SEMARAK ILMU
PUBLISHING
202103268166(003316878-P)

Journal of Advanced Research in Applied
Sciences and Engineering Technology

Journal homepage:
https://semarakilmu.com.my/journals/index.php/applied_sciences_eng_tech/index
ISSN: 2462-1943

Covid-19 Infection in a Boeing B737-800 Plane: Predicting the Secondary Infection using a Wells-Riley Approach

Nur Amira Nadia Mohd Ali[1], Nur Intan Syafinaz Ahmad[2,*], Nurhazirah Mohamad Yunos[2], Aini Sahira Mohamad Razali[3], Siti Adiba Mahasan[4], Aishah Mahat[2], Azita Abd Aziz[5], Siti Ramizah Jama[6], Budi Halomoan Siregar[7]

[1] Department of Mathematics, College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, 70300 Seremban, Negeri Sembilan, Malaysia
[2] Department of Mathematics, College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, Bandar Seri Alam, 81750 Johor Bahru, Johor, Malaysia
[3] Bodibasixs Manufacturing Sdn Bhd,, 41050 Klang, Selangor, Malaysia Department of Information Technology, 41050 Klang, Selangor, Malaysia
[4] Prokhas Sdn Bhd, Bukit Damansara, 50490 Kuala Lumpur, Malaysia
[5] Malaysia Airlines Berhad Engineering Service (MABES) (Engineering Complex), South Support Zone, Kuala Lumpur International Airport, 64000 Sepang, Selangor, Malaysia
[6] Department of Mathematics, College of Computing, Informatics and Mathematics, Universiti Teknologi MARA, 78000 Alor Gajah, Melaka, Malaysia
[7] Department of Education, Universitas Negeri Medan, Kabupaten Deli Serdang, Sumatera Utara 20221, Indonesia

ABSTRACT

In March 2020, the first covid-19 cases have been detected in Malaysia. Since then, number of Covid-19 infection in Malaysia has grown relatively until Malaysia become the highest number of positive cases in Southeast Asia. Previous studies have been done to analyse the airborne transmission of infection in different closed spaces. This information is important for many sectors to take any relevant action in order to minimize infection. This study is focusing on estimating the potential risk of Covid-19 infection among passengers on Boeing B737-800 aircraft. The aim of this study is to calculate secondary infection for Covid-19 virus in the Boeing B737-800 aircraft due to airborne transmission. Aircraft are preferred over other enclosed spaces like trains and buses because they require passengers to spend longer time in the enclosed spaces during flight without any interruption between the journeys. A major risk to passengers in a cabin could be posed by massive droplets and airborne transmissions given the high density and close proximity of passengers. The Wells-Riley model is used in this study because it has been frequently used for quantifying the infection risk assessment of infectious illnesses in indoor settings. In this study the secondary risk of infection is calculated for every susceptible passenger flying for one, two, three- and four-hour's journey. The relationship between exposure time and number of infected people are positive linear relationships. This means that the longer time a passenger is exposed to the infected people in the cabin, the higher chance of the passenger getting infected by the virus. The reproduction number is estimated to be 2 passengers when the exposure duration is less than 2 hours for 80 passengers. This estimation indicates that the reproduction rate of secondary infection is high. Therefore, it can be concluded

---

[*] *Corresponding author.*
E-mail address: nurin395@uitm.edu.my

https://doi.org/10.37934/araset.61.1.95103

Keywords:
Airborne; aircraft; infection; Covid-19; Wells-Riley model

that there is a high chance passengers may get infected in the aircraft and the risk will increase when the exposure time is increasing. The best alternatives for protection are wearing mask and face shield, social distancing and sanitizing hands frequently. An improvement in ventilation also seems to be effective to prevent infection.

1. Introduction

In the end of the year 2019, the world has been shocked by the Covid 19 virus. Since then, numerous studies have been conducted to determine the factors that contribute to the infection and stay in closed spaces with infected individuals for a predetermined amount of time is one of them. An aircraft is one form of public transit that is required for prolonged stays in enclosed spaces. Airline passengers will be more at risk due to the infection compared to others public transport. Considering the high density and near proximity of passengers, large droplets and airborne transmissions may represent a significant risk to passengers in a cabin.

According to the World Health Organization [1], airborne transmission is described as the spread of an infectious agent through droplet nuclei (aerosols) that remain infectious when suspended in air over long distances and time. These would also be influenced by numerous factors, especially in enclosed interior environments, such as the ventilation system, air temperature, relative humidity, and social distance Zhao *et al*., [2] The widespread air in confined spaces enhances the risk of infection. The virus can be spread in crowded, poorly ventilated indoor areas where people frequently spend longer periods of time. According to Yan *et al.,* [3], diseases that contain infectious pathogens (such as influenza and tuberculosis) that are released by index patients through coughing or sneezing would cause direct person-to-person infections during the flight travelling. Furthermore, it is essential to understand their transport behaviours in the cabin environment to make accurate predictions regarding the likelihood of infection for each individual passenger Olsen *et al.*, [4].

Covid-19 caused a variety of symptoms. According to Sykes *et al*., [5], the most frequently reported symptom was breathlessness, experienced by 60% of individuals who noted an increase compared to their pre-COVID-19 condition. Other prevalent symptoms included muscle pain (51.5%), anxiety (47.8%), severe fatigue (39.6%), low mood (37.3%), and sleep disturbances (35.1%). Despite the mild to moderate symptoms that most Covid-19 patients experience, the condition can occasionally cause serious medical problems and even death. According to Harvard Health Publishing Harvard Medical School [6], after contracting the coronavirus, some children have been developing a disorder known as multisystem inflammatory syndrome in children (MIS-C). It may result in issues with the heart and other vital bodily organs that are potentially life threatening. Data from John Hopkins Medicine [7] shows that of more than 3,000 persons between the ages of 18 and 34 who got Covid-19 and became ill enough to need hospital treatment, 21% spent time in intensive care, 10% were given breathing assistance, and 2.7% passed away. The risk of dying from Covid-19 increases significantly with age Centres for Disease Control and Prevention [8].

The Wells-Riley model in an epidemiological study on a measles outbreak was developed by Riley, C.E., Murphy, G. and Riley [9]. Several studies used the Wells-Riley model to evaluate infection risk in a variety of situations such Yan *et al*., [10] and Zhang *et al*., [11]. According to Vernez *et al*., [12], they overcome the issues of Covid-19 by constructing a unique spatiotemporally resolved Wells-Riley model for predicting the transmission risk of distinct Covid-19 variants in indoor environments. It has also been applied to a variety place of risk Covid-19 analysis study, including estimating the SARS-CoV-2 transmission probability and evaluating the impact of environmental characteristics and individual intervention on epidemic prevention Chen *et al.,* [13] by using Monte Carlo simulation and the improved Wells-Riley model. Furuya [14] discussed on quantify the public health risk related with inhaling infectious pathogens during train commute in Japan using a model based on the Wells-Riley model. A study from Ahmad *et al.,* [15] used the Wells-Riley model to estimate the secondary infection caused by airborne transmission in public transport where it focuses on the KTMB train. Furthermore, Stephens [16] developed a study on air conditioning (HVAC) filtration and the Wells-Riley approach to assessing risks of infectious airborne diseases in buildings. The author describes and uses a modified Wells-Riley approach to estimate the effect of generally accessible HVAC filtration on the transmission of infectious disease. Guo *et al.,* [17] mentioned assessing and controlling infection risk with Wells-Riley model and spatial flow impact factor (SFIF). The intent of the author is to develop a novel approach to analyse the spatial distribution of probability of infection (PI) to optimize the placement of persons (infected and exposed), and facilities (such as air purifiers), in a closed area.

Based on previous literature, there are limited studies focusing on airborne transmission in aircraft. As the number of passengers onboard is increasing, the chances of getting infected by Covid-19 is quite high, especially in an enclosed area. As a response, the findings will assist Malaysia Airlines in developing regulations that will ensure that the aircraft are properly taken care for the passengers who use their aircraft service. The data will be significant to determine the risk of these diseases to the general population. It is also important to educate people about Covid-19 awareness, particularly in enclosed areas and to minimize the spread of airborne infections. Wearing surgical masks and exercising hand hygiene remain the most effective ways to lower the risk of transmission for passengers on planes [18]. Thus, the aim of this study is to present some theoretical findings about the Covid-19 infection caused by airborne transmission in aircraft, particularly the Boeing B737-800 model. The main objectives are to evaluate the probability of Covid-19 infection on different time exposure in the aircraft and to calculate the reproduction number of secondary infection for Covid-19 virus by using Wells-Riley model.

2. Methodology

As stated in introduction, the Wells-Riley model is well known for offering an accurate estimation of the risk of airborne infection under well-mixed and steady condition. Thus, the Wells Riley is defined as Eq. (1):

$$P=\frac{D}{S}=1-e^{\frac{Ipqt}{Q}\left[1-\frac{v}{Qt}\left(1-e^{\left(-\frac{Qt}{v}\right)}\right)\right]} \tag{1}$$

where P is probability of infection for susceptible people, I is the initial number of infectors, D is final number of infectors that caused by I, S is total number of susceptible people, q is quantum generation rate ($quanta/h$) of an infected person, p is breathing rate per person (m^3/h), t is total exposure time (h), Q is outdoor air supply rate (m^3/h) and v is volume of the ventilated space (m^3).

The term "quantum" is used to refer to the "infectious dose," which is the average number of infectious particles that it takes to infect $(1-e^{-1})$ susceptible person when inhaled by all susceptible individuals at a rate of one quantum. By referring to Eq. (1), there are a few pieces of information that need to be set first before evaluating the probability of COVID-19 infection at different times of exposure in the aircraft. The initial number of infectors considered in this study was one. The total exposure time was calculated as the total number of hours the infectious person spent on the aircraft. By considering the nature of the Boeing B737-800, which focuses on domestic flights, it is considered to be from one (1) to four (4) hours only. On the other hand, the number of susceptible people was assumed to be equal to the total number of passengers on a flight at any given moment. Here, based on the size of Boeing B737-800, the number of passengers recommended are 166 with 16 business class, 144 economy class and 6 cabin crew. According to Chua [19], the breathing rate per person is used as a specific case, while the volume of ventilated space is $234m^3$ [17].

In general, in order to achieve the primary objectives, it requires the following steps:

i. Obtain the fraction of indoor air that was exhaled by the infector.
ii. Calculate the quantum generation rate of an infected person.
iii. Determine the probability of Covid-19 infection at different times of exposure in the aircraft.
iv. Then determine the reproduction number of the secondary infection for Covid-19 virus.

The outdoor air supply rate, Q can be calculated by using Eq. (2):

$$Q = \frac{np}{f} \tag{2}$$

where f is fraction of indoor air that exhaled by infector, n is total number of people in the ventilated airspace, p is breathing rate per person and Q is outdoor air supply rate.

However, since the fraction of indoor air that exhaled by infector (f) are still unknown, alternatively the outdoor air supply rate (Q) can be calculated from prior study from Furuya [14] by using the relationship between the outdoor air supply rate, Q and the volume of the ventilated space, v given by Eq. (3),

$$\frac{Q}{v} = 13. \tag{3}$$

From the perspective of statistics, Riley believed that the average probability of infection was subject to Poisson distribution, hence quanta (q) was defined as the quantity of infectious particles capable of infecting 63.2 percent of susceptible persons in an indoor setting based on Chen [13]

In order to make the Wells-Riley equation more applicable to big interior spaces, such as hospitals, aircrafts, and others, Eq. (2) was substituted into Eq. (1). Thus, the model has been reduced to Eq. (4),

$$P = \frac{D}{S} = 1 - e^{\frac{Ipft}{n}\left[1-\frac{vf}{npt}\left(1-e^{\left(-\frac{npt}{vf}\right)}\right)\right]} \tag{4}$$

After some modifications, the probability of Covid-19 infection on different time exposure in the aircraft can be calculated by using Eq. (4). On the other hand, the reproduction number of secondary infection for Covid-19 virus can be related with the probability of infection, where the relationship is stated in Eq. (5).

$$R = (n-1)P \tag{5}$$

such that R is the average number of secondary infected people by one primary infected patient during the infectious period and P is probability of infection for susceptible people. According to Furuya [5], the fundamental reproductive number (R) in the limited airspace may be calculated when $I = 1, S = n - 1$.

Based on the calculations, when $R > 1$, the infection is spreading at a faster pace through people, whereas $R < 1$ indicates that the infection is disappearing. $R = 1$ indicates that the infection has stabilized at a regional level [4].

3. Results

This section will provide the results that have been calculated after the data entered in Section 2.

Boeing B737-800 can accommodate 166 passengers with 16 business class, 144 economy class and 6 cabin crew. In order to calculate the fraction of indoor air exhaled by infector f, the value of Q is calculated from Eq. (3) and by assuming $v = 234m^3$. Thus, $Q = 3042m^3$.

Table 1 presented the fraction of indoor air that exhaled by infected people, f. This value is different based on the number of passengers on board.

Table 1
Fraction of Indoor Air That are Exhaled by Infector Based on the Number of Passengers

Number of passengers, n	Fraction of indoor air that exhaled by infected people, f
80	0.012886259
100	0.016107824
120	0.019329389
140	0.022550953
166	0.026738988

Table 1 presents the calculated result for fraction of indoor air exhaled by the infector, f for each number of passengers, n is the same for different time exposures (1 to 4 hours). Thus, by considering the f values obtained, the probability of infection for susceptible people, P can be calculated by using Eq. (4) for the total exposure 1 hours, 2 hours, 3 hours and 4 hours. The results are illustrated in Figure 1.

3.1 Probability of Infection for Susceptible People Against Time Exposure

The line graph in Figure 1 shows the probability of infection for susceptible people against time exposure. The probability of infection for susceptible people, $\boldsymbol{P}$ increased as the time exposure increased. The line graph rose up as the time elapsed between 1 hour to 4 hours. The probability of infection for susceptible people, $\boldsymbol{P}$ at 1 hour time exposure is 0.009353021. Then, the probability of infection for susceptible people, $\boldsymbol{P}$ gradually increased to 0.019386812, 0.029318955, 0.039150501 in 2 hours, 3 hours and 4 hours respectively.

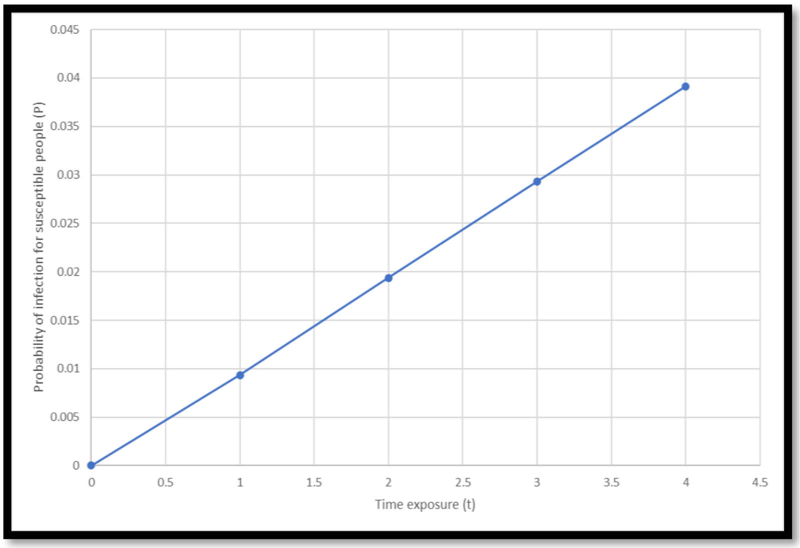

Fig. 1. Graph probability of infection for susceptible people against time exposure

In order to determine the reproduction number of secondary infections, R, the number of secondary infections that arise which is R when a single infectious case is introduced into susceptible people in a close space by assuming there is 1 infector. By using the P obtained, it is possible to estimate the reproduction number of secondary infections, R by considering Eq. (5). R is calculated for $n = 80, 100, 120, 140, 166$ and for $t = 1, 2, 3, 4$ with respect to its P from Figure 1. The results are then demonstrated as in Figure 2 and Figure 3, where Figure 2 illustrates the reproduction number of secondary infection against time exposure based on number of passengers and Figure 3 illustrates reproduction number of secondary infection against number of passengers.

3.2 Reproduction Number of Secondary Infection Against Time Exposure Based on Number of Passengers

Figure 2 shows the reproduction number of secondary infection, $\boldsymbol{R}$ against time exposure based on the number of passengers. The graph only shows the risk of infection on 2 different numbers of passengers in an aircraft. The blue line indicates the scenario where there are 80 passengers in an aircraft and the orange line represents 140 passengers in an aircraft.

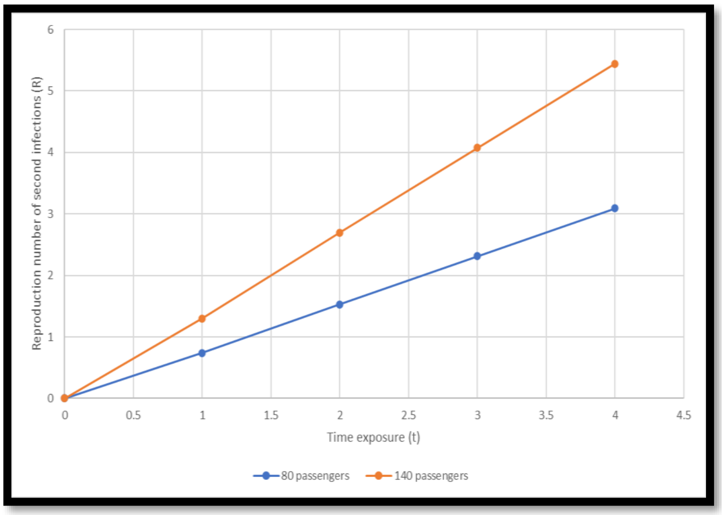

Fig. 2. Graph reproduction number of secondary infection against time exposure based on number of passengers

The reproduction number of secondary infection, $\boldsymbol{R}$ for both 80 passengers and 140 passengers increase linearly with the amount of time a susceptible person spends with an infected person. The reproduction number of secondary infection, $\boldsymbol{R}$ for 80 passengers and 140 passengers in 1 hour is 0.738888674 and 1.300069945 respectively. Next, the $\boldsymbol{R}$ increased to 1.53155817 and 2.694766907 in 2 hours. Then, it still rose to 2.316197466 and 4.075334782 in 3 hours. In 4 hours, the reproduction number of the secondary infection, $\boldsymbol{R}$ still increasing to 3.092889541 and 5.441919572 for 80 passengers and 140 passengers respectively.

3.3 Reproduction Number of Secondary Infection Against Number of Passengers

The graph on Figure 3 shows the reproduction number of secondary infections, $\boldsymbol{R}$ against the number of passengers based on the time exposure. The graph also shows that more people are getting infected when the exposure time is increased.

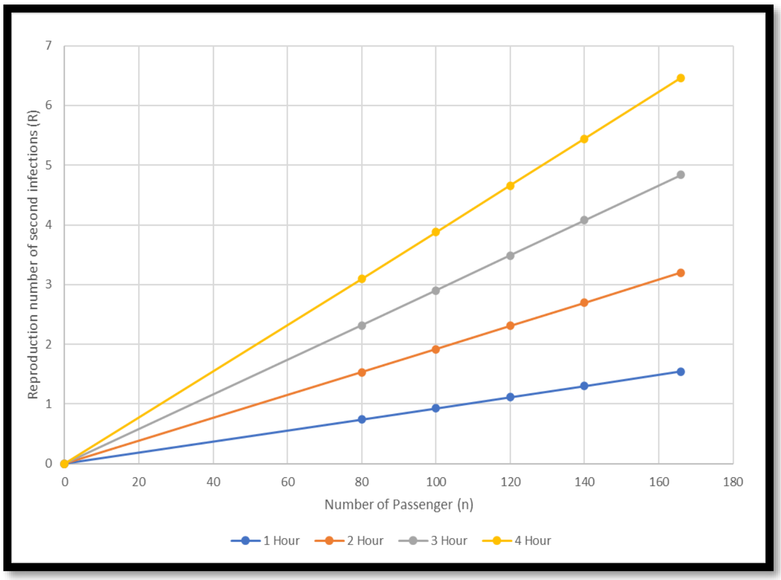

Fig. 3. Reproduction number of secondary infection against number of passenger

The line graph above shows the reproduction number of secondary infections, $\boldsymbol{R}$ against the number of passengers $(\boldsymbol{n})$ based on the time exposure $(\boldsymbol{t})$. The graph shows the risk of infection on 5 different numbers of passengers which are 80, 100, 120, 140 and 166 passengers in an aircraft within 4 hours. The blue line represents passengers in the aircraft for 1 hour, the orange line represents passengers in the aircraft for 2 hours, the grey line represents passengers in the aircraft for 3 hours and the yellow line represents passengers in the aircraft for 4 hours.

With the amount of time a susceptible person spends with an infected person, the reproduction number of secondary infection, $\boldsymbol{R}$ grows linearly for all passengers within 4 hours. In 1 hour, the reproduction number of secondary infections $\boldsymbol{R}$ is 0.738888674 for 80 passengers, 0.925949098 for 100 passengers, 1.113009522 for 120 passengers, 1.300069945 for 140 passengers, 1.5432484962 for 166 passengers. Then, in 2 hours, the reproduction number of secondary infections $\boldsymbol{R}$ is 1.53155817 for 80 passengers, 1.919294416 for 100 passengers, 2.307030662 for 120 passengers, 2.694766907 for 140 passengers, 3.198824026 for 166 passengers. In 3 hours, the reproduction number of secondary infections $\boldsymbol{R}$ is 2.316197466 for 80 passengers, 2.902576571 for 100 passengers, 3.488955677 for 120 passengers, 4.075334782 for 140 passengers, 4.837627619 for 166 passengers. Lastly, in 4 hours, the reproduction number of secondary infections $\boldsymbol{R}$ is 3.092889541 for 80 passengers, 3.875899551 for 100 passengers, 4.658909562 for 120 passengers, 5.441919572 for 140 passengers, 6.459832586 for 166 passengers. The graph reveals that more people are getting infected when the exposure time is increased.

3.4 Discussion

The time of exposure and the numbers of passengers are adjusted to determine the impact of environmental conditions. Since the spread of infection caused by airborne is affected when passengers are crammed inside an aircraft. This study estimates the probability of infection for susceptible people in the aircraft for 4 hours. The results showed a positive linear relationship, such that the longer the time, the higher the probability of getting infection. Based on the probability value obtained, this study focuses to calculate the value of R, which indicates the secondary number of people getting infected to Covid-19 during airborne transmission in the aircraft. The reproduction number is estimated to be around 1 passengers when the exposure duration is less than 2 hours for 80 passengers or less than 1 hour for 166 passengers. Since the reproduction rate of secondary infection is high, it indicates that the risk of secondary infection is not under control. According to Olsen *et al.*, [4], R is sensitive to the number of passengers as the exposure period increases, and it is not on the epidemic control scale because if the reproduction number of secondary infections, R greater than 1, the spread of the epidemic cannot be controlled. The fact that it is known that if the R is more than 1, a disease may grow in this environment and the infection is spreading at a faster pace through people. Therefore, if even one of the passengers in this region is susceptible, then others may get ill as well.

4. Conclusions and Recommendations

In conclusion, the result from the calculation evaluated indicates that the risk of secondary infection is not under control and that the secondary infections reproduction rate is high. Based on the results, almost all of the reproduction numbers of secondary infection, $\boldsymbol{R}$ for every hour in different numbers of passengers are greater than 1. This indicates that the infection is spreading at a faster pace through people by Olsen *et al.*, [4]. Therefore, it may be concluded that there is a significant risk that passengers will become ill inside the aircraft, and that risk will increase as exposure time's increase. As recommendation for the future study, researchers can calculate the risk on an international flight using Wells-Riley model and including other elements like sanitising hands frequently, face shield, wearing mask, vaccinated people and social distancing for the international flight. According to Tretiakow, Tesch, and Skorek [20], keeping a safe distance and wearing protective gear like face shields, masks, and goggles could significantly reduce the spread of the SARS-CoV-2 virus in the environment.

Acknowledgement

We would like to express our sincere gratitude to all the individuals and organizations that have contributed to the publication of this research paper. Finally, we would like to thank our family and friends for their encouragement and support throughout the research process. Without their love and support, we would not have been able to complete this research. This research was not funded by a any grant.

References

[1] Brief, WHO Scientific. "Transmission of SARS-CoV-2: implications for infection prevention precautions." *World Health Organization* (2020).

[2] Zhao, Xingwang, Sumei Liu, Yonggao Yin, Tengfei Zhang, and Qingyan Chen. "Airborne transmission of COVID-19 virus in enclosed spaces: an overview of research methods." *Indoor air* 32, no. 6 (2022): e13056. https://doi.org/10.1111/ina.13056

[3] Yan, Yihuan, Xiangdong Li, Yidan Shang, and Jiyuan Tu. "Evaluation of airborne disease infection risks in an airliner cabin using the Lagrangian-based Wells-Riley approach." *Building and environment* 121 (2017): 79-92. https://doi.org/10.1016/j.buildenv.2017.05.013

[4] Olsen, Sonja J., Hsiao-Ling Chang, Terence Yung-Yan Cheung, Antony Fai-Yu Tang, Tamara L. Fisk, Steven Peng-Lim Ooi, Hung-Wei Kuo *et al.,* "Transmission of the severe acute respiratory syndrome on aircraft." *New England Journal of Medicine* 349, no. 25 (2003): 2416-2422. https://doi.org/10.1056/NEJMoa031349

[5] Sykes, Dominic L., Luke Holdsworth, Nadia Jawad, Pumali Gunasekera, Alyn H. Morice, and Michael G. Crooks. "Post-COVID-19 symptom burden: what is long-COVID and how should we manage it?." *Lung* 199 (2021): 113-119. https://doi.org/10.1007/s00408-021-00423-z

[6] Maragakis, Lisa Lockerd. "Coronavirus and COVID-19: Younger adults are at risk, too." *Johns Hopkins Medicine* (2020).

[7] Feldstein, Leora R., Erica B. Rose, Steven M. Horwitz, Jennifer P. Collins, Margaret M. Newhams, Mary Beth F. Son, Jane W. Newburger *et al.,* "Multisystem inflammatory syndrome in US children and adolescents." *New England Journal of Medicine* 383, no. 4 (2020): 334-346. https://doi.org/10.1056/NEJMoa2021680

[8] Brief, Scientific. "SARS-CoV-2 transmission." *Centers for Disease Control and Prevention* (2021).

[9] Riley, E. C., G. Murphy, and R. L. Riley. "Airborne spread of measles in a suburban elementary school." *American journal of epidemiology* 107, no. 5 (1978): 421-432. https://doi.org/10.1093/oxfordjournals.aje.a112560

[10] Yan, Yihuan, Xiangdong Li, Yidan Shang, and Jiyuan Tu. "Evaluation of airborne disease infection risks in an airliner cabin using the Lagrangian-based Wells-Riley approach." *Building and environment* 121 (2017): 79-92. https://doi.org/10.1016/j.buildenv.2017.05.013

[11] Zhang, Sheng, and Zhang Lin. "Dilution-based evaluation of airborne infection risk-Thorough expansion of Wells-Riley model." *Building and Environment* 194 (2021): 107674. https://doi.org/10.1016/j.buildenv.2021.107674

[12] Vernez, David, Sophie Schwarz, Jean-Jacques Sauvain, Christiane Petignat, and Guillaume Suarez. "Probable aerosol transmission of SARS-CoV-2 in a poorly ventilated courtroom." *Indoor air* 31, no. 6 (2021): 1776-1785. https://doi.org/10.1111/ina.12866

[13] Chen, Linlin, Guangze Ban, Enshen Long, Gretchen Kalonji, Zhu Cheng, Li Zhang, and Shurui Guo. "Estimation of the SARS-CoV-2 transmission probability in confined traffic space and evaluation of the mitigation strategies." *Environmental Science and Pollution Research* 28 (2021): 42204-42216. https://doi.org/10.1007/s11356-021-13617-y

[14] Furuya, Hiroyuki. "Risk of transmission of airborne infection during train commute based on mathematical model." *Environmental health and preventive medicine* 12, no. 2 (2007): 78-83. https://doi.org/10.1007/BF02898153

[15] Ahmad, Nur Intan Syafinaz, Aishah Mahat, Ahmad Khudzairi Khalid, Nurhuda Ismail, and Muhammad Syawal Abd Halim. "A novel mathematical model of airborne infection." *JOURNAL INFORMATION AND TECHNOLOGY MANAGEMENT (JISTM)* 4, no. 11 (2019): 62-72.

[16] Stephens, Brent. "HVAC filtration and the Wells-Riley approach to assessing risks of infectious airborne diseases." *National Air Filtration Association (NAFA) Foundation Report* (2012).

[17] Guo, Yong, Hua Qian, Zhiwei Sun, Jianping Cao, Fei Liu, Xibei Luo, Ruijie Ling, Louise B. Weschler, Jinhan Mo, and Yinping Zhang. "Assessing and controlling infection risk with Wells-Riley model and spatial flow impact factor (SFIF)." *Sustainable Cities and Society* 67 (2021): 102719. https://doi.org/10.1016/j.scs.2021.102719

[18] Mboreha, Chanfiou Ahmed, Changchun Jilin, and China Gaurav Kumar. "Risk and preventing of COVID-19 in a commercial aircraft cabin: an overview." *Int J Eng Appl Sci Technol* 5 (2020): 661-670. https://doi.org/10.33564/IJEAST.2020.v05i03.115

[19] Chua, A. "Boeing 737 Aircraft Profile," *Flight Global.* (2008).

[20] Tretiakow, Dmitry, Krzysztof Tesch, and Andrzej Skorek. "Mitigation effect of face shield to reduce SARS-CoV-2 airborne transmission risk: Preliminary simulations based on computed tomography." *Environmental Research* 198 (2021): 111229. https://doi.org/10.1016/j.envres.2021.111229