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# COVID-19 Healthcare Demand Projections: Austin, Texas

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# COVID-19 Healthcare Demand Projections: Austin, Texas

*Presented to the city of Austin on March 24, 2020*

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## Overview

To support planning by the city of Austin, we analyzed the Austin-Round Rock module of our *US COVID-19 Pandemic Model* to project the number of hospitalizations under four different social distancing scenarios. Note that the results presented herein are based on multiple assumptions about the transmission rate and age-specific severity of COVID-19. There is still much we do not understand about the transmission dynamics of this virus, including the extent of asymptomatic infection and transmission. We update our model inputs on a daily basis, as our understanding of the virus improves. These results do not represent the full range of uncertainty. Rather, they are meant to serve as plausible scenarios for gauging the likely impacts of social distancing measures in the Austin-Round Rock Metropolitan Area.

We are posting these results prior to peer review to provide intuition for both policy makers and the public regarding both the immediate threat of COVID-19 and the extent to which early social distancing measures can mitigate that threat. Our projections indicate that without extensive social distancing measures, the emerging outbreak will quickly surpass healthcare capacity in the region. Although these analyses are specific to the Austin-Round Rock metropolitan area, we expect that the impacts of the mitigation strategies will be qualitatively similar for cities throughout the US.

* Contributed equally

# COVID-19 projections for the five-county Austin-Round Rock MSA with school closures and social distancing

We used our *US COVID-19 Pandemic Model* to simulate COVID-19 epidemics in the Austin-Round Rock Metropolitan Area through mid-August, 2020, assuming the following initial conditions and key parameters:

- Starting condition: March 23, 2020 with 84 infected adults and 18 infected children
- Epidemic doubling time: 4 days
- Reproduction number: 2.2
- Average incubation period: 7.1 days
- Proportion of cases asymptomatic: 17.9%

All other model parameters, including age-specific hospitalization and fatality rates are provided in Appendix 1. The full structure and the Texas component of the US COVID-19 Pandemic Model are described in Appendix 2.

Table 1 and Figures 1-4 summarize results of COVID-19 simulations for the Austin-Round Rock MSA. Each simulation began on March 23 with 102 infectious COVID-19 cases and ended on August 17, 2020. The model structure and parameters are described in Appendix 1 and Appendix 2, below.

**Table 1. Estimated cumulative COVID-19 cases, hospitalizations, ICU cases, cases requiring mechanical ventilatory therapy, and deaths for the Austin-Round Rock MCA from March 23 through August 17, 2020.** The values are medians across 100 stochastic simulations based on the parameters given in Appendix 1.

| Outcomes | No measures | School closure | School closure + 50% social distancing | School closure + 75% social distancing | School closure + 90% social distancing |
|---|---|---|---|---|---|
| **Cases** | 1,765,147 | 1,758,960 | 1,562,949 | 689,107 | 132,415 |
| **Hospitalizations** | 87,501 | 86,069 | 61,388 | 18,056 | 3,254 |
| **ICU** | 14,659 | 14,419 | 10,307 | 3,040 | 548 |
| **Ventilators** | 9,773 | 9,613 | 6,871 | 2,026 | 365 |
| **Deaths** | 10,908 | 10,542 | 6,317 | 1,472 | 267 |

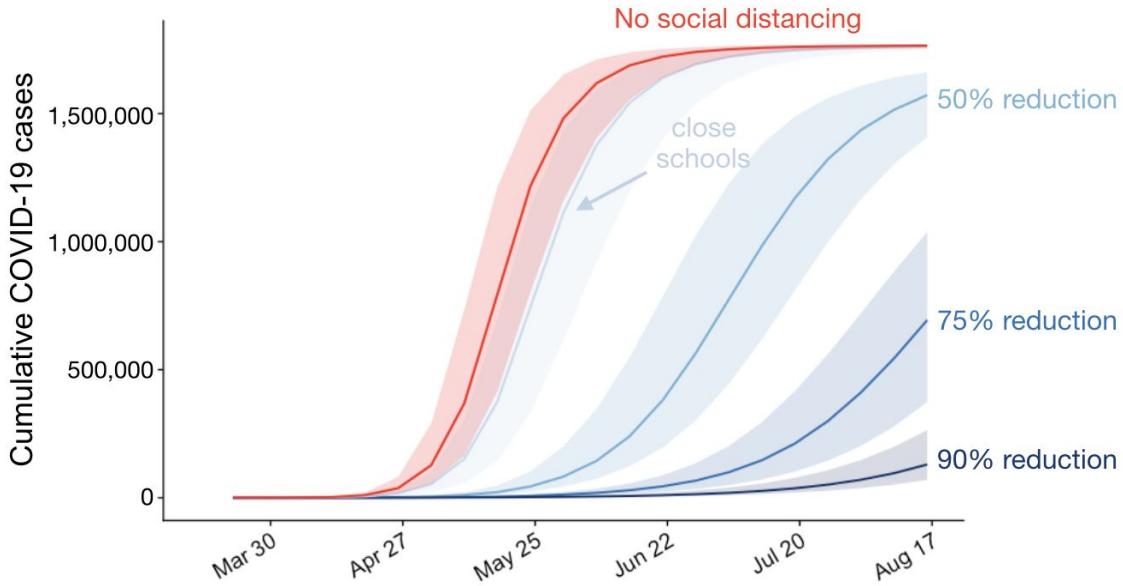


**Figure 1. Projected COVID-19 cases in the Austin-Round Rock MSA under school closures from March 23 to August 17, 2020 coupled with different degrees of social distancing.** The red line projects COVID-19 transmission assuming no interventions. The blue lines show increasing levels of social distancing interventions, from light to dark: school closures plus social distancing interventions that reduce non-household contacts by either 50%, 75% or 90%. Lines and shading indicate the median value and interquartile range across 100 stochastic simulations.

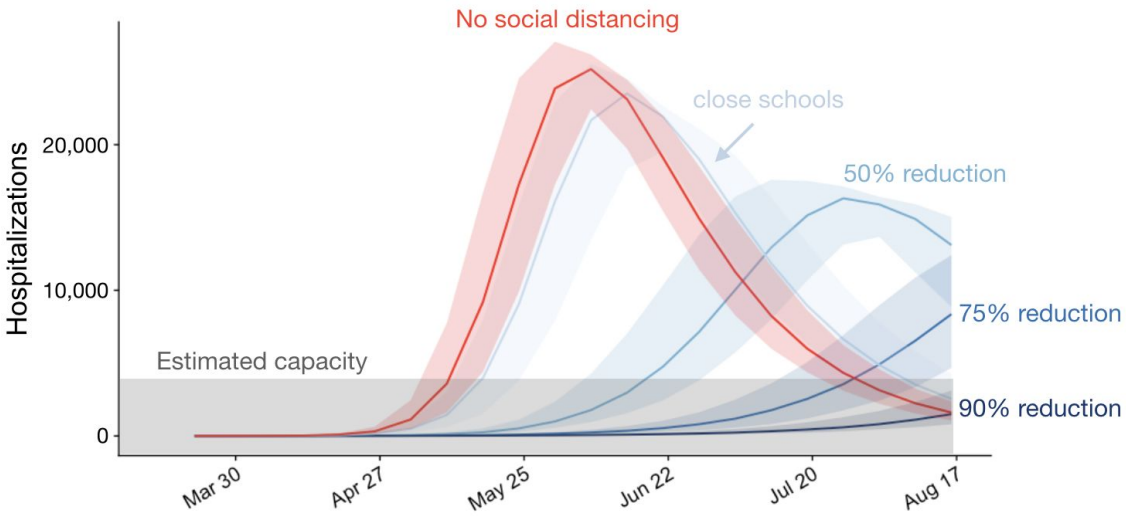


**Figure 2. Projected COVID-19 hospitalizations in the Austin-Round Rock MSA under school closures from March 23 to August 17, 2020 coupled with different degrees of social distancing.** The red line projects COVID-19 transmission assuming no interventions. The blue lines show increasing levels of social distancing interventions, from light to dark: school closures only or school closures plus social distancing interventions that reduce non-household contacts by either 50%, 75% or 90%. Lines and shading indicate the median value and interquartile range across 100 stochastic simulations. The estimated total daily hospital capacity in the Austin-Round Rock MSA for COVID-19 patients is 4000 beds.

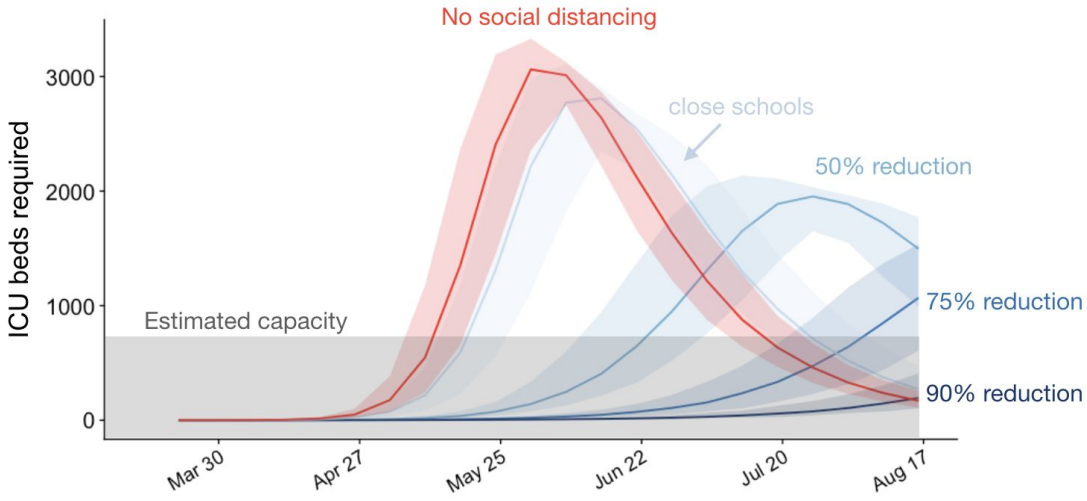


**Figure 3. Projected COVID-19 cases requiring ICU treatment in the Austin-Round Rock MSA under school closures from March 23 to August 17, 2020 coupled with different degrees of social distancing.** The red line projects COVID-19 transmission assuming no interventions. The blue lines show increasing levels of social distancing interventions, from light to dark: school closures only or school closures plus social distancing interventions that reduce non-household contacts by either 50%, 75% or 90%. Lines and shading indicate the median value and interquartile range across 100 stochastic simulations. The estimated total daily ICU capacity in the Austin-Round Rock MSA for COVID-19 patients is 750 beds.

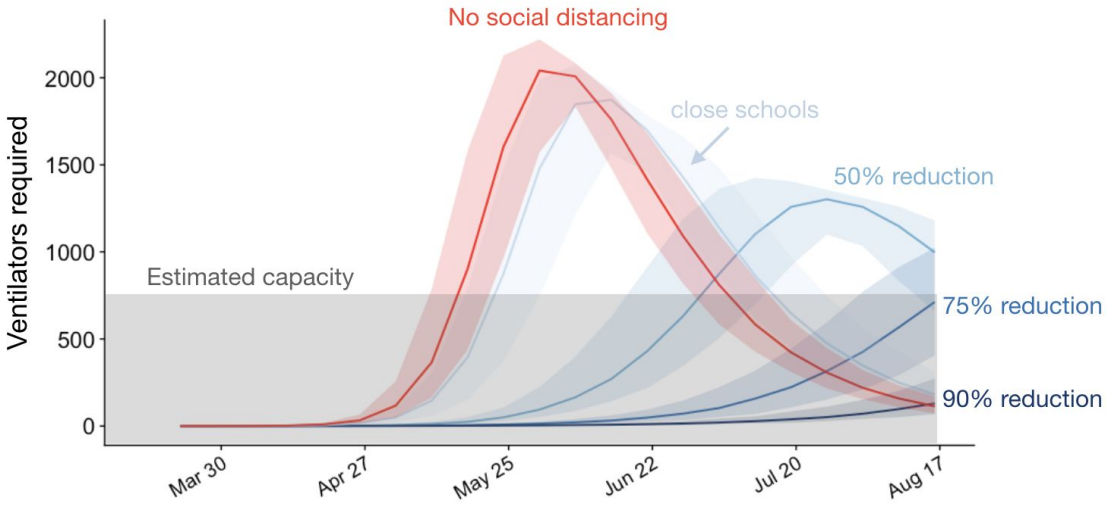


**Figure 4. Projected COVID-19 patients requiring mechanical ventilation in the Austin-Round Rock MSA under school closures from March 23 to August 17, 2020 coupled with different degrees of social distancing.** The red line projects COVID-19 transmission assuming no interventions. The blue lines show increasing levels of social distancing interventions, from light to dark: school closures only or school closures plus social distancing interventions that reduce non-household contacts by either 50%, 75% or 90%. Lines and shading indicate the median value and interquartile range across 100 stochastic simulations. The estimated total number of ventilators available in the Austin-Round Rock MSA for COVID-19 patients is 750.

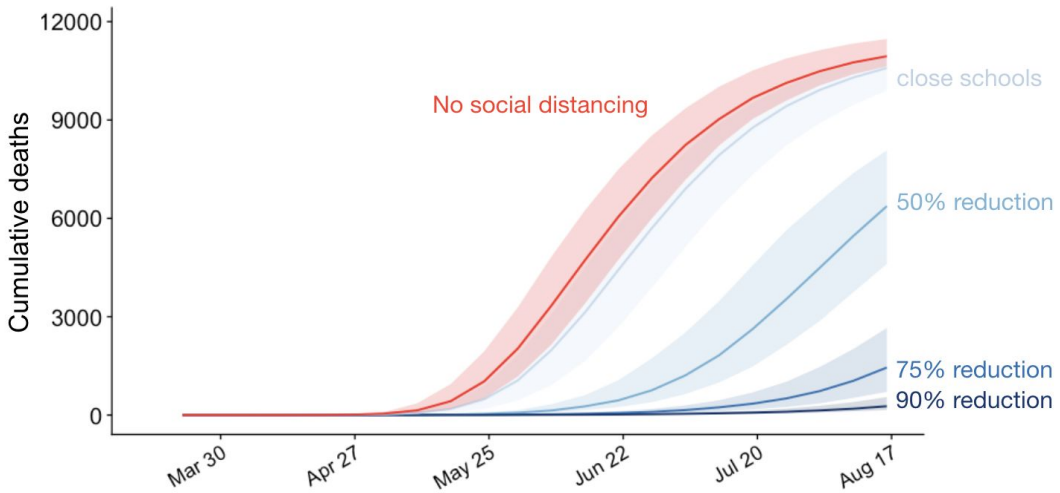


**Figure 5. Projected cumulative COVID-19 deaths in the Austin-Round Rock MSA under school closures from March 23 to August 17, 2020 coupled with different degrees of social distancing.** The red line projects COVID-19 transmission assuming no interventions. The blue lines show increasing levels of social distancing interventions, from light to dark: school closures only or school closures plus social distancing interventions that reduce non-household contacts by either 50%, 75% or 90%. Lines and shading indicate the median value and interquartile range across 100 stochastic simulations.

# Appendix 1

## Scenario specifications

**Table A1.1 Initial conditions, school closures and social distancing policies**

| Variable | Settings |
|---|---|
| Initial day of simulation | 3/23/2020 |
| Initial infection number in locations | 102 symptomatic cases distributed proportional to population in 5-year olds and older |
| Trigger to close school | 3/14/2020 |
| Closure Duration | Until start of 2020-2021 school year (8/17/20) |
| α: Reduction of non-household contacts (work and other) | Four scenarios: 0%, 50%, 75%, 90% |
| Age-specific and day-specific contact rates | Home, work, other and school matrices provided in Tables A.3-A.6<br><br>Normal weekday = home + work + other + school<br>Normal weekend = home + other<br>Normal weekday holiday = home + other<br><br>Social distancing weekday = home + (1-α)*(work + other)<br>Social distancing weekend = home + (1-α)*(other)<br>Social distancing weekday holiday = home + (1-α)*(other) |

**Table A1.2 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.

| Parameters | Best guess values | Source |
|---|---|---|
| $R_0$ | 2.2 | [1] |
| $\delta$: doubling time | 4 days | [2] |

| | | |
|---|---|---|
| $\Lambda$: growth rate | 0.1733 | $\Lambda = \frac{\ln(2)}{\delta}$ |
| Serial interval | 6.92 days | $\frac{R_0 - 1}{\Lambda}$ |
| $\beta$: transmission rate | 0.02599555 | Fitted to obtain specified $R_0$ given $\delta$ |
| $\gamma_A$: recovery rate on asymptomatic compartment | Equal to $\gamma_Y$ | |
| $\gamma_Y$: recovery rate on symptomatic non-treated compartment | $\frac{1}{\gamma_Y} \sim \text{Triangular}(21.2, 22.6, 24.4)$ | [3] |
| $\tau$: symptomatic proportion (%) | 82.1 | [4] |
| $\sigma$: exposed rate | $\frac{1}{\gamma_Y} \sim \text{Triangular}(21.1, 22.6, 24.4)$ | [5] |
| *P*: proportion of pre-symptomatic (%) | 12.6 | [6] |
| $\omega_E$: relative infectiousness of infectious individuals in compartment E | $\omega_E = \frac{(\frac{YHR}{\eta} + \frac{1-YHR}{\gamma_Y})\omega_Y \sigma P}{1-P}$ | |
| $\omega_A$: relative infectiousness of infectious individuals in compartment $I^A$ | 0.4653 | Set to mean of $\omega_E$ |
| *IFR*: infected fatality ratio, age specific (%) | Low risk: [0.0016, 0.0049, 0.084, 1.000, 3.371]<br>High risk: [0.0016, 0.0049, 0.084, 1.000, 3.371] | Age adjusted from [3] |

| | | |
|---|---|---|
| $h$: high-risk proportion, age specific (%) | [8.2825, 14.1121, 16.5298, 32.9912, 47.0568] | CDC |
| $rr$: relative risk for high risk people compared to low risk in their age group | 10 | Assumption |
| School calendar (2019-2020) | AISD | Published calendar of the Austin Independent School District |
| **Hospitalization Parameters** | | |
| $\gamma_H$: recovery rate in hospitalized compartment | 0.0714286 | 14-day average from admission to discharge. Assumption |
| *YHR*: symptomatic case hospitalization rate (%) | 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 [3] |
| $\pi$: rate of symptomatic individuals go to hospital, age-specific | $\pi = \frac{\gamma_Y * YHR}{\eta + (\gamma_Y - \eta)YHR}$ | |
| $\eta$: rate from symptom onset to hospitalized | 0.01695 | 5.9 day average from symptom onset to hospital admission [7] |
| $\mu$: rate from hospitalized to death | 0.0892857 | 11.2 day average from hospital admission to death [8] |
| *HFR*: hospitalized fatality ratio, age specific (%) | Low risk: [4, 12.365, 3.122, 10.745, 23.158] High risk: [4, 12.365, 3.122, 10.745, 23.158] | $HFR = \frac{IFR}{YHR(1-\tau)}$ $HFR_l = \frac{HFR}{1+(rr-1)*h}$ $HFR_h = rr * HFR_l$ |
| $\nu$: death rate on hospitalized | Low risk: [0.0390, 0.1208, 0.0304, 0.1049, 0.2269] | $\nu = \frac{\gamma_H HFR}{\mu + (\gamma_H - \mu)HFR}$ |

| | | |
|---|---|---|
| individuals, age specific | High risk: [0.0390, 0.1208, 0.0304, 0.1049, 0.2269] | |
| *ICU*: proportion hospitalized people in ICU | [0.15, 0.20, 0.15, 0.20, 0.15] | CDC planning scenarios (based on US seasonal flu data) |
| *Vent*: proportion of individuals in ICU needing ventilation | $[\frac{2}{3}, \frac{2}{3}, \frac{2}{3}, \frac{2}{3}, \frac{2}{3}]$ | Assumption |
| $d_{ICU}$ : duration of stay in ICU | 10 days | Assumption, set equal to duration of ventilation |
| $d_V$ : duration of ventilation | 10 days | Assumption |

**Table A1.3 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 |

**Table A1.4 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 |

**Table A1.5 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 |

**Table A1.6 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 |

# Appendix 2

## Model of COVID-19 Transmission in the Austin-Round Rock MSA

The model consists of the following components, with links to data tables:

- Population structure within Austin Round-Rock metropolitan area:
    - Population sizes of 5 distinct age groups within each node (0-4, 5-17, 18-49, 50-64, and 65+) based on 2017 American Community Survey 5-Year Data [9] (Figure A1.3).

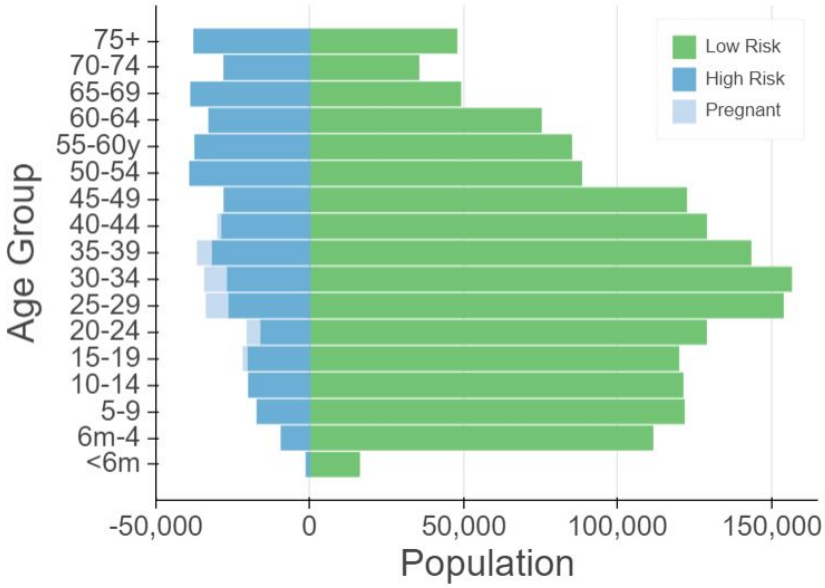


**Figure A1.3. Demographic and risk composition of the Austin-Round Rock population.** Bars indicate age-specific population sizes, separated by low risk, high risk, and pregnant. High risk is defined as individuals with cancer, chronic kidney disease, COPD, heart disease, stroke asthma, diabetes, HIV/AIDS, and morbid obesity, as estimated from the CDC 500 Cities Project [16], reported HIV prevalence [17] and reported morbid obesity prevalence [18,19], corrected for multiple conditions. The population of pregnant women is derived using the CDC's method combining fertility, abortion and fetal loss rates [20–22].

- School calendar: Assume published calendar for Austin Independent School District.

- Contact matrices (Tables A1.3-A1.6). Ref. [14] provides contact rates for the United States derived from population-based contact diaries in eight European

countries from the POLYMOD study [15]. The original POLYMOD data was used to estimate age and location specific contact patterns, which were then extrapolated to other countries based on the similarity to the original countries using demographic and household structure information, as well as school participation and workforce enrollment. The rates are broken down by age group (0-4, 5-9, 10-14, 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-75, 75+) and by type of contact (at home, work, school and other locations). Then each location specific contact matrix was aggregated into the 5 age groups used in our model, using US population in each of those age groups. We classify days into four categories and used these reported values to estimate the corresponding contact matrices as follows:

  - Weekdays when school is in session: All reported contacts
  - Weekdays during school holidays: All reported contacts except those occurring in school
  - Weekdays during social distancing: All reported contacts except those occurring in school and a specified fraction of those occurring outside of home.
  - Weekends: All reported contacts except those occurring in school and work.

- Epidemiological dynamics. Disease transmission within Austin-Round-Rock MSA is governed by an age- and risk-stratified SEIR model that incorporates the school calendar and implements school closures as changes to age-specific contact rates (Figure A2.2).
  - Subpopulations are defined by age group *a* and risk group *r*
  - Each subpopulation is split into epidemiological compartments: susceptible, exposed, asymptomatic, symptomatic, hospitalized, recovered, and deceased.

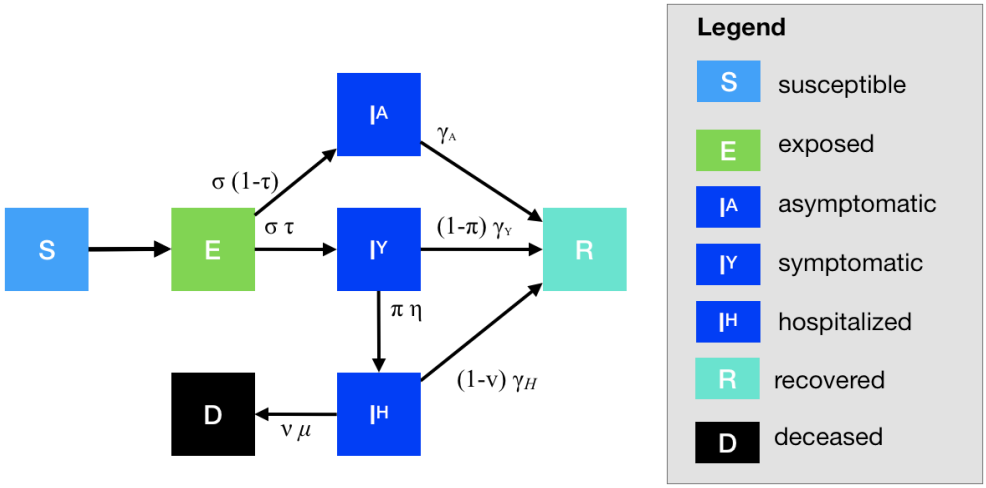


**Figure A2.2. Diagram of compartmental model of COVID-19 transmission within the Austin-Round Rock MSA.** Each subgroup (defined by age class and risk group) is modeled with a separate set of compartments. Upon infection, susceptible individuals (S) progress to exposed (E) where they are pre-symptomatic and possibly infectious and then to either symptomatic infectious ($I^Y$) or asymptomatic infectious ($I^A$). All asymptomatic cases eventually progress to a recovered class where they remain permanently protected from future infection (R); symptomatic cases are either hospitalized ($I^H$) or recover. Influenza mortality (D) varies by population subgroup and is assumed to be preceded by hospitalization. We model stochastic transitions between compartments using the $\tau$-leap method [80,81] with key parameters given in Appendix 1.

- Force of Infection.
  - The *within-node force of infection* for susceptible people in group of *i, a, r* is given by

$$\Upsilon_{i,a,r} = \sum_{g \in G} \sum_{k \in K} (E_{i,g,k}\omega_E + I^Y_{i,g,k}\omega_Y + I^A_{i,g,k}\omega_A)\beta_i \phi_{a,g} / N_{i,g}$$

    where *G* and *K* indicates all possible age groups and risk groups, respectively. All other variable and parameter symbols are defined in Table 2.1.

## Texas and US COVID-19 Pandemic Models

The Austin-Round Rock MSA COVID-19 model is one component of a national COVID-19 model built by the University of Texas at Austin which includes 217 metropolitan areas across the US. The model contains 22 metropolitan areas in Texas (Figure A2.3) that can be analyzed individually or at the state level.

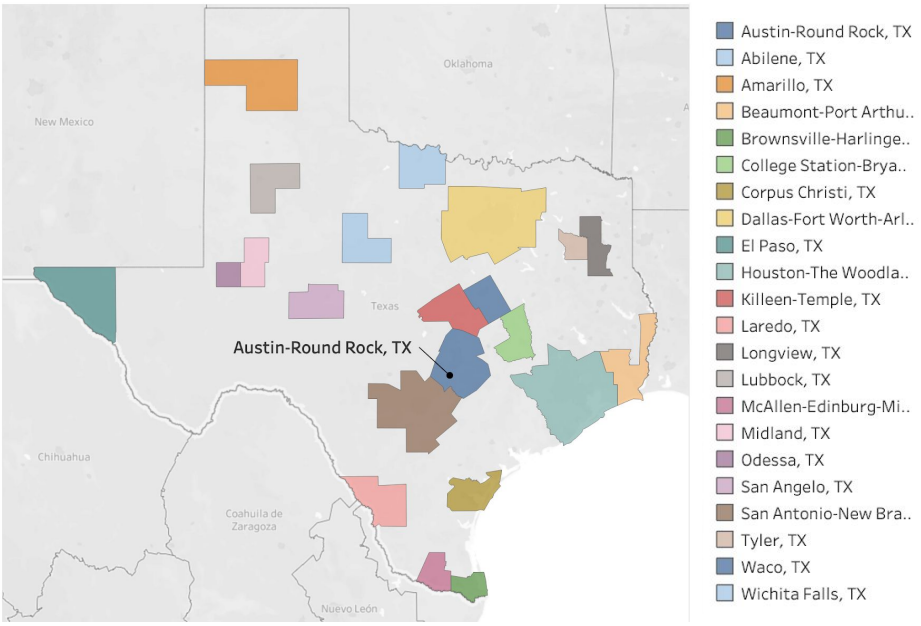


**Figure A2.3. Texas cities and metropolitan areas included in the US COVID-19 Pandemic Model.** The Austin-Round Rock module covers five counties: Bastrop, Caldwell, Hays, Travis, and Williamson and 57 cities/towns (Table A.1).

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