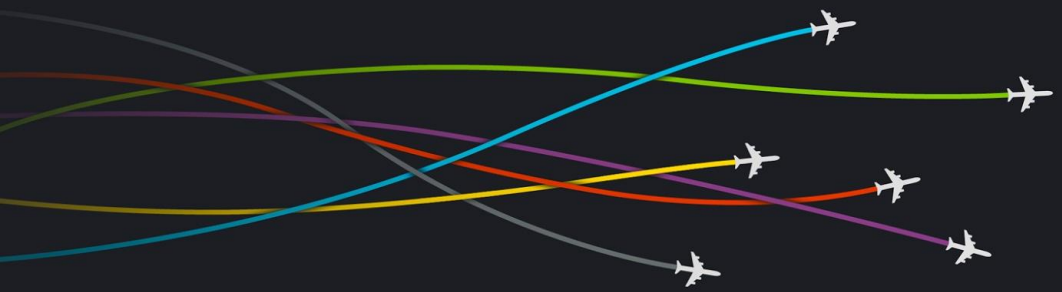

European Flight Restrictions May Inhibit International Propagation of Ebola

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Dr. Christopher Leary, Dr. Gregg Hartvigsen
Departments of Biology and Mathematics
SUNY Geneseo

Can flight restrictions prevent the spread of Ebola?

Outbreak
The Model
Model Validation
Results
Future Applications

Outbreak

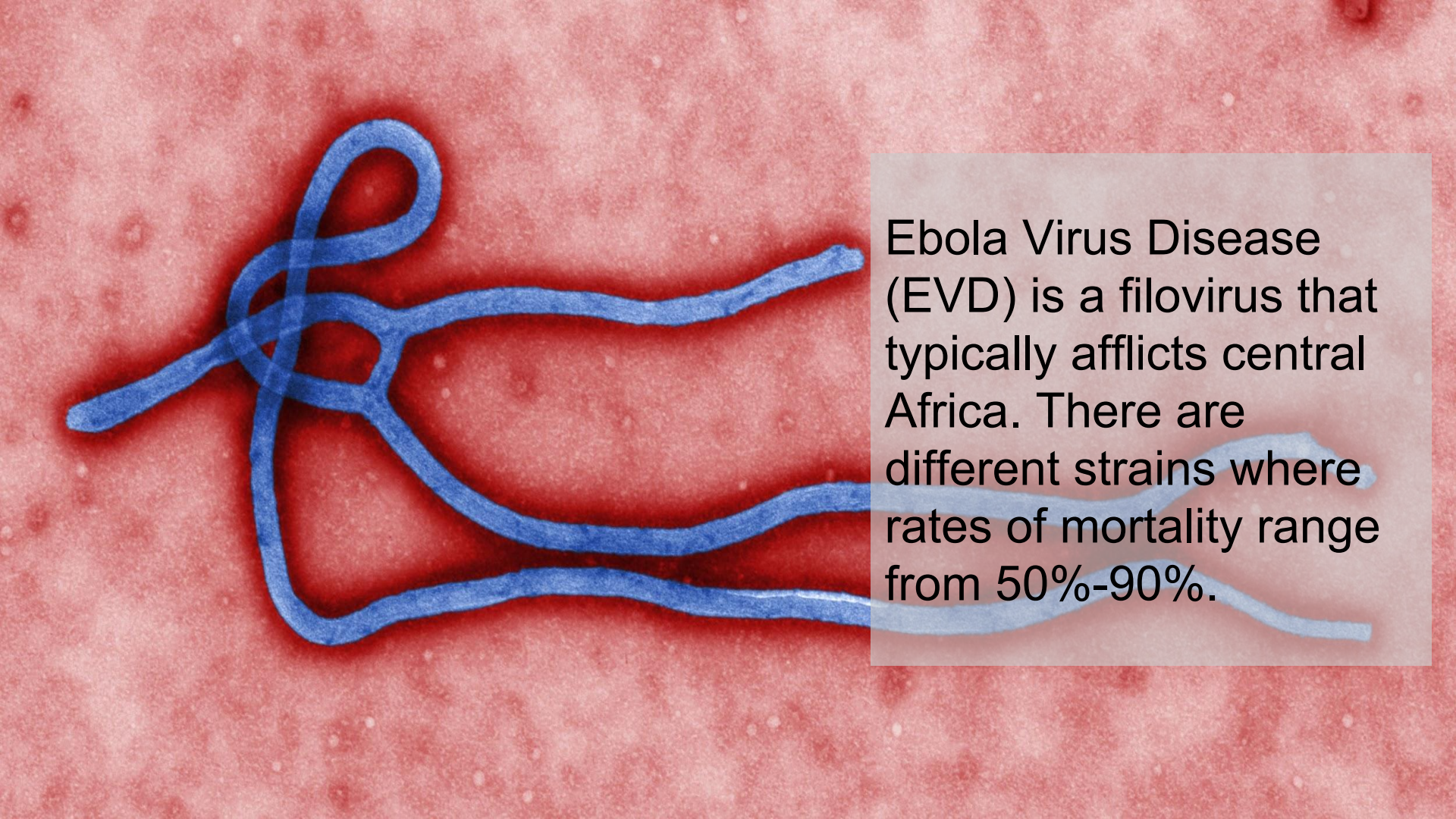
The Model

Model Validation

Results

Future Applications

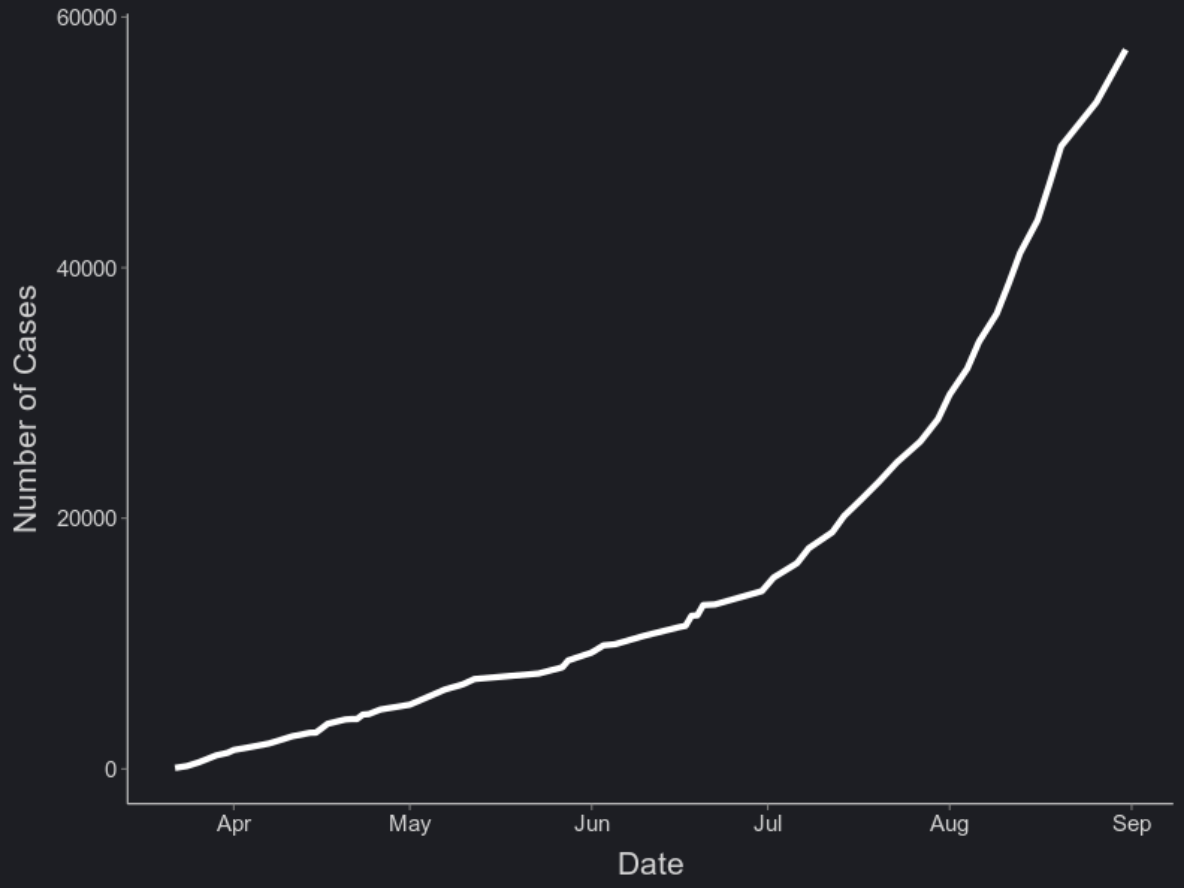
“On 26 December 2013, a 2-year-old boy in the remote Guinean village of Meliandou fell ill with a mysterious illness characterized by fever, black stools, and vomiting. He died 2 days later.” WHO Global Alert and Response[2]

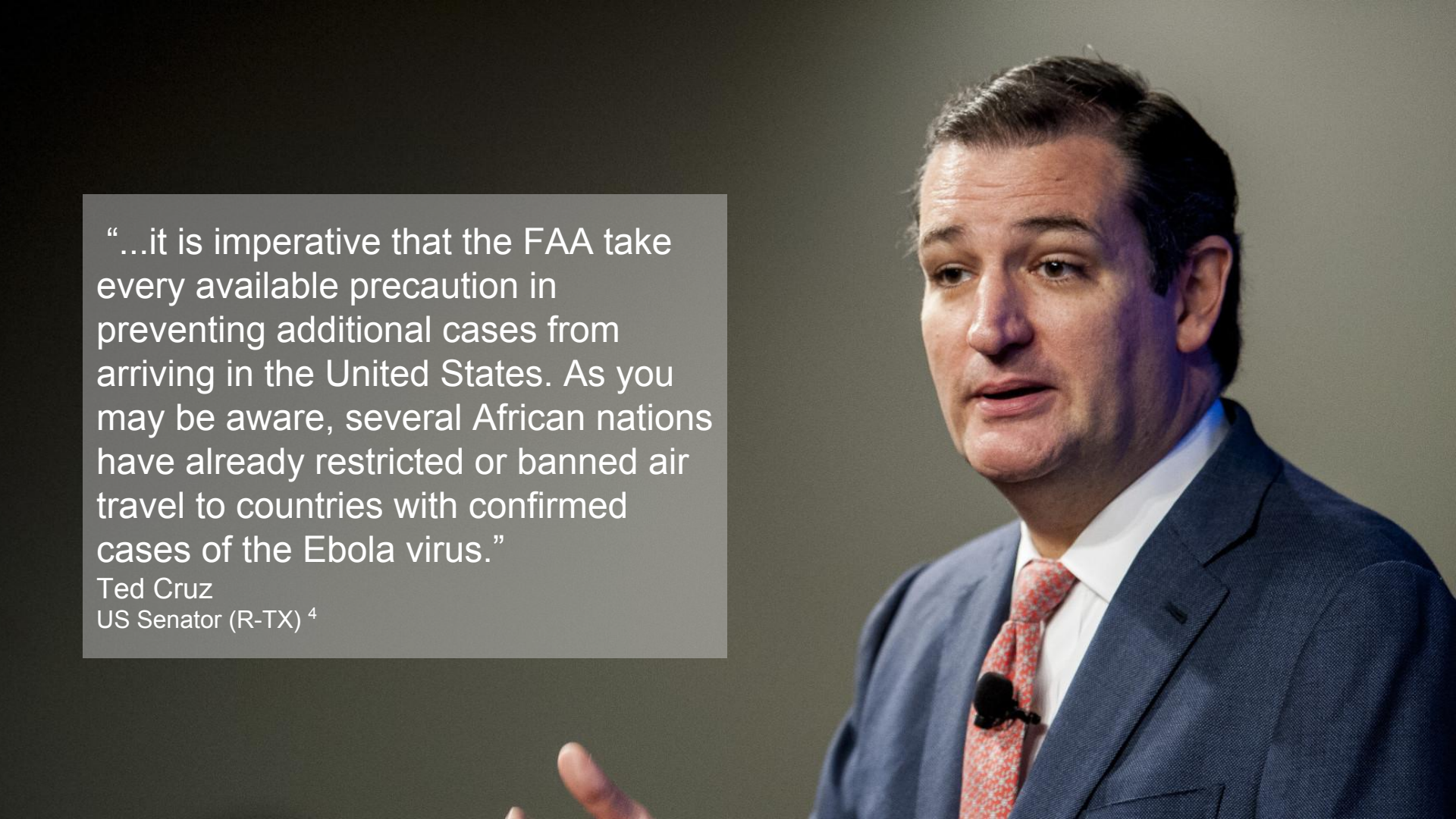


Ebola Virus Disease (EVD) is a filovirus that typically afflicts central Africa. There are different strains where rates of mortality range from 50%-90%.

"It is the world's first Ebola epidemic, and it's spiraling out of control."

Dr. Tom Frieden
Director of the CDC[3]
September 2nd, 2014





"...it is imperative that the FAA take every available precaution in preventing additional cases from arriving in the United States. As you may be aware, several African nations have already restricted or banned air travel to countries with confirmed cases of the Ebola virus."

Ted Cruz
US Senator (R-TX) [4]


“... for every complex problem, there’s a solution that’s quick, simple, and *wrong.*”
Dr. Tom Frieden
Director of the CDC[5]
October 13th, 2014
Photo courtesy of Jessica McGowan

Can flight restrictions prevent the spread of Ebola?

Outbreak

The Model

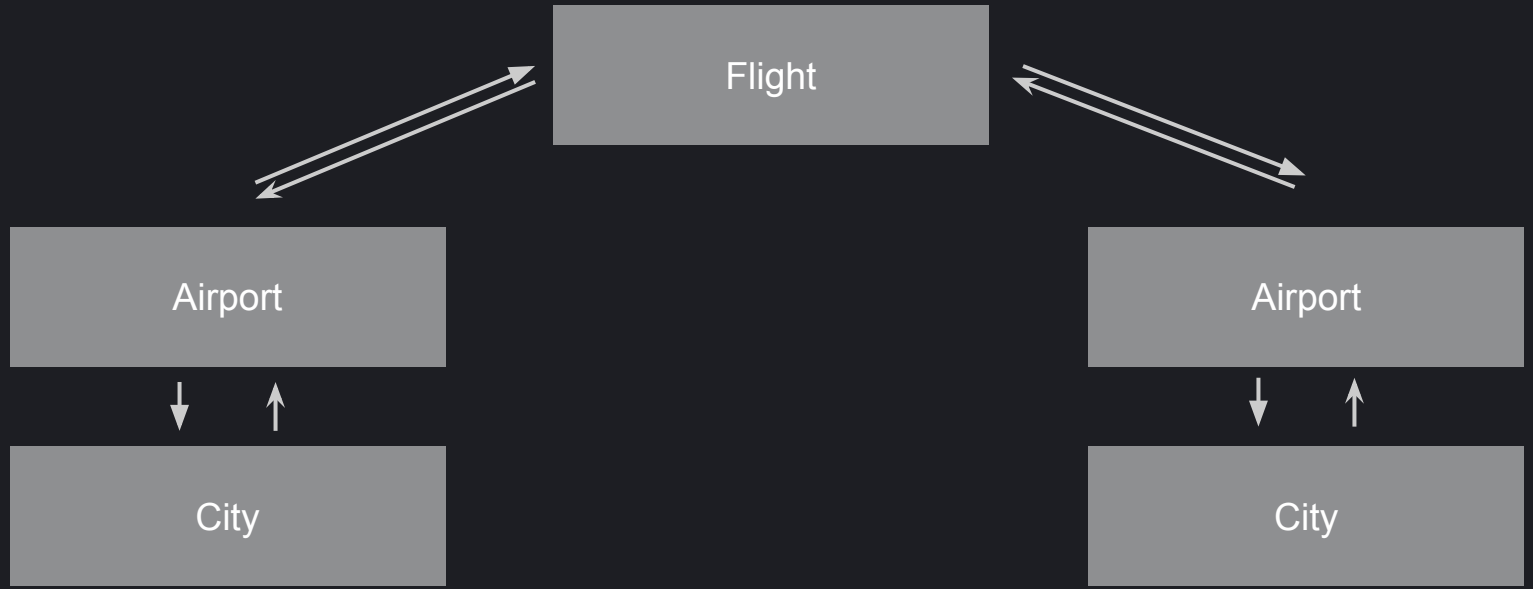
Model Validation

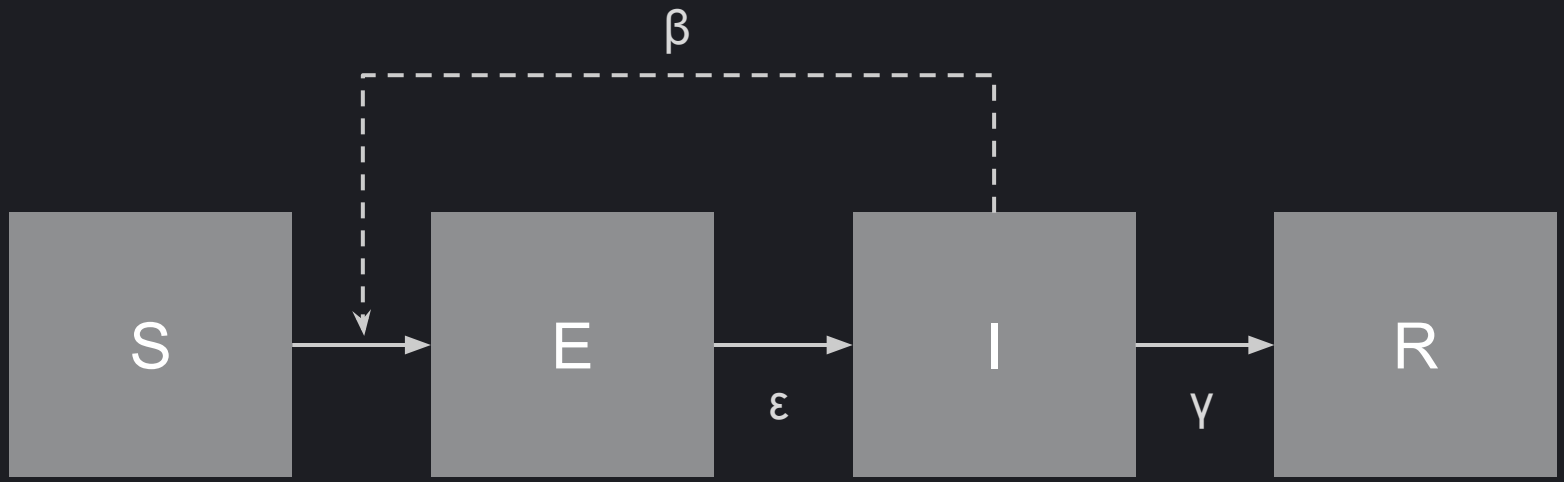
Results

Future Applications

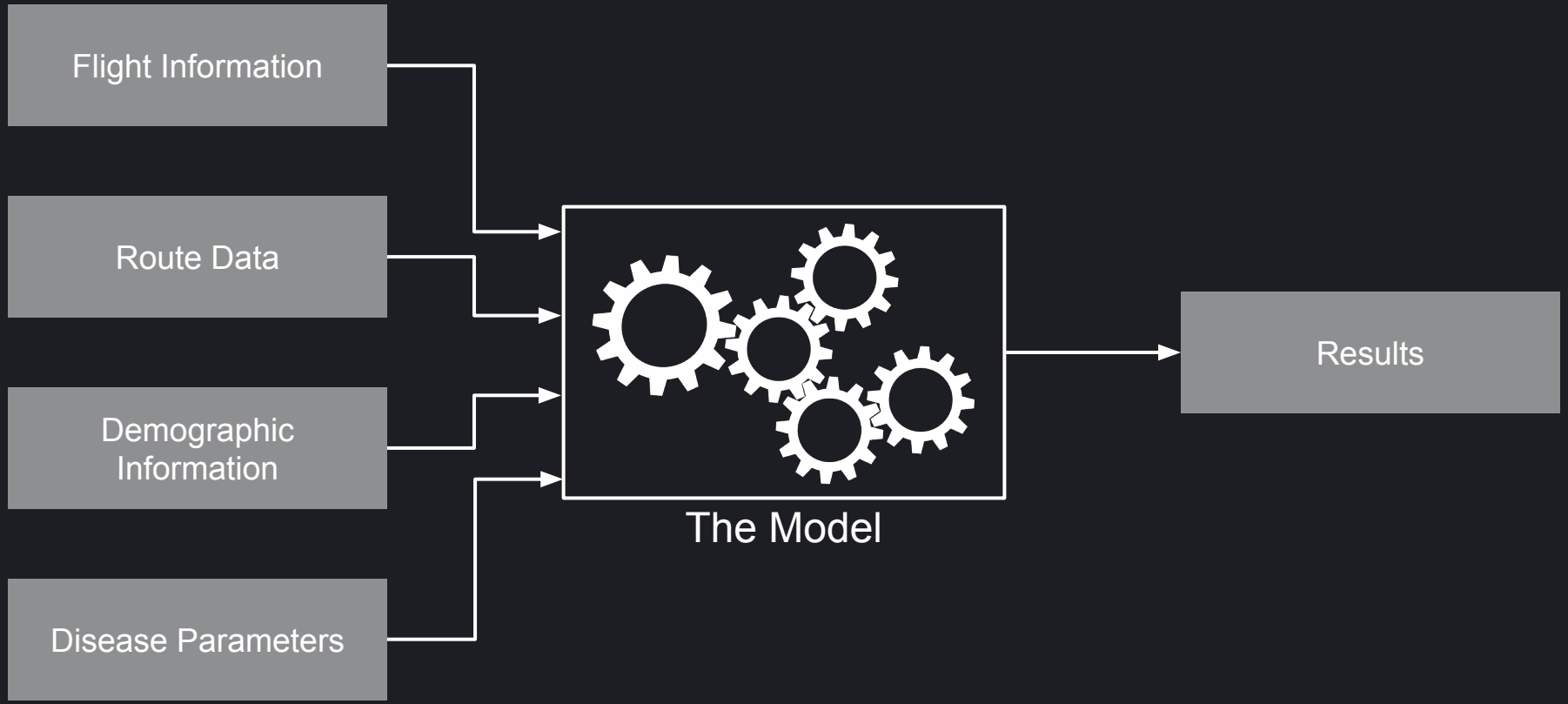
Metapopulation Network Model

A network of multiple subpopulations connected by a means of transportation.


Flight
Airport
Airport
City
City



β - Disease transmissible contact rate
ε - Incubation rate
γ - Recovery rate


Flight Information
Route Data
Demographic Information
Disease Parameters
The Model
Results

Flight Information

Route Data

Demographic Information

Disease Parameters

- 528,000 Raw Flights
  - 82,000 Unique Flights
- Information Included:
  - Origin
  - Destination
  - Time of Departure
  - ICAO Plane Type

Flight Information

Route Data

Demographic Information

Disease Parameters

- Airport Locations
  - GPS Coordinates
- Wake Turbulence Class (WTC)
- Haversine Distance
  - Useful for estimating flight time

Flight Information

Route Data

Demographic Information

Disease Parameters

- NASA’s Gridded Population of the World
  - Census data
  - Associates GPS coordinates with population estimates

Flight Information

Route Data

Demographic Information

Disease Parameters

- Current values from literature for the 2014 West African Outbreak
- Parameters for past outbreaks used for validation

Outbreak

The Model

Model Validation

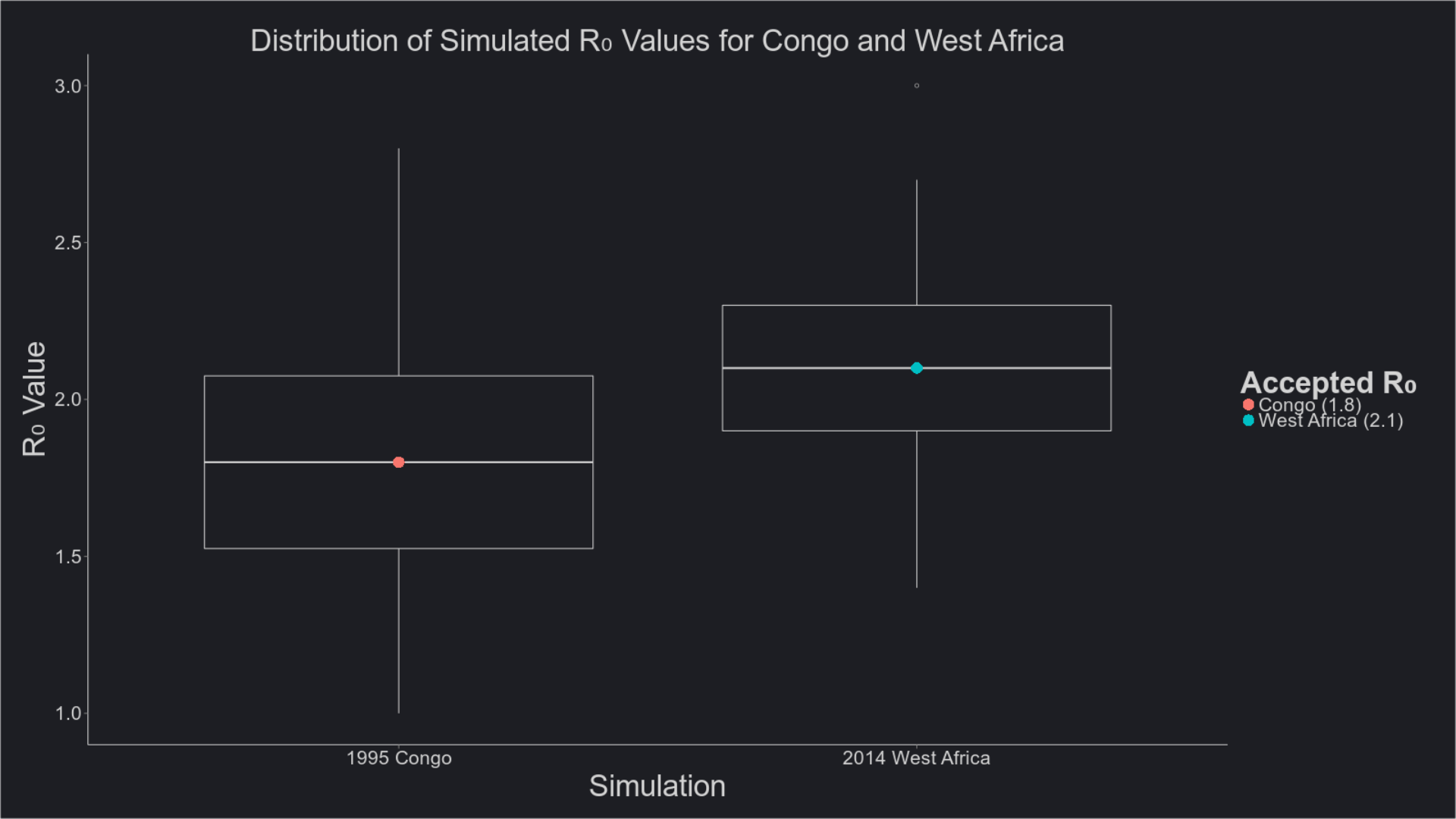
Results

Future Applications

Parameters	1995 Congo	2014 West Africa
β – Rate of disease transmissible contact	0.38	0.30
ε – Incubation rate	0.1728	0.1667
γ – Recovery rate	0.1887	0.10

R_0: The basic reproductive number.

The number of individuals exposed by a single infectious individual in an otherwise susceptible population.


Distribution of Simulated R0 Values for Congo and West Africa
3.0
2.5
2.0
1.5
1.0
R0 Value
1995 Congo
2014 West Africa
Simulation
Accepted R0
Congo (1.8)
West Africa (2.1)

Our model captures the transmission dynamics of Ebola.

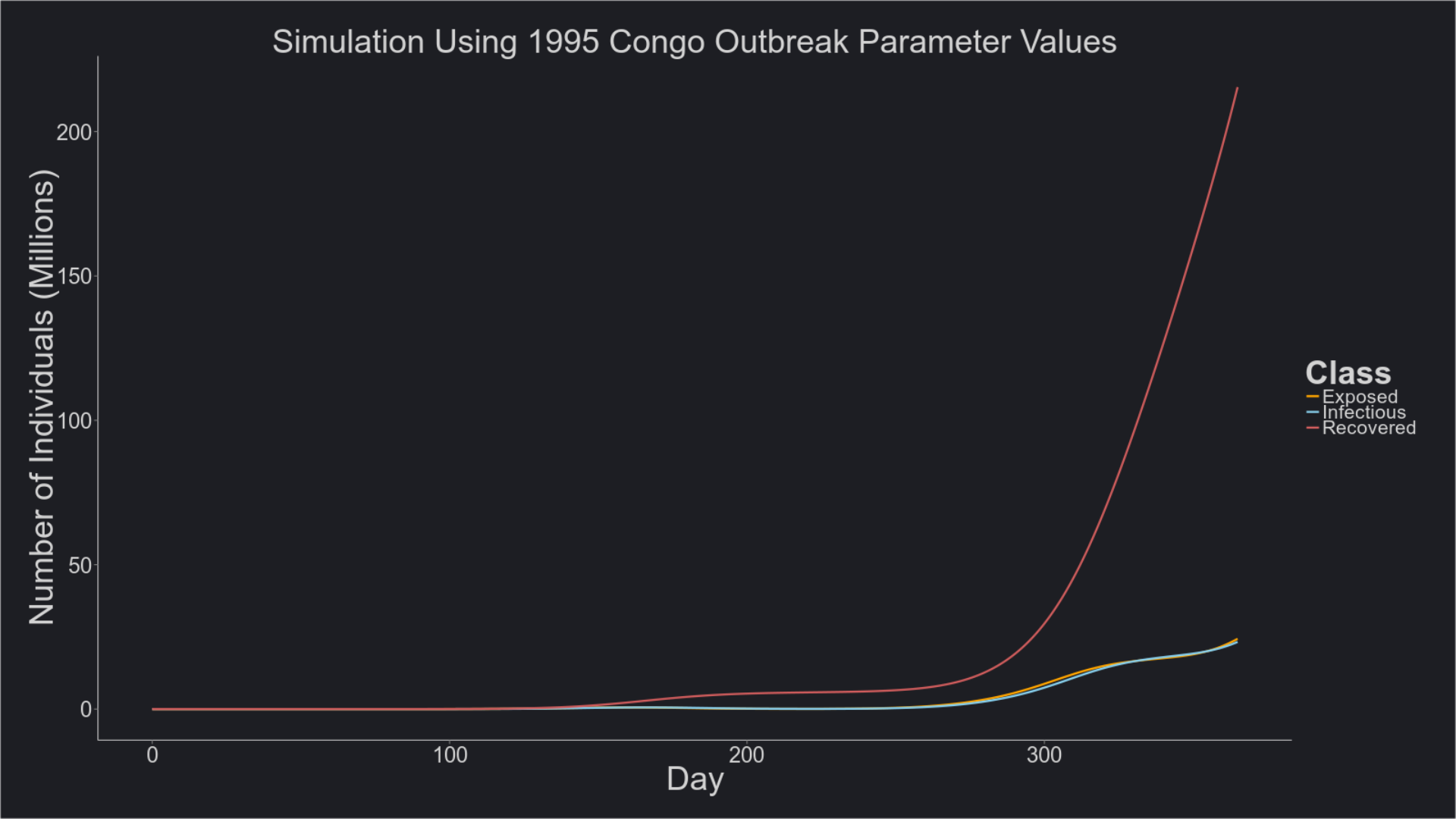
Outbreak

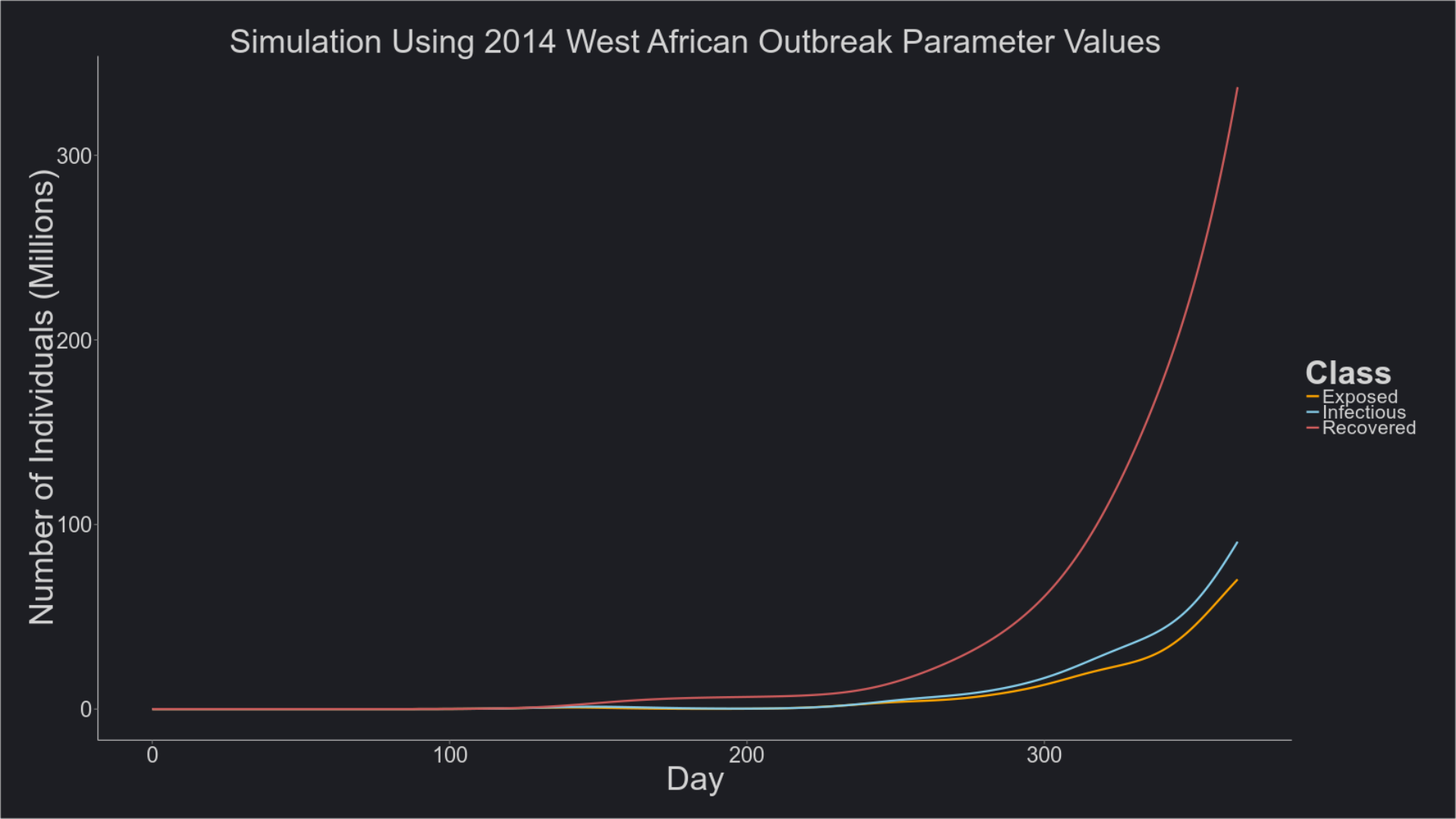
The Model

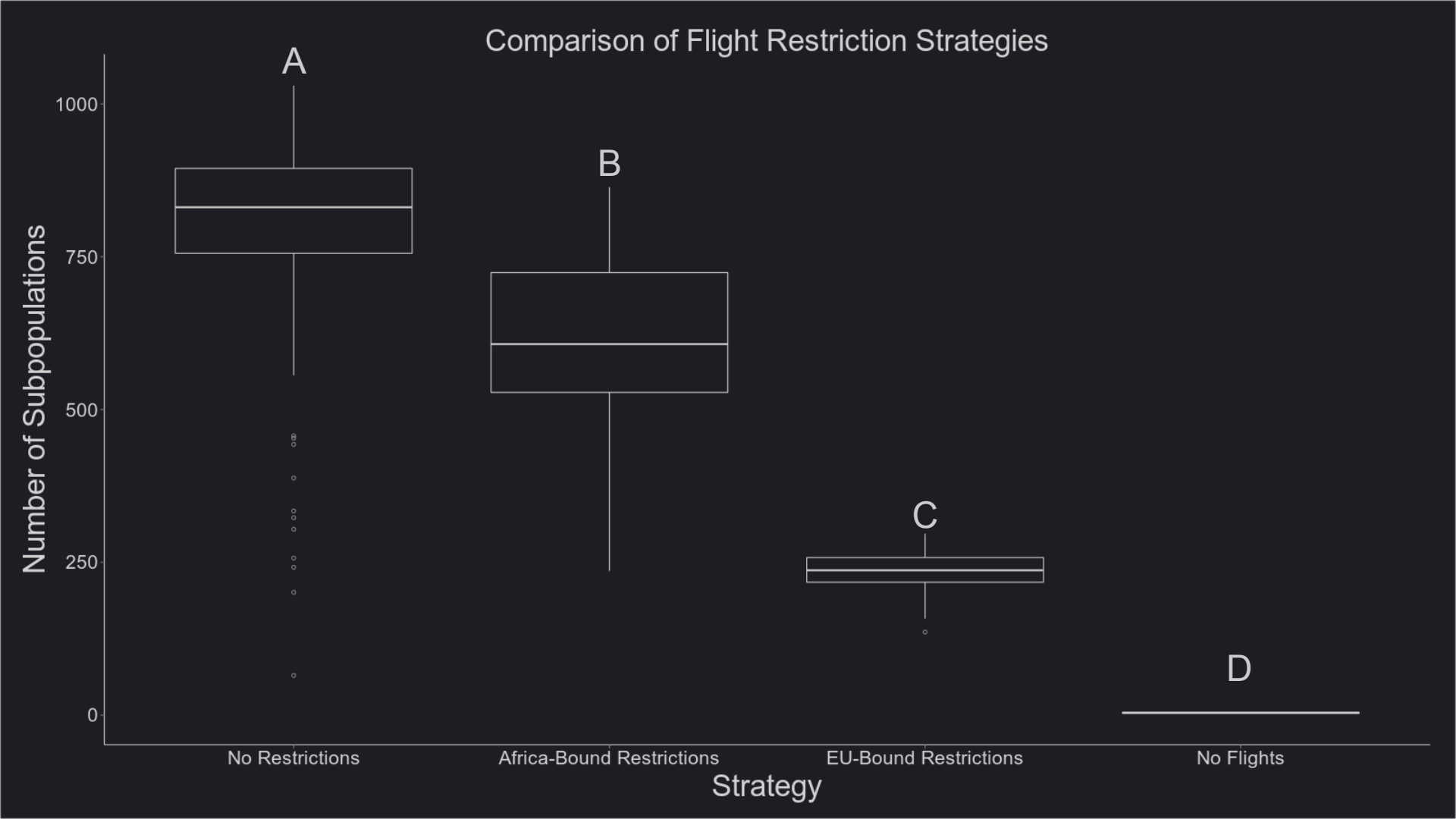
Model Validation

Results

Future Applications


Simulation Using 1995 Congo Outbreak Parameter Values
Number of Individuals (Millions)
200
150
100
50
0
0
100
200
300
Day
Class
Exposed
Infectious
Recovered


Simulation Using 2014 West African Outbreak Parameter Values
Number of Individuals (Millions)
300
200
100
0
0
100
200
300
Day
Class
Exposed
Infectious
Recovered


Comparison of Flight Restriction Strategies
A
B
C
D
1000
750
500
250
0
Number of Subpopulations
No Restrictions
Africa-Bound Restrictions
EU-Bound Restrictions
No Flights
Strategy

Outbreak

The Model

Model Validation

Results

Future Applications

Future Applications

Prediction

Simulation

Analysis

Future Applications

Prediction

Simulation

Analysis

Future Applications

Prediction

Simulation

Analysis

Future Applications

Prediction

Simulation

Analysis

Acknowledgements

FlightAware

Openflights

NASA Socioeconomic Data and Applications Center (SEDAC)

R, RStudio, and the R Community

Python, the Python Community

Dr. Hartvigsen and Dr. Leary

Patty Hamilton-Rodgers

BIG (Biomathematics Innovation Group)

Works Cited

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4. “Roll Call: Ted Cruz Asks FAA About Ebola Flight Ban.” Ted Cruz. October 2nd, 2014. Accessed January 19th, 2015.
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