Proceedings of the 2nd International Conference on Biological Engineering and Medical Science (ICBioMed 2022), Part II
DOI: 10.54254/2753-8818/4/20220615

Effects of Air Pollutants on Respiratory Viral Infection

Zhixuan Liu

Mississauga Campus, University of Toronto, L5L 1C6, Canada.

www135497@gmail.com

Abstract. Air pollution is one of the leading causes of respiratory viral infection. Particulate matter (PM2.5) is an example of air pollution that incorporates virus and bacteria small enough to float in the atmosphere. Which with its involvement within the respiratory system causes multiple cases that originated from simplicity to more complicated situation. In this review, different micro-material / gaseous were discussed. The function of microbiome located in the respiratory tract and how immune system would react in the presence of air pollution to respiratory viral infection.

Keywords: Air Pollutants, Microbiome, Respiratory Pathogens, Immune system, Immune responses.

1. Current status of development of target-related method or content

Respiratory viral infections being the majority of respiratory tract infections[1], includes several infections in sinuses , throat, lung and airways of the human body. Direct contact is the most obvious way to get respiratory viral infection through mouth, nose, and eyes. Distantly, via air particles carrying said virus or contaminated surfaces after contact are the common ones known. Upper respiratory infections are very common among the population. Yet, children often have a higher possibility of being infected since children tend to place their finger in the mouth and touch things without realizing. People who have a medical history with lung or heart or weak immune system are also classified at higher risk level. In addition, elderly are under the effect of age and a decaying body, which makes their cases severe and difficult to treat. As bacteria or viruses enter the respiratory tract, air pollution has the ability to change the growth circumstances of bacteria and viruses and form biofilms. Air pollutants include toxic particles and gas emitted from combustible material. These micro substances can penetrate the airway and cause airway inflammation, dysfunction, fibrosis[2]. It is also able to intervene in the response of the human immune system, causing unexpected changes. In general, air pollution will decrease the quality of life and life expectancy[2]. In the study of the effect of air pollution on respiratory viral infection, we tend to explore new ways to prevent respiratory viral infection in the threat from air pollution.

The effect of air pollution to respiratory viral infection is a important topic that relates to the health issue of everyone in the modern history as different factories produce pollutants since the industrial revolution. The inhalation of combustion-derived material increases vulnerability to airway infection dates back to at least the 1952 london smog[3]. In the study of air pollution and respiratory infection, pneumonia caused 12000 excess deaths that were confirmed in the acute and persisting exposure of

© 2025 The Authors. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

DOI: 10.54254/2753-8818/4/20220615

1952 london smog[3]. Pneumonia is a common lung infection that caused by bacteria, virus, and fungi. The most common way to get infected with virus in respiratory system is when you touch a surface area or person who's sick. Then you place your hand in your mouth or even on lips, this will cause germs to enter mouth and cause infection. Not only Pneumonia, air pollution can also developed series of respiratory diseases such as acute chronic airway disease[2,3]. These respiratory disease has increase the morbidity[2,3], mortality in children younger than 5 years[3]. Rhinovirus and bronchiolitis are two well-known respiratory infection caused by virus[4]. In 2001, Snell described three agents that was widely approved to treat viral respiratory tract infection (RSV), amantadine, rimantadine, and ribavirin[4-6]. With current study of symptoms includes cough, sore throat, runny nose, nasal congestion, headache, low-grade fever, facial pressure, sneezing, malasize, and myalagias. Ribavirin[4-6], is the thrapy of nucleoside antiviral that has been approved to treat RSV infection[6]. Series of clinical trials and ancilliary studies were conducted to insure the safety and tolerability of this agent. Even though ribavirin has improved clinical signs, oxygen saturation, and duration and severity of RSV infection. It still has its disadvantage, this treatment is expensive and inconvenient. Breathing is an action of survival, human need functional respiratory system to live. All the medicals and biological agents were created to save or cure the damage caused by viral infection.

However, thrapy should not be the single method to reduce the chance of respiratory viral infection by air pollutant. There are sufficient data suggest that air pollutants resulted in adverse health effect. Burning of fossil fuel is the biggest source of air pollutants. Reduction of fossil fuel emission should be advocate to protect human health. In the study of Becker and Soukop, they discover and introduce a confusing phenomenon that exposure of airway epithelial cells to 0.5ppm NO2 in 60 minutes will increase RSV internalization, but exposure to 1.5ppm will decrease RSV internalization. N-related pollutants is related to climate change that is happening around the global[7]. These gaseous pollutants perturb the function of immune system and increase the susceptibility to infectious disease[8]. There are actions taken to reduce air pollution, such as take public transportation instead of driving personal vehicle, recycle materials to prevent overproduction, use less power or electricity. These are all low cost actions to reduce emission yet, are also economizing and cheap. Differently, economize daily usage is not a long-term plan to establish. Even though the air pollution policies and economic changes were implement in action, the increase rate of culture-negative pneumonia and influenza still presense. The toxicity of different PM2.5 mixtures and increased pathogen virulence will vary. Air pollution poses bigger threats to severe pneumonia in children than did respiratory viruses[9].

The severity of respiratory viral infection varies widely from common cold to coronavirus or Pneumonia or Influenza. Common cold has become a very normal disease that hanppens in people's life. Usually, it only takes a week or less for people to heal. Differently, other virus infection like Pneumonia (can cause bacteria and virus to enter bloodstream that may infect other organ and cause organ failuring), and Influenza can give rise to ear infection, sinus infection, worsening of chronic medical condition such as congestive heart failure. Even coronavirus that create this COVID-19 pandemic. COVID-19 virus have same symptoms compare to flu, However, It also has side effect such as anosmia (lack of smell), and ageusia (lack of taste).

2. Perspective on respiratory viral infection, possible precuation and functionality of microbiome in respiratory tract

Respiratory viral infection has a huge impact on morbidity and even mortality on human health. The study of understanding the exacerbate of respiratory viral infection on its susceptibility and severity. Air pollution can affect respiratory microbiome and induce dysbiosis. Air pollution affects airway microbiota by changing the airway environment. Excluding this, air pollutants specifically can result in cardiovascular diseases which given the effect of higher chances in premature death, typically by bioaerosol[2]. On the other hand, chemical disposal is another kind of air pollutant nowadays, an instance being nitrogen oxides as an important component which can be produced from a range of sourced throughout the process of combustion. Similar to bioaerosol, it has the capability to result in

DOI: 10.54254/2753-8818/4/20220615

several serious health effects, as well as premature death, which other than this it has impacts on the environment of earth, changing the living conditions of organisms with a possible impact on health under its effects. As previously mentioned, enhancement of susceptibility and the severity of respiratory infections and sensitization to allergens can be caused by air pollutants such as ozone[7]. Moreover, according to recent statistics, multiple genetic polymorphisms that has involvement in several biologic pathways have an increase in susceptibility as a response to the effect caused by air pollutants, however, a further view must be taken to confirm this fully. Furthermore, an increased risk of health issues as a factor of the growing traffic emissions have been recognised, with those housing within a 92 meters range from highways consisting of 4 or more lanes, railroads and airports generally having a higher percentage of vulnerability to environmental hazards[10]. In addition, relating to the datas from the nearest decades, around 1 within 20 deaths as a result of cardiovascular disease was an attribution of air pollutant exposure[7].

Air pollution is composed of different kinds of small particles, viruses, bacteria that can invade the respiratory tract and lungs, therefore causing viral infection. The immune system itself consisted of two different mechanisms, one being specific and one being non-specific, when a foreign body has been detected within the body, non-specific immune response occurs as there has been no clear record of the substance or in any terms of relation with an invasion of harmful bacterial or viral substances, which most of the air pollutants will be identified as, especially polluting particles and elements such as dust, particulates and pollen. On the other hand, specific immune responses highly rely on previous encounters with said substance and the system itself's memory. Once a foreign substance has been detected, lymphocytes and antibodies which aim to bind and destroy the invaded substance. According to certain assessments upon the effect of man-made chemical pollutant exposure, an instance being polychlorinated biphenyls(PCBs), which the response varied depending on the amount of exposure, and the animal involved within the testing process. With rabbits, the germinal center and lymphnodes decreased in number and functionality, after application to skin, lymphopenia was spotted. Pushing further, less neutralizing antibodies were produced in an observation with injection of pseudorabies virus vaccine as the result of introducing 300mg of PCB dissolved into the rabbits' stomach. Onto a more common air pollutant being nitrogen dioxide(NO2), as a result of inhalation of it by monkey squirrels, infection of respiratory pathogens caused experience of a higher mortality, similarly in mice but with a combination of ozone and NO2[8]. Which assumption could be brought up that under the effect of a viral respiratory infection, similar result could be observed from patients, or any in vivo experimentation carried out. The pre-existing data allowed prediction about possible human immune response to said chemicals involved in the examinations, and the likely trend of development along the increasing time and amount in contact.

Microbiome also has a great impact on respiratory viral infection as it plays an essential role on the immune system of distal organs such as the lung[11]. Microbiome dysbiosis occurs when changes of airway physical environment happens[11]. Invasive pathogens or gaseous pollutant will trigger the raise of oxidative stress, therefore, induce the chances of inflammation, epithelium damage, and immune dysregulation[Figure1.] [11]. Microbiota can resist the colonization of respiratory pathogens and different outcoming respiratory threats. The maturation and maintenance of respiratory homeostasis of respiratory physiology and immunity[12]. If the micro-ecosystem becomes unbalanced, this phenomenon will trigger bacteria overgrowth and further development of respiratory infections[13]. Microbial immigration, microbial elimination, and relative reproduction rate of microbial are determinable factors of the microbiome in the lung. These factors can interfere with the status of the lung microbiome during the disease period. The adhesion receptor on the mucosal surface and nutrients are the important factors that microbiome and invading pathogens are competing for. As the microbiome grows and colonizes, it limits the chances for invading pathogens to grow, replicate, disseminate, and cause disease[13]. Another pathway of microbiome to affect the developing stages is the biodiversity of microbiome. Wide range of biodiversity of microbiomes can effectively reduce the colonization of invading pathogens by consuming nutrition and resources to prohibit further growth.

DOI: 10.54254/2753-8818/4/20220615

Patients with increased susceptibility to pollutants tend to have a lower diversity of lung microbiome[14]. This suggest that microbiome would react to inhaled pollution through metabolition[Figure2.] [14]. Expectation of further development of lung microbiome includes the process of biotransformation of pollutants to non-toxic compounds[14]. The further development of lung microbiome is still under discovering. It is important to understand how microbes interact with host[15].

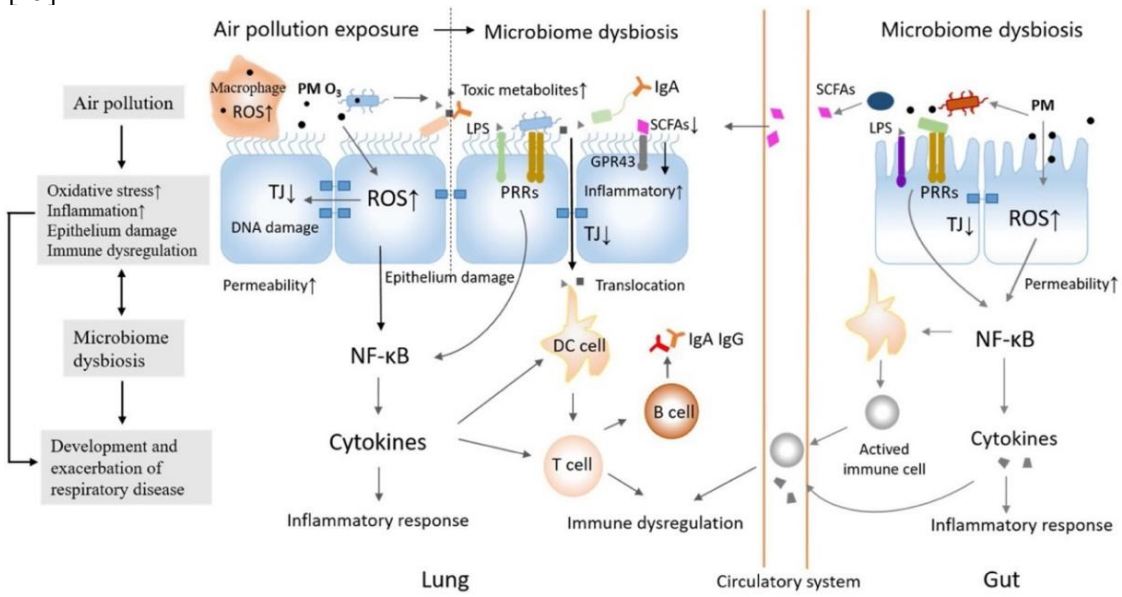


Figure 1. This is the mechanism of air pollution induction of microbiome dysbiosis and respiratory disease.

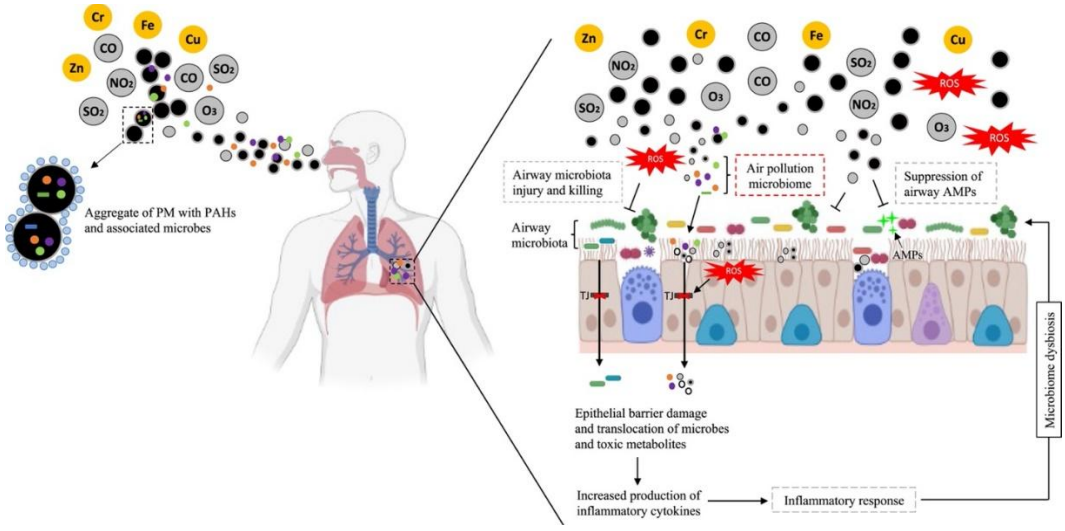


Figure 2. Interactions between air pollution and the microbiome in and on the RT. Inhalation of polluted air introduces a mixture of gases, PM, polycyclic aromatic hydrocarbons (PAHs), and microorganisms into the RT.

The antiviral agent ribarivin was evaluated and reviewed in a treatment of infants hospitalized with lower-respiratory tract disease from respiratory syncytial virus[5,6]. This clinical trial consists two different treatment groups of ribarivin and placebo. The test result shows distinct improvement on the severity of illness, in lower respiratory tract signs and arterial oxygen saturation[4]. This clinical trial

DOI: 10.54254/2753-8818/4/20220615

used ribarivin in the form of aerosol[4,5]. There is no side effects and toxicity associated with this aerosol therapy. Also, in another double-blind study, one treatment used ribarivin aerosol to treat bronchiolitis associated with respiratory syncytial virus infection, another treatment used saline aerosol to treat bronchiolitis associated with respiratory syncytial virus infection. There is no local or systemic intolerance and there are no symptoms of hematologic or organ toxicity observed in the ribarivin-trested patients[4].

3. Conclusion

In this review an attempt is made to present and summarize the impact of air pollution on respiratory viral infections. This article also analyzes three different points that play an important role in respiratory viral infections and invasive pathogens from the external environment (air pollution). It is relatively important to conduct more studies on the enhanced microbial communities in the respiratory tract to stop the spread and replication of invasive pathogens.

References

[1] R. S. Denise, P. V. Vinícius, M. M. Alice, P. L. Fernando and R. D. Paulo. Influ and Other Respiratory Viruses(2013),pp. 42-52.
[2] Y. G. Lee, P. H. Lee, S. M. Choi, M. H. An and A. S. Jang. International journal of environmental research and public health (2021),pp. 9905.
[3] Grigg J. (2018). American journal of respiratory and critical care medicine, (2018). 198, pp. 700–701.
[4] Taber, L. H., Knight, V., Gilbert, B. E., McClung, H. W., Wilson, S. Z., Norton, H. J., Thurson, J. M., Gordon, W. H., Atmar, R. L., & Schlaudt, W. R. (1983).. Pediatrics, (1983). 72, pp. 613–618.
[5] Hall, C. B., McBride, J. T., Walsh, E. E., Bell, D. M., Gala, C. L., Hildreth, S., Ten Eyck, L. G., & Hall, W. J. The New England journal of medicine, (1983). 308, pp. 1443–1447.
[6] Ventre, K., & Randolph, A. G. The Cochrane database of systematic reviews. (2007). 1, CD000181.
[7] Jennifer, L. P., Richard, H., Valerie, G., Armistead, G. R., & Lucas, N. Biogeochemistry, (2013). 114, pp. 121-134.
[8] Linda, D. C. BioScience, 1981. 31, pp. 582-586.
[9] Wang, Z. B., Ren, L., Lu, Q. B., Zhang, X. A., Miao, D., Hu, Y. Y., Dai, K., Li, H., Luo, Z. X., Fang, L. Q., Liu, E. M., & Liu, W. Clinical infectious diseases : an official publication of the Infectious Diseases Society of America, (2021). 73, pp. e513–e522.
[10] Niemeier-Walsh, C., Ryan, P. H., Meller, J., Ollberding, N. J., Adhikari, A., & Reponen, T. PloS one, (2021). 16, e0244341.
[11] Xue, Y., Chu, J., Li, Y., & Kong, X. Toxicology letters, (2020). 334, pp. 14–20.
[12] Man, W. H., de Steenhuijsen Piters, W. A., & Bogaert, D. (2017). Nature reviews. Microbiology, (2017). 15, pp. 259–270.
[13] de Steenhuijsen Piters, W. A., Sanders, E. A., & Bogaert, D. Philosophical transactions of the Royal Society of London. Series B, Biological sciences, (2015). 370, 20140294.
[14] Hamidou Soumana, I., & Carlsten, C. The Journal of allergy and clinical immunology, (2021). 148, pp. 67–69.
[15] Li, Kj., Chen, Zl., Huang, Y. et al. Respir Res 20, (2019). 272.