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Climate Change, Environmental Pollution and Covid-19 Pandemic: The Triangle Impacts on Mental Health

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Abstract

Converging data have recently received attention due to the linkages between environmental pollution, the COVID-19 pandemic, climate change, as well as mental health. This encourages explored the intricate interplay between climate change, environmental pollution, and the Covid-19 pandemic, shedding light on their collective impacts on global mental health. The empirical evidence presented reveals how climate-induced disasters and pollution exacerbate mental health challenges, while the pandemic's multifaceted effects further compound these burdens. Vulnerable populations, including low-income communities, children, and frontline workers, face disproportionate mental health implications in this context. As the implications of this "triangle impact" become increasingly evident, urgent and comprehensive action is imperative. Policymakers and healthcare practitioners must adopt an integrated approach that incorporates climate adaptation measures, pollution mitigation strategies, and pandemic preparedness efforts to address these complex challenges. Equitable access to mental health services is crucial, recognizing mental well-being as a cornerstone of overall resilience. By fostering collaborative and empathetic action, society can forge a path toward a sustainable and mentally healthy future for all.

Keywords: Climate change, Pollution, Covid-19, Mental health

1. Introduction

The definition of climate change can be "a change in the climate which directly attributes to human activities and alter the composition of the planetary atmosphere as well as adding natural climatic variability that has been observed on time intervals which are similar," by the United Nations Framework Convention on Climate Change (UNFCC). Recent advances in developed countries like Japan, the United States (US), Korea, and developing countries like China have resulted in a rise in global temperatures that has compelled all countries to address and resolve environmental challenges, particularly climate change. Note that the world average temperature is on the rise each year [Ghosh, et al. (2023); Shaari, et al. (2023); Voumik, et al. (2023a); Voumik, et al. (2023b); Hendrawaty, et al. (2022); Kumaran, et al. (2020); Ridzuan, et al. (2021a); Ridzuan et al. (2021b)]. Even though that climate change has enhanced concerning the face of the COVID-19 pandemic, all states should not rest on their laurels, as the pandemic will inevitably end in a few years.

More significant climate change will recur, and all countries will have to cross the bridge when they come to it. Increased CO_2 emissions and other greenhouse gases are the main factors that cause climate change [Pujiati, et. (2023); Majekodunmi, et al. (2023a); Shaari et al. (2022a); Shaari, et al. (2021); Mohamed Yusoff, et al. (2023); Ridzuan,et al. (2022a); Ridzuan, et al. (2020a); Ridzuan et al. (2019); Md Razak, et al. (2017); Zainal, et al. (2020)]. Therefore, the inextricable relationship between global temperatures and greenhouse gases,

especially CO_2, has been on everyone's lips. Figure 1 illustrates the condition of our earth in mean temperatures. From 2011 to 2020, the global mean temperature has risen from 0.91 ℃ in 2011 to 1.27 ℃ in 2020, suggesting that the earth has become warmer since 2016. Consequently, the world recorded the warmest year in 2016 at 1.29 ℃, while the lowest temperature was in 2011.

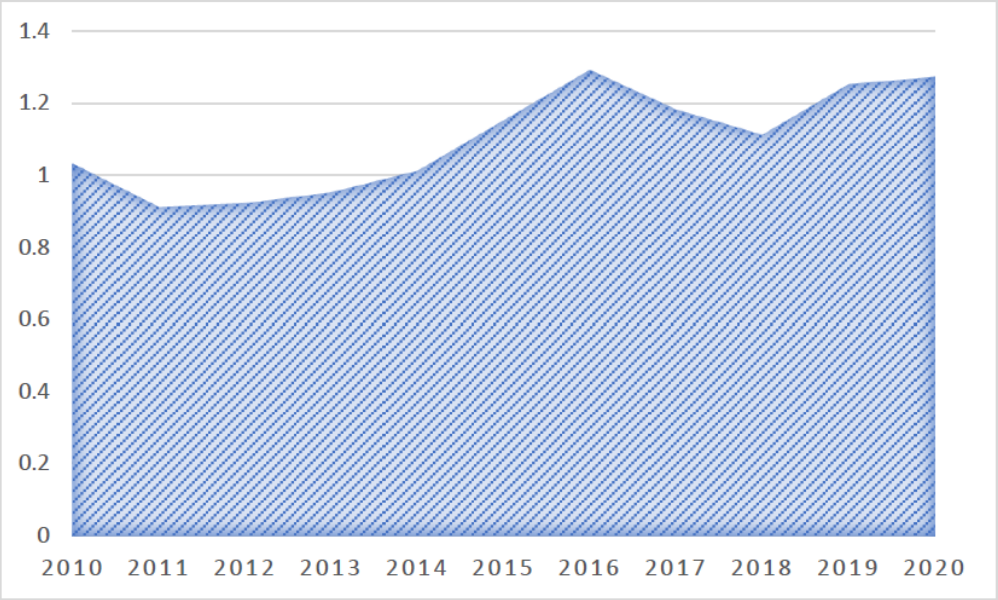

Figure 1. Global Mean Temperature from 2010 to 2020

Source: Berkeley Earth (2020)

1.1 Top 10 Largest Producers of CO_2 Emissions in the World

Since the rapid industrial revolution, the trend in global CO_2 emissions has steadily increased and set alarm bells ringing to all countries across the globe. CO_2 emissions can contribute to global warming, risking the world population to innumerable problems and threatening human health. An inexorable increase in CO_2 emissions each year exacerbates climate change and global warming [Majekodunmi, et al. (2023b); Pujiati, et al. (2023b); Shaari, et al. (2022b); Handayani,, et al. (2022); Ridzuan, et al. (2022b); Borhan,, et al. (2021); Ridzuan, et al. (2020b)]. Based on Figure 2, China, a nation with the largest population and the second-largest economy globally, contributed the largest share of total global CO_2 emissions, standing at 27.92% in 2019, followed by the US (14%). Although the US possesses the largest economy and records the third-largest population globally, it was still not ranked first as the largest producer of CO_2 emissions in 2019. India was ranked third as the significant producer of CO_2 emissions at 7.17%. The lowest was Saudi Arabia (1.59%), followed by South Korea (1.67%), Indonesia (1.69%), Germany (1.92%), Iran (2.13%), Japan (3.03%), and Russia (4.6%).

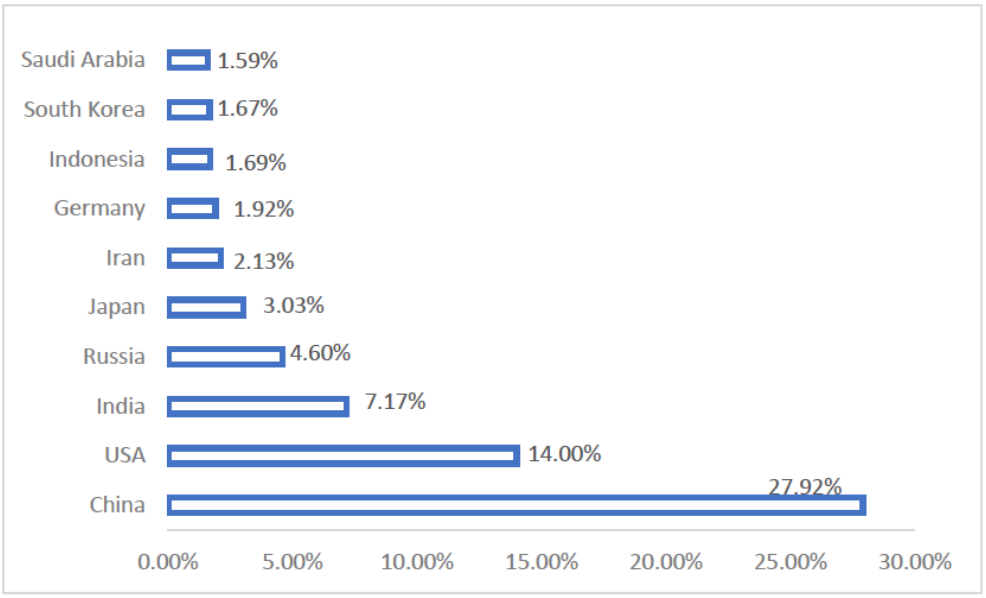

Figure 2. Top 10 Largest Producers of Fossil Fuel CO_2 Emissions in the World

Source: Statista (2020)

Meanwhile, the trend of global energy that contributes towards CO_2 emission can be viewed in Figure 3. The trend showcased an upward trend since 1995 and continued to rise until the global recession between 2007 and 2008 [Ridzuan, et al. (2018a); Ridzuan et al. (2018b); Ridzuan et al. (2018c)]. Consequently, the unemployment rate hit 10%, affecting global consumption. Lower global consumption reduces production, reducing carbon emissions release. However, the decreasing trend of carbon emissions released declined only briefly before rising again at a slower rate. The recent COVID-19 outbreak that hit the world in 2019 until the present contributed to the sudden drop in carbon emission release. However, the decline does not linger for long, as acceleration was observed in the middle of 2020.

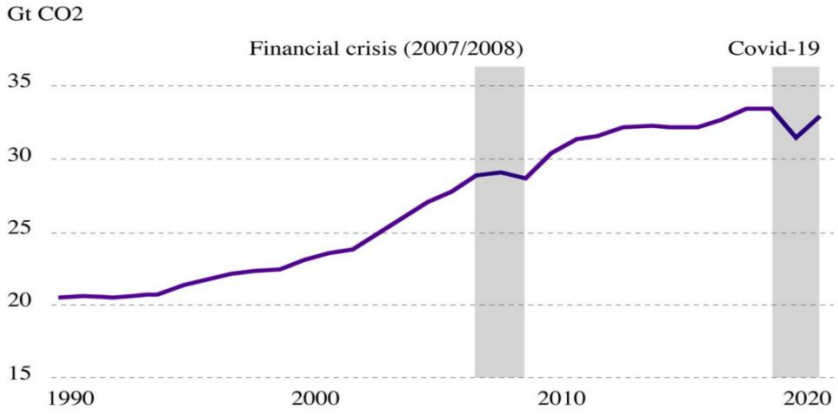

Figure 3. Global Energy-Related CO_2 Emissions 1990-2021

Source: International Energy Agency (2021)

2. Climate Change Effect as Well as Environmental Pollution on COVID-19

The COVID-19 pandemic is wreaking havoc globally, leading to a world health crisis and forcing economic growth to hamper because of strict quarantine measures. It has intriguingly impacted the environment as it spreads in several parts of the globe, forcing borders to be closed, hand sanitiser scarcity, as well as social distancing protocol implementations.

During the pandemic's first phase, at least cases were found in every 105 people. On the other hand, the rate of deaths every 105 people (PDP) was high in regions in the north, according to Sarmadi et al. (2020), who investigated the global distribution concerning the COVID-19 pandemic. The world's high latitudes, including North America, Asia, and parts of Europe, all have cooler climates and better socioeconomic conditions, and some environmental and demographic factors were linked to distribution patterns. Moreover, the availability of diagnostic equipment as well as medical facilities may vary between the northern and southern hemispheres of the earth (Bi et al., 2020).

Additionally, regarding climate change, the urban slums, having limited living areas, have the risk of COVID-19 infection. Climates that are colder and greater in population densities may also accelerate the transmission of the disease, as previously stated (Sajadi et al., 2020; Xie and Zhu, 2020). Although it has not yet been established, certain data have presented a link between the spreading of COVID-19 outbreaks and other environmental factors, including humidity, climate latitude, and temperature (Poole, 2020; Chen et al., 2020). Note that the weather substantially influences respiratory infections (Wang et al., 2010; Sajadi et al., 2020). Humidity, temperature, wind speed, and visibility can all impact a droplet's stability in the environment, which in turn can impact the virus's capacity to survive and the radio waves that cause infectious diseases (Chen et al., 2020). In China, the temperature has been demonstrated as an environmental factor for the onset of COVID-19, and in recent cases, a decrement has been seen in the infection transmission rate (Shi et al., 2020).

In contrast, some research has discovered that higher temperatures are effective against various viruses, including SARS (Van Doremalen et al., 2013; Chan et al., 2011). According to Ma et al. (2020), there is a link between body temperature as well as COVID-19 mortality because low temperatures can affect the function of the liver and immune system. The environment will therefore be favorable for the activity of an infection agent and the transmission of the virus (Davis et al., 2016; Li et al., 2019). Nevertheless, no relation between the ratio of COVID-19 as well as absolute humidity (Shi et al., 2020). Similar findings from a study conducted among Jakarta residents in Indonesia presented a strong correlation between the average temperature as well as COVID-19 dissemination (Tosepu et al., 2020). In the meantime, a study that has been performed relying on the data from Wuhan revealed that the basic reproduction ratio of COVID-19, an epidemiological measure used to define the spread of infectious agents or contagiousness, was inversely related to both temperatures as well as humidity (Delamater et al., 2019; Gao et al., 2020).

In mortality cases, there is a positive relationship between both COVID-19 death as well as daytime temperature via a study that collected data on daily death caused by COVID-19 concerning Wuhan weather conditions between both COVID-19 as well as relative humidity

(Ma et al., 2020). Many studies analysed the relationship between SARCoV2 and global meteorological variable infection and mortality. The result indicated that when the common daily temperatures rise by one degree, the active cases of COVID-19 will be decreased. Additionally, there is a positive correlation between precipitation as well as SARCoV2 and an indirect correlation between mean temperature and the number of cases COVID-19. According to Sobral et al. (2020), some countries with greater rainfall presented a higher disease transmission rate than those with lesser rainfall.

With all of those factors, the prevalence, incidence, and mortality caused by COVID-19 seem to correlate with air pollution, more specifically, PMs, for their negative effects on health. Previous research by Kim et al. (2015) stated that inhalable coarse particles 2.5 to 10 μm and particulates not more than 2.5 μm are the foremost dangerous PMs. According to Coccia (2020), increasing PM 2.5 concentrations and contaminants like nitrogen dioxide and PM are linked to the increment in the number of infected people as well as admissions to hospitals from respiratory viruses (Carugno et al., 2018; Glencross et al., 2020). Other than that, Wu et al. (2020) stated that even modest increments in PM 2.5 levels may affect the course as well as prognosis of the disease and be associated with a considerable rise (of about 15%) in COVID-19 mortality. Immune dysregulation is thought to have a significant role in the worse outcomes of respiratory infections, particularly those brought on by COVID-19 and SARS.

Evidence suggests that residents of polluted areas experience higher COVID-19 mortality rates, given the exposure to environmental pollution (Cui et al., 2003). A systematic investigation into the relationship between chronic air pollution, particularly particulate matter (PM 2.5 and PM 10), as well as nitrogen dioxide exposure and the risk of COVID-19 cases and mortality revealed significant associations. The study applied the Cochrane rapid review method to analyse the connection between air pollution and an increased likelihood of COVID-19 transmission and severity (Félix Arellano et al., 2020). A substantial correlation between PM 2.5, as well as COVID-19 infection has been detected in 120 cities, according to recent Chinese research (Xie and Zhu, 2020). In Hubei, China, a case study of the spatiotemporal COVID-19 infectious diseases spread showed that the spread of infectious diseases is higher than in other parts of China. Over time, the geographic distribution of infectious diseases tends to remain steady. Note that infectious disease epidemics are also due to several factors, including economic connectivity, population distribution, transportation, healthcare accessibility, and mean temperature (Xie et al., 2020).

In Italy, a few researchers have examined the relationship between the COVID-19 pandemic as well as particle contamination, observing that the course of infection varies widely across country regions (Setti et al., 2020). Some data have highlighted a possible association between a high air pollutants concentration in the north of Italy and also the high COVID-19 spread (Coccia, 2020; Martelletti, 2020). A link between the incidence of COVID-19 as well as exceeding the legal limit of PM 10 concentrations was observed in the first observational study based on initial epidemic diffusion (Setti et al., 2020). In line with other research on other viral infections, the data showed a relationship between COVID-19 cases and PM 10 contamination concentrations (Setti et al., 2020).

In summary, although not definitive, some evidence indicates that SARSCoV2 could utilise PM as a possible vector, demonstrating that it may reduce infection against air pollution and spread the disease (Wue et al., 2020; Setti et al., 2020). Apart from that, because particulate contamination is related to the increase of COVID-19 morbidity as well as mortality, reducing environmental pollutants can decrease severe cases theoretically.

2.1 Effects of Air Pollution and Climate Change on Mental Health

Extreme natural disasters, as well as gradual climate variation, are just two of the many environmental and weather changes that are a result of changes in the climate. The long- or short-term psychological effects pertaining to climate change, either directly or indirectly, have recently attracted more attention (Reifels et al., 2015). Correspondingly, the existing evidence reveals that the effects pertaining to climate change on mental health are prone to anxiety, clinical disorders, depression, sleep disturbances, as well as stress/trauma-related diseases, along with mild symptoms of stress and discomfort (Blanc et al. al., 2019; Hayes et al. al., 2018; Ursano et al., 2017).

As COVID-19 spreads rapidly worldwide, it causes a significant degree of fear and concern among certain groups of people, especially geriatric care providers and those with underlying health conditions. Moreover, in terms of public mental health, the primary psychological impacts are stress as well as anxiety. However, when new countermeasures and impacts are introduced, it is anticipated that there will be an increase in the prevalence of suicidal or self-harming behaviour as well as depression, harmful alcohol and drug use, and loneliness. The effects of quarantine may be felt in daily life or among many people. Some of these effects directly relate to COVID-19's characteristics (Tsvetelina Filipova, 2020). For instance, a high infection risk encourages an overall state of vigilance, which in turn causes a pathological fear of infection as well as feelings of threat, raising stress and also anxiety levels (Jungmann and Witthöft 2020). It also impacts front-liner medical professionals, where life or death decisions must be made without clear guidance or information, setting the precedence for mental health disorders related to pandemic trauma.

Other side effects on mental health can be caused by the process rather than the infection. Numerous aspects of our daily life, including mobility, work, as well as education, might be unpredictable or out of one's control, affecting neurobiological processes and leading to mental health issues. It might trigger depression, anxiety, and chronic activation of burnout (Holmes et al., 2020). Additionally, social isolation will impact mental health by raising the likelihood of depression and suicide through the subjective states of loneliness and worthlessness. In some countries, work-related burdens are expected to affect emotional status, especially in workload and unemployment, which are expected to be high (Cianconni et al., 2020). Note that vulnerability in the context of health and mental health is related to financial resources and a reduction in the safety perception as well as security in public spaces, the street, and the workplace due to domestic violence. These uncertainties could lead to violence against women, especially in the household struggling with caregiving activities, jobs, and interpersonal conflicts. When ordinary activities are lost, psychological fragility results from the prevalence of negative thoughts and emotions, including dread, worry, lack

of hope, and future uncertainty (Cianconni et al., 2020). The psychological distress may quickly progress to serious mental illness, including stress and trauma (Salcioglu et al., 2007), depression, anxiety, suicidal thoughts, and substance misuse in between 7%-40% with regard to predisposed as well as poorly resilient patients (US Global Change, 2016).

Based on the previous study by Berry et al. (2008), the effect of gradual changes in climate on mental health, which include rising temperatures and sea levels, and changes in precipitation patterns, is still unclear because they are challenging to study, the evidence is scarce and genuinely indirect. Hence, loss of affection and possessions, being cut off from the community, and deteriorating social ties can all support or hasten the development of mental health issues in these situations (Cohen et al., 2004). Moreover, the most common gradual climate change is characterised by prolonged peak heat and drought, forcing many people to leave their homeland (Berry et al., 2010). Stress can harm mental as well as physical health and is linked to involuntary migration (Schwerdtle et al., 2017). In places with high risks of drought, elevated rates of despair, as well as depression, have been documented (Campbell et al., 2007; Huq et al., 2007), and increased suicide rates among farmers residing in these areas have also been noticed (Kjellstrom 2009). In the long run, dissociative symptoms can lead to more complicated psychopathological disorders, like identity problems and personality abnormalities, the extinction of plant species and animals, as well as the destruction of indigenous environments and landscapes (Woodbury, 2019; Wei et al., 2017).

Global climate change may possibly damage mental health indirectly, even while the awareness of existing climate change alone might provoke negative emotional reactions, such as reduced guilt and distress. Consequently, highly stressed subjects are the most affected, and additional stress loads can overwhelm their capacity for recuperation, claims Brugha and Cragg (1990). Unfortunately, there is currently no viable method that can be used consistently to analyse these reactions. Many studies indicate that only a significant proportion of the population is concerned regarding the stress as well as anxiety caused by climate change (Clayton, 2020). Since climate change-related psychiatric disorders are new yet poorly understood, new terms have been created to define some, presenting the clinician with the latest challenges. The term "ecological anxiety" refers to the stress that subjects first face in recognising that they are naturally soft and vulnerable, and secondly, they cannot face such dramatic changes (Lee et al., 2019; Arcanjo, 2019).

In addition to the impacts of climate change as stated by Ridzuan et al. (2017a) and Ridzuan et al. (2017b), air pollution may also affect mental health (Buoli et al., 2018; Khan et al., 2019). According to several research conducted on healthy individuals, elevated PM 2.5 concentrations are associated with worsened cognitive function or psychological distress (Sass et al., 2017; Shehab and Pope, 2019). The stress prevalence, a decline in quality of life, depression diagnosis, as well as suicidal thoughts are all positively correlated with prolonged exposure to a high concentration of nitrogen dioxide (NO_2), particulate matter <10μm (PM 10), carbon monoxide (CO_2), as well as sulfur dioxide (Shin et al., 2018).

According to some evidence, areas with greater air pollution levels also have high levels of depression. For example, according to Vert et al. (2017) and Kiourmourtzoglou et al. (2017),

in particular, the concentration of NO_2, O_3, PM 10, as well as PM 2.5, raised the risk of depression symptoms. Subsequently, subjects exposed to concentrations high in PM 10 and PM 2.5 are likely significantly prone to experience anxiety symptoms (Power et al., 2015). According to various studies, air pollution plays a crucial role in the pathophysiology of neurodevelopmental diseases, having Attention-Deficit Hyperactivity Disorder (ADHD) being particularly linked to pollution (Saez et al., 2018). Nevertheless, the latest comprehensive review discovered this association is vulnerable (Donzelli et al., 2019).

In addition, pollution was believed to have a role in the pathophysiology of Alzheimer's Disease (AD), Parkinson's disease, as well as a variety of other sclerosis by increasing the expression of neurodegenerative disease markers, including alpha-synuclein and beta-amyloid (Costa et al., 2020; Chen et al., 2017). As per epidemiological research, being exposed to air pollution was linked to cognitive decline as well as pathological changes in the brain. Other than that, reliable information is sparse despite notable evidence indicating environmental pollution and climate change may cause unsafe mental health. However, there is no doubt that this is an interesting and developing field that needs to be explored more in the future through carefully monitored research in larger and more diverse groups that may better represent the clinical setting.

2.2 Effects of SARS-CoV-2 on Mental Health

Increasing evidence has proven the negative impacts of the SARS pandemic on the worldwide psychological well-being of the population from both biological as well as social consequences (Xu et al., 2020; Gia Comelli et al., 2020; Mao et al., 2020; Chen et al., 2020; Moriguchi et al., 2020; Helms et al., 2020). The imprecise percentage of the disease, symptoms of confusion, depression, insomnia, memory impairment, depressive mood, the fear of infecting family members or/and becoming infected, the fatality rate as well as the uncertainty of recovery, ambiguity about the treatments' effectiveness of received, has created sense insecurity and bewilderment with regard to the population (Xiang et al., 2020; Galea et al., 2020; Brooks et al., 2020; Szcześniak et al., 2021). On the other hand, the impacts of this outbreak have bad influences that collapse the socioeconomic balance, affecting overall mental health (Pfefferbaum and North, 2020; Xiang et al., 2020; Galea et al., 2020; Brooks et al., 2020; Reger et al., 2020). Additionally, the effects of the increasing trends of media social consumption should not be underestimated. The study by Marazziti (2020) and Yao (2020) demonstrated that people would seek information from unreliable sources due to fake news and confusing messages. Note that the frequency and variety of COVID-19 news exposure in the media were related to psychological and anxiety distress (Bendau et al., 2021).

The COVID-19 outbreak has significantly contributed to a large number of psychological consequences. The growing psychological distress, anxiety, insomnia, fear of death, demoralisation, feelings of hopelessness, anguish, being ignored, dangerous behaviour, which includes raised use of alcohol as well as abuse of substances, and social media addiction are seen among a large part of children, adolescents, and adults (Cao et al., 2020; Shahyad et al., 2020; Li et al., 2020; Varshney et al., 2020; Rodríguez-Rey et al., 2020). It was also noted that the distress suffering is expected to be much higher in Low- and Middle-Income

Countries (LMICs), leading to an economic trap of disease burden and psychological decline. The situation worsens when the pandemic hits the world (Rathod et al., 2017).

Several data have been collected to understand the psychological and psychiatric repercussions and their emotions, such as fear, insecurity, emotional isolation, confusion, traumatic stress, and stigma (Pfefferbaum et al., 2020). These unhealthy effects can increase community anxiety, increase the perception of danger, feelings of loneliness, and reduce the sense of certainty, security, lack of control, and unpredictability over someone's life (Peretti-Watel et al., 2020). In addition, the reactions of the population psychologically have a significant role during an infectious disease outbreak in shaping emotional distress and social disorder (Cullen et al., 2020). Furthermore, the intolerance of distress escalates anxiety and fear, exacerbating situations due to forced isolation and mass quarantine (Usher et al., 2020).

Another study reported that the post-pandemic and epidemics are crucial to ensuring the patients' safety culture after they have experienced such disease. The psychological symptoms of forced isolation, quarantine, as well as social distancing would impact psychological well-being and people's emotional reactions (Talevi et al., 2020). Besides that, the role of healthcare workers should not be underestimated. Their safety culture also is the primary concern of medical institutions. Additionally, a recent study offered critical insight into the staff's well-being under unprecedented crisis circumstances. Their outcomes propose that the burden of enduring the pandemic and the responsibilities of protecting the nation's health results in increased exhaustion among healthcare workers. Even though there is an increase in the efficiency of management mode with more resources being mobilised, the disadvantages may outweigh these benefits (Chen et al., 2021). The burdens of emotional reactions they face throughout the challenges can threaten their mental health.

3. Conclusion

A pandemic known as COVID-19 that originated in the Chinese province of Hubei's city of Wuhan overtook the entire world. These outbreaks have rapidly spread over the world, causing misery and fatalities among people. However, climate change, pollution, and viruses that have caused outbreaks can have significant, complicated effects, including negative environmental and economic effects (Norouzi et al., 2020). The unprecedented events quickly spread throughout the globe and have changed most people's day-to-day lives. Several data have been accumulated as evidence to look at the effects caused by COVID-19. Literature reveals that global NO_2 emissions have been reduced by almost 30%, contributing to a short-term cooling since the declaration of the COVID-19 pandemic on 11 March 2020 (Forster et al., 2020). The ongoing COVID-19 outbreak pandemic has taught us how to make a quick response to climate change. The Global Commission on Adaptation (GCA) has emphasised climate adaptation related to the natural environment, food security, water, disaster risk management, and infrastructure, where the new investments in these subjects would be benefited worldwide. This is particularly in the areas of climate-resilient infrastructure, early warning systems, global mangrove protection, enhanced dryland agriculture crop production, as well as investment in generating water resources much more resilient (Herrero and Thornton, 2020). The integration of climate resilience into all decisions

and investment in innovative solutions is identified as a recovery method from the COVID-19 global pandemic. It is a call to governments as well as organisations to respond to COVID-19-related stimulus packages to invest in climate resilience.

Climate change's implications on mental health present a significant problem for our communities, country, and world. Different populations that are physically exposed and vulnerable to the effects of climate change on their mental health may be affected indirectly or directly over short or extended periods of time (Cianconi et al., 2020). According to Padhy et al. (2015), temperature rise as well as aggressive behaviour, have a positive correlation. The study found rising crime and aggressive behaviour rates in the hot summer, demonstrating a direct link between aggressive behaviours and temperatures. In a nutshell, the triangle effects on mental health currently seem unavoidable. Rising sea levels, floods, increasing ambient temperatures, and other consequences of climate change can produce psychological distress through numerous mediators. Hence, resilience thinking should guide the efforts to overcome all these effects so that we have an appropriate response to deal with the vital challenge of effects in the future. Furthermore, the consequences of COVID-19 have emphasised us to improve the mutually effective connection between humans and nature.

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