A review about COVID-19 in the MENA region: environmental concerns and machine learning applications

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Abstract
Coronavirus disease 2019 (COVID-19) has delayed global economic growth, which has affected the economic life globally. On the one hand, numerous elements in the environment impact the transmission of this new coronavirus. Every country in the Middle East and North Africa (MENA) area has a different population density, air quality and contaminants, and water- and land-related conditions, all of which influence coronavirus transmission. The World Health Organization (WHO) has advocated fast evaluations to guide policymakers with timely evidence to respond to the situation. This review makes four unique contributions. One, many data about the transmission of the new coronavirus in various sorts of settings to provide clear answers to the current dispute over the virus’s transmission were reviewed. Two, highlight the most significant application of machine learning to forecast and diagnose severe acute respiratory syndrome coronavirus (SARS-CoV-2). Three, our insights provide timely and accurate information along with compelling suggestions and methodical directions for investigators. Four, the present study provides decision-makers and community leaders with information on the effectiveness of environmental controls for COVID-19 dissemination.

Keywords COVID-19 · Environmental analysis · Meteorological factors · Machine learning · Artificial intelligent · MENA

Introduction
The current COVID-19 outbreak or SARS-CoV-2 which has been recorded for the first time in Wuhan City in China (Shawaqfah and Almomani 2021; Dubey et al. 2022; Kulshreshtha and Sharma 2022) represents one of the most difficult public health concerns the world has ever seen. On January 30, 2020, the World Health Organization (WHO) declared COVID-19 a global health emergency (Sohrabi et al. 2020; Gupta et al. 2022; Mujwar, 2021; Bruce and Liang 2020). According to the WHO, more than 517 and a half million confirmed cases and more than 6 million fatalities occurred globally during the second week of May
2022. The most difficult aspect of COVID-19 is its high-speed transmission. Because some cases were detected with no travel history to the primarily afflicted areas, there was a substantial chance of community transmission. COVID-19 is transmitted in two ways: directly and indirectly. The direct method of transmission comprises (1) aerosols generated during surgical and dental operations and/or in the form of respiratory droplet nuclei; (2) various bodily fluids and secretions such as feces, saliva, urine, sperm, and tears; and (3) mother-to-child transfer. Indirect transmission can occur through (1) fomites or surfaces (e.g., furniture and fixtures) in an infected patient’s local environment and (2) things used on the infected person (e.g., stethoscope or thermometer). Because many of these modalities are underutilized, it is vital to highlight and demonstrate them (Karia et al. 2020). Several precautionary measures such as lockdowns and travel limitations have already been implemented globally to confront the pandemic and reduce its transmission (Pandey et al. 2021; Kadi and Khelfaoui 2020; Atalan 2020; Komarova and Wodarz 2020). These actions have disrupted people’s lives in all nations and communities, as well as harmed global economic progress. The same methods, however, lowered air and air pollution levels, improved the ozone layer, and reduced carbon emissions (Chakraborty and Maity 2020; Venter et al. 2020).

Climate conditions such as weather parameters and air quality conditions have attracted researchers’ attention because they have a direct impact on SARS-CoV-2 transmission (Eslami and Jalili 2020; Anis 2020; Hamd et al. 2022; Chen et al. 2020a, b; Poole 2020; Habeebullah et al. 2021). According to emerging literature, the pace of transmission of SARS-CoV-2 varies throughout MENA area nations due to differences in land nature and latitudes and water and air quality. As a result, a growing body of research in the field to investigate the bidirectional link between COVID-19 spread and the regional environmental factors in the MENA region is highly recommended. Due to its fast propagation, WHO (Ziaeepour et al. 2008) has suggested studies and financed research programs to offer timely information to policymakers to act and confront the spread of the pandemic.

The coronavirus has slowed regional development in the Middle East and North Africa region, influencing the socioeconomic lives of MENA nations and, in some cases, causing a change in lifestyles in the region. Because of the virus’s pervasiveness, the World Health Organization declared a global health emergency in early 2020. (WHO 2020). Millions of documented SARS-CoV-2 cases had all been reported in the MENA region by the end of April. Once the epidemic became a pandemic at the end of March 2020, half of the MENA region’s workforce was halted, resulting in a regional closure of industrialized activity across all of the region’s territories (Alaoui-Mdaghrí et al. 2020). Both aerial and ground transportation have been hampered as a result of people’s incapacity to relocate (Ji et al. 2021; Sheikh Ismail et al. 2021). Reduced transportation outcomes, on the other hand, result in reduced energy and fuel consumption, both of which provide ecological advantages (Hashim et al. 2021a, b; Abdelsattar et al. 2021). Furthermore, toxic effluents, primarily from the use of fossil fuels, have been linked to a variety of ailments around the globe, including asthma (Tyagi et al. 2022; Gao and Zhao 2022). The quarantine system has resulted in large drops in nitrogen dioxide concentrations in several nations, notably Saudi Arabia, Egypt, Iraq, Algeria, Qatar, and the United Arab Emirates (Abdelsattar et al. 2021; El Knawy et al. 2021; Lu et al. 2020; Benchrif et al. 2021).

Some fast evaluations sought to investigate COVID-19-related studies (Ferrante and Fearnside 2020; Alamo et al. 2020; Sahai et al. 2020; Davenport and Kalakota 2019). Even though dozens of publications have been published on the interaction of COVID-19 and the ecosystem, there is no evaluation of COVID-19 environmental concerns available in the MENA region. Because the COVID-19 environmental correlation findings are ambiguous, a reassessment is urgently required. To confront the present situation, WHO and medical industry experts are trying to develop new technology to screen and diagnosis the infection at various stages, invent SARS-CoV-2 vaccines, and track its spread. Machine learning (ML) and artificial intelligence (AI), according to recent research, may be considered an excellent technology alternative that has been used by many medical experts. ML and AI provide greater scale-up, faster processing power, and even outperform humans in some healthcare jobs (Davenport et al. 2019; Khelfaoui et al. 2022a, b).

The present study aims to make this contribution by addressing COVID-19 environmental problems in MENA area nations. In this review, publications investigate the influence of environmental variables on SARS-CoV-2 and provide four unique contributions. One, the recent works that discuss the transmission of the virus in various sorts of contexts to provide definitive directions to the current discussion about virus transmission are investigated. Two, highlight the most significant ML applications to predict, forecast, and diagnose SARS-CoV-2 infection. Three, our findings provide future researchers in the field with relevant insights as well as methodological guidelines. Four, based on the findings obtained, the importance of good environmental management to control the spread of the pandemic is already clarified to be applied by MENA policymakers. The paper is structured into five sections: “Introduction” describes the impact of environmental conditions on the spread of COVID-19, followed by “Thematic discussion” that analyzes the themes, while “Significant applications of ML for the COVID-19 pandemic” discusses the ML application in the spread of COVID-19; “Advice and future research
directions” provides future instructions and recommendations to the scientists in the field; final decisions and conclusions are present in “Conclusions and future perspective.”

Thematic discussion

As presented in figure S1, several metrological and non-metrological conditions influence the COVID-19 pandemic in the MENA region (Chen et al. 2020a, b; Mansouri Daneshvar et al. 2022; Bentout et al. 2021; Lodder et al. 2020). Transmission can also be detected by inhaling exhaled viruses in respiratory droplets (Jones 2020). The durability of SARS-CoV-2 in the ecosystem, particularly water, soil, and aerosol, necessitates an immediate and thorough examination (Sharma et al. 2021).

MENA region’s air pollution influence the transmission of the pandemic

Many diseases are caused by insufficient or excessive immune responses, including the COVID-19 pandemic. Thus, it is critical to investigate how contaminants impact the immune system and, as a result, disease vulnerability (Quinete and Hauser-Davis et al. 2021; Glencross et al. 2020). Analytical method advancements and adjustments have aided immunotoxicology research. Environmental contaminants have been linked to marine animals in field research, captive feeding tests, and in vitro laboratory studies (Desforges et al. 2016). High levels of airborne pollutants cause health consequences including the MENA region (Al-Hemoud et al. 2022; El-Nadry et al. 2019; Khajavi et al. 2019). Consequently, Mostafa et al. 2021 evaluated nitrogen dioxide (NO2), ozone (O3), and other particulate matter and found that the lockdown in Egypt reduces the air pollution indexes (Mostafa et al. 2021). Another study revealed that sand or dust particles could act as a transporter of COVID-19 (Marquès et al. 2021). A similar work investigated three of Saudi Arabia’s most impacted cities (Riyadh, Jeddah, and Makkah) and concluded that air pollution and climatic factors significantly influenced the daily development of infections in these locations where the illness incidence was very high throughout the summer of 2020 (Ben Maatoug et al. 2021). According to the findings, air pollution may be a substantial risk factor for respiratory illnesses and viral transmission. Gaseous compounds and particulate matter in urban air pollution are well-known aggressive and irritants to the respiratory system (Glencross et al. 2020).

Daily SARS-CoV-2 was confirmed to have been significantly associated with air pollution in Saudi Arabian in a study proposed by Ghanim and team (Ghanim 2022). The study aimed to explore the association between air pollution levels such as PM10 and the propagation of the pandemic. Similar studies have confirmed such a correlation as shown in Fig. 1. Transmission, patient numbers, urgent cases, and fatality rates are all part of the mentioned study. According to the results obtained, Saudi Arabia’s most polluted regions have recorded a high number of confirmed cases. The majority of SARS-CoV-2 cases, with a higher fatality rate and severe cases in these areas than in other parts of the country. Thus, a positive association has been confirmed between air pollution levels and the spread of the pandemic in the region.

To investigate the results obtained by the previous study (Ghanim 2022), excellent research has been conducted in the United Arab Emirates (Mansouri Daneshvar et al. 2022) that studied how COVID-19 reduces pollution at the local scale of the country. As a result, this study and others have also found that SARS-CoV-2 lockdown reduces air pollution levels in MENA nations including Morocco, Kuwait, Tunisia, Qatar, and Iraq (Khomsi et al. 2020; Al-Hemoud et al. 2021; Jribi et al. 2020; Mahmoud et al. 2022; Hashim et al. 2021a, b).

Pollution levels have dropped by 30% points throughout the epidemic in places such as China, the EU, and the USA, suggesting that the pandemic has a transient advantage (Muhammad et al. 2020; Le et al. 2020). Moreover, Hashim and his colleagues suggest that during the lockdown in Baghdad, Iraq, positive air condition shifts were observed as the reason of decreasing air pollution levels (Hashim et al. 2021a, b). Based on the research, Baghdad's indicator of air quality (AQI) increased by 13% points versus the pre-lockdown periods, while NO2 concentrations in Iraq reduced by 35 to 40%. It has been remarkable to watch how nature’s changes in behavior patterns have been incredibly advantageous, with the atmosphere, hydrosphere, and biosphere all recovering, creating the sense that the world is on standby for maintenance. In contrast, quarantine restrictions have led to an increase in wastewater, notably medicinal wastes. During the summer season (June–August 2020), hygienic actions were carried out in Egypt and Saudi Arabia to assess the existing rubbish and then discard it. Nearly every day, Alexandria, Hurghada, and Jeddah gathered 3673, 255, and 848 articles, respectively. Medicine-utilized instruments such as masks amounted to 40–60% of all garbage recovered in both locations where the operations were held, while plastic sacks amounted to 7–20% of overall plastic waste gathered (Hassan et al. 2021). In Contrast, the epidemic has moved focus to a new paradigm focused on the contemporary economy, knowledge-based economy, robust economy, and industry 4.0, which has a lower impact on the environment while disclosing its detrimental impact on human society (Grinin et al. 2022; Nundy et al. 2021).

Over the last 2 years, the pandemic has efficiently rebuilt the ecosystem, which has had a positive effect on worldwide climatic changes (Le Quéré et al. 2020; Klenert et al. 2020).

To summarize, because COVID-19 is prevalent in most regions of the world, one of the key concerns is the
The association between COVID-19, Air Pollution and Climate Change

There were two sides to the relationship between COVID-19 and air pollution and meteorology. Some air pollutants such as PM and O₃ tend to increase COVID-10 cases, whereas COVID-19 lockdowns tend to decrease air pollution problem and short-term global temperature.

AIR POLLUTION PANDEMIC

COVID-19 PANDEMIC

COVID-19 Cytokine storm

Inflammation
Platelet activation
Prothrombotic
Antifibrinolytic
Prooxidant
Less vasodilation
More vasocostriction
More proliferation

Atherosclerosis

Acute coronary syndrome
Heart failure
Arrhythmia
Stroke
interaction between environmental parameters such as air humidity and temperature (Abbasi et al. 2020).

According to one study, the frequency of positive daily SARS-CoV-2 cases is related to three environmental factors: maximum relative humidity, maximum temperature, and maximum wind speed. Chin et al. (2020) found that the SARS-CoV-2 was resistant at 4 °C for a long period, but only 5 min at 70 °C. Heat, high or low pH, and sunshine, in general, make it simpler to destroy the coronavirus (WHO 2020). A research, however, found that the virus is stable at pH levels ranging from 3 to 10 at room temperature (Chin et al. 2020) (Fig. 2).

Many scientists then indicate that outdoors air pollution, generated by a combination of elements such as meteorological records, industrialization degree, and geographical topography, could act as both an infection transmitter and an aggravating driver of COVID-19 aggressiveness (Isaifan 2020; Martelletti and Martelletti 2020). Setti’s team lately reported provisional proof that SARS-CoV-2 RNA can be encountered on open air particulates, suggesting that in circumstances of atmospheric stability and elevated PM concentration levels, it could serve as an important sign of COVID-19; however, it does not give details on COVID-19 evolution or magnitude (Setti et al. 2020). Some other studies supported these findings, although they discovered that the influence of PM$_{2.5}$ on daily verified cases was larger compared to that of PM$_{10}$ (Zhu et al. 2020). The lack of a link between PM$_{10}$ and COVID-19 prevalence and fatality may be due to particulates greater than 5 m being unable to enter type II alveolar cells, which have the SARS-CoV-2 cell entrance receptor (ACE2). For a considerable period, we have understood that reducing outdoor and indoor harmful emissions in countries can have an instant effect on health, and the advantages can far exceed the expenses. Definitely, the world’s major health catastrophe stresses how environmental research is a vital juncture of reference for helping to improve comprehension of contagious diseases and how all academic and financial funds must be dedicated to accelerating initiatives to enact environmental regulatory requirements to improve air quality and build innovative urban planning treatments. Relatively brief absorption of polluted air was also demonstrated to be statistically significantly associated with a rise in new daily occurrences of COVID-19, even when meteorological conditions were accounted for. Nevertheless, a negative connection with relatively brief PM$_{10}$ exposure has been reported (Saez et al. 2020).
Additional research reveals that, in complement to concentrations, the contact period may influence SARS-CoV-2 aberrant volatility. Information on the spread of pollutants in the atmosphere (\(\text{NO}_2\), \(\text{O}_3\), \(\text{PM}_{2.5}\), and \(\text{PM}_{10}\)) in Italian areas over the last four years, as well as days surpassing legislative thresholds and years in the last decade with at least 35 days surpassing the thresholds, demonstrate that Northern Italy has been constantly subjected to persistent air pollution. Long-term data on air quality were significantly linked with Covid-19 cases in as many as 71 Italian localities, providing further proof that long exposures to atmospheric pollution may provide a suitable atmosphere for virus proliferation. Pro-inflammatory responses and a large rate of respiratory and cardiac disorders are well known, but the coronavirus’s ability to link particulate particles is unknown (Fattorini and Regoli 2020).

Based on these studies, we suggest that air quality should be considered a component of a comprehensive plan for ecological sustainability, human preventive care, and the prevention of pandemics such as COVID-19. More investigation is deemed necessary to effectively comprehend the significance of polluted air during the COVID-19 pandemic, namely cross-disciplinary research to enhance scientific proofs and assist conclusive results, which will be effective in making pandemic implementation strategies to appropriately avoid new pandemics.

**Land processes impact the spread of the pandemic in the MENA region**

The seasonality or dispersibility of a virus, as stated in various publications, is influenced by the atmospheric period (Poole 2020; Lofgren et al. 2007). Similar annual variation is feasible for the present pandemic and other coronaviruses (Poole 2020; Davenport et al. 2019; Auler et al. 2020) when weather conditions promote seasonal respiratory viral spread. In a regional study, the results have confirmed an association between the weather parameters in high-latitude locations and the spread of COVID-19 (Chen et al. 2020a, b). Similarly, Hamd and coworkers (Hamd et al. 2021) demonstrated that there is a relationship between numerous climatic conditions and COVID-19 transmission, but that the virus does not go away as the temperature rises, contrary to popular belief. Our theory is that when the temperature rose, the virus grew more active in Egypt and its latitude or the humidity got unstable. A log-linear quasi-Poisson regression model was used to evaluate the connection between the examined meteorological variables and COVID-19 dissemination. Deforestation has been attributed to several infectious diseases propagated by viruses carried by birds and bats (Afelt et al. 2018). Minhas affirms that population increase would generally lead to city expansion, which will directly or indirectly lead to deforestation, meaning that such novel cities and/or regions will host probably the next pandemics if any (Minhas 2020). COVID-19 is a bat-borne viral epidemic (Afelt et al. 2018). To combat the pandemic, billions of dollars are being invested in the development of diagnostics, therapy, and pharmaceuticals. However, essential preventive actions like forestation and wildlife habitat conservation are being overlooked. As a result, the world must understand the value of trees and support as much afforestation as possible (Chakraborty and Maity 2020).

Finally, infectious disease outbreaks are more likely in quickly deforested tropical environments. Agricultural factors are linked to about half of all zoonotic illnesses that have developed in humans (Rohr et al. 2019). The impending recession caused by the COVID-19 pandemic may potentially exacerbate poverty and food insecurity in deforestation frontiers, leading to increasing bush meat intake and the emergence of new zoonotic illnesses. In this context, governments will face challenges in protecting people’s lives and tropical forests, as well as providing assistance to local communities living on the periphery of the cash economy in deforestation frontiers (Ferrante et al. 2020), which can be critical in preventing new pandemics (Everard et al. 2020).

Based on the findings of th section, we concluded the following points:

- Preventing illicit deforestation should be prioritized during the epidemic.
- Forest fires may exacerbate COVID-19’s health hazards.
- Tropical deforestation raises the prospect of developing zoonotic illnesses.
- Why Indigenous peoples should be given special consideration during the present epidemic.

**MENA region’s meteorological factors on the spread of the pandemic**

The bulk of research points to weather as one of the most critical elements in forecasting COVID-19 pandemic future trends (Hamd et al. 2021; Chen et al. 2020a, b). As highlighted in Figs. 3, 4, and 5, meteorological parameters such as rainfall, wind, and temperature are climatic variables that influence the survival of viruses and help to spread the infections (Poole 2020; Davenport et al. 2019; Kroumpouzos et al. 2020). (Sangkham et al. 2021) investigated air pollutants, AQI, and meteorological factors, as well as their parameter correlations with the daily number of confirmed COVID-19 cases during the epidemic. The temperature, relative humidity (RH), and wind speed (WS) were shown to be positively linked with daily verified COVID-19 cases in the research. As a result, these factors have the potential to promote SARS-CoV-2 sustained transmission.
A study analyzed the influence of outdoor and weather on daily reported COVID-19 cases in Saudi Arabia’s western areas from March to October 2020 (Habeebullah et al. 2021). The findings suggested that during the hottest periods of the year, the most SARS-CoV-2 confirmed cases were observed in Makkah and Madinah which confirms a concrete
association between the pandemic spread and weather conditions, temperature in particular. Outdoor humidity and daily COVID-19 incidences were shown to have a partial negative association. However, there was no evident link between daily COVID-19 incidences and wind speed suggesting that confirmed cases took place in several indoor settings where the study have been conducted.

By examining the influence of climatic elements in nine Turkish cities, Tosepu (Tosepu., 2020) reveals a significant correlation between wind speed and temperature and the transmission of the pandemic. However, in Algeria, the influence of meteoroogical settings on the spread of covid19 was studied in fourteen cities from April to August 2020 (Boufekane et al. 2022). To find a possible link between climatic factor fluctuations and day-to-day confirmed infections, researchers used a complete time series analysis and linear regression. The data demonstrated a weak correlation between daily confirmed cases and meteorological conditions in all of the areas studied. SARS-CoV-2 can adapt to different temperature levels and humidity, and factors other than the environment, such as demography and human contact, can impact virus replication. Similarly, a previous study on the relationship between temperature and germ and viral transmission reveals, that Anis and coauthors (Anis 2020) investigated the impact of temperature on the spread of the virus in Egypt. The study found that the best average temperature for viral activity and transmission is between 13 and 24 °C. Egypt is then used as a model to validate
the link between temperature and coronavirus activity and distribution in the MENA area. A study explored the link between climatic characteristics and COVID-19 in Algeria and Egypt, concluding that SARS-CoV-2 spread has a substantial relationship with temperature and humidity (Zhao et al. 2020a, b; Davenport et al. 2020). As mentioned earlier, several studies confirmed a significant association between weather and SARS-CoV-2 spread; some studies disagree, however, suggesting that weather parameters alone may not result in a reduction or increase in the number of confirmed cases (Habeebullah et al. 2021; Ismail et al. 2022; Jamil et al. 2020). Ismail and coworkers conducted a study in six Saudi Arabian cities with various weather conditions, such as moisture and temperature, and found that such conditions are unrelated to the frequency of new cases in those areas (Ismail et al. 2022).

The findings of this subsection demonstrated that climatic parameters such as humidity, temperature, and rainfall are important drivers of infectious disease management in many regions of the world (Islam et al. 2020). Elevated temperatures, for example, may inhibit the spread of droplets that transmit coronaviruses, most likely by fast evaporation. Simultaneously, other variables like humidity may increase COVID-19 survival time in the environment and thus alter the infection rate. Previous research has found that humidity impacts the infection rates of the COVID-19 epidemic (Wang et al. 2020; Demongeot et al. 2020). It is uncertain whether seasonal temperature rises will reduce the rate, which warrants additional inquiry. To present, the function of environmental variables in COVID-19 transmission has not been demonstrated. Concrete and evidence-based arguments are required to be investigated, whereas probabilistic determination methods may assist in obtaining potential clues.

The shift in daily COVID-19 instances, according to (Islam et al. 2021a, b), has a significant correlation with AH and RH, which travel southward to enhance easterlies. Our data revealed that the total COVID-19 pandemic in Bangladesh is mostly impacted by humidity changes. According to several researches, temperature and relative humidity are the most important environmental factors impacting COVID-19 cases in other countries. Alkhowailed et al. (2020) presented an outstanding paper that determined the influence of climatic conditions on the infectivity rate of COVID-19. Temperature, humidity, and wind speed were shown to be key variables influencing COVID-19 infectivity in this investigation. We discovered that when the temperature and relative humidity were lower, the number of COVID-19 cases rose. We also discovered that the number of positive cases rose in places with lower average wind speed, particularly in congested areas where lower wind speed was related to a significant rise in positive instances. Because the emergence of the pandemic in Saudi Arabia occurred just four months ago, additional research on the relationship of COVID-19 infectivity rate with weather fluctuation is needed. Overall, PM$_{10}$ and O$_3$ levels increased with the number of verified COVID-19 cases every day. Positive trends were observed for wind and humidity levels that exceeded certain thresholds, 20 m/s for wind and 80% for humidity. Furthermore, temperatures above 25 °C revealed a negative correlation with the number of COVID-19 cases. Insolation also exhibited a definite growing curve over 9 h. While the Precipitation curve was variable below 22 mm and declining beyond that number.

As a result, the literature on this subject has disparate findings. Hence, we raise the attention that in the MENA region, the impact of weather conditions on COVID-19 spread is unknown yet, as sometimes sounds unclear and ambiguous (Boufekane et al. 2022; Zhao et al. 2020a, b). To study such correlational data in the MENA, it is necessary to investigate the combined effect of others based on the demographic features, healthcare facilities, social policies such as lockdowns, and so on.

**MENA region's non-meteorological factors impact on the spread of the pandemic**

Technically, similar to other respiratory viral epidemics, combined with meteorological conditions, non-meteorological factors such as human behaviors and traditions, and population parameters including age, gender, and also population density may have actions of SARS-CoV-2 spread. To confirm this hypothesis, academics have conducted several works to simultaneously examine their effect on the propagation of the pandemic. For this purpose, and to simulate, analyze, and understand the dynamics of the coronavirus via non-meteorological conditions such as population density, population age, and also population behavior and traditions, and their attitude toward the environment, several mathematical modeling studies have been developed (Lodder et al. 2020; Rashed et al. 2020; Kada et al. 2020; Alrasheed et al. 2020). The studies have confirmed the following:

- Elder people are the most vulnerable part of society to SARS-CoV-2 infection and they have a direct influence on the spread of the pandemic.
- In the MENA region, population behavior and traditions such as weddings gathering, public transport, and greetings (shaking hands or kissing) have accelerated the spread of the pandemic.
- Irresponsible behavior toward the environment (throwing masks, gloves, and other infected medical tools in public sites) has also accelerated the propagation rate of the pandemic.

When it comes to the influence of meteorological factors on the pandemic spread, Sitkowska, Doremalen, and coworkers (Doremalen et al. 2013) feel that environmental
factors in MENA have a bigger impact on the spread of the virus, which changes depending on non-meteorological conditions related to human behavior. A similar study investigated if Algerian local population density has an action on day-to-day SARS-CoV-2 confirmed cases (Kadi and Khelfaoui 2020). According to their research outcome, they confirmed a positive association between population density and the spread of the pandemic in the nation. The authors, on the other hand, suggested also that increasing public awareness can help slow the virus’ spread. Because SARS-CoV-2 may survive on different surfaces such as plastics and glasses (Kampf et al. 2020; Holshue et al. 2020; Davidson 2021), its propagation remains active and moderate. So, human behaviors such as throwing infected medical tools in public or using infected glasses and spoons in coffees and restaurants should be avoided.

**MENA region’s wastewater impact on the spread of the pandemic**

As shown in Fig. 6, human sewage could be carrying the virus also (Lodder et al. 2020), and a hypothesis has been validated since the first diagnosis of COVID-19 in wastewater (Holshue et al. 2020). Infected people can spread infections via their feces, according to a study published in Saudi Arabia by Ibn Alahdal and the team, highlighting the need for accurately used water treatment plants, as well as the virus’s subsequent spread into the environment (Alahdal et al. 2021). Drinking water is one of the most common ways for humans to be exposed to contaminants (Mandour 2012). This calls attention to several key contaminants in the water supplies that are known to be immunotoxic, as well as potable water routes that may restrict the efficiency of human immune responses (McKeown and Bugyi 2016; Rajkhowa et al. 2021).
According to the literature, a ML device has been used to identify, forecast, and predict certain diseases and calamities, including SARS-CoV-2 (Chamola et al. 2021; Caballé-Cervigón et al. 2020; Merkin et al. 2022; Rahimi et al. 2021). To appropriately assess the transmission of the pandemic, Harrow and coauthors built a presumption data-driven approach, as shown in Figure S2. To do so, the study employed Bayesian optimization to fine-tune the Gaussian process regression (GPR) hyperparameters to build a successful GPR-based prediction model that recovered and confirmed SARS-CoV-2 cases in India and Brazil, two of the most severely affected nations.

ML developed intelligent systems based on AI that helped governments worldwide to take decisions and launch regional lockdowns as a trial to stop the fast spread of the virus at its source in the MENA region (Guezzaz et al. 2021, Ahmed et al. 2021; Saba et al. 2021; Pasayat et al. 2020; EPC 2020). After evaluating those data sets, it can be inferred that using ML approaches to foresee and predict the spread of COVID-19 might be beneficial (figure S2). ML helps humans effectively deal with complex data and/or mathematical approaches in massive volumes of data that are difficult to understand (figure S3). ML algorithms may quickly discover a causal relationship between COVID-19 and another component and/or condition, for example. In addition to detecting them, it may improve or change their actions over time. Efficiency and accuracy improve as data amount increases (Vabalas et al. 2019; Guezzaz et al. 2021; Alsaui et al. 2022; Mirbolouki et al. 2022). Better choices and predictions are made by the algorithm that learns from the data. Another significant benefit is that this method can modify in real-time without the need for human intervention (L’Heureux et al. 2017; Mehmood et al. 2019).

Steps involved in the construction of ML algorithms.

1. Data collection from the local authorities and world meters with various criteria.
2. Train, validate, and test the sample datasets that have been obtained.
3. Predict COVID-19 data trends using the suggested hybrid model.
4. Predict the final COVID-19 data scenarios with dynamic parameters.

Key features of using ML for SARS-CoV-2.

1. Creating a computational hybrid approach for pandemic long-term forecasts over the world.
2. Combing various ML approaches to increase prediction accuracy.
3. Anticipating the pandemic’s future spread and impact by applying historical inputs.
4. Using seasonal statistics such as heat, air quality, and other inputs, the hybrid approach was chosen to forecast SARS-CoV-2 future behavior, as well as state-by-

state and date-by-date data views. Table 1 shows typical examples of diagnosis of COVID-19 using ML models.

### Table 1  SARS-CoV-2 Screening using ML models

| Reference          | ML model                  | Data                      | Validation     | Accuracy (%) |
|--------------------|----------------------------|---------------------------|----------------|--------------|
| (Ardakani et al. 2020) | Convolutional neural network | Clinical, mammographic    | Holdout        | 99.51        |
| (Ozturk et al. 2020)  | Convolutional neural network | Clinical, mammographic    | Cross-validation | 98.08        |
| (Sun et al. 2020)    | Support vector machine     | Clinical, demographics    | Holdout        | 77.5         |
| (Wu et al. 2020a, b) | Random forest algorithm    | Clinical, mammographic    | Cross-validation | 95.95        |

Provide an intelligent platform for healthcare infrastructure

AI and deep learning could be considered possible strategies for treating emerging coronavirus infections (figure S4). Computers can now apply big data-enabled models for infection pattern recognition, interpretation, and prediction thanks to advances in technology such as natural language processing and computer vision. Because of the pandemic’s rapid spreading over the MENA region, it is critical to explore and develop AI to detect and identify COVID-19-infected persons in the MENA region. Qatar has developed an AI-powered mobile software called “Ehteraz” that can instantaneously detect new infections, even when in groups, in order to predict the highest infected areas. In a rapidly moving pandemic, Ehteraz may be utilized to offer a clear vision about the spread of the pandemic and record confirmed cases effectively in the Qatari cities which allow the local authorities to act and take decisions toward...
the pandemic spread in such an effective manner (Ahmed et al. 2021). In response to the coronavirus outbreak, the UAE has been using AI, big data, and network devices at multiple levels to monitor, assess, and fully comply with lockdown restrictions (Huber 2020). The authorities have used Internet-connected devices to check people's compliance with COVID-19-related laws and restrictions. Dubai Police, for instance, used a system 'Oyoon' which offers an in-site diagnosis of the pandemic (EPC 2020).

A healthcare company, Nabta Health, applies AI to detect SARS-CoV-2 symptoms and estimate related impacts based on medical conditions (Hassan et al. 2022). In Dubai, a digital firm called Nybl has been launched, Nybl helped the government manage health supplies by providing AI and big data solutions. By detecting available resources and hospital requirements, and acquiring supplies as needed, these methods enabled supply to meet demand (Huber 2020). Another AI firm established in Abu Dhabi, Group 42 (G42), has been using technology for testing and research in collaboration with diverse organizations (EPC 2020). The company teamed up with BGI, a global genome sequencing company, to create a COVID-19 detection facility that will allow reverse transcription polymerase chain reaction (RT-PCR) screening and identification to be scaled up to the population level (BGI 2020). Quick viral genome analysis, COVID-19 and tuberculosis screening can be used in vitro model creation to reduce drug testing time are among the company's other services (G42, 2020a, b).

Contact tracing is an important public health strategy for stopping SARS-CoV-2 from spreading (EPC 2020). As shown in Table 1, MENA countries have developed a digital contact tracing process using a mobile application that incorporates various technologies such as Bluetooth, GPS, Social graph, contact information, network-based API, mobile tracking data, card transaction data, and system physical address (Table 2).

### COVID-19 forecasting

Anticipating is one of the most effective statistical approaches to discovering and analyzing COVID-19, as well as forecasting future repercussions, and may be used in a variety of fields all around the globe. Depending on the source and data available, a variety of statistical procedures and AI techniques have been used to achieve this aim. For example, Chew and the team employed a proposed G parameter as a function of fused data variables such as defined weather conditions, socioeconomic factors, and regulatory limits to develop a deep learning model to predict COVID-19 transmission rates globally (Chew et al. 2021). They analyzed similar research that modeled the intricate link between COVID-19 transmission rate and many parameters such as climatic and socioeconomic situations in their study. A simulation model based on theories, limited to brief time data, exclusion of affect transformation factors such as time changes, geographic influence, weather patterns, size of the sample, reliance on records, and finally changes of future policies based on assumptions are all drawbacks that must be resolved while doing deep learning (Pasayat et al. 2020; Jaulip and Alfred 2022). Several studies (Pinter et al. 2020; Shrivastav and Jha 2021; Ronald Doni et al. 2022) have been published to predict SARS-CoV-2 infection and fatality rates. To find out the correlation between various characteristics and SARS-CoV-2 transmission rate, researchers used a range of linear regression ML models (figure S5). Furthermore, (Malki et al. 2020) used algorithms to examine the effect of meteorological parameters such as temperature and humidity on COVID-19 transmission by extracting the correlation between the number of confirmed cases and weather factors in particular areas. To test the suggested strategy, relevant datasets relating to weather and census variables were gathered and processed. When compared to other census factors such as population, age, and urbanization, the experimental findings demonstrate that weather data (such as temperature and humidity data) are more useful in predicting mortality rates. Furthermore, another work helped the whole community globally to tackle the five various challenges, such as (I) Predicting the spread of coronavirus across areas. (II) Compare for each nation how SARS-CoV-2 spread and what strategies were used to stop this transmission locally. (III) Predicting the course of

| Nation     | Application's name       | Tracking tool         | Started on |
|------------|--------------------------|-----------------------|------------|
| Algeria    | Coronavirus Algeria      | GPS                   | April 2020 |
| KSA        | Tawakkalna (COVID-19 KSA)|                      |            |
| Kuwait     | Shlonik                  |                       |            |
| Jordan     | AMAN App—Jordan          |                      |            |
| Bahrain    | BeAware Bahrain          |                      |            |
| Egypt      | Egypt Health Passport    |                      |            |
| Tunisia    | E7mi                     |                      |            |
| Morocco    | Wiqayatna                |                      |            |
| Qatar      | Ehteraz                  | Bluetooth and GSM     |            |
| UAE        | TraceCovid               | Bluetooth             |            |
the pandemic and investigating its spread rate and how the weather could affect it (Yadav et al. 2020).

To be well prepared and minimize life loss, it is vital to anticipate the number of expected COVID-19 cases to provide medical care. As highlighted in Table 3, supervised ML methods such as LASSO regression, support vector machine (SVM), and exponential smoothing (ES) have been used to anticipate the transmission of the illness, with ES showing to be the appropriate design when compared to alternative approaches (Rustam et al. 2020). The LSTM model is an excellent deep learning approach since it can handle time-based datasets.

### Environmental impact of COVID-19: estimation

ML might be a useful method for estimating and evaluating the impact of the new COVID-19 pandemic on the environment and its resources. For this purpose, a study published by (Rybarczyk and Zalakeviciute 2021) suggested a model in which a ML algorithm is trained to learn the effects of meteorological variables and time on air pollution. Chemical transport models function poorly in difficult terrain regions (Pani et al. 2020) and require an updated emissions inventory, which Quito does not have. NO₂, SO₂, CO, and PM₂.₅ are measured in the Ecuadorian capital, unlike in earlier research. The disparities in pollution reduction are analyzed in different districts with different sources of contamination because the lockdown mostly affected human movement (e.g., traffic vs. industry). To predict pollution concentrations from meteorological and temporal characteristics without the lockdown, one model is constructed for each city area and contaminant. By comparing the value produced by the model to real observations, the concentration variations owing to reduced human activity may be quantified. The authors assess the direct and positive influence of the lockdown in China on local air pollution (Cole et al. 2020; Grange et al. 2018; Vu et al. 2019; Ben-Michael et al. 2021).

### Advice and future research directions

The accurate association between SARS-CoV-2 spread and meteorological and non-meteorological conditions along with air quality parameters has been highlighted and discussed in this review. Through the present study, the authors orient researchers and scientists to focus more on the following points:

- Raise public awareness about the long-term impacts of deforestation and the hazards connected with anthropized, since multiple studies have established that SARS-CoV-2 is a bat-borne virus.
- Another major issue for future researchers is the transfer of coronaviruses from multicellular to unicellular creatures, as well as their proliferation, mutation, and transmission. One of the major spread factors is the human direct contact but still needs research on the aerial transmission of the virus and how air quality could support the SARS-CoV-2 spread in MENA countries.
- Population age and gender may influence the pace of viral transmission in susceptible groups (women, children, the elderly, and the immune-compromised); hence, such non-metrological variables should be investigated.
- The transmission of the pandemic in the region is influenced by air conditions (temperature, humidity, and pollution). It is strongly advised that researchers should devote more time and resources to investigating and modeling these elements to predict the current virus’s behavior and forecast future situations to prevent a blanket ban.
- Since the diagnosis of COVID-19 in feces, wastewater-based epidemiology should be considered while researching SARS-CoV-2 pathogenesis. On the other side, treatment plants should be designed to eliminate the virus from the water.
- Studies of indoor vs. exterior transmission rates should be done since the virus can spread through ventilation and air conditioning systems.
- It is critical to understand viral survival mechanisms and create low-cost, user-friendly approaches to eliminate coronavirus now. Modeling via ML and AI is crucial for analyzing factors such as metrological and non-metrological parameters including air quality to have a clear vision of how to forecast the spread of the pandemic. Future studies should add complicating factors including social cognition, demographic shifts, health care systems, and societal taboos like lockdowns to better understand transmission patterns.

### Table 3 SARS-CoV-2 forecasting using ML models

| Reference                | ML model                        | Data                  | Validation   | Accuracy (%) |
|--------------------------|---------------------------------|-----------------------|--------------|--------------|
| (BBC., 2020)             | SVM                             | Clinical              | Holdout      | 96.49–99.13  |
| (Ribeiro et al. 2020)    | XGBoost classifier              | Cross-validation      | 90%          |              |
| (Yan et al. 2020)        | LSTM network                    | Demographic           |              | –            |
| (Chimmula et al. 2020)   | Hybrid wavelet-autoregressive   |                       | –            | –            |
Many of us have begun to consider human extinction as a consequence of the pandemic, which is why it is critical to advance these research pathways to better manage future pandemics and protect human health and the environment in the MENA area throughout the world.

While applying machine learning to forecast SARS-CoV-2, researchers have to bear in mind that:

- ML requires large data which requires time and this could be considered a massive challenge when applying ML.
- To achieve a high level of accuracy, ML may need a huge quantity of resources to function. And this may necessitate greater computer processing power.
- Another significant challenge is appropriately interpreting the findings given by the algorithms. It is an obligation to select the algorithms that are suitable to the application's needs and finally.
- ML is self-contained, however, it is prone to mistakes. For instance, if an algorithm is trained on data sets that are too tiny to be inclusive, the model will provide biased predictions based on a biased training set.

Conclusions and future perspective

For the first time in the MENA area, theme analysis and bibliometric assessment of dozens of research publications on the spread and the propagation is conducted, of new coronaviruses in different environments, and the evidence supporting COVID-19’s environmental issues is summarized.

The environment and its parameters have a favorable link with COVID-19 transmission in the region. The present work concludes that temperature and humidity are drivers of COVID-19, but that they are not the only ones. The speed of this transfer, on the other hand, is unrelated to humidity or temperature. In warmer regions, there is some evidence that SARS-CoV-2 expansion can be slowed.

The most obvious technique for limiting the spread of an epidemic is to have a good public health infrastructure and emergency plans. Little study has been done on the usefulness of public health infection, prevention, and control (IPC) techniques in controlling SARS-CoV-2 spread during the current outbreak. Literature on pandemic viral outbreaks derived from clinical samples can also aid in the identification of priority IPC interventions for preventing and limiting pandemic spread. Monitoring clinics and laboratories, according to the literature, are insufficient for fast and accurate diagnosis and control of such emergencies. As a result, a surveillance plan for environmental exposure, as well as a thorough exposure status and sickness effects, are necessary.

The present pandemic is a global threat that needs worldwide involvement and a serious concern, requiring global researchers and academics, legislators, and partners to extend the study on the virus and track its spread and fury as rapidly as possible. Future scholars and professionals should make conscious efforts to aid present or future epidemics throughout the world to keep this potential.

As the globe grapples with COVID-19, every ounce of technical innovation and creativity deployed to combat the epidemic moves us closer to eradicating it. ML and AI have been already applied for an accurate and effective understanding of the spread of the pandemic and they could offer strategies to handle such crises in the future. Because ML can treat big data, the research groups must work more on this subject to mitigate the current situation of SARS-CoV-2, prevent future medical crises, and predict the long- and short-term impacts of such a situation on our society, and economic and environmental lives.

Through the present study, the authors recommend MENA nations leverage their ML capabilities in the battle against COVID-19 in various areas, including understanding how COVID-19 spreads, what factors affecting this spread, and investigating how this pandemic affects our lives.

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