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Factors Affecting Indoor Air against the Transmission Risk of Coronavirus Disease 2019: Systematic Review and Policy Analysis

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Abstract

BACKGROUND: Coronavirus disease 2019 (COVID-19) is thought to be transmitted primarily through droplets and contaminated surfaces through aerosols.

AIM: Therefore, this study aims to identify the risk of COVID-19 agents in aerosol form and how indoor air control technique plays a role in the risk of disease transmission. It also examines the existing policies as administrative controls in managing the risk of COVID-19 transmission through indoor air control techniques.

METHODS: This is a systematic review and policy study carried out in line with the preferred reporting item for systematic review and meta-analysis guidelines using ProQuest, PubMed, ScienceDirect, and Scopus databases. Furthermore, the search strategy was carried out using keywords with the Boolean AND and OR operations, namely, "COVID-19 AND (Transmission OR Spread) AND (aerosol OR airborne OR microdroplet) AND (Indoor OR Indoor Air OR Ventilation).

RESULTS: In the policy review, the analysis unit was obtained from the official websites of the Indonesian Government and World Health Organization in the form of regulations, recommendations, guidelines, or other protocols that regulate indoor activities during the pandemic. There is a risk of COVID-19 agents from aerosols in indoor air. Meanwhile, the control of indoor air techniques plays a role in reducing the risk of transmission through aerosols by (1) increasing the exchange of indoor with outdoor air, (2) using air purifiers, and (3) paying attention to the layout of ventilation devices, airflow direction and distribution, as well as the flow of clean and dirty air in a room.

CONCLUSION: Based on the results, the existing policies are still minimal in preventing transmission risk through indoor aerosols; hence, policy development is needed.

Introduction

In December 2019, a new disease caused by the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) virus was confirmed in Wuhan, China. It was named *Novel* Coronavirus Disease 2019 (COVID-19) and causes severe acute respiratory syndrome. Furthermore, the World Health Organization (WHO) [1] declared COVID-19 outbreak a global pandemic on March 11, 2020. The number of cases reached 445.6 million on March 6, 2022, with a death toll of 6 million worldwide, while cases in Indonesia reached 5.7 million with 150,172 deaths [2].

Given the pandemic conditions, the public health system and service facilities faced enormous challenges in the management of these non-natural disasters. The public health system plays a role in responding to non-natural disasters, implementing comprehensive and non-comprehensive planning, as well as coordinating pandemic management and policy making [3]. Meanwhile, health-care facilities are at the forefront of conducting disease tests, tracing close contacts, and treating COVID-19 patients. However, the unprecedented pandemic conditions in the modern era have created a real gap in the preparedness of public health systems and health-care facilities [4]. Besides, the pandemic condition also has the risk of causing social and economic problems. This resultantly affected economic activities, thereby triggering an increase in inequality and poverty globally [5].

To prevent the spread of COVID-19 and to keep the economy moving, the Indonesian Government implemented partial social restrictions [6], [7]. In practice, the public is allowed to carry out shopping, visit offices, and recreational activities while still complying with the health protocols. However, despite the adherence to the health protocols, the number of new cases from July 2020 to January 2021 continues to increase [8].

SARS-CoV-2 was thought to be transmitted primarily through droplets and close contact with infected individuals. However, the mode was not the absolute transmission mechanism [9]. This is supported by various studies which reported that SARS-CoV-2 is transmitted through aerosols, namely, microdroplets measuring ≤5 μm and survives in the air for several hours [10]. Transmission through aerosols is also at risk of being the most dominant route [11].

According to the WHO [12], COVID-19 has a higher risk in closed, confined, and poorly ventilated environments. Furthermore, Nishiura *et al*. [13] stated that the transmission of COVID-19 has higher risk in a closed environment than in the open. Therefore, there is a need to review the factors that affect indoor air as a risk factor for transmission media. This study aims to examine the factors that influence indoor air for transmission risk by examining control techniques through systematic studies and administrative controls related to indoor activities during the pandemic through policy studies. The policies studied in this study are policies that aim to control COVID-19 by regulating air circulation in the room and can be accessed online.

Methods

Identification of analysis units

This study used a qualitative approach with two methods, namely, systematic and policy studies. A systematic review was conducted to assess the risk of COVID-19 transmission through aerosol and indoor air control techniques. Meanwhile, the policy review was conducted to examine the administrative control of indoor activities during the pandemic. The systematic review used the stream preferred reporting item for systematic review and meta-analysis (PRISMA) [14], [15], [16] while the policy review was carried out using a literature review approach [14], [15].

All analysis units were obtained through an online search, for the systematic study, the sources include ProQuest, PubMed, ScienceDirect, and Scopus databases. The search strategy was carried out using keywords Boolean AND and OR operations, namely, “COVID-19 AND (Transmission OR Spread) AND (aerosol OR airborne OR microdroplet) AND (Indoor OR Indoor Air OR Ventilation)” by utilizing advanced search features on each database. Meanwhile, the literature type selected was only non-reviewed research articles published between November 2020 and April 2021. In the policy studies, the analysis units were obtained from the official websites of the Indonesian Government and WHO in the form of regulations, recommendations, guidelines, and other protocols governing indoor activities during the pandemic. In addition, several COVID-19 control guidelines that regulate indoor air circulation in Singapore, England, The State of North California, and Daerah Khusus Ibukota (DKI) Jakarta Province also reviewed in this study.

Data extraction

Based on the results of the study identification, 12 literatures were included from 2115. The study locations were in: China (3), United States (3), Spain (1), Singapore (1), Sweden (1), South Korea (1), and the Netherlands (1). However, one literature did not provide information on the study location. The inclusion process was carried out based on several criteria, namely:

1. Literature is a non-reviewed research article
2. Have titles and abstracts that are relevant to the study topic
3. Accessed in full text for free or using a member account of the Universitas Indonesia Library
4. Used Indonesian or English
5. Answers study questions with the PICO approach [15], namely:
   a. *Problem*: The potential presence of SARS-CoV-2 in aerosol form
   b. *Intervention:* Indoor air control technique
   c. *comparator*: Not taken into account in this study
   d. *Outcome*: Indoor risk of COVID-19 transmission
6. Only one literature was selected if duplication was found.

Details of the PRISMA process flow applied in this study are described in Figure 1. In the policy review (Table 1), three Decrees of the Indonesia Ministry of Health, and three policies from the WHO in the form of one policy brief, one recommendation, and one guide were selected as the analysis unit. In addition, several COVID-19 control guidelines that regulate indoor air circulation in Singapore, England, the State of North California, and DKI Jakarta Province also reviewed in this study.

Data analysis

The data analysis process consists of a general description, as well as identification of literature and policies, and a synthesis process where the results of literary works are summarized. Furthermore, the synthesis process was carried out in several stages. The first stage involves the search for similarities (compare) and differences (contrast); meanwhile, the next process is to criticize the gaps in the literature that were collected and linked to the theory described in the literature review (criticize) to make conclusions (summarize). These studies were only analyzed to make a synthesis and conclusion.

Results

Systematic study

The analysis units of the systematic study include 12 kinds of *literatures* from various countries. Meanwhile, the study design used consisted of modeling, experimentation, and epidemiological investigations. However, one study used only two methods, namely,

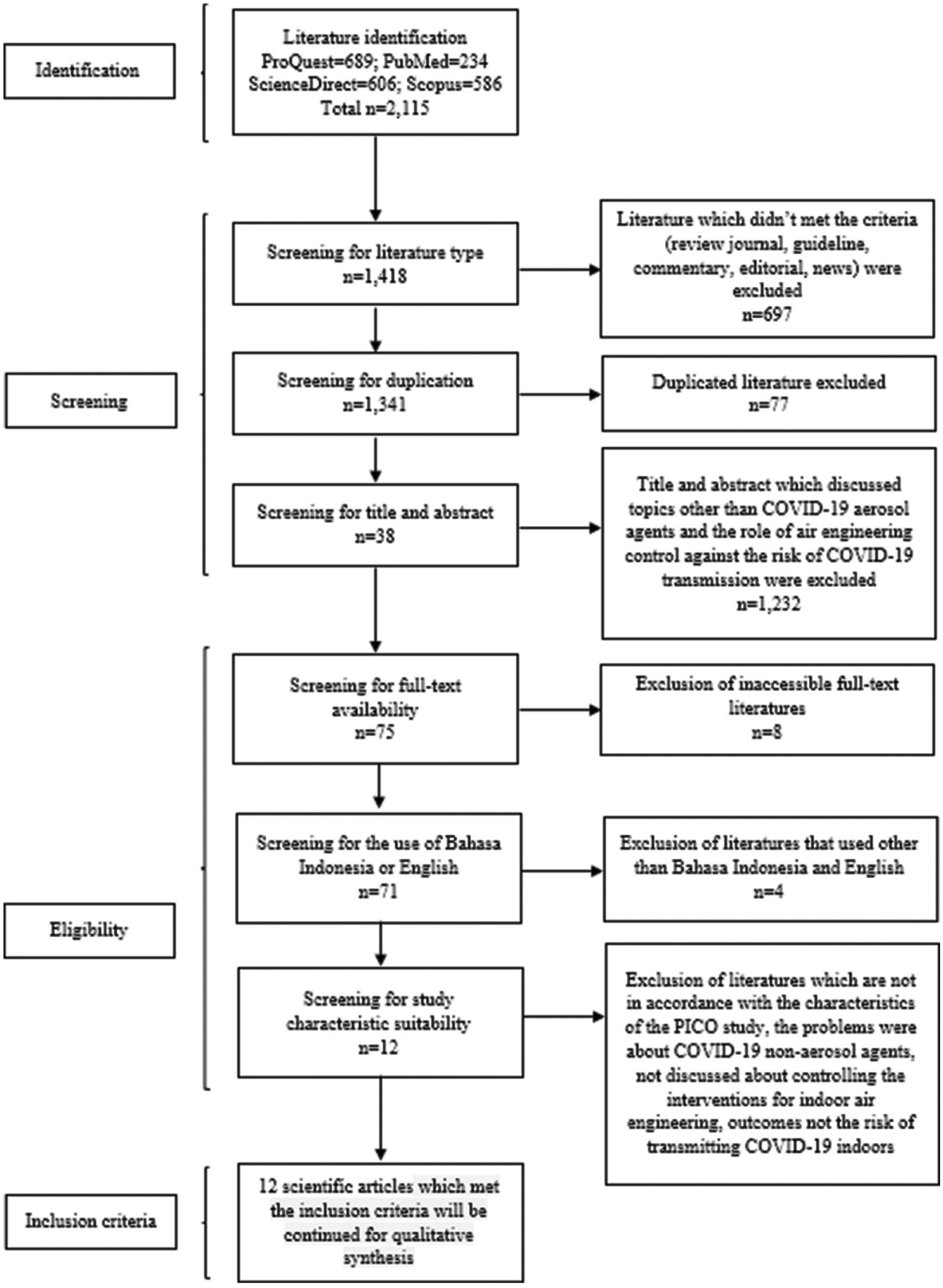

Figure 1: Preferred reporting item for systematic review and meta-analysis flow in systematic review literature selection

experimental and epidemiological investigations. In total, 26 variables were found. The number of each literature and description of the characteristics are listed in Table 2.

Table 1: Policy review overview

Literature maker	Literature type	Publication year	Literature title
Indonesian Ministry of Health [27]	Ministerial decree	2020	Decree of the Indonesian Ministry of Health Number Hk. 01.07/Menkes/382/2020 about Public health protocol in public places and facilities in the context of prevention and control of COVID-19
Indonesian Ministry of Health [28]	Ministerial decree	2020	Decree of the Indonesian Ministry of Health Number Hk. 01.07/Menkes/328/2020 about guide to prevention and control of COVID-19 in the office and Industrial workplace in supporting business continuity in a pandemic situation
Indonesian Ministry of Health [29]	Ministerial decree	2020	Decree of the Indonesian Ministry of Health Number Hk. 01.07/Menkes/2322/2020 about guide to Islamic boarding school community empowerment in the prevention and control of COVID-19 in Islamic boarding school
World Health Organization and International Labour Organization [30]	Policy Brief	2021	Preventing and mitigating COVID-19 at work
World Health Organization [31]	Recommendation	2020	Considerations for school-related public health measures in the context of COVID-19
World Health Organization [32]	Guide	2020	COVID-19 management in hotels and other entities of the accommodation sector
Central for disease control and prevention United States (CDC) [35]	Guide	2021	Ventilation in buildings summary of recent changes
Central for disease control and prevention United States (CDC) [36]	Guide	2021	Improving ventilation in your home
United Kingdom Government Services Information [37]	Guide	2021	How to stop the spread of coronavirus (COVID-19)
North California department of health and human services [38]	Guide	2021	NC COVID-19 information for health care, child care, education, business, individual, families and community, human services, housing and sheltering
Singapore Standards Council [39]	Regulation	2021	Singapore standard code of practice for air-conditioning and mechanical ventilation in buildings: updated guidance note on improving ventilation and indoor air quality in buildings amid the COVID-19 situation
Singapore National Environment Agency [40]	Guide	2021	Guidance on improving ventilation and indoor air quality in buildings amid the COVID-19 situation
DKI Jakarta Provincial Government [41]	Provincial regulation	2020	DKI Jakarta Governor Regulation Number 79 of 2020 concerning the Implementation of Discipline and Law Enforcement of Health Protocols as an Effort for Prevention and Control of COVID-19
DKI Jakarta Provincial Government [42]	Provincial regulation	2020	DKI Jakarta Governor Regulation Number 101 of 2020 concerning Amendment to Governor Regulation Number 79 of 2020 concerning the Implementation of Discipline and Law Enforcement of Health Protocols as an Effort to Prevent and Control COVID-19
DKI Jakarta Provincial Government [43]	Provincial regulation	2021	DKI Jakarta Governor Regulation Number 3 of 2021 concerning the Implementing Regulation of Regional Regulation Number 2 of 2020 concerning the Prevention of COVID-19
DKI Jakarta Provincial Government [44]	Provincial decree	2021	DKI Jakarta Governor Decree Number 721 of 2021 concerning Amendments to Governor Decree Number 980 of 2020 concerning Controlled Isolation Management Procedures in the Context of Handling COVID-19

WHO: The World health organization, COVID-19: Coronavirus disease 2019

Although all units selected in the systematic review were assessed according to the PICO approach, not all analysis units directly account for the potential presence of aerosolized COVID-19 agents which were described in three literatures. Furthermore, the role of indoor air control technique as an intervention against the risk of COVID-19 transmission in the analysis unit was carried out through several variables, namely, the ventilation, airflow rate, direction and distribution, temperature, as well as relative humidity.

The risk of aerosolized SARS-CoV-2 transmission was described in each literature, as the control technique influences indoor air. Airflow direction and distribution play a role in the spread of indoor aerosolized SARS-CoV-2 [17], [18], [19], [20], [21], [22], [23], [24]. Furthermore, ventilation rates play a role in changing indoor with outdoor air, thereby reducing aerosol agents [18], [19], [25]. Temperature affects the movement of air particles [18], [19], [23], while relative humidity affects the survival of aerosol in the air [20], [26]. In addition, ventilation type, rate, and temperature affect the airflow direction and distribution [17], [18], [19], [20], [21], [22], [23], [24].

Policy study

The analysis units in the policy review include three Decrees of the Indonesian Ministry of Health, as well as three policies from the WHO in the form of one policy brief, one recommendation, and one guideline. In addition, one guideline each from CDC, British Columbia Center for Disease Control, United Kingdom, the State of North California, and two guidelines from Singapore and four regulations from DKI Jakarta province were reviewed in this study. The overview of the selected policies is presented in Table 1. Based on the analysis units, it was found that the health protocol for indoor activities during the pandemic provides directions for preventing COVID-19 transmission for individuals and environmental settings. In general, the health protocols obtained have similarities for individuals and the environment.

Indonesian Government and WHO policies have promoted six points to prevent COVID-19 transmission for individuals and in the communities as well as: (1) Hand hygiene with soap or hand Cuci Tangan Pakai Sabun and/or using hand sanitizers, (2) wearing mask, (3) implementing cough etiquette, and (4) keeping social distance. Preventive actions based on the environmental arrangement include (1) providing hand hygiene facility, (2) regularly disinfecting facilities, (3) setting physical distancing, (4) forming a COVID-19 transmission prevention team, (5) recommending online activities, and (6) regulating and monitoring indoor air. However, the health protocols made by the Indonesian government have not regulated the exchange of indoor with outdoor air, the position of clean and dirty air areas, and air recirculation [27], [28], [29], [30], [31], [32].

Table 2: Characteristics overview of a systematic study

Author	Research title	Publication year	Research location	Study design	Variables	Conclusion
Arias and Heras [26]	The mechanical effect of moisturization on airborne COVID-19 transmission and its potential use as control technique	2021	Spain	Modeling	Relative humidity	This study considers the absorption time of the COVID-19 agent aerosol with a function of temperature, relative humidity, and water vapor size. It was found that the higher the temperature and relative humidity of the room, the lower the risk of COVID-19 aerosol agents' presence
Blocken *et al*. [33]	Ventilation and air cleaning to limit aerosol particle concentration in a gym during the COVID-19 pandemic	2021	Netherlands	Experimental	COVID-19 agent aerosol, ventilation type, ventilation rate	The application of mechanical ventilation with a room cleaning support each other to reduce the risk of COVID-19 agents' presence but cannot replace each other's functions
Hussein *et al*. [25]	Indoor model simulation for COVID-19 transport and exposure	2021	-	Modeling	COVID-19 agent aerosol, ventilation rate	The risk of exposure to aerosolized COVID-19 agents for occupants of rooms with low ventilation rates is higher than others with well-ventilated rates.
Kwon *et al*. [17]	Evidence of long-distance droplet transmission SARS-CoV-2 by direct air flow in a restaurant in Korea	2020	South Korea	Epidemiological investigation	Airflow direction and distribution	Transmission of COVID-19 occurs within a distance of about 2 meters through direct airflow from an infected person
Li *et al*. [18]	Effects of ceiling fans on airborne transmission in an air-conditioned space	2021	Singapore	Experimental	Ventilation type, rate, direction, and distribution of air flow, temperature	The movement of particles in the air, including aerosols of COVID-19 agents, is mainly affected by the thermal effects of the indoor environment. The use of mechanical ventilation devices in the form of ceiling fans increases ACH and distributes air particles better in a room thereby reducing the risk of COVID-19 transmission.
Li *et al*. [34]	Probable airborne transmission of SARS-CoV-2 in a poorly ventilated restaurant	2021	China	Epidemiological and experimental investigation	Ventilation type and rate	COVID-19 outbreak at a restaurant in Guangzhou, china occurred because the room had poor ventilation and was too crowded
Liu *et al*. [19]	Simulation-based study of COVID-19 outbreak associated with air-conditioning in a restaurant	2021	United States	Modeling	Airflow direction, distribution, and temperature	The thermal effect affects the movement of air particles in the room and is influenced by the stability of the air hence, mechanical ventilation is needed.
Nissen *et al*. [20]	Long-distance airborne dispersal of SARS-CoV-2 in COVID-19 wards	2020	Sweden	Experimental	COVID-19 agent aerosol, airflow direction and distribution, relative humidity	There are aerosols of COVID-19 agents in hospital ventilation systems that manage the transmission at low ventilation rates and relative humidity hence, there is a risk of transmitting disease
Pease *et al*. [21]	Investigation of potential aerosol transmission and infectivity of SARS-CoV-2 through central ventilation systems	2021	United States	Modeling	Ventilation rate, direction and distribution of airflow	The use of filters in ventilation devices, alternating indoor with outdoor air, and increasing ACH reduces the risk of COVID-19 transmission
Tung *et al*. [22]	Enlightenment of re-entry Airflow: The path of the airborne pollutants transmission in buildings	2021	China	Experimental	Airflow direction and distribution	The occurrence of air recirculation occurs due to the low wind speed and the role of the air flow mechanism
Deng *et al*. [23]	Control of exhaled SARS-CoV-2-laden Aerosols in the interpersonal breathing microenvironment in a ventilated room with limited space air stability	2021	China	Experimental	Ventilation rate, direction and distribution of air flow, temperature	Room conditions with stable air are riskier than rooms with neutral to unstable air conditions. The recommended use of devices in room conditions with stable air is local ventilation
Foster and Kinzel [24]	Estimating COVID-19 exposure in a classroom setting: a comparison between mathematical and numerical models	2021	United States	Modeling	Ventilation type, relative humidity	Air in an unventilated room generates a localized and poorly distributed air footprint hence, there is a greater risk of colliding into a mechanically ventilated room

SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2

Discussion

The role of indoor air control techniques against the risk of COVID-19 transmission through aerosols

Based on the results, COVID-19 transmission through aerosols has a high risk of transmission in indoor air because humans naturally produce droplets with micro-sized droplets (0.25–10 μm) [25], [33]. Nissen *et al*. [20] found ten out of 17 positive samples of SARS-CoV-2 virus protein in hospital ventilation with a height of 49–60 m above the floor surface; hence, it is believed that the virus might be transmitted through microsized droplets. The small size of the SARS-CoV-2 virus and its ability to survive in the air was found to enhance COVID-19 transmission in a restaurant in South Korea with 6.5 m and direct airflow conditions [17]. However, Nissen *et al*. [20] showed that the SARS-CoV-2 virus found in indoor air was not contagious. These findings indicate the need for further studies on the infectivity of the SARS-CoV-2 virus through aerosols.

Airborn is the medium is where the disease is transmitted; therefore, an action is required to disrupt the airflow to reduce the disease transmission risk. The airflow direction and distribution influence the risk of transmission through aerosols and the distribution of particles in the air [17], [18], [20], [21], [22], [23], [24]. To reduce the transmission risk through aerosols, the direction and distribution of airflow need to be regulated [21] from clean to dirty air [24], avoid dirty air areas [17], [24], and air recirculation [19], [22]. Meanwhile, factors affecting the airflow direction and distribution include ventilation rate [18], [20], [21], [24] and type [18], [24], as well as temperature [18], [19], [23].

Ventilation rate is the degree and the quality or air exchange between indoor and outdoor [45], [46]. Based on the results, an increase in the ventilation

rates reduces aerosol concentrations of SARS-CoV-2 in indoor air [18], [19], [25], [33]. However, Deng *et al*. [23] stated that an increase in the ventilation rate has a maximum impact on indoor air that ranging from neutral to unstable. Furthermore, Pease *et al*. [21] reported that the increase in ventilation rates should be associated with certain building design to avoid aerosols of SARS-CoV-2 spreading to other rooms in a building.

Li *et al*. [18], Liu *et al*. [19], and Deng *et al*. [23] explained that the temperature of environmental components in a room affects the dynamics of the particulate's movement in the air, including aerosols of SARS-CoV-2. Furthermore, Li *et al*. [18] showed that in natural ventilation, the airflow movement is mainly affected by thermal effects. Aside from its effect on the air particles movement, temperature also affects the comfort of the room occupants; hence, temperature regulation is generally incorporated in the mechanical ventilation system. However, based on research, there are no studies that explain the ideal temperature to reduce the risk of transmitting COVID-19 through aerosols. Furthermore, relative humidity affects the ability of aerosolized SARS-CoV-2 to survive in the air [20], [26]. The recommended relative humidity, based on Arias and Heras [26], corresponds with the appropriate comfort level for the room occupants is 30–70%. The higher the relative humidity, the lower the risk of COVID-19 transmission through aerosols.

The ventilation type also influences the direction and distribution of airflow and ventilation rate. Based on the results, the air particles movement is mainly affected by thermal buoyancy. Meanwhile, mechanical ventilation is influenced by the fan used [18], [24], [32], [33], [34], while the use of air purifiers is highly recommended to reduce the risk of COVID-19 transmission through aerosols [19], [21], [33], [34]. However, Blocken *et al*. [33] stressed that the use of air purifiers is not meant to replace the ventilation role. This shows that air purifiers need to be supported by good ventilation to obtain optimal results in preventing transmission through aerosols.

Indoor activity policy during the COVID-19 pandemic

SARS-CoV-2 is initially thought to be mainly transmitted through droplets [47]. Hence, the designed protocols prioritized preventing the spread of droplets, including using masks and/or face shields, maintaining distance, handwashing with soap or using hand sanitizer, and surface disinfectants [48]. As the study progresses and mutations are found in the SARS-CoV-2 virus, it is clear that it survives in the air for several hours and spreads over a certain distance. Meanwhile, the SARS-CoV-2 virus in aerosol form is also thought to have caused various mass transmission events in various places, especially indoors [18], [22], [34]. A study conducted in student dormitories showed that rooms with pure outdoor air and mechanical ventilation system had fewer cases of respiratory tract infection compared to rooms with only air filtration [49].

There are differences in the regulation and monitoring of indoor air between the health protocol for indoor activities issued by the Indonesian government and the one issued by the WHO. In the protocol established in Indonesia, indoor air regulation only requires maintaining air quality by optimizing air circulation and sunlight, as well as cleaning AC filters. In addition, essential workers who continue to work in the office are encouraged to optimize air circulation and sunlight at home, let outdoor air and sunlight enter the house, also and clean the workspace used by people under surveillance Orang Dalam Pemantauan, patient under supervision Pasien Dalam Pengawasanpositive confirmation of COVID-19 [27], [28]. This approach is not mentioned in the protocol for boarding school. Meanwhile, in the protocol made by the WHO, regulation and monitoring related to air are explained in several points, namely, (1) maximizing natural ventilation, (2) monitoring, inspection, and cleaning the heating, ventilation, and air-conditioning (HVAC) system, (3) increasing the total airflow supply of outdoor air, and regulating the relative temperature and humidity of the available HVAC system, (4) cleaning airflow to dirty air by evaluating the position of the air supply and air outlet as well as ensuring the room occupants are in the clean air area, (5) performing a non-active mode on the demand-controlled ventilation setting, (6) ensuring the exhaust fan runs optimally when there are activities in the building, and (7) avoiding air recirculation caused by the ventilation system. When this is not possible, the exchange of indoor with outdoor air is increased using natural ventilation such as doors and windows and minimizes the possibility of air moving directly from one person to another to avoid the spread of droplets and aerosols [30], [31], [32].

CDC also recommends a layered approach to controlling COVID-19 in buildings and households. The approach is carried out with several strategies, including increasing the use of building ventilation to reduce the spread of disease and reduce the level of exposure risk [35]. Ventilation for households is recommended to use fresh air from outside the house as much as possible, use air filters, turn on exhauster fans in bathrooms and kitchens, use fans to increase air flow and limit guests, and the time guests spend in the house [36].

The COVID-19 control guidelines in the UK explain that there are several ways that can be done to ventilate the room and minimize transmission risk by maximizing the open ventilation. The more ventilation, the fresher air comes in for breathing and the lower the chance of inhaling air that contains infectious particles [37].

Singapore's National Environment Office has also developed guidelines on improving ventilation and air quality in buildings during the COVID-19 pandemic.

This guide presents how to measure air quality in air conditioning and regular ventilation rooms [39]. In addition, the Singapore Government has amended air conditioning and mechanical ventilation regulations concerning the COVID-19 pandemic [40]. The North California State Government also regulates the use of natural and mechanical ventilation as an effort to control COVID-19 in indoor fitness facilities [41].

DKI Jakarta Government has also issued several Governor Regulations and Governor Decrees in controlling COVID-19. Some of them also mention about indoor air such as the minimum standard and room criteria for patient isolation in private and public facilities [44], regulate air circulation in places contaminated with sick workers and confirmed positive COVID-19 [41], [42], as well as optimize the design and function of a workspace with good air circulation and get enough sunlight [43].

Based on the policy analysis, the health protocols for indoor activities during the pandemic developed by the Indonesian Government are still inadequate in regulating and monitoring of indoor air as a medium with a high risk of transmitting COVID-19 through aerosol. Meanwhile, the essential and non-essential sectors are still allowed to carry out activities indoors. Therefore, the Indonesian government needs to develop health protocols, by considering the risk of aerosolized SARS-CoV-2 which survives in the air for a certain distance and time.

Conclusion

Based on the systematic review, SARS-CoV-2 is found in the aerosols. Therefore, there is a high risk of indoor transmission. Furthermore, indoor air control technique affects the risk of transmission through aerosols. Proposed efforts to reduce the risk of transmission through aerosols during indoor activities include (1) increasing the rate of indoor air exchange with outdoor, (2) using air purifiers, and (3) paying attention to the layout of ventilation devices, airflow direction and distribution, as well as the flow of clean and dirty air in a room. However, based on the indoor activity policy in Indonesia, transmission through aerosols has not become a major concern because the regulation and monitoring of indoor air are still minimal; therefore, health protocols in Indonesia are still needed.

Recommendation

Even though currently there is no more restriction related to COVID-19; however, the likelihood of infectious diseases reemergence in the future, it may still happen, so it is necessary to develop any health's preventive and promotion actions and guidelines in indoor air such as on ventilation and air circulation in rooms such as homes, gyms, meeting rooms, and residential/office buildings so that people have healthy ventilation during the COVID-19 pandemic.

Ethics Approval and Consent to Participate

This study was approved by the Research and Community's engagement Ethical Committee, Faculty of Public Health, Universitas Indonesia, No. 366/UN2.F10.D11/PPM.00.02/2021.

Authors' Contributions

MM contributed substantially to the concept, work design, data analysis, data interpretation, and manuscript drafting. BW made critical input to the concept and supervising the process of data interpretation. DS made critical revisions of important intellectual content and finalized approval of the version to be published. AS add revision and critical substance in the manuscript.

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