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Environmental Health with the Standardization of Air Ventilation Covid Radiology Examination Room-19 at Mardi Waluyo Hospital, Blitar City

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ABSTRACT

Air as an important environmental component in life needs to be maintained so that the quality of health is always excellent. Poor air ventilation and high concentrations of aerosols are one of the transmissions of COVID-19, therefore WHO has issued guidelines for regulating hospital air conditioning, while Permenkes RI No.07 of 2019 requires quality standards for environmental health and hospital health including: water; air; etc. The Radiology Installation includes supporting services for examining COVID-19 patients, with minimal air ventilation requiring environmental health studies. Knowing the air system, especially the air ventilation system in the radiology examination room for COVID-19 at Mardi Waluyo Hospital, Blitar City, in the context of improving public health. Observation, interviews, problem identification, socialization of results and recommendations for improvement, with instruments fishbone diagrams, ultrasound and SWOT analysis. Radiology examination room for COVID-19 = p 4.80 x l 4.25 x h 3.50 m, door 1.8 X 2 m without windows, using Split HVAC (AC) system 2.5 PK, average daily temperature 22^{0}C and humidity < 60%, no air intake from the outside, ventilation with a portable HEPA air purifier Medina / type - T 1000 system with a coverage area of 120 m^2. Air Flow Max=1000 m^3/hour and there is no procedure shutdown *time*. In calculating the max ACH ability of this tool 14.17 times / hour so it requires shutdown *time* 19.5 minutes to restore its air quality. The COVID-19 Radiology Room at Mardi Waluyo Hospital, Blitar City, is used as a room for X-photo examination of COVID- and Non-COVID patients, allowing aerosol spread to occur in that room and
this requires further study.

Keywords: covid, health, radiology, ventilation

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INTRODUCTION

One of the important components in the environment is air. As a result, pollutants in the air cause the death of around 7 million people / year, this is 3 (three) times greater than deaths from AIDS, tuberculosis and malaria. WHO in 2020 has issued guidelines for the management and regulation of HISPA treatment centers in hospitals considering that COVID-19 can live long enough in the air and spread through the air very quickly. (Rahardhiman, Yudhastuti, and Azizah 2020). Meanwhile, the Government of the Republic of Indonesia through RI No.07 of 2019 concerning Hospital Environmental Health stated that in order to achieve compliance with environmental health quality standards and requirements health as well as protecting health workers, patients, visitors including the community around the hospital from various kinds of diseases and/or health problems that arise due to environmental risk factors, it is necessary to organize hospital environmental health, which is the quality standard for environmental health and hospital health requirements as referred to in paragraph (1) specified in environmental media which includes: water; air; land; food; facilities and buildings; and vectors and disease-carrying animals (RI PMK 2019).

The Regional General Hospital (RSUD) Mardi Waluyo Blitar City is a supporting element of the Blitar City Government which organizes health services to the community by the motto of the hospital "Your Health and Satisfaction Is Our Happiness". This is in line with the vision of Mardi Waluyo Hospital, Blitar City, so that the existence of the Radiology Installation is a very important supporting service in the service of COVID-19 patients supported by service equipment: General X-Ray and CT 16 Slice which can help establish the diagnosis of COVID-19 patients quickly, precisely and accurately and it is hoped that service activities Radiodiagnostics is safe for staff, patients and the public.

With the number of COVID-19 patients from 10 to 15 patients/day, this room includes an aerosol-producing room from the respiration of COVID-19 patients (Scheuch 2020), so it needs air change/air change per house (ACH) 12 times/hour or 160 L /s/ patient (0.16 m3/s/ patient) with a clean ambient air source intake. Currently the air ventilation of this room does not meet the standards set by WHO and the Indonesian Ministry of Health, but there are efforts to use a hepa filter purifier air system that requires further study so that the transmission of COVID-19 through aerosols in this room is as minimal as possible.

Air ventilation consists of three things, namely:**Ventilation rate, airflow direction and distribution of airflow patterns.**

Ventilation Rate

Also called Air changes per hour (ACH), is the volume of outside air supplied to the room, showing how many times, for 1 hour, the air volume of a room is completely replaced with good outside air

Distribution of airflow patterns

Air distribution or outside airflow patterns must be distributed to each part of the room and dirty air from each part of the room must also be removed/replaced in an effective and efficient manner, by means of: natural, mechanical and hybrid/mixed.

Natural ventilation

In this system the ventilation rate (ACH) is difficult to achieve because it only relies on wind speed and cannot be applied if the air comes from a less clean source. To find out the rate of ventilation / ACH can be calculated by the following formula:

LjV (L/s) = k X V-wind X L-smallest aperture(m2) X 1000 (L/s)

Lju= Laju Ventilasi

V-wind = wind speed

K = constant (0.5 for one-sided ventilation and0.65 for cross ventilation) (WHO 2019).

Mechanical Ventilation

The use of Mechanical Ventilation in the hospital environment according to PMK RI

No.7 of 2019 Concerning Hospital Environmental Health is determined as follows:
The exhaust fan should be placed at the end of the ventilation system.
A 100 m3 room has at least 1 (one) fan with a diameter of 50 cm with an air flow rate of 0.5 m3/second, and the frequency of air changes per hour is 2 (two) to 12 times.

Intake of air supply from outside, except for individual room units, at least 7.50 meters from the exhauster or combustion equipment.
Minimum intake height of 10.9 meters from the roof
The system should be pressure balanced.

Air supply for sensitive areas: operating rooms, baby care, taken near the ceiling and exhaust near the floor, 2 (two) exhaust fans should be provided and placed at least 7.50 cm from the floor.
Air supply above the floor.

Corridor air/exhaust fan exhaust from each room should not be used as an air supply, to toilets, toilets, and warehouses.

Ventilation of sensitive rooms should be equipped with 2 bed filters. Filter I is installed in the air receiving section from the outside with an efficiency of 30% and filter II (bacterial filter) is installed with 90%. To study the central ventilation system in buildings, you should study the central air conditioning system specifically.

Mechanical ventilation using an exhaust fan or air conditioner is installed at a minimum height of 2.00 meters above the floor or a minimum of 0.20 meters from the ceiling. To reduce the level of germs in indoor air, it must be disinfected using the appropriate materials and methods.

Monitoring of indoor air quality at least 2 (two) times a year by taking samples and checking air quality parameters (germs, dust, and gas)
Hybrid Ventilation Or Mixed Mode

Principle Hybrid or mixed mode ventilation relies on the power of natural air to provide the desired (design) flow rate, and uses mechanical ventilation when the flow rate of natural ventilation is too low.
Air flow direction
airflow direction to minimize exposure to healthcare workers

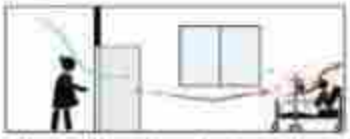

Figure 1.1 Cross ventilation with the direction of air entering the patient (WHO 2019).
wall or window air extractors or whirlybirds or the use of overhead fans placed close to open windows can allow ventilation

Figure 1.2 Hybrid Fan (WHO 2019)
Separating ventilation of patient rooms and health workers rooms with skat / anteroom

Figure 1.3 Separate Ventilation System (WHO 2019)

Using the air inlet from below and exhaust above to avoid the effect of airflow stagnation

Figure 1.4 Exhaust ventilation ducts above (WHO 2019)

Sistem HVAC (Heating, ventilation, and air conditioning)

It is better not to use a Split AC because: it gives poor filtration and is difficult to maintain and does not provide any ventilation because the air only circulates. So if the split AC is still used, the air intake and exhaust must be controlled with a filter system (hEPA FILTER) and maintain negative pressure in the room as shown below

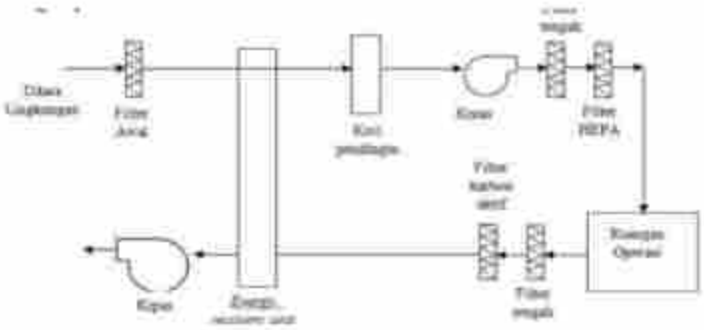

Figure 1.5 Ventilation Chart with HEPA Filter (Parman, Wirawan, and Rachmanto 2015) The filters recommended for air filtration are:

1. Pre Filter → G3/G4 (25-35%) or MERV 7
2. Medium Filter → F7/F8 (85-95%) or MERV 14/15.
3. HEPA Filter at chat operating room axle → H13/H14 (99.97 % - 99.997%) or MERV 17-20
4. Using UVc (Short Wave) Germicidal Irradiation Lamp, 2 x 100Watt
5. Using the Variable Air Volume rotation regulator from the Exhaust fan with PLC
6. Fresh Air : Only Pre Filter Exhaust Air : Pre, Medium dan HEPA (Hedrick et al. 2013).

Portable Air (HEPA) Purifiers.

Portable air purifiers with HEPA filtration have not been standardized by WHO and are a new technology that is currently considered very effective and efficient with an efficacy of around 65% in reducing aerosols (Lindsley et al. 2021), the things that need to be considered about the ability of this tool are:

Coverage	? m^2
Humidify	Yes
Air Flow Max	? m^3/hour
HEPA	Yes
Deodorizing	Yes

Filter Life	10 Years
Power Source Max	103 Watt
Power Source Med	29 Watt
Power Source Low	6.4 Watt

With this tool the resulting ACH can be calculated and *shutdown time* until get 65% clean air in the room after AGP or aerosol generation occurs with the following formula:

BUT = (CHDR /V) X (60) h-1

BUT	= air change per house
CHDR	= clean air delivery rate (air flow ft3/mnt or m3 /h)
IN	= room Volume

Shutdown time (min) =((-ln 0.01) X 60) / BUT

Which ln 0.01 is the constant determined by the US CDC/ Centers for Disease Control and Prevention (Liu et al. 2021).

METHODS

This community service residency activity at the Radiology Installation of Mardi Waluyo Hospital is in the context of improving public health status by standardizing air ventilation in an effort to reduce the spread of COVID-19 through aerosols in the radiology examination room. Activities consist of Pre-implementation, begins with observation of the X-photo room and the surrounding environment as well as interviews with related parties. Identify problems using fishbone analysis (Kusnadi 2011) and prioritize problems with ultrasound **method**(Urgency, Seriousness, Growth) (Regulation of the Minister of Health of the Republic of Indonesia 2016), studies the latest literature and preparation of materials related to ventilation standards based on WHO guidelines and the Ministry of Health of the Republic of Indonesia and analyzes strengths, weaknesses, opportunities and threats with analysis**SWOT** (Dr. Paulus Wardono 2011). Submission of problems and the urgency of completing air ventilation in the radiology room to related partners / parties at the Hospital in order to gain a common understanding. Submission of recommendations Monitoring and evaluation of results where partners convey the implementation of the recommendations.

RESULTS

Partner Profile

Mardi Waluyo Hospital is a hospital owned by the City Government of Blitar City with the classification of a Type B Hospital. This hospital has been registered since 14/03/2013 with the permit number P2T/7/03.23/02/VI/2012 and the license date is 26/06 / 2012 from the Governor of East Java which is permanent and valid for 5 years. After carrying out the ACCREDITATION process for Hospitals throughout Indonesia. This Blitar City Government Hospital has a land area of 46,841 with a building area of 35,640.

The Radiology Installation is one of the supporting services at Mardi Waluyo Hospital, Blitar City, which is a referral hospital for COVID-19 patients in Blitar City. Thoracic Services-Photographs of COVID-19 patients are taken at R Radiology-2 using a mobile X-ray. This room has no natural, mechanical and mixed air ventilation, however, there is ventilation effort with a portable air purifier HEPA fiter purifier brand Medina / type - T 1000 with a coverage area of 120 m3, Air Flow Max = 1000 m³/hour

a) Problem study presentation

With a first bone diagram, the problem formulation is obtained as shown in Figure 3.1

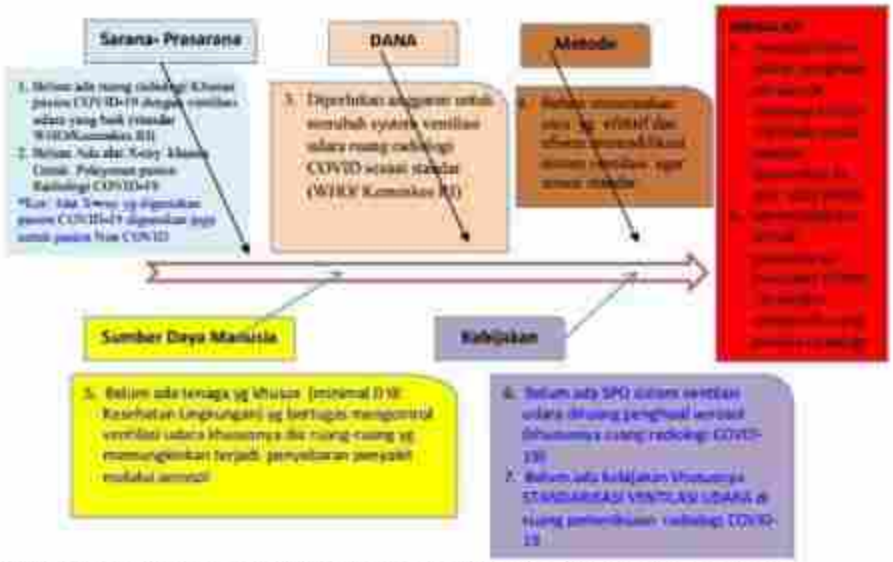

Figure 2.1 Firstbone Diagram of the study of air ventilation in the COVID-19 radiology room (Mardi Waluyo Hospital, Blitar City, 2021)

b) Discussion Urgency Problem Solving And Follow-up

Based on the two problem formulations that have been obtained with the fishbone diagram, namely: 1) Aerosol-producing room air ventilation (Radiology R. COVID-19) does not comply with the standards of the Indonesian Ministry of Health and/or WHO and 2) It is possible for the spread of disease/COVID-19 to occur through aerosols in the room radiological examination, to determine the urgency of solving the problem, an ultrasound is carried out with a priority scale of 1-5 with the following results:

Table 3.1 Determining the Priority of Problems with the USG Method

No	Indicator	IN	S	G	UxSxG	Rank
1	There is no special radiology room for COVID-19 patients with good air ventilation (WHO standard/Ministry of Health Republic of Indonesia)	3	3	1	9	4
2	There is no special X-ray equipment for COVID-19 radiology services	3	3	1	9	4
3	A budget is needed to change the air ventilation system for the COVID-19 radiology room according to standards (WHO/Kemenkes RI)	5	5	1	25	3
4	Haven't found an effective and efficient way yet Modify ventilation system to standard	5	5	5	125	1
5	There is no special staff (at least Diploma III in Environmental Health) who is in charge of controlling air ventilation, especially in spaces where this is possible spread of disease via aerosols	5	5	1	25	3

6	There is no SPO for the air ventilation system in the aerosol-producing room (especially the radiology room). COVID-19)	5	5	5	125	1
7	There is no policy especially STANDARDIZATION OF AIR VENTILATION in the room radiological examination for COVID-19	5	5	4	100	2

From the table above, two problems can be solved by finding an effective and efficient way to modify the ventilation system so that it conforms to standards and create an SPO for the air ventilation system in the aerosol-producing room (especially the COVID-19 radiology room), and to determine a follow-up plan to do it with a SWOT analysis. as follows:

Table 3.2 Calculation of the Internal Factor Evaluation (IFE) Matrix

No	Factors Analysis	Weight	Rating	Score
	A. Strength –*Strengths* (S)			
1	The number of human resources of 848 people with different professional backgrounds in both the health and non-health fields, as well as the composition of civil servants and non-civil servants is a strength large company to manage Mardi Waluyo Hospital, Blitar City	0.1875	3	0.5625
2	The facilities and infrastructure currently owned are sufficient to meet the Minimum Service Standards (SPM) for Type B Hospitals. Related to Radiology, Laboratories, Inpatient Care, Special Isolation Rooms, etc., has passed plenary accreditation	0.1875	3	0.5625
3	The moral and material support from the Blitar City Government for Mardi Waluyo Hospital, Blitar City is quite large, as evidenced by the planned expansion of the hospital building in accordance with the master plan. new plans	0.1875	5	0.9375
	Total *Strengths*			2.0625
	B. Weaknesses –*Strengths (S)*			
4	Haven't found an effective and efficient way to modify it air ventilation system in all possible spaces	0.176	2.9	0.5118
	occur aerosol / AGP to comply with existing standards			
5	There is no knowledge and no special attention to the system ventilation in other aerosol-generating rooms (other than special treatment rooms for COVID, isolation R and surgery)	0.176	2.5	0.4412
6	There is no policy in particular STANDARDIZATION OF AIR VENTILATION during the construction of the building/room	0.118	2.5	0.2941
	Total *Weakness*	1		1.247
	Total IFE : S - W (2.6025 - 1.247) = 0.69 (very strong)			**0.69**

Table 3.3 Calculation of the External Factor Evaluation (EFE) Matrix

No	Factors Analysis	Weight	Rating	Score
C. Opportunity –*Opportunities* (O)				
1	Immediately make policies especially VENTILATION STANDARDIZATION AIR for the aerosol/ AGP generator room effectively and efficiently	0.429	4	1.714
2	Realizing the Hospital Building with a new master plan (equipped with standard air ventilation system)	0.143	3	0.429
	Total *Strengths*	1		2.143
D. Threats –*Threats* (T)				
1	Lots of private and government-owned hospitals around RSUD Kota Blitar which is improving itself to be better	0.429	2.9	1.243
2				
	Total *Weakness*			1.243
Total EFE: S - W (2.143 - 1.243) = 0.9 (Big chance)				0.9

From the table above total Strengths (S) on internal factors minus Strengths (S) = 0.69 indicates sufficient strength to make internal changes, while external factors Opportunities (O) minus Threats (T) = 0.9 indicate considerable opportunities.

DISCUSSION

Radiological examination room for COVID-19 patients with ventilation that is not yet available according to WHO standards and the RI Ministry of Health with both natural and mechanical systems which cannot be changed quickly when a pandemic occurs, therefore based on the literature sources, studies and analysis mentioned above On top of what is currently possible, a portable air purifier with a HEPA filter that has an Air Flow Max specification of 1000 m^3/hour is an alternative that can be applied with modifications based on calculations using the following formula:

BUT = **(CHDR /V) X 60 ….. h^{-1}**

= 1000 m^3/hour / (4,80 x 4,25 x 3,50) m3 X 1 (h^{-1})

(1000/70,56) X 1

14.17

14.17 times / hour (exceeds WHO standard 12x / hour)

Shutdown time (min) = { (-ln 0.01) X 60) / BUT

= 4. 6052 X**60** /14.17

= 276. 3/14.17

= 19.5 minutes

So: For every time there is an aerosol from a COVID-19 patient who is examined, the next examination must wait **19.5 minutes**

CONCLUSION

The COVID-19 Radiology Room at Mardi Waluyo Hospital, Blitar City, is used as a room for X-photo examination of COVID- and non-COVID patients, which allows the spread of aerosols to occur in that room and this requires further study.

In order not to become a transmission of COVID-19 aerosols, the ventilation system in the radiology examination room should be repaired/modified immediately to at least maintain the current system and infrastructure, namely portable *air purifier HEPA Filter* by creating and

implementing guides shutdown *time*.

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