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The emerging evidences related to the Inter-relationship between COVID-19 and climate change: A scoping review perspective

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Abstract

Coronavirus Disease 2019 (COVID-19) has affected a number of integral aspects and climate change is one of them. The inter-relationship between COVID-19 and climate change has garnered the interest among scholars across the globe to probe into the related emerging issues. With the escalating number of published articles, a pressing need is present to map and review all available studies in order to capture comprehensive and organised views for future scholars to draw upon the existing pattern of the interchanging correlation between COVID-19 and climate change. This scoping review is guided by a primary research question - what is the inter-relationship between COVID-19 and climate change. Related articles and documents were retrieved from Scopus, Science Direct, and Google Scholars databases. The thematically analysis data were classified into four emerging themes: (1) reduced air pollution, (2) low carbon emission, (3) the impact of temperature and humidity variation on COVID-19, and (4) the impact of air pollution on COVID-19. Variances in the outcomes, particularly on the effects of temperature, humidity, and polluted air on COVID-19, suggest further exploration endeavours. Essentially, the economic impact exerted by COVID-19 and its overall effect on budget to combat climate change remain untapped.

1. INTRODUCTION

Coronavirus Disease 2019 (COVID-19), a highly infectious disease spread by the newly discovered Corona virus, has befallen on planet Earth. The fallen victims of this fatal viral infection display a series of symptoms including fever, dry cough, fatigue, aches, and nasal congestion; while some patients do not indicate any symptom but are tested positive with COVID-19. Severe cases can result in respiratory problem and even pneumonia. Notably, those elderly and diagnosed with health conditions face higher risk if they become infected with this disease. The World Health Organisation (WHO) (2020) reported that up to 21st August 2020, more than 22 million confirmed cases of COVID-19 were recorded across the globe with the death toll hitting almost 800,000 cases. Several countries, such as the USA, Brazil, India, Russia, and South Africa, had recorded unimaginable skyrocketing number of cases. As a result, COVID-19 has been declared as a pandemic on 11th March 2020 by the WHO. In fact, the public have been projected to face its worse scenario due to absence of a viable vaccine or antiviral to combat COVID-19, despite flash news announcing several vaccines being developed at the time of this study (Fanelli and Piazza, 2020).

Regardless of their socio-economic status, the public are vulnerable to the lethal COVID-19. In the absence of strategic deployment(s), the COVID-19 wave is set to continue spreading like wildfire across the globe. This is reflective of the barbarous appetite displayed by The Evil Thanos from the movie entitled Avengers, wherein the pandemic has been claiming countless victims for a period unknown to any. In response to this, countries across the globe have begun devising their preventive actions. Several countries, including the USA, China, Italy, and Spain, have executed complete lockdown to deploy social distancing and contain the disease; whereas other countries, such as Malaysia and South Korea, implement Movement Control Order (MCO). These actions have urged people to stay at home for extended durations, thus adversely affecting the economic, social, and psychological factors within communities. The total lockdown signifies, for instance, unemployment issues and deprivation of food amongst the impoverished, crowded slum dwellers stricken with mental stress, and escalating

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social issues stemming from women and children abuse (Brooks et al., 2020; Roy et al., 2020).

Amongst the vast impacts of COVID-19 on the aspects of human life, the pandemic has disrupted the human socio-economic routines. Common practices have turned uncommon as we are urged to stay at home and embrace the virtual platform. Another essential aspect linked to COVID-19 is climate change. Climate change denotes a change in the patterns of weather, oceans, land surfaces, and ice sheets that occurs over time scales, usually involving a long period of time. Despite viewing COVID-19 and climate change as two different elements, one may easily relate the latter to environmental issues and the former to medical issues. This misperception needs to be rectified as both aspects are interchangeably related. Regardless of COVID-19 or climate change, both may serve as independent or dependent variables, hence affecting each other in a unique manner.

The emergence of COVID-19 is the buzz topic amongst scholars worldwide. For example, Cao et al. (2020) performed a comparative genetic analysis; Sun et al. (2020) assessed lower mortality due to COVID-19 by early intervention and recognition, while Zhao et al. (2020) examined the network-based drug repurposing. Stoye (2020), upon investigating the trend of Coronavirus related publications until the end of January 2020, concluded that more than 50 English language papers were published pertaining to the rapid spread of the disease, the length of its incubation period, and the disease structure or genetic make-up proven useful to identify drug targets or to develop vaccine, to name a few. Although most of the available articles tapped into COVID-19 from the medical, public health, and biological domains, another school of studies focused on the scientific segment, as follows: Xie and Zhu (2020), Ma et al. (2020), Liu et al. (2020), and Tosepu et al. (2020) assessed the effects of weather on the number of confirmed COVID-19 cases; Wang et al. (2020) probed into severe air pollution during COVID-19; Xie and Yang (2020), Xia (2020), and Bao (2020) investigated COVID-19 lockdown and online education activities; while Asna-ashary et al. (2020), Tobias et al. (2020), and Dantas et al. (2020) studied the effect of COVID-19 lockdown on generating better air quality.

To have these studies to stand alone without support is not good enough. Empirical findings from these studies need to be mapped and reviewed to capture comprehensive and organised views for future scholars, while concurrently enhancing their understanding on the existing patterns of the interchanging relationship between COVID-19 and climate change. This is meant to assist them in detecting gaps, devising strategies for their next research, and identifying shortcomings that demand improvement. With the emergence of COVID-19 between November and December 2019, the scoping review method is adequate to review all the existing evidences. A scoping review is a suitable technique when the topic has not been extensively reviewed or is of a complex or heterogeneous nature (Mays et al., 2001). Despite the absence of a clear definition to describe scoping review, the aims of this technique are to determine the key characteristics or pattern or factors of past findings in a given field, to identify and analyse knowledge gap, and to serve as a precursor in a systematic review (Munn et al., 2018; Sucharew and Macaluso, 2019). Scoping review differs from systematic review in terms of several aspects. First, scoping review includes a greater range of study designs and methodologies. Second, scoping review offers a descriptive review of the existing studies without critically appraising individual studies or synthesising evidence from different studies (Munn et al., 2018; Pham et al., 2014)

This study sought to develop a scoping review on the interchanging relationship between climate change and COVID-19 based on the available sources. The review captured both positive and negative sides of this relationship. This study is integral as it unravels the current pattern, thus initiating the ideas on elements that should be weighed in by future scholars, particularly from the lens of the interchanging relationship between climate change and COVID-19.

2. MATERIALS AND METHODS

2.1. Formulation of research question

The research question formulated in this study, as follows, served as guidance to the scoping review: what is the inter-relationship between COVID-19 and climate change impacts?

2.2. Systematic Searching Strategies

Three phases were involved in the systematic searching strategies, namely identification, screening, and eligibility. These phases were performed to ensure the conduct of a rigorous investigation (Figure 1).

2.2.1 Identification

This first phase was performed to enrich the keywords applied in the search process. At this stage, it was indeed essential to use multiple keywords and databases to avoid retrieval bias (Durach et al., 2017). The search relied on the main keywords; COVID-19 and climate change, as well as several other related keywords; coronavirus, SARS-CoV-2, global warming, temperature, air pollution, low carbon habit, online activities, online learning, and online meeting. Whenever possible, the basic functions of Boolean operator OR or AND, as well as phrasal-level search, were deployed. The article were combed through based on two main indexing databases; Scopus and Google Scholar, as well as several other journal databases; Science Direct, Science of the Total Environment, Nature, SSRN Electronic Journal, Best Evidence of Chinese Education,

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and Science Insight Education Frontier. The search process was conducted between March and May 2020. This effort had retrieved 136 potential articles for the scoping review and no duplicate record was identified.

2.2.2 Screening

Screening was the second process of the systematic search strategies, which distinguished suitable articles from unsuitable ones for the review. Kitchenham and Charters (2007) accentuated that any criteria can be selected by the authors as long as the criteria can address the research question. As COVID-19 is a new global issue, articles were selected amongst those published from 2017 to 2020 and only peer-reviewed articles/documents were selected to assure the quality of articles. As prescribed by Linares-Espinos et al., (2018), only articles published in the English language were reviewed to avoid confusion, minimise cost, and reduce time consumption. After discarding 66 articles that had failed to meet the criteria, only 70 articles were retained for the next stage of selection.

2.2.3 Eligibility

In the third process, which refers to eligibility, the selected 70 articles were re-examined to ascertain adherence to the selection criteria. At this stage, the abstracts were read to determine the suitability of the articles. The full article was skimmed if the article suitability was not clearly conveyed in the title. As a result, 13 articles were excluded as they deviated from COVID-19 and climate change topics, were not peer-reviewed articles, review paper or were in the form of a newsletter. Therefore, 57 articles were finally selected for the scoping review.

2.3. Data extraction and analysis

The data extraction process was guided by the research question. All data extracted from the selected studies were related to the impacts of either climate change on COVID-19 or COVID-19 on climate change. The indirect impacts were considered upon determining their ability to address the research question. This qualitative study adopted the thematic analysis to assess the captured data. This analysis identified the themes based on the patterns retrieved from the selected studies based on their similarities and correlations between the abstracted data (Braun and Clarke, 2006). At the first stage of the synthesis, data that were similar or related to each other were pooled in a specified theme. At this stage, six main themes were identified. At the second stage, the themes were re-examined to assure their usefulness and accurate representations of the data. During this process, two themes - economic impacts of COVID-19 and cancellation of important events - were excluded due to their limited connectivity with the main research question. The other four themes that were retained are: reduced air pollution, behavioural change, temperature and humidity variation impacts on COVID-19, as well as air pollution impact on COVID-19.

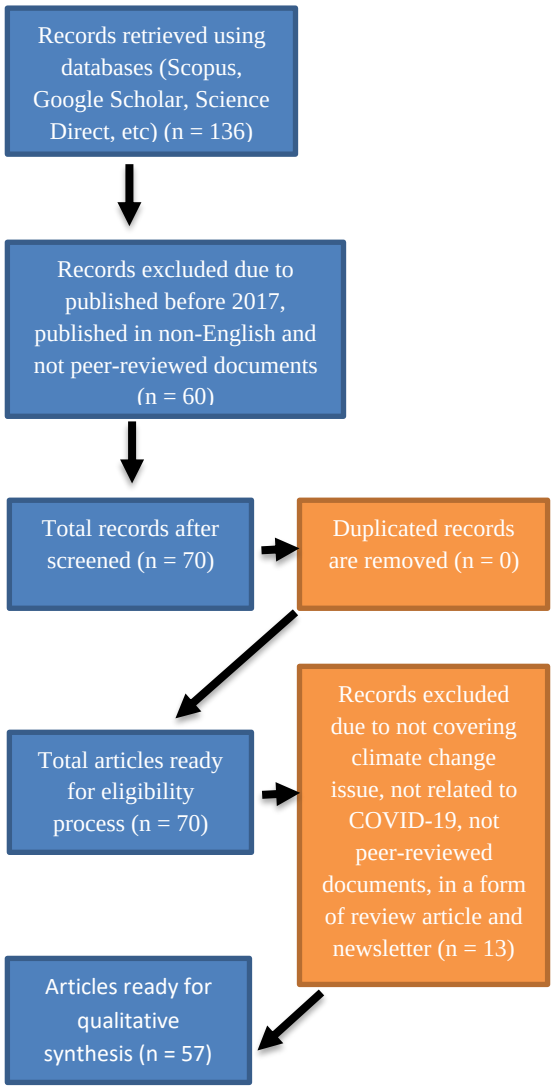

Figure 1: Systematic searching strategies of the scoping review

3. RESULTS

This study had organised the inter-relationship between climate change and COVID-19 into four main categories, namely reduced air pollution, low carbon habit, temperature and humidity variation impacts on COVID-19, as well as air pollution impacts on COVID-19. Before tapping into the four main categories, this study looked into the characteristics of the selected studies

3.1. Characteristics of the selected studies

This study involved 57 articles. As expected, most of the studies were conducted in China (20 studies), where the disease had originated. This is followed by Italy (7 studies), Brazil (4 studies), Iran (3 studies), and the USA (3 studies). Most of the selected studies were published in 2020 (56 studies) in the form of journal articles (55) and reports (2) (Figure 2, Figure3, and Figure 4).

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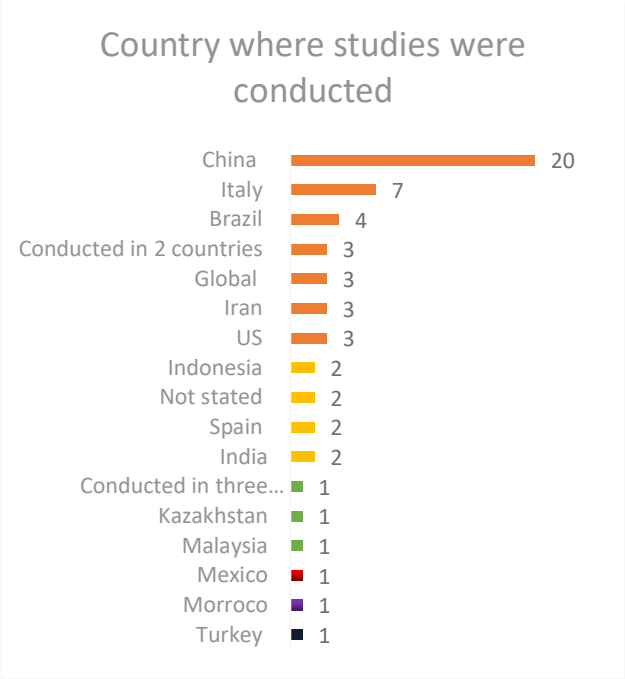

Figure 2: Countries where studies were conducted

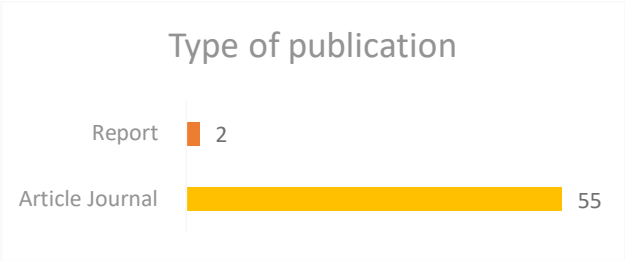

Figure 3: Types of publication

Figure 4: Publication timeline

3.2 The emerging themes

3.2.1 Reduced air pollution

The COVID-19 pandemic has forced countries to shut down their borders and implement stricter lockdown regulations for its people, whereby such actions have resulted in a major decline in air pollution – a significant cause for global warming. This notion was highlighted in 16 studies (Dutheil et al., 2020; Collivignarelli et al., 2020; Wang et al., 2020; Asna-ashary et al., 2020; Tobias et al., 2020; Dantas et al., 2020; Li et al., 2020; Lal et al., 2020; Bashir et al., 2020; Abdullah et al., 2020; Sharma et al., 2020; Bao and Zhang, 2020; Kerimray et al., 2020; Zambrano-Monserrate et al., 2020; Otmani et al., 2020; Kando Nakada and Urban, 2020). Out of these 16 studies, four studies were conducted in China, two in Brazil, two in India, as well as one study each in Spain, Italy, the USA, Kazakhstan, Morocco, Malaysia, and Iran. Meanwhile, Zombrano-Monserrate (2020) had conducted their study at the global level. Most of the studies demonstrated a significant drop in pollution elements, such as SO_2, $PM_{2.5}$, PM_{10}, NO_2, and CO, across globe since the start of the outbreak stemming from restricted people and transportation movement. Kando Nakada and Urban (2020) reported a stunning 77.3% decrease in NO concentrations ($\mu g \cdot m^{-3}$) in Brazilian urban roads, while Otmani et al., (2020) observed 73.0% reduction in PM_{10} in Morocco. Meanwhile, Wang et al., (2020) and Li et al., (2020) revealed contrasting outcomes as the massive and slight reduction of emissions from transportation and industrial sectors, respectively, during COVID-19 pandemic did not significantly change the severe air pollution in China, especially due to unfavourable meteorology.

3.2.2 Low carbon habit

COVID-19 has spurred behavioural change that has lowered carbon habit, particularly amidst educators and students. During the pandemic lockdown, they preferred staying at their home, limited their movement, and indulged in online activities, thus contributing to less carbon release into the air. Ten studies published in 2020 had looked into this particular aspect. Eight case studies conducted in China had listed the strategies deployed by students, teachers, parents, and school administrators to implement their online classes during the COVID-19 lockdown (Cai and Wang, 2020; Dong, 2020; Dai et al., 2020; Xie and Yang, 2020; Xia, 2020; Bao, 2020; Zhao et al., 2020; Kong et al., 2020). Based on two studies within the context of the USA, Hammond et al., (2020) carried out a cross-sectional survey that determined the effects of online learning on several factors, including community sharing and feelings of social isolation during the COVID-19 pandemic, whereas Vargo et al. (2020) conducted a case study to assess online learning activities among doctors and patients, in which telemedicine enabled them to communicate 24/7 using smartphones or webcam-enabled computers.

3.2.3 Temperature and humidity variation effects on COVID-19

The impacts of temperature and humidity on COVID-19 were discussed in 24 studies (Xie and Zhu., 2020; Shi et al., 2020; Auler et al., 2020; Ma et al., 2020; Sobral et al., 2020; Gupta et al., 2020; Liu et al., 2020; Tosepu et al. 2020., Sajadi et al., 2020; Ahmadi et al., 2020; Prata et al., 2020; Poole, 2020; Poirier et al., 2020; Iqbal et al., 2020; Qi et al., 2020; Wang et al., 2020; Anis, 2020; Sahin, 2020; Shahzad et al., 2020; Mendez-Arriaga, 2020;

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Jahangiri et al., 2020; Briz-Redon and Serrano-Aroca, 2020; Asyary and Veruswati, 2020; Polgreen and Polgreen, 2017). Tosepu et al., (2020) and Anis (2020) concluded that temperature influenced COVID-19 transmission in Indonesia, Australia, and Egypt. Interestingly, contradicting results indicated that warmer temperature functioned as predictor, while others noted cooler temperature was more likely to favour COVID-19 transmission. Studies by Sahin (2020), Sobral et al., (2020), Qi et al., (2020), and Mendez-Arriaga (2020) confirmed the negative correlation between temperature and COVID-19 cases. Briz-Redon and Serrano-Aroca (2020), Prata et al., (2020), and Jahangiri et al., (2020), on the other hand, found no evidence for reduction in COVID-19 cases at warmer mean, minimum, and maximum temperatures. Liu et al., (2020) and Poole (2020) claimed that certain elements, such as low temperature, mild diurnal temperature range, and low humidity, were likely to favour COVID-19 transmission. In a study that assessed 122 affected cities in China, Xie and Zhu (2020) discovered that 1 °C rise in the mean temperature was connected to almost 4.9% increase in the daily confirmed cases, whereas Sajadi et al., (2020), Shi et al., (2020), Wang et al., (2020), and Poirier et al., (2020) depicted that high temperature and high humidity significantly reduced the COVID-19 transmission in Iran and China. Meanwhile, Ma et al., (2020) noted that increase in temperature was associated to reduction in daily new deaths, while 1% increase in relative humidity was linked with reduction in daily new cases and deaths. In the context of Jakarta in Indonesia, Asyary and Veruswati (2020) concluded that sunlight was significantly correlated with recovery of COVID-19 patients. Polgreen and Polgreen (2017) found that climate change impacts (e.g., temperature rise and extreme weathers) had forced some species and environmental conditions prevalent in tropical regions to start the spread out from traditional areas and seek new habitat, hence increasing the risk of migration of zoonotic disease.

3.2.4 Air pollution effects on COVID-19

Eight studies had looked into the potential correlation between distribution of severe COVID-19 outbreaks and air pollution stemming from a combination of specific climatic conditions, local human emissions, and regional topography (Frontera et al., 2020; Ogen, 2020; Yongjian et al., 2020; Fattorini and Regoli, 2020; Conticini et al., 2020; Setti et al., 2020; Coccia, 2020; Bontempi, 2020). Seven studies focused on Italy, particularly the northern region, such as Po valley, Lombardia, Emilia-Romanga, Piemonte, and Veneto (Frontera et al., 2020; Ogen, 2020; Fattorini and Regoli, 2020; Conticini et al., 2020; Setti et al., 2020; Coccia, 2020; Bontempi, 2020). Ogen (2020) covered Germany and Spain in his study, while Yongjian et al., (2020) looked into China. Most of these studies reported that people living in areas with high levels of pollutants were more prone to COVID-19 infections. Yongjian et al., (2020), Fattorini and Regoli (2020), Ogen (2020), and Setti et al., (2020) concluded that rapid COVID-19 spread can be connected to atmospheric levels of PM2.5, PM10, carbon monoxide, NO_2, and sulphur dioxide; while Conticini et al., (2020) evidenced that dwellers in areas with high levels of pollutants were more prone to develop chronic respiratory conditions and exposed to infective agents, such as COVID-19. On the contrary, Bontempi (2020) noted that PM10 concentration trends cannot be directly linked to COVID-19 reported cases.

4. DISCUSSION

Temperature, humidity, and air pollution are among the most studied environmental elements in regard to COVID-19. Most of these studies are still at the initial stage with vast contrasting outcomes. In the context of temperature effects, while Sahin (2020) noted that lower temperature escalated the number of COVID-19 cases, Xie and Zhu (2020) stated that 1 °C rise in the mean temperature was connected to almost 4.9% increase in the daily confirmed cases. The contradiction between these studies denotes a mounting need for more investigations related to the effects of temperature, humidity, and air pollution on COVID-19.

Undeniably, COVID-19 lockdown has cultivated a low carbon habit among people. Studies by Dutheil et al., (2020), Asna-ashary et al., (2020), Tobias et al., (2020), and Bashir et al. (2020) demonstrated significant decline in pollution across the globe since the start of the outbreak due to restricted people and transportation movement. This drop in pollution is largely contributed by the lockdown implemented across the affected countries. People seemed to prefer online activities that limited their movement and saved energy, thus minimising carbon release into the air. Based on the findings, educators and students were actively involved in virtual activities (Cai and Wang, 2020; Dong, 2020; Dai et al., 2020; Xie and Yang, 2020; Xia, 2020; Bao, 2020; Zhao et al., 2020; Kong et al., 2020; Hammond et al., 2020; Vargo et al., 2020). Some may not be prepared to teach/learn virtually due to certain difficulties, as such unprecedented platform, as well as limited ICT access and skills. The stress had led people to favour anguish and a fierce search for new knowledge acquisition, in which they gradually acquire the skills and get comfortable doing so (de Oliveira Araujo et al., 2020).

In addition to class cancellation, the rapid spread of COVID-19 had forced postponement of some important events, including those related to climate change (Viglione, 2020; Tollefson, 2020b; Castelvecchi, 2020; de Oliveira Araujo et al., 2020). Hence, organisers were forced to devise alternative ways and to rethink the concept of events entirely, wherein virtual platform is an option (Viglione, 2020). For instance, events organised by the UNFCCC

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(UN climate secretariat) to gather collective efforts in combating global warming had been postponed. The Glasgow summit in November 2020 was among the major climate-related events since the 2015 Paris agreement, while the Intergovernmental Panel on Climate Change (IPCC) was racing with time to produce timely report related to global warming (Tollefson, 2020b). This might delay important decision making and policy development related to climate change. Viglione (2020) asserted that although virtual events offered more benefits, such as inclusivity of all members, lower risk of infection, and low carbon emission (absence of events transportation), not all big events can suddenly be made online.

The prior studies denoted that the lockdown might temporarily reduce a significant amount of carbon emission, despite the possibility of post-COVID-19 to release more emission than the amount it reduced during the pandemic appears alarming. Thinking too much about COVID-19 could result in fear, anxiety, and depression among the public (Roy et al., 2020; Meng et al., 2020; Cao et al., 2020). Acknowledging the importance of physical distancing to minimise the possibility of contracting the disease might force people to think on alternative ways to move, hence the preference to travel in their own vehicle instead of using the public transportation – some might even ride bicycles and other green means of getting around (Asna-ashary et al., 2020; Prem et al., 2020; Tellis et al., 2020; He, 2020; Han et al., 2020; Becchetti et al., 2020). On the other hand, some may be eager to go out after being trapped at home for so many days, which could cause a significant rise in transportation demand for tourism purposes. Both situations; usage of more individual transportation and increase in demand for tourism-related transportation may eventually release significantly more carbon emission during post-COVID-19.

Polgreen and Polgreen (2017) elaborated how rising temperature or extreme weathers force certain animal species to seek new habitats, which can create the possibility of them getting into contact with other animals that they normally would not and open ways for pathogen to get into new hosts. The Ebola and MERS outbreaks stemmed from virus that spread from animal to human in disturbed natural habitats (Rojas et al., 2020). Similarly, Lassa fever (Nigeria), Nipah (Malaysia), and Sars (China) had killed more than 700 people in 30 countries from 2002 to 2003 (Jalloh et al., 2020). In the case of COVID-19, it was suspected that the virus was transmitted to humans at a ‘wet market’ in Wuhan, China where fresh wildlife meat was sold (Zhao et al., 2020; Sun et al., 2020).

5. CONCLUSION

This scoping review on the inter-relationship between climate change and COVID-19 signifies that conserving the nature strengthens the future and helps to combat pandemic, such as COVID-19. This study concludes that climate change and COVID-19 are indeed inter-related - either climate change affects COVID-19 or COVID-19 affects climate change. Although issues related to temperature and humidity, as well as their impacts on COVID-19, emerged as significant, some glaring contradictions amongst the studies demand further exploration to gain comprehensive understanding. The different views between scholars on whether or not air quality contributes to the rising number of COVID-19 cases demand further investigations from future scholars. Scholars need to assess how COVID-19 lockdown has resulted in better air quality across the globe, while simultaneously cultivating a low-carbon habit among people. Another essential aspect yet to be uncovered by scholars is the economic effect of COVID-19 and how this effect has affected the budget on combating climate change. The formidable impact of COVID-19 on the global economic performance is portrayed through the halt of multiple economic activities, deficits across industries, as well as rising poverty level and unemployment rates. Due to economic downfall, some countries have slashed their budget meant for several aspects and climate change could be one of them. Despite the pressure to ensure that budgets to combat COVID-19 and climate change are distributed equally; the worsening pandemics, the immediate threats of the disease, the economic fallout, and the gradual or yet unseen impacts of climate change may push climate down the list of priorities amongst governments.

Prevention is better than cure. Proactive responses and awareness can both flatten the curve for COVID-19 and decrease the increasing death rate. The governments, the community, the scientists, and the rest have reckoned that a similar strategy to combat Covid 19 may be applied for combating the climate change impacts. The disease warns us that if people wait until they can see the impacts, they are too late to stop the damage. Based on the vast reported experiences in handling the pandemic, it is crucial for the public to start new norms, to collaborate and change their behaviour The experience reminds us that there is a critical need to adopt more climate-friendly development and conserve the priceless natural resources, which are directed towards a more sustainable path. Nevertheless, one cannot deny that proactive actions and responses that aim to flatten the curve for climate change impacts pose as a huge challenge. Understandably, COVID-19 has brought immediate threat to the public in a crystal-clear manner, nevertheless, unlike COVID-19, the impacts of climate change are gradual and cannot be witnessed immediately - a scenario that falsely leads the public to perceive that the impacts do not exist, thus not deleterious. In this case, one should be reminded of the extinction of dinosaurs and the grave Pompeii disaster – the fatal effects of climate change that were gradual, but definite and unescapable.

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