transport.

- Control of the air diffusion system and indoor air flow patterns.
- Study the position and distance of people in indoor premises. Avoid air flows coming from another person.

- Reduce air velocity in the occupied area. Avoid air currents between people in the breathing zone.

#### 5. Inactivation of pathogens in bioaerosols.

- Use of germicidal equipment of physical action that can contribute to reinforce the hygiene of the indoor environment. With two conditions for their use:
  - 1) Scientific evidence of the effectiveness of the system against SARS-CoV-2 virus.
  - 2) The dose applied and the residues resulting from its application do not pose any risk to people.

#### 6. Personal protection against bioaerosols.

- Use masks with adequate filtration capacity to avoid transmission from/to other persons. Use of PPE in the work environment.

### CONCLUSION:

**Indoor Environmental Quality (IQ) is defined in the UNE 171330:2008 Standard. Since the onset of the COVID-19 pandemic, numerous studies have been published that have noted an increase in the number of COVID-19 outbreaks caused by aerosols in restaurants, gyms, boats, buses, choirs, and other enclosed places with poor ventilation. The Spanish Ministry of Health published a document proposing measures to prevent the transmission of SARS-CoV-2 by aerosols.**

### WHAT IS THE RELATIONSHIP BETWEEN OUTDOOR AND INDOOR POLLUTION? WHAT ARE, BROADLY SPEAKING, THE MEASURES TO MAINTAIN HEALTHY AIR IN THE WORK ENVIRONMENT? CAN THESE MEASURES BE APPLIED TO COVID-19 PREVENTION?

#### Teresa Álvarez Bayona

WHO estimates that 3.8 million deaths occur annually from diseases attributable to indoor air pollution often caused by the use of inefficient solid fuels [53]. In countries such as Spain, people spend between 60% and 80% of their time indoors [54] and the effects of polluted indoor air accumulate in the body regardless of where the pollution occurs. CO<sub>2</sub> is a pollutant that serves as an indicator of indoor air quality associated with human activity. Its use requires reference to the outdoor concentration [55] since in reality, outdoor air is neither "clean" nor "fresh".

The technical measures for the control of indoor air will be aimed at controlling the risks related to the environment: reduce the emission of the source, prevent or reduce its spread through the air and, finally, act on people. When the source cannot be eliminated, nor can the emission be reduced, it is necessary to screen the source. It is a measure whose objective is to interpose a physical barrier that reduces the emission of the pollutant into the air [56].

The next group of measures is aimed at acting on the en-

vironment. The most effective measure is ventilation, whether natural, mechanical or mixed. The objective is that, indoors, the "polluted" air is renewed at an adequate rate. As the most effective and cheapest ventilation is natural ventilation, preferably cross ventilation, it should be chosen whenever it is feasible and sufficient [57]. Sometimes, the programming and adjustments of the air conditioning systems should be directed to a greater contribution of outside air flow. The use of appropriate filters for the recirculated air fraction and their maintenance are other key aspects [57].

The latest technical measures in the preventive field are aimed at acting directly on the worker. Many of them coincide with the measures aimed at controlling the source, since the workers to be protected must also be considered as possible sources.

Focusing on the throbbing problem of SARS-CoV, this virus identified in 2019 belongs to the *Coronaviridae* family [58] and its transmission route and behavior is similar to that of other viruses of the same family [59]. It is transmitted by nasopharyngeal secretions through droplets of more than 5 microns and by aerosols from human respiration [60]. In other words, if the focus is avoided, the "contamination" is eliminated. The most direct way is to prevent people from coming to the workplace, for example, by teleworking. As this is not always possible, exposure should be reduced, even if the risk is not eliminated, and measures should be taken to distance and minimize contact. In this case, the barrier is the mask, and the better its efficiency and fit, the lower the emission of aerosols into the environment. There are autonomous governments that have made it compulsory to wear the mask at all times in the workplace [61].

Some studies suggesting the viability of SARS-CoV-2 in aerosol form during three hours [58]. This is the reason for recommendations such as ventilating before entering workstations. But not all spaces have windows or elements that ensure proper air renewal. One situation that occurred at the beginning of the pandemic was to consider fans that remove air as a substitute. Their effect is the opposite: instead of providing "clean" air, they recirculate and concentrate pollutants including aerosols. In these cases, it is necessary to resort to mechanical ventilation, which is more expensive and requires specialized expertise. In the case of SARS-CoV-2, distances of 2 meters will be sufficient to avoid droplets, but this is not the case for aerosols. The aerosol has a medium-dependent aerodynamics influenced by temperature, humidity, and air speed. Thus, increasing the relative humidity above 40% affects its aerodynamics in the sense that it favors the precipitation of aerosols and, therefore, hinders their propagation [59].

All these technical measures to control the transmission of the virus through the air do not work unless the behavior of workers is also changed. In medium- and low-risk companies, the main causes of virus transmission have probably been coffee outings, retirement parties or other social events. For employee awareness to be successful, information must be coherent and adjusted to the level of knowledge of the recipient

so that the worker can apply common sense. Unfortunately, these days, this task has been made more difficult due to the contradictory media over-information that has made the general population's opinion on such a specialized and delicate aspect as this one.

#### CONCLUSION:

**WHO estimates that 3.8 million deaths occur annually from diseases attributable to indoor air pollution frequently caused by the use of inefficient solid fuels. Technical measures for indoor air control should be aimed at eliminating or controlling sources of pollutants, decreasing their spread through the air, and increasing and improving ventilation and air renewal, sometimes including the programming and adjustment of air conditioning systems and the use of appropriate filters. SARS-CoV-2 can remain viable in aerosols for three or more hours and therefore distancing and ventilation measures are recommended.**

#### WHAT IS BEING DONE TO REDUCE AIR POLLUTION FROM INDUSTRY, ARE THERE FEASIBLE PLANS, AND CAN RENEWABLE ENERGIES HELP IMPROVE AIR QUALITY?

**Paulino Pastor Pérez**

When we talk about indoor environmental quality, we often reflect that we spend 90% of our time indoors, to better visualize the magnitude of this exposure, let us consider that for a 55 year old person, this means 50 years in an indoor environment, divided between residential, work and leisure exposure, therefore, it is clear that enclosed spaces are the main source of exposure to air pollution.

Indoor air quality is conditioned by outdoor air quality, since the first measure to improve it is to ventilate with fresh outdoor air, the problem is that this air does not always meet the thermal or purity conditions (absence of pollutants) to produce an effective improvement of indoor air, so it is necessary to condition and treat the air by purification and filtration systems before introducing it into indoor environments.

Improving indoor air quality usually involves an energy cost, and that paradoxically produces pollution outside, especially if we do it through energy from fossil fuels, so it is essential to work on the decarbonization of our buildings in such a way that we end up achieving the necessary indoor air quality and thermal comfort without compromising the quality of outdoor air.

Fortunately, renewable energies, in generation (solar, thermal, biomass, etc.) as well as the improvement in the forms of energy consumption (aerothermal, geothermal, etc.) and the reduction of the energy demand of buildings through improvements in the envelope and others, are allowing us to approach a point of balance between healthiness and comfort indoors and neutrality in terms of emissions to the atmosphere by the building stock.

Nowadays, building owners, mainly office buildings, are starting to devote more and more resources to achieving sustainable buildings (environmental certifications such as LEED or BREEAM), but in recent years the importance of healthy and comfortable buildings (WELL certification) is also being emphasized.

The environmental trend in the tertiary sector is clear; however, other building sectors are not yet in line with this trend. Residential buildings, industrial buildings, logistics centers, hotels, transportation centers and even shopping centers are still far from starting the decarbonization process on a massive scale.

If we compare the real estate sector with other energy-intensive areas such as transport (electric vehicles), we can be sure that it is still far behind. The recent incentive plans by the administration will most probably help technologies to start to be implemented, because currently the technology exists, but the main barrier is the availability of financial resources for the rehabilitation of buildings.

#### CONCLUSION:

**Improving indoor air quality usually involves an energy cost, and that paradoxically produces pollution outside, especially if it is done through energy from fossil fuels.**

**It is essential to work on decarbonization by progressing towards environmental certifications such as LEED, BREEAM or WELL.**

#### WHAT IS THE CURRENT SITUATION OF LEGIONELLOSIS IN SPAIN? ARE SUFFICIENT MEASURES BEING TAKEN FOR ITS PREVENTION? WHAT DOES THE LEGISLATION ESTABLISH?

**María Luisa Pedro-Botet**

*Legionella spp.* is an intracellular aerobic Gram-negative bacillus that causes pneumonia in both community and hospital settings in the form of sporadic cases or outbreaks. The *Legionellaceae* family has more than 60 species and more than 70 serogroups of which *L. pneumophila* sg 1 stands out in both the aquatic reservoir and in human pathology.

The term legionellosis refers to the clinical manifestations caused by this microorganism and includes mostly the pneumonic form and, less frequently, a febrile form without pneumonia or "Pontiac fever". The most commonly accepted mechanism of transmission to humans is the inhalation of aerosols emanating from colonized water, sanitary or from cooling systems (cooling towers and cogeneration) although exceptionally aspiration is described after oropharyngeal colonization in hospitalized patients with dysphagia.

According to data published by the European Centre for Disease Control (ECDC), a total of 30 countries reported 11,343 cases of legionellosis in 2018 to the European Survei-

llance system, representing an incidence of 2.2 cases/100,000 inhabitants, the highest recorded in recent years. Among the countries that have declared the most cases, France, Germany, Italy and Spain stand out. In Spain, the number of cases declared in 2018 was 1,513 and the incidence was 3.3 cases per 100,000 inhabitants. In the Spanish territory, cases and outbreaks are monitored by the autonomous communities and notified through the National Epidemiological Surveillance Network (RENAVE) to the National Epidemiological Center of the ISCIII.

Legionellosis mortality in Europe stood at 8% in 2018 and 32 outbreaks have been reported in that year accounting for between 2 and 11 affected per outbreak and of which only 6 have originated in hospital environment.

Climate change, the aging of the population, the eventual deterioration of buildings and their water distribution systems and a greater awareness and sensitivity of countries towards the diagnosis and reporting of legionellosis cases to the ECDC undoubtedly justify the increase in cases and incidence of this disease in Europe.

Current legislation does not provide for any action on air quality in the case of legionellosis and, on the contrary, on the design, operation and maintenance phase of water systems that are the source of Legionella infection in humans. In the case of health centers, the ventilation system should be closed, as a measure to stop the possible entry through the windows of aerosols generated outside in facilities at risk for legionellosis. If the hospital has central air conditioners, the humidification, heating (for heating) and cooling (for cooling) chambers should be monitored, since a failure in these systems could lead to the passage of aerosols possibly contaminated by Legionella into the distribution air of the hospital rooms [62-67].

## CONCLUSION:

**Aerosol-borne microorganisms of the genus *Legionella* are a cause of pneumonic and non-pneumonic infections both inside and outside hospitals. Their prevention is focused on avoiding and treating the colonization of water reservoirs from which aerosols that reach the airway of people can be generated.**

## WHAT ARE THE HEALTH, SOCIAL AND ECONOMIC COSTS OF POLLUTED INDOOR AIR?

### Eduardo Olier Arenas

In 2013, the World Bank and the University of Washington's Institute for Health Metrics and Evaluation estimated that indoor air pollution alone led to wealth losses of around \$1.5 billion [68].

There are few studies on the socio-economic effects of indoor air pollution in developing countries. France, however, is one of the countries that have understood the importance of this type of pollution and its harmful social and economic

effects. Perhaps not much attention has been paid to this problem because the economic effects of pollution constitute "negative externalities": an economic concept that is difficult to account for in many cases. As a prelude to what follows, we will say that an economic externality is one in which the costs of producing or consuming a good or service, or the benefits of doing so, are not reflected in market prices. In other words, these are side effects that occur when an economic activity does not take into account the costs or benefits that it itself produces. And, in this case, pollution, being a negative externality, causes economic consequences that are difficult to estimate, as it is difficult to evaluate the corresponding market prices.

Indoor air pollution is a fact that has been little studied in general, since more emphasis and effort is placed on policies aimed at mitigating the effects of climate change and, in particular, the effects produced by greenhouse gases. So much so that the current 750 billion euro Next Generation EU Program, approved by the European Council on July 21, 2020, has been approved by the European Council on July 21, 2020 [69]. The issue of indoor air pollution is a long-standing economic problem that Ronald Coase, winner of the Nobel Prize in Economics, highlighted as early as 1960 when he discussed the harmful effects of certain factories whose emissions were damaging to the health of the population.

The issue of pollution is an old economic problem that Ronald Coase, winner of the Nobel Prize in Economics, brought to light as early as 1960 when he discussed the harmful effects caused by certain factories, whose emissions were damaging the health of the inhabitants of nearby towns and cities [70]. Coase refuted those economists who sought to solve this problem by taxing polluting industries, since the real problem to be solved – Coase – understood – had to focus on avoiding pollution, not on accepting it by applying a tax treatment; since, in reality, it is a problem related to the social cost of the damage produced, which should consider whether the cost of pollution is greater or lesser than the problem caused by it [70]. This issue can be extended to all the problems related to the pillars of the welfare state enjoyed by advanced countries, which is none other than the analysis between economic efficiency and the problem of equity between those who pollute and those who suffer such effects [71].

This is a circumstance that, in general, does not take into account its full dimension, since the problem is usually alleviated with fiscal or financial solutions through the well-known emissions markets created under the Kyoto Agreements [72]. In what follows, without being exhaustive, we will give some ideas on the socioeconomic problem of indoor air pollution which, in Spain, by the way, has not been an issue that has attracted much attention to date.

The main pollutants in indoor spaces come mainly from three sources: (i) chemical pollutants (volatile organic compounds, nitrogen oxides, carbon monoxide, aromatic hydrocarbons, etc.); (ii) bio-pollutants (molds, dust mites, pets, pollen, cockroaches, etc.); (iii) suspended particles and fibers (asbestos,

artificial mineral fibers, inert particles, etc.) [73]. The philosophy behind this criterion, however, focuses on solving the problem by taxing the supposedly polluting companies, i.e., imposing a tax according to the level of the economic externality produced, which requires knowledge of the type of pollutant and its effects on the environment, in addition to determining the polluting agent. Once again, this mechanism tries to solve pollution problems with new taxes, for which fiscal criteria are imposed with ex-ante criteria, instead of carrying out ex-post analyses, which are necessary to know in detail the undesirable effects of pollution, where they come from and what measures should be taken to avoid them.

With regard to the economic impact of indoor air pollutants, at least two aspects must be considered: (i) the opportunity cost, related to the loss of economic activity due to the illness of workers or, in extreme cases, the loss of human lives, and (ii) the direct cost of pollution on the public or private economy, which is related to the marginal cost that governments or companies have to bear because of pollution; that is, the additional costs that they have to assume due to the polluting event. A circumstance also dealt with by Ronald Coase in his day, which gave rise to the so-called Coase Theorem, according to which, in the absence of monetary transactions, as in the case we are dealing with, private and public costs coincide [74]; It is understood that the market alone will not be able to accommodate the two extremes, and it will be up to the regulator, i.e., the corresponding government, to provide an equitable solution to the problem, in order to find the optimum point between efficiency and equity, apart from the simple application of new taxes. Figure 3 shows the equity vs. efficiency scheme [71].

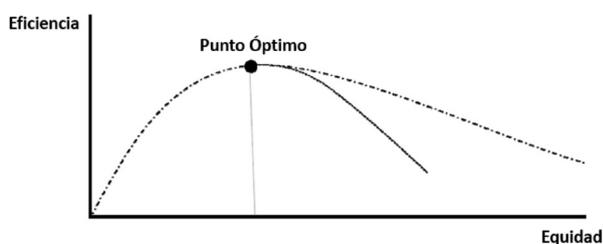


Figure 3 | Search for tax equity

One way of expressing the socioeconomic cost produced by indoor air pollution takes the following form for the case of the public costs associated with it:

$$W = \Delta CE + \Delta G \times (1 + \alpha)$$

where:  $W$  is the socioeconomic cost;  $\Delta CE$  the variation of costs due to loss of human lives, degradation of quality of life or production losses;  $(1 + \alpha)$  the negative impact on public finances; and  $\Delta G$  the variation of other concepts such as: retirement or disability pensions, investments in research, added

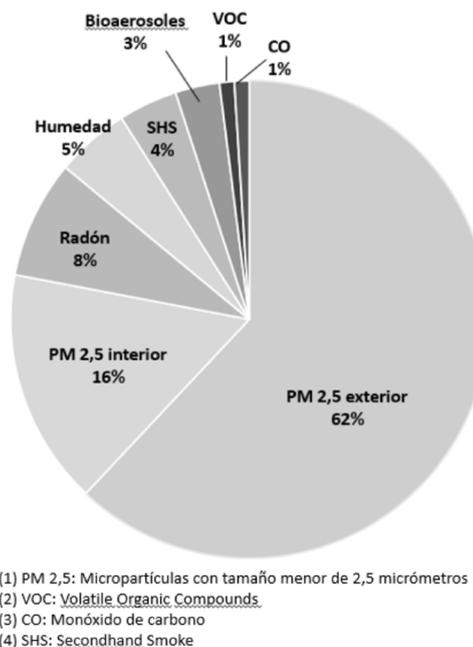


Figure 4 | Influence of different particles in interior spaces.

health expenses, etc.; with "x" as multiplication sign [75]. This study, led by Guillaume Boulanger, also shows the health effects of a number of pollutants (benzene, radon, carbon monoxide, tobacco smoke, etc.) in France in 2004: 19,879 deaths, with an impact on morbidity of 26,046 people, and a total cost of 19,443 million euros to the public purse. In addition, a report by the European Parliament [76] reference a study estimating, for 26 European Union countries, a loss of 700,000 years of "healthy life" due to indoor air pollution [77], with a distribution of the produced harm by different particles as it is shown in Figure 4. The risk, as shown here, is greater in the case of microparticles coming from outdoors, so that outdoor pollution is also harmful indoors, with a higher incidence in people suffering from some type of respiratory diseases or dysfunction, both young and old, and, in current times, especially in people suffering from the coronavirus pandemic (COVID-19).

## CONCLUSION:

Indoor air pollution is an understudied fact in general, as more emphasis and effort is placed on policies aimed at mitigating the effects of climate change and, in particular, the effects produced by greenhouse gases and outdoor pollution. Indoor air pollution alone leads to wealth losses of around \$1.5 billion. In addition to the opportunity cost of lost economic activity due to worker illness or, in extreme cases, loss of human life, there is the direct cost of pollution to the public or private economy, which is related to the marginal cost borne by governments or companies as a result of pollution.

## WHAT IS THE RELATIONSHIP BETWEEN AIR POLLUTION AND CLIMATE CHANGE, AND WHAT ARE THE IMPLICATIONS FOR THE HEALTH SECTOR?

Felipe Villar Álvarez

Air pollution and climate change are the two main environmental problems. Both are closely related, but they are not the same. Just as the definition of the former has been well defined above, we can say that climate change, according to the WHO, is a statistically significant variation in the mean state of the climate or its variability, persisting over an extended period of time (usually decades or longer). Climate change is due to natural internal processes or external forcings, and to persistent anthropogenic changes in the composition of the atmosphere. The United Nations Framework Convention on Climate Change defines climate change as "a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods". PM<sub>2.5</sub> can come from all kinds of combustion, such as from automobiles, factories, wood and agricultural burning, or other activities, and can also affect the climate. Primary pollutants such as soot can absorb heat, thereby increasing local temperatures [78], and secondary aerosols such as sulfate particles cool the climate and contribute to aerosol-cloud interactions [79,80]. Near-surface ozone is another secondary pollutant formed by the interaction of precursor compounds with sunlight, including ultraviolet radiation [81]. The rate of formation depends on temperature. Because of this, ozone increases on hot, cloudless days [82]. On the other hand, wind and dry deposition can reduce their levels [83]. This near-surface ozone formation is the result of chemical reactions that depend on emissions of ozone precursors from natural and anthropogenic sources. The main precursors include several primary and other secondary pollutants such as volatile organic compounds (VOCs), methane (CH<sub>4</sub>) and carbon monoxide (CO), which react with the hydroxyl radical (OH) to ultimately produce ground-level ozone. In addition, the formation of hydroxyl radicals is associated with CH<sub>4</sub>, another greenhouse gas [84].

Global warming of the planet is accelerated by the emission of greenhouse gases caused by human activities. The main ones are carbon dioxide (CO<sub>2</sub>), CH<sub>4</sub> and nitrogen oxide (N<sub>2</sub>O). The two main effects of climate change on air quality are the amplification of atmospheric chemistry and the degradation of air removal processes [83]. These will affect primary and secondary pollutants. Rising temperatures, with consequent changes in plant metabolism, will alter emissions of VOCs and secondary organic aerosols, leading to changes in secondary particulate matter levels [85]. Climate change may lead to more forest fires, dust storms and transport of dust particles, which may change the annual average concentrations of PM<sub>2.5</sub> in  $\pm 1 \mu\text{g}/\text{m}^3$  [81].

Climate change and air pollution can affect each other's health directly or indirectly. Air particles, especially from combustion, and gases such as ozone can increase cardiopulmonary mortality and hospitalizations, and are related to respiratory diseases such as asthma, chronic bronchitis or rhinitis [86,87].

Other diseases associated with air pollution include rheumatic diseases, neurodegenerative diseases, diabetes, premature birth, and cognitive impairment [86,87]. On the other hand, primary and secondary pollutants can drive climate change, which in turn affects public health through, for example, more extreme temperatures [88]. Secondary pollutants such as ozone can also affect crop yields which, in combination with climate change, can affect food safety and public health [89,90].

The direct impacts of climate change, such as the spread of vector-borne diseases, higher temperatures, droughts, severe storms and floods, as well as the mass migration of climate refugees, have consequences for health, through an increase in infectious, cardiovascular, respiratory, mental or allergic diseases, and even the onset of malnutrition. These will disproportionately affect the most vulnerable and marginalized populations, and will increase in intensity over time [91].

Each country's healthcare sector releases greenhouse gases and contributes to carbon emissions through energy consumption, transportation, and the manufacture, use and disposal of products [91]. The climate footprint of the health sector is equivalent to 4.4% of global net emissions (1.6 gigatons of CO<sub>2</sub> equivalent) [92]. Emissions emanating directly from health facilities make up 17% of the sector's global footprint, while indirect emissions from purchased energy sources such as electricity, steam, cooling and heating account for another 12%. The majority of emissions (71%) come from the health sector supply chain [91].

### CONCLUSION:

**Air pollution and climate change are closely related and share the same main culprit: the burning of fossil fuels. Finding solutions to reduce air pollution and climate change requires joint actions through clean energy to reduce air emissions, reduce mortality and disease occurrence, and reduce health care costs.**

## THIRD BLOCK: AMBIENT AIR AS A CAUSE OF HOSPITAL AND HEALTH CENTER-ACQUIRED DISEASE

### WHAT DO WE MEAN BY HEALTHY AMBIENT AIR IN HOSPITALS AND HEALTHCARE CENTERS?

Ángel Asensio

We could define a healthy air environment in healthcare facilities as one that provides comfortable activity and safe conditions for both patients and workers or visitors [93].

Comfort and safety criteria will often overlap. Comfort will depend on parameters such as temperature, humidity and air velocity and safety will cover aspects from the point of view of protection against harmful biological, physical or chemical agents.

In the healthcare environment, of all the risks associated with ambient air, and leaving aside the risks common to other workplaces, biological risks are the most important. And these risks will be proportional to the vulnerability of the patients. Therefore, the maintenance of good air quality will in many cases be an important non-pharmacological strategy for the prevention of infections and the maintenance of health [94].

Heating, ventilation and air conditioning (HVAC) activities, in addition to their primary purpose of providing a comfortable and safe environment for patients and others, play a fundamental role in preventing patient infection [95,96]. The essential functions of HVAC systems include heating and cooling, humidification and dehumidification, ventilation and air distribution, and filtering to remove dust particles and biological contaminants such as fungi, viruses or bacteria from the air. These air conditioning functions are important for the prevention of contamination and cross-contamination, and for the protection of both patients and workers [97].

Numerous diseases are related to poor air quality management in hospitals. From filamentous fungal infections (*Aspergillus*,...) to the transmission of bacteria (*Enterobacteriaceae*, non-fermentative Gram-negative, Gram-positive, *Legionella*,...), mycobacteria (tuberculosis,...) or viruses (RSV, varicella, influenza, rhinovirus, coronavirus,...).

Patients with severe immunosuppression, those undergoing surgery, and those housed in Intensive Care Units will be very vulnerable groups of patients to airborne biological agents. Therefore, it will be in the rooms where these patients are housed where air safety conditions must be more stringent.

When we need to create a special protective environment for patients at very high risk of infection, we must ensure that the quality of the ambient air is ultra-clean by means of very high efficiency filtration (High Efficiency Particulate Air filter, or HEPA filters) and by ensuring that the pressure inside the room is positive so that when the doors are opened, air currents entering the room from the potentially contaminated outside are prevented.

On the other hand, we must ensure that patients with airborne infections are housed in controlled environments that prevent contagion to other patients or workers. This is the case of infections caused by microorganisms that can generally be sent to the environment from the respiratory tree of infected patients, and which, depending on the type of vehicle (size of the exhaled particles) and the viability and survival of the agents, can contaminate patients or professionals. In these cases, HVAC systems must be adapted to contain and purify the agents, creating conditions of airtightness, negative pressure, purification and exhaustive air renewal.

The most complex situation occurs when we must accommodate in a protective environment patients who in turn can be infectious for others in which case the HVAC systems must ensure through intermediate chambers between the patient's room and the corridors, a positive pressure for the patient and in turn positive between the corridor in front of the intermediate chamber.

Another important section in the environmental safety of healthcare facilities is related to airborne physical or chemical noxious agents such as dusts, gases and irritants that must be addressed by measures including containment or elimination of the emitting source, filtration or purification.

Finally, while the mechanism of transmission of infections by contact is the most frequent, that of airborne transmission is more difficult to control, and one where engineering sciences play an important role in limiting the spread of microorganisms.

## CONCLUSION:

**We understand healthy hospital air to be that which provides comfortable activity and adequate safety conditions for both patients and workers or visitors. The risks of hospital air for patients will be proportional to their vulnerability.**

## WHAT TYPES OF AMBIENT AIR PROTECTION LEVELS SHOULD BE IN PLACE IN HOSPITALS AND HEALTHCARE FACILITIES? ARE THERE SPECIAL MEASURES TO PREVENT COVID-19?

### Gloria Cruceta Arboles

If there is a building or space where air quality becomes the main protagonist of our health, it is in hospitals and healthcare centers. Immunosuppressed patients are susceptible to airborne infections from microorganisms (bacteria, fungi, viruses...) that may be common in the general environment, but that can cause nosocomial infection in sick persons, with an often irreversible impact.

The protection of the ambient air in hospitals is achieved through three fundamental means, which are:

- 1-Ventilation.
- 2-Filtration.
- 3-Purification.

The combination of these elements must be studied in function of the patient's needs required by the patient, the intervention to be performed, or the complementary actions to be carried out.

Ventilation is very important as it dilutes the contaminants, whether chemical or biological, and there are regulations in this regard, in RD 1027/2007, RITE, which categorizes air quality in healthcare centers as IDA 1, which means maximum ventilation.

Filtration is essential to limit the passage of particles, knowing that microorganisms are always suspended in them, it is basic to restrict their propagation in the air. In hospitals there are controlled environment rooms, which, in order to protect the patient, are equipped with high efficiency HEPA filtration, being able to retain up to 99.95% of the particles. These rooms, especially for immunocompromised patients,

surgical areas, areas for the preparation of parenteral drugs, etc., should have HEPA filtration and must also have a pressure differential to ensure that the air always goes from the cleanest to the most contaminated area.

Current regulations require that the design of the controlled environment areas be adapted to the needs of control and protection, establishing a classification, according to the danger that exists for the patient to be contaminated, from a slight risk to a very high risk. Likewise, It also establishes the obligation of annual validation and qualification of these rooms, contained in the UNE 171340:2020 Standard.

The combination of these elements and other purification elements, such as photocatalysis, electrostatic filtration and photocatalysis, electrostatic filtration or UV lamps, increase the efficiency of the systems and installations, to the point of providing systems and installations air free of microorganisms, to the treated areas in healthcare facilities [98-104].

In the case of SARS CoV-2, it is another biological agent that can be transmitted through airborne aerosols and, therefore, as with the other microorganisms, the three aforementioned protection mechanisms mentioned above are applicable to it [105-109].

Antibiotics and corticosteroids are frequently used in patients with COVID, and a new form of invasive aspergillosis called COVID-Associated Pulmonary Aspergillosis (CAPA) has been described [110-113]. It is recommended in some of these patients, isolation from adjacent areas and the use of supportive air purification equipment with high-efficiency HEPA filters, ultraviolet radiation lamps, and electrostatic filtration.

#### CONCLUSION:

**Immunosuppressed patients admitted to hospitals are susceptible to contracting infections through the air, by different microorganisms (bacteria, fungi, viruses...) that can be common in the general environment, but that can produce in very sick people a nosocomial infection, with an impact, in many occasions irreversible.**

**The protection of the ambient air in hospitals is achieved through three fundamental ventilation, filtration and purification.**

#### WHAT ARE THE MAIN AIRBORNE FUNGI THAT ARE POTENTIALLY PATHOGENIC TO HUMAN HEALTH?

##### Jesús Guinea

Invasive mycoses are serious opportunistic infections caused by fungi in hospitalized patients with varying degrees of immunosuppression. In general terms, the fungal kingdom is composed of yeasts and filamentous fungi or molds, the latter group being a series of species that multiply and proliferate by means of spores. These spores are airborne, and their accidental inhalation by high-risk patients can trigger the development of invasive mycoses that generally affect the lung locally

and in some cases spread to other deep organs. This phenomenon is especially relevant in the hospital environment, which is where patients reside at times of increased risk for the development of invasive mycoses [114-117].

Considering the air as its natural vehicle, any spore-producing filamentous fungal species can be detected in the air. Without protective measures, the spores present in the air of the hospital environment will be a reflection of what is occurring in the street air [118, 119].

It is estimated that there are about 4 million species of fungi in nature, although only a few dozen are of clinical interest, being the species belonging to the genera *Aspergillus*, species of *Mucorales*, *Fusarium*, *Scedosporium* and *Pseudoallescheria*, the most relevant filamentous fungi. *Aspergillus fumigatus* is by far the filamentous fungus causing the greatest number of serious mycoses, known as invasive aspergillosis.

#### CONCLUSION:

**The main filamentous fungi present in ambient air and capable of causing invasive mycoses in hospitalized immunocompromised patients are the various species belonging to the genera *Aspergillus*, *Mucorales*, *Fusarium*, *Scedosporium* and *Pseudoallescheria*.**

#### WHAT PARAMETERS SHOULD BE MEASURED AND WHERE IN HOSPITALS AND HEALTHCARE CENTERS TO DEFINE THE QUALITY OF THEIR AMBIENT AIR? WHAT DOES OUR LEGISLATION SAY? IS IT HOMOGENEOUS IN ALL THE AUTONOMOUS COMMUNITIES?

##### Jesús Guinea

There is a relationship between the acquisition of invasive mycoses and the presence of filamentous fungal spores in the patient's environment. Indirect data suggest this relationship come from the disproportionate occurrence of aspergillosis cases in the form of hospital outbreaks when activities leading to high levels of spores in the air, such as renovation work, take place near areas where high-risk patients reside [120]. Similarly, the location of these same patients in areas equipped with high-efficiency HEPA protection is associated with fewer cases [121]. The most direct and clear evidence comes from the demonstration by means of molecular typing of the presence of the microorganism causing the infection in the air of the patient's environment [122,123].

Particulate counters are a quick and simple method to monitor the presence of airborne particles, but they simply alert of the presence of airborne particles, without discriminating between fungal spores or other particles (dust, pollen, etc.). For the specific detection of filamentous fungal spores, it is necessary to resort to the culture of air samples, which involves the aspiration of specific volumes of air and their subsequent culture in special media, identification, and calculation of spores per cubic meter of air sampled (CFU/m<sup>3</sup>). The spore load tolerated in the air will depend on the level of protection

of the sampled area. While in street air spore levels of up to  $10^5$  CFU/m<sup>3</sup> are accepted, in unprotected areas of the hospital environment the presence of  $>25$  CFU/m<sup>3</sup> has been defined as a risk threshold, while in those protected with HEPA filters the fungal levels should be 0 CFU/m<sup>3</sup> [124]. The regulations applicable to the hospital setting have not been very specific and are based on guides developed specifically for the design of operating rooms or of wider application in the hospital (Guía Práctica para el Diseño y Mantenimiento de la climatización en Quirófanos del Insalud; 1996 and Guía INSALUD 99 Verificación de Bioseguridad ambiental frente a hongos oportunistas; 1999). Therefore, in the absence of specific regulations, the centers where this type of sampling is carried out base their policy on the recommendations of scientific documents. Current scientific recommendations recommend air monitoring in rooms/protected areas, operating rooms, critical-burn patient units and oncohematology units [124]. CDC (Centers for Diseases Control and Prevention) recommendations recommend hospital air sampling both during periods of high risk due to construction work and periodic sampling to determine air quality, the effectiveness of barrier measures, or the condition of air conditioning systems [62]. Hospital centers such as the Gregorio Marañón Hospital apply a monthly sampling policy in protected environment areas, quarterly sampling in unprotected environment areas, and whenever there are high risk activities (construction sites) or within a hospital outbreak of invasive aspergillosis. This evaluates the integrity of filters, the detection of unknown spore niches, detects abnormally high levels of spores, and generates awareness of the problem among all hospital personnel responsible for air quality.

## CONCLUSION:

**Hospital ambient air quality is usually measured generally by particle counters and more specifically by counting per cubic meter the number of filamentous fungal spores. Acceptable quantities are different in different environments and in the case of operating rooms and neutropenic patient rooms a zero count is intended. Legislation on this aspect is not common either internationally or in Spain.**

## WHAT ARE THE MAIN DISEASES THAT CAN BE ACQUIRED IN A HOSPITAL DUE TO THE PRESENCE OF INADEQUATE AMBIENT AIR?

### Patricia Muñoz García

Air is the medium through which a large number of infections are acquired, both inside and outside hospitals. This risk is especially high in hospitals and healthcare centers where fragile patients with a high risk of infection are concentrated, such as immunocompromised patients, elderly, operated, intubated patients, etc. These patients can acquire an infection either because of a general hospital air quality problem, to which this review is dedicated, or because of a specific failure of isolation and prevention of transmission of microorganisms

from another patient, a visitor or a sick worker. Examples of these latter situations are the nosocomial transmission of respiratory infections such as influenza, chickenpox, respiratory syncytial virus, or even COVID-19 [113,125,126]. These cases must be recognized and avoided, since they cause significant morbidity and mortality.

However, as we were saying, the subject that concerns us are the diseases acquired by poor care of the aeration systems, which can constitute a hospital responsibility. Although this problem can cause different infections, the most paradigmatic is invasive aspergillosis, the most important clinical characteristics of which I will briefly describe. Aspergillosis is the name given to diseases caused by filamentous fungi of the genus *Aspergillus*, which is a ubiquitous microorganism that can be isolated from soil and dust and is universally distributed. It is characterized by producing small conidia, which, given their size, can be easily inhaled reaching the lung and paranasal sinuses, from where they can spread to any organ. The infection can also be acquired by direct inoculation in operated patients, when *Aspergillus* is in the air of an operating room [127].

Acute invasive aspergillosis usually affects immunocompromised patients, although the types of patients affected are becoming increasingly diverse [128]. The most frequent underlying diseases are hematological diseases (leukemia, lymphoma, progenitor transplantation), which account for almost 60% of cases in some series [129]. It is also described in other immunocompromised patients (solid organ transplants, HIV, high doses of steroids, solid tumors, etc.) and in patients with fulminant hepatic failure, advanced cirrhotics, critically malnourished patients, major burns, etc.

As the microorganism penetrates through the air, the most frequent invasive clinical forms in immunocompromised patients are pulmonary aspergillosis and rhinosinusitis. Less frequent are airway aspergillosis (obstructive bronchial, invasive tracheobronchitis, ulcerative or pseudomembranous), primary cutaneous, central nervous system (CNS) and disseminated aspergillosis. The invasiveness of the fungus is due to its great angioinvasive capacity and it can spread both by contiguity and by hematogenous route to organs distant from the primary infection, such as the CNS, liver, spleen, kidneys, prostate, etc. [130].

Pulmonary aspergillosis may begin asymptotically and be a radiological finding or be accompanied by cough, fever, dyspnea, chest pain and hemoptysis. It is advisable to perform whenever possible a high-resolution chest CT scan, which usually provides more data than plain radiography and is a requirement in international diagnostic criteria [131]. The radiological manifestations considered suggestive of pulmonary aspergillosis are nodular lesions with or without a surrounding attenuation halo - halo sign (early), cavitations and the air meniscus or crescent sign (later). However, aspergillosis can have other radiological presentations, especially in populations other than neutropenic patients. Early treatment (patients with halo or crescent sign) has been associated with longer survival than when treatment is initiated already with cavitation.

Tracheobronchial forms are more frequent in lung transplant recipients. Accepted clinical criteria require fibrobronchoscopy in which tracheobronchial ulcers, nodules, pseudomembranes, plaques or eschar should be observed. The diagnosis of sinusitis requires its radiological demonstration together with at least one of the following clinical data: acute localized pain sometimes radiating to the eye, nasal ulcer with black eschar or paranasal extension of the infection beyond the bony barriers and sometimes affecting the orbit.

The forms of invasive aspergillosis that appear in non-immunosuppressed patients associated with tissue damage, surgery or presence of foreign material are also extraordinarily important due to their clinical and legal significance. Some examples are post-surgical or post-traumatic keratitis or endophthalmitis, skin infections in burn patients, wound or surgical area infections, and those related to the placement of prosthetic valves, dialysis or central venous catheters, pacemakers, etc. [132-134].

Mortality of this infection is very high (around 60%), reaching more than 80% in very immunosuppressed patients, with CNS involvement or disseminated infection. At present, somewhat more satisfactory figures are obtained partly due to earlier detection and treatment with better tolerated and highly effective drugs.

## CONCLUSION:

**The paradigm of infection conveyed by poor quality ambient air in a hospital is Invasive Pulmonary Aspergillosis. It occurs in very vulnerable patients and with relatively small exposures, as in the case of neutropenic onco-haematological patients. On the other hand, it can occur in immunocompetent patients with massive exposures or by direct exposure of deep tissues and organs to ambient air, as in the case of infections acquired during extracorporeal surgery.**

## CAN ZERO INCIDENCE OF HOSPITAL-ACQUIRED INVASIVE MYCOSES BE ACHIEVED?

### Patricia Muñoz García

The ambition to achieve zero incidence in various nosocomial infections is embodied in well-structured and ambitious campaigns, which have significantly reduced the incidence of catheter-related bacteremia, pneumonia in mechanically ventilated patients, surgical wound infections and even infections due to multi-resistant bacteria. It is therefore legitimate and very pertinent to try to approach zero incidence of hospital-acquired invasive mycoses.

As with many other infections, invasive mycoses diagnosed in the hospital may have been acquired in the community (food, plants, unfiltered air, dust) or in the hospital, and within the hospital, either in the area where the patient is admitted or during their movements around the center for tests or interventions. It is therefore difficult to establish the place of

acquisition of aspergillosis [135]. On the other hand, there are many environmental factors (climate, wind, rain, vegetation, etc.) that can influence an increase in the number of specific cases. In addition, the problem is exacerbated by the fact that the incubation period of the disease is not well defined and depends on the immune status of the patient, the route of acquisition and the concentration of spores to which the patient has been exposed. We describe a well-documented case in which the time of infection could be determined and establish an incubation period of 15-20 days for our patient [122].

Despite these considerations and difficulties, it is imperative to try to detect hospital-acquired cases and prevent them through the strict implementation of general and specific measures. General measures include, among others, the following recommendations: Transfer of high-risk patients to a protected area distant from the construction or remodeling site and avoid exposure to plants, showers, contaminated food, etc; Keep doors and windows closed in areas with high-risk patients; Use of N95 masks by high-risk patients when leaving protected areas; Optimal isolation of construction sites with impermeable barriers; Reducing traffic through affected areas; Routine environmental measurements and in case of suspected nosocomial episode, to ensure that they do not exceed the levels allowed in each area; Optimal cleaning of surfaces with wet wipes and immediate removal of debris. Careful recording of filter changes; Follow-up of possible infections in patients at risk of IA; Regular meetings with all involved (infectious diseases, microbiology, preventive, hospital management, affected services, engineering) [124,136-140].

Specific measures include the administration of antifungal prophylaxis to patients at risk. This measure has to be directed only to patients with a very high risk, either because of their baseline conditions, or because they have been exposed to high levels of spores in the hospital, given that we are going to administer potentially toxic drugs to people who do not yet have the disease. But it is worth it, because these measures work.

As an example, I will give our experience with aspergillosis in a cardiac transplant program. In this population group the recommendation was to give prophylaxis to all patients, but we observed that, as long as there were no massive environmental exposures, only patients with certain risk factors suffered from aspergillosis. We defined which factors increased the risk and the duration of the increased risk in relation to each of the factors. With this we designed a prevention protocol in which we only administered prophylaxis to that particular group of patients and only for the minimum time necessary. In this way we managed to reduce the incidence of aspergillosis in our transplant program to zero for several years, with a very important impact on the overall survival of our patients and with good tolerance [141,142]. Figure 5 shows that in several years of the program there was not a single case, neither nosocomial nor community. Subsequently, a new nosocomial airborne contamination led to the appearance of nosocomial cases [132], which later disappeared again.

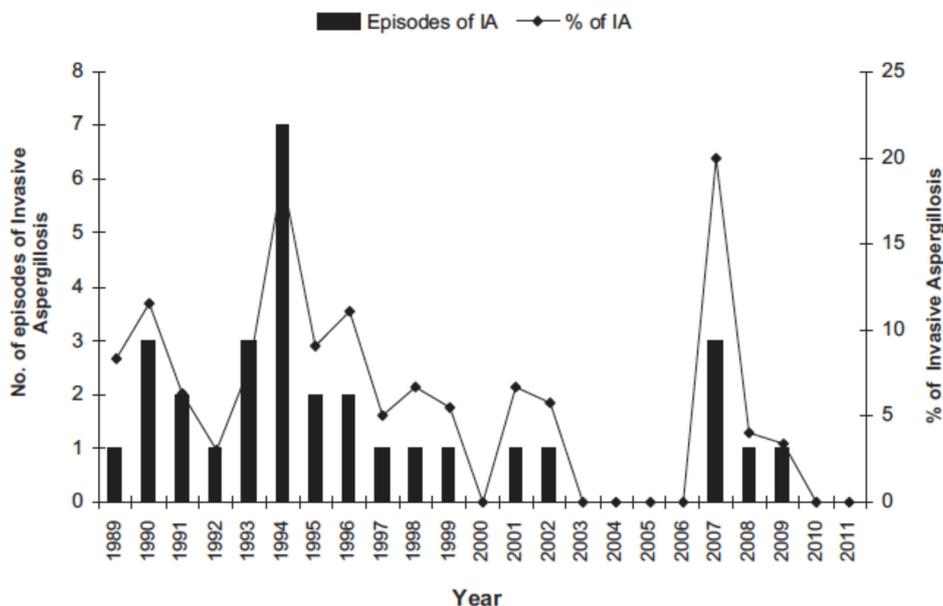


Figure 5 Annual distribution of cases of invasive aspergillosis in heart transplant recipients.

It is necessary to insist on the need to be rigorous and exquisite in the observance of all prevention recommendations, including the measurement of spores in hospital air. We must be exemplary in the observance of the law on "zero tolerance" of spores in protected air (operating rooms, hematology) and not exceeding reasonable levels (25 ufc/m<sup>3</sup>) in unprotected air [143]. This extraordinary care will mean that, unlike in many centers, we will not have to regret cases acquired in the operating room, which often complicate cardiac surgeries and lead to high mortality. Finally, if the episode could not be prevented, it is necessary to diagnose and treat it promptly and record it for subsequent analysis by all parties involved.

#### CONCLUSION:

Zero incidence of systemic mycoses in the hospital environment should be a reasonable goal and involves the implementation of a series of measures to protect the ambient air and sometimes also antifungal prophylaxis measures. We are not aware of the stable achievement of this objective, but the measures that have been tried have been associated with a clear decrease in the number of episodes.

**WHAT IS THE CURRENT SYSTEM FOR MEASURING CONTAMINANTS, IS IT EFFECTIVE, AND WHAT MEASURES ARE MOST EFFECTIVE TO ENSURE GREATER SAFETY AND PREVENT DISEASE IN HOSPITALS AND HEALTH CENTERS?**

Miguel Angel Gil Amigot

The Ministry for Ecological Transition and Demographic Challenge (MITECO) is the body in charge of collecting all the information and making an evaluation report annually regarding the values recorded in the environmental pollutant monitoring stations in each Autonomous Community (C.A.). This information is evaluated in relation to the legislation in force in Spain (Royal Decree 102/2011) which was constituted from the Directive 2008/50/EC on ambient air quality and a cleaner atmosphere in Europe. The evaluation is carried out according to the following criteria: the classification of the zone in relation to pollutant levels is determined by the highest value of each pollutant detected in the stations belonging to the zone [144,145].

The legislation establishes limit values that all Autonomous Regions must comply with in their air quality measurement zones. In the event that any Autonomous Region exceeds the legal limit values for a certain pollutant, it must take the necessary measures to reduce it to a permitted level. In addition, the legislation sets national target values for all Autonomous Regions to take measures and achieve a reduction of certain pollutants (PM<sub>2.5</sub>, O<sub>3</sub>, Cd...) for the specified year [146].

The World Health Organization (WHO) conducts global and European studies to analyze the impact of pollution on the health of the population. According to the results obtained, it is estimated that air pollution causes 3.2% of the world's illnesses and some 3.1 million premature deaths per year. The effects of pollution on health are mainly related to respiratory and cardiovascular diseases and cancer of the respiratory system. In Spain, the National Center for Environmental Health (CNSA) is the body in charge of controlling air pollution and carrying

out studies to contribute to the protection of people's health.

Due to the great impact of air pollution on people's health, healthcare centers, hospitals and health centers must adopt measures to control the indoor air quality level (IDA) of the centers. The air circulating inside healthcare facilities can be loaded with both small particles and gases from outside air and infectious bacteria and viruses exhaled by patients suffering from respiratory infections in the facility itself. Air conditioning and air ducts in healthcare facilities are essential elements for controlling the quality of the air that enters the facility and circulates within the hospital. In the case of air conditioning, the air coming from outside is filtered and acclimatized in the Air Handling Units (AHUs) and circulates through the air ducts to the different rooms. In the most sensitive areas of hospitals where the air quality must be optimal, i.e. in operating theaters and controlled environment rooms, current legislation regarding air conditioning requires compliance with certain requirements: a number of filtration stages, the application of filters with a high level of efficiency (HEPA filters), a permitted microorganism concentration and a minimum number of air renewals per hour.

In the rest of the hospital spaces, consultations, bedrooms, meeting rooms, general services, etc., less demanding requirements must be met in terms of air quality. From the point of view of the facilities, there are a series of important measures to be considered and adopted for the control of pollution in healthcare centers, as well as the use of the Air Treatment Units (AHU) and their maintenance, i.e. cleaning of the air conditioning units and air distribution ducts of the air driven by the AHUs, replacement of pre-filters and medium and high efficiency filters and checking the correct operation of the air conditioning system. In addition, continuous air renewal in all indoor spaces and window openings for supplementary ventilation are effective measures to reduce the transmission of respiratory infections.

## CONCLUSION:

**The most effective measures to ensure the quality of hospital ambient air is the establishment of filters in areas of maximum risk and for the protection of the most vulnerable patients.**

## WHAT ROLE CAN THE MEDIA PLAY IN THE DISSEMINATION AND AWARENESS OF THE GENERAL PUBLIC ABOUT THE PROBLEM OF AMBIENT AIR QUALITY AND IN PARTICULAR ABOUT PEOPLE WITH SOME TYPE OF RESPIRATORY DISEASE?

**Javier Tovar García**

Having established the importance and relevance of this problem for the present and future health of citizens, as well as its enormous repercussions on the sustainability of healthcare systems, we point out a group of considerations on the role that the media and journalism can and should play to mi-

tigate these considerable effects and risks.

The media have a social responsibility to develop through good informative practices, distribution and dissemination capacity to reach the population, rigor and truthfulness of the contents and informative work to inform about the relationship between Health and Environment.

The role of the media in raising public awareness in order to value both the defense of health and a healthy environment is a crucial and essential part of their tasks.

Both health and environmental issues have acquired enormous importance for decades in the general and specialized media, beyond the very intense and specific media impact that the COVID-19 pandemic has generated since March 2020.

The conjunction of these two factors, preservation of a sustainable environment (in this case focused on achieving clean air) and the defense of health and well-being as a citizen's right, already has a certain presence in the media through news, reports, reports, debates, interviews and other types of journalistic content.

The Health/Sanitation and Environment sections occupy places in the newsrooms, although not with the resources and people that society demands; in addition, these departments have seen their staffs reduced as a result of the economic crisis that, since 2008, affected the media, both in the loss of revenue, the effects of the technological revolution and the bankruptcy of the business model.

It is necessary that, in the organization, structure and planning of media content strategies, the Environment and Health sections be strengthened and move towards greater coordination in order to offer joint informative production works that link and connect, with greater depth and breadth, the binomial Health/Environment.

In my opinion, the media have among their informative tasks to expose, both from the news and from the dissemination, rigorous, complete and contrasted, clear and truthful contents, of the reality that focuses and surrounds environmental pollution and its effects on health.

Issues, among others, such as environmental and health policies, and the connection between them; the denunciation of polluting situations of risk to health; the opinion of experts on this casuistry; the work, research and reports of both public and private organizations and institutions; giving a voice to those who suffer most directly from these problems; and other contents of social relevance, with specifics, examples, cases and stories that show and demonstrate the damage to health.

They must also complement the contents generated by the actors in the sector with their own initiative to offer quality information to society which, in turn, helps to alleviate the hoaxes and misinformation that are also produced in this area.

The protection of those who are especially harmed by air pollution, such as children, the elderly or people with respiratory diseases, must involve an added effort through content that gives visibility to reprehensible situations, measures or actions.

While it is true that the issue at hand, unlike other social or health problems, does not remain relegated or cornered in the media, I believe it is the responsibility of the media to increase its presence in prominent places on the journalistic agenda and in information showcases.

In addition, the media must be demanding in monitoring the actions of public authorities on the risks of pollution and its effect on health; monitoring compliance with standards and the strategies of industry and companies to collaborate in cleaner air, both in public and private spaces, workplaces, academics, hospitals or health centers, to give some examples.

It is also the role of the media to inject awareness and responsibility in citizens so that they commit, within the scope of their actions and decisions, to achieve clean air in homes and cities.

#### CONCLUSION:

**The media must help to get out of the certain social numbness that leads the citizenship not to be really aware of the enormous health risks of breathing, day after day, unhealthy air that prevents our organism from functioning in a healthy way, and that acts as a kind of invisible killer that is difficult to detect and control.**

#### WHAT ETHICAL ASPECTS WOULD YOU HIGHLIGHT? WHAT REFLECTIONS FROM THE PERSPECTIVE OF ETHICS ARE RAISED IN THIS PANDEMIC?

##### Diego Gracia Guillén

The current pandemic is new not only because it is produced by an agent different from all those known to date, but also because it is posing a new and unprecedented challenge to the health system. The latter was prepared to deal with epidemics of short duration, sudden onset and rapid end. In fact, that is what the term "epidemic" means. *Dêmos* is the Greek word for population, and *epí* is a prefix meaning over or through. To the essence of epidemic diseases belongs that they are transient and usually brief. In this they differ from endemic diseases, those in which the disease remains in a population for very long periods of time, reaching a certain degree of equilibrium between the germ and the populations it affects. The paradigmatic example of this is malaria, which has been so endemic in certain areas of the planet that its inhabitants have ended up developing certain genetic mutations that allow it to coexist with the parasite, as is the case of the modification of the hemoglobin cell that protects against malaria, even though it produces another disease, sickle cell anemia.

Epidemic diseases are characterized by their great aggressiveness, so that they affect very high percentages of the population, killing a large number of people and immunizing the rest. The immunity acquired during the epidemic prevents the germ from finding a place to reproduce, resulting in its disappearance.

All this is well known in medicine and something for which health systems, and with them advanced societies in general, are prepared. Crises are acute situations that require special measures, not only in health care but also in politics, economics, etc. The latter, for example, are aimed at maintaining economic activity by means of public subsidies to private companies and to workers who lose their jobs during the quarantine period, which in epidemics is, by definition, supposed to be short.

The current epidemic has two characteristics that make it peculiar. Firstly, it is a global epidemic, since it is the first, or one of the first, of the so-called "era of globalization" in which we find ourselves. The second characteristic is that it is lasting much longer than a classic epidemic. To such an extent that it is becoming so prolonged that it is beginning to have features more typical of endemics. This is something for which no one was prepared, neither the health system nor economic theory. When a pandemic begins to present symptoms typical of endemic diseases, as is the case in the present one, the social system as a whole enters into crisis. It was assumed that the advances in science, and more specifically in medicine, made the emergence of a phenomenon such as the one described impossible. As a result, what has happened has come as a surprise to everyone, and not exactly a pleasant one.

Medicine has played a fundamental role in the chronification of this epidemic. Left to its natural course, this disease would have very quickly infected a large part of the world's population, and after killing a certain percentage and immunizing the rest, it would have disappeared. That is the natural history of an epidemic disease. Chronification is the consequence of the preventive measures put in place by the political authorities in application of the principles of the preventivists. These measures undoubtedly save many lives, but at the price of delaying the immunization of the population, which is thus susceptible to infection for much longer, until all or most of the population is immunized, or until all or most of them are artificially vaccinated. The problem is that, in a pandemic, immunization has to reach all or most of the inhabitants of the earth, which poses all kinds of challenges for which our society is at present poorly and ill-prepared. The big question is whether the lessons learned during this crisis by the social system as a whole, and particularly by the health system, will serve to correct the enormous number of dysfunctions identified, or not. And this at all levels, from the local to the global.

The return to the "new normal" has become a slogan. Nothing could be more dangerous than this. If there is one thing we have to learn from this crisis, it is that we cannot go back to the past, so that this pandemic passes like a bad dream. We cannot go back to the past, because that will mean that we have learned nothing from this, which will leave the problems unresolved. This is not just about the profound reforms that the healthcare system requires. If what we are talking about is hygiene and public health, then many things have to change in people's habits and in the culture of society. Epidemic diseases are due to the Darwinian principle of the struggle for life of the different animal species, but they are also due to

the disruption of ecological balances. Historical epidemiology is a good witness to this cause. And the belief, so widespread today, that the human being is the king of creation and that everything else is at his service, so that he can use and abuse nature as he pleases, is a very serious error. Whoever does not treat nature, even inanimate nature, with respect, there is no reason to think that he will treat human beings with respect. And what is said about people is also true for companies and governments.

This crisis must be understood as a first warning that the path humanity is following is not correct, that it needs to be rectified, and that this must be rapid and profound. Otherwise, the warnings will follow one after the other, and they will become more and more serious.

## CONCLUSION:

**Ethics is the study of the correctness or incorrectness of the habits and customs of human beings. The present health crisis is not a mere fortuitous event, but a consequence of the way in which human beings are depredating nature and altering its equilibrium. It is necessary to promote a new culture of respect for nature and its balances, if only because it is the environment in which human life, our own life, is possible. In the face of a predatory culture, it is necessary to promote another based on respect and the maintenance of equilibrium. If this is not done, this pandemic will have been only a first warning, after which others, probably more serious, will follow.**

## TRANSPARENCY DECLARATION

For transparency purposes, we inform you that GSK has collaborated in the financing of this publication. Its contents reflect the authors' own opinions, criteria, conclusions and/or findings, which may not necessarily coincide with those of GSK. GSK always recommends the use of its products in accordance with the data sheet approved by the health authorities.

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