This Week in Virology

TWiV 1156 Clinical Update

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Vincent Racaniello: *This Week in Virology*, the podcast about viruses, the kind that make you sick. From *MicrobeTV*, this is TWiV, *This Week in Virology*, Episode 1156, recorded on October 10, 2024. I'm Vincent Racaniello, you're listening to the podcast *All About Viruses*. Joining me today from New York, Daniel Griffin.

Daniel Griffin: Hello, everyone.

VR: It's on the bow tie today, Daniel.

DG: I know I've worn this before, but it seemed very appropriate. It is a filovirus. I'm sticking with my filovirus theme because we're going to be revisiting Marburg again.

VR: It's a good choice.

DG: Apparently, I have two of these, two Ebola bow ties.

VR: Exact same bow tie?

DG: Slightly different. It's very similar in pattern. This is like a slightly thicker bow tie where I buy the actual tie with a thicker fabric. I send it up to Beau Ties in Vermont, B-E-A-U ties. They, yes.

VR: Excellent.

DG: All right, let's jump right in. I will start off with a Mark Twain quotation. "Diligence is a good thing, but taking things easy is much more restful." I think you and I have been talking about the fact that maybe things are getting a little quieter with COVID for a bit. Then we'll see how long we can follow Mark Twain's advice. A couple updates. Just keeping up on polio, the UN aims to start the second round of the polio vaccinations in Gaza mid-October, which is right about now. RSV, more good news from GSK. GSK announced new data from the ongoing Phase 3 trial that indicates that, well, I'm going to couch this.

They indicate that a single dose of its RSV vaccine, Arexvy, is protective across three seasons, even in people at increased risk for virus complications. They say after three RSV seasons, the company said cumulative protection after a single dose was still meaningful, with an efficacy of 62% against lower respiratory tract disease caused by RSV, 67.9% against severe disease when compared with placebo. For the third season, the efficacy was down at 48% for RSV-

related lower respiratory tract disease. Now, that's all right. Maybe what about time for a booster?

VR: Looks like we're going to have to boost because that's not acceptable. Forty-eight percent, is it?

DG: We were up at 80%. The whole idea that it's like this just really means, they should celebrate, "Hey, you need to get a dose every two years or something." That's fine.

VR: This is a protein-based vaccine, right?

DG: Actually, I think they're adenoviral vector-based. They're not mRNA. Actually, we can check in real-time. Do you want to check in real-time?

VR: Let me check. Because we have this ongoing discussion about whether protein-based vaccines are better or not. This is losing efficacy, but may not be a protein-based. Let's check.

DG: Let's see what it says here.

VR: No, it's a protein-based RSVF protein with an adjuvant.

DG: OK, so protein-based versus adjuvant.

VR: OK. That's not great. We thought protein-based would be more durable.

DG: We did get, this is the issue here going into the third season. This isn't like getting boosted twice a year. We'll talk a little bit about.

VR: No, this is better than that. I agree. Not everyone, but for people at risk, over 65, they would need to get every few years.

DG: The way they have it now is if you're over 75, then go ahead. Maybe it's going to be every two years if you're under 75, but with certain risk factors. Yes, it's a little bit of subtlety here, but maybe it's every two years. That seems reasonable. Actually next week, we'll talk a little bit about the mpox vaccination. This is the data that I want. I don't want to just see antibody levels. I want to see efficacy. Is it working to prevent disease?

All right, moving into mpox. I do not know much about this, but I am going to share. We heard that there was a case of mpox found in a jail in Central Uganda. Prison spokesperson said that this person has been isolated. They're receiving treatment. Never great to have mpox in an overcrowded situation like a prison. Now, this person, they're staying there. They're not releasing them on bail or anything like that because this person is being held for murder. The suggestion is that they came in with mpox rather than acquiring it in the prison. We'll see what happens there.

Marburg, I want to give people an update here because things are not as positive as I thought they would be at this point. I'm going to leave in a link so people can follow this themselves. I just looked at the most recent update from the Republic of Rwanda Ministry of Health, Wednesday, the 9th of October. We're already up to 58 confirmed cases. We already had 13 deaths, so another death. Here's what I'm hearing. The King Faisal Hospital had cases. There

also have been cases at the Academic Center, and also, cases at a third hospital. That's at least what I'm hearing. What's going on?

We also hear from the U.S. CDC that the Republic of Rwanda's Ministry of Health reported cases of Marburg in the country, including patients in health facilities. Most of the people infected actually are healthcare workers, particularly those working in the intensive care unit. This became an issue, actually, having our Columbia infectious disease discussion this morning. Someone was supposed to present, but they overslept, so we got to talk about Marburg instead. The CDC, and this already applies to some of the workers coming back to Columbia from Rwanda, they need to actually isolate, stay out of work for 21 days, and then let us know if they have symptoms like fever, chills, unexplained bleeding.

Then they need to seek immediate medical advice. There's this 21 days, and why is that? Marburg can potentially have this 21-day from exposure. It's a hemorrhagic viral disease similar to Ebola. Listeners may be more familiar with Ebola. Currently, there are no treatments or proven vaccines. We don't know what works. There is a plan, and it's basically already rolling out. There's going to be a vaccine using a modified chimpanzee adenovirus. It's a ChAD3 platform from the Sabin Vaccine Institute based in Washington. They've already shipped the initial 700 doses. They're going to use this as part of a trial targeting frontline health workers. They're going to do this in six clinical sites in Rwanda.

Now, what are they currently doing in the moment? While we're waiting to see if things work, they're using remdesivir, which was donated by Gilead, and they're using monoclonal antibodies. I'm hoping they work, but then, as mentioned, we don't have the evidence behind that. The USAID has activated a dedicated Marburg outbreak response team to coordinate response efforts. Actually, since the response team activation, the USAID has provided an initial $1.35 million in pre-positioned outbreak response funding to address urgent gaps related to disease surveillance, contact tracing, case management, risk communications, community engagement, et cetera.

Really going to help with testing, with sample collection, with personal protective equipment. They're coordinating with the government of Rwanda, and really a number of international partners. WHO is involved, UNICEF, International Federation of Red Cross and Red Crescent, the UN Food Agricultural Organization, and MSF, Medicine Sans Frontieres, is involved as well.

VR: Daniel, since most of these cases are in healthcare workers, it seems they really need some infection control instructions, right?

DG: I think a lot of that worry about it being at an Academic Center where we're trying to teach people. I don't know, maybe the Academic Center has more resources. This is a transmission issue and really need to focus on preventing the spread and transmission here. We're seeing about a 30% mortality, not great. All right, COVID, we've got, is that Kentucky? Is that yellow, right?

VR: It sure is.

DG: Yes, 4% to 6%. Down in the Southeast, 2% to 4% in a lot of areas. Florida, Georgia, South, North Carolina. Now, we're seeing a little bit of a post-, I guess, beginning of the Jewish holiday uptick because a lot of older folks wanted to participate. We have a large Jewish population

here in the New York tri-state area. Just admitted another one yesterday, prior to that, we had a bunch in the ER, went to these gatherings, didn't want to be the only person wearing a mask. Unfortunately, now we have some folks in the hospital. I'll talk a little bit about how one of those ladies ended up in the hospital, how that might have been prevented. Good news, looking at the wastewater.

VR: Still going down, yes.

DG: Really on the way down. A little bit of ignore what's going on in the West, almost a little bit of a - Hopefully, the trajectory keeps going down here. The variants, it's all KP3.1.1, and remember that's a JN.1 lineage. That moves us right into vaccination. Vincent, a little more information for our concerns. The article, “The Platform Trial in COVID-19 Priming and Boosting,” the PICO-BOO, you like that? That's catchy, the PICO-BOO trial, immunogenicity, reactogenicity, and safety of different COVID-19 vaccinations administered as a second booster, fourth dose, in folks that were primed with AZD1222, the AstraZeneca.

This was published in *Journal of Infection*. Really, the big thing was that the repeat of one of our concerns that all the vaccines got a really nice boost. Actually, maybe the mRNA got a higher antibody boost, but more rapid waning after the mRNA vaccines.

VR: Do they have protein-based in here? Do you know?

DG: I wish we had more of the protein-based in here.

VR: Yes, there's a little Novavax here.

DG: Yes, and that's the comparator. The Novavax, the trajectory of the waning is not as rapid with the Novavax as it is with the mRNA vaccine. Yes, this does actually let us address a little bit of that question. We are seeing more and more evidence that the mRNA vaccines we talked about last week do not seem to induce the long-lived plasma cells in the bone marrow. We seem to see more rapid waning after mRNA vaccines than we've seen with other vaccines and here head-to-head.

VR: Here is just immunogenicity. It's not clinical efficacy.

DG: Yes, that's what we really need. How much does this actually matter? The data we had looking up above with the RSV, that's the data that we need, not just following some antibody levels over time. This is another interesting one. This is the article, “COVID-19 Disease Incidence and Severity in Previously Infected Unvaccinated Compared with Previously Uninfected Vaccinated Persons,” recently published in *JID.* We're going to avoid using that term that other people use when they talk about infections that occur in vaccinated individuals. We'll let that remain nameless and be forgotten to history.

Here, they're asking this very simple question. "Who does better? Those that are relying on the protection afforded by surviving a prior infection or those that are counting on those vaccines." They're going to use again, the VA COVID-19 national database to create matched pairs of previously uninfected vaccinated. Here, you just got two or more of the mRNA vaccine doses compared to previously infected, but unvaccinated individuals. First, what about

protection against infections? Is that different? Really not, the incidence rate of infections among vaccinated, unvaccinated, but previously infected, that was the same.

Now, what about what we really care about, severe disease? The incidence rate of hospitalization or death was higher after reinfection compared with the rate after infections that occurred in vaccinated folks. That was 7.31 compared to 4.69. I'll point out that this is almost twice as high for those folks relying on prior infection as opposed to vaccination with regard to disease, with regard to hospitalization, and death. I just want people who still seem to think prior infection provides better protection than vaccination to let that sink in. I also want to point out that looking at the unvaccinated, reinfected age greater than or equal to 65, the incidence rate of hospitalization or death per 1,000 persons was 16.62.

I also want to point out that the comparative here was just getting two vaccine doses, which I'm not even thinking is fully vaccinated. Certainly, doesn't qualify as being up-to-date with current vaccine recommendations. The incidence of hospitalization death is significantly higher after reinfection if you're unvaccinated compared to infection after you have that protection of vaccination. Get those vaccinations, folks. We still have for passive vaccination Permgarda, and we'll leave a link in there to a locator.

Now COVID-19 early viral phase. We've been talking for a while. What do the experts recommend? What is the NIH? What is the ID Society? What did they recommend?

Perhaps in contrary to some of those providers and folks that follow the mainstream media, they recommend early antiviral treatment. Let's talk about what's going on. We've got the *MMWR,* "Differences in COVID-19 Outpatient Antiviral Treatment among Adults Aged Greater Than or Equal to 65 Years by Age Group. National Patient-Centered Clinical Research Network, United States, April 2022 through September 2023." Here, we read that fewer than one-half of adults aged 65 and older with an outpatient COVID-19 diagnosis received a recommended COVID-19 antiviral medicine. Including 48% among adults aged 60 to 75, 44% among 75 to 89, and only 35% among those aged 90 and over.

That's really high-risk folks, and they have a nice graphical abstract. Perhaps even more striking is the figure from the paper. We've talked about this for a while. You look at the people's ages, and I don't know, is this like elder bias? We just don't like our elders in our society? You can see folks 65, 66, just under half of them get offered therapy. As you drop down to 90, we have only about a third. The others, so folks that end up in the hospital, what percent of those actually got early antiviral treatment? You can see that starting in folks in their 60s, it's only about 1% to 2%. 98% of those folks did not get antiviral treatment that end up in the hospital.

Even we get up to folks in their 90s, still, 92%, 93% did not get offered early antiviral treatment. You can basically see that the big thing about all those thousands of people that end up in the hospital. By the way, the over 1,000 a week that are still dying here in the U.S., is that they did not get antivirals during the first week. Even during this lull, we're in a lull, we're seeing about 15,000 people hospitalized for COVID each week, and we see we could reduce that down to 1,500.

VR: This is presumably physician-driven to a great extent, but I don't understand the age bias at all.

DG: I don't either. Is it just, "Oh, they're on too many medicines, it would be too challenging for me to deal with drug-drug interactions?" We're going to talk, actually, about - I'll bring it up right now. Right now I've got a woman in her 80s, she's in the ICU, and the story was she goes to see an ENT because she's having some symptoms a few days after the Jewish holidays, the first Jewish holiday. We're in that 10 days when you can atone for your sins. The ENT diagnoses her with COVID, says, "Hey, I'm going to send you to your primary so they can get you on the Paxlovid."

Goes to the primary, the primary says, "Oh, you're on a statin, I'm a little worried about the drug-drug interactions. Why don't we wait and see how you do? Now she's in the ICU. OK, so what are you supposed to do? What do the experts say? Number one, Paxlovid. Number two, remdesivir. If you're worried about the drug-drug interactions, we're spoiled in the New York area. They can go over to one of the Catholics, they've got a fast track, they'll pop you right in, get you that first day, and then you come back for two more days. Ninety percent reduction in progression based on the Pine Tree data. Molnupiravir, about 30%. Instead of 15,000 people ending up in the hospital, we could make that 10.

We could reduce, instead of 1,500 people a week dying of COVID, we could get that down to 1,000. That's just using molnupiravir, which we think of as an inferior option. Convalescent plasma in certain situations. Yes, if you've got acute COVID, you are contagious. Think about that.

VR: Daniel, the patient with the statin conflict, what would you have done?

DG: Statins are an easy one. There's a few that we should have memorized. If you're on a statin, you stop the statin for a week. It doesn't matter, "Oh, have you taken your statin today?" If you took your statin today and you started Paxlovid, the statin is just going to remain at whatever level it is for a longer period of time. It doesn't shoot up. It's not like ritonavir increases the statin. It just keeps it there. If you get diagnosed, you say, "It doesn't matter which cholesterol medicine you're on, just stop it for a week." When you're done with the Paxlovid, give it a few days, you can start back up.

Again, there's the link, and we leave it in all the time, to the Liverpool Checker. You go to COVID-19 Drug Interactions, Liverpool. You put in the nirmatrelvir/ritonavir. You put in whatever medicine. It tells you exactly what to do. During that second week, the early inflammatory week, that's when you might consider steroids. The right dose, right patient. Anticoagulation, pulmonary support, still a window for remdesivir and immune modulation. This is when you're the five days versus the three days of remdesivir. We got a couple really interesting articles here in the late phase, PASC/Long-COVID.

The first one is, “COVID-19 is a Coronary Artery Disease Risk Equivalent and Exhibits a Genetic Interaction with ABO Blood Type.” This was published in the journal *Arteriosclerosis, Thrombosis, and Vascular Biology*. There's also a nice press release out by the Cleveland Clinic. The title there, “History of COVID-19 Doubles Long-Term Risk of Heart Attack, Stroke, and Death,” really got it all there in the title. This study found that people with any type of COVID-

19 infection were twice as likely to have a major cardiac event, such as a heart attack, stroke, or even death, for up to three years after diagnosis.

The risk was significantly higher for patients hospitalized for COVID-19 and more of a determinant than even a previous history of heart disease. Interesting stuff. There's this whole blood type thing, which apparently you want to have blood type O.

VR: Is this an age-dependent association or just elderly?

DG: It's always going to be whatever that baseline risk is. If your baseline risk is 1%, it goes to 2%. If it's 10%, it goes up to 20%. We're going to wrap it up with really an interesting article with a lot of cool images, figures. This is the article, "Quantitative Susceptibility Mapping at 7T in COVID-19 Brainstem Effects and Outcome Associations." published in the journal *Brain.* What is going on here? Now, neuroradiological changes have been described in severely affected hospitalized patients with SARS-CoV-2 causing COVID-19. The most common acute findings are these cerebral microhemorrhages, encephalopathy, white matter hyperintensities.

Brainstem involvement in COVID-19 has been reported in autopsy studies showing tissue neurodegeneration, inflammatory responses. These abnormalities are reflected by MRI visible changes in the brainstem in the acute phase of illness. Such brainstem abnormalities have been proposed as a mechanism for post-acute COVID, PASC, which may be part of this Long COVID. Here, the investigators recruited people who are hospitalized with COVID-19 and subsequently discharged, so post-hospitalized patients. Then they're going to have these healthy control groups. They're going to have three subgroups.

People scanned before any possible exposure, people scanned during the pandemic who no symptoms, no history. They're going to break those down. They're going to actually look. They're going to perform MRIs. They're going to find differences, significant differences, mainly in the brainstem. We've got a nice figure two, where we've got these dot plots looking at brainstem, looking at medulla, midbrain, pons. My favorite is Figure 1 with these 3D projections, where they've got these 3D. Don't they look like chickens or parakeets or something?

VR: They do.

DG: You can actually see the different abnormalities in these areas. Basically, what they're doing is they're seeing differences that they tell us are consistent with a neuroinflammatory response. The fact that these regions that are affected are in sites of respiratory pathways. Suggesting that maybe part of this respiratory pathology, respiratory issue that we're seeing afterwards, may actually be coming from brainstem inflammatory injury.

VR: There was some hypoxia as well, right?

DG: Yes.

VR: The control group here never had COVID. We don't even know that any of these people went on to get Long COVID. I don't really like that.

DG: If only people were ready for the pandemic.

VR: Well, I understand.

DG: They could have these nice longitudinal studies going forward.

VR: You can always get a group of people who weren't hospitalized and do MRIs on them and see.

DG: People are going to get COVID and Long-COVID going forward. You can always set up, "OK, you're our cohort. Let's see what happens. Oh, you went on to get Long COVID. Oh, you've got respiratory difficulties. Let's compare you to these other folks, and then sort it out."

I will close, as we have for a while, by saying no one is safe until everyone is safe. We're finishing up. This is the last month of our Floating Doctors fundraiser, August, September, and now October. We will double those donations. We're hoping to get up to a maximum donation of $20,000.

VR: It's time for your questions for Daniel. You can send yours to daniel@microbe.tv. Nicole writes, "I was hoping you could review any data informing risk-benefit ratio of the updated 2024-25 COVID booster for healthy children. Who have already received the primary series as well as last year's updated vaccine and had prior natural infection. Can you review data supporting the U.S. universal recommendation that children with such a history should receive,(i.e., are expected to meaningfully benefit from), the updated 2024-25 booster? The implication that they will benefit from annual boosters, even considering they are likely to experience natural infection in any given year?"

Dr. Offit spoke on the topic of boosters previously on *TWiV* last year. He speculated there was probably little benefit of the 2023-24 booster for children who had already received the primary series. Which he emphasized was the most important, especially since most of them had natural infection at some point. He also cautioned that the vaccines are not entirely without risk. If I misinterpreted Dr. Offit's prior statement on *TWiV*, please omit mention of him, but that's my recollection. I was hoping we would have better-updated data this year to better inform risk-benefit of annual boosters in healthy children.

DG: Paul Offit's great in really being evidence-driven. You always want to be careful with vaccines. You don't want to push something and then end up having people become vaccine-hesitant because they feel like we haven't been honest. We tell everyone, "You need to follow the data, and then if we don't do it, where's our credibility go?" As we've seen over time, people who've been infected in the past, people who've been vaccinated in the past, there is a certain sustained protection that we're seeing. As we've talked about there is some waning of protection.

What can we expect these vaccines to offer? What we saw last year, we won't have the data for this year until next year. It's always one year behind. We saw that folks that have been boosted had a shorter duration of the illness. We've also seen that people who are vaccinated tend to spread it to less other people. You're protecting them, you're protecting their siblings, you're protecting the parents, and same way, parents back the other way. Also with kids, the

big thing is Long-COVID. It's a very low percent of children that are going to end up in the hospital, but there are a number of kids that are going to end up taking weeks to get better.

Yes, I think that Paul is being fair in saying that we don't really have as much data as we would like. We'll get more data going forward. It's not as compelling here as the cases in folks 65 and over, people with comorbidities, et cetera.

VR: Sue writes, "On *TWiV* 1152, you mentioned your family was on team Novavax this year. Was that because of lower reactogenicity or you feel there's more durability, or does it have to do with the lineage. JN.1 versus KP3? Of course, XEC recombinant may be another problem." There are a lot of unknowns here. Take that part first, Daniel.

DG: Yes. There's a couple issues here. One is reactogenicity I really like. A lot of people are like, "I'm not going to do another one of those mRNA vaccine is because I felt crummy and I was down for a day." If we can get people to get a vaccine, we're like, "Oh, I got the vaccine and I didn't see any sort of cost here. I felt fine." So, I like the lower risk of reactogenicity. The other is we keep talking about that issue with mRNA vaccines may not have the ability to produce these bone marrow long lived plasma cells. That seems an issue. More rapid waning of antibodies, we see. This is a way to get something you mentioned.

It's not that the vaccines only protect against JN.1 or KP, et cetera., it's just the targeting. Was it a JN.1 lineage match? Was it a JN.1 variant match? Was it a KP2? We don't really know how close you need to get to the moving target. Again, we'll learn more over time. We don't know what's going to be more important, getting as close as you can to the circulating variant or using a vaccine with more sustainable response.

VR: Before you decide on the vaccine, all you have are neutralization data. You don't have clinical data yet. You have that after the fact, and then so you have to make a decision ahead of time.

DG: Yes.

VR: She wants to also know if the mRNA vaccines and/or Novavax can be associated with the development of type 1 diabetes. I know autoimmune arthritis can occur after mRNA vaccines.

DG: We always have to acknowledge that as Paul Offit, these are biologically active substances. They have an effect, and there is going to be a, not common, but there will be a certain percent, say one in 100,000, who are going to have a problem after the vaccines. I've taken care of folks that had arthritis after Novavax. I've had some other folks with mRNA vaccine have some issues afterwards. Again, these are small numbers and much smaller numbers than the number of individuals that have ongoing issues after the infection.

VR: Margie writes, "I asked my doctor for a prescription to Paxlovid to take on a European cruise. I'm 74. I take no meds, no health issues. She mistakenly ordered the low dose instead of the standard dose, and she told me the low dose should work fine. Is that an acceptable solution?"

DG: It's really not. I know older folks, a lot of physicians caring for older folks say, "Oh, I'm just going to use the lower dose. I don't have to worry about renal." No, if you've been seeing this

doctor, there's a kidney function available. You should get the dose that's been studied for your kidney function.

VR: Bruce writes, "Last week you referred to an editorial suggesting use of gowns and gloves by healthcare workers attending COVID patients may be out of step with current knowledge concerning transmission. I raised this question with my daughter, who's a pediatric nurse. Her immediate reply was, 'What about when the COVID patient coughs on me? Would this cover my clothes and face with infectious particles if I'm not wearing a gown, gloves, face mask, which could lead me to be infected?' It seems like a reasonable question. What do you think a scientific response would be?"

DG: Yes, so this is reasonable. Let's think through this. Let's see what's going on. I have a colleague, he was running through his infection control practices with me. He sees patients in an urgent care environment and, well, he uses a surgical mask with everyone, but then he says, "I'm not going to change the mask between every single patient, but if I see a patient and they test positive, then I change my mask. Does that make sense?" I was like, "Well, let's think about it. What are you thinking? You saw a patient with COVID, you probably saw a lot of patients that you didn't realize had COVID."

Now, let's say, as you described, they cough or whatever. Now those particles are on the mask. Are you then going to take that mask and shake it in the air and then breathe it in. Because you don't get COVID from touching a mask with droplets on it. You get COVID by breathing in it. When that person coughs and sprays you in the face, sprays your mask, sprays your clothes, your clothes don't then become an infectious hazard for the next person. They're also not an infectious hazard for you.

Remember this is respiratory. You get this by breathing in. What do we estimate? One in every 10,000th case of COVID may have been contact-related, maybe. I see the thinking, but this is respiratory. That 200 gallons a week of unnecessary trash that we're generating is not based on science.

VR: The gown is not needed, but a mask would be a good idea. What about the gloves?

DG: The mask is a good idea and wear a proper mask. N95 is going to actually protect you. Do you need gloves? Do you need a gown? No.

VR: All right. Finally, Ruth writes, "I wonder if it's really a surprise that any type of SARS-2 vaccine would fail to induce long-lasting antigen-specific B-cell responses. One of the characteristics of coronaviruses is their ability to produce reinfection, suggesting that they can evade long-lasting immune responses. In addition to comparison with protein-antigen vaccines, it would be interesting to see if durable B-cell response results from infection."

DG: Yes, no, Ruth, this is great. As we keep sharing, we're learning more about what's going on, how much of this is coronavirus-specific, how much of it is mRNA-specific, that sort of growing evidence there. As we just discussed this time, the trajectory of the weighting of those antibody levels is much more rapid with the mRNA vaccines than we're seeing with the other vaccines. That's from the COVID data, and we're also seeing that with the RSV data.

VR: Something's going on with the seasonal coronas because every infection is milder and milder. I suspect you're getting T-cell memory, not B-cell. That's protecting you against severe disease, but we'll see.

DG: We will.

VR: That's *TWiV*, weekly clinical update with Dr. Daniel Griffin. Thank you, Daniel.

DG: Oh, thank you. Everyone, be safe.