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Airborne Transmission: A Clinical Review

A summary of excerpts and findings from published research papers demonstrating the significance of airborne transmission and the importance of treating the air in the fight against the spread of infection.

AIRBORNE TRANSMISSION

"More than one-third of all nosocomial infections possibly involve airborne transmission at some point."

(Kowalski, 2007)

"One of the challenges facing practitioners, particularly in an enclosed building, is that even large-sized droplets can remain suspended in air for long periods."

(Fernstrom and Goldblatt, 2013)

"Airborne transmission accounts for 20%–24% of post-operative wound infections."

(Kundsin, 1980)

"Indoor air can be an important vehicle for a variety of human pathogens."

"Emerging pathogens, such as noroviruses and *Clostridium difficile*, have also been detected in indoor air, with a strong potential for airborne dissemination. Pathogens discharged into the air may settle on environmental surfaces, which could then become secondary vehicles for the spread of infectious agents indoors."

"The possible transmission of drug-resistant bacteria by indoor air adds another cause for concern. A combination of on-going societal changes is adding further to the potential of air as a vehicle for infectious agents. The quality of indoor air is therefore a prominent public health concern that requires a clear understanding of the transmission processes for the development and implementation of targeted infection prevention and control measures."

(Ijaz et al., 2016)

"Air, in general, is crucial to the establishment and maintenance of the indoor microbiome, and the continual redistribution of microbes indoors occurs at the air-surface-nexus."

"Although classic airborne spread of pathogens occurs via droplet nuclei, droplets can potentially contaminate environmental surfaces, depending on their size and prevailing environmental conditions, thereby creating secondary vehicles for pathogens."

"Therefore, targeting airborne pathogens could potentially provide an additional advantage by reducing environmental surface contamination."

(Ijaz et al., 2016)

"Droplet nuclei (0.1–5.0 μm) are emitted that carry pathogens and can stay airborne for extended periods of time, traveling great distances. These droplet nuclei can subsequently be inhaled by an uninfected recipient, resulting in secondary infection."

(Fiegel et al., 2006)

"Droplet nuclei produced during respiration, talking, coughing and sneezing from such patients are very small, less than 5 μm in diameter, and behave similarly to smoke particles in air."

"Large droplets may become small droplets then droplet nuclei via the process of evaporation. This may explain why some infectious agents, normally only associated with short-range transmission, may occasionally cause outbreaks over greater distances."

(Tang et al. 2006)

"The concept of aerosol transmission is of primary importance to occupational health and will enable physically accurate communication about exposure and intervention selection."

"Recognizing a pathogen as having the potential to be transmitted through the aerosol route should trigger consideration for controls, such as respiratory protection, that limit workers' exposures when in proximity to infectious patients, regardless of evidence for airborne transmission."

(Jones and Brosseau, 2015)

Mechanics of aerosol transmission of infectious agents:

"Particles of diameters 1-3 μm remained suspended almost indefinitely, 10 μm took 17 min, 20 μm took 4 min, and 100 μm took 10 s to fall to the floor."

(Tang et al. 2006)

AIRBORNE TRANSMISSION OF BACTERIA AND MOULD SPORES

"In conclusion, MRSA was recovered from either patients or their environment on 50% of sampling occasions with patterns suggesting dispersal from patients to the surrounding air. This suggests that aerial transmission from patient to patient maybe common."

(Creamer et al., 2014)

"MRSA can be found in the air around those who are colonised or infected with the organism. The degree of airborne contamination is significantly increased with activities such as bed making that promote airflow."

"It is significant to note that the current general cleaning practices utilised in the clinical areas investigated in the included studies are not sufficient to remove MRSA."

(Halcomb, Griffiths and Fernandez, 2008)

"Environmental contamination is known to play an important contributory role in the spread of CDAD and it is suspected that contamination might be occurring as a result of aerial dissemination of *C. difficile* spores."

(Roberts et al., 2008)

"Environmental decontamination focusing on surfaces will not fully prevent *A. baumannii* transmission.

""What goes up must come down," and it seems likely that *A. baumannii* in the air above and around patients has the potential to contribute to infection transmission in several ways."

1) by recontaminating surfaces in a room after environmental services personnel have disinfected those surfaces, but not the air in the room;

2) by spreading organisms from one colonization site on a patient to multiple sites on the same patient, as airborne bacteria settle out of the air;

3) by airborne contamination of healthcare providers' clothes and hands, even if adequate hand hygiene is done before entering the room;

4) by airborne contamination of medical instruments (e.g., portable x-ray devices and wheelchairs) that travel from room to room and are not cleaned between rooms."

(Spellberg and Bonomo, 2013)

"In this study, we confirmed that MRSA could be acquired by medical staff and patients through airborne transmission. The findings suggest the importance of protecting patients against cross infectious agents existing in aerosols."

(Shiomori, Miyamoto and Makishima, 2001)

"Aerosolization of *C. difficile* occurs commonly but sporadically in patients with symptomatic CDI. This may explain the widespread dissemination of epidemic strains."

"Activities known to liberate particles into the air, such as bed making and curtain drawing, as well as contact with these items may contribute to the spread and aerosolization of *C. difficile*."

(Best et al., 2010)

"In all but one outbreak, air was the route of fungal spore transmission and the major site of primary infection (356 patients) was the lower respiratory tract."

"Routes of aspergillus transmission in nosocomial outbreaks other than airborne spores are rarely described."

"Even concentrations of *Aspergillus* spp. below 1 colony-forming unit/m^3 were sufficient to cause infection in high-risk patients. Virtually all outbreaks of nosocomial aspergillosis are attributed to airborne sources, usually construction."

(R-P. Vonberg and Gastmeier, 2006)

AIRBORNE TRANSMISSION OF VIRUSES

"It is now recognized that vomiting with airborne norovirus dispersion is an important route of virus dissemination."

(Said, Perl and Sears, 2008)

"Our results suggest that aerosol transmission is an important mode and possibly the predominant mode of influenza A virus transmission in households. Aerosol transmission was estimated to account for approximately half of all transmission events."

(Cowling et al., 2013)

"Influenza virus can be transmitted by air. Breathing, talking, coughing, and sneezing release influenza virus into air, with sizes ranging from submicron particles (during breathing) to large droplets (during coughing/sneezing)."

"The size of airborne particles determines how influenza virus is transmitted. Large particles (diameter, 20 μm) have limited travel distance, while smaller particles (diameter, <5 μm) stay airborne loner and spread widely. We found that up to 89 percent of influenza virus–carrying particles were <4.7 μm in diameter."

(Bischoff et al., 2013)

"The detection of significant concentrations of human norovirus genomes in the air of corridors and nursing stations suggests that they can remain suspended in the air for prolonged periods of time. This provides additional support to the hypothesis that human norovirus may be an airborne disease.

Although norovirus is an intestinal pathogen, noroviruses could be transmitted through the airborne route and subsequently could, if inhaled, settle in the pharynx and later be swallowed.

The findings presented in this report suggest that air may be an important but yet underappreciated mode of transmission of norovirus and may explain in part the well-known difficulty of controlling norovirus outbreak."

(Bonifait et al., 2015)

"Detection of influenza virus RNA in aerosols at low concentrations in patient rooms suggests that healthcare workers and visitors might have frequent exposure to airborne influenza virus in proximity to infected patients."

(Leung et al., 2016)

Bibliography

Best, E., Fawley, W., Parnell, P. and Wilcox, M. (2010). The Potential for Airborne Dispersal of Clostridium difficile from Symptomatic Patients. *Clinical Infectious Diseases,* 50(11), pp.1450-1457.

Bischoff, W., Swett, K., Leng, I. and Peters, T. (2013). Exposure to Influenza Virus Aerosols During Routine Patient Care. *The Journal of Infectious Diseases,* 207(7), pp.1037-1046.

Bonifait, L., Charlebois, R., Vimont, A., Turgeon, N., Veillette, M., Longtin, Y., Jean, J. and Duchaine, C. (2015). Detection and Quantification of Airborne Norovirus During Outbreaks in Healthcare Facilities. *Clinical Infectious Diseases,* 61(3), pp.299-304.

Cowling, B., Ip, D., Fang, V., Suntarattiwong, P., Olsen, S., Levy, J., Uyeki, T., Leung, G., Malik Peiris, J., Chotpitayasunondh, T., Nishiura, H. and Mark Simmerman, J. (2013). Aerosol transmission is an important mode of influenza A virus spread. *Nature Communications,* 4.

Creamer, E., Shore, A.C., Deasy, E.C., Galvin, S., Dolan, A., Walley, N., McHugh, S., Fitzgerald-Hughes, D., Sullivan, D.J., Cunney, R., Coleman, D.C. and Humphreys, H. (2014). Air and surface contamination patterns of methicillin-resistant Staphylococcus aureus on eight acute hospital wards. *Journal of Hospital Infection,* 86(3), pp.201–208.

Fernstrom, A. and Goldblatt, M. (2013). Aerobiology and Its Role in the Transmission of Infectious Diseases. *Journal of Pathogens*, 2013, pp.1-13.

Fiegel, J., Clarke, R., Edwards D.A. (2006) Airborne infectious disease and the suppression of pulmonary bioaerosols. *Drug Discovery Today*, pp. 51 – 57.

Halcomb, E., Griffiths, R. and Fernandez, R. (2008). Role of MRSA reservoirs in the acute care setting. *International Journal of Evidence-Based Healthcare*, 6(1), pp.50-77.

Ijaz, M., Zargar, B., Wright, K., Rubino, J. and Sattar, S. (2016). Generic aspects of the airborne spread of human pathogens indoors and emerging air decontamination technologies. *American Journal of Infection Control*, 44(9), pp. S109-S120.

Jones, R. and Brosseau, L. (2015). Aerosol Transmission of Infectious Disease. *Journal of Occupational and Environmental Medicine,* 57(5), pp.501-508.

Kowalski WJ. (2007). Air-treatment systems for controlling hospital-acquired infections. *HPAC Engineering,* 79(1), pp. 28–4.

Kundsin, R. (1980). Documentation of airborne infection during surgery. *Annals of the New York Academy of Sciences,* 353(1), pp.255-261.

Leung, N., Zhou, J., Chu, D., Yu, H., Lindsley, W., Beezhold, D., Yen, H., Li, Y., Seto, W., Peiris, J. and Cowling, B. (2016). Quantification of Influenza Virus RNA in Aerosols in Patient Rooms. *PLOS ONE*, 11(2), p.e0148669.

Roberts, K., Smith, C., Snelling, A., Kerr, K., Banfield, K., Sleigh, P. and Beggs, C. (2008). Aerial Dissemination of Clostridium difficile spores. *BMC Infectious Diseases,* 8.

R-P. Vonberg and Gastmeier, P. (2006). Nosocomial aspergillosis in outbreak settings. *Journal of Hospital Infection,* 63(3), pp.246–254.

Said, M., Perl, T. and Sears, C. (2008). Healthcare Epidemiology: Gastrointestinal Flu: Norovirus in Health Care and Long Term Care Facilities. *Clinical Infectious Diseases,* 47(9), pp.1202-1208.

Shiomori, T., Miyamoto, H. and Makishima, K. (2001). Significance of Airborne Transmission of Methicillin-Resistant Staphylococcus aureus in an Otolaryngology–Head and Neck Surgery Unit. *Archives of Otolaryngology–Head & Neck Surgery,* 127(6), p.644.

Spellberg, B. and Bonomo, R. (2013). "Airborne Assault". *Critical Care Medicine,* 41(8), pp.2042-2044.

Tang, J.W., Li, Y., Eames, I., Chan, P.K.S., Ridgway,G.L. (2006) Factors involved in the aerosol transmission of infection and control of ventilation in healthcare premises. *Journal of Hospital Infection,* 64 pp. 100 -114.

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