Health Risk Score of US Counties for COVID-19

Introduction

The COVID-19 pandemic has spread rapidly across the country, posing a great threat to health. However, not every county shares the same risks for the pandemic. This project aims to help us better understand which counties are prime targets for COVID-19. The script scores the US counties based on the health risk for COVID-19 and visualize the health risk. The health risk for COVID-19 is based on the demographic and social indicators that have a potential relationship with the infection of COVID-19. The counties with higher score experience higher risk of being hit severely by the pandemic.

Scoring Standards

Index

1. **Population Density Index**

   Many studies have identified the relationship between population density and the spread of pandemic. In theory, populated areas lead to more face-to-face interaction among residents, which makes them potential hotspots for the rapid spread of pandemics. Additionally, high population density makes social distancing difficult.

   - Population density: `POP2000 / AREA`

2. **Population Health Index**

   The statistics from CDC shows that the elderly, the teens, and the children are more likely to be impacted by COVID-19. The population in age groups of under 5, between 5 and 17, over 65 have higher risk of infecting with the virus. Additionally, research shows that racial and ethnic minorities are disproportionately affected by COVID-19. Black people, Hispanic people, and non-Hispanic American Indian or Alaska Native people have a COVID-19 hospitalization rate over 2.5 times that of non-Hispanic white people. The disparity in races reflects the underlying socioeconomic status. Many people of color have jobs that cannot be done remotely and involve interaction with the public, increasing exposure to the virus.

	Hospitalization[1]	Death[2]
0-4 years	4x lower	9x lower
5-17 years	9x lower	16x lower
18-29 years	Comparison Group	Comparison Group
30-39 years	2x higher	4x higher
40-49 years	3x higher	10x higher
50-64 years	4x higher	30x higher
65-74 years	5x higher	90x higher
75-84 years	8x higher	220x higher
85+ years	13x higher	630x higher

Figure 1. COVID-19 Hospitalization and Death by Age
Source: https://www.cdc.gov/coronavirus/2019-ncov/covid-data/investigations-discovery/hospitalization-death-by-age.html

Rate ratios compared to White, Non-Hispanic Persons	American Indian or Alaska Native, Non-Hispanic persons	Asian, Non-Hispanic persons	Black or African American, Non-Hispanic persons	Hispanic or Latino persons
Cases[1]	2.8x higher	1.1x higher	2.6x higher	2.8x higher
Hospitalization[2]	5.3x higher	1.3x higher	4.7x higher	4.6x higher
Death[3]	1.4x higher	No Increase	2.1x higher	1.1x higher

Figure 2. COVID-19 Hospitalization and Death by Race/Ethnicity
Source: https://www.cdc.gov/coronavirus/2019-ncov/covid-data/investigations-discovery/hospitalization-death-by-race-ethnicity.html

- The percentage of population the age over 65: `AGE_65_UP / POP2000`
- The percentage of population the age over 65: `AGE_5_17 / POP2000`
- The percentage of population the age under 5: `AGE_UNDER5 / POP2000`
- The percentage of racial and ethnic minorities: (`BLACK + AMERI_ES + ASIAN_PI + HISPANIC) / POP2000`

3. **Household Structure Index**
   Female households with children are more likely to have underlying health conditions.
   - The percentage of female household with children: `FHH_CHILD / HOUSEHOLDS`
4. **Living Density Index**
   Housing with 50 + units and attached houses have more residents living together, share living space, facilities and having interactions, which lead to higher risk of affected by COVID-19.
   - The percentage of housing with 50 + units: `UNITS50_UP`
   - The percentage of attached houses: `UNITS_1ATT`

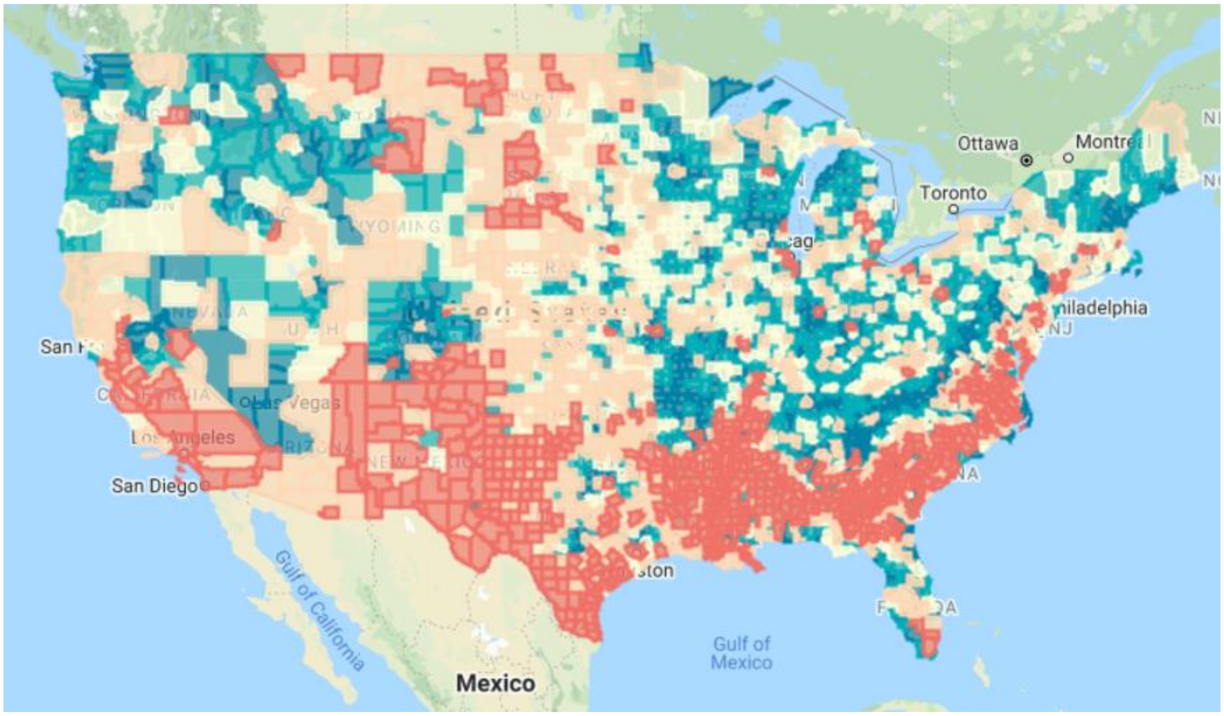
Weights of Index

Index	Weight Value	Indicator	Weight Value for Total Score (Weight Value for Sub-Index)
Population Density Index	0.25	Population density: `POP2000 / AREA`	0.25 (1)
Population Health Index	0.4	The percentage of population the age over 65: `AGE_65_UP / POP2000`	0.15 (0.375)
		The percentage of population the age over 65: `AGE_5_17 / POP2000`	0.1 (0.25)
		The percentage of population the age under 5: `AGE_UNDER5 / POP2000`	0.05 (0.125)
		The percentage of racial and ethnic minorities: (`BLACK + AMERI_ES + ASIAN_PI + HISPANIC) / POP2000`	0.2 (0.5)
Household Structure Index	0.1	The percentage of female household with children: `FHH_CHILD / HOUSEHOLDS`	0.1 (1)
Living Density Index	0.25	The percentage of housing with 50 + units: `UNITS50_UP`	0.15 (0.6)
		The percentage of attached houses: `UNITS_1ATT`	0.1 (0.4)

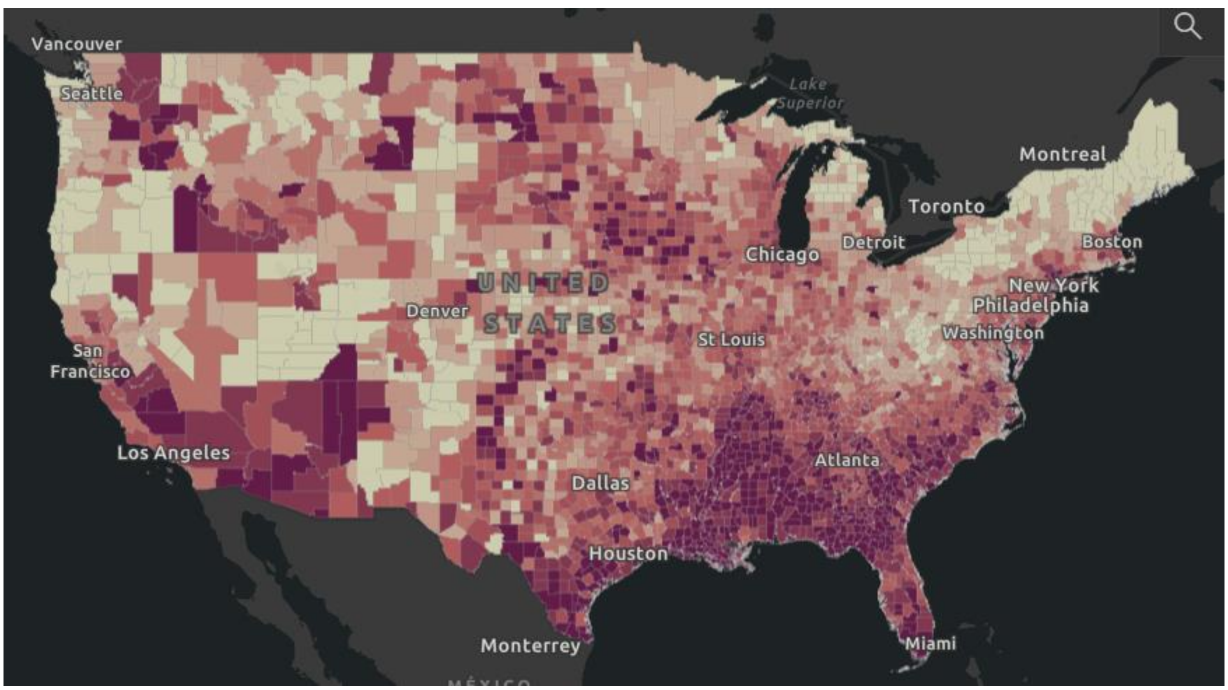
Result

Compared the Health Risk for COVID-19 map with the COVID-19 cases map.

Health Risk for COVID-19 by County



COVID-19 United States Cases by County



Source: https://coronavirus.jhu.edu/us-map

Overview

1. **Import the feature collection.**

```
// Import the dataset
var CountyFEATURES = ee.FeatureCollection("users/cdanatomlin/Counties");
print(CountyFEATURES);

// Add the layer to the map
Map.addLayer(CountyFEATURES, {color:'00b2ca'}, 'Counties');
Map.centerObject (CountyFEATURES, 4);
```

2. **Clean the dataset, remove all the null values in the columns.**

```
// Create a new dataset to remove the null value in original dataset
var CleanData = CountyFEATURES.filterMetadata('POP2000', 'not_equals', 'null')
.filterMetadata('AREA', 'not_equals', 'null').filterMetadata('AGE_UNDER5','not_eq
uals', 'null')
.filterMetadata('AGE_65_UP', 'not_equals', 'null').filterMetadata('AGE_5_17', 'no
t_equals', 'null')
.filterMetadata('AMERI_ES', 'not_equals', 'null').filterMetadata('BLACK', 'not_eq
uals', 'null')
.filterMetadata('ASIAN_PI', 'not_equals', 'null').filterMetadata('HISPANIC', 'not
_equals', 'null')
.filterMetadata('FHH_CHILD', 'not_equals', 'null').filterMetadata('HOUSEHOLDS', '
not_equals', 'null')
.filterMetadata('UNITS50_UP','not_equals', 'null').filterMetadata('UNITS_1ATT', '
not_equals', 'null');
```

3. **Create functions to calculate the indicator value for each county.**

```
// Calculate population density for each county
var pop_density = function(feature){
  var pop_density = ee.Number(feature.get('POP2000')).divide(feature.get('AREA'))
;
  return feature.set('pop_density', pop_density);
};
var CleanData = CleanData.map(pop_density);

// Calculate the percentage of population in age groups of under 5, between 5 and
 17, over 65
// Age under 5
var pct_age_under5 = function(feature){
  var pct_age_under5 = ee.Number(feature.get('AGE_UNDER5')).divide(feature.get('P
OP2000'));
  return feature.set('pct_age_under5', pct_age_under5); };
```

```
var CleanData = CleanData.map(pct_age_under5);

// Age between 5 to 17
var pct_age_517 = function(feature){
  var pct_age_517 = ee.Number(feature.get('AGE_5_17')).divide(feature.get('POP200
0'));
  return feature.set('pct_age_517', pct_age_517); };
var CleanData = CleanData.map(pct_age_517);

//Age over 65
var pct_age_over65 = function(feature){
  var pct_age_over65 = ee.Number(feature.get('AGE_65_UP')).divide(feature.get('PO
P2000'));
  return feature.set('pct_age_over65', pct_age_over65); };
var CleanData = CleanData.map(pct_age_over65);

// Calculate the percentage of racial and ethnic minorities
var pct_color = function(feature){
  var pct_color = ee.Number(feature.get('BLACK')).add(feature.get('AMERI_ES')).ad
d(feature.get('ASIAN_PI'))
  .add(feature.get('HISPANIC')).divide(feature.get('POP2000'));
  return feature.set('pct_color', pct_color); };
var CleanData = CleanData.map(pct_color);

// Calculate the percentage of female household with children
var pct_fmh = function(feature){
  var pct_fmh = ee.Number(feature.get('FHH_CHILD')).divide(feature.get('HOUSEHOLD
S'));
  return feature.set('pct_fmh', pct_fmh); };
var CleanData = CleanData.map(pct_fmh);
```

4. **Create a function to calculate the Population Density Index for each county.**

```
// Calculate the Population Density Index
var pop_density_score = function(feature){
  var Reducers1 = ee.Reducer.minMax();
  var ranges = CleanData.reduceColumns(Reducers1, ['pop_density']);
  var ScoreMin  = ee.Number(ranges.get('min'));
  var ScoreMax  = ee.Number(ranges.get('max'));
  var ran = ee.Number(ScoreMax.subtract(ScoreMin));
  var pop_density_score = ee.Number(feature.get('pop_density')).subtract(ScoreMin
).divide(ran).multiply(100);
  return feature.set('PopDensityScore', pop_density_score);
};
var Score = CleanData.map(pop_density_score);
```

5. **Create functions to calculate the health score of population in different age groups and ethnic minorities for each county.**

```
// Calculate the Population Health Index
// Calculate the health score for the population of age under 5
var under5_health_score = function(feature){
  var Reducers1 = ee.Reducer.minMax();
  var ranges = CleanData.reduceColumns(Reducers1, ['pct_age_under5']);
  var ScoreMin  = ee.Number(ranges.get('min'));
  var ScoreMax  = ee.Number(ranges.get('max'));
  var ran = ee.Number(ScoreMax.subtract(ScoreMin));
  var under5_health_score = ee.Number(feature.get('pct_age_under5')).subtract(Sco
reMin).divide(ran).multiply(100);
  return feature.set('under5_health_score', under5_health_score);
};
var Score = Score.map(under5_health_score);

// Calculate the health score for the population of age between 5 and 17
var a517_health_score = function(feature){
  var Reducers1 = ee.Reducer.minMax();
  var ranges = CleanData.reduceColumns(Reducers1, ['pct_age_517']);
  var ScoreMin  = ee.Number(ranges.get('min'));
  var ScoreMax  = ee.Number(ranges.get('max'));
  var ran = ee.Number(ScoreMax.subtract(ScoreMin));
  var a517_health_score = ee.Number(feature.get('pct_age_517')).subtract(ScoreMin
).divide(ran).multiply(100);
  return feature.set('a517_health_score', a517_health_score);
};
var Score = Score.map(a517_health_score);

// Calculate the health score for the population of age over 65
var over65_health_score = function(feature){
  var Reducers1 = ee.Reducer.minMax();
  var ranges = CleanData.reduceColumns(Reducers1, ['pct_age_over65']);
  var ScoreMin  = ee.Number(ranges.get('min'));
  var ScoreMax  = ee.Number(ranges.get('max'));
  var ran = ee.Number(ScoreMax.subtract(ScoreMin));
  var over65_health_score = ee.Number(feature.get('pct_age_over65')).subtract(Sco
reMin).divide(ran).multiply(100);
  return feature.set('over65_health_score', over65_health_score);
};
var Score = Score.map(over65_health_score);

// Calculate the health score for racial and ethnic minorities
var color_score = function(feature){
```

```
  var Reducers1 = ee.Reducer.minMax();
  var ranges = CleanData.reduceColumns(Reducers1, ['pct_color']);
  var ScoreMin  = ee.Number(ranges.get('min'));
  var ScoreMax  = ee.Number(ranges.get('max'));
  var ran = ee.Number(ScoreMax.subtract(ScoreMin));
  var color_score = ee.Number(feature.get('pct_color')).subtract(ScoreMin).divide
(ran).multiply(100);
  return feature.set('color_score', color_score);
};
var Score = Score.map(color_score);
```

6. **Create a function to calculate the Population Health Index by adding the health score of population in different age groups and ethnic minorities based on their weights.**

```
// Scoring Population Health Index
var PopHealthScore = function(feature){
  var W_AU5_Score = ee.Number(feature.get('under5_health_score')).multiply(0.125)
;
  var W_A517_Score = ee.Number(feature.get('a517_health_score')).multiply(0.25);
  var W_AO65_Score = ee.Number(feature.get('over65_health_score')).multiply(0.375
);
  var W_Color_Score = ee.Number(feature.get('color_score')).multiply(0.5);
  var PopHealthScore = W_AU5_Score.add(W_A517_Score).add(W_AO65_Score).add(W_Colo
r_Score);
  return feature.set('PopHealthScore', PopHealthScore);
};
var Score = Score.map(PopHealthScore)
```

7. **Create a function to calculate the Household Structure Index for each county.**

```
// Calculate the Household Structure Index
var fmh_score = function(feature){
  var Reducers1 = ee.Reducer.minMax();
  var ranges = CleanData.reduceColumns(Reducers1, ['pct_fmh']);
  var ScoreMin  = ee.Number(ranges.get('min'));
  var ScoreMax  = ee.Number(ranges.get('max'));
  var ran = ee.Number(ScoreMax.subtract(ScoreMin));
  var fmh_score = ee.Number(feature.get('pct_fmh')).subtract(ScoreMin).divide(ran
).multiply(100);
  return feature.set('HouseholdStructureScore', fmh_score);
};
var Score = Score.map(fmh_score);
```

8. **Create functions to calculate the living density score based on the percentage of housing with 50 + units and the percentage of attached houses for each county.**

```
// Calculate the Living Density Index
// Calculate the living density score using the percentage of housing with 50 + u
nits
var housing_unit_score = function(feature){
  var Reducers1 = ee.Reducer.minMax();
  var ranges = CleanData.reduceColumns(Reducers1, ['UNITS50_UP']);
  var ScoreMin  = ee.Number(ranges.get('min'));
  var ScoreMax  = ee.Number(ranges.get('max'));
  var ran = ee.Number(ScoreMax.subtract(ScoreMin));
  var housing_unit_score = ee.Number(feature.get('UNITS50_UP')).subtract(ScoreMin
).divide(ran).multiply(100);
  return feature.set('housing_unit_score', housing_unit_score);
};
var Score = Score.map(housing_unit_score);

// Calculate the living density score using the percentage of attached houses
var atthousing_score = function(feature){
  var Reducers1 = ee.Reducer.minMax();
  var ranges = CleanData.reduceColumns(Reducers1, ['UNITS_1ATT']);
  var ScoreMin  = ee.Number(ranges.get('min'));
  var ScoreMax  = ee.Number(ranges.get('max'));
  var ran = ee.Number(ScoreMax.subtract(ScoreMin));
  var atthousing_score = ee.Number(feature.get('UNITS_1ATT')).subtract(ScoreMin).
divide(ran).multiply(100);
  return feature.set('atthousing_score', atthousing_score);
};
var Score = Score.map(atthousing_score);
```

9. **Create a function to calculate the Living Density Index by adding the living density score of housing unit and housing structure based on their weights.**

```
// Scoring Population Health Index
var LivingDensityScore = function(feature){
  var W_HU_Score = ee.Number(feature.get('housing_unit_score')).multiply(0.6);
  var W_AH_Score = ee.Number(feature.get('atthousing_score')).multiply(0.4);
  var LivingDensityScore = W_HU_Score.add(W_AH_Score);
  return feature.set('LivingDensityScore', LivingDensityScore);
};
var Score = Score.map(LivingDensityScore);
```

10. Calculate the COVID-19 Risk Score for each county.

```
// Calculate the Health Risk Score for COVID-19 using the weight value
var CovidRiskScore = function(feature){
  var W_PopDensityScore = ee.Number(feature.get('PopDensityScore')).multiply(0.25
);
  var W_PopHealthScore = ee.Number(feature.get('PopHealthScore')).multiply(0.4);
  var W_HouseholdStructureScore = ee.Number(feature.get('HouseholdStructureScore'
)).multiply(0.1);
  var W_LivingDensityScore = ee.Number(feature.get('LivingDensityScore')).multipl
y(0.25);
  var CovidRiskScore = W_PopDensityScore.add(W_PopHealthScore).add(W_HouseholdStr
uctureScore).add(W_LivingDensityScore)
  return feature.set('CovidRiskScore', CovidRiskScore);
};
var Score = Score.map(CovidRiskScore);
```

11. Normalize the COVID-19 Risk Score to 0 to 100.

```
// Normalize the Covid Risk Score to 0 to 100
var FinalScore = function(feature){
  var Reducers1 = ee.Reducer.minMax();
  var ranges = Score.reduceColumns(Reducers1, ['CovidRiskScore']);
  var ScoreMin  = ee.Number(ranges.get('min'));
  var ScoreMax  = ee.Number(ranges.get('max'));
  var ran = ee.Number(ScoreMax.subtract(ScoreMin));
  var FinalScore = ee.Number(feature.get('CovidRiskScore')).subtract(ScoreMin).di
vide(ran).multiply(100);
  return feature.set('FinalScore', FinalScore);
};
var Score = Score.map(FinalScore);
```

12. Visualize the COVID-19 Risk Score by percentile.

```
// Visualize the Health Risk for COVID-19
// Calculate the average score and scores at 20%, 40%, 60%, and 80% percentile of
 the whole score
var ReducerMean = ee.Reducer.mean( );
var mean = Score.reduceColumns( ReducerMean, ['FinalScore'] );
print(mean)

var ReducerPct    = ee.Reducer.percentile([20, 40, 60, 80] );
var Percentile = Score.reduceColumns( ReducerPct, ['FinalScore'] );
print(Percentile)
```

The ranges, mean and scores at 20%, 40%, 60%, 80% percentile

```
▾Object (2 properties)
   max: 100
   min: 0
```

```
▾Object (1 property)
   mean: 16.78539432838391
```

```
▾Object (4 properties)
   p20: 11.780254090729143
   p40: 13.740008042344725
   p60: 15.74620812466176
   p80: 21.250777583976713
```

```
// Set Percentile and visualize the risk score
var pct20 = Score.filterMetadata('FinalScore', 'not_greater_than', 11.780254090729143)
Map.addLayer(pct20, {color:'0081a7'}, '0% - 20% COVID-19 Risk Score' )

var pct40 = Score.filterMetadata('FinalScore', 'greater_than', 11.780254090729143)
var pct40 = pct40.filterMetadata('FinalScore', 'not_greater_than', 13.740008042344725)
Map.addLayer(pct40, {color:'00afb9'}, '20% - 40% COVID-19 Risk Score' )

var pct60 = Score.filterMetadata('FinalScore', 'greater_than', 13.740008042344725)
var pct60 = pct60.filterMetadata('FinalScore', 'not_greater_than', 15.74620812466176)
Map.addLayer(pct60, {color:'fdfcdc'}, '40% - 60% COVID-19 Risk Score' )

var pct80 = Score.filterMetadata('FinalScore', 'greater_than', 15.74620812466176)

var pct80 = pct80.filterMetadata('FinalScore', 'not_greater_than', 21.250777583976713)
Map.addLayer(pct80, {color:'fed9b7'}, '60% - 80% COVID-19 Risk Score' )

var pct80 = Score.filterMetadata('FinalScore', 'greater_than', 21.250777583976713)
Map.addLayer(pct80, {color:'f07167'}, '80% - 100% COVID-19 Risk Score' )
```

The Code Link

https://code.earthengine.google.com/13c8ef49c8678e510c0df4a632d9e331

Reference

Emsi County Health Risk Index: https://www.economicmodeling.com/2020/06/04/county-health-risk-index/

COVID-19 Hospitalization and Death by Age: https://www.cdc.gov/coronavirus/2019-ncov/covid-data/investigations-discovery/hospitalization-death-by-age.html

COVID-19 Hospitalization and Death by Race/Ethnicity: https://www.cdc.gov/coronavirus/2019-ncov/covid-data/investigations-discovery/hospitalization-death-by-race-ethnicity.html

Does Density Aggravate the COVID-19 Pandemic?: https://www.tandfonline.com/doi/full/10.1080/01944363.2020.1777891

COVID-19 United States Cases by County: https://coronavirus.jhu.edu/us-map