Proceedings from a Special Symposium and Panel Session

Aerosol Science of Infectious Diseases: What We Learned and What We Still Need to Know

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For the best of reasons

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Abstract

The COVID-19 pandemic has instigated considerable discussion and research about the role of aerosols in infectious respiratory disease transmission. The American Association for Aerosol Research (AAAR) community has been at the forefront of this process, leading scientific studies of how SARS-CoV-2 and other respiratory pathogens, such as influenza and tuberculosis, are transmitted and can be mitigated to protect public health. At the 2022 Annual Conference, AAAR hosted a special symposium panel session entitled, “Aerosol Science of Infectious Diseases: What we’ve learned and still need to know about transmission, prevention, and the one health concept.” The panel included leading scientists in the field of aerosol science who were heavily involved in the COVID-19 response. The first session discussed “Lessons Learned from the COVID-19 Pandemic” and the second session discussed “Gaps in Aerosol Science Identified During the COVID-19 Pandemic.” The questions and answers were documented, and the panelists are currently preparing a letter to the editor to capture the outcomes of the special symposium that will inform future research responses to emerging infectious diseases. This poster highlights the key findings from 2022 AAAR special symposium panel on the aerosol science of infectious diseases.

Introduction

The 2022 AAAR special symposium on the aerosol science of infectious diseases convened aerosol experts from across government and academia who played key roles in the response to the COVID-19 pandemic. The experts shared their experiences, challenges, and successes through each of their unique perspectives. Despite different backgrounds and roles in the COVID-19 response, similar themes from the panelists quickly emerged during the symposium. Although panels were split into “What We Learned” and “What We Still Need to Know,” both panels had very similar challenges and recommendations. While the experiences were in response to COVID-19, the findings are broadly applicable to any future emerging infectious disease. The authors aim to capture these lessons to enable an improved response to the next emerging infectious disease.

Watch the special symposium

Scan the QR code to view the full recording of the 2022 special symposium on YouTube.

What We Learned

Science evolves—expect the unexpected. Early in the pandemic, aerosol research focused on healthcare facilities and then shifted to fitness centers and restaurants. At the end of the pandemic, research identified that homes, because of poor ventilation, had the highest viral aerosol concentration and risk of spread.

There is a high degree of variability of aerosol generation from person to person. There are unknown physiological and temporal factors. Superspreader events are an example of how the high degree of variability can have a significant impact on public health.

There is a high degree of variability between aerosol studies due to the absence of standards for aerosol sampling, virus enumeration, and test subjects. Different aerosol samplers have different efficiencies that need to be characterized and the sensitivity of detecting genomic material is much higher than infectious virus.

Technology can mitigate aerosol transmission of infectious diseases and while individual implementation is straightforward, a coordinated, layered approach remains challenging. Masks, increased filtration and air exchange, and disinfection technology, such as UV light, are readily available, but achieving widespread public implementation has been the barrier to reducing infectious aerosol transmission. To effectively deploy mitigation technologies, the aerosol science community needs to improve communication (see below).

Multidisciplinary teams are critical in an infectious disease response. Aerosol scientists and engineers must collaborate with microbiologists to ensure rigor in studies and mitigation strategies. Engaging stakeholders, such as healthcare providers, is critical to ensure that mitigation strategies are applicable to real-world conditions and implementation. Policy and regulatory experts are required to translate scientific results into strategies and to ensure that technologies meet requirements. The COVID-19 pandemic also highlighted the need for collaboration with sociologists and psychologists to aid in the implementation of nonpharmaceutical interventions and improve buy in through improved communication.

Communication must be improved. Communicating highly technical information to the general public has been challenging and public distrust can significantly impact the course of an infectious disease outbreak. Terminology, such as droplet versus aerosol, created confusion during the beginning of the pandemic.

What We still Need to Know

How to assay viral aerosols? Studies have used both molecular detection, such as polymerase chain reaction (PCR), and culture to assay virus in aerosols. PCR is the most sensitive assay but does not differentiate between infectious and noninfectious virus. Viral culturing methods, such as plaque assays and $TCID_{50}$, only measure infectious virus but require cell culture capabilities and more expertise to execute.

What are the mechanisms behind the high degree of variability in aerosol generation from person to person? Studies have demonstrated that people have different rates of aerosol generation, which is further complicated by additional differences during activities, such as a talking or singing. Physiological differences and the timepoint within the disease course have a significant effect on aerosol generation, but the underlying mechanisms remain unknown and conducting human studies is difficult.

What standards for aerobiology studies and mitigation technologies are needed? Different aerosol samplers have different sampling efficiencies that can either under or overestimate values. The procedures for analysis, including sample extraction and assay method (PCR versus culture) also impact results. Developing standard scientific procedures and surrogates will improve confidence between studies and ensure more consistent results.

How does the scientific community evaluate mitigation strategies? Mitigation strategies and technologies are developed and tested in laboratories that may not reflect real-world conditions. For example, disinfection studies with virus in culture media is not reflective of virus in saliva or lung fluid, which may protect the virus from UV light. UV light can also have secondary effects including generating secondary volatile organic compounds that may have a negative health effect.

How should mitigation technologies be regulated? In the United States, most mitigation technologies, such as UV disinfection systems, are not regulated for safety and efficacy. Regulation will ensure investments in mitigation technologies will have a positive impact on public health.

How can the built environment improve public health? Increased filtration and air exchange can reduce aerosol transmission of infectious disease, but have increased power consumption, which has a negative impact on climate change. Optimizing the built environment requires collaboration with architects and other stakeholders.

Conclusions

Infectious disease outbreaks have occurred throughout history. Over the last 20 years, we have faced severe acute respiratory syndrome in 2003, influenza H1N1 in 2009, Middle East respiratory syndrome in 2012, Ebola virus disease in 2014, Zika virus disease in 2015, the COVID-19 pandemic in 2020, and Mpox in 2022. When looking into the future of emerging infectious disease, the question is not “if” but rather “when.” Additionally, well-known diseases such as tuberculosis and Legionnaires' disease are infectious through aerosols. The COVID-19 pandemic led to an unprecedented response, including investment in aerosol research and development and multidisciplinary collaboration. While there were many successes in the response, there were also many lessons learned, which can be applied to future infectious disease outbreaks. Applying these lessons to the scientific community before the next outbreak will save time, resources, and ultimately lives. The key findings from 2022 AAAR special symposium panel on the aerosol science of infectious diseases serve as a guide for future research and collaboration.

Recommendations

The special symposium identified several key findings to prepare for the next infectious disease outbreak, including:

- Development of standards for infectious disease aerosol research (sampling, assay, extraction)
- Research into the factors of human aerosol generation
- Development of standards for mitigation technologies
- Improved regulation of mitigation technologies
- Increased multidisciplinary collaboration among healthcare providers, regulatory and policy experts, communication specialists, sociologists and psychologists.

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Get Involved

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