Infectious Disease Outbreaks and Human Migration: A Network Analysis

More New People Bring More Influenza Cases

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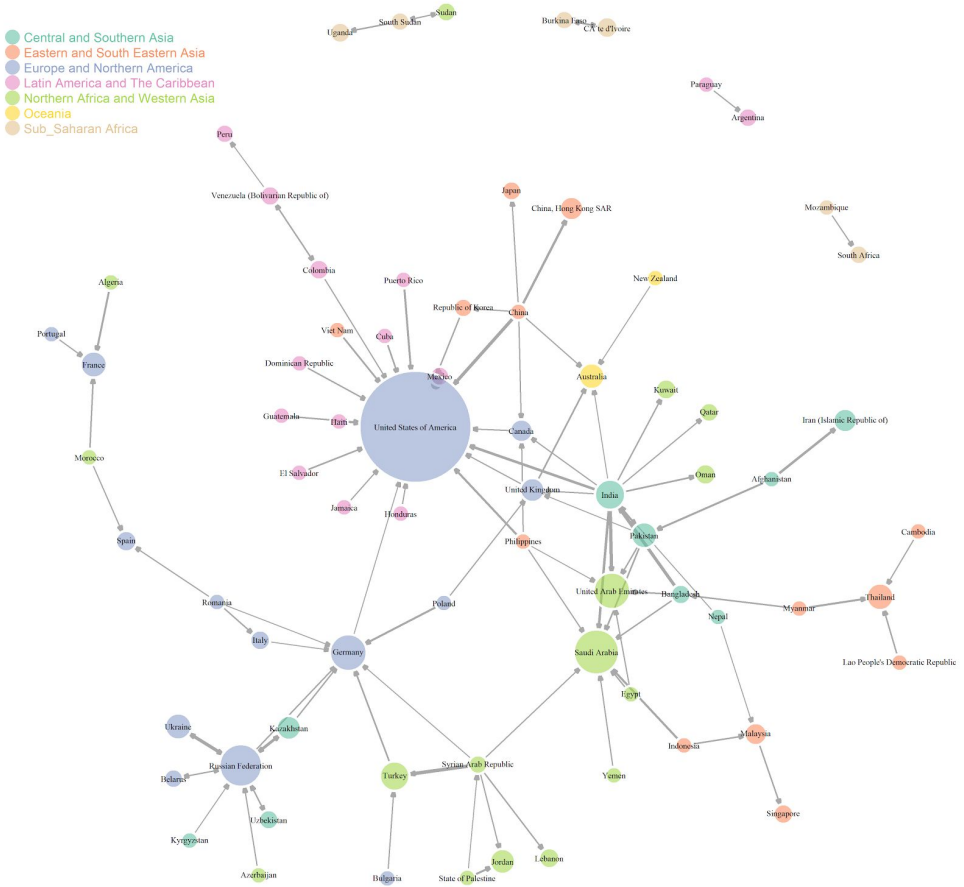
Network Data Science



Top 100 Migration Corridors in 2019

Note: This plot uses only migration flow data.

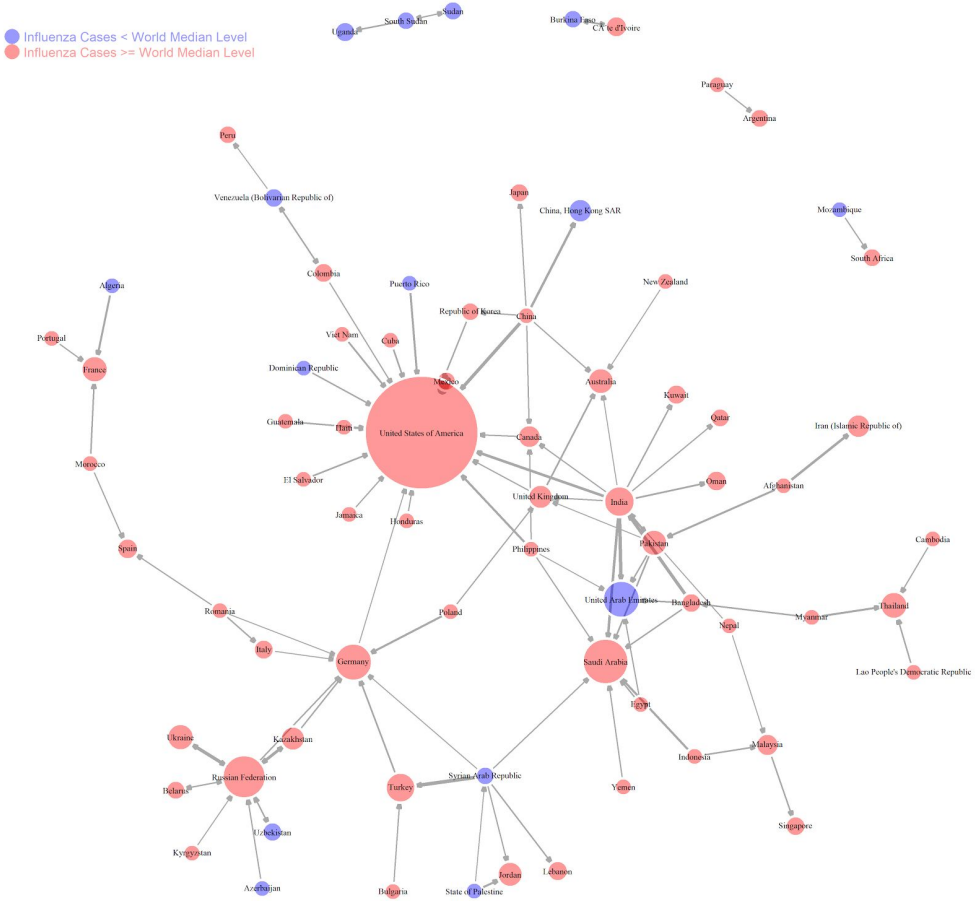
The total number of new immigrants from these top 100 migration corridors accounts for approximately 50% of the entire migration population in 2019.

Link: migration corridor (top 100 migration corridors)
Link Width: total number of new immigrants of the corresponding migration corridor

Node: country or area in the world (74 countries)
Node Size: total number of new immigrants to a country from the connecting migration corridors displayed in this graph
Node Color: region in the world (7 regions, see legend)

The top five in-flow migration hubs are: US, Saudi Arabia, Russia, Germany, and United Arab Emirates (UAE); The top five out-flow migration hubs are: India, Mexico, Russia, China, and Syrian Arab Republic.

Geographical closeness among countries and areas in the world retained in this new network.



Top 100 Migration Corridors and Influenza Big Countries

Note: This plot brings in influenza data. Influenza data is present in the form of colors.

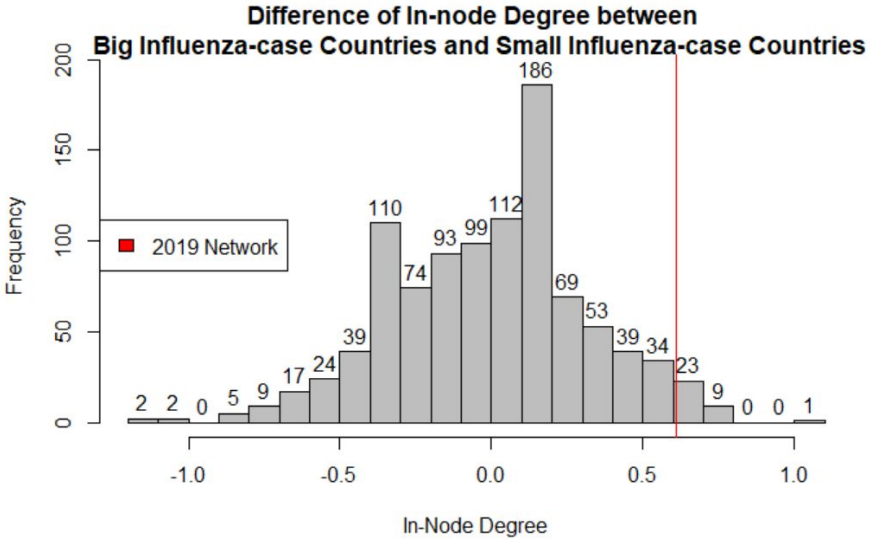
Link: migration corridor (top 100 migration corridors)
Link Width: total number of new immigrants of the corresponding migration corridor

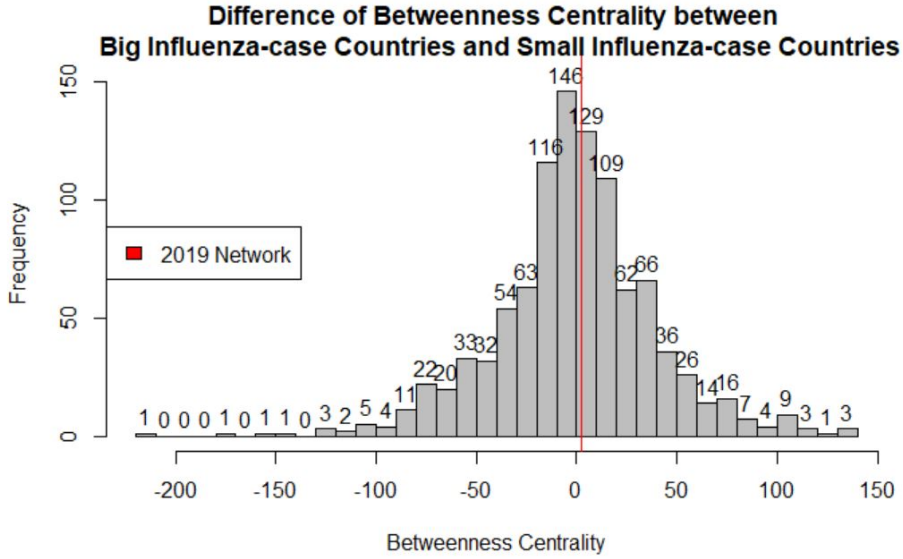
Node: country or area in the world (74 countries)
Node Size: total number of new immigrants to a country from the connecting migration corridors displayed in this graph
Node Color:

- **Red**: Influenza case number above the world median level in 2019
- **Blue**: influenza case number lower than the world median level in 2019

Among the top five in-flow hubs in this graph, UAE is the only hub that had high new immigrants rate, but low influenza case number. The rest of the hub countries follow the pattern that the more new immigrants, the higher the influenza cases.

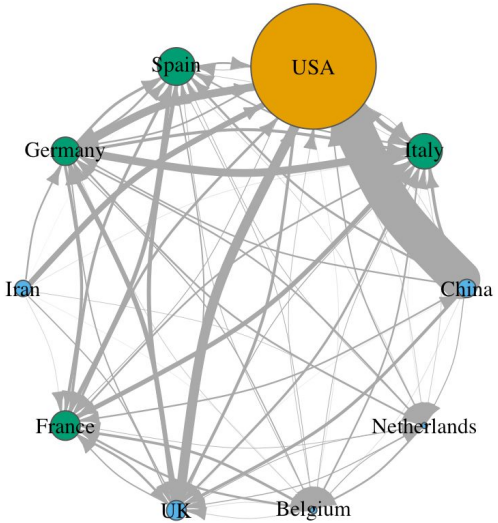
	Mean In-node Degree Centrality	Difference of Mean In-node Degree Centrality	Mean Betweenness Centrality	Difference of Mean Betweenness Centrality
Random Network	1.35			
2019 Network	1.35	0.61 (Histogram)	2.45	2.42 (Histogram)





The Relationships between Migration & COVID-19

Total Cases of COVID-19 and Number of Immigrants

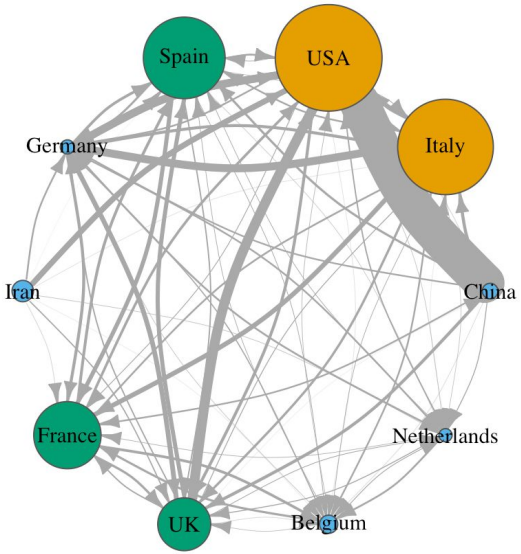


- Above 500,000
- Below 100,000
- Between 100,000 & 200,000

Parameters:

- **Node**: Top 10 countries that have the greatest number of COVID-19 cases
- **Node Size**: total cases
- **Link Width**: number of migrants
- **Layout**: layout_in_circle

Total Deaths due to COVID-19 and Number of Immigrants



- Above 20,000
- Below 10,000
- Between 10,000 & 20,000

Parameters:

- **Node**: Top 10 countries that have the largest number of deaths
- **Node Size**: total deaths
- **Link Width**: number of migrants
- **Layout**: layout_in_circle

Appendix

Data

Metadata

- **Migration Data**: United Nation migration stock data by destination and origin (link)
- **Influenza Data**: World Health Organization weekly influenza data (link)

Metadata Preprocessing

- **Edgelist Dataframe:** used Python to read, clean, generate yearly migration flow and migration increase rate data, and format the data in edgelist style for plotting network graphs
- **Node Dataframe**: used Python to process influenza data
- **Python code** uploaded here (v5_Data_Preprocessing.ipynb)

Dataframes for plotting

- Subset corresponding data for year 2005, 2010, 2015, and 2019 from the Node Dataframe and Edgelist Dataframe. A screenshot of the Node Dataframe and Edgelist Dataframe for year 2019 are shown below:

1	Country	Label	Region	UN_Region	Influenza2019	Total_New_Immigrants_19	Rescale_TNI2019
2	Afghanistan	Afghanistan	Southern Asia	Central and Southern Asia	278	0	4
3	Algeria	Algeria	Northern Africa	Northern Africa and Western Asia	33	0	4
4	Argentina	Argentina	South America	Latin America and The Caribbean	6477	690948	4.454480456
5	Australia	Australia	Australia New Zealand	Oceania	14002	3073203	6.021441121

1	Origin	Destination	flow2019	Rescale_MF_19
2	Mexico	United States of America	11489684	3.79307656
3	Syrian Arab Republic	Turkey	3743494	1.432369313
4	India	United Arab Emirates	3419875	1.33374409
5	Russian Federation	Ukraine	3308515	1.299806327

Node Size Data

The node size is determined by the total number of immigrants (in-flow) to a destination country. The top 10 countries measured by raw migration data and rescaled data are provided below.

Top In-flow Country <chr>	Total Immigrants <dbl>
United States of America	33446666
Saudi Arabia	9922066
Russian Federation	9097984
Germany	6969858
United Arab Emirates	6923122
India	4720227
Turkey	4396394
Thailand	3483122
Ukraine	3308515
France	3283220

Top Out-flow Country <chr>	Total Emigrants <dbl>
India	15456396
Mexico	11489684
Russian Federation	8315795
China	7909731
Syrian Arab Republic	7022850
Bangladesh	5428729
Pakistan	4116540
Afghanistan	3899438
Philippines	3859139
Kazakhstan	3500007

Top In-flow Country <chr>	Total Immigrants (rescaled) <dbl>
United States of America	15.4403381
Saudi Arabia	5.3559214
Russian Federation	4.5217514
Germany	4.1647022
United Arab Emirates	3.5674340
India	2.3130608
Australia	2.1026309
Thailand	1.9360441
Turkey	1.9228578
France	1.8751226

Top Out-flow Country <chr>	Total Emigrants (rescaled) <dbl>
India	7.6255734
China	4.1596227
Russian Federation	3.9918611
Mexico	3.7930766
Syrian Arab Republic	3.5978268
Bangladesh	2.5289819
Pakistan	2.4205954
Philippines	2.3421505
Afghanistan	1.7714069
Kazakhstan	1.6496774

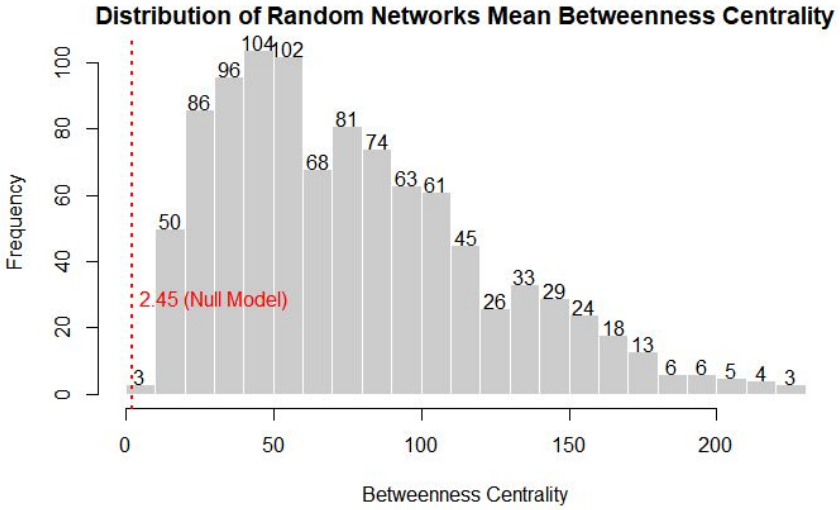
Top 10 Countries with Large Number of Influenza-cases

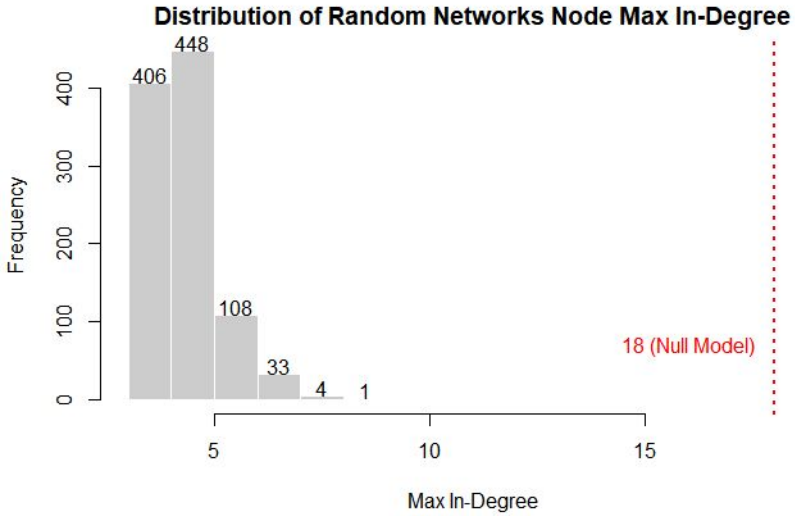
Country <chr>	Influenza2019 <dbl>
United States of America	267384
China	122757
Canada	43196
United Kingdom	42432
France	25405
Russian Federation	19340
Spain	17232
Australia	14002
India	10422
Japan	9525

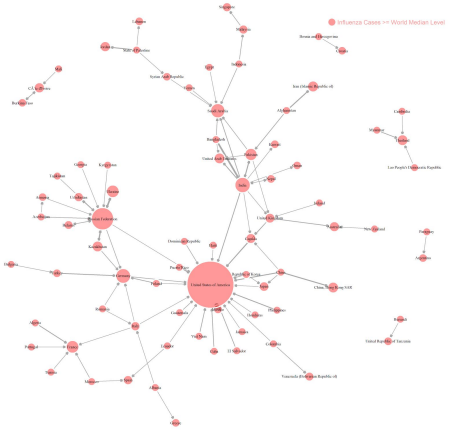
Top 10 Betweenness Centrality in 2019

	Betweenness Centrality (2019) <dbl>
India	40
United States of America	37
Russian Federation	35
Germany	27
Bangladesh	12
Pakistan	11
Syrian Arab Republic	6
United Kingdom	5
Turkey	3
Colombia	2

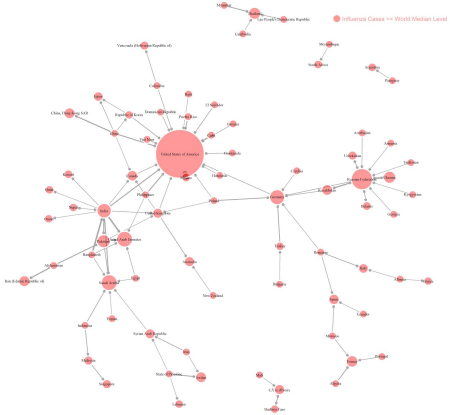
Other Network Measures



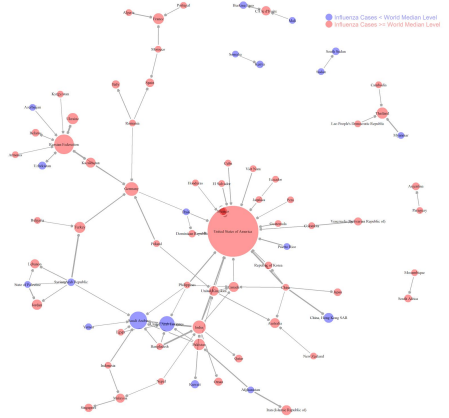




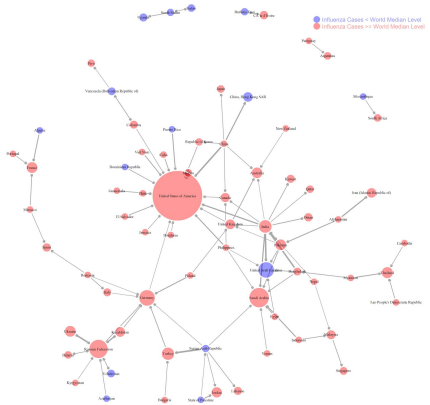
2005



2010



2015



2019

Time Series 2005 - 2019: Top 100 Migration Corridors and Influenza Big Countries

Note: This plot brings in influenza data. Influenza data is presented in the form of colors.

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Link Width: number of new immigrants of the corresponding migration corridor

Node: countries/regions
Node Size: total number of new immigrants to a destination country from the existing migration corridors associated with that country in this plot
Node Color:

- **Red**: Influenza case number was greater than the world median level in the respective year
- **Blue**: influenza case number was smaller than the world median level in the respective year