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SHORT COMMUNICATION

The dramatic impact of Coronavirus outbreak on air quality: Has it saved as much as it has killed so far?

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ABSTRACT

The outbreak of coronavirus disease (COVID-19) was first reported from Wuhan, China, on December 31st, 2019. As the number of coronavirus infections has exceeded 100,000 with toll deaths of about 5000 worldwide as of early March, 2020, scientists and researchers are racing to investigate the nature of this virus and evaluate the short and long term effects of this disease. Despite its negative impacts that obliged the World Health Organization to declare COVID-19 epidemic as a Public Health Emergency of International Concern, the rate of mortality of this infection has not exceeded 3.4% globally. On the other hand, the mortality rate caused by ambient air pollution has contributed to 7.6% of all deaths in 2016 worldwide. The outbreak of COVID-19 has forced China to lockdown its industrial activities and hence dropped its NO_2 and carbon emissions by 30 and 25%, respectively. This work reports on the first case study that compares the air quality status before and after the crisis. It sheds light on the facts related to the demographics of deaths by gender, age and health status before infection. The historical data on air quality, estimates of annual deaths and its economic burden have been presented and analyzed. The actual daily deaths due to COVID-19 have been obtained from the official records of the daily Situation Reports published by World Health Organization as of March 11th. The rate of mortality due to COVID-19 was impacted by two factors: age and health status. Results show that 75% of deaths were related to cases that had underlying present diseases with the majority aged of 80+ years. The reported figures were compared with the average daily mortality due to poor air quality which reached up to 3287 deaths due to high levels of NO_2, O_3 and PM. The air quality status before the crisis was compared with the current situation showing that COVID-19 forced-industrial and anthropogenic activities lockdown may have saved more lives by preventing ambient air pollution than by preventing infection.

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INTRODUCTION

In December 2019, several cases of "unknown viral pneumonia" have been reported which were initially linked to the exposure at the Huanan Seafood Market, Wuhan, China (WHO, 2020d). In January 2020, a novel coronavirus was detected (Fig. 1), capable of infecting humans and termed COVID-19 (Cui *et al.,* 2019). By the 11th of March 2020, there were 80,955 confirmed cases inside China and 37,367 with COVID-19 globally (WHO, 2020b). Common symptoms of COVID-19 include dry cough, fever and fatigue. The current official incubation period of COVID-19 is between 2 and 14 days.

Fig. 2 shows the distribution of the reported COVID-19 cases around the world as of March 11th, 2020.

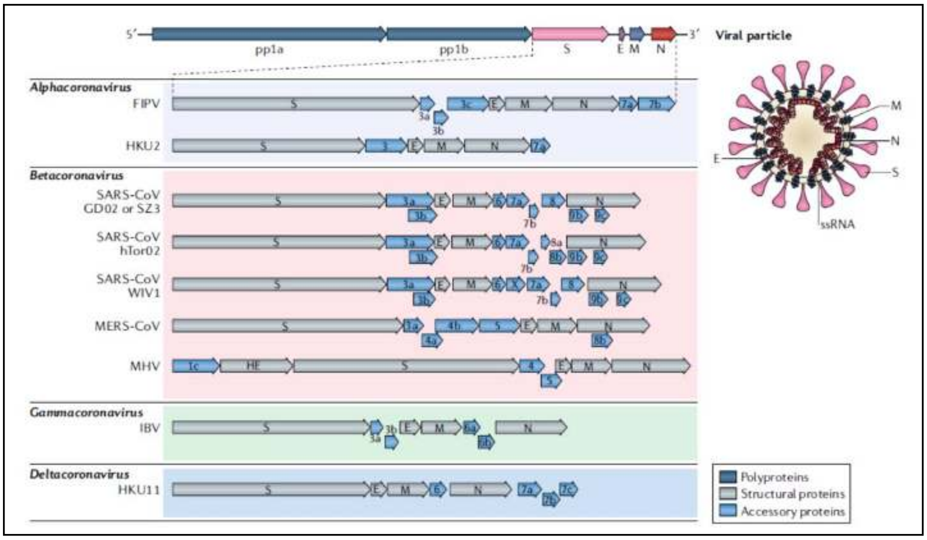

Fig. 1: The genomes, genes and proteins of different coronaviruses (Cui *et al.,* 2019)

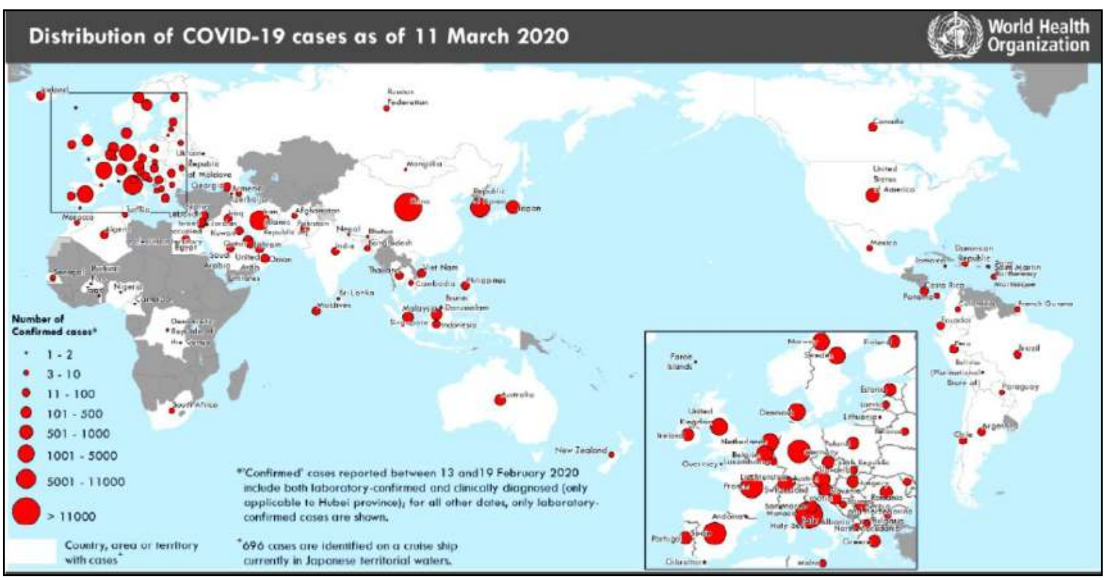

Fig. 2: Countries, territories or areas with confirmed reported cases of COVID-19 as of the 11th of March 2020 (WHO, 2020b)

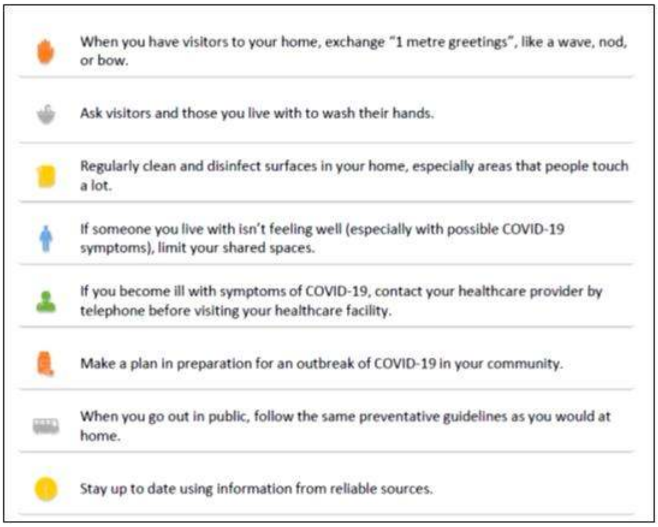

Fig. 3: Key advice for older adults and people with pre-existing conditions (WHO, 2020b)

The WHO has issued several recommendations to avoid further infections as shown in (Fig. 3). Most of these are devoted to elderly people and those with pre-existing health condition as both groups are found to be at higher risk if infected.

This study has been carried out in March, 2020 to highlight the possible impacts of the dramatic reduction of air pollution due to the lockdown of major activities in China in order to control the spread of the virus. It reports on the first case study that compares the air quality status before and after the crisis. This study sheds light as well on the facts related to the demographics of deaths by gender, age and health status before infection. To this end, the evaluation of deaths due to poor air quality vs. COVID-19 leaves the answer to the main question open; whether this infection has saved more people than it has killed so far. On the 4th February 2020, The National Health Commission (NHC) of China stated that national mortality rate due to COVID-19 was about 2.1%. The formula that was used using the figures on the 3rd of February is given by Eq. 1.

Mortality rate = cumulative current total deaths / current confirmed cases (1)

To apply the above formula using the status as of 24:00 on the 3rd of February 2020, the mortality rate was 2.1 % of confirmed cases. Hence, the above formula was used to calculate specific mortality rates in different provinces which resulted in the figures shown in (Table 1).

Table 1: Mortality rates due to COVID-19 as per the 3rd February, 2020 (Worldometer, 2020)

Province	Mortality rate (%)
Wuhan	4.9
Hubei Province	3.1
Nationwide	2.1
other provinces	0.16

Figs. 4 and 5 show the cumulative number of deaths and the change in the number of daily mortalities, respectively.

The results show that although the number of deaths increases on daily basis, the rate of change in daily mortality decreases with time. This might indicate that the rate of infection is not changing from day to day; rather, the numbers of new infections/ mortalities are getting closer in value.

Another method to evaluate the mortality rate was proposed by Ghani *et al.,* (2005). The study was published in the American Journal of Epidemiology and was considered simple due to the advantage of not having to estimate a variable, yet the results were reasonable if the hazards of death and recovery are proportional at any time "t" measured from admission to the hospital. The cited formula was as given by Eq. 2.

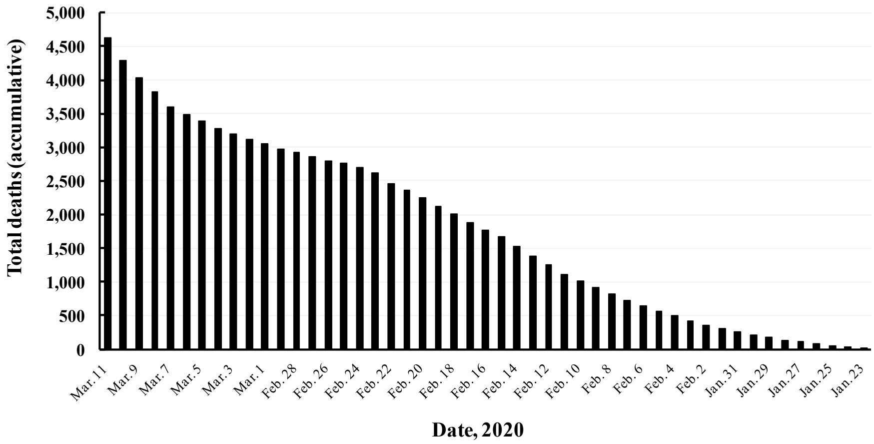

Fig. 4: Accumulative number of deaths by COVID-19. Data is obtained from Situation Report 51 (WHO, 2020b)

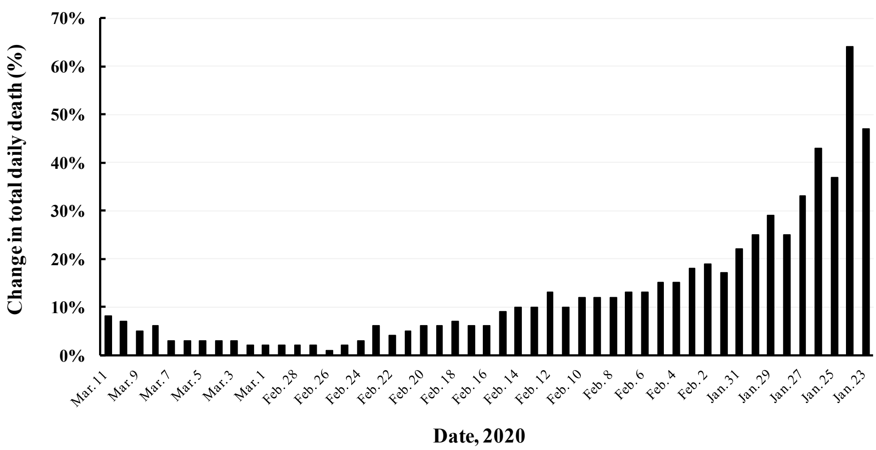

Fig. 5: Change in the number of daily deaths by COVID-19. Data is obtained from Situation Report 51 (WHO, 2020b)

Mortality rate = deaths / (deaths + recovered) (2)

Further analysis of COVID-19 death cases related to the demographic profile showed that males have accounted for 2/3 of the reported deaths with females accounting for 1/3 (Fig. 6).

In addition, the mortality rate is given by Eq. 3.

Mortality rat**e** = (number of deaths/ number of cases) = probability of dying if infected by the virus (%) (3)

The percentages should not necessarily add up to 100%, as they do not represent the share of deaths by sex.

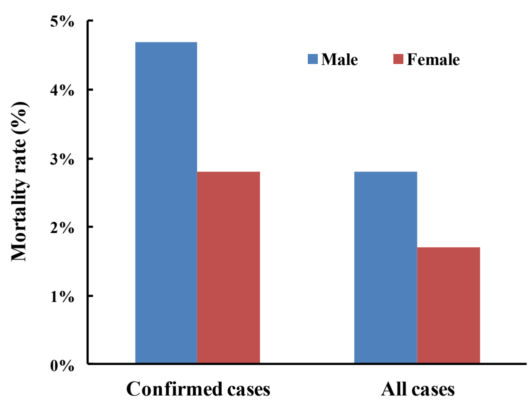

Fig. 6: COVID-19 mortality rate by sex (Worldometer, 2020)

Table 2: COVID- 19 Mortality rate* by age group (Worldometer 2020)

Age	Mortality rate (%) (confirmed cases)	Mortality rate (%) (all cases)
80+ years old	21.9	14.8
70-79 years old		8.0
60-69 years old		3.6
50-59 years old		1.3
40-49 years old		0.4
30-39 years old		0.2
20-29 years old		0.2
10-19 years old		0.2
0-9 years old		no fatalities

*Mortality rate = (number of deaths/number of cases) = probability of dying if infected by the virus (%). The percentages should not necessarily add up to 100%, as they do not represent the share of deaths by age group.

Table 3: Mortality rate of other diseases caused by viruses

Virus	Mortality rate (%)
SARS	9.6
MERS	34
Swine flue	0.02
COVID-19	3.4

In terms of age groups, mainly elderly people aged 80+ years are more susceptible (Table 2). It is worth noting though, that more than 75% of deaths were related to cases that had underlying present diseases such as heart and cardiovascular diseases, diabetes and, in some cases, different types of tumors (NHC, 2020; Worldometer, 2020).

The mortality rate was further compared with other viruses as shown in (Table 3). Table 2 clearly shows that elderly people are more susceptible to death compared with younger age. This trend is not only related to COVID-19, but it also applies to other viral and non-viral diseases since the immunity system of the human beings deteriorates with age. This implies that older people would have higher mortality rate than younger healthy ones.

It is worth noting that the mortality rate of COVID-19 was significantly higher when the patient had pre-existing health condition before being diagnosed with coronavirus. Table 4 shows that death rate is always greater when the patient has a pre-existing health condition related to the most common diseases compared with healthy patients before infection.

Nevertheless, The WHO has reported in 2016 that 4.2 million deaths have been caused by ambient air pollution worldwide. Ambient air pollution is estimated to cause about 29% of lung cancer deaths, 24% of stroke deaths, 25% of heart disease deaths and 43% of other lung diseases (Fig. 7). Moreover, air pollution has attributed to 26% of respiratory infection deaths, 25% of chronic obstructive pulmonary disease (COPD) deaths and about 17% of ischemic heart disease and stroke (WHO, 2020c). It is worth noting at this stage that the death rate by COVID-19 is significantly higher for those with chronic respiratory and cardiovascular diseases. These diseases are well linked with air pollution as well which would imply that air pollution might be considered as a secondary factor for these mortalities. The impact of air pollution on developing these health conditions has been confirmed by previous studies. Further detailed studies on the mortalities by COVID-19 taking into consideration the pre-existing health conditions of the patients shall contribute to a clear conclusion about the link between COVID-19 and air pollution mortalities.

The negative health impacts of air pollution have generated considerable interest in the previous decades where several studies have confirmed that exposure to air pollution has increases health risks related to respiratory, cardiovascular, pulmonary, and other health-related outcomes (Karimzadegan *et al.*, 2008; Xing *et al.*, 2016). The economic and social impacts of air pollution arising from its

Table 4: COVID-19 mortality rate with pre-existing health conditions (Worldometer, 2020)

Pre-existing condition	Death rate (%) (confirmed cases)	Death rate (%) (all cases)
Cardiovascular disease	13.2	10.5
Diabetes	9.2	7.3
Chronic respiratory disease	8.0	6.3
Hypertension	8.4	6.0
Cancer	7.6	5.6
no pre-existing conditions		0.9

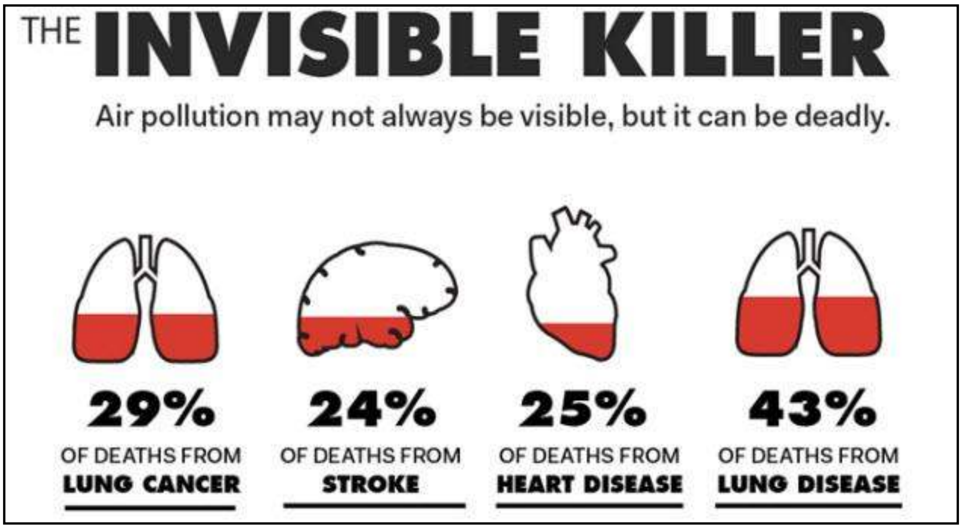

Fig. 7: Ambient air pollution death related diseases (WHO, 2020a)

negative effects on public health have been reported extensively, especially in China and other countries around the world (Matus *et al.,* 2011; Slovic *et al.,* 2016). The situation in China has gained attention due to the unprecedented growth and development that led to a substantial cost on the environment and posed a threat to public health and human welfare (Liu *et al.,* 2018). In 2016, Fang et al., has conducted research on the health impact of air pollution on the inhabitants of 74 leading cities of China. The results showed that air pollution in 2013 was responsible for about 32% of the reported deaths, with a mortality rate of 1.9% that were associated with $PM_{2.5}$. The reported deaths were linked to cardiovascular,

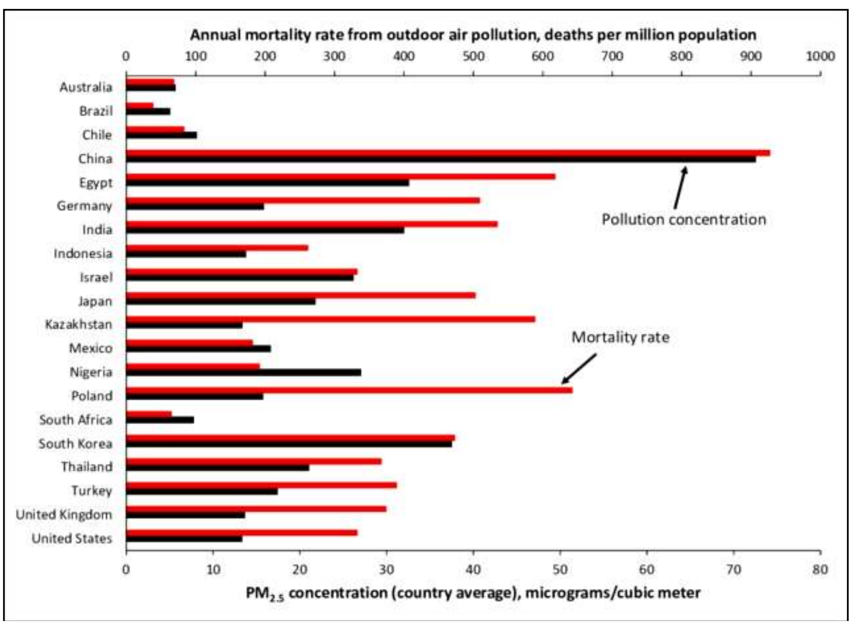

Fig. 8: Annual mortality rate from ambient air pollution (deaths per million populations) (Parry *et al.,* 2017).

respiratory and lung-cancer diseases (Fang *et al.,* 2016). In 2003, an unpublished internal report by the Chinese Academy of Environmental Planning estimated that about 300,000 people die annually from ambient air pollution, mostly due to lung cancer and heart diseases (Jeffries, 2011). Those figures have dramatically increased to 1.2 million annually due to poor air quality in China (Mokoena *et al.,* 2019). Globally, the WHO estimates that 92% of the world's population lives in places where air quality is below guideline levels, and that outdoor air pollution causes about 3 million premature deaths every year (Fig. 8).

In addition to the impact of air pollution on human health, it has significant negative effects on materials, structures and welfare that account for huge economic burden annually (Aissa *et al.,* 2016; Al-Thani, Koc, and Isaifan 2018; Roshan *et al.,* 2019; Isaifan *et al.,* 2017). One of the most significant impacts on building structures as well as surfaces of solar panels is due to soiling. Soiling refers to the accumulation of dust or particulate matter on the surfaces which causes significant drop in the energy output of solar power if it was not cleaned regularly (Isaifan *et al.,* 2017). Although China has taken several measures to reduce its ambient air pollution, the continuous industrial and urbanization activities have contributed to elevated levels of air emissions in the past decades (Fig. 9). The emissions of air pollutants including fine particulate matter from vehicles, industrial manufacturing, power plants, industrial manufacturing, burning coal and wood have caused severe adverse health impacts. Recent research has found that despite the continuous efforts to limit future emissions, the number of premature deaths linked to air pollution will continue to increase in the next two decades unless more stringent targets are set. The results of several analysis show that China and India account for 55% of the global deaths caused by air pollution which represent 1.6 and 1.4 million deaths in China and India, respectively (Gopalaswami, 2016). The figures continue to rise if indoor air pollution is accounted for as per a recent study reported by Jyoti *et al.* (2020) who indicated that more than 5.5 million people die prematurely every year due to indoor air pollution combined together where more than half of deaths taking place in India and China, both representing the world's fastest growing economies (Jyoti *et al.,* 2020).

The main driving activity of air pollution in China is attributed to coal burning. It was reported recently

Fig. 9: Buildings are seen amid smog on a polluted day where a blue alert is issued, in Beijing - China April 2, 2018 (Reuters, 2018).

that outdoor air pollution from coal alone caused an estimated 366,000 deaths in China in 2013. The researchers have also expected that by 2030, approximately 990,000-1.3 million premature deaths will be caused in case China did not implement efficient energy policies and pollution controls to strict coal combustion (Science Daily, 2016). The outbreak of COVID-19 was an alarming incident that resulted in major lockdown of most industrial and commercial activities in China. This has tremendously impacted the air quality reducing its emission levels to what have not been witnessed in years since the last mega event of the Olympic Games. In 2008 Olympic games, China has responded to the global concerns to host the games and had enforced clean-up controls on air quality in Beijing over the period of the Games (Shen *et al.,* 2011; He *et al.,* 2015). During that summer, government officials in Beijing shut down factories and imposed limited vehicle movement before and during the games in order to improve air quality. This action has caused the level of some air pollutants to drop by half. Another control measure that was taken during 2008 Olympic Games was the odd-even car ban which implied that, based on the license plate number; vehicles should be kept off the road on alternative days. Moreover, the government has banned about 2 million motor vehicles during that period. The evaluation of the impact of these actions on air quality was linked with course and fine particulates since they are mainly linked with health impact (Shen *et al.,* 2011; He *et al.,*2015). Another period that witnesses an occasional reduction in air pollution is the weeks that follow the Chinese New Year. Nevertheless, there was no systematic evaluation on the reduction of other air pollutants such as nitrogen oxides, sulfur gases or ammonia. Right after that period, a study of a group of young men and women reported an improved lung and cardiovascular functionality during that time period in Beijing (Rich, 2012). The study has also included pregnant women and reported higher weight of new born babies whose mothers had a third trimester pregnancy during the Olympics games duration when the air quality was better compared with those who were born a year before and a year later.

Fig. 10 shows the deaths caused by particulate

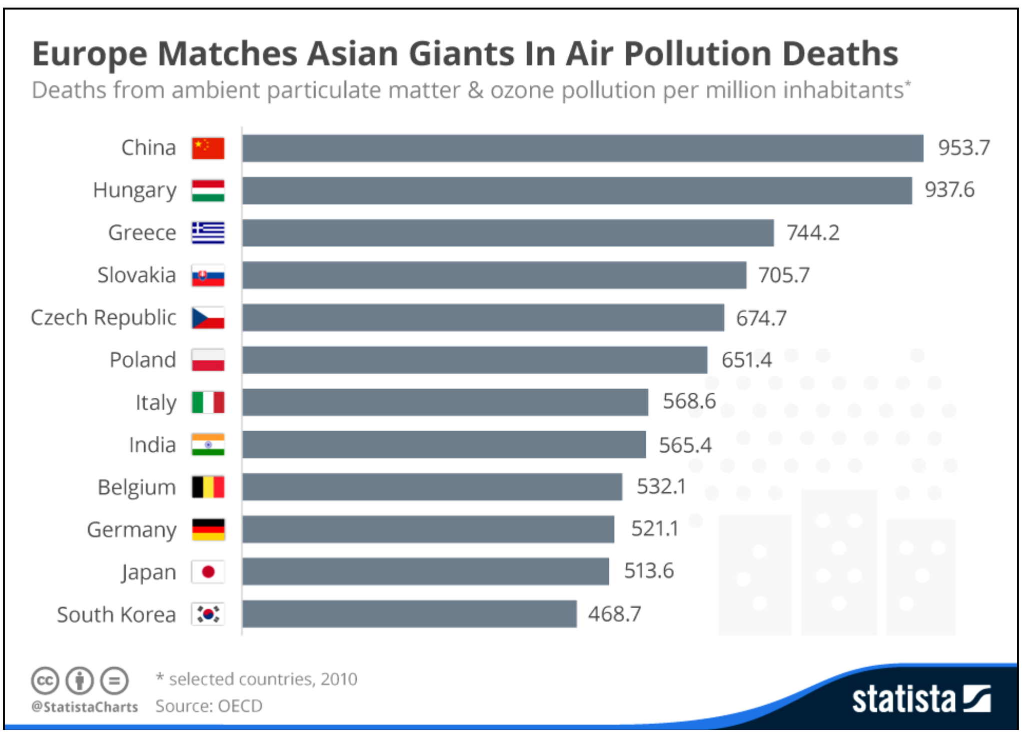

Fig. 10: Death per million inhabitants due to particulate matter and ozone (Statistica, 2016)

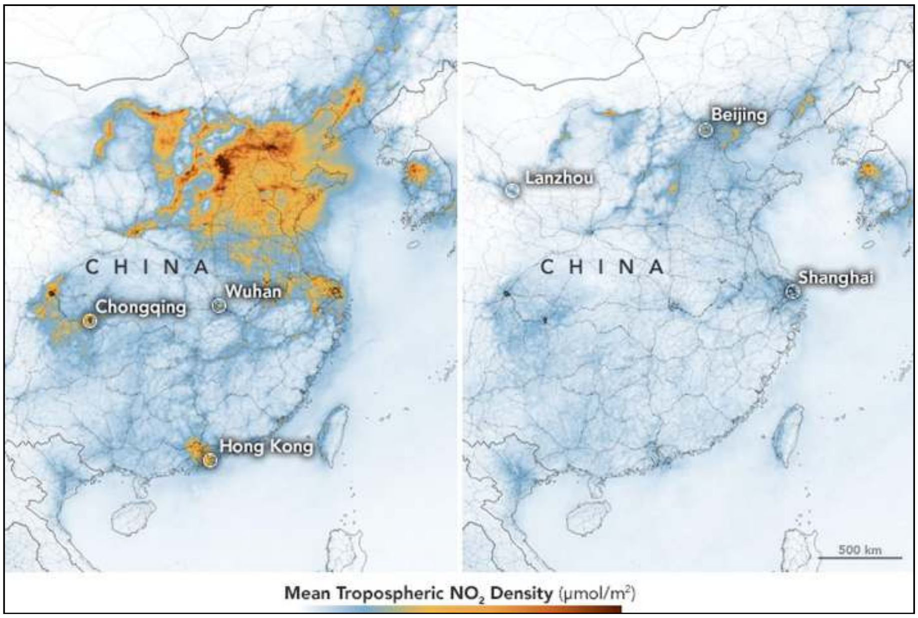

Fig. 11: NASA Earth Observatory images by Joshua Stevens, using modified Copernicus Sentinel 5P data processed by the European Space Agency (NASA, 2020)

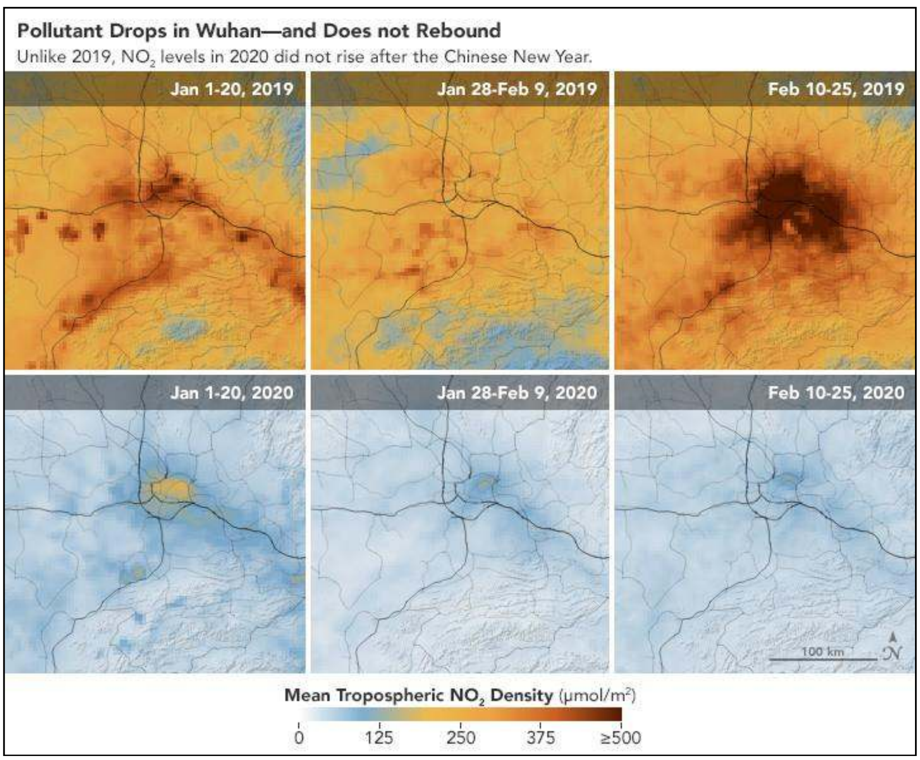

Fig. 12: Levels of nitrogen dioxide over the epicenter of COVID-19 outbreak; Wuhan, China (NASA, 2020). The images of the country before and after the quarantines (from January 1st to 20th- top) and (from February 10th to 25th- bottom), respectively (The Verge, 2020)

matter and ozone pollution in the European Union countries compared with China, India, Japan and South Korea. The figures represent data captured in 2010 and show that those pollutants can sum up to several millions of deaths annually if kept at those levels.

MATERIALS AND METHODS

The study area of concern is China. Study duration was performed during December 2019 to March 11th, 2020.

COVID-19 data: obtained from Situation Report 51 as published by the World Health Organization (WHO, 2020b).

Air pollution data: obtained from WHO and other published works as cited throughout the manuscript. The average daily mortality due to air pollution was evaluated based on the annual reported figures (1.2 million deaths); (Mokoena *et al.,* 2019). The daily average deaths due to air pollution were obtained by dividing this value over 365 days which yield 3287 deaths every day.

RESULTS AND DISCUSSION

In a recent press by researchers in the University of British Columbia, it was stated that Beijing and New Delhi will continue to report on high daily levels of particulate matter if they resumed their activities. This anthropogenic level of PM is 1,200 per cent higher than the WHO guidelines (set at 25 μ/m^3) (UBC, 2016). Nevertheless, several satellite images have recently captured dramatic reduction in air pollution over China. Fig. 11 shows satellite images over China during February 2020 in the lower atmosphere (troposphere) of nitrogen dioxide (NO_2), a pollutant primarily from burning fossil fuels and coal combustion. The images show a dramatic decline in NO_2 concentrations compared to early January when power plants were operating at normal levels.

The closure of coal-fired power plants and other industrial facilities over the last months have caused air pollution levels to drop by 25%. In addition, the limitation over vehicle driving to control the spread of coronavirus has reduced NO_2 pollutant concentration tremendously. Further detailed maps of NO_2 levels in Wuhan, China from the 1st of January through the 25th of February 2019 show the region covered in fiery colors, with deeper darker shades indicating much higher concentrations of NO_2 (Fig. 12) The images were compared with the same period in 2020 after the breakout of coronavirus where significant reduction in NO_2 levels has been observed.

The drop in emissions captured by NASA's images shows steep fall that took place more rapidly than what was observed in 2008. This drop in air pollution was also extended for longer period compared with

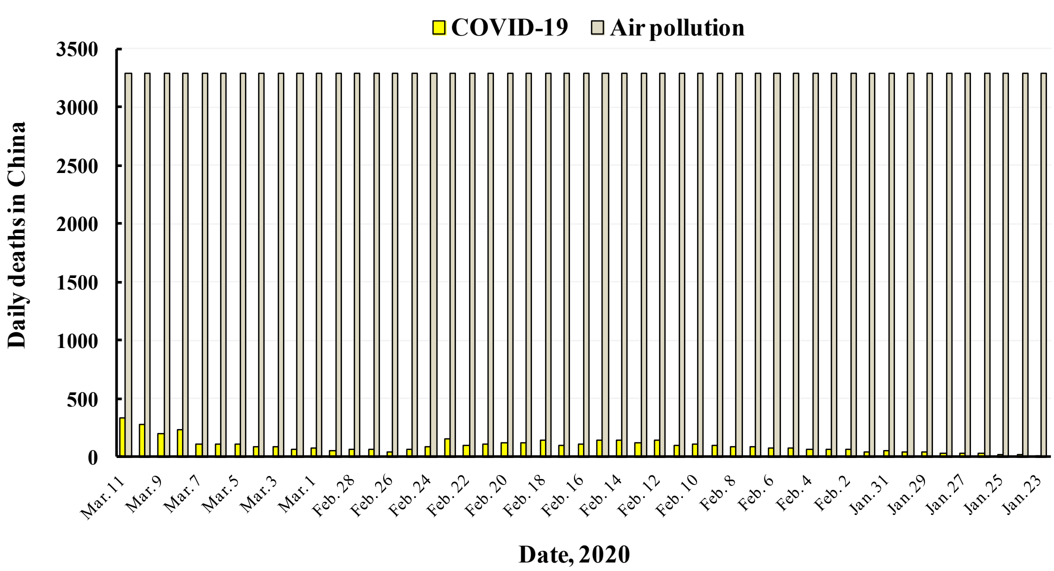

Fig. 13: Actual daily deaths due to COVID-19 vs. averaged daily deaths due to poor air quality in China (WHO, 2020b)

Table 5: Estimated absolute consumption and welfare losses due to air pollution in China (Matus *et al.,* 2011)

	Consumption Loss				Welfare Loss			
	Lower-bound		Upper-bound		Lower-bound		Upper-bound	
Year	bn US$	%	bn US$	%	bn US$	%	bn US$	%
1975	4.7	7.0	31.2	46.2	6.8	4.4	42.2	27.3
1980	5.4	6.0	33.2	36.9	7.4	3.6	42.5	20.7
1985	6.8	4.5	46.0	30.6	9.3	2.7	59.6	17.4
1990	6.5	3.0	48.3	22.5	8.6	1.8	61.1	12.8
1995	9.3	2.4	77.5	19.9	13.1	1.5	105.9	11.8
2000	11.1	1.9	101.6	17.3	15.9	1.2	143.9	10.6
2005	14.8	1.6	148.4	15.8	22.6	1.0	228.6	10.3

Unit: billions of 19997 US$, % of historical consumption/welfare level.

the situation reported in Beijing during the Olympics in 2008 (Shen *et al.,* 2011; The Verge, 2020). This shocking decline in air pollution over China was caused by official decision to quarantine major cities which included halting subway traffic as well as planes and most private vehicles. As the virus spread outside the Province of Wuhan, further quarantine measures were taken to shut down businesses and hold on travel movement which curbed emissions immensely. The cleaner air is believed to provide some relief and positive health impacts as China copes with a novel coronavirus that affects the lungs. On its own, nitrogen dioxide can inflame airways and make it harder for people to breathe and it has proven to be linked with lung cancer (Al-Ahmadi and Al-Zahrani, 2013). It has been associated with high correlation factors in the development of lung and breast cancer incidences, followed by prostate, bladder, cervical and ovarian cancers. It also reacts with other chemicals to create soot, smog, and acid rain (The Verge, 2020). The lockdown that took place in China in reaction to COVID-19 has not only impacted NO_2 emissions but it has also reduced carbon emissions by 25% by February 2020 (Carbon, 2020). Several dramatic changes have taken place which included 36% less coal consumption at power plants, 15% less rates on main steel production, 23% less utilization rate of coking plants, 34% less utilization of oil refinery capacity, 10% less global passenger aviation volume and an overall of 15-40% less output across key industrial sectors (Carbon, 2020). Those dramatic impacts of COVID-19 had resulted in lower demand for electricity and industrial output compared to the time before the infection outbreaks. Consequently, 25% less on CO_2 emissions was recorded. Over the same period in 2019, China released around 800 million tones of CO_2 (Mt CO_2), meaning that the virus could have cut global emissions by 200 Mt CO_2 to date (Carbon, 2020). If considered combined, the reductions in coal and crude oil use indicated a reduction in CO_2 emissions by quarter or more, compared with the same two-week period following the Chinese new year holiday in 2019. This reduction in CO_2 amounts to approximately 100 Mt which is equivalent to 6% of the global emissions over the same period. To properly evaluate the impact of COVID-19 on air pollution and consequently on daily deaths, the average daily mortality due to air pollution was evaluated based on the annual reported figures (1.2 million deaths); (Mokoena *et al.,* 2019). The daily average deaths due to air pollution were obtained by dividing this value over 365 days which yield 3287 deaths every day. This average fixed value was plotted against the actual deaths due to COVID-19 reported on daily basis in China (Fig. 13).

The results show tremendous difference in deaths caused by CORVID-19 considering that the majority of deaths are related to cases with pre-existing health conditions as was shown earlier by the data in Tables 2 and 4. Although the economic consequences of China's lockdown are not within the scope of discussion in this article, the financial impacts have been highlighted in the media. Several factors play a key role to determine the extent of impact of COVID-19 on China as well as the global economy. In China, the construction sector depends mainly on migrant workers who should as well comply with the restrictions on movement and can be enforced to stay at home for days or weeks; hence the resumption of operations is not straightforward. Another factor to evaluate the size of economic impact would be related to decision makers on how fast operations would return to normal. Nevertheless, the local governments continue to hold on and even take more stringent action to control traffic movement and keep businesses shut. This implies that the governments are more considerate towards the implementation of safer procedures that keep the economy stagnant than contributing to new viral outbreak (Carbon, 2020). The potential for wider financial disruption might be related to high level debts by households as well as local government which pose extra stress as lack of cash adds to the complexity of the situation. In response, the leadership in Beijing is apparently aware of the consequent financial risks of this lockdown. Hence, the government has called on banks to roll over loans among other procedures to reduce rents and other costs (Carbon, 2020). Nevertheless, the economic burden of air pollution has always cost China billions of dollars annually. A report published by group of researchers at MIT Joint Program on the Science and Policy of Global Change has elaborated on the economic impacts of air pollution in China. The figures show tremendous annual losses caused by consumption and welfare losses due to deterioration in air quality (Table 5).

CONCLUSION

The outbreak of COVID-19 in China in December 2019 has imposed several health threats to human beings as more than 5000 deaths have been reported globally. The vast spread of the virus beyond the borders of China has obliged the WHO to declare COVID-19 as a Public Health Emergency of International Concern (PHEIC) on January 31, 2020. In response to control the spread of the infection, the Chinese government put major cities in quarantine. This action has put major industrial and commercial activities on hold and hence, an unprecedented drop in air pollution levels over China has been captures by Satellite images of NASA. The huge reduction in anthropogenic pollution emissions accounted for 30% less in NO_2 levels and 25% less in carbon emissions due to quarantine measures taken strictly all over the Chinese cities to control the spread of the virus. In this work, the daily mortality data due to the infection by COVID-19 was gathered from the Situation Report 51 published by WHO as of March 11th, 2020. The annual mortality related to poor air quality was obtained from WHO and other published studies. Recent images by NASA showing the levels of NO_2 pollution before and after the outbreak of COVID-19 were presented. The comparison between the daily deaths caused by COVID-19 and the average daily deaths due to air pollution shows huge difference in both values. Although the outbreak of COVID-19 has its impact on human health and welfare, the confirmed adverse effect of air pollution have long been reported to kill 7 million people annually with the majority of deaths taking place in China and India. Results show that 75% of deaths were related to cases that had underlying present diseases with the majority aged 80+ years. The most common diseases among deaths reported by COVID-19 were chronic cardiovascular and respiratory illnesses which are also strongly connected with air pollution. Moreover, the burden of disease caused by air pollution was presented and the current economic efforts of China's lockdown were highlighted. The dramatic reduction in air pollution due to COVID-19 might impose short term benefits for human health but the evaluation of this impact should consider critical factors such as the impact of indoor pollution where people are forced to stay in door and might not be able to commute to hospitals to receive treatment and proper medical care if infected. Moreover, the long term benefits of air pollution reduction depends on whether the impacts are sustained, or if they will be offset or even reversed in case COVID-19 crises was brought to an end.

AUTHOR CONTRIBUTIONS

R. Isaifan has performed the literature review, analyzed and interpreted the data and prepared the manuscript text.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

ABBREVIATIONS

%	Percentage
bn	Billion
CO_2	Carbon dioxide
COVID-19	Coronavirus disease 2019
Eq.	Equation
Fig.	Figure
$\mu g/m^3$	Microgram per cubic meter
NASA	The National Aeronautics and Space Administration
NO_2	Nitrogen dioxide
O_3	Ozone
PM	Particulate matter
WHO	World Health Organization

REFERENCES

Aissa, B.; Isaifan, R.J.; Abdulla, A.; Madhavan, V., (2016). Structural and physical properties of the desert-dust particles and their influence on the PV panels' performance in Qatar. Sci. Rep., 6: 31467.

Al-Ahmadi, K.; Al-Zahrani, A., (2013). NO_2 and cancer incidence in Saudi Arabia. Int. J. Environ. Res. Public Health. 10(11): 5844–5862 **(19 pages).**

Al-Thani, H.; Koc, M.; Isaifan, R., (2018). Investigations on deposited dust fallout in urban Doha: Characterization, source apportionment and mitigation. Environ. Ecol. Res., 6(5): 493–506 **(14 pages).**

Carbon, B., (2020). Analysis: Coronavirus has temporarily reduced China's CO_2 emissions by a quarter.

Cui, J.; Li, F.; Shi, Z.L., (2019). Origin and evolution of pathogenic coronaviruses. Nature Rev. Microbiol., 17(3): 181–192 **(12 pages).**

Fang, D.; Wang, Q.; Li, H.; Yu, Y.; Lu, Y.; Qian, X., (2016). Mortality effects assessment of ambient PM2.5 pollution in the 74 leading cities of China. Sci. Total Environ., 569(1): 1545–1552 **(8 pages)**.

Ghani, A.C.; Donnelly, C.A.; Cox, D.R.; Griffin, J.T.; Fraser, C.; Lam, T.H.; Ho, L.M., (2005). Methods for estimating the case fatality ratio for a novel, emerging infectious disease. Am. J. Epidemiol., 162(5): 479–486 **(8 pages).**

Gopalaswami, P., (2016). A study on effects of weather, vehicular traffic and other sources of particulate air pollution on the city of Delhi for the year 2015. J. Environ. Pollut. Hum. Health. 4(2): 24–41 **(18 pages).**

He, G.; Fan, M.; Zhou, M., (2015). The effect of air pollution on mortality in China : Evidence from the 2008 Beijing Olympic Games, HKUST Institute for Emerging Market Studies **(62 pages).**

Isaifan, R.J.; Samara, A.; Suwaileh, W.; Johnson, D.; Yiming, W.; Abdallah, A.A.; Aïssa, B., (2017). Improved Self-cleaning properties of an efficient and easy to scale up TiO2 thin films prepared by adsorptive self-assembly. Sci. Rep., 7(1): 9466 **(9 pages).**

Jeffries, I.,(2011) Economic developments in contemporary China: A Guide, Routledge, New York, **(717 pages)**.

Jyoti, K.; Kumar, A.; Arora, M.; Deshpande, A., (2020). Estimating premature mortality attributable to PM2.5 exposure and benefit of air pollution control policies in China for 2020. Sci. Total Environ. 612, 683–693 **(11 pages).**

Karimzadegan, H.; Rahmatian, M.; Farhud, D.; Yunesian, M., (2008). Economic valuation of air pollution health impacts in Tehran area, Iran. Iran. J. Public Heal. 37(1): 20–30 **(11 pages).**

Liu, W.; Xu, Z.; Yang, T., (2018). Health effects of air pollution in China. Int. J. Environ. Research Public Heal. 15(7): 1–15 **(15 pages).**

Matus, K.; Nam, K.; Selin, N.E.; Lamsal, L.N.; Reilly, J.M., (2011). Science and Policy of Global Change Health Damages from Air Pollution in China, MIT Joint Program on the Science and Policy of Global Changes **(25 pages).**

Mokoena, K.; Ethan, C.; Yu, Y.; Shale, K.; Liu, F., (2019). Ambient air pollution and respiratory mortality in Xian China: A time-series analysis. Respir. Res. 20: 1–9 **(9 pages).**

NASA. (2020). Airborne nitrogen dioxide plummets Over China.

NHC, (2020). New Coronavirus Pneumonia Prevention and Control. National Health Commission of the People's Republic of China.

Parry, I.; Mylonas, V.; Vernon, N., (2017). Reforming Energy Policy in India : Assessing the Options. IMF Working Paper **(51 pages).**

Reuters, (2018). Beijing sees April pollution levels rise as industry curbs end.

Roshan, D.; Koc, M.; Isaifan, R.J.; Shahid, M.; Fountoukis, C., (2019). Aerosol optical thickness over large urban environments of the Arabian Peninsula -speciation, variability and distributions. Atmosphere 10(5): 228–249 **(22 pages).**

Science Daily, (2016). Poor air quality kills 5.5 million worldwide annually.

Shen, J.; Tang, A.; Liu, X.; Kopsch, J.; Fangmeier, A.; Goulding, K.; Zhang, F., (2011). Impacts of pollution controls on air quality in Beijing during the 2008 Olympic Games. J. Environ. Qual., 40(1): 37-45 **(9 pages).**

Slovic, A.D.; de Oliveira, M.A.; Biehl, J.; Ribeiro, H., (2016). How can urban policies improve air quality and
help mitigate global climate change: A systematic mapping review. J. Urban Heal. 93(1): 73–95 **(23 pages).**

Statistica, (2016). Europe matches Asian giants in air pollution deaths.

UBC, (2016). Poor air quality kills 5.5 million worldwide annually. University of British Columbia.

The Verge, (2020). Maps show drastic drop in China's air pollution after Coronavirus quarantine.

WHO, (2020a). Air pollution. World Health Organization.

WHO, (2020b). Coronavirus disease 2019 (Situation Report-51). World Health Organization.

WHO, (2020c). Mortality and burden of disease from ambient air pollution. World Health Organization.

WHO, (2020d). Pneumonia of unknown cause- China. World Health Organization.

Worldometer. (2020). Coronavirus (COVID-19) mortality rate.

Xing, Y.F.; Xu, Y.H.; Shi, M.H.; Lian, Y.X., (2016). The impact of PM2.5 on the human respiratory system. J. Thorac. Dis. 8(1): E69–E74 **(6 pages).**

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