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Impact of building ventilation systems and habitual indoor incense burning on SARS-CoV-2 virus transmissions in Middle Eastern countries

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Abstract

Majority of countries across the globe have employed improving building ventilation, quarantine, social distancing, and disinfections as a general measure of preventing SARS-CoV-2 virus transmissions. However, arid Middle Eastern countries with hot climate (elevated outdoor temperature and humidity levels) are experiencing a different situation. Unfortunately, these harsh ambient climatic conditions in Middle Eastern countries make it impossible for most buildings to utilize natural/mechanical ventilation systems. Besides, indoor air temperatures of most buildings are very low due to overconsumption of air conditioning, thereby, it can be a potential factor of virus spread in most residential homes and public buildings. Most importantly, habitual indoor burning of incense which is the major source of coarse (PM10; aerodynamic diameter <10 μm) and fine (PM2.5; aerodynamic diameter <2.5 μm) particulate matters (PM) could facilitate the transmission of SARS-CoV-2 virus droplets and particles in indoor environments. In fact, it increases the spread of the virus via inhalation in these countries, especially where the wearing of masks is not regulated in public, commercial and residential buildings. It is therefore highly recommended for the relevant public health agencies to critically assess the role of poor indoor environmental conditions including the burning of incense on virus transmissions, which may help to develop control measures for the future viral outbreak effectively.

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1. Discussion

World Health Organization (WHO) declared severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), hereafter virus, which causes novel Coronavirus disease 2019 (COVID-19), as a global pandemic on 12 March 2020 (WHO/Europe, 2020). As of 22 April 2020, this disease has infected 2,558,959 people and causing 177,704 mortalities across 210 countries and territories, making it one of the most serious public health threat to humanity in the world’s history (Worldometer, 2020). Till current, there are no therapeutic drug and vaccines to treat/stop the spread of COVID-19, thereby, the only approach would reduce the transmission of the virus by practicing protective measures. Social distancing, quarantine, handwashing and disinfection, especially in outdoor environments are among some of the common preventive approaches that the world could use (WHO, 2020a). Following these measures, the US Centers for Disease Control and Prevention (CDC) recommended wearing of locally made facial cloth covers in public settings except for children with less than two years old and those with breathing difficulties (CDC – National Center for Health Statistics, 2020). Public Health Agency of Canada (PHAC) advised that respiratory droplets are deemed as one of the main routes of virus transmission (yet does not constitute the cause of all COVID-19 diseases) (PHAC, 2020). This has been further confirmed by WHO (2020c) that droplet particles with aerodynamic diameter of >5 to 10 μm of someone who has respiratory symptoms (e.g. coughing or sneezing) could carry the virus and may cause COVID-19 disease. However, a study has argued that liquid droplet aerosols (>0.8 μm) generated during exhalation could evaporate, become smaller (by shrinkage) and easily transported by airflow (Morawska et al., 2009). The subsequent study concluded that the virus is transmitted by air and could serve important information in developing more reliable measures of reducing the spread of the virus in amidst of vaccine developments (Morawska and Cao, 2020). Based on the above findings, the following measures of removing liquid droplets and airborne particles in indoor environments have been recommended. These include (1) improving ventilation rates, (2) adoption of natural ventilation, and (3) personalized-ventilations personalized-exhaust system (PV-PE) for micro-environments such as workplaces (Qian and Zheng, 2018). While these measures may work well in countries with tropical and
temperate climatic conditions, the situation in most Middle Eastern and
countries with extremely high predicted maximum ambient temperate
(about 38–42 °C) and humidity (>90%) levels during the long summer
(April–September) season will be different (AccuWeather, 2020; NCSI,
2018).
This is because of the buildings in these countries have been de-
signed to suit these harsh outdoor weather conditions. The architec-
tural designs of these buildings do not allow natural and mechanical
ventilations but rather only air conditioning systems to maintain in-
door thermal comfort (Aljofi, 2016). Several studies from these Mid-
dle Eastern countries have revealed poor indoor building ventilation
levels in most homes, public settings and offices (Amoatey et al.,
2020; Amoatey et al., 2018). The maximum ventilation rates in liter
per second per person (l/s/p) of 5 (Behzadi and Fadeyi, 2012), 3
(Fadeyi and Taha, 2013) and air exchange velocity of 0.04 m/s
(Indraganti and Boussa, 2017) in most school buildings, restaurants
and offices failed to meet the American Society of Heating, Refrig-
erating and Air-conditioning Engineers (ASHRAE) limits of 8 l/s/p and
0.18–0.25 m/s, respectively. Besides, the average low indoor temper-
ature of 23.1 °C in most public buildings due to overconsumption of
air-conditioners may be an important factor for viral activation
(Indraganti and Boussa, 2017). Similar findings have been revealed by
another study, where most severe acute respiratory syndrome coro-
navirus (SARS-CoV-1) seems inactivated on surfaces at the tem-
perature of 40 °C compared to 20 °C (Casanova et al., 2010). These
limited building ventilation systems and favorable cold indoor envi-
ronments from Middle Eastern countries may be a major contributor to
the spread of the virus especially in airports, shopping malls, mosques,
ofices and residential buildings. While there are not any
 current scientific data supporting this assertion, additional research
works are urgently needed to understand the impact of building ven-
tilation rates and the transmission of the virus in indoor environ-
ments in these countries.
Recent epidemiological studies have evident the transmission of
SARS-CoV-2 viruses in several indoor environments. On 26 January
2020, Jianyun et al. (2020) assessed air-conditioning system (airflow)
and transmission of the virus in an indoor environment (restaurant
in China. The results indicated that most people who ate at the restau-
rant contracted the virus due to high airflow of the central air-
conditioning system, and recommended the need for improvement of
indoor air temperature and ventilation rate (Jianyun et al., 2020). Also,
from 4 January to 11 February 2020, among a total of 318 COVID-19 dis-
ease outbreaks constituting 1245 active cases, outbreaks from indoor
environments (79.9%) were found to be the highest compared to trans-
port environments (34%), therefore, it emphasizes the need for epi-
demiological studies to concentrate on indoor environments (Qian et al.,
2020). However, it is difficult to conclude that such transmissions were
mainly attributed to poor indoor environmental conditions.
In Italy, it was revealed that the expiratory viral load (based on
quanta emission rate estimates) of a virus-infected person due to speak-
ing and breathing were 320 and 10.5 quanta/h, respectively. However,
depending on the nature of activities including resting, standing and
light exercises, the viral load could range from 33.9–1030 quanta/h
(Buonanno et al., 2020). Based on the above scientific findings, it is evi-
dent that indoor transmissions of the virus in Middle East countries may
be high, especially could be exacerbated by their unfavorable indoor en-
vironmental conditions (low ventilation and low indoor air tempera-
ture) (Amoatey et al., 2020). Now the question is, what will be the
behavior (e.g. durations, survival rate and inactivation) of SARS-CoV-2 virus
droplets under a typical indoor environment in Middle Eastern countries?. The research question is very crucial in providing novel
knowledge that SARS-CoV-2 virus prevention measures need to
exist. According to WHO (2020b), the major determinants of incidence/
transmission of disease in the population include customs, traditions
and social environmental factors. In the case of Middle Eastern coun-
tries, burning of incense (locally called Bakhour or Oud) in indoor envi-
ronments (homes, restaurants, shopping malls, and offices) are the
most common cultural practices (Al-Rawas et al., 2009; Amoatey
et al., 2018; Mesallam et al., 2015). There is a piece of evidence that in-
cense burning produces large amount of fine (PM2.5) and ultrafine par-
ticles (UFPs; aerodynamic diameter <100 nm). For example in United
Arab Emirates (UAE), burning of incense produces a median concentra-
tion of 36.95 and 6.20 μg/m3 for PM2.5 and PM2.5 respectively (Yeatts
et al., 2012). Cohen et al. (2013) also found 1420 μg/m3 of PMs, includ-
ing PM2.5 and PM10, during the peak period of Arabian incense burning
in a living room. This habit is rampant and it deems as cultural practices
without any consideration for future health impacts since there are no
current regulations on the duration, intensity and type of incense burn-
ing in these countries (Vallès et al., 2019). For more than two months
now following the outbreak of COVID-19 disease from Wuhan, China,
the world including Middle East countries are still reporting of high
cases of COVID-19 disease with very low recovery rate (Worldometer,
2020). In the case of Middle East countries, it is imperative to assess
the impacts of PM emissions due to incense burning and the virus trans-
mission in indoor environments. Morawska and Cao (2020) have men-
tioned that there is a possibility of inhaling PM bearing solid materials
(with aerodynamic diameter of >5 μm) produced from virus-laden
droplets after evaporation. There is still an unanswered question
about whether indoor PM2.5 and PM10 emissions due to the burning of
incense could carry SARS-CoV-2 virus and increase the spread of
COVID-19 disease in Middle East countries?
While recent findings have demonstrated the transmission of the
virus through bioaerosols produced from an infected person (National
Research Council, 2020), it is important to critically evaluate how PM
emissions from incense burning could increase the spread of the virus.
In Italy, which was an epicenter for COVID-19 disease, the contribution
of daily ambient PM exposure levels and rate of the virus infections
were investigated. The study found a strong positive correlation (R² = 0.97) between a number of infected people with the virus and ex-
cedance of PM10 levels (50 μg/m³) across seven provinces based on
lag14 days (Setti et al., 2020). According to Gaddi and Capello (2020), the
virus infection could mimic the spread of other air pollution-
related diseases, and thus, SARS-CoV-2 virus droplets of 0.3–2.5 μm
and 2.5–10 μm could be carried by PM2.5 and PM10 respectively. There-
fore, indoor environments of Middle Eastern countries, where PM2.5 and
PM10 are mainly produced by incense burning (Amoatey et al., 2018;
Elsayed et al., 2016; Vallès et al., 2019), have the potential to spread
the virus despite lockdown strategies adopted by these countries. This
situation may be exacerbated as wearing of masks have not been cur-
rently regulated in homes and public places (malls, restaurants and of-
ices) in most Middle Eastern countries. Furthermore, the building
architectural design in these countries which do not support natural/
mechanical ventilation, may lead to buildup of PMs carrying virus dro-
plets/particles and increase the spread of the disease due to lack of
ventilation.
Based on the above pieces of evidence and assumptions, it is im-
perative for the governments of Middle Eastern countries to ac-
knowledge that SARS-CoV-2 virus prevention measures need to
also consider indoor local environmental conditions due to building
architectural designs and socio-cultural practices. It is highly recom-
manded that these countries need to recognize that lack of indoor
building ventilation, low indoor air temperature due to excessive
use of air conditioning systems and burning of incense (causing PM
emissions) will increase the infection of SARS-CoV-2 virus unless im-
mediate actions are taken. We advise that datasets that will be gath-
ered through research concerning the above potential cofounders in
the course of this pandemic will provide valuable knowledge on
combat the future viral outbreak.
To sum up, based on the theoretical knowledge from computational fluid dynamics, aerosol science and ventilation built environment technology, we wish to draw the hypothesis to Middle Eastern countries that PM emissions due to indoor burning of incense, poor building ventilation and low indoor temperature may increase the spread of SARS-CoV-2 virus. In view of this, we highly recommend the relevant government agencies and scientific research communities to assess these factors so as to better understand how they affect viral transmissions of the virus to help control of future viral infections.

Declaration of competing interest

Authors declared no potential conflict of interest.

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