Environmental Research 188 (2020) 109819

Contents lists available at ScienceDirect

Environmental Research

journal homepage: www.elsevier.com/locate/envres

Review article

Transmission of COVID-19 virus by droplets and aerosols: A critical review on the unresolved dichotomy

Mahesh Jayaweera[a,*], Hasini Perera[b], Buddhika Gunawardana[a], Jagath Manatunge[a]

[a] *Department of Civil Engineering, University of Moratuwa, Sri Lanka*
[b] *Department of Forestry and Environmental Science, University of Sri Jayewardenepura, Sri Lanka*

ARTICLE INFO

Keywords:
Airborne transmission
Coronavirus
Lockdown
Masks
SARS-CoV-2

ABSTRACT

The practice of social distancing and wearing masks has been popular worldwide in combating the contraction of COVID-19. Undeniably, although such practices help control the COVID-19 pandemic to a greater extent, the complete control of virus-laden droplet and aerosol transmission by such practices is poorly understood. This review paper intends to outline the literature concerning the transmission of virus-laden droplets and aerosols in different environmental settings and demonstrates the behavior of droplets and aerosols resulted from a cough-jet of an infected person in various confined spaces. The case studies that have come out in different countries have, with prima facie evidence, manifested that the airborne transmission plays a profound role in contracting susceptible hosts. The infection propensities in confined spaces (airplane, passenger car, and healthcare center) by the transmission of droplets and aerosols under varying ventilation conditions were discussed.

Interestingly, the nosocomial transmission by airborne SARS-CoV-2 virus-laden aerosols in healthcare facilities may be plausible. Hence, clearly defined, science-based administrative, clinical, and physical measures are of paramount importance to eradicate the COVID-19 pandemic from the world.

1. Introduction

Coronavirus disease 2019 (COVID-19) was first reported in Wuhan, China, in December 2019 (Chen et al., 2020). The disease is caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) (Gorbalenya, 2020) and asseverated to be transmitted from human-to-human by multiple means, namely, by droplets, aerosols, and fomites (Wang and Du, 2020). It has been more than 120 days that COVID-19, later declared as a pandemic and highly contagious, was first reported. As of May 05, 2020, there have been more than 3.5 million confirmed cases and 243,401 deaths by the COVID-19 disease worldwide (WHO, 2020a). COVID-19 infection triggers severe acute respiratory illness, with fever, cough, myalgia, and fatigue as common symptoms at the onset of illness (Huang et al., 2020; Judson and Munster, 2019; Nicas et al., 2005).

Infectious agents may spread from their natural reservoir to a susceptible host in different pathways. There are various classifications reported in the literature for modes of transmission of different infectious agents. Morawska (2006) has presented a classification for virus transmission, including human-human transmission, airborne transmission, and other means of transmission such as endogenous infection, common vehicle, and vector spread. However, many respiratory viruses are believed to transmit over multiple routes, of which droplet and aerosol transmission paths become paramount, but their significance in transmitting the disease remains unclear (Morawska and Cao, 2020; Shiu et al., 2019). In general, infected people spread viral particles whenever they talk, breathe, cough, or sneeze. Such viral particles are known to be encapsulated in globs of mucus, saliva, and water, and the fate/behavior of globs in the environment depends on the size of the globs. Bigger globs fall faster than they evaporate so that they splash down nearby in the form of droplets (Grayson et al., 2016; Liu et al., 2016). Smaller globs evaporate faster in the form of aerosols, and linger in the air, and drift farther away than the droplets do.

Respiratory particles may often be distinguished to be droplets or aerosols based on the particle size and specifically in terms of the aerodynamic diameter (Hinds, 1999). One could dispute that, unlike larger droplets, aerosols may pose a greater risk of the spread of the COVID-19 disease among many susceptible hosts positioned far from the point of origin. Nevertheless, it has been proven that viral disease outbreaks via aerosol transmission are not as severe as one would think, because of dilution and inactivation of viruses that linger for extended periods in the air (Shiu et al., 2019). There has been no discernible evidence on the minimum infectious viral load for COVID-19 pandemic,

* Corresponding author.
E-mail address: mahesh@guom.lk (M. Jayaweera).

https://doi.org/10.1016/j.envres.2020.109819
Received 7 May 2020; Received in revised form 1 June 2020; Accepted 10 June 2020
Available online 13 June 2020

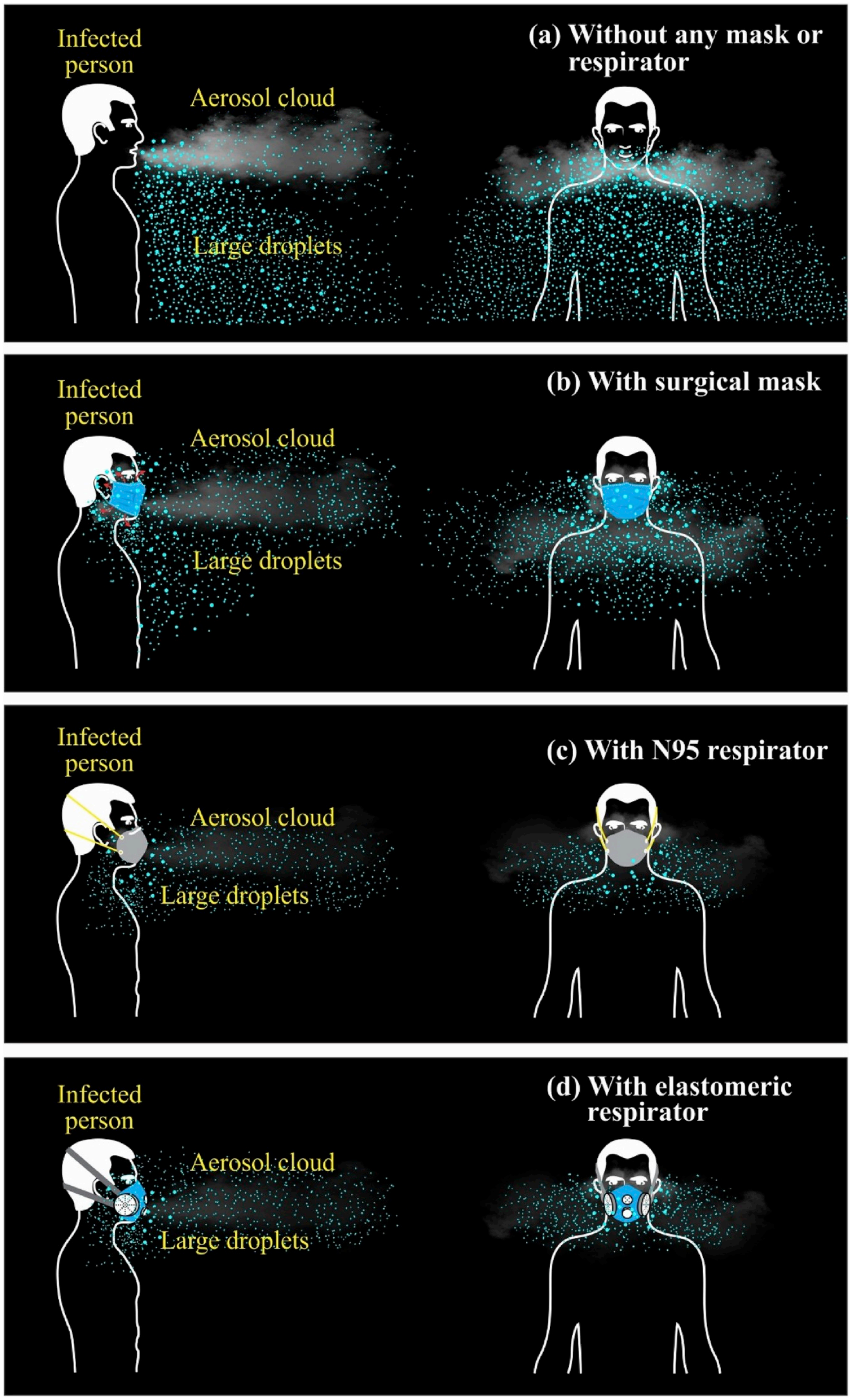

Fig. 3. Trajectories of droplets and aerosols from an infected patient in the event of coughing with different masks and respirators worn (a) without any mask or respirator (b) with surgical mask (c) with N95 respirator (d) with reusable elastomeric respirator.

dissipation of advective transport. Such movement supports an agglomeration of virus-laden aerosols in fomites at passenger levels. It is, therefore, crucial to decide by all airlines that such suspicious fomites such as papers, magazines, pillows, and blankets be disposed of perhaps subjected to thermal destruction until the COVID-19 pandemic recedes.

Fig. 5c illustrates how the cough-jet trajectory travels with the patient equipped with a surgical mask. With the surgical mask worn, the droplets are meant to travel up to one-two seats forward, and one seat backward. Such phenomena maybe because of the jet coming out from either side of the mask, as the mask is not tight enough on both sides. Nevertheless, the aerosol cloud will travel far from two seats front and one seat behind by the Brownian motion coupled with the airflow trajectories of the cabin. The streamlines of airflow are usually directed downward so that there will be a contribution of virus-laden aerosols back to the people on board. The illustration in Fig. 5d is more or less the same as that of 5c, with the exception that both droplets and aerosols do not travel far. With the N95 mask worn, an infected patient sheds droplets forward and backward by one seat and more than one seat for aerosols. The behavior of virus-laden aerosols resulted from a cough-jet has not yet been aerodynamically modeled with reasonable accuracy; hence, the actual level of impact that a single cough-jet envisages could not be simulated well. However, there exists evidence to