World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-51 October 2025
ISSN: 2749-3644

EPIDEMIOLOGICAL CHARACTERISTICS OF AIRBORNE DROPLET INFECTIONS

Kuchkorova Munavvar Fakhriddin Qizi
Faculty of Advanced Training and Retraining of Physicians,
Department of Pediatric Endocrinology, Phthisiology, Infectious Diseases, and Epidemiology, Assistant PhD

Article history:

Received: September 28th 2025
Accepted: October 26th 2025

Abstract:

Airborne droplet infections represent a significant mode of transmission for many respiratory pathogens. These infections occur when respiratory secretions—such as from coughing, sneezing, talking or singing—produce droplets and droplet nuclei that contain infectious agents. The size, evaporation and transport dynamics of these particles are critical in determining their infectious potential. Smaller droplets may evaporate rapidly, forming droplet nuclei that remain suspended in air for extended periods and travel beyond short-range distances, while larger droplets settle quickly. Factors such as indoor airflows, humidity, ventilation, crowding and susceptibility of hosts influence epidemiological characteristics. Key features include rapid person-to-person spread in closed environments, variable incubation periods, and the possibility of asymptomatic or pre-symptomatic transmission. Understanding these dynamics is crucial for preventive measures including masks, ventilation improvements, distancing and hygiene. This review outlines the epidemiological features of airborne droplet infections, describing pathogen sources, modes of transmission, environmental and host factors impacting spread, and implications for control and prevention.

Keywords: airborne transmission, droplet nuclei, respiratory infections, epidemiology, ventilation, humidity, coughing, sneezing, indoor transmission, infection control, aerosols, transmission dynamics.

INTRODUCTION

Airborne droplet infections refer to diseases transmitted via respiratory secretions that are expelled into the air in the form of droplets or droplet nuclei and subsequently inhaled or contact the mucosa of a susceptible person. According to epidemiological textbooks, airborne transmission is defined as infection spread by droplet nuclei or dust-borne particles that can travel more than about 1 m from the source and remain suspended in the air for a prolonged time. In contrast, classical droplet transmission involves larger particles (>5-10 μm) that fall to the ground within short distances (typically <1 m) and settle rapidly. The distinction between airborne and droplet modes is relevant for infection control, yet the boundary is not strictly dichotomous: particles form a continuum and environmental conditions (humidity, airflow) affect their behavior.

Epidemiologically, airborne droplet infections often exhibit the following: localization of the infectious process in the respiratory tract; production of droplets via coughing/sneezing; dissemination of pathogens into the environment; inhalation by susceptible hosts; and rapid spread in enclosed or crowded settings. Given their public health relevance (e.g., Measles, Tuberculosis, COVID-19), a clear understanding of their epidemiological features is essential for prevention and control. Airborne droplet infections constitute one of the most important and challenging mechanisms of infectious disease transmission in both community and healthcare settings. They are primarily spread through respiratory secretions expelled by infected individuals during activities such as coughing, sneezing, talking, or even breathing. These secretions produce particles of varying sizes that can carry pathogenic microorganisms, including bacteria, viruses, and fungi. Depending on their diameter, these particles either settle quickly on surfaces (large droplets) or remain suspended in the air as droplet nuclei and aerosols, which may travel significant distances and be inhaled by susceptible hosts. The classical distinction between "droplet" and "airborne" transmission has long guided infection control. Droplet transmission traditionally refers to particles larger than 5–10 μm that travel short distances (usually less than one meter), while airborne transmission involves particles smaller than 5 μm that can remain suspended for extended periods and spread over longer ranges. However, this distinction is increasingly recognized as a simplification because respiratory particles exist along a continuum. Factors such as airflow, relative humidity, temperature, and human behavior can alter droplet behavior and

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-51 October 2025
ISSN: 2749-3644

infectious potential. From an epidemiological perspective, airborne droplet infections are characterized by their rapid spread, particularly in enclosed or poorly ventilated spaces, and their ability to cause outbreaks with high secondary attack rates. Diseases such as tuberculosis, measles, influenza, and COVID-19 exemplify the global significance of airborne droplet transmission. These pathogens can persist in droplet nuclei or aerosols for varying durations, depending on environmental stability and humidity levels, making indirect exposure a major concern. Host susceptibility, pathogen virulence, and environmental conditions all influence the dynamics of transmission. For example, the measles virus can remain viable in the air for up to two hours after an infected person leaves the area, while Mycobacterium tuberculosis can survive in droplet nuclei for extended periods under dry conditions. Such features make control challenging, as infection may occur without direct physical contact. he COVID-19 pandemic has further emphasized the importance of understanding airborne transmission pathways. It demonstrated that normal speech, singing, and breathing could generate aerosols capable of carrying infectious viral particles, leading to transmission even in the absence of coughing or sneezing. These findings have reshaped the understanding of respiratory disease epidemiology and highlighted the need for integrated control strategies combining personal protection, ventilation, and environmental disinfection. Overall, studying the epidemiological characteristics of airborne droplet infections is essential for improving infection prevention, outbreak management, and public health preparedness. This paper analyzes the key epidemiologic features, transmission mechanisms, and influencing factors of airborne droplet infections, emphasizing the implications for infection control in both healthcare and community environments.

METHODS

This review draws on published peer-reviewed literature and authoritative public health guidance relating to respiratory droplet and airborne transmission. Databases such as PubMed and PMC were consulted for empirical and review articles examining droplet evaporation, sedimentation, transport, and infection-risk modelling (for example studies on droplet behaviour in indoor environments). Specific attention was given to physical-chemical modelling of droplet evaporation and sedimentation times, reviews on humidity effects, and epidemiologic descriptions of transmission dynamics in outbreaks. For broader epidemiologic context, standard textbooks of infectious disease epidemiology were used. Data were synthesized qualitatively, focusing on key determinants of spread, typical patterns, and environmental/host factors rather than meta-analysis of quantitative incidence. This paper is a qualitative literature-based review designed to synthesize current knowledge about the epidemiological characteristics of airborne droplet infections. A comprehensive literature search was conducted between 2015 and 2024 using databases such as PubMed, Scopus, ScienceDirect, and Google Scholar. Key search terms included *"airborne transmission," "droplet nuclei," "respiratory infection epidemiology," "ventilation," "humidity,"* and *"infection control."* Both peer-reviewed research articles and official public health documents were included. Selection criteria focused on studies that analyzed the physical and biological aspects of airborne droplet transmission, environmental influences, epidemiologic patterns, and preventive measures. Research on classical airborne diseases (e.g., tuberculosis, measles) and emerging respiratory infections (e.g., influenza, SARS-CoV-2) was prioritized. Articles written in English and published in reputable journals such as *The Lancet*, *Nature*, *Indoor Air*, and *BMC Infectious Diseases* were included.

Data from selected studies were reviewed and categorized into four thematic domains:

- **Droplet and aerosol generation:** How respiratory activities create infectious particles.
- **Environmental factors:** Effects of humidity, ventilation, and temperature on particle behavior.
- **Epidemiological patterns:** Outbreak characteristics, secondary attack rates, and population susceptibility.
- **Preventive measures:** Engineering and behavioral interventions to reduce transmission.

The analysis used a descriptive and comparative approach. Quantitative findings such as particle size distributions, air suspension times, and infection rates were summarized but not meta-analyzed. Priority was given to conceptual synthesis to highlight mechanisms and control implications. To ensure data reliability, only studies that reported clear methodologies and used validated detection or modeling techniques were included. Institutional guidelines from the **World Health Organization (WHO)** and the **Centers for Disease Control and Prevention (CDC)** were also reviewed for standard definitions and infection control recommendations. This methodological approach allows for a comprehensive understanding of airborne droplet infection dynamics from both epidemiologic and environmental perspectives. The combination of empirical data and theoretical models supports a robust discussion of transmission mechanisms and prevention strategies applicable to healthcare and community settings.

RESULTS

Pathogen source and droplet generation

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-51 October 2025
ISSN: 2749-3644

Respiratory activities such as coughing, sneezing, talking and breathing generate droplets of a wide size range from <1 μm up to several hundred μm. For example, cough-generated droplet nuclei concentration for influenza have been measured in size ranges 0.3–0.4 μm, 0.4–0.5 μm, 0.5–1 μm and 1–5 μm, with high number concentrations in the smallest size ranges. These droplets may contain infectious viruses or bacteria shed from the upper or lower respiratory tract of an infected person.

Droplet behaviour: evaporation, sedimentation & transport

Physical-chemical factors determine how long droplets remain suspended before settling or evaporating to droplet nuclei. Small droplets (<5 μm) may evaporate rapidly, forming droplet nuclei that remain airborne for hours, significantly increasing infection risk. Relative humidity plays a key role: low indoor humidity favours evaporation and suspension of droplet nuclei, prolonging airborne lifespan. Airflow, human body plumes, ventilation and building design also influence droplet dispersion in indoor settings.

Transmission dynamics and epidemiologic patterns

Airborne droplet infections often spread rapidly in enclosed, poorly ventilated spaces. The capacity of small particles to travel beyond 1–2 meters means traditional "short range only" assumptions may underestimate risk. Certain pathogens are classically airborne: for example Mycobacterium tuberculosis (via droplet nuclei) and measles virus (which remains viable in droplet nuclei long enough to infect after source leaves the room). For other respiratory infections (e.g., influenza, SARS-CoV-2) the dominant route may still be droplets but aerosol/airborne spread under specific conditions (crowding, poor ventilation) has been documented. Host susceptibility (immunocompromise, age, comorbidities), exposure duration, crowding, and environmental factors (ventilation, humidity) all modify risk.

1. Droplet generation and composition

Respiratory activities such as coughing, sneezing, talking, and even breathing produce droplets that vary in size from less than 1 μm to over 500 μm. Studies show that approximately 80% of these particles are under 5 μm, allowing them to remain airborne longer and reach the lower respiratory tract of exposed individuals. Coughing and sneezing generate turbulent jets capable of propelling droplets several meters, while smaller aerosols may linger in stagnant air for hours. These droplets contain mucus, water, salts, and pathogenic microorganisms, whose survival depends on relative humidity and temperature.

2. Environmental influences on droplet behavior

Humidity and air movement are critical determinants of droplet evaporation and sedimentation. At low relative humidity (<40%), droplets rapidly evaporate into droplet nuclei, prolonging airborne survival of pathogens such as influenza virus and Mycobacterium tuberculosis. Conversely, high humidity (>80%) causes droplets to grow and settle faster. Ventilation rate and airflow direction greatly affect the spread of airborne particles: poorly ventilated spaces promote accumulation and increase infection risk, while systems with ≥6 air changes per hour significantly reduce airborne concentrations.

3. Epidemiological patterns and transmission dynamics

Airborne droplet infections demonstrate rapid person-to-person transmission, particularly in closed or crowded environments such as hospitals, schools, and public transportation. The secondary attack rate can exceed 80% for highly infectious agents like measles. COVID-19 outbreaks on cruise ships and airplanes highlighted the ability of small aerosols to travel beyond two meters, contradicting earlier assumptions about limited droplet range. Host factors such as age, immune status, and comorbidities influence susceptibility, while asymptomatic carriers play a substantial role in silent transmission chains.

4. Pathogen examples and persistence

Measles virus, varicella-zoster virus, and Mycobacterium tuberculosis are classical airborne pathogens capable of surviving in droplet nuclei for hours. Influenza and SARS-CoV-2 show hybrid transmission behavior—predominantly droplet-based but capable of aerosol spread under certain environmental conditions. Laboratory studies confirm that SARS-CoV-2 can remain viable in aerosols for up to three hours at 40% humidity, underscoring the role of airborne spread.

5. Prevention and control implications

Effective prevention requires a combination of environmental engineering and behavioral interventions. Strategies include increasing ventilation and filtration efficiency, using HEPA filters, maintaining indoor humidity between 40–60%, enforcing mask use, and reducing crowding. In healthcare settings, N95 respirators and negative-pressure isolation rooms are essential for airborne pathogens. Public education on respiratory hygiene and early case detection remain cornerstones of community control.

Collectively, these findings emphasize that airborne droplet infections are influenced by complex physical, biological, and environmental interactions. Understanding these mechanisms is crucial for developing targeted interventions and improving preparedness for future respiratory pandemics.

DISCUSSION

The epidemiological characteristics of airborne droplet infections highlight a complex interplay of

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-51 October 2025
ISSN: 2749-3644

microbiologic, physical, environmental and host factors. The traditional demarcation between droplet (>5-10 μm) and airborne (<5 μm) transmission has been found overly simplistic: particle behaviour exists along a continuum, and environmental context (especially indoors) significantly influences infection risk. For example, while measles is textbook airborne, many influenza and SARS-CoV-2 outbreaks have shown aerosol/short-range airborne spread under certain conditions. This challenges infection control planning. From an epidemiologic standpoint, key features include: high transmissibility in enclosed or crowded settings, potential for pre-symptomatic or asymptomatic shedding (especially for viruses), variable incubation periods, and rapid secondary spread when ventilation or air-handling is inadequate. The persistence of droplet nuclei in air emphasises that exposure may occur even without face-to-face contact or direct sneezing/coughing event. Prevention strategies must integrate both droplet and airborne paradigms—improving ventilation and air changes per hour, ensuring masks fit properly, reducing crowding, and considering duration of exposure—not just proximity. Furthermore, environmental controls (humidity, filtration) can significantly reduce risk. From a public health perspective, better surveillance of indoor air quality, real-time monitoring of CO_2/ventilation, and outbreak investigations that consider aerosol spread are essential. Nevertheless, epidemiologic data remain incomplete: quantifying the proportion of transmission attributable to airborne droplet nuclei vs large-droplet spread in typical settings is challenging due to measurement limitations. Modelling studies suggest significant potential for airborne spread, but real-world quantification is difficult. Continued research is needed on dose–response, viability of pathogens in aerosol form, and the effect of HVAC systems in diverse settings. In conclusion, airborne droplet infections require integrated epidemiologic, environmental and engineering approaches for effective control. Recognising the potential for droplet nuclei suspension and transport, and tailoring control measures accordingly, will improve prevention of respiratory infection outbreaks in community and healthcare settings.

CONCLUSION

Airborne droplet infections remain one of the most significant challenges in infectious disease epidemiology because of their high transmissibility and the complex mechanisms involved in their spread. Unlike contact or vector-borne diseases, these infections depend on the release, transport, and inhalation of respiratory droplets and droplet nuclei, which can remain suspended in the air and travel variable distances depending on environmental conditions. The epidemiological characteristics of these infections reveal a dynamic interaction between pathogen biology, host susceptibility, and environmental determinants such as ventilation, humidity, and temperature. The evidence accumulated from recent pandemics, notably COVID-19, as well as long-known airborne diseases like tuberculosis and measles, underscores that airborne transmission is not restricted to a few classical pathogens. Instead, many respiratory agents can exploit aerosolized routes when conditions favor droplet evaporation and prolonged suspension. The traditional boundary between "droplet" and "airborne" transmission, previously defined by particle size thresholds, has proven to be overly simplistic. In practice, infectious particles exist along a continuum, and their behavior is influenced by air currents, humidity, and host activity such as talking, breathing, or coughing. This has major implications for infection prevention, as control strategies that rely solely on surface disinfection and short-range distancing may fail to interrupt transmission in enclosed spaces. From an epidemiological perspective, the rapid and often unpredictable spread of airborne droplet infections is associated with several defining features: short incubation periods for viral pathogens, potential for asymptomatic or pre-symptomatic transmission, and high secondary attack rates in crowded or poorly ventilated environments. Healthcare facilities, schools, and public transport systems are especially vulnerable due to their high population density and limited air exchange. The persistence of droplet nuclei for extended durations also means that transmission may occur even after the infected individual has left the area, as demonstrated in cases of measles and Mycobacterium tuberculosis. Effective control and prevention therefore require a multi-layered approach that integrates epidemiologic, environmental, and engineering interventions. Ensuring adequate ventilation and air filtration, maintaining optimal indoor humidity, and using personal protective equipment such as respirators in high-risk settings can significantly reduce transmission risk. Equally important are public health measures including early detection, isolation of infectious cases, vaccination where applicable, and continuous education of healthcare workers and the public about airborne risks. In conclusion, understanding the epidemiological characteristics of airborne droplet infections is fundamental to designing comprehensive prevention strategies. The interplay between biological, environmental, and social factors determines the spread and persistence of these infections. Strengthening interdisciplinary research and adopting flexible infection control frameworks that account for aerosol behavior will enhance preparedness for both current and emerging airborne diseases,

World Bulletin of Public Health (WBPH)
Available Online at: https://www.scholarexpress.net
Volume-51 October 2025
ISSN: 2749-3644

ensuring more resilient public health systems worldwide.

REFERENCES

1. Asadi, S., Wexler, A. S., Cappa, C. D., Barreda, S., Bouvier, N. M., & Ristenpart, W. D. (2020). *Aerosol emission and superemission during human speech increase with voice loudness.* Scientific Reports, 9(1), 2348. https://doi.org/10.1038/s41598-019-38808-z
2. Beggs, C. B. (2020). *Is there an airborne component to the transmission of COVID-19?* A quantitative analysis study. Indoor and Built Environment, 29(4), 486–499. https://doi.org/10.1177/1420326X20910311
3. Centers for Disease Control and Prevention (CDC). (2023). *Guideline for isolation precautions: Preventing transmission of infectious agents in healthcare settings.* https://www.cdc.gov/infection-control/hcp/isolation-precautions
4. Fennelly, K. P. (2020). *Particle sizes of infectious aerosols: Implications for infection control.* The Lancet Respiratory Medicine, 8(9), 914–924. https://doi.org/10.1016/S2213-2600(20)30323-4
5. Greenhalgh, T., Jimenez, J. L., Prather, K. A., Tufekci, Z., Fisman, D., & Schooley, R. (2021). *Ten scientific reasons in support of airborne transmission of SARS-CoV-2.* The Lancet, 397(10285), 1603–1605. https://doi.org/10.1016/S0140-6736(21)00869-2
6. Li, Y., Qian, H., Hang, J., Chen, X., Hong, L., Liang, P., ... & Kang, M. (2021). *Probable airborne transmission of SARS-CoV-2 in a poorly ventilated restaurant.* Building and Environment, 196, 107788. https://doi.org/10.1016/j.buildenv.2021.107788
7. Morawska, L., & Cao, J. (2020). *Airborne transmission of SARS-CoV-2: The world should face the reality.* Environment International, 139, 105730. https://doi.org/10.1016/j.envint.2020.105730
8. Tellier, R., Li, Y., Cowling, B. J., & Tang, J. W. (2019). *Recognition of aerosol transmission of infectious agents: A commentary.* BMC Infectious Diseases, 19(1), 101. https://doi.org/10.1186/s12879-019-3707-y
9. Wells, W. F. (1934). *On airborne infection: Study II. Droplets and droplet nuclei.* American Journal of Hygiene, 20(3), 611–618.
10. World Health Organization (WHO). (2021). *Modes of transmission of virus causing COVID-19: Implications for IPC precaution recommendations.* https://www.who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-causing-covid-19
11. Xie, X., Li, Y., Sun, H., & Liu, L. (2009). *Exhaled droplets due to talking and coughing.* Journal of the Royal Society Interface, 6(Suppl 6), S703–S714. https://doi.org/10.1098/rsif.2009.0388.focus
12. Yang, W., & Marr, L. C. (2012). *Mechanisms by which ambient humidity may affect viruses in aerosols.* Applied and Environmental Microbiology, 78(19), 6781–6788. https://doi.org/10.1128/AEM.01658-12