COVID Information Commons (CIC) Research Lightning Talk

Transcript of a Presentation by Chang-Yu Wu (University of Miami), April 24, 2023

Title: Environmental Surveillance to Assess Aerosol Transmission Pathways of COVID-19 Enabled by On-The-Spot Sampling and Detection

Chang-Yu Wu CIC Database Profile

NSF Award #: 2030844

YouTube Recording with Slides

Spring 2023 CIC Webinar Information

Transcript Editor: Lauren Close

Transcript

Slide 1

Thank you. Can you year me? Yes, ok, good. Yeah, thank you for the invitation, we are very happy to share our research endeavors in assessing aerosol transmission pathways of this virus.

Slide 2

Ok, so going back to the beginning of the pandemic, it was a very chaotic time because we had no clear idea of how the virus was transmitted from one person to the other. Based on the previous knowledge about flu transmission - so WHO and the CDC advised that the transmission is probably by our droplets or they may be transmitted by contact. In that case, if you can maintain social or physical distancing, or you wash your hands, you should be fine. That was in the beginning of the pandemic, but as an aerosol scientist, I had a question about that because respiratory virus is supposed to be airborne face.

Slide 3

But let's just wait for one minute. If you follow the physical distancing, and the washing hands, are you protected? Well apparently there were quite a few cases that told us not really. One example is in Skagit County in Washington state. Following a 2.5 hour choir practice attended by 61 people, 45 were infected and two people died. They practiced the physical distancing and also they washed their hands. So definitely something else. At that time, we said: we have to do something, we have to do air sampling to prove that it is transmitted in in the airborne state.

Slide 4

So how do you do that? Conventionally, you would use this kind of air sampler which are filter based to collect these particles on filters, then do the analysis. However, these viruses may get inactivated due to desiccation during sampling. Also, the other challenge is the recovery of viruses from filter may be an issue for certain filter. And if the viruses are not viable anymore, then we cannot really convince the WHO doctors that the airborne transmission is an important pathway. So how about collecting them in the liquid medium using this type of sampler that can help conserve their viability? That's a good idea from the conservation perspective, but if you look at this figure over here, you can see the collection efficiency is very very low. It's 5-10% for the 100 nanometer particles. We know that the SARS-CoV-2 variant is about a 100 nanometer particle. So we are in a dilemma. How can we efficiently collect the virus aerosols and maintain their viability? That was our challenge.

Slide

We developed a device inspired by natural processes. So this happens in our respiratory system. When you have these virus aerosols getting into the human respiratory system, there will be a water vapor condensing onto these particles and making them much larger. In that case, you will be able to collect it more efficiently. We actually engineered the same device using this same principle. In this device, which we call the viable virus aerosol sampler, first you cool the particles into a cold state. Then next, you introduce them into a moist environment. You have a lot of water vapor condensing onto these particles, making them much larger and at the same time, conserving their viability so you can collect it and do analysis. This is the photo of our device. So, how good was it?

Slide 6

We first tested it with a lab generated H1N1 virus. The x-axis is the the amount of infectious virus generated during the sampling. The y-axis is the number of viruses - infected viruses - infectious viruses collected. As you can see, the virus was very close to the one to one line, which is the ideal situation. The bio sampler, which is the industrial standard and was the one outer magnitude lower. This test demonstrated the superior performance of the virus compared to the bio sampler.

Slide 7

Then, it was the pandemic time. So we took our virus into a hospital housing a SARS-CoV-2 patient. At that time, the WHO said, you know, this physical distancing, if it's more than two meters, you will be safe. We wanted to prove that we have to be careful about that. We placed our samplers and this BioSpot is a commercial version of the virus. So we put the two samplers at a two meter distance from the patients. We collected the air samples. We then come here with the human specimen from the patient and they match. So this demonstrates that the aerosol can be a possible route for the transmission of the virus.

Slide 8

Furthermore, we inoculate the cells with these error samples. You can see that after four days, seven days, and ten days, the cytoplastic effects of the cells. They are infected and died because of the infection of the virus in the air sample. Also, as the days go on, you can see the Cq value decrease. That means a higher concentration in the sample. That tells us that the viruses are growing in the cells. So that means the viruses are viable. This was the first study to show a viable SARS-CoV-2 in the air greater than two meters away from the COVID patient. The New York Times reported this as a "smoking gun" that the WHO and the CDC advice on how we can better protect ourselves - we have to consider the airborne viruses, not just the droplets or the formal transmission. So this finding provided evidence that helped change the WHO and CDC guidelines.

Slide 9

But the virus transmission doesn't just happen in the hospitals. Especially after there was a good practice of using the personal protective equipment (PPE). We were thinking: where else does this transmission happen? Where is the hot spot? Our hypothesis was that, actually, the residential space would be the hotspot. At home typically, you don't wear masks and there is no social distancing. There is no constant ventilation to reduce the concentration of the virus. We did one sampling in a volunteer's house. This is where the impacted individual sits. So this is the isolation bedroom. We also conducted samples in a bedroom far away from the isolation room which we call bedroom two. In the same household, there are different rooms. You can see the collection of the samples in the isolation room and the bedroom where the person was supposed not to be. We were able to culture the virus in the air sample at the isolation room. This was the first study showing viable virus in air samples outside of healthcare facilities and in the home. This is because of the use of this new tool. What we learned from here is that SARS-CoV-2 aerosol can be transported to other rooms far away in the same building. That will change how you would deal with how - what kind of advice you give to people to better protect them from exposure.

Slide 10

We did some more sampling in the volunteer - in several volunteers' rooms. Here we have the primary room and the secondary room. Primary room is the self-isolation room where the infected individual spends most of their time. And the secondary room is the outside of the room where the infected individual doesn't spend too much time, at least according to what they told us. The y-axis is the concentration of the viable virus. You can see, essentially, statistically there is no real significant difference between these two. What does it mean? Well, this tells us that the, you know, the risk in this primary room and the secondary room probably is very similar. So this was the first study showing the air sample in the secondary room and that viable SARS-CoV-2 can be transported to other space in the same building. Again, this is due to the use of the new tool that was developed.

Slide 11

So what is the application or implication? Several of them are the new knowledge that we learned from the sampling. This tells us that, hey, you got to have good ventilation when there is

someone sick in the residence, right? There are also other things you should do protect yourself like wearing a mask when there is a co-occupant that is sick in the space. Also, very important, this research will demonstrate that you need to use the right air sampler in order to give you the correct information because there are a lot of studies using the conventional air samplers, but they are not able to capture the virus. They will say, it's fine, it's not really an issue, but that is because the limitation of the samplers that you used.

Slide 12

Ok, I'm going to change the topic to a somewhat different direction which is also part of our project. The virus was very good in collecting the samples, but the analysis takes days. Very often, we would like to have the information - is the virus over there in the space in a short period of time, right? So that's the point of having this point of care detection. We wanted to be able to do the analysis right over there and we will have the answer very quickly. Here we have our - my collaborator has developed this reading device and this is where you have the samples from the virus. You don't have to use pipettes in this analysis, you just need to slide this device from one, two, three, four - you can do the lysis of the samples, the RNA binding and washing, and then the mechanism is like the ballpoint pen. You have this pushpin that will release the chemicals and you will do all these things without, again, without using pipettes. Everything will be done within one hour. The results shown over here that we were able to detect the SARS-CoV-2 virus or influenza virus right over there within one hour. You don't have to take the samples back to your lab.

Slide 13

So finally, just the summary: I hope I have demonstrated that we have to use the right tools and water vapor condensation is a very good method to help us amplify the particle size, and therefore conserving the viability of the virus for effective analysis. With this tool, we were able to isolate - collect and isolate - from air samples from the hospital room, the primary room, and the secondary room far away from the primary using this device. From that, we know that good ventilation and PPE are very important in keeping low risk in the indoor space. Additionally, if we would like to develop the point of care detection capability, we can have rapid risk assessment of exposure to the respiratory viruses right over there. You don't have to take the samples back to your lab for analysis and wait for days.

Slide 14

Finally, I would like to acknowledge the financial support from NSF and NIH and also my collaborators and students working on this project.

Slide 15

That's all I have and thank you very much for your attention.