“Fortune amidst misfortune”: The impact of Covid-19 city lockdowns on air quality

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**ABSTRACT**

Air pollution is one of the major causes of health risks as it leads to widespread disease and death each year. Countries have invested heavily in fighting air pollution, arguably without convincing results. The outbreak of the highly infectious disease COVID-19 in December 2019 has been declared a pandemic and a worldwide health crisis by World Health Organization (WHO). Countries resorted to city lockdowns that sternly curtailed personal mobility and economic activities to control the spread of this deadly coronavirus disease. This paper examines the impact of Covid-19 city lockdowns on air quality. The researchers adopted a comprehensive interpretative document analysis for this study, which guided the careful but rigorous examination of air quality and coronavirus data. This method affirmed the authenticity of the information examined and interpreted in the US, Italy and China, the study areas. The study found that Covid-19 city lockdowns have contributed to a significant improvement in air quality within the first four months of the outbreak of Covid-19. National Aeronautics and Space Administration (NASA) had reported that NO₂ concentrations in the study areas had reduced significantly using evidence from their Sentinel-5P instrument. Air quality in Covid-19 cities’ lockdowns also improved because of the enforcement of other types of measures enacted to battle the virus. WHO still believes that the amount of NO₂ concentration in the atmosphere is still high for their standards and regulations. Based on this, the researchers recommend that governments and other stakeholders put in much effort in terms of legislation to “win the war” against air pollution.

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1. Introduction

In December 2019, a pandemic known as the coronavirus broke out in Wuhan-China (Xie & Chen, 2020; Zhu et al., 2020) and quickly spread worldwide. Coronavirus are a massive family of viruses that may cause infection in animals or humans. Pandemics are known to be diseases that spread through a large region, possibly an entire continent or even worldwide, affecting many people (Taubenberger & Morens, 2009). Several coronaviruses cause respiratory diseases in humans, including common cold to more severe diseases such as Severe Acute Respiratory Syndrome (SARS) (Wang et al., 2020). According to the WHO, 2020, the recently exposed coronavirus is the source of the deadly coronavirus disease named COVID-19.

Several researches reveal that the novel coronavirus is an acute respiratory disease affecting the lungs and respiratory system (Gautam & Trivedi, 2020; Chen et al., 2020). The pandemic spread fast such that four months after it broke out, 2,709,483 persons had been infected and about 190,861 persons had died out of this disease (WHO, 2020). There are three categories: heart diseases, old age, and one’s history of smoking, which are considered essential factors related to the development of the coronavirus in humans (Wu et al. 2020; Liu et al., 2020; Gautam and Trivedi 2020). The deadly coronavirus can quickly spread from persons to persons who have close contact with infected people (Cascella et al., 2020). Fortunately, the quick spread of the coronavirus can be controlled when people practice proper social distancing, personal hygiene, avoid visiting crowded places, among others (WHO, 2020; Bherwani et al., 2020; Gautam, 2020b).

The spread of Covid-19 in the first four (4) months dominated in countries that suffer more from air pollution issues (Bashir et al., 2020). Air pollution causes some severity of threatening diseases, causing people’s death (Kan et al., 2012). According to the WHO (2016), air pollution caused about 4.2 million premature death in
2016; among which 90% emerged from low-income countries. Persinger et al. (2002) add that the effect of being exposed to NO₂ for a long time will damage one’s lungs (epithelial cells) and respiratory functions. The primary sources of NO₂ in the atmosphere are fumes from transportation and power plants (He et al., 2020; Sharma et al., 2020). Jones et al., (2007) adds that in 1918 flu pandemic broke out in American cities due to the burning of more coal for electricity than cities that used less coal.

Coincidentally, the deadly coronavirus symptoms include intensified asthma, lung disease and irregular heartbeat due to prolonged exposure to toxic elements like NO₂ (Shin et al. 2020). More so, the coronavirus spread has been reported through the air in the form of aerosols and the influx of NO₂ causing widespread mortality (Gautam, 2020b; Muhammad et al., 2020). Gautam et al., (2020a) released a report that unraveled that 481 patients with background respiratory diseases passed away due to the coronavirus’s contraction. From the SARS outbreak in 2002 in China, researches (Brake et al., 2020; Zhao et al., 2016) confirmed that a lot of the SARS patients who were present in most air-polluted cities in China at the time were twice susceptible to passing away than those located in less air-polluted cities. The emergence of COVID-19 has placed a force majeure compelling a lot of countries to go under lockdown. As a result, there has been a swift improvement in air quality; something environmental debate did not see forthcoming (S. Gautam, 2020a). Figures 1, 2 and 3 illustrate that air pollution in the US, Italy and China reduced in the first half of the year (NASA, 2020), observing the assessed periods’ NO₂ concentration levels. The figures show the NO₂ concentration levels between January to April 2019 and 2020 concurrently.

Although several researches have explored air quality and air pollution issues, countries including United States (US), Italy and China have invested heavily in fighting air pollution (Vennemo et al., 2009; Melnick, 2010; Zattra, 2018) arguably without convincing results. This has been due to issues of non-compliance to air pollution regulations by citizens and exceptionalism to air pollution regulations enacted by the state (Laitos & Wolongevicz, 2015), among others. Additionally, with the remote and immediate causes of the coronavirus pandemic and its transmission through the air (Bherwani, Anjum et al., 2020), more theoretical and empirical researches are needed to ascertain the effects of the transmission reduction mechanisms on air quality. In this regard, the current study contributes to the literature by exploring the hypothesis that staying home to reduce the quick spread of the deadly Covid-19 has caused an improvement in air quality. Additionally, to the best of the authors’ knowledge, no study yet has altogether examined the influence of Covid-19 lockdowns on air quality in America (US), Europe (Italy) and Asia (China).

2. Literature review

Air pollution and its pollutants in the atmosphere, including NO₂, SO₂, and others, are vital information, primarily to decision-making in human health, environmental protection, agriculture, and climate change (Gautam, 2020a); thus, useful in assessing air quality management policies (Cristina et al., 2020). Observing the atmosphere has become essential since the outbreak of the Covid-19 as some
researchers have unraveled that these air pollutants aid in the quick spread of the virus (Dutheil et al., 2020; Gautam et al., 2020). Following the recent outbreak of the Covid-19, air quality management has become an essential issue to the government worldwide, especially researchers (Bashir et al., 2020; Cristina et al., 2020; Wang et al., 2020) have linked the Covid-19 to air quality. Table 1 presents various air pollutants and their observations in the study areas.

Since the outbreak of COVID-19 in Wuhan, the virus has spread worldwide and has been declared a pandemic by the WHO (Xie & Chen, 2020). Countries, including China, Italy, Spain, UK and the US have suffered from the COVID-19 pandemic as there have been high mortality ratios (Gautam, 2020b). However, researchers (Cristina et al., 2020; Onufrio, 2020) believe that the lockdown due to COVID-19 has caused an enormous improvement in the air quality during this period. Consequently, the lockdown of significant cities worldwide due to the quick spread of the Covid-19 has led to reducing air pollution, especially in areas like China, Italy and US (Calma, 2020a, 2020b). Based on the severity of the Covid-19 pandemic, countries have strengthened their existing environmental regulations and policies, especially those that have been lying idle for a long time (Xie & Chen, 2020).

Crespo Márquez and SIM Research Group (2020) state that evidence emerging from global statistics
unravel that polluted air has made COVID-19 more disastrous. Polluted air causes more death, according to the European Environment Agency (2005) than vehicle motor accidents. Generally, air pollution is a global canker and does not exempt developed countries such as Europe, where about 193,000 people died in 2012 from airborne particulate matter (Ortiz et al., 2017). Cohen et al. (2017) support the argument that 4.6 million people die yearly from diseases directly associated with air pollution. In a global health statistical survey, air pollution accounts for approximately 40% of respiratory infections and about 20% of other chronic heart diseases (Mehta et al., 2012). Although the outbreak of COVID-19 has caused a temporal improvement in the quality of air globally, health researchers (Dong et al., 2020; Rudan, 2020) explain that these health conditions do not disappear, so the patients who are suffering the severity of these conditions will still face the combination of their conditions and, potentially, COVID-19. Poor air quality has also caused significant economic loss and poor health results (Xu et al., 2015; Chen et al., 2016).

NO$_2$ is one of the common Green House Gases (GHGs) associated with air pollution and causes high mortality (He et al., 2020a,b). Interestingly, NASA (2020) reported that NO$_2$ reduction was first found in Wuhan, the origin of the COVID-19 pandemic before it eventually spread globally. In China, NO$_2$ emissions were reduced by 30% (NASA, 2020) when the COVID-19 broke out earlier. Also, Carbon dioxide (CO$_2$) is another GHG that is associated with air pollution (Hanaoka & Masui, 2020), which also decreased by 25% in China and by 6% worldwide.

The quick shift in air pollution also represents the largest-scale experiment in terms of industrial emissions. Furthermore, the Sentinel-5P satellite imagery reflects that over several weeks of lockdown in countries worldwide, there has been a drastic reduction in NO$_2$ seen from busy cities and industrial firms across Europe and Asia predominantly. The emission of NO$_2$ is discharged from car engines, power plants and some heavy industrial machinery. WHO (2020) continues to describe NO$_2$ as a very harmful gas that speeds up pathogens’ growth in addition to other pollutants that aid in the spread of the recent COVID-19.

According to Panagi et al. (2020), when air pollution is reduced drastically, there could be many such as the reduction in respiratory and other related diseases. There could be a significant boost in agriculture to a more considerable extent because air pollution affects plants’ proper growth (Sharma et al., 2017). On the European frontier, especially in Italy, air pollution cases from smoke, trapped from heavy industrial operation against the Alps at the end of the Po Valley have been recorded, making it one of the hotspot zones of air pollution in Europe (Pirovano et al., 2015). However, following the recent COVID-19 lockdown across Europe, NO$_2$ levels in Milan, Italy, have dropped by about 40% (Watts & Kommenda, 2020). Although the considerable drop has been recorded in previous years; they barely last for a day due to weather conditions (Watts & Kommenda, 2020), making this no emission record unprecedented. Cristina et al. (2020) further add that COVID-19, which has led to a lockdown of cities in Italy, has caused a hefty

### Table 1. Presents various air pollutants and their observations in the study areas

| Study area | Pollutant types | Key observations | Author |
|------------|----------------|------------------|--------|
| China      | Sulfur Dioxide (SO$_2$), Nitrogen Dioxide (NO$_2$), Carbon monoxide (CO), Particulate Matter (PM2.5) | 1. It is observed that the new types of cars produced have lower emission standards, making them produce and emit more of these into the atmosphere. 2. Due to the rapid growth and increased demand for transportation, food and other consumer goods, there are heavy industries established to meet these demands and as such more of these pollutants are released daily 3. These air pollutants are much seen in areas that are near cities than in remote areas | Xue et al. (2020) |
| US         | Ground-level ozone, Carbon monoxide (CO), Sulfur Dioxide (SO$_2$), Nitrogen dioxide (NO$_2$), Particulate Matter (PM2.5/10), lead | 1. These air pollutants affect people’s health and are more severe at sources that are near industrial cities and roadways 2. There has been an increased demand for heavy industrial machinery. These heavy industrial machineries are known to contribute heavily to air pollutant emission | United States Environmental Protection Agency (2018). |
| Italy      | Sulfur dioxide (SO$_2$), nitrogen dioxide (NO$_2$), carbon monoxide (CO), Particulate Matter (PM2.5/10) | Exposure to these pollutants usually is higher in cities than those in the countryside. This is because in the cities the issues of traffic are high, the use of power generators and domestic heating systems are intense | Battista et al. (2018) |

Authors Own Construct, 2020.
3. Materials and methods

A comprehensive literature and policy review-based approach was adopted to help achieve this paper’s primary goal; hence, an extensive review was conducted to identify substantial works published (Creswell & Zhang, 2009) to date concerning air pollution, air quality and the coronavirus pandemic. A range of online scholarly databases, search engines and websites of recognized international and national organizations and publishers was searched to spot the substantial works in the area. The researchers carefully examined the documents to understand their contents (Tuffour, 2017). Having the paper’s primary aim in mind, the researchers summarized the main ideas of the documents gathered (van Hoek & Mary, 2016). Furthermore, the main ideas were grouped into themes and were given a detailed understanding of the secondary data examined (Tuffour, 2017).

The researchers collected local governments’ lockdwoninformation on the Covid-19 pandemic city lockdown from various news media and government announcements. The researchers determined the study areas as locked down when the following three actions were all enforced: (1) ban of unnecessary commercial activities for people’s daily lives, (2) ban of any type of gathering by residents, (3) limitations on private (vehicles) and public transportation.

Finally, the facts from the examined documents were rigorously evaluated and presented in a cogent write-up to reflect how Covid-19 lockdowns affect air quality in US, Italy and China. The study was focused on US, Italy and China because these countries experienced an exponential increase in the Covid-19 outbreak, which compelled these countries’ governments to lockdown their cities as a countermeasure to decrease the virus’s rapid spread (Chen et al., 2020). In these lockdown cities, people were forced to stay home while transportation, heavy commercial and industrial activities were banned. These countries were also considered because they suffer from severe air pollution and related problems (Kassebaum et al., 2014). Some estimates suggest that air pollution is associated with an annual loss of nearly 25 million healthy life years.

This paper’s findings were through the interpretative document analysis that guided the careful but rigorous examination of air quality and coronavirus. This analysis method affirmed the credibility and authenticity of the information examined and interpreted (Heffernan, 2013). More so, the documents are stable, “non-reactive” data sources, meaning that the researchers had the opportunity to read and review the documents multiple times and remained unchanged by the researchers’ influence (Bowen, 2009, p. 31).

4. Results

Figure 1 gives a visual comparison between air pollution concentrations for China in 2019 and during the COVID-19 period. A significant reduction is seen in NO₂. NASA collected air quality data by using the Sentinel—5P satellite during COVID-19 lockdowns. The result in China showed a 30% reduction in NO₂ concentration in the atmosphere which indicate a significant change in the level of NO₂ identified due to COVID-19.

Figure 2 also provides a visual comparison between Italy’s historical and current air pollution concentrations during the Covid-19 period and the same period in 2019. Measurements of NO₂ reveal a decline in concentrations.

Figure 3 gives a visual comparison between air pollution concentrations for US in 2019 and during the COVID-19 period. A significant reduction is seen in NO₂ concentration. From NASA’s the data collection using the Sentinel-5P satellite the present findings show that air pollution has declined across the US during the COVID-19 pandemic, including a 25.5% reduction in NO₂.

5. Discussions and implications

The current Covid-19 pandemic is seen as “a fortune amidst misfortunes,” especially in the areas relating to ozone depletion and air pollution. The Covid-19 pandemic has caused industrial activities for major countries like China, Italy and the US to be shut down. Many flights and vehicular schedules have been canceled, implying a sharp slash of greenhouse gas emissions and air pollution worldwide. This consequently suggests that we might breathe in low carbon dioxide. The decreases in NO₂ are associated with less concentration in the operation of transportation and industrial
activities. During the Covid-19 lockdown, due to limited transportation and industrial output, air pollution is significantly reduced (Wang et al. 2020).

Air quality during the Covid-19 pandemic has impacted global health significantly. Pollutants such as NO$_2$ and others like PM2.5, resulting in various health damages such as respiratory diseases, cardiovascular diseases, and mortality (Rudan, 2020), have been significantly reduced. As indicated in Figures 1, 2 and 3, there has been a considerable fall in NO$_2$ concentrations. As air pollution is seen to affect morbidity and productivity, the oblique benefits could be even more significant if such improvement could sustained (Zhang, 2020). The improved air quality induced by the counter COVID-19 measures could avert 24,000 to 36,000 premature deaths every month (Gupta et al., 2020).

The study outcomes also indicate improved air quality quickly, reducing NO$_2$ (Wang and Su 2020). This is very helpful and useful for environmental regulatory agencies, demonstrating that reducing air pollution at the source can improve air quality. Especially in areas that went on early lockdown like China, Italy and US (Berman & Ebisu, 2020; Bherwani, Nair et al., 2020), it affirms the reduction in NO$_2$ and PM2.5 in areas that are going on early lockdowns like China, Italy and US (Pei et al., 2020). For instance, during China’s lockdown, they experienced a 20% reduction in NO2 concentration than in previous years (Berman et al., 2020).

This study of Covid-19 and air quality has some implications on policies. To begin with, there is a welfare policy implication of Covid-19 city lockdown. Based on the earlier discussions, it has been unraveled that Covid-19 city lockdown has considerably improved air quality, which is vital for assessing the benefit of such lockdowns. WHO (2020) has added that about 7 million deaths are linked to air pollution each year globally. Under this study, the countries US, China and Italy record high mortality rates due to high air pollution (Cao et al., 2011). Furthermore, many studies on air pollution (Bherwani, Nair et al., 2020; You 2013) significantly affect people’s health outcomes, such as life expectancy and mortality. Therefore, it is evident that air pollution has levied a substantial problem, and the possible health benefits derived from the improvement in air quality following the COVID-19 pandemic could be substantial.

More so, as it has been established, Covid-19 city lockdowns have significantly reduce air pollution levels. Comparing with other air pollution regulations implemented in these countries, there are other ways to improve air quality at a moderate cost (Song et al., 2017). The restrictions on gasoline fuels effectively reduce some harmful GHG like SO$_2$, improving air quality. Hence, it implies that covid-19 city lockdown is not the only means to improve air quality but has only contributed to improving air quality.

Although air quality has improved during this Covid-19 city lockdown, there has not been a complete end to air pollution. Other discussions still have it that air pollution is still on the rise despite the Covid-19 city lockdown. The NO$_2$ concentration levels during these Covid-19 city lockdowns are still seen to be more than what WHO considers very safe (Pei et al., 2020). This implies that other sources of pollutants affect air pollution in this Covid-19 city lockdown period although almost all business, industrial and transportation activities were banned during the lockdown periods. For example, in China, the government uses a coal-fired heating system during winter, which emits harmful pollutants into the atmosphere affecting air quality (Quadrelli & Peterson, 2007). This means that even during the Covid-19 city lockdown, there is still air pollution. Hence, governments will have to incur extra costs to reduce pollution emanating from coal heating to improve air quality.

6. Conclusion

Although China, Italy, and the US have enacted policies and laws to battle the “wars of air pollution,” they had not won the fight against air pollution. It is interesting to note that city lockdown due to Covid-19 has helped in the battle against air pollution. The decrease in air pollution due to Covid-19 city lockdown is a temporal phenomenon as touted by many researchers (Berman & Ebisu, 2020; S. Gautam, 2020a; P. Wang et al., 2020) and can only serve as a benchmark for government to review their approach to battling air pollution. The Covid-19 pandemic should aid governments to reflect on how things can be done differently after the pandemic, because Covid-19 is a continuing pandemic and currently does not look like ending. However, the study confirmed that this city lockdown due to COVID-19 has greatly reduced air pollution. This implies that as countries recover from this Covid-19 pandemic and resume their production, air quality improvement would be short-lived. Also, as cities on lockdown lift, such restrictions on public transport and flights indicate that air pollution reduction has been temporal. This is to encourage researchers, government, policymakers and all stakeholders to make judicious use of the available resources drawing a clue from the Covid-19 city lockdown and the existing enacted
air pollution laws to maintain the environment quality when Covid-19 pandemic cases.

The spread of the Covid-19 pandemic has reached almost all the global borders, and many countries have adopted the city lockdown approach. This means that air quality has improved globally. Other researches in other countries that went on lockdown due to Covid-19 show that there have been an improvement in air quality. Nonetheless, amidst all the contributions, the study was limited in the following two ways. First, the interpretive document analysis used in the study limited the overall scope of this paper. This was because not all the documents retrieved and rigorously examined provided all the necessary information to achieve the study’s aim. Some of the documents provided very useful data, while others provided minimal information. Additionally, at the time of conducting the study, the researchers relied on available study’s information on the pandemic to ascertain the study’s intended objective. As the coronavirus pandemic remains the “new normal” and countries put more measures to reduce its spread, more research can be conducted on the impact of these measures on air quality.

Other researchers can also investigate the impact of the Covid-19 pandemic and industrial pollutants like SO₂. These are beyond this paper’s scope, but future research on these issues is necessary to understand the full implications and draw valuable policy lessons from this Covid-19 city lockdown.

**Abbreviations**

| Abbreviation | Full Form |
|--------------|-----------|
| CO₂          | Carbon dioxide |
| Covid-19     | Coronavirus disease 2019 |
| GHG          | Green House Gases |
| NASA         | National Aeronautics and Space Administration |
| NO₂          | Nitrogen dioxide |
| SARS         | Severe Acute Respiratory Syndrome |
| SO₂          | Sulfur dioxide |
| WHO          | World Health Organization |

**Data availability statement**

The data that support the findings of this study are available in [www.theguardian.com](https://www.theguardian.com/environment/2020/mar/23/coronavirus-pandemic-leading-to-huge-drop-in-air-pollution) at https://www.theguardian.com/environment/2020/mar/23/coronavirus-pandemic-leading-to-huge-drop-in-air-pollution

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**Notes on contributors**

Emmanuel Mensah Aboagye is currently a master’s student at Zhongnan University of Economics and Law, China. He is the founder of Unique Motivations. The authors’ work contributes to studies on Covid-19 lockdowns and air quality. Specifically, this study examines the impact of Covid-19 city lockdowns and reduced mobility on air quality in US, Italy and China. Through publications, he is able to satisfy his genuine passion for research. His research interests transcend varied boundaries in academia to encapsulate anything he finds interesting; Environmental law, International law, Gender studies, etc.

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**PUBLIC INTEREST STATEMENT**

Globally, the “war against air pollution” has become a burden on governments. Despite governments’ endless efforts to win this fight, arguably, the results do not look convincing. Air pollution continues to pose more threats to the environment, especially to human health; respiratory diseases. Unfortunately, there was an outbreak of a deadly coronavirus named Covid-19. The spread of the virus was severe, that shortly after it broke out, the World Health Organization
declared it a pandemic. In an attempt for various countries’ governments to control the menace, city lockdowns and social distancing were adopted, which placed a ban on mobility and economic activities. The authors argued that Covid-19 city lockdowns adopted by various governments had significantly reduced air pollution. Covid-19 city lockdowns are not the only means to fight air pollution. Hence, with stricter legislation enacted, countries will see more improvement in air quality.

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