PROFESSOR: So now, we can summarize the safety guideline in a very simple formula, using the steady state transmission rate as a more conservative estimate than worrying about the transient buildup of aerosols in the room, and using the simplification of introducing an effective size for particles, R bar, that includes and encodes all the information about the radius dependent mass penetration factor or sedimentation rate and infectivity, et cetera, in droplet size distribution.

And the safety guideline looks like this.

It basically bounds the cumulative exposure time, which is n minus 1, the number of susceptible people when one person enters a room of occupancy n, maximum occupancy, and stays for a time tau.

And I should mention the time tau does not need to be continuous.

So if you think of, say, a classroom or an office, you will be adding up the time, total time.

So if this safe time is 100 hours and you spend 10 hours a day, you might get 10 days, according to this calculation.

And so that relationship is plotted as this yellow curve.

And if you're below that curve, you're safe.

So you have either smaller time than that or a lower occupancy.

And that's how you can decide the safety.

Again, this is a safety exposure guideline for indoor airborne transmission.

And we will talk about other types of transmission later.

What's nice about this formula is it allows you to immediately see the effects of the scaling, some of which we've already talked about before.

So if we would like to move it in this direction, obviously, we would like the curve to be up here somewhere.

So this is obviously making the room more safe.

If I can push it in this direction, I can either get more people or more time or whatever combination that I'd like.

How can I get there?

So Cq is a disease specific parameter.

But we will see that Cq does depend on the type of respiration and activities, such as singing or heavy exercise or loud speaking are much worse than resting or breathing.

So to get in this direction, we could do smaller Cq, which could be resting versus speaking or singing.

And we'll come back to characterizing that more carefully.

So we can at least change that type of activity in the room.

Well for physical parameters, we can increase V, the room volume.

So if you take everything the same, same number of people, and you make the room much bigger, obviously the air gets more diluted.

And hence, there's less chance of transmission if people are sort of scattered about the room.

What else can we do?

We can lower Qb, which means breathe slowly or in a more relaxed way.

So again, coming back to the activity in the room, if you have heavy physical exercise, your Qb might increase, although it doesn't increase that much.

Resting breathing is around 0.5 meters cube per hour.

And even heavy exercise doesn't get much higher than about 3 meters cubed per hour.

And so that's a total of a factor of 6 or so.

But it comes in squared.

So that could actually be significant.

So definitely heavy exercise is not as good as resting.

And what else do we have?

We have masks.

Well, obviously, we can wear masks.

And that is actually very helpful, because as we've already discussed, it comes in squared.

And that is something which is sort of very simple fix.

And if the mask penetration factor is 10% or even possibly less, it comes in squared.

So that can have a very big effect of pushing this over, as we will see.

So this is basically lower P mask.

So when there's no mask, Pm is equal to 1.

Finally we also have an lambda C, because we had written that out earlier, that also includes several effects, such as better ventilation.

So increase ventilation, so the flow rate of outside air, so the air change rate should be increased.

And that gives us a larger lambda C.

We can introduce air filtration.

And that's sort of buried within lambda C.

That's PF lambda F. Although as we discussed earlier, because you have to have a certain amount of fresh air coming into the room, air filtration doesn't give you as much benefit as you might hope, but can still give you a factor of 5 or something like that if you have 20% outdoor fresh air coming in.

And so those are some of the key scalings that we can understand.

And just simply by plugging into a formula like this, we can get a sense of how different mitigation strategies can be compared and also how different types of rooms can be compared in terms of the occupancy time and the number of people that could be allowed as a maximum occupancy.

And what remains now is the parameterize this for COVID-19 specifically, which boils down to understanding this parameter Cq.