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Validation of an Airborne SARS-CoV-2 Surveillance System in a Controlled Space, Cinema, and Mosque in Indonesia

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Abstract

Viable respiratory viruses, including SARS-CoV-2, can be carried by aerosols and remain suspended in the air for an extended amount of time. This is especially significant in an indoor setting where viable viruses can accumulate, causing transmission even without direct contact with the infected person. We developed and validated an indoor air SARS-CoV-2 surveillance protocol capable of detecting airborne SARS-CoV-2. We validated our system in a controlled space, five cinemas, and a semi-outdoor mosque.

Introduction

Various studies had shown that respiratory viruses, including SARS-CoV-2, can be carried by aerosols generated through coughing, sneezing, breathing, talking, and singing. These activities can generate varieties of droplet sizes that can harbor viable viruses in the air column for an extended amount of time.^{1,2,3,4,5,6} The risk is exceptionally high in an indoor setting, especially with poor ventilation, compared to an outdoor setting. Due to the lack of air exchange, viable viruses in an indoor setting can be accumulated, causing transmission even without having direct contact with the infected person.⁷ A study recently demonstrated that SARS-CoV-2 remained viable in lab-generated aerosols, in particles that were 5 microns and smaller, for the entire 3-hour duration of the experiment.⁶

The threat of the accumulating virus indoors was observed in several cases. For instance, twelve people got infected from attending a St. Patrick's Day celebration at a bar in Ho Chi Minh City in Vietnam. Among those twelve people, only four of them had direct contact with the infected person.⁸ The transmission of SARS-CoV-2 was also recorded in three fitness facilities even when physical distancing was followed.⁹ There were also reports of outbreaks at quarantine hotels in Australia. It was suggested that hotel staff stagger meal delivery times in order to avoid everyone opening their doors simultaneously.¹⁰ These reports demonstrate the importance of indoor air SARS-CoV-2 surveillance. In this study, we devised and validated a surveillance method for airborne SARS-CoV-2. Validation was performed in a controlled space, five cinemas, and a semi-outdoor mosque.

Material and Methods

Simulation of aerosolized viral particles was performed using a SARS-CoV-2 RNA-based positive control. The RNA was diluted in a Tris EDTA buffer and nebulized as 0.3–0.5 μm droplets during the spraying with a nano-sprayer. The aerosol was generated in a controlled space with an isolated air circulation system totaling a volume of 366.3 m^3 . The set-up consisted of two nano sprayers positioned on top of a 1.5-meter platform to simulate human breathing. The Sartorius MD8 air sampler was placed vertically between these platforms at a height of 1 m with a distance of 0.5, 1.0, 1.5, and 3.0 m. The sampler was operated for one hour at 50 L/min during each sampling variation. RNA extraction from the gelatine filters was performed using QIAamp Viral RNA Kit (Qiagen, Germany) and a modified in-house protocol. Quantification of the sampling result was performed using mBioCoV19 RT PCR kit (Nusantics, Indonesia) which has Limit of Detection (LoD) of 5 GE (Genome Equivalent) copies/reaction.

Sampling at five branches of Cinema XXI was performed mainly at spots with high foot traffic, such as the studio entrance, cinema halls, and foyer. The sampling in large rooms was performed by dividing the rooms into quadrants, and the MD8 portable air sampler was placed in each quadrant for one hour with a flow rate of 50 L/min.

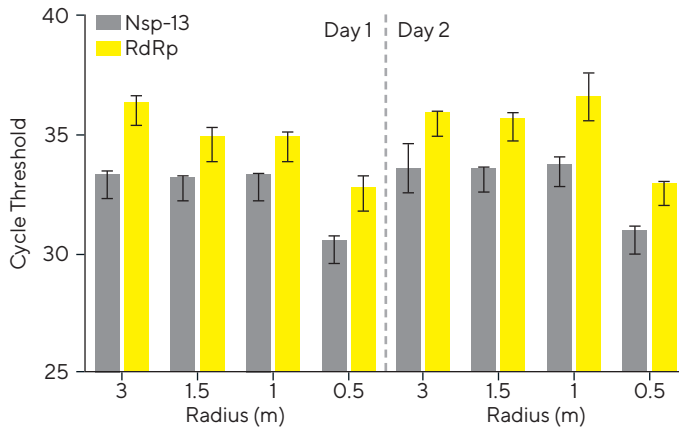
Air sampling at one of Indonesia's largest mosques was conducted by carrying the Sartorius MD8 portable air sampler horizontally. The sampler was operated for one hour with a flow rate of 50 L/min and was moved every 5 minutes for one hour to cover the area. In doing so, both static and dynamic sampling was trialed.



Results and Discussions

I. Standard Procedure for Airborne SARS-CoV-2 Surveillance With the MD8 Portable Air Sampler

Figure 1



Note. The CT value showed a similar pattern between Day 1 and Day 2, where the CT from 0.5 m is slightly lower than the rest.

As shown in Figure 1, the obtained cycle threshold (CT) demonstrated successful retrievals of SARS-CoV-2 positive control from all distance variations and similar patterns were observed between Day 1 and Day 2. The CT values indicated that the aerosol was homogenously distributed. The CT for the 0.5 m distance is marginally higher because of the proximity between the sampler and the nano sprayer. Overall, the result suggested that the sampling method with one MD8 portable air sampler can cover at least 28.26 m².

II. Field Trial

Field trials were performed to ensure the applicability of the surveillance system at a semi-outdoor mosque and Cinema XXI.

A semi-outdoor mosque and cinema halls were chosen to compare the set-up in settings with variable rates of air exchange.

The trial in one of the biggest mosques in Indonesia was performed to test the system in a semi-outdoor setting. The result showed that one out of eight tested rooms tested positive, as shown in Table 1. This result indicates that our sampling system is functional in a semi-outdoor room with a relatively high air exchange rate.

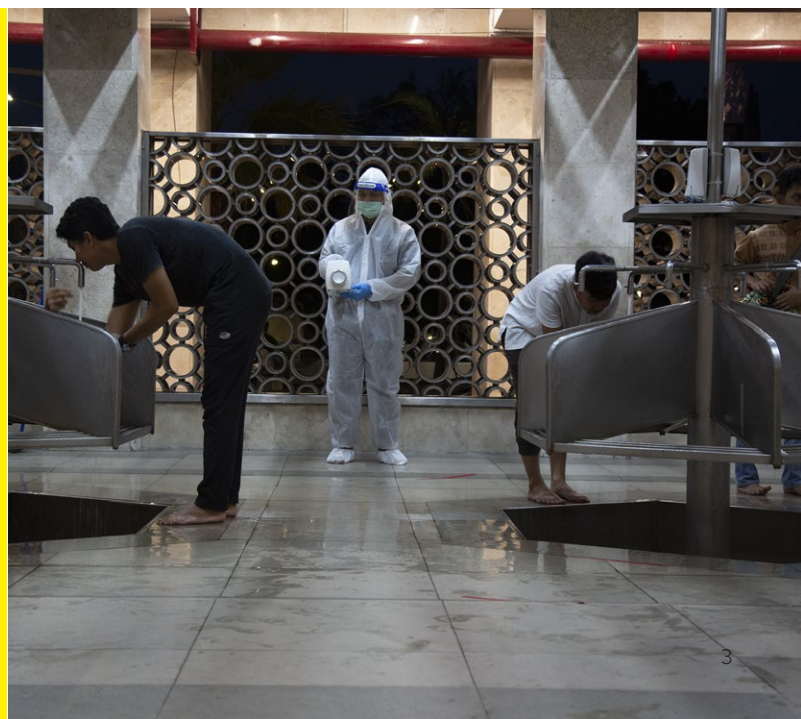
Table 1

The Result of Sampling at One of the Largest Mosques in Indonesia

Sampling Location	CT of Gene Target	
	Nsp-13	RdRp
Ablution room (men)	-	-
Ablution room (women)	38.321	44.325
Praying room (men)	-	-
Praying room (women)	-	-
Lobby	-	-
Studio room	-	-
Toilet (men)	-	-
Toilet (women)	-	-

Note. One out of eight air surveillance samples tested positive.

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The Cinema XXI has a fully isolated airflow system with a HEPA filter. The architecture of the building is inclined with a slight height increase for every row to allow sightline clearance from every seat. As can be seen in Table 2, the result from this trial was all negative. The result was expected, considering that the use of HEPA filter will minimize the number of airborne virus particles.¹¹

Table 2
The Result of Sampling at Five Branches of Cinema XXI

Sample		Target Genes	
		Nsp-13	RdRp
Metropole	Before show	-	-
	After show	-	-
Plaza Senayan	Before show	-	-
	After show	-	-
Gandaria City Mall	Before show	-	-
	After show	-	-
Pondok Indah Mall 2	Before show	-	-
	After show	-	-
Mall Kelapa Gading	Before show	-	-
	After show	-	-

Note. The result showed all samples were negative.

Conclusion

During the COVID pandemic, MD8 air samplers and gelatine membrane filters have been deployed globally by several governmental agencies to monitor public spaces, such as schools, airports, and metros | subways. The high retention efficiency of the gelatine filters for virions and phages (96–99.9%), paired with efficient recovery of the captured particles due to its unique water-soluble properties, made it the air monitoring system of choice during the MERS outbreak in 2011 and more recently the COVID pandemic.^{12,13,14,15} Paired with the highly sensitive mBioCoV19 RT-PCR kit from Nusantics, we now redefine standards for bio-surveillance. Based on our findings, we recommend the routine air monitoring of indoor spaces to act as an early warning system to trigger the implementation of risk mitigation strategies.



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