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LETTER TO THE EDITOR
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Airborne Transmission of the SARS-CoV-2 Delta Variant and the SARS-CoV-2 Omicron Variant

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ABSTRACT

An extensive study on the airborne transmission of respiratory viruses was published recently. The various kinds of discussions, including the history and scientific mechanisms behind viral aerosols were summarized in the study. However, the key experimental results were interpreted inadequately. The understanding in the study pointed toward an inappropriate direction for studies on viral aerosols in the COVID-19 pandemic. In this letter, two critical points from the point of view of aerosol sciences are discussed against the study on the airborne transmission of respiratory viruses. In the generation mechanism of viral aerosols, the important point is the viral load. The average viral loads in hosts infected with the SARS-CoV-2 Delta variant were unprecedentedly high, therefore the SARS-CoV-2 Delta variant aerosols must be considered in this pandemic. The viral load in respiratory fluids, rather than the preference of the virus toward small particles in deep respiratory tracts, was essential in viral aerosol generation. In addition, if the novel SARS-CoV-2 Omicron variant satisfies the fundamental conditions for universal principles of rapidly spreading respiratory viruses, the airborne transmission of the SARS-CoV-2 Omicron variant needs to be considered.

Keywords: COVID-19, Viral aerosol, Air infection, B.1.617.2, Viral load

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An extensive study regarding the airborne transmission of respiratory viruses was published recently (Wang *et al*., 2021). Various kinds of discussions, including the history and scientific mechanisms behind viral aerosols, were summarized. However, the key experimental results regarding viral aerosols were interpreted inadequately in the study (Wang *et al*., 2021). It was insisted that infectious viruses were enriched in small aerosols ($< 5\ \mu m$), based on the detection of viral genes in the small aerosol particles (Gralton *et al*., 2013; Lindsley *et al*., 2010a, b; Yang *et al*., 2011). Thus, it was inferred that small particles, originating from the deep respiratory tracts, contributed to many infectious viral aerosols; therefore, the particles in the deep respiratory tracts were important for viral aerosols (Wang *et al*., 2021).

Two points need to be considered from the point of view of aerosol sciences. First, respiratory particles that contain the virus undergo quick moisture evaporation following emission from the human respiratory tract. The water evaporation time for most respiratory particles ($< 25\ \mu m$) in the airflow is only seconds (usually $<$ 10 seconds) (Wang *et al*., 2016; Marr *et al*., 2019). However, the time interval between the emission of respiratory particles and the size detection of sampled aerosols typically lasted at least dozens of seconds in aerosol sampling devices. Therefore, viral genes are expected to exist in small aerosols because of the rapid water evaporation of respiratory particles. Captured virus-laden particles in aerosol sampling devices contain many desiccated respiratory particles, not just the small particles from the deep respiratory tracts. Second, viruses do not have any active mobility outside human cells. They do not prefer small particles to large particles. It is reasonable that the virion distribution in respiratory flowing fluids is assumed to be homogeneous under conditions of sufficient mixing. Although respiratory particles are generated from various sites in the respiratory tract (alveolar, tracheobronchial, nasopharyngeal), all of them must enter the oral and nasal passages after passing through the highly humid (nearly saturated) respiratory tract with hygroscopic growth (Haddrell *et al*., 2017). It is highly probable that the respiratory particles carrying virions from various sites in the respiratory tract are coagulated and mixed with respiratory flowing fluids in the upper respiratory tract, including the oral and nasal passages, before being emitted to the external air. Therefore, sufficient mixing of various virions in the upper respiratory tract, including the oral and nasal passages, can be a reasonable assumption. However, the homogeneous and nonhomogeneous distributions of virions in fluids are related to their site of generation and the mixing conditions. Further studies are needed for elucidating the degree of homogeneity in distributions of virions in various respiratory flowing fluids. In summary, many viral genes were detected in small aerosols (< 5 µm) because of the rapid water evaporation of respiratory particles, rather than the preference of the virus toward small particles in the deep respiratory tracts.

In the generation mechanism of viral aerosols, the important point is the viral load. High viral loads in respiratory tract flowing fluids can decrease the minimum size of virus-laden respiratory particles; therefore, more virus-laden aerosols can be generated under a high viral loads condition (Lee, 2020). The average viral load values of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) Delta variant of concern (VOC) were evaluated to be unprecedentedly high ($> 10^9$ copies mL^{-1} in 1848 cases during the 4 days after symptom onset) (Korea Disease Control and Prevention Agency, 2021; Lee, 2021b). The viral load of the SARS-CoV-2 Delta VOC went beyond the analytic minimum viral load ($\sim 10^6$ copies mL^{-1}) for viral aerosol generation (Lee, 2021b). Therefore, the SARS-CoV-2 Delta VOC aerosols must be considered in the COVID-19 pandemic. In specific, viral clouds consisting of many SARS-CoV-2 Delta VOC aerosols can spread viruses to surrounding people in a short period of time and cause massive outbreaks in enclosed spaces (Lee, 2021a). In addition, if the novel SARS-CoV-2 Omicron VOC (B.1.1.529) satisfies the four fundamental conditions (asymptomatic host, high viral load, stability of viruses in air, and binding affinity of viruses to human cells) for universal principles of rapidly spreading respiratory viruses (Lee, 2021b), the airborne transmission of the SARS-CoV-2 Omicron VOC needs to be considered.

The viral load in respiratory fluids with the minimum viral load for viral aerosol generation (Lee, 2021b), rather than the preference of the virus towards small particles in the deep respiratory tracts, could explain the airborne transmission of respiratory viruses.

ADDITIONAL INFORMATION

Conflicts of Interest

The author declares no conflicts of interest.

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REFERENCES

Gralton, J., Tovey, E.R., McLaws, M.L., Rawlinson, W.D. (2013). Respiratory virus RNA is detectable in airborne and droplet particles. J. Med. Virol. 85, 2151–2159. https://doi.org/10.1002/jmv.23698

Haddrell, A.E., Lewis, D., Church, T., Vehring, R., Murnane, D., Reid, J.P. (2017). Pulmonary aerosol delivery and the importance of growth dynamics. Ther. Deliv. 8, 1051–1061. https://doi.org/10.4155/tde-2017-0093

Korea Disease Control and Prevention Agency (KDCA) (2021). Central Disease Control Headquarters, COVID-19 cases in Korea (24 August 2021) Gov't briefs. (in Korean) http://ncov.mohw.go.kr/tcmBoardView.do?brdId=3&brdGubun=31&dataGubun=&ncvContSeq=5855&contSeq=5855&board_id=312&gubun=ALL (assessed 24 August 2021).

Lee, B.U. (2020). Minimum sizes of respiratory particles carrying SARS-CoV-2 and the possibility of aerosol generation. Int. J. Environ. Res. Public Health 17, 6960. https://doi.org/10.3390/ijerph17196960.

Lee, B.U. (2021a). A high attack rate of 90% of SARS-CoV-2 Delta variant infections in crew personnel on a single navy ship. J. Travel. Med. taab168. https://doi.org/10.1093/jtm/taab168

Lee, B.U. (2021b). Why does the SARS-CoV-2 Delta VOC spread so rapidly? Universal conditions for the rapid spread of respiratory viruses, minimum viral loads for viral aerosol generation, effects of vaccination on viral aerosol generation, and viral aerosol clouds. Int. J. Environ. Res. Public Health 18, 9804. https://doi.org/10.3390/ijerph18189804

Lindsley, W.G., Blachere, F.M., Davis, K.A., Pearce, T.A., Fisher, M.A., Khakoo, R., Davis, S.M., Rogers, M.E., Thewlis, R.E., Posada, J.A., Redrow, J.B., Celik, I.B., Chen, B.T., Beezhold, D.H. (2010a). Distribution of airborne influenza virus and respiratory syncytial virus in an urgent care medical clinic. Clin. Infect. Dis. 50, 693–698. https://doi.org/10.1086/650457

Lindsley, W.G., Blachere, F.M., Thewlis, R.E., Vishnu, A., Davis, K.A., Cao, G., Palmer, J.E., Clark, K.E., Fisher, M.A., Khakoo, R., Beezhold, D.H. (2010b). Measurements of airborne influenza virus in aerosol particles from human coughs. PLoS One 5, e15100. https://doi.org/10.1371/journal.pone.0015100

Marr, L.C., Tang, J.W., Van Mullekom, J., Lakdawala, S.S. (2019). Mechanistic insights into the effect of humidity on airborne influenza virus survival, transmission and incidence. J. R. Soc. Interface 16, 20180298. https://doi.org/10.1098/rsif.2018.0298

Wang, C.C., Prather, K.A., Sznitman, J., Jimenez, J.L., Lakdawala, S.S., Tufekci, Z., Marr, L.C. (2021). Airborne transmission of respiratory viruses. Science 373, 981. https://doi.org/10.1126/science.abd9149

Wang, Y., Yang, Y., Zou, Y., Cao, Y., Ren, X., Li, Y. (2016). Evaporation and movement of fine water droplets influenced by initial diameter and relative humidity. Aerosol Air Qual. Res. 16, 301–313. https://doi.org/10.4209/aaqr.2015.03.0191

Yang, W., Elankumaran, S., Marr, L.C. (2011). Concentrations and size distributions of airborne influenza A viruses measured indoors at a health centre, a day-care centre and on aeroplanes. J. R. Soc. Interface 8, 1176–1184. https://doi.org/10.1098/rsif.2010.0686