A Mathematical Model of the Risk Assessment for Airborne Transmission in a Classroom with a Ventilation System and Nine Distinct Face Mask Efficiency

Benjawan Janmanit, and Nopparat Pochai

***Abstract*— TB, COVID-19, MERS, and SARS are all serious infectious diseases that are transmitted by the air or aerosol via coughing, spitting, sneezing, speaking, or wounds. When restaurants and bars reopen and continue operations in some parts of the United States, the Centers for Disease Control and Prevention (CDC) gives the following suggestions for how operators can reduce risk for employees, customers, and communities while also restricting the spread of COVID-19. The more and longer a person interacts with others, the greater the risk of COVID-19 spreading. Therefore, we need to be informed of its management and treatment. As a result, for the control and reduction of potentially polluted air, such as CO2 levels, good air quality management is required. They investigated the protective effectiveness of face masks against airborne transmission of infectious SARS-CoV-2 droplets and aerosols in response to the World Health Organization's recommendation to wear face masks to prevent the spread of COVID-19. Using nine different forms of mask efficiency, this research provides a mathematical model for calculating the chance of airborne transmission in a classroom. The fourth-order Runge-Kutta approach is used to approximate the model solution. The proposed strategy strikes a balance between the number of students allowed to stay in the classroom and the effectiveness of nine different masks. We can see how utilizing nine different masks and a well-ventilated system in the classroom can help to reduce the risk of airborne infection.**

***Index Terms*— Airborne, Risk Assessment, Classroom, Ventilation Rate, Face Mask Efficiency**

I. INTRODUCTION

Tuberculosis (TB), Coronavirus Disease Starting in 2019 (COVID-19), Middle East Respiratory Syndrome (MERS), and Severe Acute Respiratory syndrome (SARS) are a hazardous communicable disease which are spread from person to person through the air or the aerosol in different ways, such as through coughing, spitting, sneezing, speaking, or through wounds. In [1], US scientists in the laboratory have shown that the virus can live in an aerosol and remain infectious for at least 3 hours. Tuberculosis (commonly known as TB), this communicable disease is caused by Mycobacterium Tuberculosis, which most often affects the lungs. At present, we have an effective TB disinfectant. TB can be treated, but recovery takes a long time. If the treatment is not continued, or is incomplete, death may result. Therefore, TB is an important public health issue in Thailand. In [2], a new procedure was developed to study the distribution of epidemics for predicting the possibility of airborne infectious diseases in high-density urban areas. It can analyze the chance of spread in sub-transportation, and it can also help understand dispersion of airborne diseases in public transportation in China. In [3], the researchers studied the behaviors of Korean TB infection. TB transmission dynamic was proposed by using mathematical TB model with exogenous reinfection. Then, the least squares method was used to approximate the considered parameters. From the results, the most significant factor was the case finding effort, which led to a decrease of active TB patients.

In [4], the researchers developed an infectious diseases model of SARS by using two methods for estimating both small-scale SARS outbreak parameter at the Amoy Gardens, Hong Kong and large-scale outbreak parameter in the entire Hong Kong Special Administrative Region. In [5], the inpatient nursing records from EMR of the University of Miyazaki Hospital were analyzed by using a text data mining technique. This result indicated that vocabulary related to appropriate treatment methods. In [6], airflow and the airborne spread of infectious agents from an indoor environment was focused on. From this, it was confirmed that infected individuals and susceptible individuals should use masks, and also should use personalized ventilation for a short-range airborne route. [10] and [11] present air quality monitoring models in an open, high-traffic roadway canyon. [12] introduces a mathematical model for risk assessments of airborne infectious diseases in an outpatient setting with a personal categorization component. [13] proposes a numerical model for measuring carbon dioxide content in a room with an open ventilation system. [14] introduces a risk model for airborne transmission and vaccine efficacy in an outpatient room with a ventilation system. [15] proposes a mathematical model for assessing the risk of airborne illness

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in a room with an outlet ventilation system.

This research introduces a mathematical model for assessing the risk of airborne transmission in a classroom using nine distinct types of mask efficiency. The model solution is approximated using the fourth-order Runge-Kutta method.

II. Governing Equation

The basis for the description of the relationship between the mass or concentration of a gaseous substance in space as a function of time is the mass balance equation. Thus, the generalized tracer mass balance equation can be presented as the following first-order differential equation [16]:

$$V\frac{dC}{dt} = F + QC_e - QC, \tag{1}$$

where C is the indoor exhaled air concentration (ppm), V is the volume of the classroom (m^3), and F is an emission of tracer gas into space by a tracer gas source (mass per time unit). Furthermore, QC_e is the transport of tracer gas from the outside air into the room air (mass per time unit), and QC is the transport of tracer gas from the room air to the outside (mass per time unit).

The basic equation for the exhaled air accumulation rate in an atmospheric carbon dioxide (CO2) space, which is then occupied, is equal to the rate of exhaled air produced by the occupants plus the ambient rate of CO2, minus the exhaled air eliminated by the rate of ventilation. Moreover, if we consider the term F of the mass balance equation in (1), we find the rate of exhaled air generated by occupants is the production rate of tracer by all sources within the enclosure, i.e., n are the number of people (person), p is the breathing rate for each person in the room (L/s), and C_a is the CO_2 fraction containing inbreathed air. Thus, the fundamental equation for exhaled air accumulation rate in the room with environmental CO_2 can be formulated as the following:

$$V\frac{dC}{dt} = npC_a + QC_e - QC. \tag{2}$$

As an indicator of exhaled air, we assume that everyone in the room will contribute to the creation of CO_2. C_e (ppm) is the ambient CO_2 concentration at the beginning of the day; n takes over. This means that, depending on the ventilation rate Q (L/s) and n, the level of exhaled air concentration that may include airborne infectious particles would start to rise in the room.

We consider the equation for exhaled air accumulation rate in the room with environmental CO_2 in (2), and we divide the ventilation rate into inlet ventilation rate and outlet ventilation rate, which can be written as:

$$V\frac{dC}{dt} = npC_a + Q_{in}C_e - Q_{out}C, \tag{3}$$

Where Q_{in} and Q_{out} are the inlet ventilation rate and outlet ventilation rate, respectively. After dividing both sides of (3) by the volume, we obtain an ordinary differential equation which describes the concentration change of the indoor exhaled air per time unit:

$$\frac{dC}{dt} = \frac{npC_a + Q_{in}C_e - Q_{out}C}{V}. \tag{4}$$

We are interested in the amount of air pollution that leads to tuberculosis. Using the same initial equation as the above equation, the equation is used to describe the CO_2 concentration in a classroom.

We obtain the below equation by dividing the carbon dioxide percentage in inhaled air *C(a)* by the volume fraction of exhaled air, f, which is determined by the measured exhaled air concentration *C(T)* in the room,

$$f = \frac{C_{(T)}}{C_a}. \tag{5}$$

where the time in the specified location is expressed as *T*.

According to [8], as was previously described, if airborne infectious particles generated by infectors reach the target infection location of the host at a threshold level, the risk of their infecting susceptible people is quite high. Even though the probability of spreading infection is quite low, some infected particles can become caught in the upper respiratory tract or reflect to other areas of the body. Let μ be the mortality rate of the infector's produced airborne infectious particles (particles/s) that do not reach the alveoli and β be the total airborne infectious particle generation rate released by the infector (particles/s). Therefore, it can be shown that the β-μ particles/s survival rate of airborne infectious particles generated by the infector that reach the target infection location of the susceptible individual to induce infection at threshold level.

The average volume fraction of rebreathed air by infectors, $(I\bar{f}/n)$, multiplied by the average concentration of airborne infectious particles released by infectors in the room that reach the target infection site of the respiratory tract, $((\beta-\mu)/\mathrm{p})$, results in the average concentration of airborne infectious particles, $\bar{N}$, that cause infection:

$$N(t) = \frac{If(\beta-\mu)}{np},\ I \geq 1 \text{ and } (\beta-\mu) \geq 1. \tag{6}$$

Let θ be a respiratory deposition fraction of airborne infectious particles that successfully reach and deposit at the target infection site of the host since not all infected particles can reach and deposit at the alveoli. As a result, the product of the volume of air that a susceptible person breathes in (pt), the respiratory deposition fraction of airborne infectious particles $\theta(0 < \theta < 1),$, and the average concentration of airborne infectious particles ($\bar{N}$) released by infectors results in the average number of airborne infectious particles, $\lambda(t)$, that cause infection:

$$\lambda(t) = pt\theta N(t),\ \mathrm{t}>0. \tag{7}$$

where t is the duration of time spent in the area leading to the infection.

The percentage of airborne infectious particles, γ, that cause airborne infectious infections in exhaled air may be calculated by computing an expected average number of airborne infectious particles in equation (13), and the assumption is that

$$\gamma(t) = \frac{\lambda(t)}{C(t)} \times 100. \tag{8}$$

where C_T is the sampled exhaled air in the given space.

[9] takes into account the assumption that airborne transmission has a Poisson distribution. We define the airborne transmission probability in [7] and [9] as

$$P(T \leq t \mid I, Q, V, p, \theta, \mu, \beta) = 1 - e^{-\lambda(t)}. \tag{9}$$

where $P(T \leq t \mid I, Q, V, p, \theta, \mu, \beta)$ denotes the probability of airborne transmission risk for susceptible individuals and T ≤ t are the random variables representing infection risk for susceptible individuals up to the time spent in the confined space given the presence of an infectious environment in the space.

The probability of an airborne active infection is described by Eq. (9), which adds extremely important parameters including particle production, survival, mortality rates, and successful deposition fraction at the site of infection. As long as the boundary condition of an infectious particle threshold level is met, the model may be applied in a variety of contaminated situations.

Eq.(9) thus calculates the probability of airborne infectious disease transmission, such as COVID-19, under non-steady state conditions. This equation's exponential term, not massless particles, refers to how many airborne infectious particles must be inhaled by each susceptible person in the area to cause infection. Additionally, for a susceptible person to become infected, this number must approach or reach the threshold level, depending on the severity of the infecting pathogen strains and the host's immunological response. This model, in our opinion, offers epidemiologists and the general public a better and more adaptable mathematical model for comprehending the risks associated with the transmission of infectious diseases.

III. Effectiveness of Face Masks Disinfection Method Against COVID-19

A. Mask Filtration Studies

Face masks are recommended by public health experts as a way to prevent others from inhaling potentially infectious particles. Through a series of projects in partnership with University of North Carolina (UNC) experts, EPA scientists are working to study the effectiveness of masks in protecting the wearer against the virus at the request of UNC Hospitals. Researchers investigated how well various masks and modifications blocked airborne salt particles, which are the same size as the tiniest SARS-CoV-2 particles but are not dangerous. Face covers were worn by members of the study team during the experiment (Environmental Protection Agency, 2021). Table 1 shows the efficacy of face mask disinfection with surgical masks [16].

TABLE I
Effectiveness of Face Mask Disinfection [16]

Masks	Consumer-Grade Masks	Fitted Filtration Efficiency (FFE)
M1	2-layer woven nylon mask	0.4400
M2	cotton bandana	0.5010
M3	single layer woven polyester gaiter	0.6220
M4	single layer woven polyester/nylon mask with ties	0.6070
M5	non-woven polypropylene mask with fixed ear loops	0.7140
M6	3-layer knitted cotton mask with ear loops	0.7350
M7	N95 respirator	0.0160
M8	surgical mask with ties	0.2850
M9	procedure mask with ear loops	0.6150

Another study examined the filtration ability of a range of medical procedure masks, fabric masks, and public-use coverings in another investigation. They put masks made of cotton, nylon, and other fabrics, as well as masks with ear loops and ties, to the test. Table I shows the efficiency of face mask disinfection for nine consumer-grade masks [16].

IV. Numerical Techniques for Solution of Governing Equation

A. Fourth-Order Runge-Kutta Method

The approximation of solution for a first order differential equation can be written as:

$$\frac{dC}{dt} = f(t, C). \tag{10}$$

The fourth-order Runge-Kutta (RK4) is a well-known method. This method is a reasonable and good general method for the numerical solution of first-order differential equation with an intelligent adaptive step-size. Thus, we use the RK4 formula for approximating the solution of (18):

$$C_{i+1} = C_i + \frac{1}{6}[F_1 + 2F_2 + 2F_3 + F_4], \tag{11}$$

where

$$F_1 = hf(t_i, C_i),$$
$$F_2 = hf\left(t_i + \frac{h}{2}, C_i + \frac{F_1}{2}\right),$$
$$F_3 = hf\left(t_i + \frac{h}{2}, C_i + \frac{F_2}{2}\right),$$
$$F_4 = hf(t_i + h, C_i + F_3).$$

We consider that (4) and (18) can be simplified to:

$$F(t, C) = \frac{npC_a + Q_{in}C_e - Q_{out}C}{v}. \tag{12}$$

The exhaled air contains about 40,000 ppm of carbon dioxide (CO_2) compared with almost 400 ppm of CO_2 in the environmental air [14],[17],[18].

V. Numerical Simulation

A. Three static cases of the number of students in a classroom

There is a risk of airborne infection when employing nine different types of mask efficiency when the number of students in a class room remains constant. Three different scenarios will be developed with 50, 40, and 30 people in the room. Table II and Fig. 1 illustrate the exhaled air in the classroom when the number of students is 50, 40, and 30, respectively. As a result, Table III and Fig. 2 both show the volume fraction of exhaled air. Table IV and Fig. 3 show the concentration of airborne infectious particles with nine different types of mask efficiency. As a result, Table V and Fig. 4 show the number of airborne infectious particles for nine different types of mask efficiency. Finally, Table VI and Fig. 5 show the probability of airborne transmission risk for susceptible individuals with nine different types of mask efficiency.

A. Three examples of student numbers that are assumed to be functions in a classroom

There is a risk of airborne infection when employing nine different types of mask efficiency when the number of students in a class room is assumed to be function in a classroom. Three different scenarios will be developed with 50, 40, and 30 people in the room. Table VII and Fig. 6 illustrate the exhaled air in the classroom when the number of students is 50, 40, and 30, respectively.

TABLE II
THE EXHALED AIR CONCENTRATION IN THE ROOM C(t) WHEN NUMBER OF STUDENTS ARE STATIC

Time (min)	n		
	50	40	30
0	0.0000	0.0000	0.0000
10	1.9781	1.5825	1.1868
20	3.3040	2.6432	1.9824
30	4.1928	3.3543	2.5157
60	5.4557	4.3646	3.2734
90	5.8361	4.6688	3.5016
120	5.9506	4.7605	3.5704
180	5.9955	4.7964	3.5973

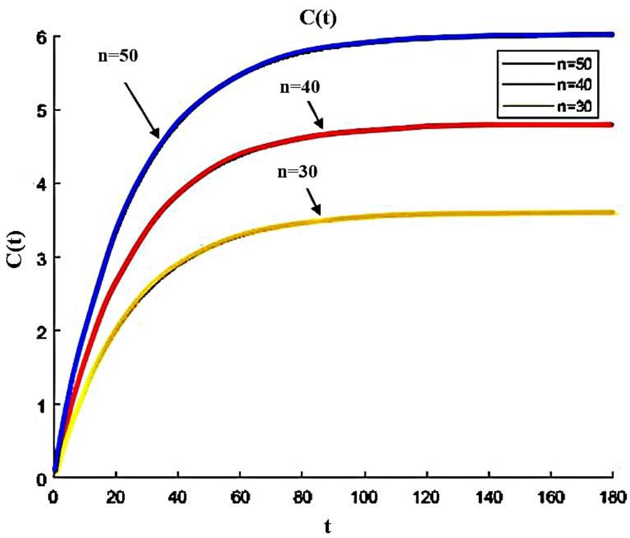

Fig. 1. The sampled exhaled air in the room when number of students are static.

TABLE III
THE VOLUME FRACTION OF EXHALED AIR f(t) WHEN NUMBER OF STUDENTS ARE STATIC

Time (min)	n		
	50	40	30
0	0.0000	0.0000	0.0000
10	49.4520	39.5616	29.6712
20	82.6007	66.0805	49.5604
30	104.8209	83.8567	62.8925
60	136.3923	109.1138	81.8354
90	145.9014	116.7212	87.5409
120	148.7655	119.0124	89.2593
180	149.8880	119.9104	89.9328

As a result, Table VIII and Fig. 7 both show the volume fraction of exhaled air. Table IX and Fig. 8 show the concentration of airborne infectious particles with nine different types of mask efficiency. As a result, Table X and Fig. 9 show the number of airborne infectious particles for nine different types of mask efficiency. Finally, Table XI and Fig. 10 show the probability of airborne transmission risk for susceptible individuals with nine different types of mask efficiency.

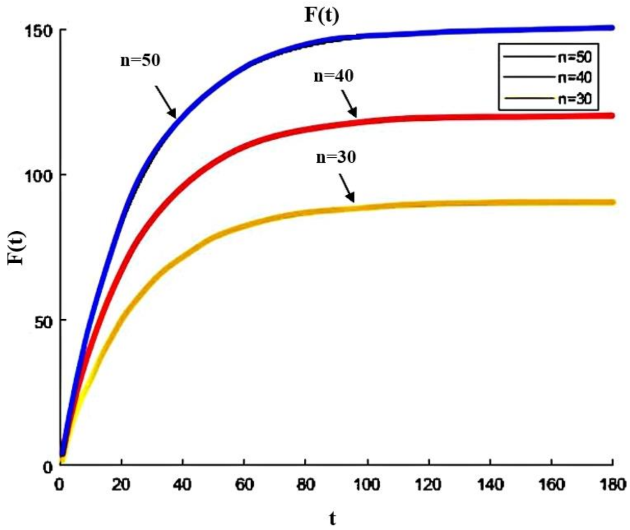

Fig. 2. The volume fraction of exhaled air when number of students are static.

TABLE IV
THE CONCENTRATION OF AIRBORNE INFECTIOUS PARTICLE N(t) WHEN NUMBER OF STUDENTS ARE STATIC

Time (min)	Masks				
	M1	M2	M3	M4	M5
0	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0403	0.0459	0.0570	0.0556	0.0654
20	0.0673	0.0766	0.0951	0.0928	0.1092
30	0.0854	0.0973	0.1207	0.1178	0.1386
60	0.1111	0.1265	0.1571	0.1533	0.1803
90	0.1189	0.1354	0.1681	0.1640	0.1929
120	0.1212	0.1380	0.1714	0.1672	0.1967
180	0.1221	0.1391	0.1726	0.1685	0.1982
Time (min)	Masks				
	M6	M7	M8	M9	
0	0.0000	0.0000	0.0000	0.0000	
10	0.0673	0.0015	0.0261	0.0563	
20	0.1124	0.0024	0.0436	0.0941	
30	0.1427	0.0031	0.0553	0.1553	
60	0.1856	0.0040	0.0720	0.1553	
90	0.1986	0.0043	0.0770	0.1662	
120	0.2025	0.0044	0.0785	0.1694	
180	0.2040	0.0044	0.0791	0.1707	

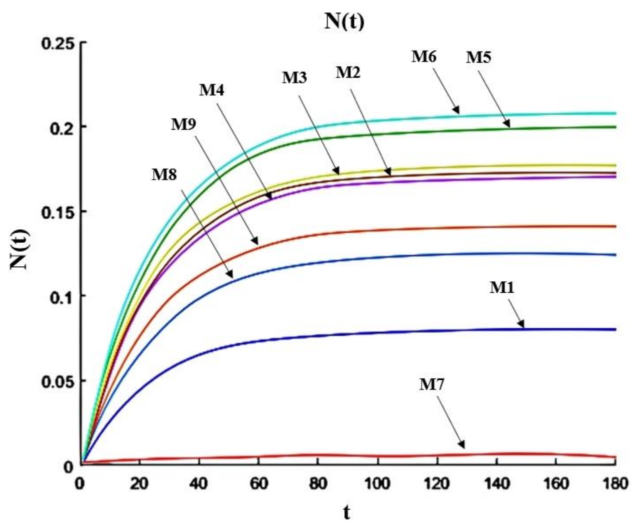

Fig. 3. The concentration of airborne infectious particle when number of students are static.

TABLE V
THE NUMBER OF AIRBORNE INFECTIOUS PARTICLES λ(t) WHEN NUMBER OF STUDENTS ARE STATIC

Time (min)	Masks				
	M1	M2	M3	M4	M5
0	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0479	0.0545	0.0677	0.0660	0.0777
20	0.1607	0.1830	0.2272	0.2217	0.2608
30	0.3064	0.3489	0.4332	0.4228	0.4973
60	0.7988	0.9096	1.1293	1.1020	1.2963
90	1.2825	1.4603	1.8130	1.7693	2.0812
120	1.7441	1.9859	2.4655	2.4060	2.8301
180	2.6366	3.0021	3.7271	3.6373	4.2784
Time (min)	Masks				
	M6	M7	M8	M9	
0	0.0000	0.0000	0.0000	0.0000	
10	0.0800	0.0017	0.0310	0.0669	
20	0.2685	0.0058	0.1041	0.2246	
30	0.5119	0.0111	0.1985	0.4283	
60	1.3344	0.0290	0.5174	1.1166	
90	2.1424	0.0466	0.8307	1.7926	
120	2.9134	0.0634	1.1297	2.4377	
180	4.4043	0.0959	1.7078	3.6852	

TABLE VI
THE PROBABILITY OF AIRBORNE TRANSMISSION RISK FOR SUSCEPTIBLE INDIVIDUALS P(t) WHEN NUMBER OF STUDENTS ARE STATIC

Time (min)	Masks				
	M1	M2	M3	M4	M5
0	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0467	0.0530	0.0654	0.0639	0.0747
20	0.1485	0.1672	0.2032	0.1989	0.2296
30	0.2639	0.2946	0.3516	0.3448	0.3918
60	0.5501	0.5973	0.6767	0.7101	0.7265
90	0.7227	0.7678	0.8368	0.8295	0.8752
120	0.8252	0.8627	0.9150	0.9098	0.9410
180	0.9284	0.9503	0.9759	0.9737	0.9861
Time (min)	Masks				
	M6	M7	M8	M9	
0	0.0000	0.0000	0.0000	0.0000	
10	0.0769	0.0017	0.0305	0.0647	
20	0.2355	0.0058	0.0989	0.2012	
30	0.4007	0.0111	0.1800	0.3484	
60	0.7367	0.0286	0.4039	0.6726	
90	0.8826	0.0456	0.5643	0.8335	
120	0.9457	0.0615	0.6769	0.9126	
180	0.9878	0.0914	0.8187	0.9749	

VI. DISCUSSION

We can observe that nine different types of mask efficiency minimize the risk of airborne infection. Two scenarios are simulated, including three static cases of the number of students in a classroom and three examples of student numbers in a classroom that are supposed to be functions. As a result, the optimum protection is provided by the M7 mask, which is an N95 respirator. The M5 mask, which is made of non-woven polypropylene and has fixed ear loops, provides the least level of protection. However, if students remain in a room for an extended period of time, such as 2–3 hours, they may be at risk of transmitting an airborne infection.

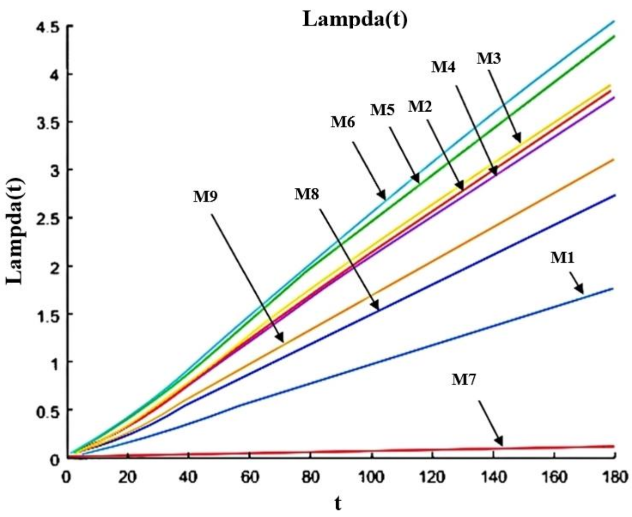

Fig. 4. The number of airborne infectious particles when number of students are static.

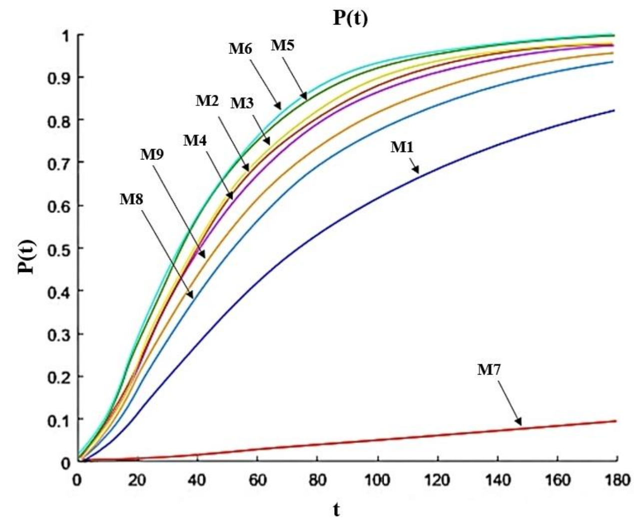

Fig. 5. The probability of AIRBORNE transmission risk for susceptible individuals when number of students are static.

TABLE VII
THE SAMPLED EXHALED AIR IN THE ROOM C(t) WHEN NUMBER OF STUDENTS ARE VARIED

Time (min)	n		
	50 + 10sin (0.1T)	50 + 10sin (0.1T)	50 + 10sin (0.1T)
0	0.0000	0.0000	0.0000
10	2.1421	2.3062	2.4702
20	3.7399	4.1758	4.6117
30	4.6823	5.1718	5.6612
60	5.1892	4.9228	4.6563
90	6.3360	6.8359	7.3359
120	5.7477	5.5448	5.3419
180	5.8592	5.7229	5.5866

TABLE VIII
THE VOLUME FRACTION OF EXHALED AIR f(t) WHEN NUMBER OF STUDENTS ARE VARIED

Time (min)	n		
	50 + 10sin (0.1T)	50 + 10sin (0.1T)	50 + 10sin (0.1T)
0	0.0000	0.0000	0.0000
10	53.5532	57.6544	61.7557
20	93.4978	104.3950	115.2922
30	117.0576	129.2944	141.5312
60	129.7307	123.0691	116.4075
90	158.3997	170.8981	183.3964
120	143.6930	138.6204	133.5479
180	146.4806	143.0732	139.6658

TABLE IX
THE CONCENTRATION OF AIRBORNE INFECTIOUS PARTICLE N(t) WHEN NUMBER OF STUDENTS ARE VARIED

Time (min)	Masks				
	M1	M2	M3	M4	M5
0	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0374	0.0426	0.0528	0.0516	0.0607
20	0.0644	0.0733	0.0911	0.0889	0.1045
30	0.0926	0.1054	0.1309	0.1277	0.1502
60	0.1122	0.1277	0.1586	0.1548	0.1821
90	0.1190	0.1355	0.1683	0.1642	0.1932
120	0.1314	0.1496	0.1858	0.1813	0.2132
180	0.1407	0.1602	0.1989	0.1941	0.2283
Time (min)	Masks				
	M6	M7	M8	M9	
0	0.0000	0.0000	0.0000	0.0000	
10	0.0624	0.0014	0.0242	0.0523	
20	0.1076	0.0023	0.0417	0.0900	
30	0.1547	0.0034	0.0600	0.1294	
60	0.1874	0.0041	0.0727	0.1568	
90	0.1988	0.0043	0.0771	0.1664	
120	0.2195	0.0048	0.0851	0.1837	
180	0.2350	0.0051	0.0911	0.1966	

VII. CONCLUSION

This study develops a mathematical model for assessing the risk of airborne transmission in a classroom using nine distinct types of mask efficiency. The model solution is approximated using the fourth-order Runge-Kutta method. The proposed technique creates a balance between the number of students permitted to remain in the classroom and the efficacy of nine distinct masks. During the air quality control technique, the suggested technique balances the number of students allowed to stay in the classroom with the effectiveness of the air ventilation system as well as the number of people differences, both static and variable.

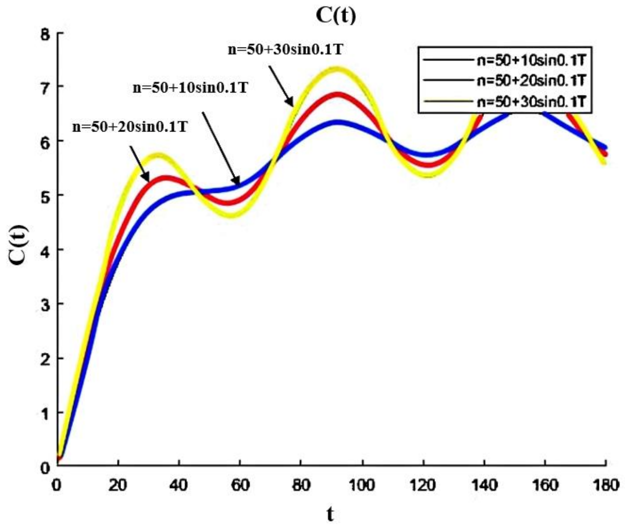

Fig. 6. The sampled exhaled air in the room when number of students are varied.

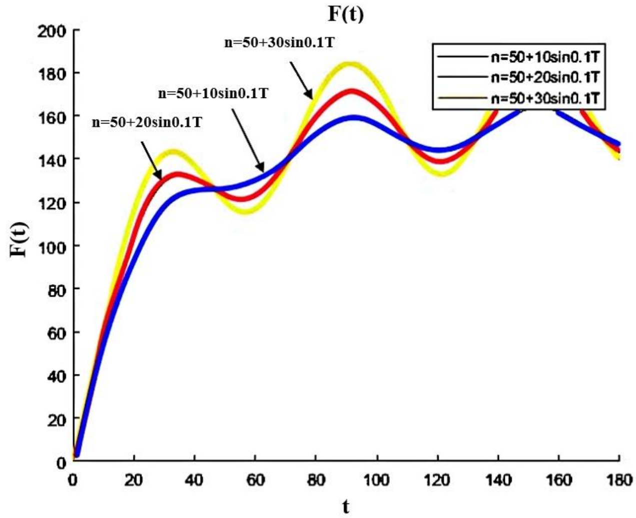

Fig. 7. The volume fraction of exhaled air when number of students are varied.

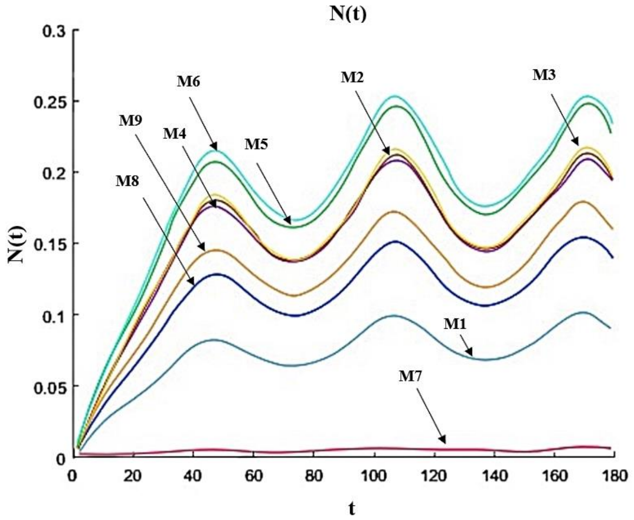

Fig. 8. The concentration of airborne infectious particle when number of students are varied.

TABLE X
THE NUMBER OF AIRBORNE INFECTIOUS PARTICLES λ(t) WHEN NUMBER OF STUDENTS ARE VARIED

Time (min)	Masks				
	M1	M2	M3	M4	M5
0	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0444	0.0506	0.0628	0.0613	0.0721
20	0.1538	0.1752	0.2175	0.2122	0.2496
30	0.3322	0.3782	0.4696	0.4583	0.5391
60	0.8064	0.9182	1.1400	1.1125	1.3086
90	1.2842	1.4622	1.8154	1.7716	2.0839
120	1.8907	2.1528	2.6727	2.6083	3.0680
180	3.0367	3.4577	4.2928	4.1893	4.9278
Time (min)	Masks				
	M6	M7	M8	M9	
0	0.0000	0.0000	0.0000	0.0000	
10	0.0742	0.0016	0.0288	0.0621	
20	0.2570	0.0056	0.0996	0.2150	
30	0.5549	0.0121	0.2152	0.4643	
60	1.3471	0.0293	0.5223	1.1272	
90	2.1452	0.0467	0.8318	1.7949	
120	3.1583	0.0688	1.2246	2.6426	
180	5.0727	0.1104	1.9670	4.2445	

TABLE XI
THE PROBABILITY OF AIRBORNE TRANSMISSION RISK FOR SUSCEPTIBLE INDIVIDUALS P(t) WHEN NUMBER OF STUDENTS ARE VARIED

Time (min)	Masks				
	M1	M2	M3	M4	M5
0	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0434	0.0493	0.0609	0.0594	0.0695
20	0.1426	0.1607	0.1954	0.1912	0.2209
30	0.2827	0.3149	0.3747	0.3676	0.4167
60	0.5536	0.6008	0.6802	0.6713	0.7298
90	0.7231	0.7683	0.8372	0.8299	0.8756
120	0.8490	0.8838	0.9309	0.9263	0.9535
180	0.9520	0.9685	0.9863	0.9848	0.9928
Time (min)	Masks				
	M6	M7	M8	M9	
0	0.0000	0.0000	0.0000	0.0000	
10	0.0715	0.0016	0.0284	0.0602	
20	0.2266	0.0056	0.0948	0.1935	
30	0.4259	0.0120	0.1936	0.3714	
60	0.7400	0.0289	0.4069	0.6761	
90	0.8830	0.0456	0.5647	0.8339	
120	0.9575	0.0664	0.7061	0.9288	
180	0.9937	0.1045	0.8601	0.9857	

We can see how having a well-ventilated system and wearing nine different masks in the classroom can help to reduce the risk of airborne infection. It is possible to expand the introduced model to take into account a two-dimensional space model.

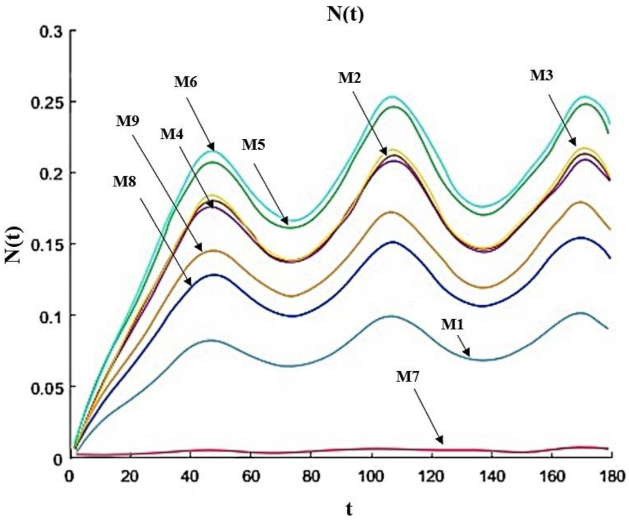

Fig. 9. The number of airborne infectious particles when number of students are varied.

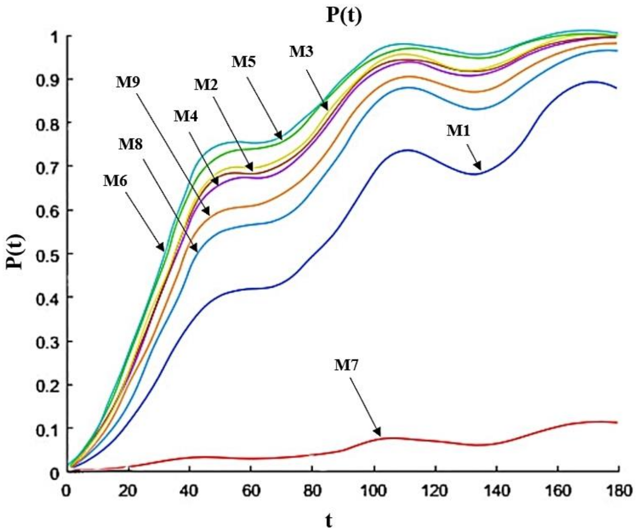

Fig. 10. The probability of airborne transmission risk for susceptible individuals when number of students are varied.

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