Potential Locations of Covid-19 Transmission in Hospitals

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Abstract. Hospital is a place with the highest risk of Covid-19 transmission. Healthcare workers should apply safety precautions in order to avoid infection. This study was conducted to obtain information about hospital loci (rooms) that are at risk of transmission of the SARSCov-2 virus. Six hospitals located in DKI Jakarta, East Java, West Java, and North Sumatra provinces were chosen as study locations. Surface swab specimens from rooms and objects that were potential as a source of transmission, based on WHO recommendations were collected. The RNA virus was detected using RT-qPCR, with N1, and N2 genes (CDC) as primers, also the RNP gene as a control. All 556 surface swab samples were retrieved on the first week of December 2020, taken from 14 types of rooms consisting of 67 rooms. The distribution of genetic material of the SARS-CoV-2 virus was mostly obtained in the ICU by 60% (3/5), followed by patient rooms, patient bathrooms, and ER, each 30% (2/6) respectively. Based on the number of specimens, the ICU rooms have also the highest proportion of positive results (12,77% of 47), then the ERs (9.8% of 51). The RNA virus was detected in oximeters, ventilation/air filters, floors, walls, beddings, IV poles, call buttons, garbage bins, tables, lavatory flush buttons, and sinks. In conclusion, ICUs, ERs, patient rooms, and patient bathrooms were sites where the RNA virus was mostly obtained in hospitals, especially in ICUs for Covid-19 patients. It is recommended that hospitals should improve measures to contain the virus and protect healthcare workers, including engineering controls, providing adequate personal protective equipment and maintaining health protocols.

Keywords: Covid-19 transmission · hospitals · swab surface · Intensive Care Unit · environment contamination

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1 Introduction

The emerging of the SARS-CoV-2 virus from Wuhan, China at the end of 2019 provided a real challenge in the health sector. Based on the World Health Organization (WHO) report in May 2022, the excess mortality related to COVID-19 in the period January 2020 to December 31, 2021, was around 14.9 million people [1].

Healthcare workers are the most affected group in the Covid-19 pandemic, healthcare workers have a risk of 10 times more likely to be infected with the SARS-CoV-2 than general patients [2]. WHO estimated around 80,000 – 180,000 health workers have died due to Covid-19 from January 2020 to May 2021 [3]. Mortality and morbidity of healthcare workers will affect a country's health burden because it will delay many health services, including non-Covid disease services and services for certain diseases. In Indonesia, the Ikatan Dokter Indonesia/Indonesian Medical Association (IDI) stated that 647 health workers died due to Covid-19 infection, consisting of 289 doctors, 27 dentists, 221 nurses, 84 midwives, 11 pharmacists, and 15 laboratory workers, based on a report from March 2020 to January 28, 2021 [4]. In the first 3 months of the Covid-19 pandemic in Indonesia, from March-May 2020, the SARS-CoV-2 virus were detected in 7.9% of routine examination samples from Healthcare workers in the Jabodetabek regions. From the positive samples, doctors and nurses were mostly exposed to the virus with a prevalence of 48.4% and 44.2% respectively [5].

Healthcare workers have the potential risk to be infected with the virus due to exposure from the workplace and inadequate use of personal protective equipment (PPE). In addition, health workers also potential to be a source of transmission to the treated patients and the community in their domicile [5]. The SARS-CoV-2 virus is transmitted in 3 main ways, first, it can transmit through inhalation of air containing viral material embedded in aerosols or very small droplets. The risk depends on the proximity of a person to an infectious patient. The second way is the deposition of existing viruses from droplets and particles onto exposed mucous membranes, usually through sprays such as when someone coughs or sneezes on us. The third is touching the mucous membranes with hands that are contaminated by other people's respiratory fluids containing the virus or touching surfaces that are contaminated with the virus [6]. Thus, the hospitals as healthcare facility for patients infected with SARS-CoV-2 have risks and the potential to become a source of transmission if inadequate prevention measures are performed. This study aimed to determine the locations and surfaces of objects where the viral material most existed, therefore hospitals can implement the control of infection prevention to be more effective.

2 Materials and Methods

Study Design and Sample

The study was conducted from September to December 2020, at 6 hospitals located in the provinces of North Sumatra, DKI Jakarta, West Java and East Java. Those provinces were chosen based on the number of physicians who died from Covid-19. This research was a part of the Ministry of Health's assessment to obtain information regarding the

risks and causes of death of healthcare workers, especially physicians due to Covid-19. Sampling was carried out to determine the potential locations for Covid-19 transmission in hospitals.

The selection of the location and object for sampling followed the epidemiological protocol issued by WHO [7], samples were taken from hospital entrances, ambulances, corridors and waiting rooms where patients passed before receiving treatment. Specimen collections were also carried out from hospital staff rooms, ante rooms, patient's bedrooms and the patient's bathrooms/toilets as well as the air outlet surface ACs or ventilations in the hospitals.

Sample collection was performed after the cleaning process, the examiner was obliged to change the gloves every time when moving to other rooms. VTM Premoistened dacron swab was used to swab an area of 25 cm^2. After wiping the surface, the swab was inserted into a specimen tube and the tube was tightly closed using parafilm. Then the specimen tube was wrapped in a tissue towel and put in a plastic clip. The plastic clips contained tubes that were packed in a cool box and then sent to the Infectious Disease Research Laboratory of the Ministry of Health.

A swab sample was taken for each hospital objects/surfaces, comprised of medical bag handles, inside part of blood pressure cuffs, ambulance walls next to the patient stretchers, ventilation exits or air purifier filters, entrance and corridor guardrails, doorknobs, keyboards, clothes, light switches, floors, patient bed rails, patient bed controllers, call buttons, tubings, masks and filters of aerosol-generating procedures, control panels, faucet handles, sinks, bedpans, IV poles, beddings, telephones, chairs, curtains, stethoscopes, hand soap dispensers, garbage bins, cups, oxygen flowmeters, oximeters, wall next to patients.

SARS-CoV-2 RNA Detection and Analysis by Real-Time Quantitative PCR

Specimen examination was carried out at the Infectious Disease Research Laboratory, Prof. Oemijati, Ministry of Health using the Real-Time quantitative PCR method to detect the N1 or N2 gene of the SARS-CoV-2 virus. The RNA extraction used QIAamp Viral RNA Mini kit (QIAGEN, Germany), Mastermix with SuperScript™ III Platinum™ One-Step qRT-PCR Kit (Invitrogen, USA) and primers and 2019-nCoV_N1, 2019-nCoV_N2 and RP (CDC, US) probes. RT-qPCR analysis was performed using a CFX98 real-time system (Bio-Rad Laboratories, Inc., US).

The RT-PCR results were considered positive if one of the genes, either N1 or N2, was detected in the sample with a CT value below 40, and the RNAse P gene as control was detected. The results of the analysis were presented descriptively.

Ethical Approval

This research waspart of the assessment of the risk of morbidity and mortality of Covid-19 Indonesia physicians and received ethical approval from the Health Research and Development Agency's Health Research Ethical Committee No. LB.02.01/2/KE.665/2020, dated Nov 30th, 2020.

3 Results

Sample collection were carried out at a hospital in DKI Jakarta, a hospital in West Java, 2 hospitals in East Java and 2 hospitals in North Sumatra. The hospitals were consisted of 2 private hospitals and 4 government hospitals. There were 14 types of rooms used as sampling locations with a total of 67 hospital rooms, while the number of surface swabs obtained amounted to 556 samples. The results of RT-qPCR analysis of N genes indicated that 12 (17,91%) rooms were contaminated with the genetic materials of the SARS-CoV-2 virus (Table 1). The most prevalent location is the Covid-19 patients' ICU (60%), while 33,3% of the patient bedrooms, patient bathrooms and emergency rooms, were contaminated with the SARS-CoV-2 virus. As for hospital entrances, waiting rooms, and anterooms group samples, only 1 sample was yielded positive result. No SARS-CoV-2 virus RNAs were found in other rooms (Ambulances, corridors, staf rooms, policlinics, delivery rooms, laboratories' and cafes).

Table 1. Distribution of swab surface sampling locations in hospitals

Swab location	Number of locations (%)	Number of contaminated locations (%)
Ambulance	6 (8,96%)	0
Entrance	6 (8,96%)	1 (8,33%)
Corridor	6 (8,96%)	0
Waiting room	5 (7,46%)	1 (8,33%)
Staff room	6 (8,96%)	0
Anteroom	6 (8,96%)	1 (8,33%)
Covid-19 Patient bedroom	6 (8,96%)	2 (16,67%)
Covid-19 patient bathroom/toilet	6 (8,96%)	2 (16,67%)
Emergency room (ER)	6 (8,96%)	2 (16,67%)
Policlinic	5 (7,46%)	0
Intensive Care Unit (ICU)	5 (7,46%)	3 (25%)
Delivery room	1 (1,49%)	0
Laboratorium	2 (2,98%)	0
Café	1 (1,49%)	0
Total	67 (100%)	12 (100%)

The number of surface swab samples for each room is detailed in Table 2. The total samples obtained were 556 samples and 20 (3.6%) positive samples were obtained. Most swab samples (162 samples) were collected from patient bedrooms in each hospital. However, only 4 (2.47%) samples were found positive. The highest proportion of object surfaces contaminated with the genetic material of the SARS-CoV-2 virus was found in the ICU, whereas 6 (12.77%) of the total 47 specimens were positively detected, then followed by the ER where 5 (9.8%) samples also contained viral genetic material.

The types of samples from surface swabs at the hospital locations where the viral RNA detected are described in Table 3. Out of the 20 surface swab samples, there were 5 floor samples contaminated with SARS-CoV-2 virus genetic material, 3 oximeters out of a total 12 (25%) were also contaminated with the RNA virus, and 4 swabs of the surface of the ventilation/air filter (out of a total of 52 ventilation samples) also positive, which came from 2 ICU air conditioners, 1 ER air conditioner and HEPA filters at the hospital entrance.

Table 2. Amount of swab surface samples taken from each hospital location

Swab locations	Numbers of swab samples (%)	Amount of positive samples (%)
Ambulance	32 (5,75%)	0 (0)
Entrance	41 (7,37%)	1 (5%)
Corridor	17 (3,06%)	0 (0)
Waiting room	15 (2,7%)	1 (5%)
Staff room	52 (9,35%)	0 (0)
Anteroom	26 (4,68%)	1 (5%)
Covid-19 Patient bedroom	162 (29,14%)	4 (20%)
Covid-19 patient bathroom/toilet	65 (11,69%)	2 (10%)
Emergency room (ER)	51 (9,17%)	5 (25%)
Policlinic	27 (4,86%)	0 (0)
Intensive Care Unit (ICU)	47 (8,45%)	6 (30%)
Delivery room	10 (1,8%)	0 (0)
Laboratorium	9 (1,62%)	0 (0)
Café	2 (0,36%)	0 (0)
Total	556 (100%)	20 (100%)

Table 3. Types of positive sample surface objects and hospital location

Hospital locations	Positive results of swab surface samples
Waiting room	Registration table
Entrance	HEPA Filter
Anteroom	Floor
Covid-19 patient bedroom	Floor < 1 m from patients, oximeter, call button, garbage bin
Covid-19 patient bathroom/toilet	Flush, sink
Emergency Room (ER)	Floor < 1 m from patients, oximeter (2 hospitals), ventilation/air filter, the wall next to patient bed
Intensive Care Unit (ICU)	Ventilation/air filter (2 hospitals), Floor < 1 m from patients, IV pole, bedding, Floor of PPE doffing after ICU room.

4 Discussion

A SARS-CoV-2 contaminated environment is a potential transmission medium, therefore efforts for identifying the extent of environmental contamination are important for hospital infection and prevention control. Hospital infection and prevention control is urgent for healthcare workers protection. The presence of live viruses recovered from fomites indicates that indirect transmission is possible for the spread of the SARS-CoV-2 virus [8].

In our study, ICUs were the most common rooms where the RNA virus was detected, followed by the ERs, patient rooms and patient bathrooms. These were also consistent with the results of a meta-analysis of similar studies, which found that ICU air samples were generally higher in virus contamination than in non-intensive care areas [9]. In our study, contaminations in the ICU were also mainly found in the air filter. The viral RNA detected from ventilation outlet air samples suggested the possibility of airborne contamination due to patient-generated aerosols. The ICU for Covid-19 patients allowed for actions that cause aerosol formation such as suctioning, intubation, bronchoscopy, cardiopulmonary resuscitation, prone positioning, manual ventilation and so on [8]. Several research results confirmed that the SARS-CoV-2 virus is an airborne virus. Viral RNA detected at a distance of more than 2 m from the source of the virus was categorized as an airborne virus [10]. The presence of the virus in the air was also associated with the length of time the patient is treated. Generally in the early days of the patient's admission, or the first week of the patient being treated, it would cause more viral RNA to be in the air [10].

A positive ventilation/air filter sample in our study was also obtained from an ER for Covid-19 patients. This may be because the aerosol-generating procedure somehow being able to be performed in the ER for some patients. It was also possible that the ER patients present respiratory symptoms such as coughing and sneezing which can caused aerosol to burst and then be trapped in the ventilation [8]. Another positive ventilation

sample was found on the HEPA filter at hospital entrance, indicating that the virus could also be present in non-treatment areas at the hospitals.

Floors contaminated with the viral RNA were generally caused by gravity and airflow that carried droplets or aerosols to the floor [11]. The discovery of viral RNA contamination on the floor of the PPE doffing area in the ICU indicated the possibility of contamination through personnel PPE or from aerosol under certain conditions [8].

The presence of the viral RNA contamination on fomites such as the call buttons, the flush button in the toilets, the walls next to the patient's bed, and especially the oximeters indicated the possibility of transmission that might be due to self-inoculation from the mucous membranes of the mouth, nose and eyes through the hands, therefore a frequently touched surfaces tended to get a positive PCR examination result [12]. Although recent studies suggest that the risk of transmission through fomites or surfaces was small [13], live viral cultures have been obtained from fomites in some studies [8], therefore healthcare workers should pay attention to hand hygiene and the use of adequate PPE. Environmental contamination of SARS-CoV-2 virus was also influenced by clinical features of the patients and time elapsed between patient diagnosis and environmental sampling [10, 14].

In this study, we did not get the results of viral exposure in doctor rooms or public rooms, except 2 samples taken from a hospital entrance and a waiting room. However, there were 3 specimens taken from the doctor room which presented invalid results (positive N gene and negative for RNP gene). Therefore virus contamination in the staff and public rooms should become hospital considerations to implement infection prevention control in the hospital areas. Prevention of healthcare workers' of covid-19 infection can reduce morbidity and mortality and improve the health system capacity and inhibit secondary transmission. The use of PPE and infection control training were associated with a reduced risk of infection or exposure [15].

The limitation of this study was the absence of patient data in related hospital rooms/areas, as well as we did not take air samples from hospitals. This study was also not followed up with viral cultures obtained from samples, therefore the RT-qPCR result was not able to distinguish the live or dead viruses.

5 Conclusion

The conclusion of the study was that the hospital had the potential risks of viral material contamination, especially in the intensive care unit for Covid-19 patients. Floors and fomites that are frequently touched by patients are also at risk of being contaminated with viruses. The RNA virus was also found in ventilation/air filter samples.

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