Airborne Transmission of COVID-19 articles

They Say Coronavirus Isn't Airborne—but It's Definitely Borne By Air

Roxanne Khamsi – Wired – March 14, 2020

- When health officials say coronavirus isn't "airborne," they're relying on a narrow definition of the term, and one that's been disputed by some leading scholars of viral transmission through the air.
- Droplets are often defined as being larger than 5 microns in diameter, and forming a direct spray that is propelled by cough or sneeze up to 2 meters away from the source patient. Aerosols, in this scenario, are smaller gobs of potentially biohazardous material that may remain afloat for longer distances.
- This 5-micron cutoff for droplets is arbitrary and ill-advised, according Lydia Bourouiba, whose lab at the Massachusetts Institute of Technology focuses on how fluid dynamics influence the spread of pathogens.
- Bourouiba's lab has found that coughs and sneezes, which they call "violent expiratory events," force out a cloud of air that carries droplets of various sizes much further than they would go otherwise.
- Whereas previous modeling might have suggested that 5-micron droplets can travel only a meter or two—as we've heard about the new coronavirus—her work suggests these same droplets can travel up to 8 meters when taking into account the gaseous form of a cough.
- No consensus among scientists as to which pathogens should be labeled airborne:
    - Julian Tang, a virologist at the University of Leicester in England, coauthored a review article last year noting that for some researchers, "airborne transmission" involves only fine aerosols. For others, it can involve both aerosols and larger droplets. Ultimately, in their paper, Tang and his colleagues settled on using the phrase to mean transmission by particles of fewer than 10 microns in diameter—a cutoff twice as large as what WHO has used.
    - Donald Milton, whose research at the University of Maryland School of Public Health includes studies of infectious bioaerosols, says that all these years later he and his peers are still trying to convince other scientists that influenza is substantially airborne. He published a paper in 2018 asserting that, contrary to what some might think, sneezing and coughing are not required for influenza virus to be released in an aerosol form that can float around.
- Re: airborne behavior of the new coronavirus:
    - A recent study published in the *Journal of the American Medical Association* on Mar. 4 looked at the hospital isolation rooms of three patients in Singapore with Covid-19. The study offered some solace because it didn't find evidence of the virus in air samples. However, the air vent blades in one patient's room did test positive.
    - A second study, described in a preprint paper published on Mar. 10, examined the hospital environments of Covid-19 patients in Wuhan, China. Although the levels of the microbe that causes Covid-19 in most rooms were undetectable or low, the study did find the presence of the virus in aerosol form.
    - Crucially, the hospital studies only looked for the genetic signature of the virus, as opposed to mixing the viral material with animal cells to see whether it would wreak havoc. As such they could not know whether the viral material present in the ventilation

system or the air was infectious. This is a critical point—virologists emphasize that the presence of residual RNA or DNA left by pathogens in no way guarantees that people might get sick from it
    - The question of whether the new coronavirus is infectious as an aerosol was explored in another paper posted as a preprint this week. In that study, scientists used a laboratory machine to force the virus into aerosolized form and then tracked it for 3 hours. They found the pathogen was still able to infect animal cells at the end of that timeframe, although there was substantially less of virus suspended in the air from one hour to the next.
- **These three new papers should not be over interpreted. Only one of them has been vetted by peer review. It also remains unclear, and undemonstrated, whether the Covid-19 virus released from patients' lungs comes out in aerosol form; whether aerosolized particles of this virus travel significant distances; and, if so, whether they do so in sufficient number to cause infection.
- Notably, while the joint WHO-China mission report published in late-February said that although airborne particles were "not believed to be a major driver of transmission," it noted that such a mode "can be envisaged if certain aerosol-generating procedures are conducted in health care facilities."

COMMENTARY: COVID-19 transmission messages should hinge on science

Lisa Brosseau, ScD – March 16, 2020

Dr. Brosseau is a national expert on respiratory protection and infectious diseases and professor (retired), University of Illinois at Chicago

- Argues that there are no studies, yet, to support any particular mode of transmission over another. Short-range aerosol transmission is also a strong possibility and must be considered.
- To strategically protect health workers during aerosol-generating procedures, the CDC should be recommending respirators with higher levels of protection than an N95 filtering face piece respirator (e.g., a powered air-purifying respirator).
- Recommends that healthcare organizations and public health agencies consider the utility of reusable respirators, such as elastomeric respirators more commonly found in industrial settings.
- Underlying the CDC and WHO statements about transmission is this: Inhalation of particles near the source may be an important mode of transmission – and inhalation is not considered part of the traditional definition of droplet transmission.
    - In risk communication guidelines for healthcare the WHO states, "COVID-19 appears to spread most easily through close contact with an infected person. When someone who has COVID-19 coughs or sneezes, small droplets are released and, if you are too close, *you can breathe in the virus*" (emphasis added).
    - For the general public, the CDC describes SARS-coV-2 transmission as primarily by droplets from coughs or sneezes, which "land in the mouths or noses of people who are nearby *or possibly inhaled into the lungs*" (emphasis added).***But, again,*** inhalation is a new addition to the traditional definition of droplets. In contrast to its recommendations for healthcare, the CDC makes no mention of airborne transmission in public settings.

- The CDC admits there's some possibility that COVID-19 may be transferred by hands to mouth, nose, or eyes from contaminated surfaces, but notes that "this is not thought to be the main way the virus spreads."
- The Chinese Center for Disease Control and Prevention says that COVID-19 transmission occurs primarily by respiratory droplets and close contact, with the "possibility of aerosol transmission in a relatively closed environment for a long time exposure to high concentrations of aerosols."
- Infectious aerosols are inhalable: Contrary to popular belief, the larger particles (5 to 15 micrometers [μm]) will not immediately drop to the ground but will remain airborne for several minutes. Smaller particles (less than 5 μm) will remain in the air for many minutes or even hours.
- All particles will immediately begin to evaporate (mucus contains a lot of water), which means the range of particle sizes will decrease overall. Smaller particles are more affected by diffusion than gravity, thus making them more likely to remain airborne. In the absence of air currents, airborne particles will disperse slowly throughout a space.
- All of the particle sizes in a typical cough or sneeze are inhalable.
- The Wuhan China experience supports likelihood of close-range aerosol transmission – Wuhan deployed a tiered hospital model, similar to that used for Ebola patients in the US. Patients with severe or critical symptoms were moved into designated wards or hospitals while those with mild symptoms were cohorted in temporary hospitals in repurposed buildings.
- Science shows that droplet transmission is probably much less important for most respiratory infectious diseases than is short-range aerosol transmission by inhalation.
- What aerosol transmission with other diseases can tell us: TB and measles remain viable in the air for long periods. The viability dissipates with time, not distance. Therefore, diseases that are considered "airborne" must also be capable of transmitting the disease by inhalation of aerosols near the source.
- Healthcare workers are most at risk due to close proximity. As of early Feb 2020, more than 3,000 healthcare workers were believed to have contracted COVID19 and at least 6 died.
- Reports of healthcare worker infections in long-term care in the US and employees on cruise ships, are suggestive of both short and long range aerosol transmission in healthcare and other work settings.

Violent expiratory events: on coughing and sneezing

Lydia Bourouiba, Eline Dehandschoewercker, and John W. M. Bush
Published online by Cambridge University Press: 24 March 2014

- This study argues that coughs and sneezes (referred to as violent respiratory events) play a key role in transferring respiratory diseases between infectious and susceptible individuals.
- Direct observation of sneezing and coughing events reveals that such flows are multiphase turbulent buoyant clouds with suspended droplets of various sizes. Previously, it was thought to be groups of unconnected particles.
- Confined environments, such as airplanes, hospitals and schools, serve as mixers where pathogens can stay suspended and spread from host to host. Hence, understanding the dynamics of pathogens indoors is critical to improving the modelling and control of epidemics (Settles 2006; Tang et al. 2006; Weber & Stilianakis 2008).

- Key findings: The turbulent multiphase cloud plays a critical role in *extending the range* of the majority of pathogen-bearing drops that accompany human coughs and sneezes.
- Smaller droplets (less than 50 mm diameter) can remain suspended in the cloud long enough for the cough to reach heights where ventilation systems can be contaminated (4–6 m).

Infectious virus in exhaled breath of symptomatic seasonal influenza cases from a college community

Jing Yan, Michael Grantham, Jovan Pantelic, P. Jacob Bueno de Mesquita, Barbara Albert, Fengjie Liu, Sheryl Ehrman, Donald K. Milton, and EMIT Consortium

Proceedings of the National Academy of Sciences January 30, 2018 115 (5) 1081-1086; first published January 18, 2018

- This study looks at the amount and infectiousness of influenza virus in exhaled breath.
- Recent reports have shown that infectious influenza virus can be recovered from exhaled aerosols.
- These studies, based on small numbers of cases or artificial breathing maneuvers, do not provide sufficient data to quantify the extent of aerosol shedding during natural breathing, nor do they identify the contributions of spontaneous coughs and sneezes commonly thought to be the most important mechanism for viral shedding, or identify other factors that may impact viral aerosol shedding.
- This study found overwhelming evidence that humans generate infectious aerosols and quantitative data to improve mathematical models of transmission and public health interventions.
- Sneezing is rare and not important for—and that coughing is not required for—influenza virus aerosolization.
- Upper and lower airway infection are independent and that fine-particle exhaled aerosols reflect infection in the lung, opened a pathway for a deeper understanding of the human biology of influenza infection and transmission.
- Observation of an association between repeated vaccination and increased viral aerosol generation demonstrated the power of our method, but needs confirmation.

An outbreak of influenza aboard a commercial airliner

Moser MR, Bender TR, Margolis HS, Noble GR, Kendal AP, Ritter DG.

July 1979 – American Journal of Epidemiology

- This report presents an outbreak of influenza that occurred in Alaska in March, 1977, among passengers and crew aboard a commercial jet aircraft following exposure to an acutely ill patient.
- The plane was en route from Anchorage to Kodiak with an intermediate stop in Homer. It had a 56-passenger compartment.
- In Homer, 31 persons boarded. Among them was a 21-year-old woman (referred to as the index case) who became acutely ill with fever, chills, and cough 15 minutes after boarding. She continued to have a severe cough while remaining on the airplane throughout the delay and also during her subsequent trip directly to Kodiak from Homer.

- During takeoff, the airplane's left engine failed and takeoff was aborted without injury. During the delay, thirty persons (including the index case) remained on board, while the other 23 left and returned for varying periods of time.
- The clinical attack rate among the other passengers varied with the amount of time spent aboard. Those passengers aboard the airplane for more than three hours had the highest attack rate (86%). Those aboard for 1-3 hours had an attack rate of 56% and those aboard for less than one hour had an attack rate of 53%.
- Influenza most commonly spreads from person to person. This case suggests a common-source, single exposure epidemic.
- Following engine failure, the ventilation system was turned off and the doors were kept closed for approximately two hours. Later, when the front cargo and rear passenger compartment doors were opened, most passengers felt that the compartment was comfortable or warm although the outside temperature was 1.7 C (29 F), suggesting that there was poor air exchange.
- Although influenza virus was not recovered from the index case, she had a greater than 4-fold rise in antibody titer to A/Alaska/77 (the virus). Prior to boarding the airplane, she had no known contact with influenza, but she and her preflight contacts became ill with influenza-like illness almost simultaneously.
- Spread of influenza virus is via droplets or droplet nuclei (9), and the period of infectivity of these particles is prolonged by low humidity (10). The high clinical attack rate among passengers aboard the aircraft was probably the result of their exposure to large aerosols of droplets produced by an ill passenger in a confined, stagnant and dry airspace.
- Proper operation of the air circulation equipment and isolation of the ill passenger might have prevented spread of the influenza virus.

Detection of airborne severe acute respiratory syndrome (SARS) coronavirus and environmental contamination in SARS outbreak units.

Booth TF[1], Kournikakis B, Bastien N, Ho J, Kobasa D, Stadnyk L, Li Y, Spence M, Paton S, Henry B, Mederski B, White D, Low DE, McGeer A, Simor A, Vearncombe M, Downey J, Jamieson FB, Tang P, Plummer F.

J Infect Dis. 2005 May 1;191(9):1472-7. Epub 2005 Mar 18

- This study looks at the risk of airborne transmission of SARS.
- Health-care workers were infected, particularly when performing procedures such as intubations of patients with SARS. This happened even with infection control precautions in place, including the use of negative-pressure isolation rooms; N95 or equivalent respiratory protection; gloves, gowns, and eye protection; and careful hand hygiene.
- The pattern of spread of SARS associated with sick patients traveling on aircraft suggested that airborne transmission may have occurred during the flights.
- Recently, a study using modeling of airflow dynamics suggested that airborne transmission could account for transmission patterns of SARS in a multiple high-rise apartment building complex in Hong Kong.
- During the Toronto outbreaks of SARS, researchers investigated environmental contamination in SARS units, by employing novel air sampling and conventional surface swabbing.

- Two polymerase chain reaction (PCR)–positive air samples were obtained from a room occupied by a patient with SARS, indicating the presence of the virus in the air of the room.
- In addition, several PCR-positive swab samples were recovered from frequently touched surfaces in rooms occupied by patients with SARS (a bed table and a television remote control) and in a nurses' station used by staff (a medication refrigerator door).
- This data provide the first experimental confirmation of viral aerosol generation by a patient with SARS, indicating the possibility of airborne droplet transmission, which emphasizes the need for adequate respiratory protection, as well as for strict surface hygiene practices.
- Results do not document any cases of airborne transmission of the SARS virus from one person to another, only the dissemination of the virus from an infected patient to the air, via breathing or coughing.

Air, Surface Environmental, and Personal Protective Equipment Contamination by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) From a Symptomatic Patient
SeanWei Xiang Ong, MBBS, Yian Kim Tan, PhD, Po Ying Chia, MBBS, Tau Hong Lee, MBBS, Oon Tek Ng, MBBS, MPH, Michelle Su YenWong, PhD, Kalisvar Marimuthu, MBBS
American Medical Association – March 4, 2020

- Coronaviruses have been implicated in nosocomial outbreaks with environmental contamination as a route of transmission. Similarly, nosocomial transmission of severe acute respiratory syndrome coronavirus (SARS-CoV-2) has been reported. However, the mode of transmission and extent of environmental contamination are unknown
- From January 24 to February 4, 2020, looked at the hospital isolation rooms of three patients in Singapore with Covid-19.
- The Air samples were negative despite the extent of environmental contamination.
- Swabs taken from the air exhaust outlets tested positive, suggesting that small virus-laden droplets may be displaced by airflows and deposited on equipment such as vents.
- This study has several limitations. First, viral culture was not done to demonstrate viability. Second, due to operational limitations during an outbreak, methodology was inconsistent and sample size was small. Third, the volume of air sampled represents only a small fraction of total volume, and air exchanges in the room would have diluted the presence of SARS-CoV-2 in the air. Further studies are required to confirm these preliminary results.
- Significant environmental contamination by patients with SARS-CoV-2 through respiratory droplets and fecal shedding suggests the environment as a potential medium of transmission and supports the need for strict adherence to environmental and hand hygiene.