Analisis Pengukuran Fisik Ruang Isolasi Pasien COVID-19 Sebelum Dipergunakan: Studi Kasus Rumah Sakit Universitas Mataram

Physical Measurement Analysis in Pre-Utility Covid-19 Isolation Room: A Case Study Universitas Mataram Teaching Hospital

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Abstrak

Latar belakang: Ruang bertekanan negatif direkomendasikan untuk perawatan pasien COVID-19. Tujuan study untuk mendeskripsikan analisis pengukuran fisik ruang isolasi Rumah Sakit Pendidikan Universitas Mataram. **Metode:** Ruang isolasi tekanan negatif yang baru dikembangkan adalah pengukuran fisik menggunakan instrumen berikut: anemometer, pengukur kelembaban, higrometer dan pengukur tekanan. **Hasil:** Penelitian ini menunjukkan pengukuran fisik sebagai berikut: 1) ACH- air change per hour (pergantian udara per jam) 23,3 / jam [minimum: 12+ ACH]; 2) perbedaan gradien tekanan antara ruang rawat inap dan anteroom -30 Pa [minimum -15 Pa]; 3) rata-rata suhu udara 24,8°C [21-24]; 4) kelembaban udara 58% [maksimum 65%] dan 5) kelembaban beton 22,45%. **Kesimpulan:** Ruang isolasi COVID-19 di Rumah Sakit Pendidikan Universitas Mataram memenuhi kriteria standar

Kata Kunci: Ruang Isolasi Bertekanan Negatif; COVID-19; Analisis Pengukuran Fisik

Abstract

Background: *Negative pressure room is recommended for the treatment of COVID-19 patients. Aim this study to describe physical measurement analysis of isolation room Universitas Mataram Teaching Hospital.* ***Methods:*** *Newly developed negative pressure isolation room was physical measure using following instruments: anemometer, moisture meter, hygrometer and pressure gauge.* ***Results:*** *This study showed physical measurement as follow: 1) ACH (air change per hour) 23.3 / hour [minimum: 12^+ ACH]; 2) the difference in pressure gradient between the inpatient room and anteroom -30 Pa [minimum -15 Pa]; 3) the mean of air temperature 24.8°C [21-24]; 4) air humidity 58% [maximum 65%] and 5) concrete moisture 22.45%.* ***Conclusion:*** *The COVID-19 isolation room at the Universitas Mataram Teaching Hospital meets the standard criteria*

Keywords*: Negative Pressure Isolation Rooms (NPIRs); COVID-19; Physical Measurement Analysis*

Background

COVID-19 patients with moderate to severe symptoms are advised to be treated at the hospital. Negative pressure rooms are recommended for procedures that induce aerosolization or for patients with prominent respiratory symptoms.[1] NPIRs apply several conditions: 1) to contain airborne pathogen contaminant within room, by a prevention of air leak to the environment, 2) negatively pressure is determined to let air streamed via outlet duct to be filtered before let it lose to the environment or to be re-circulated.[2,3] This well-engineered room is designed to prevent of COVID-19 spread to other patients, staff and visitors and to the environment. Based on above it is highly recommended that each hospital to develop a negative pressure isolation rooms (NPIRs) for the treatment of symptomatic COVID-19 patients.

Develop NPIRs is a complex task, even for developed countries, with additional climate challenge, with separated HVAC (heating, ventilation and air conditioning) system from regular room. The development of NPIRs at the Mataram University Hospital is the development of a previously existing room, to be developed into a negative pressure isolation room. In the study newly developed negative pressure isolation room was physically analyzed. Due to limitation of resources and time, the parameter measured were: 1) ACH (air change per hour); 2) pressure gradients; 3) the mean of air temperature; 4) air humidity and 5) concrete moisture.

Methods

After development of NPIRs was complete in early April 2020, we took physical analysis of isolation room in April 17, 2020. Instruments that we use are as follow: 1. Anemometer (GM8902 Benetech®), measuring the speed of air movement; 2. Moisture meter for concrete and wood (MS-7003, Lutron), measuring moisture of the concrete; 3. Digital hygrometer (HTC-1) and 4. Implanted pressure gauge (magnehelic®). Analysis of the material and monitoring system that is support for the effectiveness of isolation room is gathered through observation.

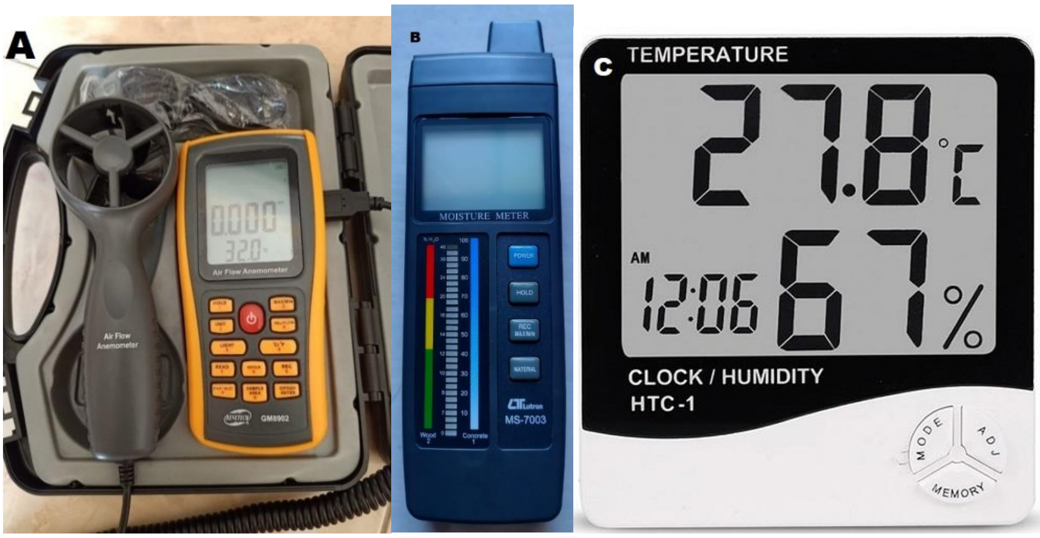

Figure 1. Instruments used in the study. A=anemometer (GM8902 Benetech®); B=moisture meter (MS-7003, Lutron); C=hygrometer (HTC-1®)

$$ACH=3.600\ sec\ X\frac{[mean\ air\ velocity\ outlet\ (\frac{m}{s})x\ outlet\ duct\ wide\ (m2)]-[mean\ air\ velocity\ inlet\ (\frac{m}{s})x\ inlet\ duct\ wide\ (m2)]}{Room\ Volume\ (m3)}$$

Air change per hour for negative pressure room is measured the difference between outlet and inlet flow times to the wide of ductus divide by room volume in one hour and describe it as following formula.[4]

Results

Negative pressure isolation rooms (NPIRs) Universitas Mataram Teaching Hospital is located in C building Ground Floor. It has 5 patient rooms with 1 designated as high care unit (HCU) (Figure 2).

Parameter measurement as follow: mean patient room volume is 53.799 m^3. In each room there are 2 outlet duct with circle exhaust, eachwith diameter of 25 cm (Figure 3) and one inlet duct Air conditioning with area of (0.62x0.08) m^2. Mean air velocity outlet was 1.4558 m/s and inlet 4.5 m/s. Include all known measurement in the formula: 3600x[(1,4558x3,14x0,25^{2}x2)-(4.5x0.62x0.08)]/53,798 m^3 and ACH was measured 23.3/hour.

Pressure gradient was observe in 5 patient rooms (Figure 4) with mean of -30Pa (28-32). Mean air humidity from 5 patient rooms was observed 58% (56-60%). Mean of concrete moisture 22.45% (21.8-23.1). On material observation we found that there is no airlock system in the patient door. The door material is aluminum framed glass. On one side of the wall was calcium board material that is not airlock ability.

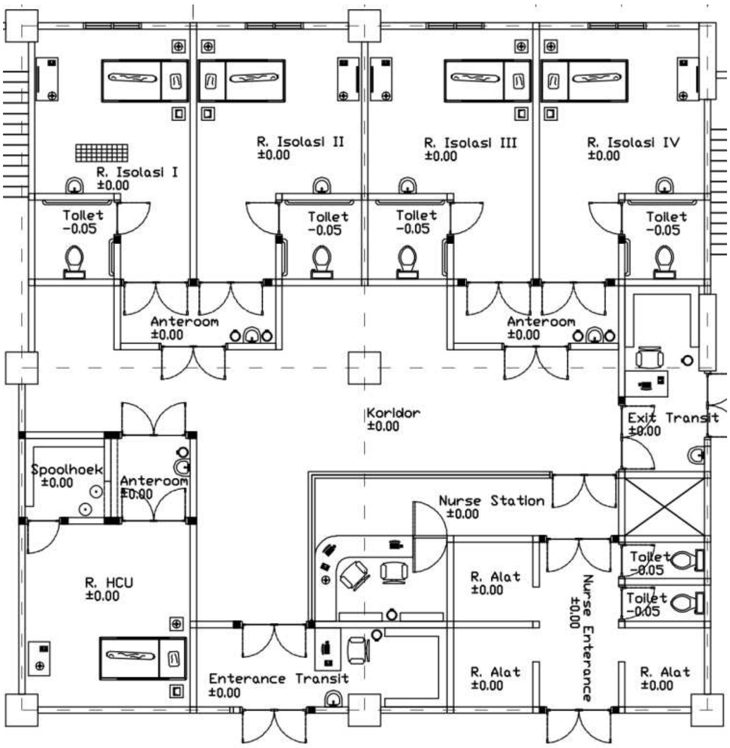

Figure 2. Schematic diagram of NPIRs. There are 5 designated patient rooms (4 regular rooms and 1 HCU room).

Figure 3. Outlet duct with 25cm in diameter. There are two outlet ducts in each NPIR

Figure 4. Implanted pressure gauge (magnehelic®)

Discussion

Infection prevention and control recommendation from WHO in facing SARS-CoV-1 is still relevant to SARS-CoV-2 especially in isolation room role.[17]

Several physical parameters need to be analyzed to assess the effectiveness of NPIRs, air change per hour (ACH) is an important parameter in ensuring that the overall air in the room added, remove, exchanges several times in one hour. ACH parameters are important in measuring whether: decreases the risk of pathogens being inhaled again by patients or inhaled by health workers and reduces the risk of environmental contamination. CDC describe ACH as time required in removing 99% and 99.9% airborne contaminant. ACH standard used in this study is 12+ [6,7] that mean will effectively remove 99% and 99.9% airborne contaminant 23 and 35 minutes, respectively. In this study, our finding ACH of 23.3 is 99 and 99.9% remove less than 14 and less than 21 minutes, respectively.[6] Even the ACH parameter showed a high calculation, it did not entirely describe IPC efficiency. Over power of negative pressure is not ideal for effective air change in the hotspots of the whole of the room. In figure 5 there are other factor to contribute in IPC beside engineering and environmental control.

Pressure gradient between patient room to anteroom is important to be maintain negative >-15 Pa is believed to be minimum pressure to contain the virus to flow through outlet duct, not to anteroom or to the corridor. In this study showed -30 Pa has fulfill the minimum requirement.

In order to increase performance and sustainability of NPIRs to contain SARS-CoV-2 should provide: 1). the airlock system in doors/ hermetic door.[8] 2). air-tight wall and ceiling material[9] 3). open and close automatic door alternately between two doors of patient room and anteroom[10] and 4). Smart setting to maintain efficient pressure gradient and ACH.[11] Those 4 aspects we are not found in our study setting.

In this study air humidity was 58%, that is stil in optimal range of maximum humidity 65% (ASHRAE, 2019) or in range 40-60%.[12,13] This study is accordance to Tungjai et al (2017) Ahlawat et al (2020) reviewed there were three different scenarios how humidity affects virus transmission in indoor setting: evaporation kinetics modulating survival microorganisms inside the viral droplets, survival rate of SARS-CoV-2 on surfaces, role of dry indoor air in airborne transmission of the virus.[14,15] Those scenarios imply that low humidity (<40%) is tend to increase its transmission rate while higher humidity tend to decrease transmission rate of the virus. The reasons are, the humid air will increase the weight of the droplets or aerosols that increase the speed of settling to the ground, while moisture-free air yields optimal route for long distance transmission from smaller droplets and aerosols. Also, moisture-free air our mucosa become dry and viscous and reduce our cilia capability to expel viral aerosols.[16]

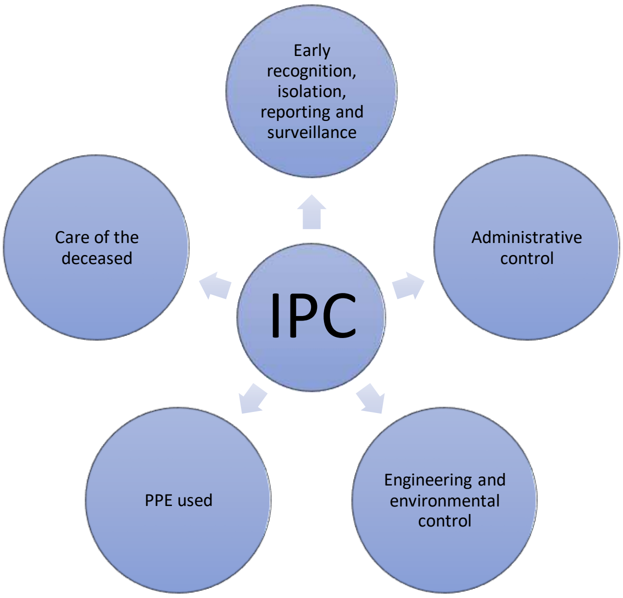

Figure 5. Position negative pressure isolation room in infection prevention and control: engineering and environmental control. IPC=infection prevention and control recommendation; PPE=personal protective equipment. Developed according to ref.[5]

Although air humidity and concrete moisture slightly contribute to the measurement of the risk of virus transmission, it is suspected that these parameters contribute to the persistence of the virus in the environment.[17,18]

Concrete moisture will affect in respiratory health. Dampness of concrete promotes the growth of bacteria and molds and release chemical. Too much moisture may cause toxic chemicals to be released from building materials and furnishings. The health effect after exposure to the dampness of moisture are: upper respiratory tract (nasal and throat) symptoms, cough, wheeze asthma symptoms in sensitized asthmatic persons.[19] No documented standard for normal value of concrete moisture, but relatively dynamic to temperature variation. In 29ºC indoor temperature, indoor concrete humidity around 60% [20][7] in this study temperature of 24.8°C correlate with concrete moisture of 22.45%.

Limitation of the study. Physical measurement analysis during utility is unable to perform due to continuously use of isolation room. It takes 48 hours operational shut down before take evaluation measurement. Effectiveness to contain virus was not evaluated.[2]

Conclusion

We conclude that physical measurement analysis of negative pressure isolation room Universitas Mataram Teaching Hospital meets standard criteria. Further periodic monitoring is recommended.

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Conflict of interest

There is no conflict of interest stated.

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