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IM - REVIEW

Environmental health, COVID-19, and the syndemic: internal medicine facing the challenge

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Abstract
Internists are experts in complexity, and the COVID-19 pandemic is disclosing complex and unexpected interactions between communicable and non-communicable diseases, environmental factors, and socio-economic disparities. The medicine of complexity cannot be limited to facing comorbidities and to the clinical management of multifaceted diseases. Evidence indicates how climate change, pollution, demographic unbalance, and inequalities can affect the spreading and outcomes of COVID-19 in vulnerable communities. These elements cannot be neglected, and a wide view of public health aspects by a "one-health" approach is strongly and urgently recommended. According to World Health Organization, 35% of infectious diseases involving the lower respiratory tract depend on environmental factors, and infections from SARS-Cov-2 is not an exception. Furthermore, environmental pollution generates a large burden of non-communicable diseases and disabilities, increasing the individual vulnerability to COVID-19 and the chance for the resilience of large communities worldwide. In this field, the awareness of internists must increase, as privileged healthcare providers. They need to gain a comprehensive knowledge of elements characterizing COVID-19 as part of a syndemic. This is the case when pandemic events hit vulnerable populations suffering from the increasing burden of chronic diseases, disabilities, and social and economic inequalities. Mastering the interplay of such events requires a change in overall strategy, to adequately manage not only the SARS-CoV-2 infection but also the growing burden of non-communicable diseases by a "one health" approach. In this context, experts in internal medicine have the knowledge and skills to drive this change.

Keywords Air pollution · COVID-19 · Environmental health · Internal medicine · Public health · Syndemic

Introduction

Internists are experts in complexity, and the COVID-19 pandemic is disclosing unexpected interactions between communicable and non-communicable diseases, environmental and socio-economic aspects. This is a scenario which makes SARS-Cov-2 infection a part of a syndemic [1], rather than a "simple" pandemic. Syndemic is due to complex cross-links generated by the spread of this communicable disease in vulnerable populations suffering from an increasing epidemiologic burden of chronic diseases and disabilities, social and economic inequalities [2]. The medicine of complexity cannot be simply limited to face comorbidities and to the clinical management of multifaceted, multidisciplinary diseases.

On March 11, 2020, COVID-19 was officially recognized as a global pandemic. To date and worldwide, we are counting over 0.6 billion confirmed cases of COVID-19, including over 6.3 million deaths and, as of 31 July 2022, a total of

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12.248.795.623 vaccine doses administered (WHO Coronavirus (COVID-19) Dashboard | WHO Coronavirus (COVID-19) Dashboard With Vaccination Data).

Globally, healthcare professionals, policymakers, economists, and citizens are obliged to face the huge effects of the pandemic both at an individual and a global level, searching for strategies able to reduce harms and damages, but also to increase the chance for resilience. Adopting a vision of the pandemic based solely on healthcare aspects, such as disease management or vaccine prophylaxis, is simply insufficient.

Instead, we need a wider view towards global public health aspects which takes advantage of the "one-health" approach, a comprehensive strategy that facilitates interdisciplinary, multidisciplinary, and transdisciplinary collaboration between the human health, animal health, and environment sectors. In particular, available evidence clearly indicates how environmental factors such as climate change [3–5], air pollution [6, 7], low income [8] and socio-economic disparities [9] can worsen the outcomes of COVID-19 in vulnerable communities. This interaction cannot be neglected.

To increase the awareness in this field, in this review we will discuss how internists can extend their role of privileged healthcare providers. We will examine the major elements characterizing COVID-19 as part of a syndemic, to explore how this harmful communicable disease interacts with environmental pollution and individual vulnerability, and to adequately manage not only the pandemic but also the growing burden of non-communicable diseases by a "one health" approach.

The pandemic as a component of a syndemic

We are learning that the consequences of COVID-19 on public health depend strongly on individual vulnerability. Thus, the analysis of risk factors which affect incidence, prevalence, spreading and clinical outcome disease must necessarily and comprehensively consider a wide panel of health determinants. There are complex and dynamic relationships between the spread of the infection by SARS-CoV-2 and several pre-existing criticalities All these elements contributed to generate the ongoing syndemic (Table 1).

The pandemic per se amplifies chronic, structural, and functional difficulties resulting from decades of inaction and/or poorly efficient policies in terms of health promotion and primary prevention of diseases.

Advanced age is a well-known risk factor which increases the mortality of COVID-19 patients [10]. This evidence has a great relevance in geographical areas characterized by increasing lifespans, such as Europe [11]. According to the WHO, the proportion of the world's population over 60 years will double between 2015 and 2050 and, by 2030, one in 6 people worldwide will be aged 60 years or over [12]. Age per se, however, cannot be considered as a synonym of individual frailty and increased vulnerability to COVID-19. Short-term exposure to air pollution, for example, affects the immune function in subjects entering hospital for COVID-19 pneumonia, and increases the in-hospital mortality independently from age [6]. Furthermore, reduced COVID-19 in-hospital mortality appears to be linked with early production of antibodies against SARS-CoV-2, and this evidence is also independent from age [13].

Table 1 Pre-existing criticalities interacting with the pandemic and generating a syndemic

Demographic unbalance (i.e., demographic crisis, progressive ageing)
Growing incidence of noncommunicable diseases
Climate change
Unsustainable urbanization
Lack of green areas, reduction of biodiversity
Environmental pollution
Socio-economic inequities and inequalities
Structural and functional limitations of national health systems
Lack of international, coordinated strategies

The increased vulnerability in elderly parallels frailty [14] and this aspect, in turn, is mainly a consequence of a reduced health span and of unhealthy ageing [15]. Both frailty and unhealthy ageing are closely linked with environmental factors across the course of life. The interaction often starts during *in-utero* life, and becomes a predisposing factor to non-communicable diseases [15].

Chronic, non-communicable diseases and the presence of comorbidities, in turn, are well-known factors able to worsen the clinical outcome of COVID patients [16]. These diseases certainly contribute to the impact of the pandemic on vulnerable populations, and negatively affect the clinical outcome in infected patients [17]. About one in five individuals worldwide is at increased risk of severe COVID-19 due to underlying health conditions, and suffers from at least one non-communicable disease [18]. This trend is particularly true with the progressive ageing of the population and the global dual epidemic of obesity and type 2 diabetes mellitus, which drive the worst outcomes of COVID-19 patients [19]. Notably, such leading noncommunicable diseases affect people independently from age. For example, obese younger than 60 years have a higher risk of severe COVID-19, as compared to older individuals [19] and this finding decreases the value of age per se as a contributor to the increased risk following SARS-CoV-2 infection. An ecological study has shown that worldwide disability-adjusted life years (DALYs) due to noncommunicable disease correlated with COVID-19 cases and deaths [20].

In a syndemic scenario, the link between noncommunicable diseases and socio-economic factors is an additional worsening element. The mortality risk from noncommunicable diseases in the age range 30–70 years is inversely related with income, with the lowest mortality recorded in high-income countries, as compared with low- and middle-income countries [8]. Conversely, the country-level income inequality in 22 OECD countries is positively associated with COVID-19 mortality in all age groups, pointing to inequality as a significant risk factor [21]. This evidence is supported by a large survey in the U.S. showing that the percentage of adults without a high school degree, and the proportion of black residents were the two socio-economic determinants of health with the strongest association with incidence and fatalities [22]. A recent study exploring COVID-19 mortality in 3,144 US counties confirmed that socio-economic disparities and disadvantage condition were strong determinants of COVID-19 mortality [9].

The negative role of progressive ageing, growing noncommunicable diseases and inequalities also links COVID-19 with the health effects of climate change. In fact, among the social categories with the highest degree of vulnerability to the health effects of global warming are aged people, people facing social disadvantages and those with chronic diseases [1].

The burden of noncommunicable diseases related to climate change has progressively increased between 1990 and 2019 [23]. Furthermore, the environmental pollution as the main driver of climate change, affects the onset and progression of noncommunicable diseases [24]. Finally, unhealthy habits and lifestyles influencing the epidemiologic progression of obesity and metabolic diseases are also markedly fueling climate change, generating a huge cost for national health systems and ecological costs in relation to the environment [25]. Animal products generate the highest values for carbon emissions [25], and the global increase in meat tread and consumption strongly contributes to diet-related chronic diseases [26].

Climate change increases the risk for infectious disease transmission since decades [27], and the onset and spread of the SARS-CoV-2, a zoonotic coronavirus with a possible origin in bats and an inter-species transmission from bats to humans [28], should not be an exception to this trend. Climate change can contribute to this process [3], and the rapid pandemic spread is facilitated by factors driving the onset and progression of climate change, namely reduced biodiversity, growing urbanization, progressive contraction of green areas, and global hypermobility.

In the syndemic context, the role of gender inequalities must also be considered, according to evidence showing increased vulnerability in sexual and gender minorities[29, 30], and a sex-based difference in COVID-19 clinical outcomes[31, 32].

We are witnessing an unprecedented stress to the national public health systems, with the interaction between pandemic and factors such as population ageing, increased burden of chronic diseases, individual vulnerability, low possibility of resilience secondary to inequities and inequalities, sexual and gender inequalities, and the central role of living in an unhealthy environment predisposing to acute and chronic diseases. The interplay between these different factors (i.e., the syndemic) contribute to increase individual vulnerability in all age classes and to decrease the possibilities of resilience, making insufficient a "purely clinical" approach to solve primary health problems, and mandatory a "one health" approach (Fig. 1).

Essential guaranteed services, mainly those oriented at chronic diseases, have been disrupted due to the diversion of human and financial resources towards COVID-19. This necessary policy has inevitably created a great harm because of inadequate management of frail patients and lack of secondary and tertiary prevention measures [33]. On the other hand, mounting evidence suggests that COVID-19 survivors with noncommunicable diseases can experience negative effects on clinical progression of several conditions, such as metabolic disorders [34], and cardiovascular [35], pulmonary [36], neurologic [37], and psychiatric [38] diseases.

The coexistence of different conditions has certainly facilitated the spread of pandemic and the crisis is still far to be solved, even though COVID-19 has the priority in international policy agenda. Despite vaccine prophylaxis contributes to face the pandemic, the lessons to be learned from the SARS-CoV-2 spreading is that we urgently need health-in-all policies in a global perspective. Starting goals must include living in a healthy environment and decreasing individual vulnerability independently of age [15].

The gap between evidence on environmental health and the clinical practice

The incidence of noncommunicable diseases is continuously rising and involves any age. An enormous burden of premature deaths is generated by the main four noncommunicable diseases, namely cardiovascular diseases, chronic respiratory diseases, cancer, and diabetes [8]. These conditions also contribute to increase individual frailty and disabilities [39], and are generally managed by Internists.

Besides lifestyle [40] and socio-economic factors [8], a central role in the onset and development of these disorders is certainly played by environmental pollution [41], which has been defined as "the largest environmental cause of disease and premature death in the world today" [41].

From a scientific point of view, environmental health is a consolidated field of research since decades. An editorial published in the year 1911 described as the term "environment offers a wide and fertile field for research" [42]. In the

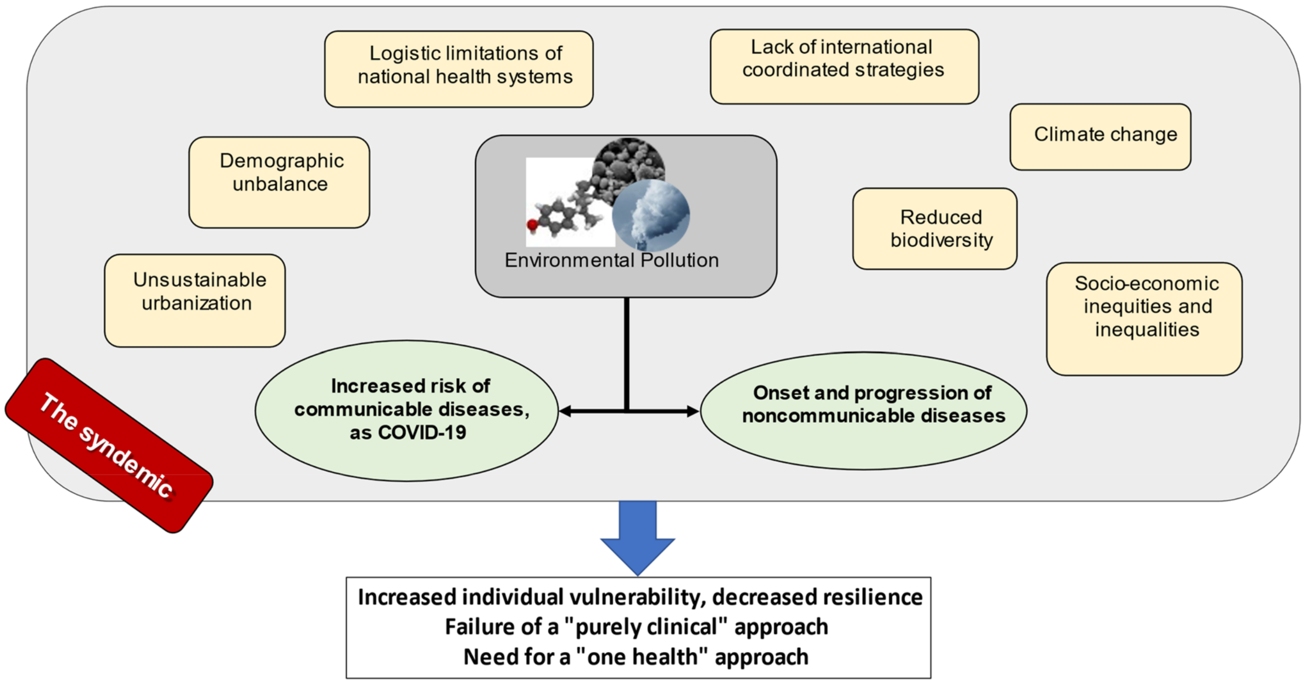

Fig. 1 The different factors contributing to the ongoing syndemic and related effects, in terms of both individual and public health

30 s of the last century, air pollution was firstly defined as a "serious menace to health", describing links with a number of acute (i.e., allergies, acute respiratory disorders, pneumonia) and chronic diseases (i.e., emphysema, depression), with pediatric mortality and, finally, with cancer [43]. In the year 1952 a paper published in the British Medical Journal described clear links between air pollution and lung cancer [44]. Starting from the 60 s of the last century, several authors found relationships between pollution, cardiovascular mortality [45] and extra-pulmonary, mainly gastrointestinal cancer [46]. More recently, epidemiologic and experimental studies find that the contamination of environmental matrices (i.e., air, soil, water) and food by toxic chemicals strongly affects the onset and progression of neurodegenerative, gastrointestinal, renal, reproductive, hormonal, psychiatric, metabolic disorders, and cancer, irrespective of age.

Nevertheless, although clinicians have an important role to play in reducing the global burden of diseases from pollution, the environmental health knowledge still remains virtually absent in clinical practice [47], also due the lack of a specific training of Internists in environmental health [48], which strongly limits their healthcare ability and potential. These limitations generate enormous consequences in terms of lack of primary prevention measures, inadequate and scarcely comprehensive disease management, and unsatisfactory cost saving.

As with traditional risk factors of noncommunicable diseases, clinicians can identify patients at high risk from pollution, and must provide recommendations and interventions to reduce the individual risk, to optimize treatments, to reduce vulnerability and to increase resilience.

Recently, 49 clinical guidelines from European, Asian, American, and Australian medical associations and organizations on typical internal medicine topics (i.e., allergies, asthma, chronic obstructive pulmonary disease, cardiovascular disease, obesity, diabetes, renal diseases, heat stroke, and colorectal cancer) have been screened to verify the presence of 30 specific keywords related with environmental and planetary health. Results revealed that most of these keywords were present in fewer than 5% of the guidelines [49].

Thus, according to the traditional translational paradigm, the development of clinical guidelines also considering advances in environmental health is urgently needed, in terms of both policy recommendations and individual actions. Recommendations include cost–benefit evaluations, analyses of cost savings due to primary prevention measures, and sustainability in decision-making processes.

The links between environmental pollution, health and SARS-CoV2 infection and spread

According to the global burden of disease study, ambient particulate matter pollution was among the largest increases in risk exposure in the period 2010 to 2019 causing, on average, 11.3–12.2% of all female and male deaths in 2019, respectively [39]. Besides mortality, environmental pollution has also a major role in promoting disabilities [39] and affects the onset and progression of other leading causes of mortality, as cardio-metabolic diseases [50, 51]. Of note, air pollution affects individual vulnerability to infectious diseases, including COVID-19 [6].

Adverse health effects of several air pollutants, often without clear safe or threshold level, are well established through numerous epidemiological studies and have been acknowledged by WHO [52]. Table 2 reports potential mechanisms linking environmental pollution with SARS-CoV-2 infection, spread and outcomes both at community [53–59] and individual [6, 60–64] level.

The COVID-19 pandemic offered a unique opportunity to study the impact of air pollution on the risk of infection and disease lethality, as the new Corona virus hit an immunologically naïve population and the prognosis of the disease was severe enough in many instances to foster public concern and hence the generation of a large amount of data.

Not surprisingly, many papers have reported associations between air pollution levels and COVID-19. Several reviews have in the meantime been published on that issue, the most recent and detailed one by Xavier Rodó et al. [7] for the Panel for the Future of Science and Technology (STOA) of the European Parliament. Searching for the string "COVID-19 AND air pollution" in PubMed (https://pubmed.ncbi.nlm.nih.gov/), returned 1,474 results (access on February 14, 2022). Table 3 lists the 27 most relevant studies among the first 40 papers sorted by the "best match" option of PubMed. The remaining 13 studies were excluded because of double counting (1 study), because they focused on indoor air pollution (4 studies), were not written in English (1 study), were rather about policy aspects or environmental justice (5 studies) or looked on the effect of COVID-19 lockdown measures on air quality, rather than on air quality effects on COVID-19 (2 studies). The present paper was not aimed at performing a systematic review and analysis about the relationships between air pollution and COVID-19. However, the short and non-comprehensive overview synthesized in Table 3 demonstrates the growing scientific interest and a huge variety of approaches to the issue of air pollution effects on the risks of COVID-19 infection, including the risk of a severe course of the disease, or death. Studies have been performed in nearly every part of the world. Both long-term chronic and short-term acute exposures have been investigated and a variety of pollutants have been considered. Experimental studies and theoretical papers discussing possible mechanisms that lead to the demonstrated effects also contribute to the wealth of information. Although there is still not a full consensus on the mechanisms and the causal role of air pollutants on the onset and course of SARS-CoV2 infection, most studies are consistent in demonstrating a positive association between air pollution and the risks of this communicable, systemic disease.

Most often, the following three mechanisms are proposed:

(1) Pollutants damage the airways and the immune system thus rendering an individual more susceptible to (later) infectious attack, but also co-exposure (with irritant gases) has a similar, albeit more immediate effect.
(2) Particulate matter serves as vehicle of viruses in the air protecting the viruses from UV-radiation, delaying sedimentation, and transporting the virus more efficiently into the deeper airways.
(3) Inflammation and oxidative stress caused by air pollution during the early stages of infection render the course of the disease more severe and thus lead to a higher lethality.

Table 2 Potential mechanisms linking environmental pollution with COVID-19 infection, spread and outcomes at community and individual levels

Level of interaction	Putative mechanisms
Community	Onset and progression of chronic disease (e.g., respiratory, and cardio-metabolic diseases) Promotion of disabilities Increased vulnerability to infectious diseases Vehiculation of SARS-CoV-2 in ambient air by particulate matter
Individual level	Vehiculation of virus into the deeper airways Inhibition of mucociliary clearance Altered respiratory epithelial barrier function Increased epithelial permeability Increased surface expression of ACE2 receptors Pro-inflammatory effects on the airways Systemic pro-inflammatory effects Oxidative stress through reactive oxygen and nitrogen species Mitochondrial dysfunction Altered immune response Changes to antiviral interferon production and viral replication Reduced macrophage uptake and phagocytosis of virus-infected cells, leading to uncontrolled viral growth

Table 3 A sample of recent studies (2020–2022) on "COVID-19 AND Air pollution"

Country	Pollutant(s)[a]	Question[b]	Study type	Main findings	References
NA	PM, NO_2, O_3	Mechanism	Review	Exposure to air pollutants can predispose to COVID-19 through immunopathologic, pro-inflammatory mechanisms and tissue damage, and can affect viral life cycle	[60]
Italy	PM, NO_2	Mechanism	Time series	Previous NO_2 exposure independently increases the mortality risk in infected individuals through immune effects	[6]
NA	PM, NO_2	Epidemiology	Review	PM and NO_2 contribute to COVID-19 spread and lethality	[53]
NA	–	Severity	Review	Air pollution and racial disparities can affect COVID-19 mortality	[75]
England	PM, NO_2	Epidemiology	Ecological	Positive association between air pollutants concentration and COVID-19 mortality and infectivity	[54]
China	PM, NO_2, O_3, CO, SO_2	Epidemiology	Time-series	Positive association between short-term (two-weeks) concentrations of air pollutants and COVID-19 infection	[55]
NA	–	Epidemiology	Review	Exposure to air pollution correlates with COVID-19 infections, severity and mortality	[76]
Austria	NO_2	Epidemiology	Time-series	Positive correlation between short-term concentration of NO_2 and the risk of infection	[77]
NA	PM, NO_2, SO_2	Meta-analysis	Ecological, Time-series	Positive correlation between exposure to air pollutants, COVID-19 incidence and mortality	[64]
USA	PM, O_3	Epidemiology	Time-series	Short-term exposure to air pollutants increases COVID-19 incidence	[56]
California	NO_2	Epidemiology	Ecological	Annual NO_2 concentrations are associated with population-level rates of COVID-19 cases and deaths, adjusting for confounders	[78]
NA	–	Epidemiology, mechanism	Review	Evidence from in vitro, animal and epidemiologic studies relating air pollutants to COVID-19 morbidity and mortality	[63]
NA	PM, NO_2, O_3, CO, SO_2	Chronic exposure	Review	Association between chronic exposure to outdoor air pollutants and the incidence, severity and mortality of COVID-19	[57]
USA	PM	Mortality	Ecological	Positive correlation between PM concentration levels and COVID-19 mortality	[58]
Mexico	PM	Mortality	Ecological, Cohort	Positive relationship between pollution (mainly long-term) and COVID-19 mortality significantly grows with age	[79]
Turkey	PM, NO_2, SO_2	Mortality	Ecological	COVID-19 mortality is related with an interaction of socio-economic factors and air pollution	[80]
Bangladesh	PM, CO, O_3	Epidemiology	Ecological	Air pollution, geo-meteorological parameters and social parameters are associated with COVID-19 infection rate	[81]
Canada, Italy, England, USA	PM, NO_2	Epidemiology	Ecological	Multi-country analysis showing that $PM_{2.5}$ (but not NO_2) long-term air concentration affects COVID-19 incidence in USA	[82]

Table 3 (continued)

Country	Pollutant(s)[a]	Question[b]	Study type	Main findings	References
Colombia	PM	Mortality	Ecological	No evidence of ecological association between long-term exposure to $PM_{2.5}$ and COVID-19 mortality, which was affected by demographics, health system capacity, and social conditions	[83]
China, Japan, Korea, Canada, America, Russia, England, Germany, France	PM, NO_2, O_3, CO, SO_2	Epidemiology	Ecological	$PM_{2.5}$, PM_{10}, SO_2, NO_2, O_3 but not CO are sensitive indicators of newly confirmed COVID-19 cases. $PM_{2.5}$ in high concentrations is the more sensitive pollutant on the spread of COVID-19 infection	[84]
USA	NA	Epidemiology	Ecological	Counties where greater COVID-19 incidence coincides significantly with higher hazardous air pollutants respiratory risk also had higher socioeconomic deprivation	[85]
Saudi Arabia	PM, NO_2, O_3	Epidemiology	Time-series	Air pollution and meteorological indices affect the daily number of infections	[86]
Spain	PM, NO_2, O_3	Epidemiology	Time-series	COVID-19 incidence and deaths are linked with seasonal variability of climate and with air concentration of pollutants	[59]
NA	NA	Mechanism	Review	Air pollution affects COVID-19 incidence and SARS-CoV-2 virulence based on epidemiological data substantiated with pathophysiologic mechanisms	[61]
China	PM, NO_2, O_3, CO, SO_2	Epidemiology	Time-series	The association between meteorological and air pollution variables and COVID-19 incidence varies with urban agglomeration	[87]
Colorado	PM	Epidemiology	Ecological	A 1 $\mu g/m^3$ increase in long-term $PM_{2.5}$ concentrations is associated with a statistically significant 26% increase in the relative risk of COVID-19 hospitalizations and a 34% increase in mortality. Communities of color are subject to higher risk of infection as well as of more severe complications	[88]
Germany	NO_2, O_3, $PM_{2.5}$	Epidemiology	Time-series	An increase of 1 $\mu g/m^3$ NO_2 increases the need for intensive care due to COVID-19 by 4.2%, and mechanical ventilation by 4.6%	[89]

NA not applicable

[a] *PM* Particulate Matter, PM10, PM2.5, *NO_2* Nitrogen dioxide, *O_3* ozone, *CO* carbon monoxide, *SO_2* sulfur dioxide,

[b] Mechanism: experimental study, Epidemiology epidemiological study, Severity impact on severity of disease, lethality

It is vital to see that these different mechanistic hypotheses differ in the timing of the relevant exposure. Further epidemiological research can therefore help to better distinguish between these hypotheses.

In many settings, monitoring data on air quality is representative for the exposure of a huge amount of people, with large health implications. This enables field studies with remarkable power that will even detect rather small effects. Thus, air pollution research serves as an example for other fields of environmental health where exposure assessment is much more difficult and costly. In these other fields, the lack of evidence should not be interpreted as evidence for the lack of effect or the absence of interactions.

Studies on the relationships between the pandemic and air pollution indicate how environmental factors can play a relevant role in both communicable and noncommunicable diseases, and how the interplays between these three elements contribute to increase the complexity of their understanding and management. This evidence points, again, towards a possible central role for internal medicine in interpreting and governing these multifaceted and multidisciplinary dynamics, orienting efforts not only to clinical management of diseases but also to primary and secondary prevention measures, and to structured educational programs.

How to learn the lesson: the role of health professionals and policymakers at the local and global level

Medicine is deemed as the science and art of treating human beings suffering from injury, disease and illness [65]. Here, internal medicine plays a privileged role due to its holistic and multidimensional approach. The history of Medicine reveals that almost universally, the management of health and diseases can be discriminated into two primary approaches: curative (according to Asclepius, god of Medicine) and health promotion/protection (according to Hygeia, goddess of hygiene and health).

The event that marked the decisive turning point in such a distinction occurred in 1942, when William Beveridge introduced a “Plan for Social Security and Allied Services” into the English Parliament. In 1946 the English Parliament approved the first National Health Service and began its organisation and operation in 1948. It was based on three core principles relating to the individual and not to the general population, i.e., (1) meet the needs of every individual; (2) based on clinical need, not on ability to pay, and (3) be free at the point of entry [66].

Many countries worldwide followed a similar pattern to that of England under the responsibility of Ministries of Health (formerly Ministries of Hygiene) or agencies similar in the national government, thus creating one of the most deceptive illusions concerning health. The illusion that mitigating, treating, caring, and sometimes curing the disease employing an industrialised organisation could improve the health of the population.

What we label as health services are no more than medical services dedicated to the care of the disease–not even to those who suffer from them—ignoring health protection and promotion and a large part of preventing illness. Big business has used Medicine to build profit-making industrial complexes that offer the consumer services of laboratories, diagnostic services, outpatient care, and hospitalisation.

In this context, internal medicine can also play a driver role, due to its attitude to prefer a model of clinical governance based on an individual-centred care, on the quality of outcome and on the maintenance of the health status, rather than on a mere administrative-based management [67].

True health services are interventions that should protect and promote health and help prevent the disease from occurring, with huge advantages also in terms of reducing health costs [68–70].

A comprehensive overview of health services [71] has included a total of 37 different items divided into five main sectors (i.e., services of health protection, individualized services for health promotion, collective services of health promotion, implementation of social capital, and preventive medical services) and ranging from environmental issues to hygiene, physical activity, lifestyle, urbanistic features, policy strategies, family planning and managing [71]. This wide concept of health services, public health, individual health, and disease prevention must therefore involve many disciplines and competencies. This change can be easily driven by the longstanding experience accumulated by specialists in internal medicine.

Over 70 occupational categories relevant to environmental health in Europe were identified in a review published in 1998, which included academics, medical specialists, environmental scientists (e.g. epidemiologists, natural scientists, social scientists and experts in hygiene occupations) and professionals (such as environmental health workers, technicians, and architects) [72]. At variance from internal medicine, however, the “one health” role of most of these categories is limited by a single, specific field of action, that makes difficult efficient interactions with different sectors, and at a global level.

To appropriately face the current COVID-19 pandemic, as also to face the progressive rise in noncommunicable diseases, we urge to reorganize health services, policies, and clinical strategies (including continuing medical education and adequate spread of medical information), towards a real awareness of the complexity of the global risks also in a local context. From this point of view, community medicine and family physicians play a critical role in facing potential future pandemics. The role is not only in terms of clinical care but also in terms of social support, screening of most vulnerable subjects, early surveillance, local monitoring of environmental health and environment-related health risk, transmission of adequate information to general public, and coordination between different health services [73].

Hence, it is essential to facilitate and to promote coherent policy initiatives at local, national, regional, and global level. This might start with encouraging greater awareness of the global dimensions of health among policymakers and health practitioners but could then be followed by specific policy decisions to optimise the benefits and mitigate the costs of globalisation for health.

Conclusions

The SARS-Cov-2 pandemic is having a major impact on public health and worldwide economy. Effects can vary depending on country and individual levels of vulnerability. The massive vaccination policy has partly improved this scenario, but the global crisis generated by the spread of SARS-CoV-2 and its variants is still far to be solved. In addition, the risk of further, future pandemics is high [74].

Evidence clearly indicates strong and complex links between the COVID pandemic, the global burden of noncommunicable diseases, demographic unbalance, individual vulnerability and unhealthy aging, environmental pollution, socio-economic inequities and inequalities and criticalities in maintaining an adequate efficiency in the national health systems.

Consequently, resilience of large communities worldwide depends by multiple factors and require a thoughtful and comprehensive approach. Experts in internal medicine have knowledge and skills to drive a change in strategy, in medical education, in public health management and in specific clinical practices, since neither the pandemic nor the growing burden of noncommunicable diseases can be simply faced as a pure technical and clinical challenge. This approach requires a holistic, global health approach, multidisciplinary and multisectoral policies and long-term, adequate policies oriented towards environmental health and sustainability, prevention programs and a reduction of individual vulnerability worldwide, also through educational and coordinated programs.

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