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Virus decay rates should not be used to reduce recommended room air clearance times

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To the Editors—

We read with concern the letter by Hurlburt et al [1] proposing revisions to the recommended room air clearance times for infectious aerosols in healthcare facilities. We believe that the calculations performed to justify the changes are based on flawed assumptions and an erroneous calculation. Experimental data on the survival of airborne SARS-CoV-2 virus and the dynamics of room ventilation do not support their conclusions.

Hurlburt et al based their proposed changes on data describing the effects of humidity on the viability of airborne influenza viruses, and on reports that influenza decays more rapidly at mid-range humidities. They then assumed that these decay rates apply to SARS-CoV-2 as well. In fact, this is not the case. Schuit et al[2] studied the decay in viability of airborne SARS-CoV-2 for relative humidities of 20% to 70% at 20°C and found that SARS-CoV-2 was relatively stable in air in the absence of sunlight (k_{infect} = 0.008 per minute) and that humidity did not significantly affect the decay rate. Other researchers have also reported either no effect or a small effect of humidity on the decay rate of airborne SARS-CoV-2.[3,4]

Using data for influenza rather than SARS-CoV-2, Hurlburt et al assumed that a relative humidity of 40% to 60% would reduce the viability of SARS-CoV-2 by 30% to 50%. Unfortunately, these researchers miscalculated the effect that this would have on air clearance times. They simply multiplied the equation for the clearance time by their assumed reduction in viability, which has the mathematical effect of assuming that the reduction in viability occurs instantaneously. In fact, experimental data for SARS-COV-2 and other viruses show that losses in viability are best modeled as an exponential decay. The correct version of the formula is

$$t = \frac{-\ln[1 - (PRE/100)]}{ACE + (k_{infect} \times 60)} \times k_{mix} \times 60$$

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where PRE is the desired percent particulate removal (%); ACH is the air exchange rate for the room ventilation (Air changes/hour); k_{infect} is the decay constant for infectivity of the virus (per minute); k_{mix} is the mixing factor (explained below); t is the time to achieve desired percent particle removal (minutes). The error in the authors' formula exaggerates the effect of losses in viability, especially over shorter times. The data from Schuit et al[2] suggest that it would take 45 minutes for airborne SARS-CoV-2 to lose 30% of its viability and 87 minutes to lose 50% of its viability, which is very different from the authors' assumption.

A second problem is that Hurlburt et al failed to include ventilation mixing factors in their calculations. The time required to remove airborne particles from a space can be estimated using the Centers for Disease Control and Prevention (CDC) Guidelines for Environmental Infection Control in Health Care Facilities (Table B.1).[5] Table B.1 matches the values in the "none" column of figure 1 of the Hurlburt et al letter. However, Table B.1 assumes that the air in the room is completely mixed; it is purely a mathematical estimate of room air dilution under ideal conditions. The footnotes to Table B.1 note that "The times given assume perfect mixing of the air within the space (ie, mixing factor = 1). However, perfect mixing usually does not occur. Removal times will be longer in rooms or areas with imperfect mixing or air stagnation." Thus, the appropriate use of Table B.1 to establish clearance times requires multiplying the times in the table by a mixing factor (k) that ranges between 1 and 10.[6,7] This factor represents how well the ventilation system mixes and dilutes the concentration of airborne particles within the room.[8] It can be experimentally determined for a specific room, or, as a rule of thumb, a mixing factor of k = 3 is often applied to rooms with higher airflow rates (≥6 ACH) and good placement of supply and exhaust grilles. In that case, the time identified in Table B.1 would be multiplied by 3 to estimate the clearance time prior to re-entry.

The corrected times estimated to reduce the concentration of viable airborne virus in a room by 95% are shown in Table 1 in this letter. For a 95% concentration reduction at an air change rate of 6 ACH and using the decay coefficient for SARS-CoV-2 from Schuit et al,[2] the room clearance time is only reduced by 2 minutes, from 30 to 28 minutes. This is very different from the authors' predicted 20- and 15-minute clearance times that assume immediate 30% and 50% reductions in viability, respectively. Table 1 further demonstrates that including the mixing factor has a large impact on the clearance time.

Finally, the decay in viability of SARS-CoV-2 (and airborne viruses in general) varies substantially depending upon the strain of the virus, the composition of the suspending medium, the air temperature, the presence of sunlight, and other factors. [2–4,9,10] Much remains to be learned about the stability of airborne viruses. Prudence dictates that adjustments to room clearance times are not made based on assumptions about virus viability until this phenomenon is better understood.

In conclusion, the modifications to the calculation of room air clearance times proposed by the authors are not supported by current scientific evidence. Near the end of the letter, the authors write, "The interaction between viruses and relative humidity is complex, and large knowledge gaps exist." We agree wholeheartedly with this statement, and it serves as

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an excellent argument against the proposed reductions in room air clearance times until the stability and decay in viability of airborne viruses are better understood.

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Table 1.

Time Required for the Concentration of Viable Airborne virus in a Room to be Reduced by 95% Using Different Assumptions for the Virus Decay Rate and the Room Mixing Factor[a]

Virus Viability Decay Constant (per min)	**No Decay**	**0.008**	**No Decay**	**0.008**
Room mixing factor	1	1	3	3
Air changes/hour	Required Time, min			
1	180	121	539	364
2	90	72	270	217
3	60	52	180	155
4	45	40	135	120
5	36	33	108	98
6	30	28	90	83
7	26	24	77	72
8	22	21	67	64
9	20	19	60	57
10	18	17	54	51
11	16	16	49	47
12	15	14	45	43
13	14	13	41	40
14	13	12	39	37
15	12	12	36	35
16	11	11	34	33
17	11	10	32	31
18	10	10	30	29
19	9	9	28	28
20	9	9	27	26
21	9	8	26	25
22	8	8	25	24
23	8	8	23	23
24	7	7	22	22
25	7	7	22	21
26	7	7	21	20
27	7	7	20	20
28	6	6	19	19
29	6	6	19	18
30	6	6	18	18

[a]The room clearance time including the virus decay are included only to demonstrate that the effects of including experimental values for SARS-CoV-2 virus decay are small. Virus decay rates should not be included in real-world applications of room clearance time calculations because of the large uncertainties in decay rates.