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Original article

Impact of sandstorm on environmental pollutants PM2.5, carbon monoxide, nitrogen dioxide, ozone, and SARS-CoV-2 morbidity and mortality in kuwait

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ABSTRACT

Objectives: Sandstorms are natural climate calamities causing severe weather changes and health problems. The sandstorm allied issues are of significant apprehension worldwide, mainly in the present pandemic. This study aims to examine the "sandstorm impact on environmental pollution particulate matter ($PM_{2.5}$), carbon monoxide (CO), ozone (O3), and daily new cases and deaths due to Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)" in Kuwait.

Methods: The two incidences of sandstorms occurred in Kuwait, dated 13 March 2021 and 13 June 2021. The data on "$PM_{2.5}$, CO, NO2, and O3, and SARS-CoV-2 cases and deaths" were documented three weeks before and after both incidences of the sandstorm. For the first incidence, the data was recorded from 18 February to 12 March 2021; and from 13 March to 2 April 2021. However, for the second incidence of sandstorms, data were documented from 23 May to 12 June 2021; and from 13 June to 3 July 2021. The daily "$PM_{2.5}$, CO, NO2, and O3 levels" were recorded from "Air Quality Index-AQI, metrological web, and data on COVID-19 daily cases and deaths were recorded from the World Health Organization".

Results: After the first and second sandstorm incidence, the air contaminants $PM_{2.5}$ was increased by 26.62%, CO 22.08%, and O3 increased 18.10% compared to before the sandstorm. SARS-CoV-2 cases were markedly amplified by (21.25%), and deaths were increased by (61.32%) after the sandstorm.

Conclusions: Sandstorm events increase air pollutants PM2.5, CO, and O3 levels, and these pollutants increase the SARS-COV-2 daily cases and deaths in Kuwait. The findings have a meaningful memorandum to healthcare representatives to advise the public about the health hazards of the sandstorm and its linkage with SARS-CoV-2 cases and deaths.

1. Introduction

Sandstorms (dust storms) are the earth's ecological events that repeatedly occur in various counties worldwide. Sandstorms sporadically happen with high breezes that take the soil particles from the arid zones around the globe (Meo et al., 2013). In the Middle East region, sandstorm events have been more intense and frequent in recent years, impacting air quality, climate conditions, and human health (Meo et al., 2021a; Vijayakumar et al., 2021). Dust storms frequently occur in Middle East countries (Reche et al., 2009). The sandstorms contribute about two billion tons of dust per annum to the worldwide environment (Gemma, 2021). The sandstorms primarily arise close to the ground surfaces. However, the fine dust pollutants may rise a few kilometers high into the environment, wherever heavy winds convey them long distances. The sandstorms may travel thousands of kilometers from the primary place, pass over towns and oceans, and deposit materials far from their primary source areas (Goudie and Middleton, 2001). It has also been reported that the emitted soil dust is highly variable in composition, space, and time and is transported and distributed across the planet (Querol et al., 2019).

The sandstorm contains plentiful air pollutants, particulate matter (PM), dust, and microorganisms and carries these pollutants around the landmasses (Goudie and Middleton, 2001; Ho

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et al., 2005). It facilitates the pollutant's far-reaching dispersal of dust allied biological elements and promotes the existence of bacteria fungiform spores (Morris et al., 2011). The composition of sandstorm pollutants is based on the source areas and pollutants trapped during the storm and its atmospheric transport. The dust storms also contain fungi, bacteria, and virus molecules (Griffin, 2007; Prospero et al., 2005). The microorganisms exist after being transported thousands of miles (Kellogg and Griffin 2006; Griffin, 2007). After traveling for long periods and from region to region, these microorganisms and air pollutants fall towards the earth (Yassin and Almouqatea, 2010). The sandstorm allied air pollutants and microorganisms speedily affect the exposed population (Meo et al., 2021b). The "SARS-CoV-2," commonly called the COVID-19 pandemic, has developed a hostile ailment with massive health and financial losses worldwide (Meo et al., 2021b). According to (the World Health Organization WHO report) worldwide on January 7, 2022, the SARS-CoV-2 confirmed cases are 298, 915, 721, and deaths are 5,469 303 (1.82%). However, the number of confirmed cases dated January 7, 2022, in Kuwait is 423,042; deaths are 2,469 (0.58%) in Kuwait.

The literature established a linkage between environmental pollution and the growing occurrence and mortality of the COVID-19 pandemic (Meo et al., 2021c,d; Shakil et al., 2020). During this pandemic, global concerns greatly increase the possible adverse effects of air pollution and SARS-CoV-2 infection, as dust events frequently occur in the Middle East. This innovative study aims to explore the relationship of sandstorm allied pollutants "Particulate matter ($PM_{2.5}$ μm), carbon monoxide (CO), ozone (O3), and nitrogen dioxide (NO2), with daily new cases and deaths due to SARS-COV 2 infection" in Kuwait.

2. Subjects and Methods

2.1. Study settings and data collection:

In this cross-sectional study, the data was based on the two different incidences of sandstorms during different periods in Kuwait, dated March 13, 2021, and June 13, 2021. These two events of sandstorms caused air pollution allied concerns in the entire community in the country. The air pollutants "$PM_{2.5}$, CO, NO2, and O3, and SARS-CoV-2 cases and deaths" were documented from 18 February 2021 to 12 March 2021 and from 13 March to 2 April 2021. The second incidence of the sandstorm occurred on June 13, 2021. The environmental pollutants "$PM_{2.5}$, CO, NO2, and O3 and SARS-CoV-2 cases and deaths" were documented 21 days before and after the sandstorm, from May 23, 2021, to June 12, 2021; and from June 13, 2021, to July 3, 2021.

2.2. Selection of study period before and after the sandstorm:

The study period of 21 days, three weeks before and after the sandstorm, was selected based on the incubation period of the SARS-CoV-2. The incubation period is about 5–6 days; it may take 14 days. The literature acknowledges that the incubation period can be around 19 days; therefore, the data on "air pollutants $PM_{2.5}$, CO, NO2, and O3, and SARS-CoV-2 cases and deaths were documented three weeks before and after both incidences of the sandstorm". To confirm the data, the co-investigators rechecked the entire data. The daily "PM2.5, CO, NO2, and O3 levels were recorded from the metrological websites (Air quality Index (AQI) (2021))", and COVID-19 day-to-day cases and deaths were recorded from the (World Health Organization, 2022), website.

2.3. Statistical analysis:

The data were evaluated using the "SPSS software version 22.0 for Microsoft Windows". The "mean values with standard error of the mean (SEM) before and after the sandstorm were calculated using a paired sample *t*-test. Linear and multiple regression analyses were performed to predict the effect of the pollutants $PM_{2.5}$, CO, O3, and NO2 on the number of SARS-CoV-2 daily cases and deaths. Spearman Rho correlation was also performed to determine the relationship, strength, and direction of the association between the air pollutants and SARS-CoV02 cases and deaths". A p-value < 0.05 was considered significant.

2.4. Ethical Statement:

The "data on the daily new cases and deaths due to COVID-2019 pandemic, particulate matter $PM_{2.5}$, CO, NO2, and O3 related information were obtained from the publicly available databases; hence ethical approval was not required".

3. Results

The data on environmental pollutants "$PM_{2.5}$, CO, NO2, and O3, and SARS-CoV-2 cases and deaths" were investigated 21 days before and after the sandstorm. The pollutants $PM_{2.5}$, 96.14 ± 5.03–121.73 ± 7.97 (p = 0.002); CO 14.12 ± 0.62–17.32 ± 1.43 (p = 0.008); and O3, 13.81 ± 0.92–16.31 ± 0.68 (p = 0.001) were expressively amplified 21 days after the onset of the sandstorm compared to 21 days before the onset of sandstorm during both sandstorm events. Moreover, there was a significant increase in SARS-CoV-2 cases 1230.88 ± 37.21–1492.50 (p = 0.0001), and daily deaths 5.21 ± 0.31–8.40 ± 0.51 (p = 0.0001) (Table 1, Fig. 1). Furthermore, it was also identified that after both incidences of the sandstorm, the environmental pollutants significantly increased $PM_{2.5}$ (26.62%), CO (22.08%), and O3 (18.10%). Moreover, the number of SARS-CoV-2 cases increased by (21.25%) and deaths (by 61.32%). The sandstorm amplified the air "pollutants, $PM_{2.5}$, CO, O3, which were linked with an increase in SARS-COV-2 cases and deaths" (Table 1).

Table 2 reveals the Poisson regression analysis, the definite dependent variable based on before and after the events of the sandstorm. It predicts establishing the linkage between pollutants and SARS-CoV-2 cases and deaths. The results demonstrate that an upsurge in "$PM_{2.5}$, CO, NO2, and O3 was related to a substantial increase in SARAS-CoV-2 cases (p = 0.0001) (Table 2). It was also identified that an increase in O3 was also linked to increased SARS-CoV02 deaths (p = 0.003). However, there was no association between $PM_{2.5}$, CO, and NO2 with SARS-CoV02 death (Table 2). The results further depicted that the SARS-CoV-2 cases were 1210.54 ± 1467.83 (p = 0.0001), and deaths were 5.12 ± 8.26 (p = 0.001) were significantly increased after the sandstorm compared to before the sandstorm as per 100,000 population (Fig. 2).

The results show the trend three weeks before and after both the events of the sandstorm. The results further depicted that linear trend of daily cases and deaths was inclined upwards after the sandstorm. The findings were homogenous during both the events of the sandstorm (Figs. 3, 4).

4. Discussion

Sandstorms frequently occur in non-green, arid, and semi-arid regions and surrounding areas. These metrological events swiftly change the weather conditions, climate, and biogeochemical cycling, disrupting commercial affairs and community well-being (Choobari et al., 2014; Mahowald et al., 2014). This study investi-

Table 1
Comparison between PM 2.5, CO, NO2, O3, SARS-CoV-2 daily cases and deaths before and after the events of Sandstrom.

Parameters	Before Sandstorm	After Sandstorm	Percentage Increase %	Significance level
Particulate matter ($PM_{2.5}$) ppm	96.14 ± 5.03	121.73 ± 7.97	26.62%	0.002*
Carbon Monoxide (CO) ppm	14.12 ± 0.62	17.23 ± 1.43	22.08%	0.008*
Nitrogen Dioxide (NO2) DU	21.26 ± 1.24	18.61 ± 1.24	−12.42%	0.135
Ozone (O3) ppm	13.81 ± 0.92	16.31 ± 0.68	18.10%	0.001*
SARS-CoV-2 Cases	1230.88 ± 37.21	1492.50 ± 35.59	21.25%	0.0001*
SARS-CoV-2 Deaths	5.21 ± 0.31	8.40 ± 0.51	61.32%	0.0001*

Note: Environmental pollutants, SARS-CoV-2 cases, and deaths are presented daily basis before and after the two events of the sandstorm.

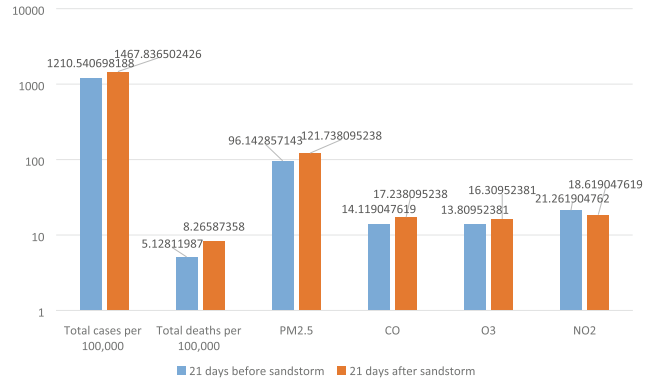

Fig. 1. PM 2.5, CO, NO2, O3, SARS-CoV-2 daily cases and deaths before and after the Sandstrom.

gates the impact of a "sandstorm on air pollutants PM 2.5, CO, O3, NO2, and SARS-CoV-2 daily cases and deaths in Kuwait". The findings demonstrate that sandstorms significantly increased the "$PM_{2.5}$, CO, O3, and NO2 levels, which further increased the SARS-CoV-2 cases and deaths" in Kuwait, the capital of Kuwait.

The present pandemic has caused a highly unreceptive and startling condition; it impaired the health and monetary systems worldwide (Meo et al., 2021b). The studies show that air pollution facilitates the swift spread of SARS-CoV-2 from region to region (Gautam et al., 2021; Zheng et al., 2021) identified that exposure to "NO2, $PM_{2.5}$, and PM10" was linked to a rise of 37.8%, 32.3%, and 14.2% in SARS-CoV-2 cases, respectively. The authors also demonstrated that air pollution relates to SARS-COV-2 infection and high susceptibility to people.

(Zhu et al., 2020) also identified a relationship between "PM2.5, PM10, CO, O3" and SARS-CoV-2 illness. Similarly, (Coccia, 2021) performed a study in Italy and reported that approximately 75% of the people got the infection, and 81% of mortality. These cases and deaths were mainly reported in people who belong to industrial zones where air pollution was significantly high. Additionally, (Qaid et al., 2022) demonstrated that PM2.5 is associated with COVID-19 cases. Bashir et al. (2020) showed a similar association between pollutants and the outbreak of the disease. It was identified that "PM_{10}, $PM_{2.5}$, SO2, NO2, and CO were linked with the COVID-19 epidemic" in California. Chakrabarty et al. (2021) reported that air pollutants PM2.5 cause the public to be more vulnerable to disease in the USA. Harmoniously, (Paital and Agrawal, 2020) also reported the same conclusions associated with air pollution and increased risk of COVID-19 disease.

The science community conducted a few studies in various regions of the globe to explore the linkage between atmospheric pollution and the COVID-19 pandemic. Meo et al. (2021d) piloted a survey of the impact of "PM2.5, CO, and O3 on the incidence and mortality of SARS-COV-2 infection in California, USA". It was found that "PM2.5 and CO" were allied with more SARS-COV-2 cases and deaths in San Francisco. Another study steered by (Meo and colleagues, 2021d) reported that "PM2.5, CO, and O3" positively correlate with cases and deaths in London, UK. Similarly, this study found that after the sandstorm, SARS-CoV-2 cases were raised and allied with an increased CO, O3, and NO2. These recently published scientific studies offered a strong supposition that "air pollutants $PM_{2.5}$, CO, and O3 are connected with SARS-CoV-2 daily cases" and deaths.

The Gulf countries have taken immediate actions to minimize the spread of the present pandemic. Nevertheless, meteorological factors such as air pollution and sandstorm could increase the risk. The present study finding may educate the people about sandstorm hazards and its linkage with the COVID-19 pandemic. This study's verdicts may support the policymakers to minimize public activities during sandstorms. The current study results recognized some mechanisms for a better understanding the sandstorms and its augmented impact on SARS-COV-2cases and deaths. The virus can spread through fine and ultrafine particles on which the virus particles lie. Sandstorms get the surface particles and swiftly convey them over a long distance (Grousset et al., 2003). The contaminated particles, once in the air, can enter the respiratory system and cause lung infection and enhance SARS-CoV-2 cases. Air pollutants cause lung injury due to "oxidative stress, macrophage disfunction, and a disrupted epithelial barrier." These are the possible factors that can cause lung damage (Zhu et al., 2020; Coccia, 2021) and deaths in patients with SARS-CoV-2.

The spread of SARS-CoV-2 and air pollutants pathophysiological links could be further clarified by overexpression of an "angiotensin-converting enzyme 2 (ACE-2)" on the respiratory

Table 2
Poisson regression analysis of SARS-CoV-2 daily cases and death for $PM_{2.5}$, CO, O3, and NO2.

Parameters	Variable	B	Standard error	Exp (β)	p-value
Particulate matter (PM2.5) ppm	Cases	0.001	7.6357E-5	1.001	0.0001*
	Deaths	0.0003	0.0011	1.000	0.815
Carbon Monoxide (CO) ppm	Cases	0.017	0.0005	1.017	0.0001*
	Deaths	0.010	0.0070	1.010	0.144
Ozone (O3) ppm	Cases	0.008	0.0007	1.008	0.0001*
	Deaths	0.027	0.0093	1.028	0.003*
Nitrogen Dioxide (NO2) DU	Cases	0.002	0.0004	1.002	0.0001*
	Deaths	0.010	0.0059	1.010	0.100

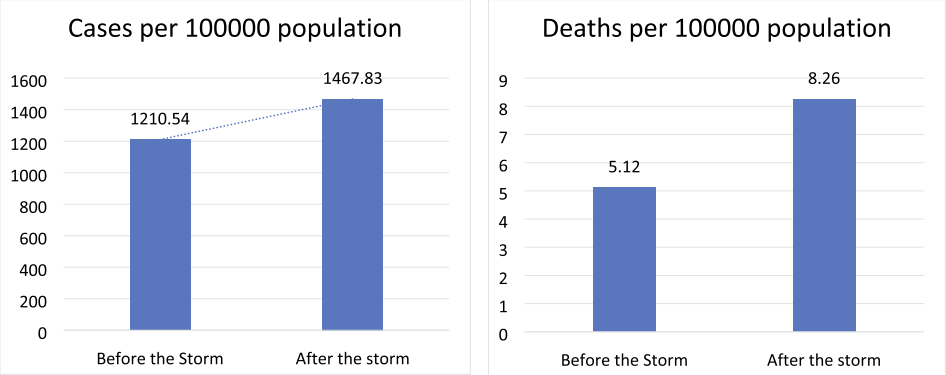

Fig. 2. SARS-CoV-2 cases and deaths per 100,000 population before and after the Sandstrom.

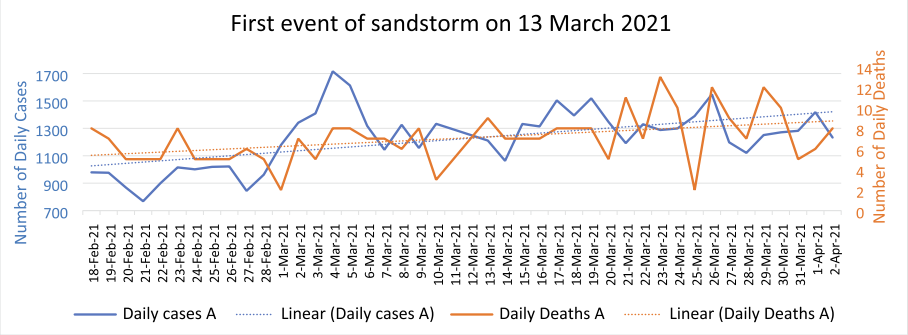

Fig. 3. SARS-CoV-2 daily cases and deaths during the first event before and after the Sandstrom.

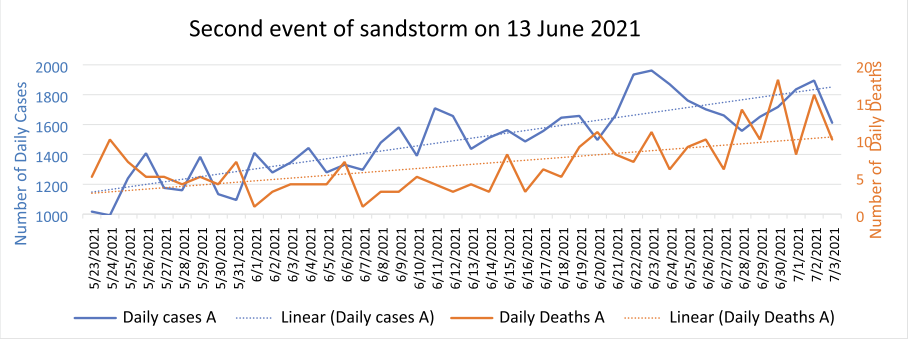

Fig. 4. SARS-CoV-2 daily cases and deaths during the second event before and after the Sandstrom.

epithelial cell. The transmission of SARS-CoV-2 is mainly due to "redox-active components of air pollutants, oxidative mechanisms, and ACE2 overexpression underlying air pollution-exacerbated SARS-CoV-2 transmission" (Lai et al., 2021). It has also been hypothesized that air pollutants $PM_{2.5}$ act as virus carriers, impair immunity, and cause the public more prone to pathogens and pandemics (Zhou et al., 2020). These evidence supports the hypothesis that air pollutants can significantly spread SARS-CoV-2 infection (Yao et al., 2020). These are the main mechanisms involved in sandstorm events, air pollutants, and increasing SARS-CoV-2 cases and deaths.

5. Study strengths and limitations

This novel study explores the impact of two different events of sandstorms on air pollutants, $PM_{2.5}$, CO, O3, and NO2, and SARS-CoV-2 daily cases and deaths in Kuwait. This study enhances the knowledge about the virus spread in the light of different air pollutants and events. This study has a limitation that the SARS-CoV-2 cases and deaths may be altered due to other factors, including gatherings, temperature, humidity, and other air pollutants such as PM10 and SO2.

6. Conclusions

Sandstorms markedly increased the air pollutants PM2.5, CO, and O3 levels, and these air pollutants are linked with increased incidence of SARS-COV-2 cases and deaths in Kuwait. The results are important message for the public, health authorities, and policymakers about the sandstorms and their relationship with environmental pollutants and rising cases and deaths due to SARS-CoV-2.

CRediT authorship contribution statement

Sultan Ayoub Meo: Project supervision, writing and editing. **Faris Jamal Almutairi:** Data collection, Entry, and analysis. **Abdulelah Adnan Abukhalaf:** Data collection, Entry, and analysis. **Adnan Mehmood Usmani:** Data collection, Entry, and analysis.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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