Is COVID-19 Infection Transmission accelerated by carriage on the Airborne Pollutant PM2.5?

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This article proposes to examine the connection between COVID-19 infection and an atmospheric microscopic pollutant, called particulate matter PM2.5. The article offers a hypothetical proposition that PM2.5 may act as a COVID-19 vector in infection transmission, and as a co-factor exacerbating infection.

COVID-19 infection appears to have initiated in the Chinese city of Wuhan, with the index case thought to have been diagnosed in early December 2019. The first case appears to have transmitted the infection at a local animal market, where the outbreak rapidly spread. Soon after, due to travellers arriving from China, COVID-19 spread to Qoms, in Iran, and Bergamo, in Italy. A few weeks later, the cities of Madrid, Paris London and New York followed suit. A month later, cities in Mexico, Brazil and India were affected. In contrast, there were cities that remained relatively unscathed by the pandemic (Figs. 1 & 2).

The 'Ro' of COVID-19 (index of transmissibility of the infection) was initially calculated to be as high as 3.28 (Liu & al., 2020). The 'Ro' of the seasonal influenza is estimated at 1 to 1.1. Translating the potential unbridled transmission, a single individual infected with COVID-19 may transmit the virus to a total of 210 persons within a one-month period. Predisposition to COVID-19-related mortality usually affects the elderly and vulnerable, however, there were exceptions where healthy individuals succumbed to the infection (Fig. 3). The application of strict social distancing has been estimated to reduce the transmission rate to 15 individuals over a period of one month.

Following the outbreak in Wuhan, the province of Hubei, of which Wuhan is the principal city, implemented a strict lockdown on the 23rd of January 2020. Almost immediately, the atmospheric PM2.5 levels improved as indicated by a website called the Air Quality Index (AQI). The AQI is a real-time website displaying the atmospheric pollution covering most cities of the world. The initial page of the website depicts the levels of PM2.5 as colour-coded flags over the cities assessed. The AQI colour-coded flags range from dark green, representing healthy levels of PM2.5, through to a spectrum of yellow, orange, red, violet and black, indicating increasingly unhealthy levels of this airborne pollutant.

At a glance, the AQI illustrates a concentration of unhealthy levels of PM2.5 conspicuously covering most cities in China. This is not surprising, as the combustion of coal (the main source of PM2.5) in China is estimated at 80,000 tonnes per day (Ghosh, 2020). Moreover, it is interesting to note that 60% of Chinese males indulge in cigarette smoking, an activity which exposes humans to the highest concentration of particulate matter. Inhaling the most unhealthy atmosphere possible, in terms of exposure to PM2.5, is equivalent to smoking two cigarettes a day. Prior to the 23rd of January, Wuhan had been through a series of days with dark red flags, indicating high levels of PM2.5, only to lighten and change to less unhealthy colour-coded depictions following lockdown. A similar pattern followed in Qoms and Bergamo.

Following the exponential increase in deaths in Northern Italy, local lockdown was initiated in Lombardy in late February, with progressive extensions of this measure to the rest of the peninsula. Scientists in Milan (Setti & al., 2020) published a paper in MEDRxIV confirming that the genes of COVID-19 were detected on particulate matter (Fig. 4). This raised the possibility that particulate matter, including PM2.5, could have acted as a vector and co-factor for COVID-19 infection. The implications of this connection suggested that PM2.5 could carry the virus beyond the human to human transmission radius of 2 metres to up to 10 metres (Fig. 4).

Chronic exposure to PM2.5 has deleterious effects on health. The World Health Organization guideline recommends that PM2.5 levels should not exceed an average level of 25μg/m^3 24-hour. Several studies have shown adverse effects on respiratory defences against lung infection following exposure to particulate matter PM2.5 (Brunekreef & Holgate, 2002, Pope & Dockery, 2006). In a study on a large American population of 65-year-olds by Wu & al., a small increment of 1μg/m3 in long-term exposure to PM2.5 led to an increase of 0.73% in all-cause mortality. Consequently, a recent study by the same authors showed that a similar increase of 1μg/m3 in long-term PM2.5 exposure correlated with an 8% increase in the COVID-19 death rate. For the same 1μg/m3 increase in PM2.5, the magnitude of COVID-19-related deaths increased eleven-fold (Wu & al., 2020).

As evidenced from the AQI, there is a spectrum of pollution with PM2.5 around the globe. Research in the infection and mortality rates related to COVID-19 appear to correlate with the PM2.5 levels (Fig. 5). Low levels of PM2.5 appear in coastal areas and concomitantly nations such as Italy (southern part), Malta, Cyprus, Greece, and Israel appear to have been relatively unscathed by the pandemic. Asian coastal countries such as South Korea, Hong Kong and Singapore, and similarly Australia and New Zealand, also demonstrated a similar pattern of infection, until recently (Figs.1 & 2).

Besides the low levels of atmospheric PM2.5, there may be other factors that may have protected the countries mentioned above. The spike protein of COVID-19 possesses a hydrophobic component (Fig. 6). The salt component of the coastal PM2.5 is richer than inland areas. Salt attracts water, and possibly, the salt-derived water element of PM2.5 may have actually deterred, or may have eliminated, adherent COVID-19 viruses (Muscat Baron, 2020a; 2020b) (Fig. 6).

The highest levels of PM2.5 are observed in subways and underground platforms. Levels of over 800μg/m^3/24hours have been recorded at Victoria Station in London. Another paper indicated that cities with high COVID-19-related deaths also had elevated subway PM2.5 levels, compared with cities with low mortality rates and low underground PM2.5 levels (Muscat Baron, 2020c) (Figs. 7 & 8). Besides the elevated PM2.5 levels, social distancing in crowded subway stations is nigh impossible with the excessive commuter congestion in underground platforms, encouraging human-to-human transinfection (Figs. 7 & 8).

There are common factors between countries that controlled the pandemic. These factors include the wearing of masks, the careful entry of travellers from affected countries, the barring of mass events, and the initial closure of schools, with extensive population testing, tracing, and imposition of quarantine measure. These basic tenets of Public Health measures support social distancing, impacting viral transmission. National lockdowns and partial regional lockdowns reduced PM2.5 levels, which in themselves may accelerate viral transmission and infection rates. There are other avenues which need investigation, as undoubtedly, the ubiquitous spread of the COVID-19 pandemic is multifactorial in nature.

The above information was presented at a number of webinars organized by the Department of Pharmacy at the University of Malta, and may be viewed on the website ResearchGate under the author's name.

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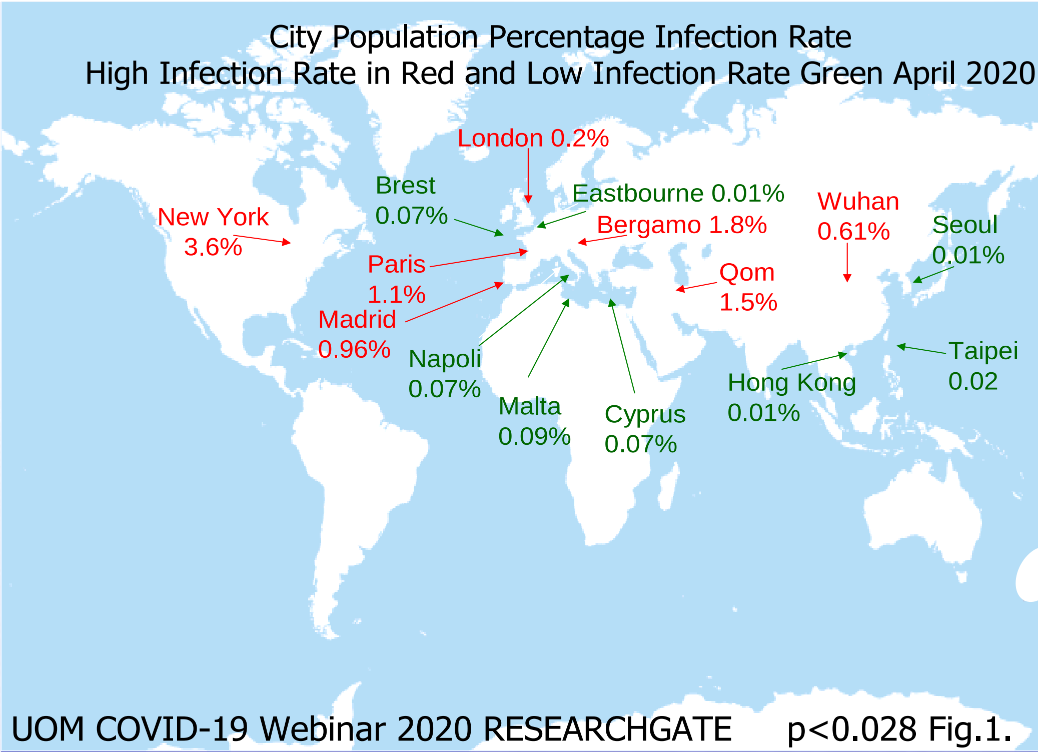
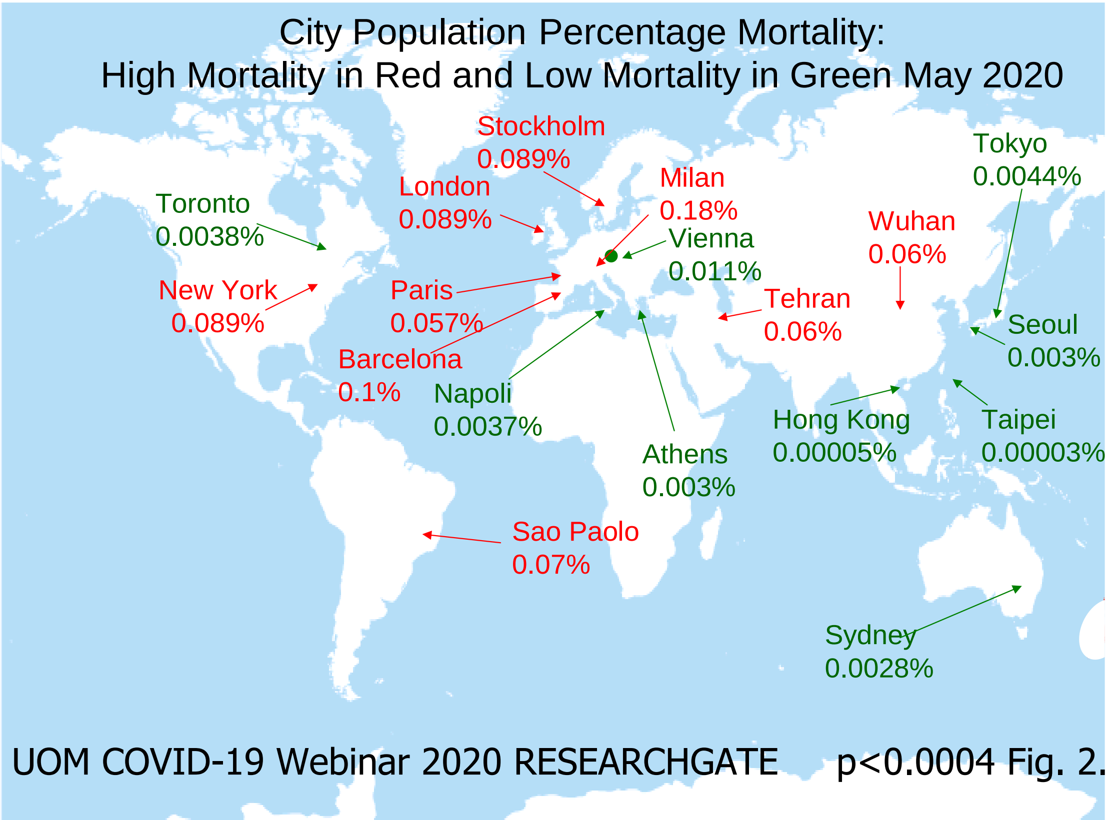

City Population Percentage Infection Rate
High Infection Rate in Red and Low Infection Rate Green April 2020
London 0.2%
Brest 0.07%
Eastbourne 0.01%
Bergamo 1.8%
New York 3.6%
Wuhan 0.61%
Seoul 0.01%
Paris 1.1%
Qom 1.5%
Madrid 0.96%
Napoli 0.07%
Taipei 0.02
Hong Kong 0.01%
Malta 0.09%
Cyprus 0.07%
UOM COVID-19 Webinar 2020 RESEARCHGATE
p<0.028 Fig.1.


City Population Percentage Mortality:
High Mortality in Red and Low Mortality in Green May 2020
Stockholm 0.089%
Tokyo 0.0044%
London 0.089%
Milan 0.18%
Toronto 0.0038%
Vienna 0.011%
Wuhan 0.06%
New York 0.089%
Paris 0.057%
Tehran 0.06%
Seoul 0.003%
Barcelona 0.1%
Napoli 0.0037%
Hong Kong 0.00005%
Taipei 0.00003%
Athens 0.003%
Sao Paolo 0.07%
Sydney 0.0028%
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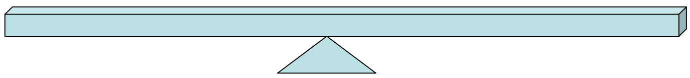
p<0.0004 Fig. 2.

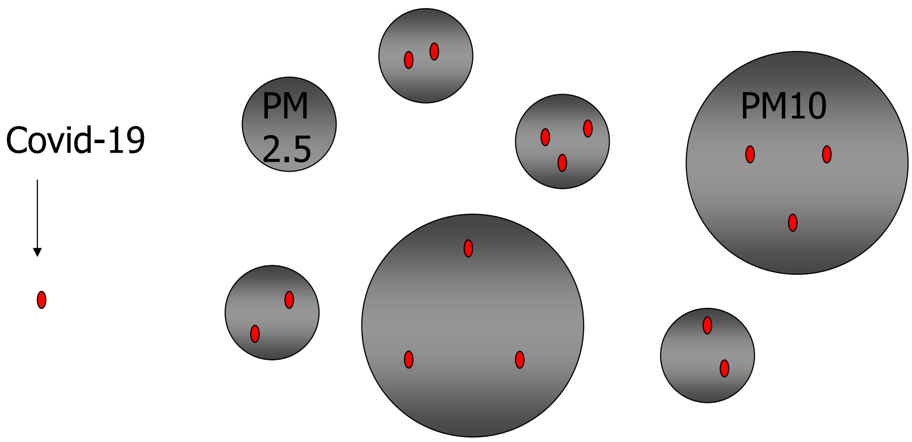
COVID-19 Infection Risk Factors

LOW RISK for COVID-19	HIGH RISK for COVID-19
Age< 65yrs	Age > 65yr
Female gender	Male gender
Low BMI	Obese/High BMI
Mild Asthma	Diabetic Hypertensive
Mild COPD	Chronic disease
Caucasian	Non Caucasian
Low PM2.5	High PM2.5
Coastal city	Landlocked city
High Atmospheric Salinity	Low Atmospheric Salinity
High Vitamin D	Low Vitamin D



UOM COVID-19 Webinar April 2020 RESEARCHGATE (Fig.3.)

Virus adheres on to PM10 and PM2.5



(Fig.4.) SARS-Cov-2 RNA Found on Particulate Matter of Bergamo in Northern Italy: First Preliminary Evidence Setti L, Passarini L:, De Gennaro G, Baribieri P et al. PRISCO PISCITELLI, Alessandro Miani. www.medrxiv.org UOM COVID-19 Webinar 2020 RESEARCHGATE

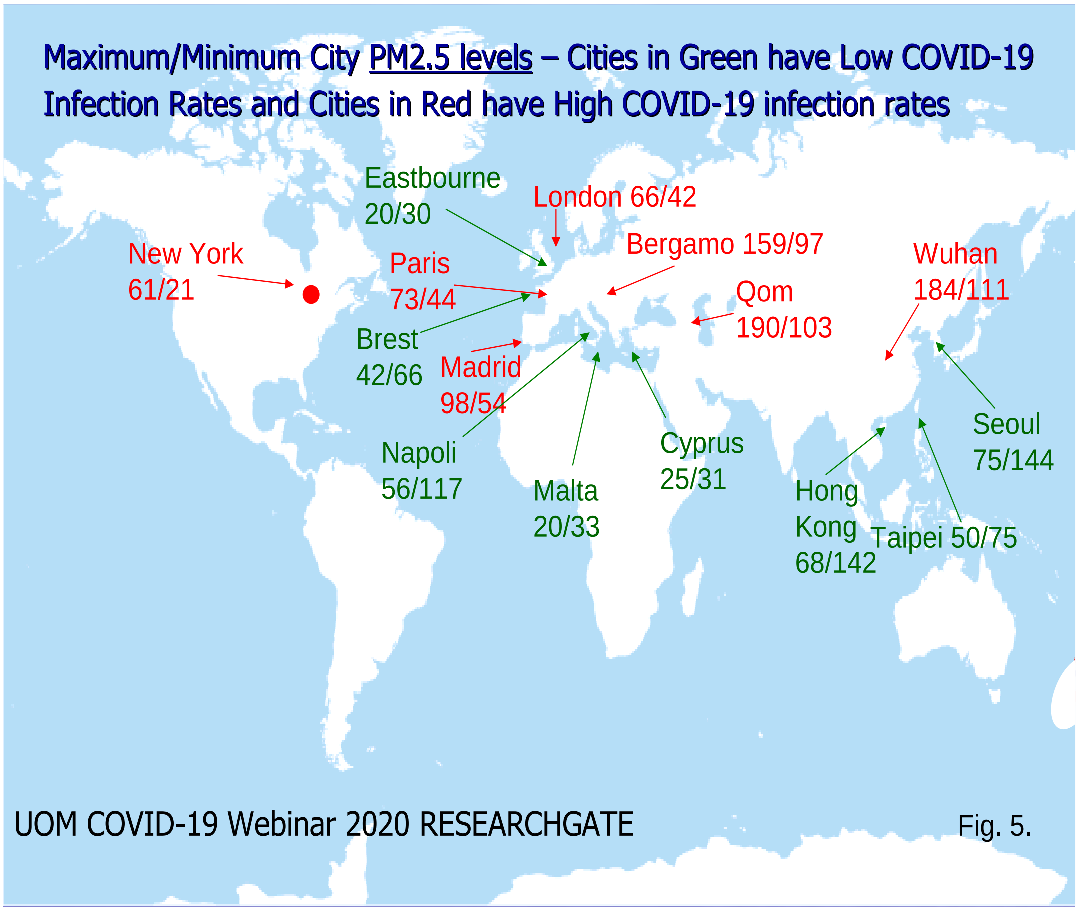
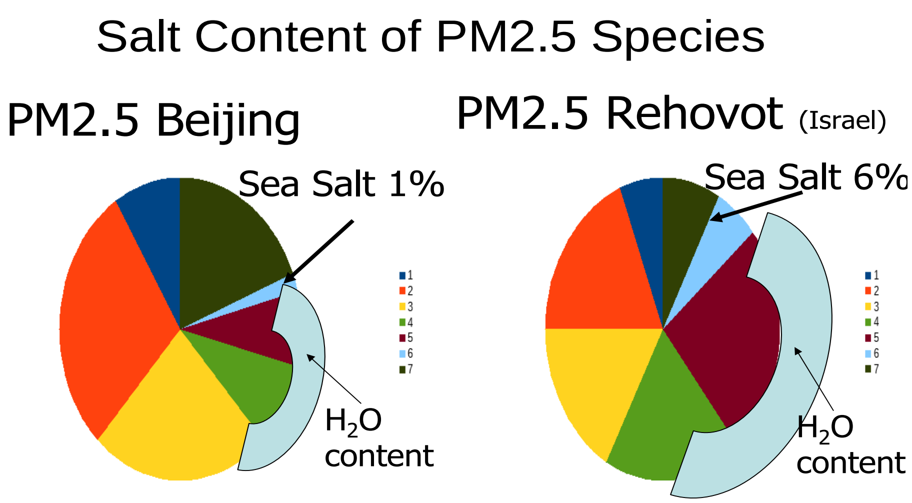


Fig. 5.



Covid-19 spike protein is hydrophobic, accordingly the PM2.5 Rehovot species would deter viral adhesion.

G A Snider, C L Weagle,K Murdymootoo et al Variation in Global Chemical Composition of PM2.5: Emerging Results from SPARTAN.February 2016. Atmospheric Chemistry and Physics. Aerosols and Climate Surface Particulate Matter Network (SPARTAN).

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(Fig. 6.)

Subway Maximum PM2.5 : Population percentage mortality correlated R = 0.83 (p<0.00001).