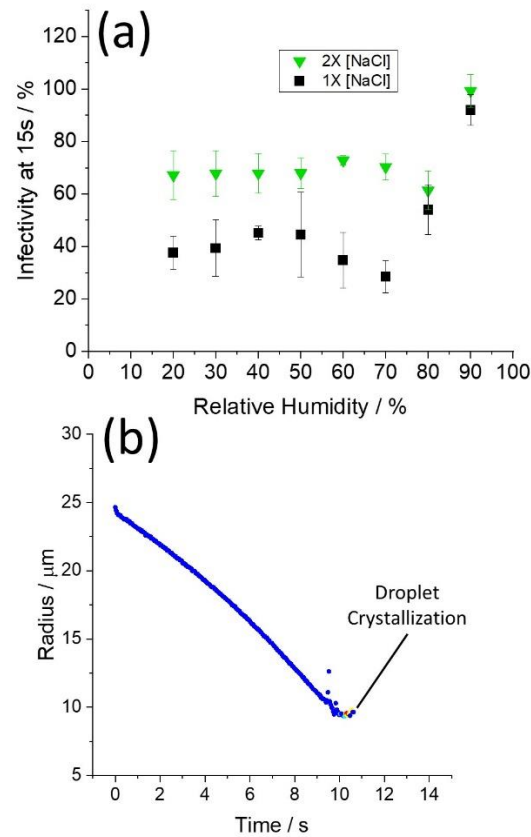


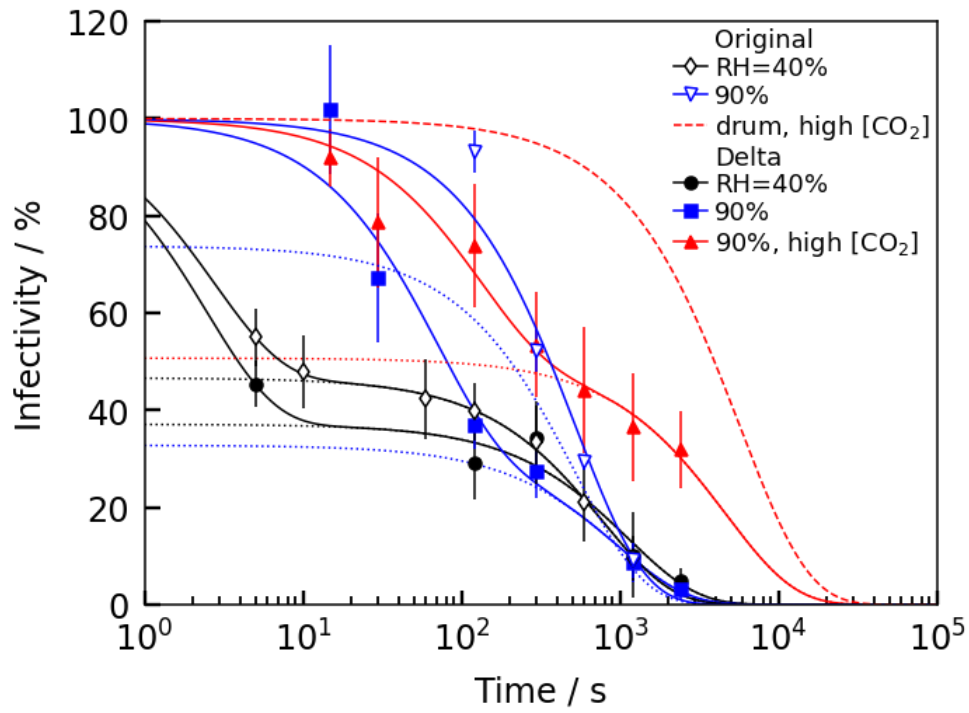
The solute composition of saliva between individuals may vary widely. Moreover, an individual's salivary [NaCl], as well as the ratio of NaCl to other solutes, may vary dramatically as a result of short-term events, such as oral stimulation ¹, or larger physiological changes, such as pregnancy ². The effect that altering the initial [NaCl] of the starting formulation on the short term aerostability is reported in Supplemental Figure 1.



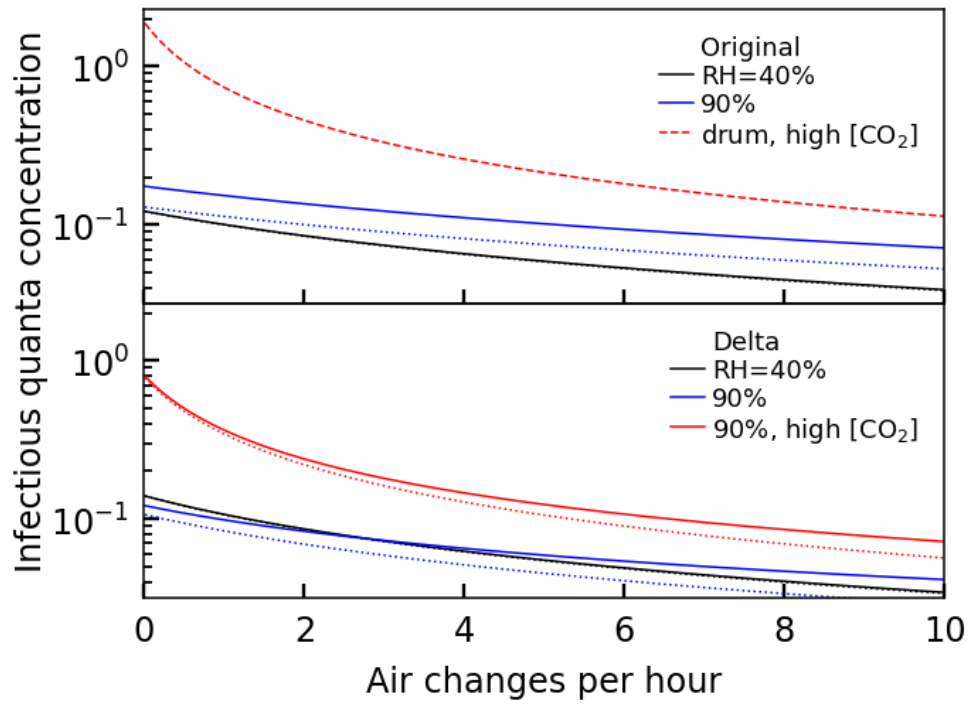
Supplemental Figure 1: Effect of NaCl concentration on (A) aerostability of SARS-CoV-2 across a range of RH and (B) droplet evaporation dynamics. (A) Infectivity of the Delta variant at 15 seconds as a function of relative humidity and the [NaCl] in the droplet. Error bars indicate the standard error. A two-way ANOVA of the data in indicated that [NaCl] had a significant effect ($P < 0.0001$), with no significant interaction between the RH and [NaCl]. (B) The evaporation profile of MEM droplets containing 2X the amount of NaCl when injected into an airflow where the RH was 69% measured with a comparative kinetic electrodynamic balance (CK-EDB) as described previously ³. Once the droplet becomes a non-spherical/non-homogeneous/amorphous solid, the droplet is no longer spherical and thus cannot be sized using Mie theory.

We previously reported that the fraction of SARS-CoV-2 in a particle that resides in the salt crystal following the efflorescence event is shielded and thus remains infectious. Accordingly, any observed increase in sustained infectivity below an RH of 50% can be attributed to the increase in the volume of the particle that forms a salt crystal. The same trend is observed in Supplemental Figure 1A: the addition of NaCl results in a significant increase in sustained aerostability at RHs below 50%. Between the RHs

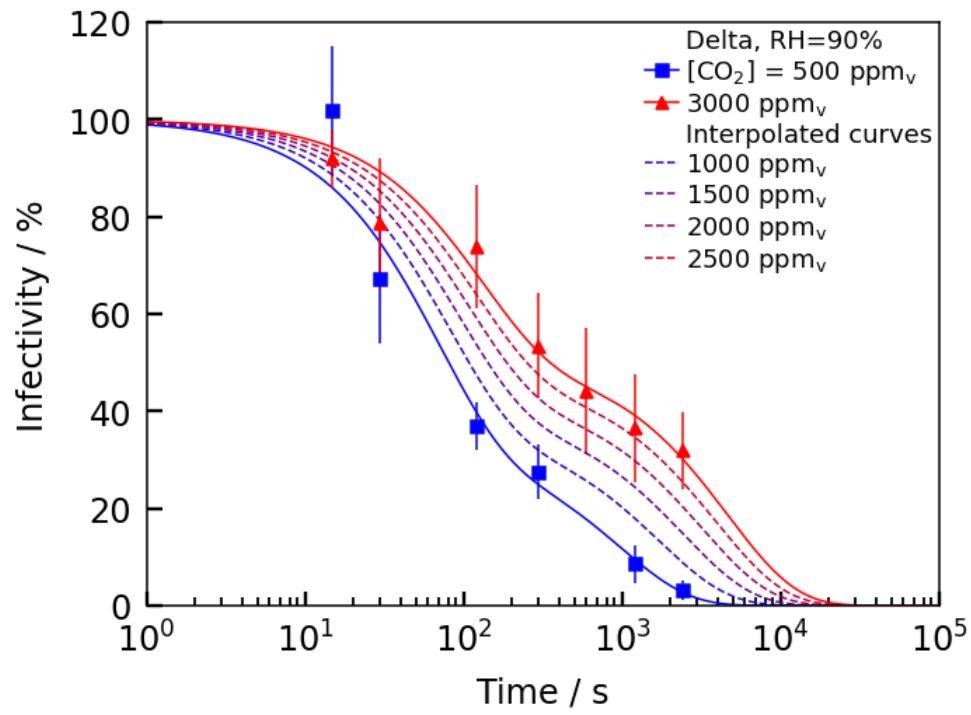
of 50% and 75%, we previously reported that the physical structures of MEM droplets is complex with phase structures across a population of droplets that are a mixture of a homogeneous liquid droplet form and liquid droplets containing a suspension (e.g. emulsion or salt crystals) ⁴. When the [NaCl] is doubled, all particles undergo a significant phase change when the RH is below ~75% (Supplemental Figure 1B). Accordingly, the crystalline form offers protection to the virus when the RH is below ~75% and this protection is more pronounced when the [NaCl] is doubled. Hence, the remaining fraction of infectious virus remains higher across all RHs below 75%. At 80% RH, no phase change is observed and the increase of [NaCl] has no effect on the viral aerostability.



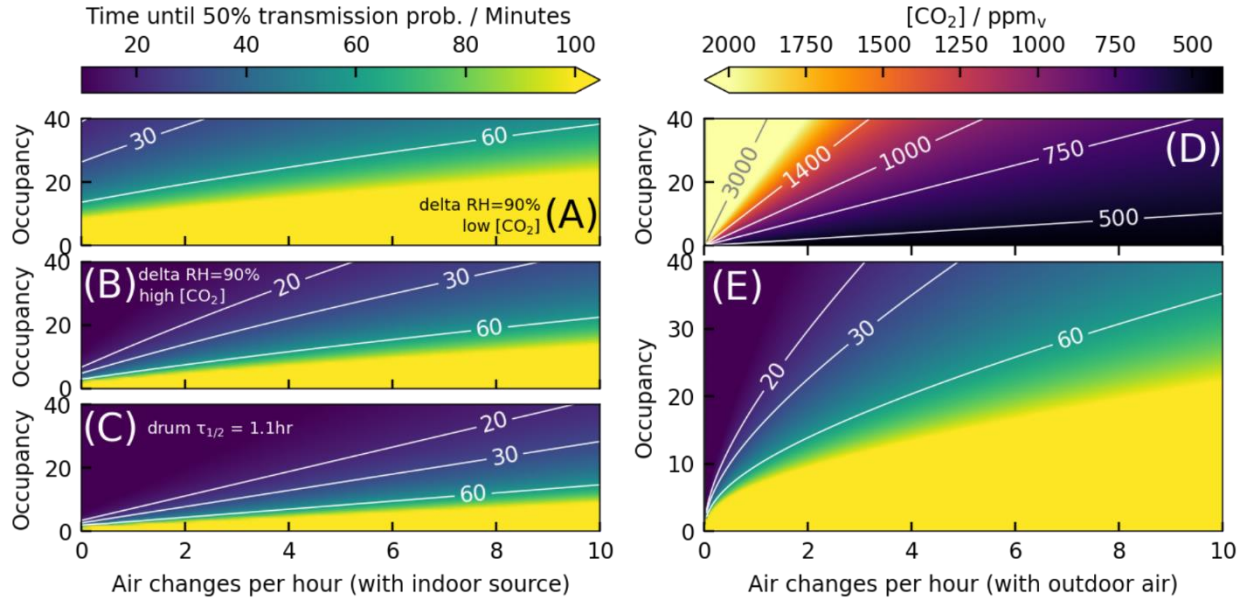
Supplemental Figure 2: Decay profile fits to the CELEBS infectivity data with two exponentially decaying functions, to capture the distinct short and long decays. We show the complete fits of the data from a two-step exponential decay (solid lines), and also just the longer time part of this fit (dotted lines). We show also the standard 1.1hr decay assumed in the literature from drum studies (dashed red).



Supplemental Figure 3: Concentration of infectious quanta in a 300m³ classroom using two-step decay fits to CELEBS data (solid lines) and just the longer time one-step decay (dotted lines). The incomplete latter fit captures the behavior very well at 40% RH, but deviates at 90% because the two-timescales in the complete fit are not neatly separated. We show also the standard 1.1hr decay assumed in the literature from drum studies (dashed red in top panel).



Supplemental Figure 4: Delta data fits (solid lines) and their crude linear interpolation across CO_2 concentration for illustration purposes (dotted lines).



Supplemental Figure 5: (A-C) Time until there is a 50% chance that at least one susceptible person will have become infected in an occupied classroom containing a single infected individual. We neglect the coupling between ventilation and [CO₂], instead using the fits to the data at fixed [CO₂], so this models air exchange with an interior source. (D) Variation in [CO₂] with occupancy and ventilation. (E) Sketch of how factoring in CO₂ changes the time using the linear interpolation shown in Supplemental Figure 4 for delta at 90% RH. This interpolation is purely intended to illustrate the nonlinear role of ventilation qualitatively, and so the numbers in (E) should not be taken literally. An infectious quanta production rate of 0.1s^{-1} is assumed in (A-C,E).

Fits of experimental data

For the Wells-Riley calculation, we fit each experimental dataset to a double exponential decay model which is more convenient for calculations. Specifically, we perform a least-squares fit of the infectivity to

$$I(t) = A \exp\left(\frac{-t}{\tau_1}\right) + (1 - A) \exp\left(\frac{-t}{\tau_2}\right)$$

where t is time, τ_1 and τ_2 are characteristic decay times, and A is a dimensionless factor representing the relative amplitude of each decay mode. The first term represents an initial short-time decay, whereas the second term represents slower decay at longer times. In Supplemental Figure 2 we show the results of fitting the raw data (solid lines) and just the slower decay at longer times (dotted lines) to show the relative size of the second mode.

Infectious quanta concentration

For the Wells-Riley calculations we must calculate the expected concentration of infectious quanta in the well-mixed environment. A droplet produced at some time Δt before the present will still be around and infectious with probability $p_{\text{active}} I$. The total number of droplets still around at time t is then obtained by integrating over all $\Delta t > 0$ i.e. over all the past. Writing α as the rate of production, we therefore find the concentration is:

$$c = \alpha \int_0^\infty p_{\text{active}}(\Delta t) I(\Delta t) d\Delta t$$

We show the result of this calculation in Supplemental Figure 3 for our assumed quanta production rate of $\alpha = 0.1\text{s}^{-1}$.

Varying CO₂

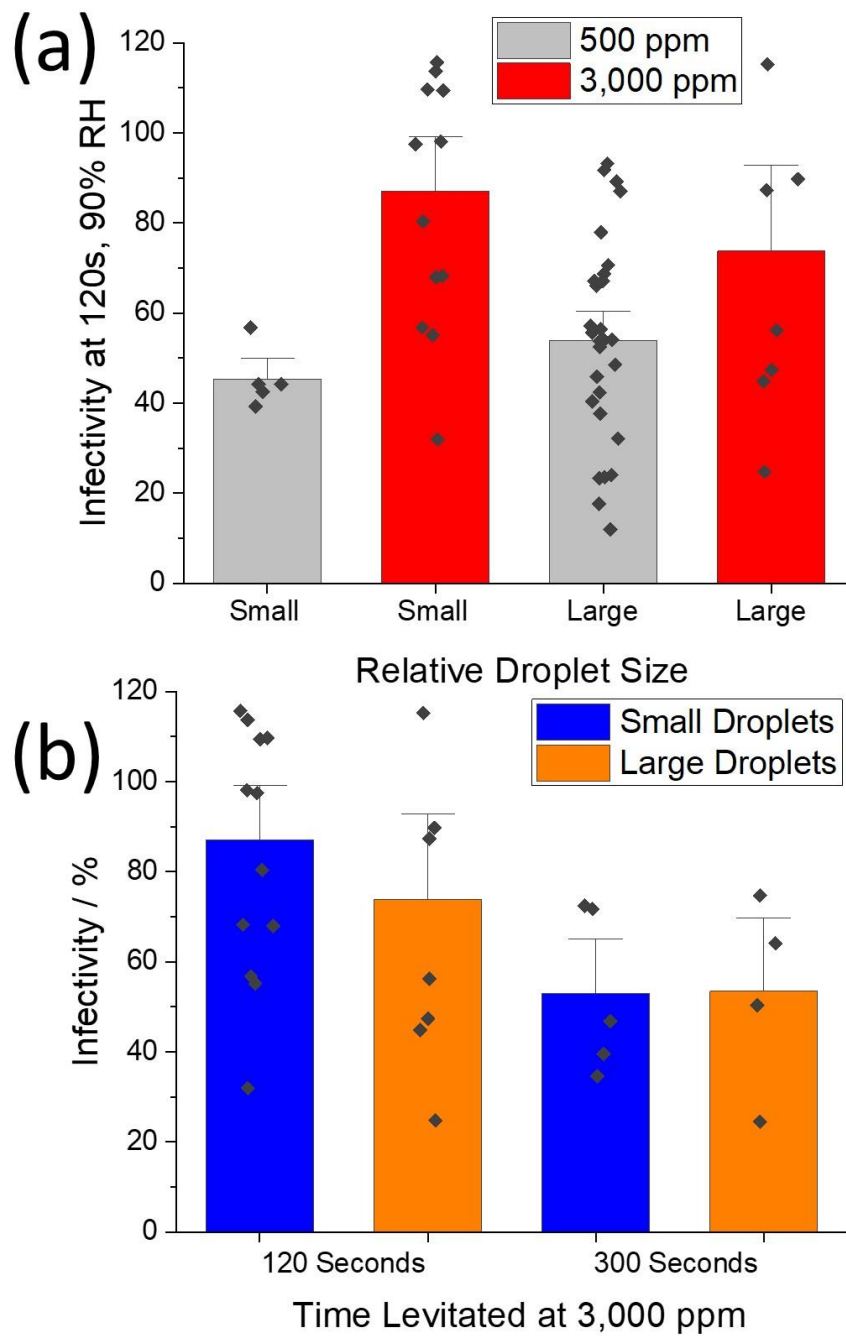
For the Delta variant at 90% relative humidity we have two datasets at CO₂ concentrations of 500ppm and 3000ppm. To obtain use data at intermediate concentrations for illustration purposes we interpolate the fit parameters (A, τ_1, τ_2) and insert them into the same fitting function. The results of this interpolation are shown in Supplemental Figure 4.

To estimate the CO₂ concentration in a room of N occupants at fixed volume, we again assume the air is well-mixed so the concentration is uniform and that the CO₂ produced by the occupants is constant. We take the average per-person CO₂ production rate typical of a high school classroom as $R=0.0065\text{l/s}$ [2]. The expected $[\text{CO}_2]$ is then

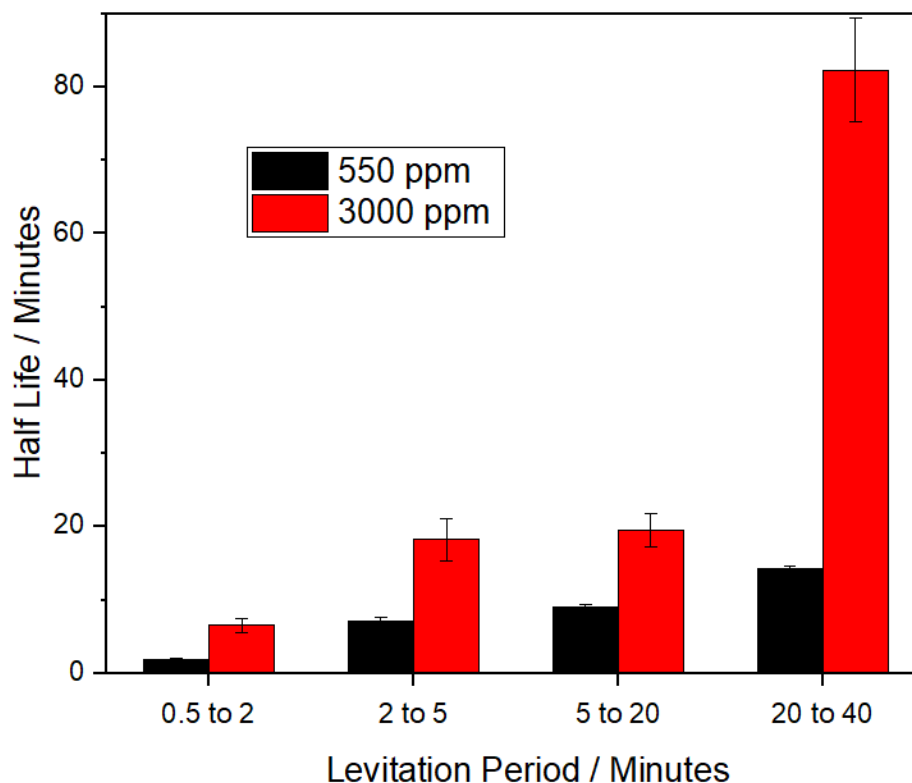
$$[\text{CO}_2] = [\text{CO}_2]_0 + N \frac{R}{Q}$$

where Q is the volumetric flow rate out of the room, and we take the background $[\text{CO}_2]_0$ as 420ppm for direct exchange with outdoor air. The resulting concentration for the 300m³ classroom with different occupancies and ventilation rates is shown in Supplemental Figure 5D.

Finally, we calculate the time until the risk of transmission reaches 50% for occupancies in the range of 0-40 at fixed $[\text{CO}_2]$ in Supplemental Figure 5A-C, and with varying $[\text{CO}_2]$ using the interpolations of Supplemental Figure 4 and the calculation above for the $[\text{CO}_2]$. These contour plots show the same data as in the main text but across the full range of occupancies.



Supplemental Figure 6: Effect of initial droplet size on the interplay between viral decay and elevated $[\text{CO}_{2(g)}]$. Based upon the viral titre per droplet, the initial volume of the "Small" droplets (0.6 infectious viral units per droplet) were approximately a quarter of the "Large" droplets (2.8 infectious viral units per droplet). (a) At 120s, increasing the $[\text{CO}_{2(g)}]$ was found to have a similar effect on both droplet sizes. $n = 54$ independent measurements. (b) Over time, the effect of the increased $[\text{CO}_{2(g)}]$ was found to be similar for both particle sizes. $n = 31$ independent measurements.



Supplemental Figure 7: Estimated half-life of SARS-CoV-2 as a function of the time range in which the decay rate is measured, and of the $[CO_2]$.

Supplemental References

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