Review Article

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COVID-19 in the Asia Pacific: Impact on climate change, allergic diseases and One Health

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ABSTRACT

Climate change and environmental factors such as air pollution and loss of biodiversity are known to have a major impact not only on allergic diseases but also on many noncommunicable diseases. Coronavirus disease 2019 (COVID-19) resulted in many environmental changes during the different phases of the pandemic. The use of face masks, enhanced hand hygiene with hand rubs and sanitizers, use of personal protective equipment (gowns and gloves), and safe-distancing measures, reduced the overall incidence of respiratory infections and other communicable diseases. Lockdowns and border closures resulted in a significant reduction in vehicular traffic and hence environmental air pollution. Paradoxically, the use of personal protective equipment and disposables contributed to an increase in environmental waste disposal and new problems such as occupational dermatoses, especially among healthcare workers. Environmental changes and climate change over time may impact the exposome, genome, and microbiome, with the potential for short- and long-term effects on the incidence and prevalence of the allergic disease. The constant use and access to mobile digital devices and technology disrupt work–life harmony and mental well-being. The complex interactions between the environment, genetics, immune, and neuroendocrine systems may have short- and long-term impact on the risk and development of allergic and immunologic diseases in the future.

Keywords: Climate change; Exposome; Genome; Microbiota; Pollution

Introduction

Global epidemiological studies have shown that climate change, reduced biodiversity, and indoor and outdoor air pollution including microplastics affect respiratory health, several noncommunicable diseases, and lifestyle-related diseases [1, 2]. This impacts work productivity, mental health, health expenditure, and economies of nations, especially those in resource-poor settings [3].

The coronavirus disease 2019 (COVID-19) pandemic caused by the SARS-CoV-2 virus declared internationally in March 2020 resulted in widespread disruptions to mankind's usual daily activities, bringing social-behavioral changes that have insidiously altered our environment and mankind [4, 5]. The term ecosyndemic describes how global environmental change contributes to local, regional, and global-level alterations of the Earth's systems. These changes have their root causes in the way that people interact with the physical, chemical, and biotic factors of the environment [6]. These interactions disturb nature with consequences in every living organism. Prior to COVID-19, APAAACI had already recognized the potential impact of pollution, climate change, and biodiversity on allergic disease [7], as genomics, the microbiota, and the exposome all interact with one another [8]. COVID-19 may be affected by climatic,

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meteorological, and environmental factors, including temperature, humidity, and air pollutants. These in turn affect socioeconomic systems, people's lifestyles, and population health. Pandemic control policies result in the reduction of emissions and population adaptations under the background of climate change, further affecting human health [9].

1. Summary of the pandemic 2020–2022

SARS-CoV-2 is an unusual virus with infectious and parainfectious manifestations including immune-mediated lung and internal organ injury [10], dermatoses [11], myopericarditis [12], and prothrombotic events [13]. Multisystem inflammatory syndrome in childhood (MIS-C) [14], MIS in neonates born to mothers with SARS-CoV-2 infection [15], and MIS in adults [16] have been defined and described in various systematic reviews: comprising Kawasaki disease-like manifestations including fever, rash, cardiovascular, and gastrointestinal involvement. Postacute sequelae of COVID-19, also known as long COVID, is a heterogeneous, multisystem, relapsing, and remitting illness where the most common symptoms of fatigue, shortness of breath, and cognitive dysfunction, may impact everyday functioning [17]. High-risk, vulnerable individuals including the elderly, immunocompromised (eg, on immunosuppressive drugs, postorgan transplant patients, hematology, and solid organ cancer patients on active treatment), and obese [18], are at risk of severe COVID-19 infection.

The outbreak response during the first year (2020) of the pandemic focused mainly on the development of rapid diagnostics, treatment, and prevention of spread. Rapid and high-throughput polymerase chain reaction kits, serological tests, whole genome sequencing for mutations, and antigen rapid tests were developed. Mitigation measures included case isolation, contact tracing, quarantine, and prevention of the spread of infection with the use of personal protective equipment, work-from-home strategies, and international border closures. Treatment involved empiric use of antivirals (eg, remdesivir) and immunomodulatory drugs (eg, corticosteroids, intravenous tocilizumab, baricitinib) in different permutations and combinations through international multicentre clinical trials. Early vaccine development using different vaccine platforms in various clinical trials were also initiated [19].

In the second year of the pandemic (2021), COVID-19 national vaccination programs became the game-changer. Highly effective novel messenger ribonucleic acid (mRNA) vaccines from Pfizer-BioNTech and Moderna created initial concerns about the risk of anaphylaxis to polyethylene glycol and polysorbate excipients in the vaccines [20]. This created an initial heightened awareness of personal histories of allergies in individuals with previous vaccine allergies, anaphylaxis to nonvaccines, and severe drug allergies which were deemed as potential risk factors for mRNA vaccine-associated anaphylaxis. It has since then been conclusively shown that the risk of anaphylaxis is no greater than other non-mRNA, non-COVID-19 vaccines [21]. Despite the risk of mRNA vaccine-induced myocarditis in the high-risk demographic (men below 40 years of age) [22] and the ChAdOx1 nCoV-19 vaccine-induced thrombotic thrombocytopaenia [23], the overall benefits of COVID-19 vaccination outweighed the risks of adverse effects in particular in vulnerable populations. Over time, alternative non-mRNA COVID-19 vaccination options were offered to the public. To improve the accuracy of reporting of vaccine anaphylaxis, the Brighton Collaboration Classification for anaphylaxis was updated in 2022 to increase the use of objective signs and reduce the dependence on subjective symptoms of anaphylaxis for vaccination centers and emergency providers to diagnose anaphylaxis [24]. Vaccine injury financial assistance programs may paradoxically have triggered unintended anxieties in some patients and parents, reducing regional vaccination rates in certain countries, and increasing the risk of severe COVID-19 among the vulnerable elderly and immunocompromised and need for healthcare resources [25–27]. Alternative vaccine platforms including inactivated virus vaccines (Sinovac-CoronaVac) and protein subunit vaccines (Novavax/Nuvaxovid) were subsequently made available for adults, with mRNA vaccination programs progressively rolled out to include children from as young as 6 months old (Pfizer-BionTech/Comirnaty and Moderna/Spikevax). Enhanced primary enhanced series was also introduced for the immunocompromised, and booster programs were introduced for adults and children 12 years old and above. In 2021–2022, oral antivirals Paxlovid (nirmatrelvir and ritonavir) and Molnupiravir were introduced for outpatient treatment of early-onset mild disease, neutralizing antibodies were made available for pre- and post-exposure prophylaxis, and baricitinib and dexamethasone were introduced as immunomodulatory agents for severe disease [28]. Public health measures also evolved from lockdowns and the use of quarantine facilities to self-isolation to progressively reopen borders and communities, and restore well-being and economic recovery [29].

As the world transits to COVID-19 endemicity and "Living with COVID", it is timely for APAAACI to review how COVID-19 may have impacted the environment, incidence, and severity of allergic and immunologic disorders, in particular in Asia.

2. Impact on the environment and climate change

COVID-19 has caused several positive impacts such as a reduction in air, water, and noise pollution during the lockdowns [30] where the quality of air and water improved significantly [31]. However, its negative impacts are by far critical such as increased death rate, increased release of microcontaminants (pesticides, biocides, pharmaceuticals, surfactants, polycyclic aromatic hydrocarbons, flame retardants, and heavy metals), increased biomedical waste generation due to excessive use of personal protective equipment and its disposal, and municipal solid waste generation [32]. Personal protective equipment can eventually break down into microplastics [33] and enter the environment, posing a threat to animal and human health by polluting aquatic, terrestrial, and atmospheric environments. Discarded protective equipment potentially harm animals by entrapment, entanglement, and ingestion.

Climate change is a potential secondary effect of environmental changes. Climate change may cause extreme air temperatures, affecting work productivity and mental health of the workers. This necessitates work and environmental modification, resulting in stress and risk of workplace injuries, in particular in healthcare. Workplace safety and health interventions and services are needed to establish new work and training norms and determine new priorities for adapting existing working conditions including remote working from home or other shared spaces [34]. Climate change may have direct and indirect impacts on health, depending on host vulnerability (children or elderly), rural or urban communities, developing or developed countries, and geographic, economic, political, and environmental situations. Other longer-term impacts of climate change on global health include famine, population dislocation, and environmental justice and education [35]. There is thus a need for international and regional professional organizations to develop a deep interest in national and international measures to mitigate the impact of pollution on climate change and the impact on immunological and allergic diseases such as respiratory allergies and asthma and other lifestyle diseases [36].

3. Impact on access to allergy/immunology services

The lockdowns and quarantines during the pandemic forced allergy clinics to pivot from face-to-face consultations [37–39] to teleconsults, creating a new model of care. This has been sustained postpandemic, reducing the need for patients to travel long distances for specialist care. Telehealth has been shown to be as effective as physical consults for allergy care where physical examination is not needed, and where in-person treatment need not be rendered, for example, subcutaneous allergen immunotherapy, or intravenous infusions of biologics [40]. Blended digital technologies may also complement telehealth in certain allergy treatments including allergen immunotherapy [41]. Emergency room visits for anaphylaxis were also reduced, possibly from decreased accidental exposures with reduced social gatherings, closed school, and reluctance to present to emergency departments [42]. This also seemed to suggest that patients and parents could be empowered to confidently carry out their own acute management of allergic emergencies at home when needed.

Pharmaceutical supply chain [43] disruptions following disruptions in transportation/air travel created some disruptions to allergy/immunology therapeutics not routinely stored in certain healthcare settings or which required periodic importation, for example, allergen immunotherapy products and biologicals. For instance, patients in the induction phase of subcutaneous immunotherapy for allergic rhinitis, insect venom anaphylaxis, or oral immunotherapy for food allergy required interruptions and adjustments to their treatment regimes especially when hospital and clinic capacities were contained. Patients on intravenous biologicals or intravenous immunoglobulins also needed adjustments to their treatment regimes when infusion centers or hospitals were locked down. Rapid transitions from intravenous to subcutaneous products or self-injectables have been described with the use of subcutaneous immunoglobulins for antibody deficiency patients converted from intravenous immunoglobulin replacement [44], and subcutaneous infliximab for rheumatoid arthritis and inflammatory bowel disease patients converted from intravenous infliximab [45].

4. Impact of personal protective equipment on skin and respiratory allergies

The use of hand sanitizers, gloves, eye protection, and surgical masks increased the incidence of hand and facial dermatitis, especially among healthcare workers [46,47]. However, a reduction in exposure to acute respiratory infections from wearing of surgical face masks did appear to reduce emergency room visits for asthma. Prolonged periods in personal protective equipment also aggravated nasal symptoms in individuals with allergic rhinitis, allergic conjunctivitis, and asthma.

5. Impact of hybrid immunity on COVID-19 infection

In the year 2021 and 2022 with the emergence of COVID-19 variants of concern including delta and omicron, and populations concurrently receiving primary and booster vaccinations, the emergence of hybrid immunity helped protect most countries in the Asia Pacific against high mortality rates from severe infection [48]. However, in countries where there were many elderly who were unvaccinated through personal and cultural beliefs, the removal of COVID-19 restrictions did result in high mortality rates during the immediate 2 to 4 weeks following lifting of measures, for example, in China. Hybrid immunity and mild acute respiratory infections thus reduced the risk of severe disease and prolonged interruption of immunosuppressive treatments in patients with chronic rhinosinusitis with nasal polyposis, severe asthma, chronic spontaneous urticaria, and severe atopic dermatitis patients on biologic therapies.

6. Psychosocial impact on disease activity and control

Lockdowns and quarantines during the mitigation phase of the pandemic resulted in anxiety and depression in particular among the elderly. Social isolation, restricted access to eldercare, and exercise facilities also resulted in rapid cognitive decline and physical deconditioning among the at-risk elderly [49,50]. The fear of contracting COVID-19 especially in the first year of the pandemic before effective COVID-19 vaccines, antivirals, and immunomodulators for the severe disease were available further added to overall negative psychological well-being.

For school children, teenagers, and working adults, while work-from-home became the default mode during the mitigation phase, family members having to use the home as the office did add stress to the psychological effects of COVID-19 [51,52]. The use of digital devices and technology at work and at home disrupted work–life harmony and mental well-being, especially when the boundaries between home and work became blurred during lockdowns [53].

7. Conclusions and moving forward

The COVID-19 pandemic resulted in many environmental changes during the different phases of the pandemic. Environmental changes over time may have short- and long-term impact on the incidence and prevalence of allergic and immunologic disease via effects on allergen load, the exposome, genome, and microbiome. Moreover, toxic substances, such as detergents, household cleaning agents, food emulsifiers, preservatives, pesticides, and microplastics, damage the epithelial barrier and increase penetration of allergens and microbes and increase the risk of allergic and immunologic diseases [54]. Complex interactions between these factors may have short- and long-term impact on the risk of development of allergic and immunologic disorders across the ages.

Going beyond the narrow disciplinary perspective of allergic diseases, One Health and Integrated care (**Fig. 1**) captures a holistic focus on human health with the ecosystem at the center. The One Health approach is part of a broader systemic transformation needed to end the triple planetary crisis of climate change, biodiversity loss, and pollution [55]. It integrates human, animal, agricultural, and ecosystem health to improve outcomes and address the triple planetary crisis (**Fig. 2**). Global organizations such as the United Nations Environment Programme (UNEP), World Health Organization (WHO), the Group of Twenty (G20), Group of Seven (G7), and policymakers are increasingly concerned about climate variability and the impact on the health, especially of vulnerable populations. In

Figure 1. One Health, One Planet, climate change, allergy, immunology, COVID-19, digital health, and science-based solutions.

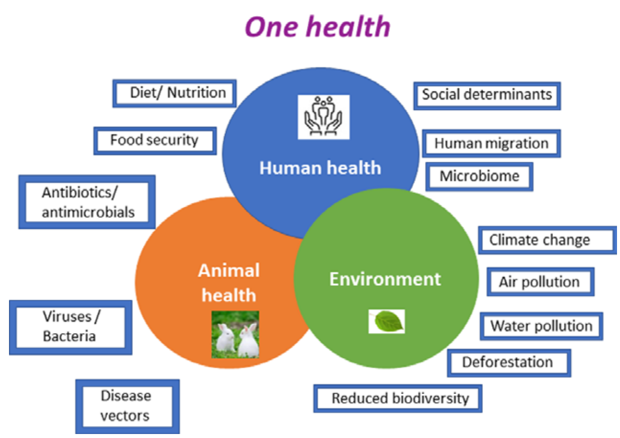

Figure 2. The paradigm of One Health.

addition to climate mitigation, they focus on one health, planetary health and the need for digital health are crucial to address these issues and real-world evidence.

Health emergencies, prevention, and pandemic preparedness are important in an ever-changing environment of not only the pandemic but also natural disasters. The health risks associated with the climate crisis is great, especially for those with preexisting comorbidities and vulnerable populations. In the face of this, healthcare systems are heavily burdened. Potential disease outbreaks should be identified early through interagency and international collaborations, and risks of zoonotic disease could be reduced. Professional organizations, academic institutions, and civil society should also engage with governments and policymakers for climate mitigation and one health.

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Conflicts of interest

The authors have no financial conflicts of interest.

Author Contributions

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