Physical Parameters. The geometry of the indoor space is specified by its floor area $A$ and mean ceiling height $H$, from which volume $V = AH$ is calculated, along with appropriate unit conversions. The ventilation outflow rate $Q = V \lambda_a$ is calculated from the air exchange rate, or air changes per hour (ACH), $\lambda_a$. This critical input parameter is governed by national or local standards for different types of indoor spaces, such as the ASHRAE standards in the United States [1]. Typical values are tabulated online [2]. Natural ventilation may be approximated as $\lambda_a = 0.34/h$, which has been measured in bedrooms with closed windows [3] and is considered the minimum standard [1], although this value will vary with both location and quality of construction. Mechanical ventilation for residences, classrooms, and businesses usually falls in the range $\lambda_a = 4 - 8/h$. Crowded spaces, such as bars, nightclubs and restaurants, often require faster ventilation, $\lambda_a = 15 - 20/h$. Hospitals in the U.S. require $\lambda_a > 18/h$ [4]. Most laboratories have $\lambda_a = 6 - 12/h$, but those handling toxic or infectious materials may have $\lambda_a = 20 - 30/h$. Forced air filtration and droplet settling in ducts may also be included through the effective air filtration rate, $\lambda_f = p_f Q_f / V$, where $p_f(r)$ is droplet filtration probability, taken to be a constant over the aerosol size range, and $Q_f$ is the air recirculation flow rate passing through the filter. The U.S. Environmental Protection Agency defines high-efficiency particulate air (HEPA) filtration [5] as removing $p_f = 99.97\%$ of aerosol particles, while ordinary air filters are assigned Minimum Efficiency Reporting Value (MERV) ratings of 1–16 for $p_f > 20\%–90\%$ in specified aerosol size ranges [6]. For ventilation systems with indoor air recirculation, the primary outdoor air fraction, $Z_p = Q / (Q + Q_f)$, is usually specified by indoor air quality (IAQ) standards, e.g. $Z_p = 20\%$ for classrooms in the U.S. [7], where $Q + Q_f$ is the primary (total) flow rate and $(Q + Q_f)/A$ is the mean air velocity. Alternatively, air filtration may be accomplished by indoor free-standing units with a specified recirculation flow rate $Q_f$.

Physiological Parameters. The first physiological parameter is the volumetric breathing flow rate, $Q_b$, which is approximately 0.5 m$^3$/h for resting and light activity. Average values for healthy males and females have been reported as 0.49, 0.54, 1.38, 2.35, and 3.30 m$^3$/h for resting, standing, light exercise, moderate exercise and heavy exercise, respectively [8], and used in simulations of airborne transmission of COVID-19 [9]. The second physiological parameter is the mean respiratory aerosol droplet size $\bar{r}$ responsible for airborne disease transmission. The definition of $\bar{r}$ is given in the Eqs. (4) and (11) of the main text, in terms of the distribution of droplet sizes for different people and types of respiration [9–12], the size-dependent infectivity of aerosol droplets [13], and the settling and ventilation rates. However, a typical range for the most common and most infectious droplets is $\bar{r} = 2 - 3\mu$m. These values are roughly consistent with the standard definition of aerosol droplets in the literature, as those having $r < 5\mu$m [9].

Disease Parameters. The most important disease parameter is the infectiousness of exhaled air $C_q$ (infection quanta per volume), as is discussed extensively in the main text. Using all of the limited information available today, we estimate $C_q = 30$ q/m$^3$ for normal breathing and light activity and provide our best estimates of $C_q$ for different respiratory activities in the figure. Our analysis indicates that $C_q$ can be an order of magnitude larger for singing or heavy activity, or an
order of magnitude smaller for sleeping and light nasal breathing. The second disease parameter is the viral deactivation rate, $\lambda_v$, at which the virus loses infectiousness in aerosol form, which for SARS-CoV-2 has been estimated to lie in the range of zero [14] to 0.63/h [15]. The effective viral deactivation rates may be enhanced by ultraviolet radiation (UV-C) [16] or chemical disinfectants (e.g. $\text{H}_2\text{O}_2$, $\text{O}_3$) [17].

**Precautionary Parameters.** The first precautionary parameter is the mask filtration factor, $p_m$, equal to the fraction of infectious aerosol droplets that pass through during the assumed respiratory activity. Many studies are available to help assign this value for different types of face coverings, ranging from surgical masks to cloth coverings [19–22]. Although filtration efficiency depends on drop size, it is typically nearly constant in the aerosol range [19, 20]. Typical values for disposable medical masks are in the range $p_m = 1−5\%$ [20, 21], while for hybrid cloth face masks, $p_m = 10−20\%$ [22]. The second precautionary parameter is the disease transmission tolerance, $\varepsilon$. We note that $\varepsilon = 1$ corresponds to the baseline of one expected transmission during the occupancy period. The choice of $\varepsilon$ should take into account the vulnerability of the population, which for COVID-19 is a strong function of age and pre-existing medical conditions [23–25]. Relative to the median age of 69 in the Skagit Valley Chorale spreading incident, used to calibrate our model, the relative rate of hospitalization with COVID-19 [23] can be calculated as $p_h = 2.5\%$ (ages 0-4), 0.8% (ages 5-17), 20% (ages 18-49), 61% (ages 50-64), 130% (ages 75-84), and 145% (ages > 85). Any choice of $\varepsilon$ based on general transmission risk could, for example, be divided by $p_h$ to reflect the vulnerability of the population. For the elderly, especially those with pre-existing conditions, $\varepsilon \ll 1$ should be chosen. For the young and healthy, if hospitals are not overwhelmed and vulnerable groups are protected, larger values of $\varepsilon$ could be considered, in light of other priorities for children and their families [26]. Choosing a sufficiently small $\varepsilon$ will also mitigate against prolonged exposure to respiratory jets, whose contributions are significant in the absence of masks.

**Results.** The spreadsheet first computes properties of the infectious aerosol in the room,
which are primarily of technical interest: the effective droplet settling speed $v_s(\bar{r})$, the concentration relaxation rate $\lambda_c(\bar{r})$, the dilution factor, $f_d$, and the infectiousness of the ambient air, $f_d C_q$, in steady state per infected person in the room. The spreadsheet then computes the indoor safety guideline in two ways with the key results highlighted in green. First, the occupancy limit $N_{max}$ is calculated for a given indoor exposure time $\tau$, as is set by the typical residence time of persons in the space, or the time between testing and removal of any infected persons. The corresponding minimum outdoor airflow per person, $Q/N_{max}$, should be compared with local standards, such as 3.8 L/s/person for retail spaces and classrooms and 10 L/s/person for gyms and sports facilities [27]. Second, the time limit $\tau_{max}$ is calculated for a given indoor occupancy $N$. These bounds are plotted and may be compared to the Six-Foot Rule and 15-Minute Rule, both of which invariably violate our guideline. For each type of bound, $N_{max}$ and $\tau_{max}$, two results are reported: the transient bound, which accounts for the buildup of infectious aerosols in the air after the entrance of an infected person, and the more conservative steady-state bound, which is reached after the relaxation time $\lambda_c \tau \gg 1$.

**Contact Tracing.** The spreadsheet can also be used as a tool for contract tracing. Using a conservative tolerance, such as $\epsilon = 0.01$, which guards against airborne transmission, the guideline defines whether or not the $N$ occupants of a room visited by the index case for a time $\tau$ should be considered as contacts for the purpose of tracing the infection network. When the safety guideline holds, few if any of the occupants had sufficient time to be exposed to a significant transmission risk. If the guideline is violated, however, then all occupants of the room must be considered contacts, regardless of their distance from the index case or their time spent together in the room. Compared to the current CDC definition of contact [28] – spending more than 15 minutes less than 6 feet apart from an infected person – this definition based on airborne transmission would often identify many more potential contacts for tracing and quarantine, especially in cases of super-spreadling events, which invariably occur in indoors.


