## S2 Appendix. COVID-19 transmission model.

**S6 Fig. Compartmental model of COVID-19 transmission in a US city.** Each subgroup (defined by age and risk) is modeled with a separate set of compartments. Upon infection, susceptible individuals (S) progress to exposed (E) and then to either symptomatic infectious (IY) or asymptomatic infectious (IA). All asymptomatic cases eventually progress to a recovered class where they remain protected from future infection (R); symptomatic cases are either hospitalized (IH) or recover. Mortality (D) varies by age group and risk group and is assumed to be preceded by hospitalization.



**S7 Fig. Comparing the relationship between peak COVID-19 cases and peak isolation bed requirements per 100 PEH in March 2020 and in July 2020.** For both of these timepoints in the pandemic, we fit 700 total stochastic simulations (100 per each of the 7 scenarios) to a linear model. In July 2020, where p(infected|tested) increased to 19.67% and p(tested|infected) increased to 20%, we found the linear model is [](https://www.codecogs.com/eqnedit.php?latex=y%20%3D%203.949%20%5Ccdot%20x%20-%200.002#0), where where [](https://www.codecogs.com/eqnedit.php?latex=x#0) is peak number of COVID-10 cases per 100 PEH and [](https://www.codecogs.com/eqnedit.php?latex=y#0) is the peak bed requirement per 100 PEH (See Table S9 for regression table). This is roughly double the March 2020 model, [](https://www.codecogs.com/eqnedit.php?latex=y%20%3D%202.938%20%5Ccdot%20x%20-%200.001#0), where p(infected|tested) was 9.8% and p(tested|infected) was 10% (See Table S8 for regression table).



**S1 Table. Initial conditions, school closures and social distancing policies.**

|  |  |
| --- | --- |
| Variable | Settings |
| Initial day of simulation | 3/1/2020 |
| Initial infection number in locations | 5 symptomatic cases in 18-49y age group |
| Trigger to close school | 3/14/2020 |
| Closure Duration | Until start of 2020-2021 school year (8/17/20) |
| ɑ: Reduction of non-household contacts (work and other) | Five scenarios: [0, .25, 0.5, .75, 0.9] |
| Age-specific and day-specific contact rates  | Home, work, other and school matrices provided in Tables S4-S7 in Appendix 2.Normal weekday = home + work + other + schoolNormal weekend = home + otherNormal weekday holiday = home + other Normal weekday during summer or winter break = home + work + otherSchool closure weekday = home + (1-ɑ)\*(work + other)School closure weekend = home + (1-ɑ)\*(other)School closure weekday holiday = home + (1-ɑ)\*(other)School closure during summer or winter break = home + (1-ɑ)\*(work + other) |

**S2 Table. Model parameters. Values given as five-element vectors are age-stratified with values corresponding to 0-4, 5-17, 18-49, 50-64, 65+ year age groups, respectively.** aThe parameter $β$ is fitted through constrained trust-region optimization in SciPy/Python. Given a value of $β$, a deterministic simulation is run based on central values for each parameter, from which we can compute the implied $\overline{R}\_{0}\left(β\right)$. We (1) track the daily number of new cases $I\_{t}$(both symptomatic and asymptomatic) during the exponential growth portion of the epidemic, (2) compute the log of the number of new cases: $y\_{t}=log\left(I\_{t}\right)$ and (3) use least squares to fit a line to this curve: $loglog \left(I\_{t}\right) =y\_{0}+g⋅t$. We then estimate the reproduction number $\overline{R}\_{0}\left(β\right)$ of the simulation for that specific value of $β$ as $\overline{R\_{0}}\left(β\right)=Γ⋅g+$ 1 where $Γ$is the generation time given by $Γ=\frac{δ\left(R\_{0}-1\right)}{loglog \left(2\right) }$. The optimizing function runs until the resulting value of $\overline{R}\_{0}\left(β\right)$ does not get closer to the target value.

|  |  |  |  |
| --- | --- | --- | --- |
| Parameters | Best guess - values (doubling time = 7.2 days) | Best guess values(doubling time = 4 days) | Source |
| R0 | 2.2 | 2.2  | Li et al. [(2)](https://paperpile.com/c/WhMEE0/TcDn9) |
| $δ$: doubling time  | 7.2 days | 4 days | Kraemer et al. [(3)](https://paperpile.com/c/WhMEE0/TOsV7) |
| $β$: transmission rate  | 0.01622242 | 0.02599555 | Fitteda to obtain specified R0 given $δ$ |
| $γ^{A}$: recovery rate on asymptomatic compartment | Equal to $γ^{Y}$ |  |
| $γ^{Y}$: recovery rate on symptomatic non-treated compartment | $$\frac{1}{γ^{Y}}∼ Triangular\left(21.2,22.6,24.4\right)$$ | Verity et al. (4) |
| $τ$: symptomatic proportion (%) | 82.1 | Mizumoto et al. [(5)](https://paperpile.com/c/WhMEE0/7HmAY) |
| $σ$: exposed rate  | $$\frac{1}{σ}∼ Triangular\left(5.6,7,8.2\right)$$ | Lauer et al. [(6)](https://paperpile.com/c/WhMEE0/V6hPW) |
|  P: proportion of pre-symptomatic (%) | 12.6 | Du et al. (7) |
| $ω^{E}$: relative infectiousness of infectious individuals in compartment E | $$ω^{E}=\frac{\left(\frac{YHR}{η}+\frac{1-YHR}{γ^{Y}}\right)ω^{Y}σP}{1-P}$$ |  |
| $ω^{A}$: relative infectiousness of infectious individuals in compartment IA | 0.4653 | Set to mean of [Shape  Description automatically generated with medium confidence](https://www.codecogs.com/eqnedit.php?latex=%5Comega%5EE#0) |
| IFR: infected fatality ratio, age specific (%) | Overall: [0.0016, 0.0049, 0.084, 1.000, 3.371]Low risk: [0.00091668, 0.0021789, 0.03388, 0.25197, 0.64402]High risk: [0.009167, 0.02179, 0.33878, 2.5197, 6.4402] | Age adjusted from Verity et al. [(4)](https://paperpile.com/c/WhMEE0/ULIBS) |
| YFR: symptomatic fatality ratio, age specific (%) | Overall: [0.001949, 0.006025, 0.10265, 1.2182, 4.10657]Low risk: [0.0011165, 0.002654, 0.04126, 0.3069, 0.78443]High risk: [0.01117, 0.02654, 0.4126, 3.06903, 7.8443] | $$YFR=\frac{IFR}{1-τ}$$ |
| $h$: high-risk proportion, age specific (%) | [8.2825, 14.1121, 16.5298, 32.9912, 47.0568] | Estimated using 2015-2016 Behavioral Risk Factor Surveillance System (BRFSS) data with multilevel regression and poststratification using CDC’s list of conditions that may increase the risk of serious complications from influenza (8-10) |
| $rr$: relative risk for high risk people compared to low risk in their age group | 10 | Assumption |
| School calendars  | Austin Independent School District calendar (2019-2020, 2020-2021)  | [(11)](https://paperpile.com/c/WhMEE0/rsbiG) |

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**S3 Table. Hospitalization parameters.**

|  |  |  |
| --- | --- | --- |
| Parameters | Value | Source |
| $γ^{H}$: recovery rate in hospitalized compartment | 0.0869565 | 11.5 day-average from admission to discharge [(1)](https://paperpile.com/c/WhMEE0/rV2Gr) |
| YHR: symptomatic case hospitalization rate (%) | Overall: [ 0.04872107, 0.04872107, 3.28757227, 11.33739519, 17.73306336]Low risk: [0.0279, 0.0215, 1.3215, 2.8563, 3.3873]High risk: [ 0.2791, 0.2146, 13.2154, 28.5634, 33.8733] | Age adjusted from Verity et al. [(2)](https://paperpile.com/c/WhMEE0/ULIBS) |
| $π$: rate of symptomatic individuals go to hospital, age-specific | $$π=\frac{γ^{Y}⋅YHR}{η+\left(γ^{Y}-η\right)YHR}$$ |  |
| $η$: rate from symptom onset to hospitalized | 0.1695 | 5.9 day average from symptom onset to hospital admission Tindale et al. [(3)](https://paperpile.com/c/WhMEE0/8XAvC) |
| $μ$: rate from hospitalized to death | 0.0892857 | 11.2 day-average from admission to death [(1)](https://paperpile.com/c/WhMEE0/rV2Gr) |
| HFR: hospitalized fatality ratio, age specific (%) | [4, 12.365, 3.122, 10.745, 23.158] | $$HFR=\frac{IFR}{YHR\left(1-τ\right)}$$ |
| $ν$: death rate on hospitalized individuals, age specific | [0.0390, 0.1208, 0.0304, 0.1049, 0.2269] | $$ν=\frac{γ^{H}HFR}{μ+\left(γ^{H}-μ\right)HFR}$$ |
| ICU: proportion hospitalized people in ICU | [0.15, 0.20, 0.15, 0.20, 0.15] | CDC COVID-19 planning scenarios (based on US seasonal flu data) |
| Vent: proportion of individuals in ICU needing ventilation | [0.35, 0.3, 0.45, 0.5, 0.45] | CDC planning scenarios (based on US seasonal flu data) |
| $d\_{ICU}$: duration of stay in ICU | 8 days | Assumption, computed as average of hospital stay and ventilation durations |
| $d\_{V}$: duration of ventilation | 5 days | CDC COVID-19 planning scenarios |
| $HCS$: healthcare capacity | Hospital bed: 4299ICU bed: 755Ventilator: 755 | Estimates provided by each of the region's hospital systems and aggregated by regional public health leaders  |

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**S4 Table. Home contact matrix (daily number contacts by age group at home).**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 0-4y | 5-17y | 18-49y | 50-64y | 65y+ |
| 0-4y | 0.5 | 0.9 | 2.0 | 0.1 | 0.0 |
| 5-17y | 0.2 | 1.7 | 1.9 | 0.2 | 0.0 |
| 18-49y | 0.2 | 0.9 | 1.7 | 0.2 | 0.0 |
| 50-64y | 0.2 | 0.7 | 1.2 | 1.0 | 0.1 |
| 65y+ | 0.1 | 0.7 | 1.0 | 0.3 | 0.6 |

**S5 Table. School contact matrix (daily number contacts by age group at school).**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 0-4y | 5-17y | 18-49y | 50-64y | 65y+ |
| 0-4y | 1.0 | 0.5 | 0.4 | 0.1 | 0.0 |
| 5-17y | 0.2 | 3.7 | 0.9 | 0.1 | 0.0 |
| 18-49y | 0.0 | 0.7 | 0.8 | 0.0 | 0.0 |
| 50-64y | 0.1 | 0.8 | 0.5 | 0.1 | 0.0 |
| 65y+ | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |

**S6 Table. Work contact matrix (daily number contacts by age group at work).**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 0-4y | 5-17y | 18-49y | 50-64y | 65y+ |
| 0-4y | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| 5-17y | 0.0 | 0.1 | 0.4 | 0.0 | 0.0 |
| 18-49y | 0.0 | 0.2 | 4.5 | 0.8 | 0.0 |
| 50-64y | 0.0 | 0.1 | 2.8 | 0.9 | 0.0 |
| 65y+ | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 |

**S7 Table. Others contact matrix (daily number contacts by age group at other locations).**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | 0-4y | 5-17y | 18-49y | 50-64y | 65y+ |
| 0-4y | 0.7 | 0.7 | 1.8 | 0.6 | 0.3 |
| 5-17y | 0.2 | 2.6 | 2.1 | 0.4 | 0.2 |
| 18-49y | 0.1 | 0.7 | 3.3 | 0.6 | 0.2 |
| 50-64y | 0.1 | 0.3 | 2.2 | 1.1 | 0.4 |
| 65y+ | 0.0 | 0.2 | 1.3 | 0.8 | 0.6 |

**S8 Table. Regression table for linear model estimating peak bed requirement from peak COVID-19 incidence in PEH under parameters from March 2020.** Here we set p(tested | infected) as 10% and p(infected | tested) as 9.8%.

|  |  |  |
| --- | --- | --- |
| *Predictors* | *Estimates* | *95% CI* |
| (Intercept) | -0.001 | -0.002, -0.001 |
| Peak Incidence | 2.938 | 2.923, 2.954 |
| Observations  | 700 |  |
| R2 / R2 Adjusted | 0.995 / 0.995 |  |

**S9 Table. Regression table for linear model estimating peak bed requirement from peak COVID-19 incidence in PEH under parameters from July 2020.** Here we set p(tested | infected) as 20% and p(infected | tested) as 19.67%.

|  |  |  |
| --- | --- | --- |
| *Predictors* | *Estimates* | *95% CI* |
| (Intercept) | -0.002 | -0.002, -0.001 |
| Peak Incidence | 3.949 | 3.925, 3.973 |
| Observations  | 700 |  |
| R2 / R2 Adjusted | 0.993 / 0.993 |  |

**S10 Table. Comparing projected cumulative hospitalizations and peak daily COVID-19 hospital admissions to observed data from the City of Austin.**

|  |  |  |  |
| --- | --- | --- | --- |
| Duration of Intervention | Contact Reduction | Projected Cumulative Hospitalizations | Peak Daily COVID-19 Hospital Admissions |
| No Intervention | 0% | 76,246 (61,598 - 91,030) | 10,892 (8,800 - 13,004) |
| 4 Weeks | 50% | 75,393 (60,757 - 91,932) | 10,770 (8,680 - 13,133)  |
| 75% | 75,948 (61,223 - 91,129) | 10,850 (8,746 - 13,018) |
| 90% | 76,127 (60,684 - 91,696) | 10,875 (8,669 - 13,099)  |
| 4 Months | 50% | 68,984 (54,971 - 83,562) | 9,855 (7,853 - 11,937)  |
| 75% | 1,971 (1,223 - 3,532) | 282 (175 - 505) |
| 90% | 444 (265 - 774) | 63 (38 - 111)  |
| Observed Austin Data |  -- | 1,685 | 78 |