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A Review of the Impacts of COVID-19 on Air Pollution in the World

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ABSTRACT

Introduction: The COVID-19 epidemic has polluted millions of people and has caused millions of deaths worldwide. Therefore, this study aims to review the effects of COVID-19 on global air pollution.

Materials and Methods: In this narrative review, articles related to the objectives of the study were selected in reliable scientific databases such as Web of Science, Ovid, Google Scholar, PubMed, and Scopus. A total of 294 browsing sources and ultimately 90 sources were selected.

Results: In the COVID-19 pandemic, NO_2 dropped from 53 to 11% in most countries, and $PM_{2.5}$ and PM_{10} from 91 to 6% in some countries. CO dropped from 92 to 5% and SO_2 had a decreasing trend from 77 to 7% in most countries, except for the largest cities in Britain, Poland, Taiwan, and Iran. Unlike other pollutants, O_3 in most countries increased from 0.3 to 63%, but O_3 decreased in some countries.

Conclusion: In the lockdown period, the reduction of most air pollutants except O_3 was observed in many countries. But after restarting, polluting activities have incresed again. Therefore, the rules implemented during lockdown time can be introduced as an appropriate option in emergencies to reduce air pollution.

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Introduction

Air pollution is one of the main public health problems. According to World Health Organization (WHO), air pollution is responsible for 7 million deaths worldwide [1]. Nowadays, the lives of more than one billion people in the world are threatened due to urban air pollution [2]. In 2016, 91% of the world's population was exposed to air pollutants, which was more than the WHO standard. Studies have shown that air pollutants such as particulate matter with an aerodynamic diameter less than 10 micrometers (PM_{10}) and particulate matter with a diameter less than 2.5 micrometers ($PM_{2.5}$), nitrogen oxides (NOx), sulfur oxides (SO_X), Ozone (O_3), carbon monoxide (CO), and volatile organic compounds (VOC) are associated with adverse health implications. Respiratory disorders, cardiovascular disease, and early death are among the consequences [3]. SARS-CoV-2 is a zoonotic virus that causes COVID-19 infectious pneumonia [4]. COVID-19 was first identified in December 2019 in Wuhan China [5, 6], and on March 11, 2020, it was announced by the World Pandemic Health Organization [7-10]. This virus has caused millions of deaths worldwide. It is the fifth epidemic that has occurred in the world in

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the last few years [11, 12]. The COVID-19 epidemic has significantly challenged people's daily lives [13]. In Iran, the first official report of death from COVID-19 was reported by the Ministry of Health and Medical Education February 2019 [14]. The first cases of COVID-19 were accompanied by severe air pollution [15]. Air pollutants can increase the risk of viruses that damage the respiratory tract. Hence, it is said that long-term exposure to air pollution puts people exposed to COVID-19. Although the role of air pollution in the transmission of virus through the air is still uncertain, the initial evidence confirms that the SARS-CoV-2 virus may exist in particulate matter. In this case, exposure to air pollution can help spread the virus [16]. Previous studies have suggested that exposure to high concentrations of contaminants such as $PM_{2.5}$, PM_{10}, CO, NO_2, and O_3 can increase the risk of damage to the health of people infected with COVID-19 [17]. Feng et al. and Llaguno-Munitxa et al. reported reductions in air pollution in China and London during the COVID-19 lockdown, respectively [18, 19]. Dubey et al. also reported that in India even a short period of closure can lead to a significant improvement in air quality [20]. In 2003, it was reported that patients with SARS-CoV-1, who lived at the average level of air pollution, lost lives 84% more than those living in areas with less air pollution [21]. COVID-19 has had an impact on human society, particularly health-care economic systems and social connections. As a worldwide strategy involving employment closure and social distancing, lockdown has had extraordinary regional implications. Although the severe health impacts of the COVID-19 are still in the main priority, it is not yet clear how the epidemic can affect other factors, especially air pollution [22]. Therefore, the present study was conducted to investigate air pollution and its impacts simultaneously on the prevalence of COVID-19 in the world.

Materials and Methods

This study was conducted as a narrative review using the keywords of air pollution, COVID-19, Iran, and the world in websites related to reliable journals in scientific databases such as Web of Science, Ovid, Google Scholar, PubMed, Scopus and SID. The articles were initially chosen based on their titles, which were linked to the research goals, and then their abstracts and related articles were separated. After a careful evaluation of the articles, studies that were relevant to the study's goals were chosen. Articles between 2014 to 2023 were evaluated to investigate air pollution and its effects simultaneously with the prevalence of COVID-19 in the world. Ultimately, 90 sources were selected by emphasizing the objectives of the study. Figure 1 shows the flowchart of how to select the articles investigated in the study.

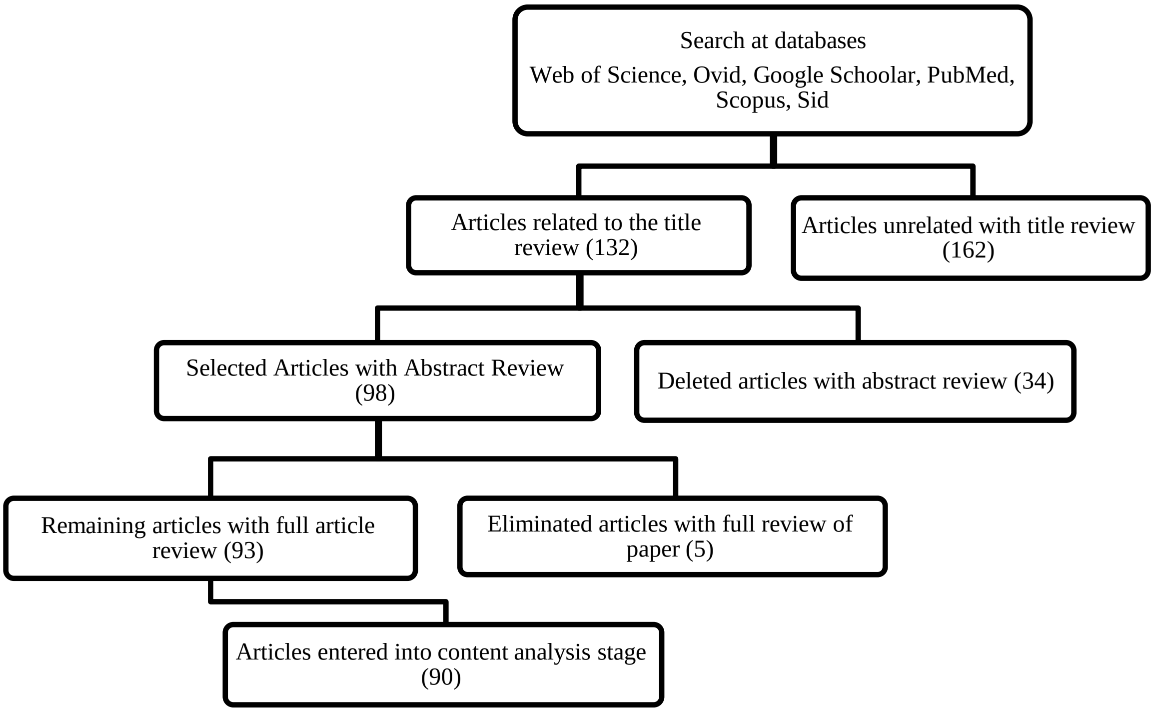

Figure 1: Flowchart of how to select the articles in the study

Ethical Issue

The present study has been approved by Kashan University of Medical Sciences with the ethics code IR.KAUMS.NUHEPM.REC.1400.043.

Results

Increase and decrease of air pollutants in the world during the COVID-19 pandemic

In Asia, Calcutta had the highest decrease, and Iran had the lowest decrease in $PM_{2.5}$ [23, 24]. In Mumbai and Delhi, India, South Korea, Wuhan, and Dhaka, decreasing in $PM_{2.5}$ was reported [25-29]. However, $PM_{2.5}$ increased in Tehran, Lahore, Karachi, and Peshawar [11, 30]. SO_2 had the highest decrease in Istanbul and the lowest in Wuhan [25, 31]. In Jeddah, Mumbai and Delhi, Tianjin and Dhaka SO_2 dropped [27, 29, 32, 33], but in Taiwan and Iran, this pollutant increased [23, 34]. In Mecca, Istanbul, and Dhaka O_3 decreased [27, 31, 32]. The highest increase was reported in O_3 in Iran and the lowest in Tianjin [23, 33]. In Cairo and Alexandria, Wuhan, Mumbai and Delhi, Tel Aviv and Haifa, O_3 increased [25, 29, 35, 36]. CO had the highest decrease in Istanbul and the lowest decrease in Cairo and Alexandria [31, 36]. This pollutant also dropped in Mumbai and Delhi, Bangalore, Wuhan, Tianjin, South Korea, Tehran, Dhaka, and Iran [23, 28, 30, 33]. Only in Taiwan was an increase of CO reported [34]. In Mumbai and Delhi, NO_2 has fallen highest in South Korea [28, 29]. In Riyadh, Wuhan, Alexandria, India, Cairo, Istanbul, Tianjin, Dhaka, Tehran, Iran and Israel, NO_2 also decreased [23, 25-27, 33, 35, 36]. PM_{10} had the highest decrease in Riyadh and the lowest decrease in Iran [23, 32]. PM_{10} fell in Mumbai and New Delhi, India, South Korea, Istanbul, Wuhan and Tianjin [25, 26, 29, 31, 33]. In Europe, $PM_{2.5}$ decreased in Poland and the largest cities in the UK, but in Warsaw it was reported to increase [37-39]. O_3 increased in the largest cities of Britain [39]. In metropolitan areas in Spain, the highest decrease was observed in NO_2 and the lowest decrease in the Czech Republic and Greece [40-42]. In Italy, Poland, Portugal, the largest cities of Britain and Warsaw the NO_2 decreased [37-39, 43, 44]. PM_{10} had the highest decrease in metropolitan areas of Spain and the lowest in France [40]. It reduced in Warsaw, Portugal, and the Czech Republic [37, 41, 43]. $PM_{2.5}$ decreased in North and South America, California, Toronto, Montreal, Vancouver, Calgary, Chile and seven states and capitals in the United States. CO decreased in Canada, California and Chile. O_3 increased in California and Chile. NO_2 decreased in California and Toronto, Argentina, Montreal, Vancouver, Calgary and Canada. PM_{10} increased in California. The highest decrease in $PM_{2.5}$, CO, and PM_{10} was in Mexico [17, 45-50]. In New Zealand, the highest reduction was in NO_2 [51]. Tables 1, 2, and 3 show the decrease and increase of air pollutants in the world during the COVID-19 period. In Nigeria, the Aerosol Optical Depth (AOD), which is one of the important parameters in dust study, decreased significantly compared to the pre-lockdown period. During lockdown, the average level of air pollution decreased by about 69% compared to pre-lockdown. The increase in air quality is attributed to seasonal changes in climatic circumstances rather than lockdown efforts, since the average level of pollution during lockdown in Nigeria in 2020 was 0.22 greater than in the same time in 2013 or 2014 [52]. NO_2 in Casablanca was 12 µg/m^3 and in Morocco was 7 µg/m^3. $PM_{2.5}$ in Casablanca was 18 µg/m^3 and in Morocco was 14 µg/m^3. CO in Casablanca was 0.04 mg/m^3 and in Morocco 0.12 mg/m^3 [53].

Table 1: Decrease and increase in air pollutants in Asia during the COVID-19 period (%)

City or country	Pollutants	Increased	Decreased	References
South Korea	$PM_{2.5}$		45.45	28
Mumbai and New Delhi India			42	29
Kolkata			85	24
India			34.84	26
Wuhan			32.92	25
Dhaka			26	27
Iran			6	23
Tehran		4		30
Xian	PM		32-51	54
Istanbul	SO_2		77	31
Jeda			44.16	32
Bombay and Delhi			41	29
Tianjin			32.7	33
Dhaka			17.5	27
Wuhan			6.95	25
Taiwan		8.7		34
Iran		15		23
Cairo and Alexandria	O_3	2		36
Mecca			18.98	32
Wuhan		2.26		25
Tianjin		0.3		33
Bombay and Delhi		2		29
Istanbul			56	31
Dhaka			9.7	27
Tel-Aviv		11		35
Haifa		1		
Iran		12		23
Istanbul	CO		92	31
Bombay and Delhi			37	29
Bangalore			58	24
Wuhan			18.24	25
Tianjin			17.8	33
South Korea			17.33	28
Dhaka			8.8	27
Cairo and Alexandria			5	36
Taiwan		6.8		34
Iran			11	23
Tehran			6	30

City or country	Pollutants	Increased	Decreased	References
Bombay and Delhi			53	29
Riyadh			44.35	32
Wuhan			38.33	25
Alexandria			33	36
Cairo			15	
Istanbul			24	31
Tianjin	NO_2		22.7	33
Dhaka			20.4	27
South Korea			4.16	28
India			48.68	26
Iran			15	23
Tehran			12	30
Israel			41	35
Riyadh			91.12	32
Bombay and Delhi			50	29
South Korea			35.56	28
Istanbul	PM_{10}		32	31
India			33.89	26
Wuhan			30.25	25
Tianjin			18.3	33
Iran			10	23

Table 2: Decrease and increase in air pollutants in Europe during the COVID-19 pandemic

City or country	Pollutants	Increased	Decreased	References
London			26	
Glasgow			25	
Belfast			30	
Birmingham			28	39
Manchester			28	
Newcastle	$PM_{2.5}$		29	
Liverpool			28	
Warsaw		12.4		37
Poland urban site			20	38
Poland a background site			23	
London		16		
Glasgow		5		
Belfast		8		
Birmingham	O_3	16		39
Manchester		12		
Newcastle		7		
Liverpool		12		
Metropolises in Spain			24	40
London		116		
Glasgow		117		
Belfast		168		
Birmingham	SO_2	130		39
Manchester		116		
Newcastle		135		
Liverpool		142		
Warsaw		190.8		37
metropolises in Spain	NO_2		51	40
Italy (urban background sites)			30	44

City or country	Pollutants	Increased	Decreased	References
Italy (regional background sites)			40	
Poland (urban site)			20	[38]
Poland (background site)			18	
Portugal			41	[43]
Greece			11	[42]
London			36	
Glasgow			44	
Belfast			41	[39]
Birmingham	AOD		39	
Manchester			37	
Newcastle			39	
Liverpool			38	
Uherske Hradiste			11	[41]
Warsaw			19.6	[37]
metropolises in Spain			27	[40]
Portugal			18	[43]
Warsaw	PM_{10}		9.9	[37]
Uherske Hradiste			9.23	[41]
France			8.3	[55]
Poland			15	[38]

Table 3: Decrease and increase in air pollutants in North and South America and Oceania during the COVID-19 period

City or country	Pollutants	Increased	Decreased	References
California			31	[45]
Toronto, Montreal, Vancouver and Calgary			17-6	[46]
7 states and capital of America	$PM_{2.5}$		12.8	[48]
Mexico			44.52	[17]
Chile			11	[47]
California			49	[45]
Canada	CO		20	[50]
Mexico			46.20	[17]
Chile			13	[47]
California	O_3	14		[45]
Chile		63		[47]
Canada			20	[50]
California	NO_2		38	[45]
Argentina			30	[49]
Toronto, Montreal, Vancouver and Calgary			31-34	[46]
California		21		[45]
Mexico	PM_{10}		44.56	[17]
Argentina			44	[49]
Argentina	AOD		38-66	[49]
New Zealand	NO_2		48-54.5	[51]

Impact of pollutants and meteorological parameters on increasing mortality due to COVID-19 in the world

In nine cities of Saudi Arabia, there was no change in humidity, temperature and wind speed parameters before and after quarantine during the COVID-19 pandemic [32]. In 219 Chinese cities, the relationship between wind speed and corona virus was negative. In northern China, COVID-19 transmission increased by increasing ambient temperature. However, in southern China, COVID-19 transmission decreased by increasing ambient temperature [56]. There was a relationship between moisture and wind speed in Islamabad with COVID-19. In Lahore, there was a positive relationship between temperature and COVID-19 [57]. In Singapore, short-term exposure to higher concentrations of Pollutant Standard Index (PSI)

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and NO_2 was associated with a higher number of COVID-19 contamination cases, while short-term exposure to higher concentrations of PM_{10}, O_3, SO_2, CO, rainfall, and humidity was associated with a lower incidence of COVID-19 [58]. The incidence of COVID-19 is caused by climatic factors such as temperature, relative humidity, and wind speed, according to research conducted in five major Indian cities (Bangalore, Chennai, Delhi, Calcutta, and Mumbai). The frequency of COVID-19 and fatality during and after lockdown was highly linked to temperature. The concentration of $PM_{2.5}$, PM_{10}, CO and O_3 and air quality index (AQI) were also correlated with positive cases and deaths during lockdown [24]. In India, there was a strong association between COVID-19 mortality and PM_{10} [26]. Cities with poor air quality have also been associated with higher incidence and mortality of COVID-19 [59]. In Japan, COVID-19 did not significantly correlate with precipitation, wind speed, humidity, NO, NO_2, O_3, and $PM_{2.5}$. However, there is a significant relationship with the average temperature, minimum and maximum daily temperature, and sunny hours [60]. During the lockdown period in Moscow, the primary pollutants levels in the environment reduced from 30 to 50% along roads and in residential areas [61]. In the city of Lombardy, Italy, the decrease in temperature and increase in humidity have been associated with the increase in the incidence of COVID-19 and the resulting deaths [62]. In 36 Italian provinces, there was a strong relationship between PM_{10} and mortality. Moreover, a high correlation between PM_{10} and $PM_{2.5}$ was reported [1]. In Vento and Emilia Romania, there was also a positive and nonlinear relationship between the high level of NO_2 in the troposphere and the mortality rate of COVID-19 [63].

In Italy, cities with high wind speeds were found to have a lower number of people with COVID-19. This study showed that high concentrations of air pollutants, along with low wind speed, cause more viral particles in the air and indirect emission of COVID-19 [64]. In Taragona, there was a positive correlation between COVID-19 deaths and chronic exposure to PM_{10} and NO_2, but O_3 had a negative relationship [65]. In Germany, temperature is the only climatic index that has significantly affected the COVID-19 epidemic in this country [66]. In France, a direct relationship between air pollution and mortality caused by COVID-19 was reported [67]. In Uherske Hradiste, a total of 2300 deaths due to reduced exposure to $PM_{2.5}$ and 1200 deaths due to decreased exposure to NO_2 have been estimated [41]. In Mexico, a positive relationship between $PM_{2.5}$ and the probability of death of a person after COVID-19 was found. This relationship increases with age, especially for people aged 40 years [16]. A study conducted in 422 cities in the US showed that long-term exposure to air pollution, in addition to the negative impact on the respiratory system and increasing the risk of death, also affects the sensitivity and severity of COVID-19 [68]. In the US, a decrease in $PM_{2.5}$ during the corona period has reduced air pollution-related deaths [48]. In Chile, the concentration of NO_2 and CO showed a strong association with COVID-19, while SO_2 had no significant relationship [69]. Lima is the largest city with air pollution problems in Latin America. In this city, there was a significant correlation between NO_2 and the prevalence of COVID-19. Industrial areas with NO_2 above 26 grams per cubic metrology can increase COVID-19 [70]. Table 4 shows the impact of pollutants on the increase in deaths caused by COVID-19 in the world.

Table 4: Impact of pollutants on the increase in mortality caused by COVID 19 in the world

Continent	City or country	The rate of increase of pollutants	Increased morbidity	Decreased morbidity	Increased mortality	References
Asia	China	$10\ \mu g/m^3\ NO_2$	37.8%			71
		$10\ \mu g/m^3\ PM_{2.5}$	32.3%			
		$10\ \mu g/m^3\ PM_{10}$	14.2%			
	Iran	$1\ \mu g/m^3\ NO_2$			2.7%	72
	China	Per 10 unit AQI	5-7%			56
	Dhaka	$1\ \mu g/m^3\ O_3$		2.9%		27
		$1\ \mu g/m^3\ CO$		53.9%		
Europe	Italy	$10\ \mu g/m^3\ PM_{2.5}$	58%			62
		$10\ \mu g/m^3 PM_{10}$	34%			
		$10\ \mu g/m^3 PM_{2.5}$			23%	73
	Northern Italy	$1\ \mu g/m^3 PM$			9%	
	Catalonia	$1\ \mu g/m^3 NO_2$	2.7%			74
	Spain	$1 \mu g/m^3 PM_{10}$	3%			
	England	$1\ \mu g/m^3 PM_{2.5}$			1.4%	75
		$1\ \mu g/m^3 NO_2$			0.5%	
	Netherlands	$1\ \mu g/m^3 PM_{2.5}$	9.4%		2.3%	55
	England	$1 \mu g/m^3 PM_{2.5}$	12%			76
	Germany	$1\ \mu g/m^3 NO_2$	5.58%			77
	Germany	$1\ \mu g/m^3 PM_{2.5}$	199.46 morbidity per 100,000 inhabitants			78
		$1 \mu g/m^3 PM_{10}$	52.38 morbidity per 100,000 inhabitants			
North and South America	America	$1\ \mu g/m^3\ PM_{2.5}$			8%	79
	America	$1\ \mu g/m^3\ PM_{2.5}$	26%		34%	80
	Los Angeles	8.7 ppb (IQR) in mean annual NO_2	31%			81

Discussion

COVID-19 lockdown in Saudi Arabia significantly reduced air pollution through traffic control, industry activities, and environmentally friendly transportation programs. Despite the decrease in concentrations of pollutants during lockdown concentrations, concentrations of CO, PM_{10}, SO_2, NO_2, and O_3 were still higher than the 24-hour standard and the annual WHO limit [32]. The major cause for the extraordinary improvement in air quality in Wuhan was climatic elements such as wind direction, wind speed, temperature, and humidity[25]. In another study, the optimal wind direction was found to reduce $PM_{2.5}$ in Wuhan. Decreased NO emission also led to an increase in O_3 during lockdown [13]. In Beijing, high concentration of $PM_{2.5}$ during the lockdown period was caused by the smoke from industry emissions, non-stop fireworks, and adverse weather conditions [82]. In Tianjin, $PM_{2.5}$, the slight increase of O_3, and reducing NO_2 indicates that the synergistic control of NOx and VOC should be considered. The humidity of the air in the lockdown period was abnormal and may be due to an increase in nitrate in this period. The reduction of SO_2 could be due to the reduction of wind speed and consequently less pollution. The reduction of NO_2 and CO might be due to the reduction of pollutant emissions from vehicles [33]. In Xian, the decrease in the concentration of suspended particles was due to restriction in human activity [54]. During lockdown, high concentrations of $PM_{2.5}$ in Karachi could be attributed to rapid population growth and business activity, while in Peshawar, the main source of $PM_{2.5}$ particles was brick kilns operating around the city 24 hours a day [11]. In Mumbai and New Delhi, O_3 was increasing due to reduced nitrogen oxide. Before the lockdown period, the AQI was at unhealthy and very unhealthy levels, but after the lockdown, it has

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been at a healthy level. Therefore, the lockdown had no long-term impact on air quality in Delhi and Mumbai [29]. In India, except for coal mine areas, air quality improved during lockdown [59]. In South Korea, air pollution reduction was probably due to the reduction of domestic sources and transnational pollutants after the start of the COVID-19 [28]. Contrary to most studies in Taiwan, increasing pollutants on working days was observed by the emergence of COVID-19. It was due to the fact that during the COVID-19 epidemic, using metro and bicycles decreased by 8 to 18%, while the use of cars and motorcycles increased by 11 to 21% in working days [34]. In Iran, a significant increase in the concentration of O_3 could be due to the reduction of PM, NO_2, and VOC. However, following the lockdown, it was discovered that the concentration of all pollutants, especially O_3, increased to some extent compared to the 5-year normal limit. The abolition of the traffic management plan and the increased usage of personal automobiles to preserve social distance were the key reasons for this increase. Starting different jobs ahead of time due to economic problems was effective [15]. Compared to 2019, the mean concentrations of O_3, NO_2, SO_2, CO, PM_{10}, and $PM_{2.5}$ increased during the COVID-19 in Tehran. It is due to the reduction of greenhouse gas emissions from traffic as a result of lockdown. The concentration of other pollutants has changed slightly, indicating that lockdown does not lead to severe changes in greenhouse gas emissions from resources [30]. In Iran, the mean concentration of contaminants in the second wave of the disease indicates that air pollution increased by resolving transport restrictions [23]. In the lockdown period, a significant reduction in NO_2 concentration was observed due to the reduction of motor vehicles and road traffic in many major cities in Poland. Furthermore, except for SO_2, the concentration of $PM_{2.5}$, PM_{10}, and NO_2 decreased, since some factories were working during the lockdown period. The main reason for decreasing $PM_{2.5}$, PM_{10}, and NO_2 was a significant reduction in international and local transportation, reducing crude oil consumption and coal, which has had a great impact on air quality [37]. The implementation of the lockdown led to an increase in the highest O_3 concentrations at both the urban and regional background sites resulting from reduced titration of O_3 by NO [44]. In 10 Spanish metropolis, $PM_{2.5}$ decreased due to increased traffic, increasing the fuel caused by burning biomass and household fuels, and weather conditions[40]. There was no significant decrease in air pollution in Greece. This might be related to the ruling conditions during the period of clustering of the corona virus, including meteorological conditions [83]. In another study in Greece, a reduction in NO_2 was further attributed to a reduction in vehicle emissions [42]. NO_x reduced in the Ostrava region due to traffic loss during lockdown. $PM_{2.5}$ contamination analysis showed that home heating is the main source of $PM_{2.5}$ in the region. The highest decrease in $PM_{2.5}$ concentration at Ostrava Českobratrská traffic station was due to vehicle traffic reduction [84]. In Hungary, 20 to 50% reduction of road traffic decreased NOx and increased O_3 and PM_{10} during lockdown [85]. New York has experienced a sharp decline in air pollution in during the COVID-19, but this decline was high in exchange for social and economic costs [86]. Unstable economic growth has increased the emission of pollutants ($PM_{2.5}$ and NO_2) in New York [87]. Increasing PM_{10} in California can be related to the growing increase in the fires around California [45]. In Phoenix, the lack of CO and NO_2 concentrations and the dramatic decrease in PM_{10} indicate that reduced travel did not reduce emissions, since people were still traveling home on local roads [88]. In Chile, an increase in the concentration of O_3 can be explained by considering complex atmospheric photochemical reactions including a mixture of VOC and NOx. The reduction of NOx increases the OH radicals that react with VOC and produces more O_3. NOx showed the highest decrease among all the studied pollutants that could be related to traffic loss [47]. Also, $PM_{2.5}$ in the open space caused by wood heating increased in prosperous areas[89]. In Mexico, a low-traffic monitoring station has had the highest reduction in pollutants [17]. COVID-19 lockdown reduced the level of traffic-related pollutants (NO_2, $PM_{2.5}$, and CO) and improved air quality in Morocco. This unique scenario might be due to the reduction of transnational pollution as a result of neighboring nations' lockdown measures [53]. Given that more than 900 million people in Africa rely on air-polluting energy sources such as domestic appliances, white oil, and coal, CO levels have been minimally reduced. Millions in Africa live in small houses with inappropriate building materials, which can increase air pollution [90]. NO_2 reduction in New Zealand can be related to removing greenhouse gas emissions [51].

Conclusion

Based on global studies, ambient air quality was significantly affected by the prevalence of COVID-19. In the lockdown period, the reduction of most air pollutants except O_3 was observed in many countries. But, after restarting work activities the pollutants concentrations increased again.

Therefore, policies used during lockdown period including traffic control, reduced industrial activity, transport constraints, reduction of polluted emissions, and restrictions in human activities can lead to improvement of air quality. Laws enforced during lockdown can be introduced as an appropriate option in resource planning and intervention policies to reduce air pollution. There is also a significant relationship between $PM_{2.5}$, PM_{10}, and NO_2 and the risk of COVID-19 incidence and death, indicating that air pollution exacerbates the disease's prevalence and fatality. As a result, decreasing air pollution is of importance in reducing the pandemic. The findings of this study may be relevant to public health policymakers and decision-makers seeking to reduce COVID-19 prevalence.

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Conflict of interest

The authors declare that they have no conflict of interest.

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