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THE IMPACT OF THE COVID-19 PANDEMIC ON GLOBAL ENVIRONMENTAL CHANGE AND ITS CONSEQUENCES FOR HUMAN HEALTH

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Abstract

The COVID-19 pandemic has had a significant impact on global environmental change, primarily through the reduction of greenhouse gas emissions and air pollution due to the sharp decline in economic activity, particularly in the transportation and industrial sectors. While these changes brought temporary environmental improvements, such as better air quality and reduced water pollution, they did not offset long-term environmental challenges. The pandemic's effects on human health have been mixed: on one hand, improved air quality may have reduced respiratory illness-related morbidity, while on the other hand, the economic downturn and disruptions in healthcare services negatively affected public health. The long-term implications of the pandemic highlight the need for a transition toward more sustainable economic activities and improved natural resource management to mitigate future health and environmental risks.

Keywords: greenhouse gas emissions, air pollution, human health, sustainable development, climate change, air quality, economic downturn

I. Introduction

The COVID-19 pandemic and the associated social restrictions such as isolation and travel restrictions have impacted various areas of society, as well as people's work and personal lives. The impact of the pandemic has varied depending on the sector of work, socio-economic situation and other factors. For example, depending on the requirements for physical presence in the workplace and the availability of remote working options, people have experienced different changes in their daily lives.

At the global level, the COVID-19 pandemic has exposed systemic weaknesses in infrastructures, supply chains, government preparedness and response, as well as human resources and public health systems. The pandemic has challenged public health officials and health system managers to maintain a coherent narrative of measures to control the spread of COVID-19. Among other challenges encountered in the fight against the virus, it became apparent that many health facilities were ill-equipped and unprepared for the influx of patients, and had insufficient medical and epidemiological training to adequately care for patients. Overall, public health systems were unprepared to deal with a new viral pathogen that was rapidly spreading across the world, as containment measures were not rigorous enough and were not effectively implemented at the most critical time.

More than two years after the emergence of SARS-CoV-2, it has become clear that collaboration in information sharing between governments and health care providers, as well as clear and timely communication with the public, are critical to slowing the spread of the disease and preventing a resurgence of the pandemic. However, it is still unclear whether health measures in any country have adapted to the possibility of another outbreak.

Part of the recovery from the pandemic requires reorganizing public health systems to be better prepared to manage new outbreaks of diseases that have overburdened the traditional hospital system and significantly reduced the quality and volume of health care. Thus, public health systems must be rebuilt to effectively and competently manage emerging infectious diseases and are framed around five key activities: (1) governance, (2) protection, (3) containment through transmission control and suppression, (4) information, and (5) support (see Figure 1).The COVID-19 pandemic has put immense pressure on global economic and healthcare systems, underscoring the extent of global interconnections and the critical need for preparedness against global health threats (fig.1). Current efforts are largely centered on pandemic response, including developing treatments and vaccines. However, other pressing health threats, driven by human activities—such as climate change, pollution, urbanization, and unsustainable consumption—may seem less urgent. These factors have caused significant environmental disruption and biodiversity loss. Addressing the pandemic in isolation from these issues, through measures like increased use of disposable materials, reduced public transport, or subsidizing polluting industries, may offer short-term economic and health benefits but would undermine long-term goals for human health and sustainability. Climate change and other environmental stressors, along with their impacts on human and ecosystem health, remain ongoing challenges. The COVID-19 crisis highlights the links between environmental changes and the emergence of infectious diseases, emphasizing the urgent need for prevention, as controlling pandemics in a globalized world has proven difficult. This situation calls for a planetary health perspective in governance and research, adopting interdisciplinary, transdisciplinary, and cross-sectoral approaches.

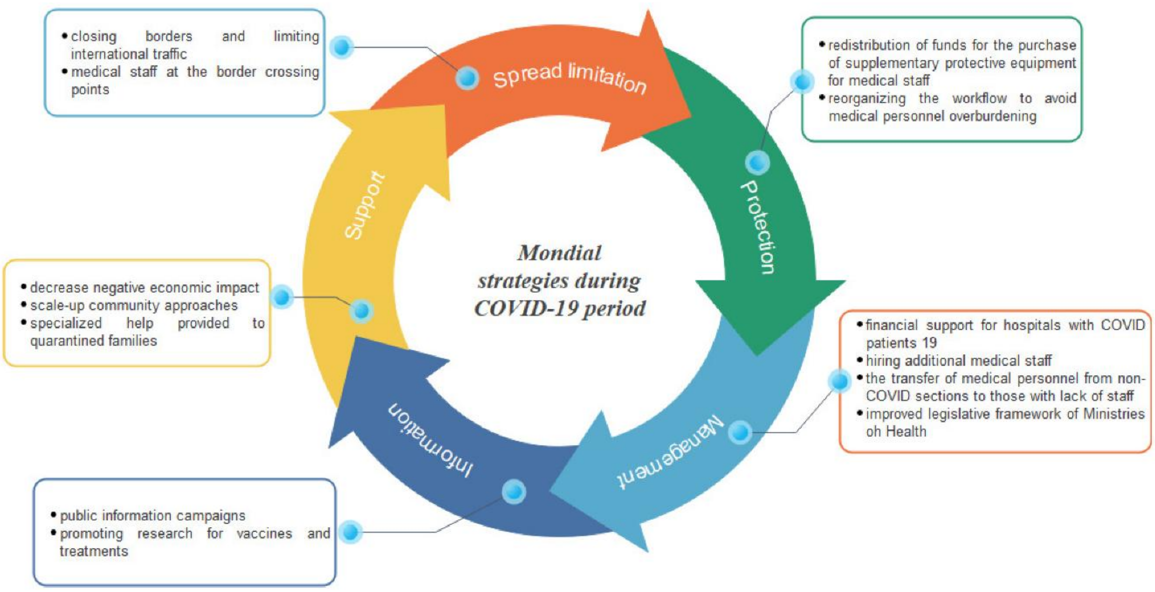

Figure 1: *Mondial strategies during C19, describing five measures that focus on redesigning public health care systems to better manage future pandemic events*

Compounding the response to COVID-19 are concurrent global challenges such as heat waves, wildfires, locust swarms in East Africa, droughts, and the severe 2020 cyclone season. Additionally, the pandemic itself is likely to impede optimal responses to these threats, overburdening under-resourced public health systems, complicating evacuations and emergency measures, and fostering the spread of misinformation and conspiracy theories. The pandemic and environmental health issues are deeply intertwined, and we argue that only an integrated global approach that simultaneously addresses infectious diseases and other environmental threats will lead to sustainable solutions and policies to safeguard both human and ecosystem health for current and future generations. In this paper, we outline the key findings of this work.

II. Methods

Improving our understanding of the ecological and behavioral drivers behind the emergence and spread of coronaviruses is crucial. While the zoonotic origin of SARS-CoV-2 has been well-established, a direct connection between the viral variants found in bats, pangolins, and humans remains unidentified, including the intermediary host(s) that transmitted the virus to humans. Understanding the ecology and epidemiology of COVID-19 also involves investigating the genetic basis of host susceptibility, whether in animal reservoirs or human populations. Key research questions include the impact of ecosystem changes—deforestation, land use, infrastructure development, and urbanization—on human-wildlife interactions, and the subsequent increased risk of zoonotic disease spillover. It is vital to determine the extent to which habitat destruction and human activities (such as farming, hunting, and wildlife trade) have contributed to recent zoonotic disease outbreaks, particularly SARS-CoV-2. In the context of climate change, the role of biodiversity loss in disease emergence also requires more in-depth investigation.

Advances in methods and tools are also necessary. For example, ecological health observatories could help analyze the social-ecological dynamics of SARS-CoV-2 and track its spatial and temporal patterns across different ecosystems (wild and domestic animals, air, and water) in both urban and rural environments. Viral genome screening of wildlife (through metagenomics) and the creation of open-access databases are needed to trace transmission pathways and viral evolution within the intermediary hosts of SARS-CoV-2. These efforts will also be critical for managing future emerging viruses. Pandemic modeling has proven essential for informed decision-making during COVID-19, and improving data integration and processing, as well as enhancing modeling capacities worldwide, is crucial. This includes models that account for climate conditions affecting viral transmissibility and models that describe human interactions to estimate effective contact rates. Thus, these models must incorporate epidemiological, demographic, ecological, evolutionary, climatic, social, and cultural data, as these are all key factors in disease evolution.

Research will require interdisciplinary collaboration across fields such as microbiology, medicine, epidemiology, ecology, environmental and evolutionary sciences, veterinary science, agriculture, social sciences, urban planning, mobility studies, anthropology, and behavioral economics. These data will be necessary to both build and validate models of disease emergence and transmission, and integrative approaches that encompass human activities and health status should be prioritized.

The combined effects of infectious diseases and environmental stressors are a major concern. COVID-19 severity has been strongly linked to age and comorbidities, including respiratory, cardiovascular, and metabolic diseases, as well as obesity, conditions partly caused by exposure to environmental stressors such as poor urban planning, unhealthy food environments, air pollution, and chemical toxicants. Better understanding of how pollutants impact immune and cardiometabolic health is essential for identifying population-level vulnerabilities and exacerbating factors. COVID-19 has disproportionately impacted low-income and minority groups, underscoring the role of socioeconomic factors in both exposure to and vulnerability to the virus.

Coordinating existing cohort studies across Europe is a key step, along with the Europe-wide development of tools and models to better assess and predict the health, social, and environmental determinants of COVID-19. The pandemic has highlighted the deep interconnections between infectious and non-communicable diseases, with the latter exacerbating the severity of the former.

It is therefore crucial to explore how viral infections interact with environmental factors of chronic diseases, such as chemical exposure, air pollution, climate change, and socioeconomic conditions.

For example, more research is needed on the dual role of indoor air quality in both environmental contamination and viral spread, as well as innovative solutions for mitigation, such as air purification technologies. Additionally, exposure to wood smoke at relatively low levels has been linked to suppressed respiratory immunity, increasing susceptibility to infections and lung diseases—a concern that is particularly relevant given the energy poverty exacerbated by recent financial crises. Similarly, the risks and benefits of spending time in parks, green spaces, and blue spaces (water bodies) need further investigation.

III. Results

The World Health Organization (WHO) officially declared COVID-19 a pandemic on March 11, 2020. In response, many countries implemented quarantine, isolation, and lockdown measures as part of public health strategies to limit the spread of the virus. While these actions were necessary to control the outbreak, they also led to severe economic downturns and significant changes in social behavior. However, this unprecedented global event also had unexpected positive effects on planetary health. The widespread shutdown of industries, travel restrictions, and lockdowns resulted in several environmental benefits, particularly due to the reduction of human-caused pollution.

The World Health Organization (WHO) reported that the SARS-CoV-2 virus can be transmitted through blood, stool, saliva, and respiration, making the availability of personal protective equipment (PPE) for healthcare workers a critical part of treatment, containment, and the health of the workers themselves. In the general public, where precautions were less strict, the disease spread widely. Testing laboratories were vital early in the pandemic and continue to play a crucial role in documenting the spread of COVID-19. While testing is a post hoc measure, it reveals the prevalence of infection, providing valuable epidemiological data and helping coordinate healthcare needs for infected individuals. Rapid identification and diagnosis of COVID-19 cases can lead to quick treatment for patients, with workflows adapting to evolving care procedures and standards for infection detection.

Generally, standard protocols for handling COVID-19 cases involved transferring patients to COVID-19 containment areas. However, the specifics of these protocols were not thoroughly investigated, making it challenging to assert the existence of a cohesive global protocol. Although public health authorities were typically notified of cases, tracking and tracing patient contacts with family members and others proved burdensome, limiting population-level containment approaches. While the majority of cases globally did not require hospitalization, patients treated at home still posed health risks, as individuals often came into contact with others due to the urban environments where most people live.

Asymptomatic individuals, who were often untested, presented a significant challenge during the pandemic; therefore, comprehensive testing strategies emerged as the best solution to mitigate the spread of the coronavirus. Asymptomatic transmission of SARS-CoV-2 is considered a major obstacle in controlling the COVID-19 pandemic. Consequently, continuous testing of staff who attend to vulnerable populations and those in need of care is essential. The use of rapid antigen tests for SARS-CoV-2 has streamlined emergency departments and facilitated public access to home-based testing methods, although false negatives are a possibility. Despite these minor drawbacks, the advantages of rapid tests and at-home testing kits are crucial in tracking the virus's spread.

According to globally established regulations, testing and metagenomics laboratories involved in the detection and sequencing of the SARS-CoV-2 virus must be managed by trained staff or experts, who are required to comply with established protocols (mainly separating input and output flows) and be equipped with nucleic acid extractors, RT-PCR devices, ultra-low freezers, UV lamps for decontamination, and other disinfection equipment, as well as automatic pipettes (robots) and contamination-free consumables.

Unfortunately, the COVID-19 pandemic has claimed many lives. However, it has also prompted a reevaluation of medical systems worldwide. The reorganization of emergency departments was beneficial, and many of the models implemented remain relevant even post-pandemic, allowing for better-organized workflows, quicker interventions, and increased medical advice sought by patients with minor needs via telephone or telemedicine.

More than any other ward, the emergency department was primarily engaged with COVID-19 cases. Most medical staff were reassigned to this department, receiving training and remaining on standby. Emergency rooms often experienced overcrowding. The organization of medical processes using a color-coded system helped alleviate the situation. For example, in Italy, a heavily impacted country, the emergency department was organized by color based on severity: white, green, yellow, and red. Red indicated immediate access, orange allowed access within 15 minutes, blue within 60 minutes, green within 120 minutes, and white within 240 minutes. This color-coding system was later adopted by hospitals in various parts of the world, representing a model of good practice.

Rapid detection of COVID-19 was crucial for patient treatment and minimizing the risk of transmission. In addition to continuous PCR testing, doctors discovered alternative methods for identifying the disease, such as ultrasound or symptom assessment. In all countries affected by the pandemic, emergency departments were supplemented with PCR equipment, CT scanners, and ICU units, either through redistribution from their own units or through donations from more developed hospitals or states assisting severely affected countries.

Funding from industry, academia, government agencies, and regulatory bodies has helped emergency departments worldwide, facilitating easier access for sick individuals to medical care and treatment. Protective equipment for emergency department staff was enhanced (including coveralls, high-protection masks, gloves, face shields, and goggles), and workflows were digitized to ensure immediate connections between reception areas and care and treatment zones. Critically ill patients were isolated in airborne infection isolation rooms or negative pressure isolation rooms with HEPA filtration of recirculated air.

IV. Discussion

Much of the work performed by dermatologists underwent significant reorganization during the COVID-19 pandemic. Many dermatologists were reassigned to COVID-19 treatment facilities, resulting in non-essential cases being sidelined to focus on critical patient care. Consequently, hospitalizations for non-medical emergencies ceased, and routine consultations transitioned to telemedicine. In instances where face-to-face consultations were essential, particularly for conditions like melanoma that require early surgical intervention, procedures were adjusted to protect staff from COVID-19 exposure. Unlike in some countries where workflow reorganization facilitated urgent dermatological treatments, many low- and middle-income countries faced challenges in addressing conditions requiring emergency care, such as solid tumors and metastatic diseases.

In dermatological emergencies, triage is essential. Dermatological consultations typically cannot occur from a distance of less than 25 cm, particularly for dermoscopies or other interventions. When patient interactions occurred, staff were required to wear PPE and adhere to strict decontamination protocols before and after contact, especially after handling contaminated surfaces or body fluids. The European Task Force on Atopic Dermatitis recommended the continuation of immune-modulating treatments, urging strict adherence to hygiene protocols, including the use of non-irritating cleansing agents and moisturizers after each application.

Similar to many hospital wards, orthopedic departments underwent complete restructuring. Non-emergency interventions were postponed to prioritize major emergency and oncological cases. Mild cases that would usually be treated in inpatient or outpatient settings were also deferred until safe conditions were restored following the pandemic. However, patients such as pregnant women, immunocompromised individuals, or those over 60 years of age continued to be classified as medical emergencies. Medical staff utilized PPE during patient intakes and procedures, with workflows adapted due to the challenges of accurately assessing patients' conditions following initial consultations. Continuous monitoring was necessary for health changes, considering potential COVID-19 symptoms like fever, loss of taste or smell, respiratory or gastrointestinal issues, and cardiac irregularities. Suspected nasopharyngeal samples were collected for PCR testing and processed in designated areas while awaiting results. Patients who tested positive for COVID-19 and presented as medical emergencies were transferred to specialized containment areas for surgical procedures.

The number of medical personnel allowed in operating rooms was limited, and procedures that could generate aerosols were avoided. Treatment equipment for COVID-19 patients, such as monitors and ultrasound devices, had to be protected from contamination and easily cleaned to minimize risks. Postoperative routines were adjusted to maximum capacities, and where possible, portable radiography equipment was used and disinfected immediately after use. Dressings and splints that could be easily changed were primarily utilized for postoperative care.

The COVID-19 pandemic posed significant risks for over 100 million pregnant women worldwide. Due to suppressed immunity, these women are at increased risk of moderate to severe infections that can also affect their fetuses. Pregnant women with COVID-19 face heightened risks of miscarriage, premature birth, and preeclampsia. Fetuses are also at increased risk of mortality and requiring intensive care. Routine screening for COVID-19 is crucial for this population. Pregnant women who contracted the virus but exhibited no respiratory symptoms were advised to quarantine at home while maintaining communication with their primary care providers.

Continuous health monitoring of pregnant women is vital, necessitating regular testing and blood tests for various important parameters. In heavily impacted areas, initial consultations were suggested to occur at home, with subsequent hospital visits to minimize unnecessary exposure to patients. Typically, patients would be hospitalized for 1-2 days before giving birth, but during the pandemic, contact with medical facilities was limited to ensure safety for both mother and fetus. This change posed scheduling challenges for hospitals and patients.

During cesarean sections, epidural anesthesia is typically administered, but the use of nitrous oxide was minimized due to the risk of aerosol generation, which could facilitate virus spread. Breastfeeding is encouraged for women infected with COVID-19, as studies indicate that both IgG and IgM antibodies can be transmitted through breast milk. Antibodies are present in breast milk as early as two weeks post-vaccination. To mitigate contamination risks, visits by outsiders were prohibited, and online communication became the primary means of connecting with family and friends. Before discharge, both mothers and newborns underwent COVID-19 testing, and they could only leave the hospital after receiving negative test results.

The pandemic also significantly impacted pediatric healthcare. Initially, the number of COVID-19 cases among children was relatively low; however, with the emergence of new SARS-CoV-2 variants, children became increasingly affected. Fortunately, symptoms in children tend to be milder, including fever, dry cough, nasal congestion, abdominal discomfort, or diarrhea, with many remaining asymptomatic. Nonetheless, there have been instances requiring pediatric emergency care. Hospitals prepared for pediatric emergencies, particularly in infectious disease wards.

Most children needing emergency care faced moderate to severe respiratory infections, such as influenza and bronchiolitis, meningitis, sepsis, osteomyelitis, and asthma. The Omicron variant, while more contagious among children, has resulted in less severe outcomes compared to the Delta variant, with lower rates of hospitalization, ICU utilization, and mechanical ventilation.

Although environmental and health professionals have an expert understanding of the spread of infectious pathogens and the potential for zoonotic pandemics, the shock of COVID-19 has been particularly profound. The confirmation of the zoonotic origin of the virus, its survivability in air, water, and surfaces, and its modes of transmission have clearly demonstrated that the COVID-19 pandemic is a global emergency based on the link between the environment and human health. The environment has played a key role in the emergence and spread of SARS-CoV-2, as well as in the societal response to this emergency.

National and subnational environmental and health structures have been affected in almost every aspect of their work. For experts who (at least in developed countries) have long focused on understanding and managing the environmental aspects of noncommunicable diseases, it has come as a surprise that infectious diseases have once again come to the fore. The pandemic has also demonstrated the importance of understanding the impact of the environment on mental health in the context of isolation and restrictions, and the need to adapt homes and public spaces to new conditions.

Before the pandemic, environmental and health professionals realized that their work transcends traditional understandings of space and time. Climate change and its impacts have shown that the key function of public authorities in this area - ensuring a safe and healthy environment - must take into account the impact of economic and social factors, as well as human activities, on ecological systems. Moreover, work at the national and subnational levels must now include concern for the environment and health of people beyond these territories. COVID-19 has once again confirmed this need.

It is important to note that climate factors and pandemics, although different phenomena, are interrelated in their origins and require the creation of societal resilience. The working hypothesis should take into account the possibility of the simultaneous occurrence of pandemics, climate events and disasters in the future. The COVID-19 pandemic has not only exposed societal resilience issues that will be exacerbated by climate change, but also exposed significant vulnerabilities across a range of sectors.

The pandemic has also exacerbated social inequalities. People with low incomes, chronic illnesses, the elderly, and other vulnerable groups were at greater risk of infection and severe consequences. One clear finding was that knowledge workers, who tend to have higher incomes, were able to work remotely, avoiding the risk of infection. At the same time, low-income workers often faced higher risks, as they were forced to be in the workplace and use public transport. This policy brief provides a high-level picture of the environmental and health impacts of the COVID-19 pandemic, without going into depth on specific issues or topics. Although WHO has declared the COVID-19 pandemic no longer a public health emergency of international concern, its impacts will be felt for a long time. Moreover, the COVID-19 literature is constantly evolving, expanding the evidence base.

The analysis presented here begins with a No COVID Base scenario representing expected development patterns in a world without the pandemic. To simulate this we rely on economic growth rates produced just prior to the pandemic in the World Economic Outlook (WEO). We apply growth rates from this report for 2019–2025 and then use IFs endogenous growth projections through 2050. For this scenario we maintain 2017 country Gini-index values through 2050. As noted previously, this scenario produces similar results to other medium-variant forecasts prior to the outbreak. We compare this No COVID Base scenario with the COVID Base scenario. This scenario simulates the effect of COVID-19 by including WEO growth projections published for the years 2021–2023. From 2023–2050 we also rely on IFs endogenous growth projections for this scenario and keep country-level income inequality values flat across time. We compare these two scenarios with six alternative scenarios that frame uncertainty by varying GDP growth and income inequality. We vary GDP growth by 1.5 percentage points for 2022 around the COVID-Base values and then converge these to the COVID Base growth trajectory by 2025. The 1.5 percentage points variation is a high-end assumption that falls within the standard variation across world GDP growth rates from the WEO during the COVID-19 period (~1.6%), and the mean difference across countries in GDP growth rates comparing the World Bank Global Economic Prospects [85] and the IMF WEO April 2021 release (~1.6%).

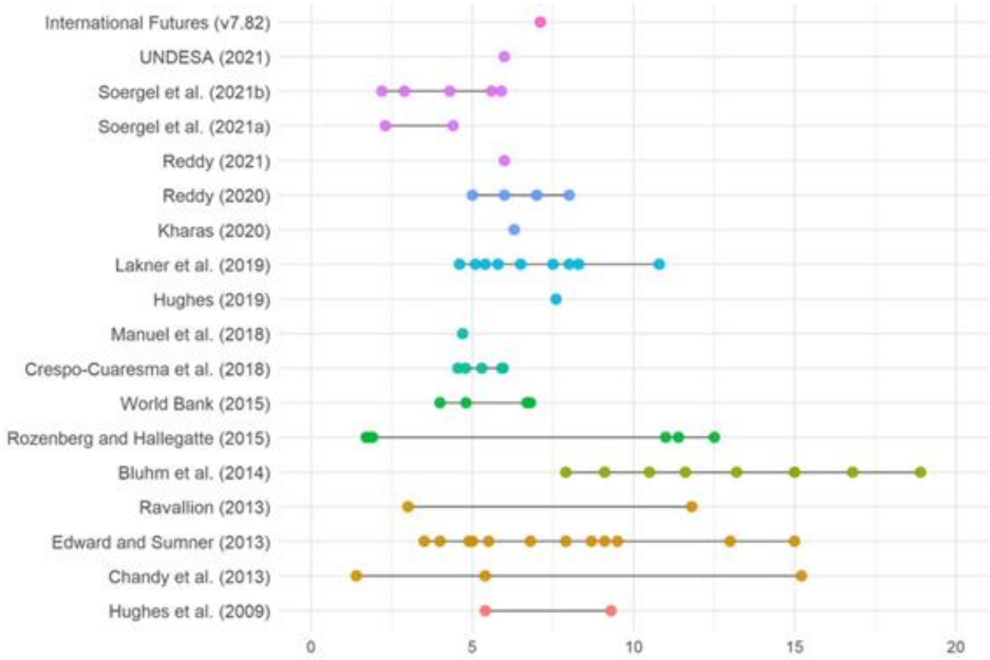

Figure 2: *Previous projections of extreme poverty levels summary that do not account for COVID-19*

This policy brief is based on a "rapid review of policy papers" (WHO Regional Office for Europe, 2023), which reviews high-quality studies published from early 2020 to early 2023. This review is structured similarly to this policy brief and provides more detailed information on the topics discussed. It also aims to facilitate access to policy papers and primary research.

The published and unpublished reviews highlight the desire for change and acknowledge the urgency of this change. The COVID-19 pandemic has caused significant disruption, and some survey results suggest that it has created a sense of urgency for change that goes beyond the academic and policy circles that provided the analyses discussed.

People are now more informed and have a better understanding of how their experiences of the pandemic and the impacts of climate change relate to their health, well-being, and ultimately the survival of humanity. Institutions and sectors of society have clearly demonstrated a lack of resilience.

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