Supplementary Materials: Resuspension of Seeded Particles Containing Live Influenza A Virus in a Full-Scale Laboratory

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1. Supplementary Information

Figure S1 illustrates the distribution of particle mass and number concentrations for the aerosol dispersed in the room using nebulization and resuspension for the Clean Surface Condition experiment. The size distribution during the initial virus emission shows a mass mode at particle diameter 2 µm and a number mode at 0.5 µm. The particle mass size distribution during the resuspension activity was more widely distributed from 0.5 to 15 µm, although the mode for the particle number size distribution for resuspension remained similar to that of the initial emission (0.5 µm). Figure S2 illustrates the distribution of particle mass and number concentrations for dust aerosol generated in the room, the nebulized viral aerosol, and the aerosol generated from resuspension for the Dusty Surface Condition experiment. The addition of the generated dust appeared to result in larger particles being resuspended, which is consistent with the larger size distribution of the generated dust. The size distributions presented in Figures S1 and S2 are one-minute data from the concentrations peaks for each of the sources.

Figures S3 and S4 provides a comparison of the PurpleAir Low-cost Particle Monitors (LCPMs) during a collocation experiment using nebulized viral aerosol as a particle source. There are strong correlations between the LCPMs (Adjusted R^2 = 0.76 - 0.94). To compare the relative concentrations across the room during the experiments, adjustment factors were determined using the collocation data and LCPMs B-E were adjusted to match LCPM A using the linear least squares regression equations shown in Figure S4. Figure S5 presents the concentrations measured by each of the LCPMs during the Clean Surface Condition experiment.

A material balance model was applied to estimate the contribution of the initial virus emission to the resuspension activity results. We modeled the continued particle concentration decay of the initial emission source after the resuspension activity began and determined the fraction of viral-laden particles that were collected during the resuspension activity period that could be attributed to the initial virus emission Figures S6 and S7. The comparison was conducted for the impinger that was located closest to the APS, which was used to measure the particle concentration. First, we determined the amount of virus collected in IMP-2i compared with the total mass measured by the APS during the IMP-2i sampling period. Then, we estimated the mass collected during the IMP-2r sampling time that would be attributed to the initial emission, and we multiplied this modeled mass by the virus/particle mass ratio from the initial emission. We compared this estimate to the actual virus measured during the IMP-2r sampling time to provide an estimate of the virus contributions from the resuspension and the initial emission. Based on our calculations, 80% of the virus collected by IMP-2r was due to the resuspension and 20% due to the initial emission for the Clean Surface Condition experiment, and 96% of the virus collected by IMP-2r was due to the resuspension and 4% due to the initial emission for the Dusty Surface Condition experiment.

2. Supplementary figures

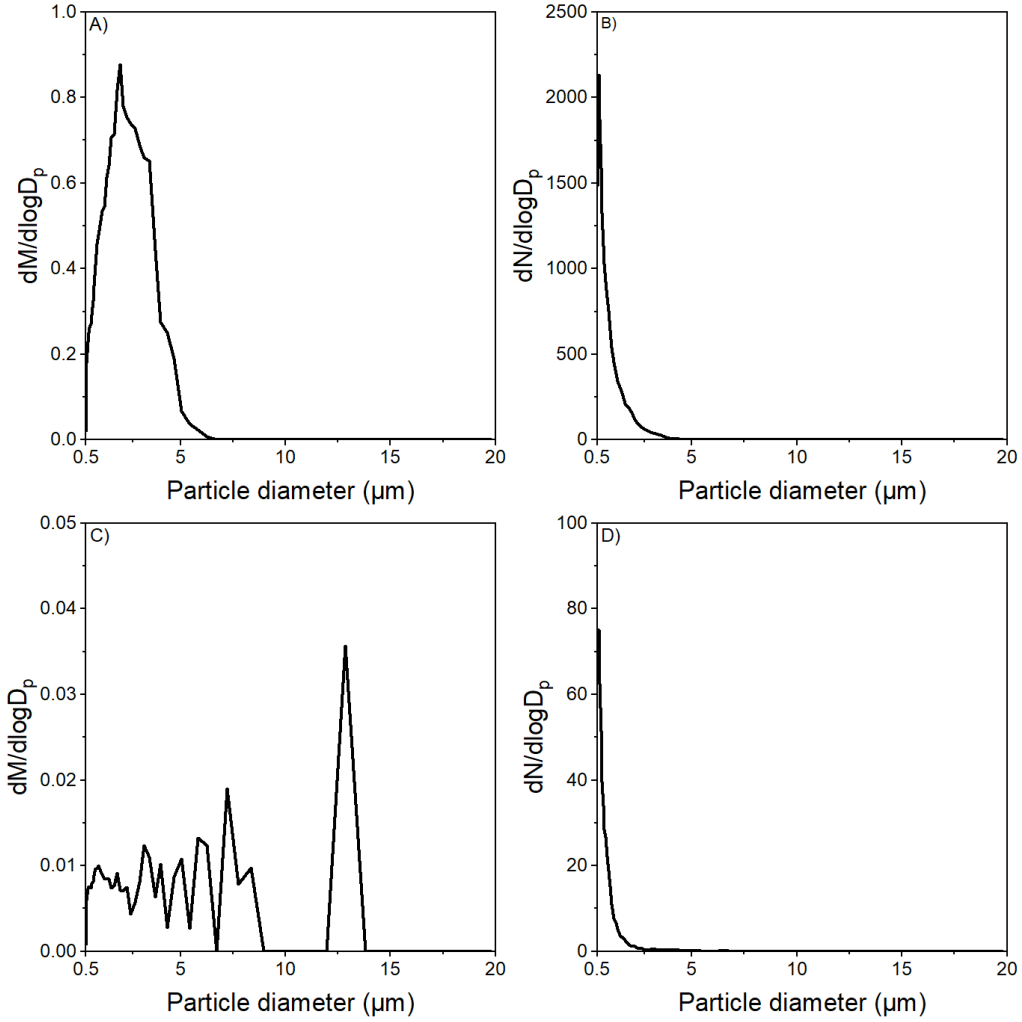

Figure S1. Particle mass size distributions (A&C) and particle number size distributions (B&D) for nebulized viral aerosol (A&B), and resuspension activity (C&D) during the Clean Surface Condition experiment.

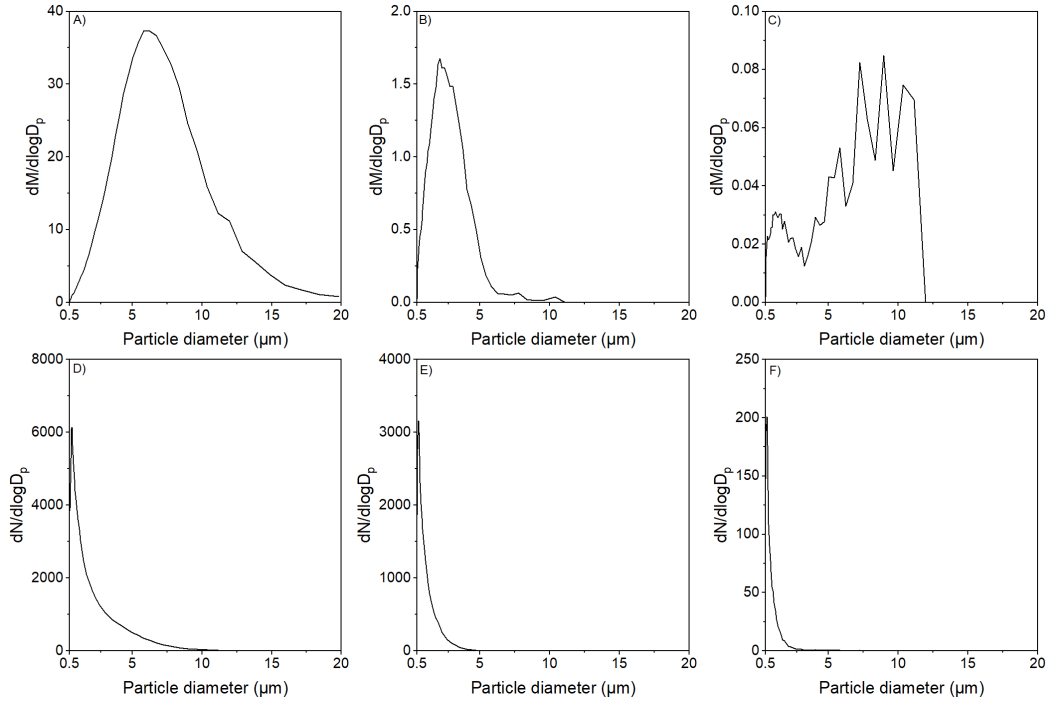

Figure S2. Particle mass size distributions (A-C) and particle number size distributions (D-F) for the generated test dust (A&D), nebulized viral aerosol (B&E), and resuspension activity (C&F) during the Dusty Surface Condition experiment.

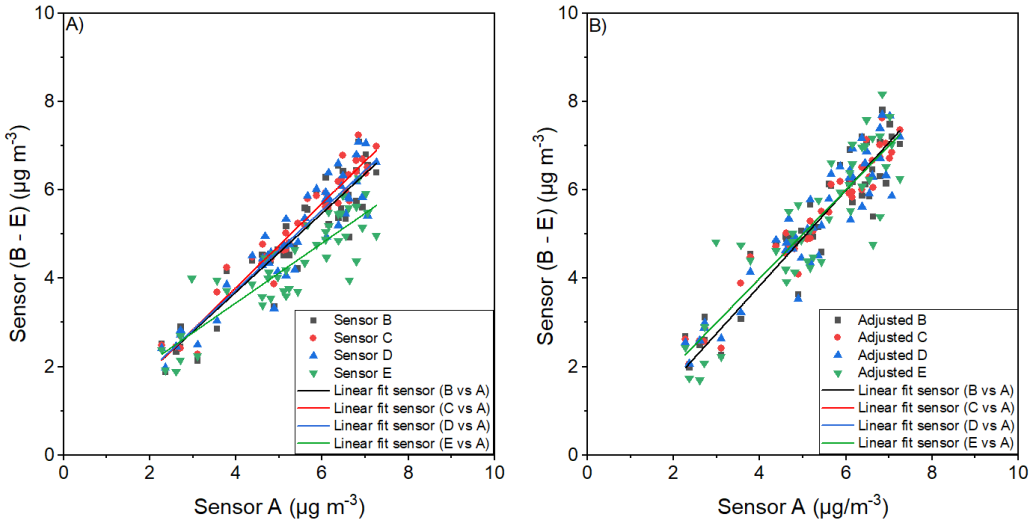

Figure S3. Comparison of the LCPMs during a collocation experiment using nebulized viral aerosol as a particle source for uncorrected data (A) and corrected data (B).

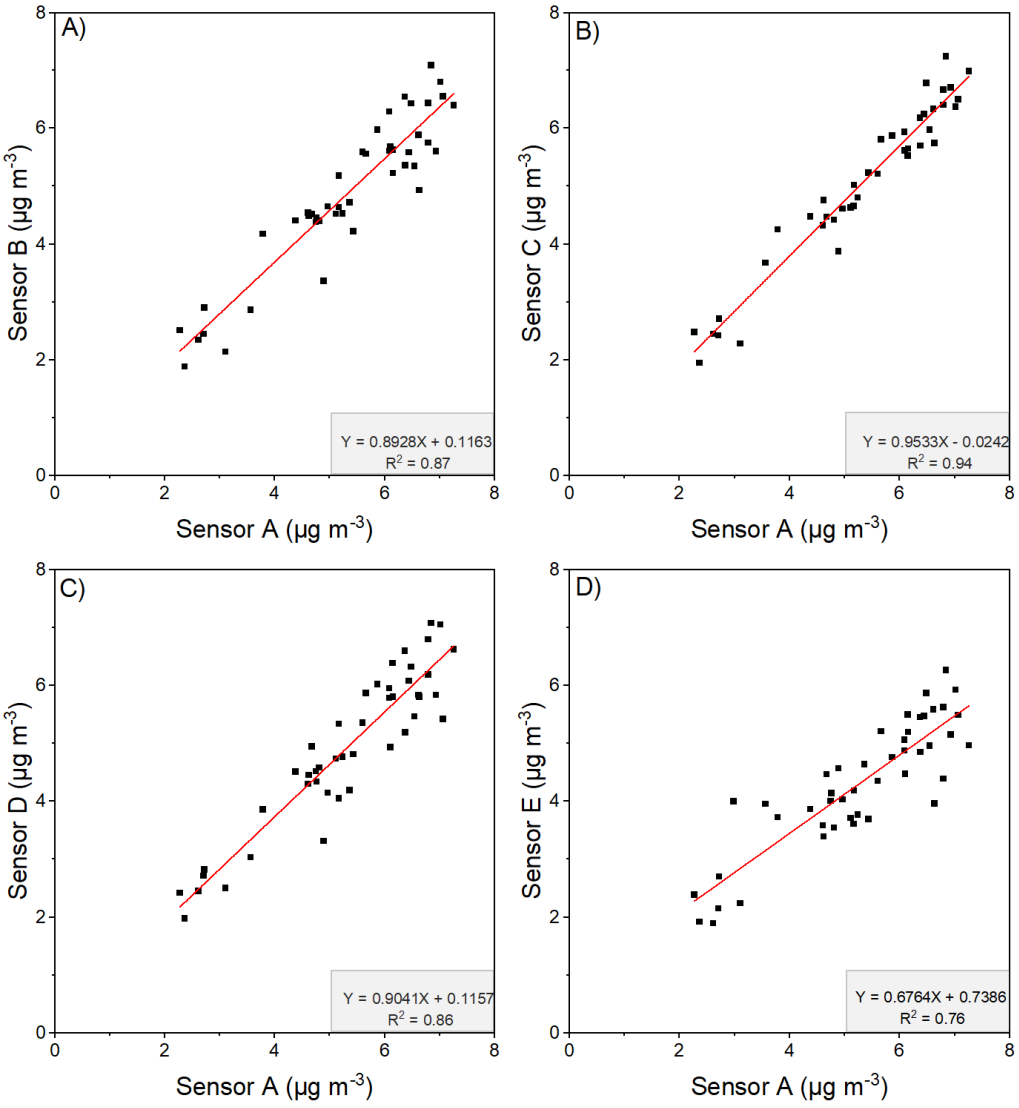

Figure S4. Comparison of the LCPMs B, C, D and E to monitor A during a collocation experiment using nebulized viral aerosol as a particle source. The linear least squares regression equations used to adjust the monitors for the experimental data are shown.

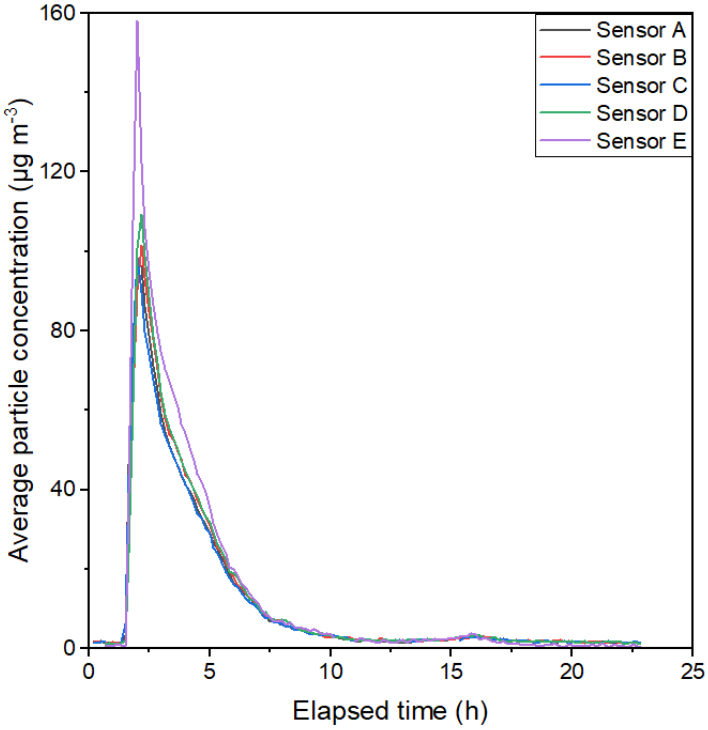

Figure S5. Concentration times series for adjusted LCPM data for the Clean Surface Condition experiment.

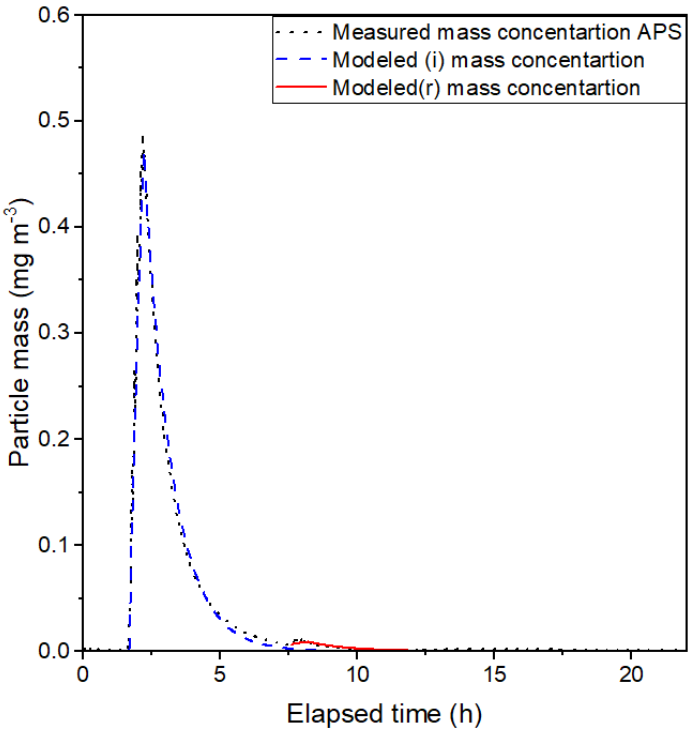

Figure S6. Measured (APS PM_{20}) and modeled concentration time series for the Clean Surface Condition experiment. Both the initial virus emission period (i, shown in blue) and the resuspension activity (r, shown in red) were conducted for 30 minutes.

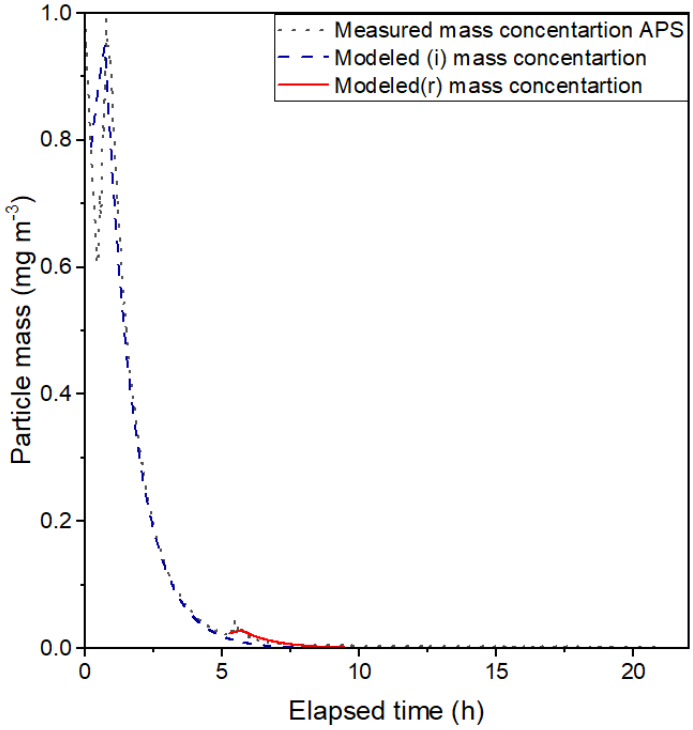

Figure S7. Measured (APS PM_{20}) and modeled concentration time series for the Dusty Surface Condition experiment. Both the initial virus emission period (i, shown in blue) and the resuspension activity (r, shown in red) were conducted for 30 minutes.

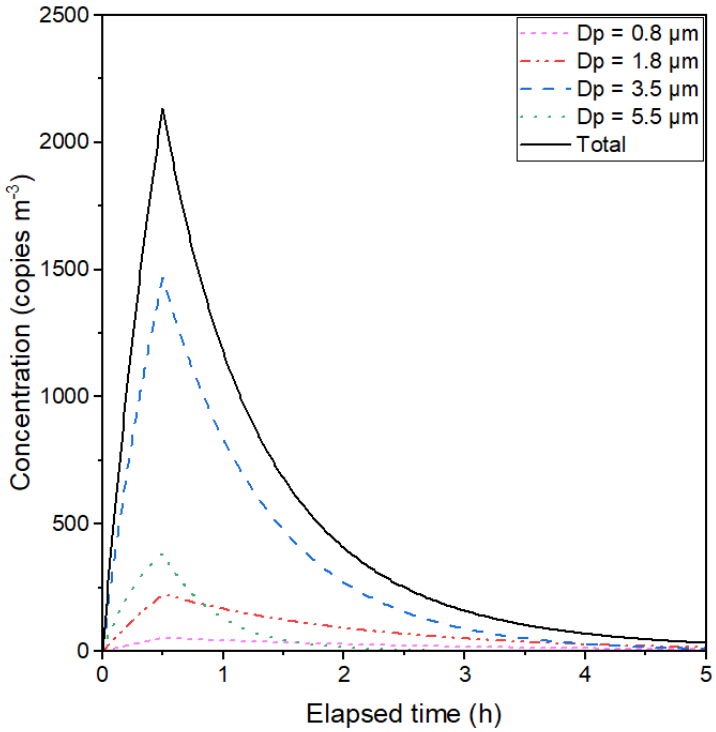

Figure S8. Resuspension modeling for 30 minute walking activity using four size bins.

3. Supplementary tables

Table S1. Detailed information of impingers running during the No Resuspension experiment.

Impinger	Flow rate (Lm^{-1})	Run time (min)
IMP-1i	3.00	390
IMP-2i	3.02	403
IMP-3i	3.00	435

Note: i = initial emission; r = resuspension

Table S2. Detailed information of impingers running during the Clean Surface Condition experiment.

Impinger	Flow rate (Lm^{-1})	Run time (min)
IMP-1i	3.02	591
IMP-2i	3.05	435
IMP-3i	3.00	329
IMP-1r	3.02	391
IMP-2r	3.02	385
IMP-3r	3.06	295

Note: i = initial emission; r = resuspension

Table S3. Detailed information of impingers running during the Dusty Surface Condition experiment.

Impinger	Flow rate (Lm^{-1})	Run time (min)
IMP-1i	3.01	174
IMP-2i	3.05	297
IMP-3i	3.00	301
IMP-1r	3.03	475
IMP-2r	3.04	524
IMP-3r	3.06	205

Note: i = initial emission; r = resuspension

Table S4. Inputs for modeled resuspension estimate.

Parameters	Value	Unit
Stepping rate (f_s)	100	step min^{-1}
Stepping rate (f_s)	1.7	step sec^{-1}
Area of foot (A_s)	0.03	m^2
Area of floor (A_f)	25	m^2
Volume of room (V)	46	m^3
Height of room (H)	2.8	m
Ventilation rate (a)	0.38	h^{-1}

Table S5. Modeled resuspension estimate using four size bins.

		Nominal D_p				
Parameters	**Units**	**0.8 µm**	**1.8 µm**	**3.5 µm**	**5.5 µm**	**Total**
Floor loading (L_j)	(RNA copies cm^{-2})	58	117	152	23	350
Floor loading (L_j)	(RNA copiesm^{-2})	5.83×10^5	1.17×10^6	1.52×10^6	2.33×10^5	3.5×10^6
Settling velocity (v_s)	($m\ s^{-1}$)	2.3×10^{-5}	1.1×10^{-4}	3.8×10^{-4}	9.2×10^{-4}	
Deposition Rate (k)	(h^{-1})	2.96×10^{-2}	1.41×10^{-1}	4.89×10^{-1}	1.18×10^0	
Resuspension fraction (r_a)		5.0×10^{-5}	1.0×10^{-4}	5.0×10^{-4}	1.0×10^{-3}	
Resuspension flux	(RNA copies $m^{-2}\ s^{-1}$)	0.0583	0.2333	1.5167	0.4667	2.275
Resuspension emission rate	(RNA copies s^{-1})	1.458	5.83	37.92	11.67	56.88
Resuspension emission rate	(RNA copies h^{-1})	5.3×10^3	2.1×10^4	1.4×10^5	4.2×10^4	2.0×10^5
Steady-state concentration from resuspension	(RNA copies m^{-3})	278.66	875.5	3416	584	5155
Average transient concentration	(RNA copies m^{-3})	24.1	82.1	338.9	58.2	503
Concentration of virus from initial virus emissions	(RNA copies m^{-3})	2.3×10^4	4.7×10^4	6.1×10^4	9.3×10^3	1.4×10^5
Modeled resuspension activity/virus emission		1.0×10^{-3}	1.8×10^{-3}	5.6×10^{-3}	6.2×10^{-3}	3.6×10^{-3}

Note: 1) Floor loading from average floor loading measured in Petri dishes for Clean Surface Condition and Dusty Surface Condition experiments with approximate size distribution applied; 2) Settling velocity calculated from Stokes' law [1]; 3) Deposition rate calculated by dividing the settling velocity by the height of the room; 5) Resuspension fraction estimated from [2,3]; 6) Resuspension flux from Equation 4 divided by the area of the room; 7) Resuspension emission rate is resuspension flux multiplied by the area of the room; 8) Steady-state concentration is calculated via Equation 6; 9) Average transient concentration is the average of the concentration calculated via Equation 5 for a 30 min source followed by a 270 min decay period (see Figure S8); 10) Concentration of virus from initial virus emissions is the average of the measured concentrations from the impinger samples/hl 11) Modeling approach adopted from Ferro et al. (2020) [4] .

References

1. Hinds, W.C.; Zhu, Y. *Aerosol technology: properties, behavior, and measurement of airborne particles*; John Wiley & Sons, 2022.
2. Qian, J.; Peccia, J.; Ferro, A.R. Walking-induced particle resuspension in indoor environments. *Atmospheric Environment* **2014**, *89*, 464–481.
3. Ferro, A.R. Resuspension. In *Handbook of Indoor Air Quality*; Springer Nature Singapore, 2022; pp. 1–18.
4. Ferro, Andrea and Marr, Linsey and Peccia, Jordan Resuspension exposure assessment for the SARS-CoV-2 virus. In *Proceedings of the 16th International Conference on Indoor Air Quality and Climate*; Indoor Air, 2020