GDMFC

GLOBAL DISEASE MODELING & FORECASTING CENTER

The Global Disease Modeling & Forecasting Center works in union with academia, industry, the US Government and global partners to develop, validate, and operationalize epidemiological models to combat infectious diseases.

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Mission

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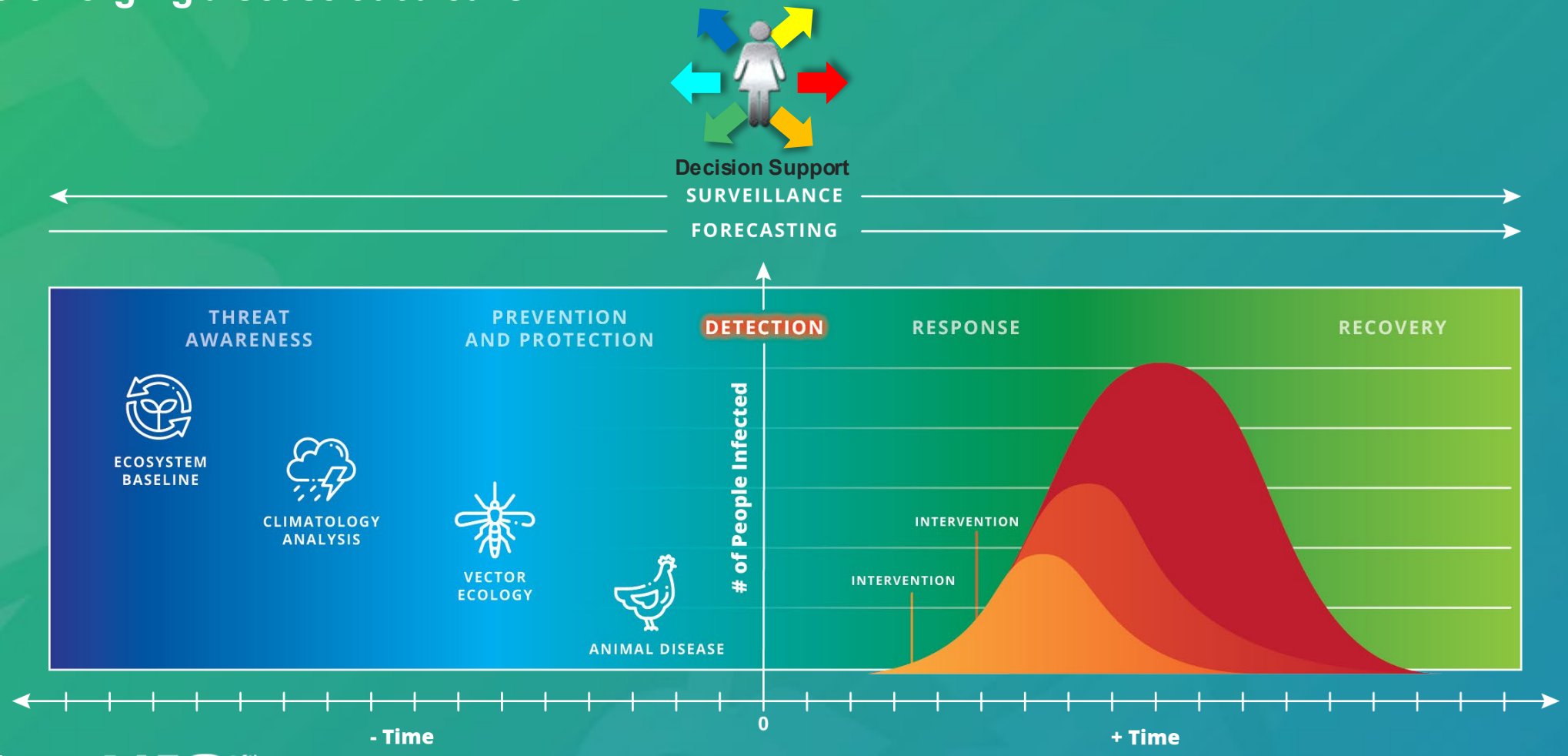
Apply multi-scale modeling and advanced data science to help the world detect, understand, forecast, prevent, and provide decision support in response to emerging and re-emerging disease outbreaks.



Our Role

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Create a bridge between science and policy

- Integrate and visualize data and modeling results in an effective way
- Help local and federal officials make critical decisions to improve preparedness and response
- Trusted entity, strong partnerships

Provide situational awareness and early warning

- Move detection efforts to the left of the curve
- Illuminate options to aid decision makers to the right of the curve
- Technical reach back on emerging and re-emerging threat assessments

Provide validated modeling frameworks that can

- Identify risk of spread of newly identified pathogens
- Forecast the potential spread of diseases
- Assess the impact of pharmaceutical and non-pharmaceutical interventions

Provide expertise in multiple disciplines to help the global community understand pathogenic organisms through

- Surveillance
- Mechanistic understanding of threat
- Development of countermeasures

Why LANL?

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LANL provided support for:

HIV	antibiotic resistance
Ebola	influenza
FMD	chikungunya
Anthrax	SARS-CoV-2
SARS-1	and more…

Diseases are a national security challenge

LANL scientists are leaders in R&D

- Leaders in uncertainty quantification
- Leaders in high-performance modeling & simulation
- Leaders in complex systems integration

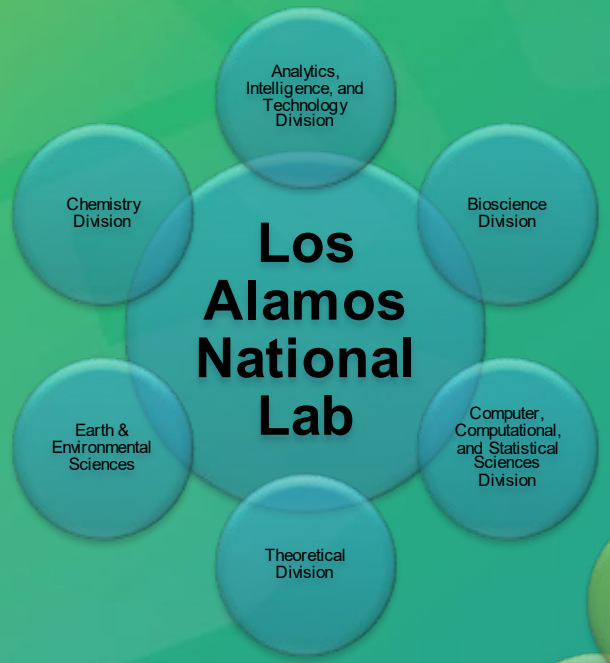
- LANL provides technical decision support for emerging and re-emerging threats
- FFRDC & FIE Status
- LANL coordinates research related to global epidemiological modeling

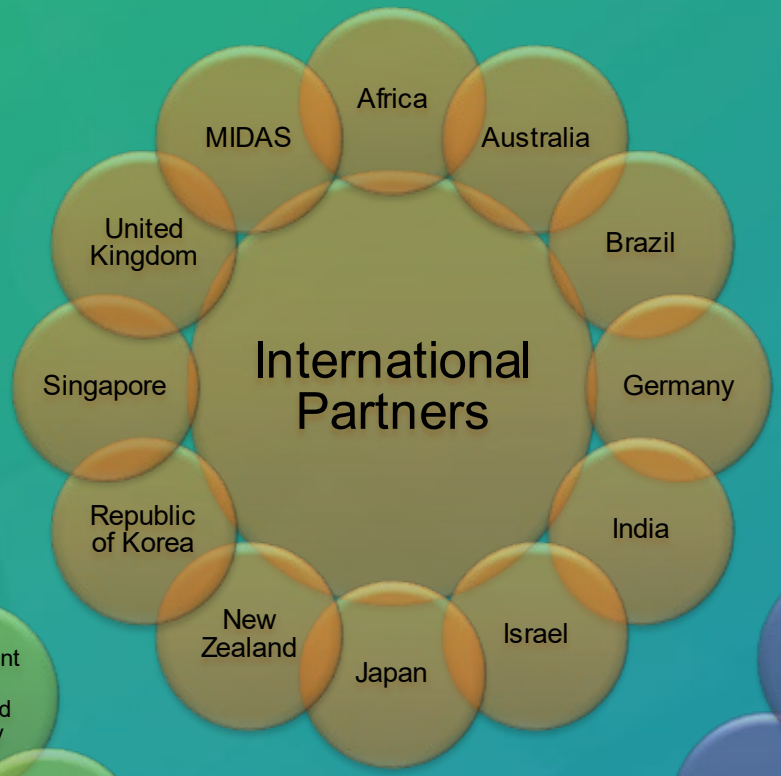
DOE/LANL enables decision making

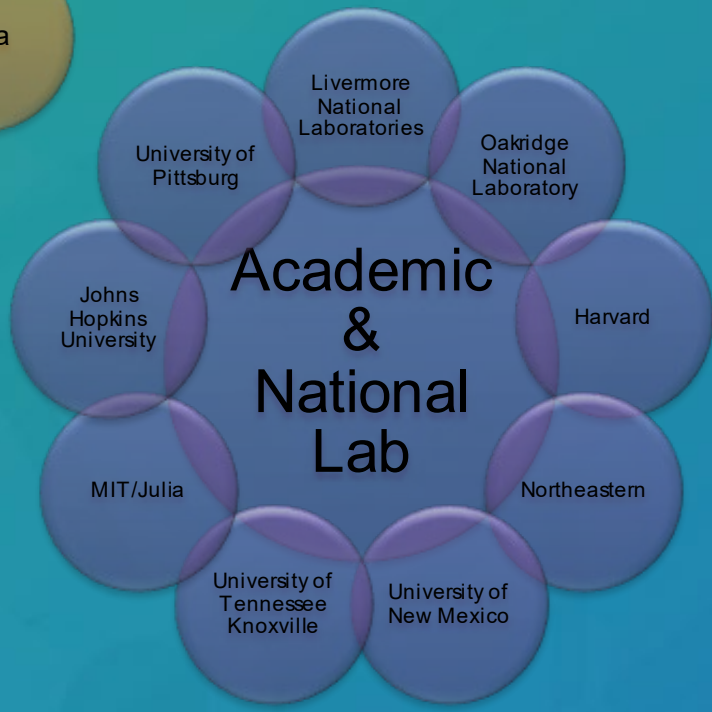
Strong ties with local, state, and federal partners

- NIH, CDC, DoD, DHS, and industry
- LANL strives to be a Trusted Entity for Government, Public and Private Groups

Partnership for Success







Our Core Team Disciplines

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Epidemiological Modeling

- Multi-scale mathematical and statistical modeling
- Machine learning and data science
- Agent-based simulation
- Understanding, tracking, and forecasting outbreaks
- Assessment of control strategies through projections
- Combining global and historical data to inform recommendations
- Evaluation of various transmission dynamics (airborne, vector-borne, sexually transmitted, etc.)

Disease Surveillance and Pathogenesis

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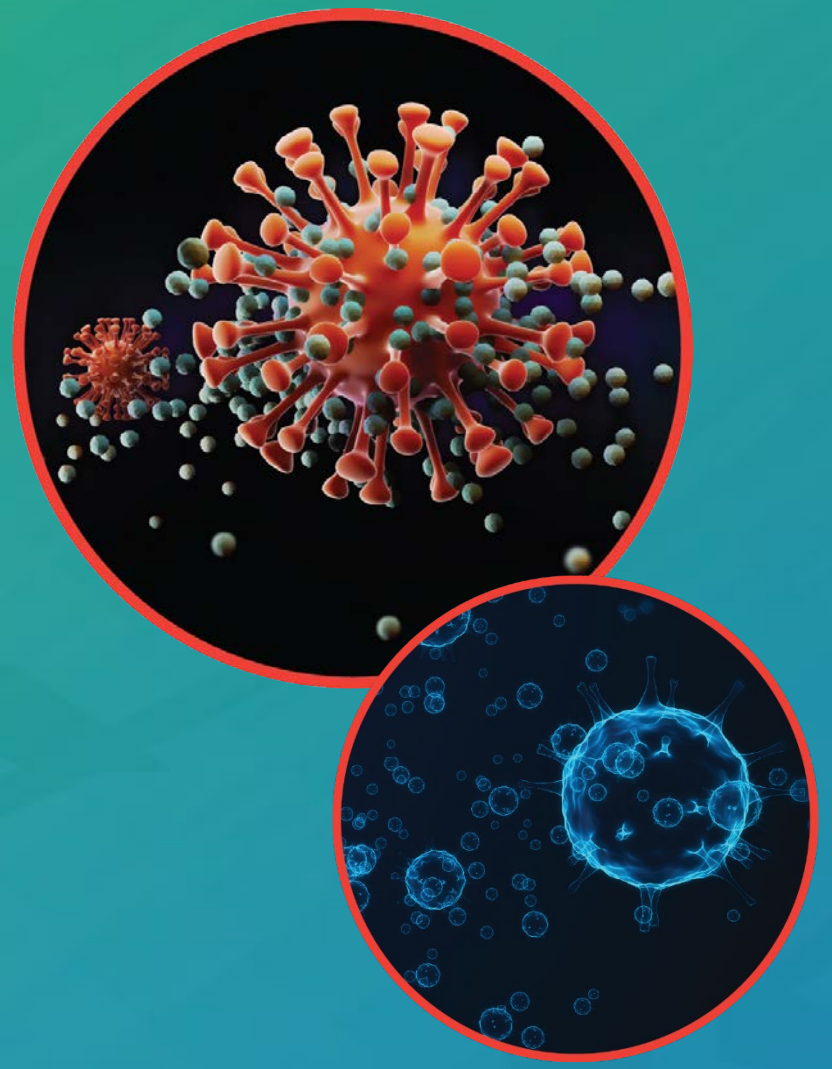
- Genomic data analysis
- Identification of emerging and re-emerging diseases
- Evolution-informed vaccine design and effectiveness analysis
- Understanding key mechanisms that drive disease spread
- Logistics modeling (supply chain to testing capacity)
- Transmission monitoring: microscopic to macroscopic behavior analysis
- Evaluation of the role of antimicrobial resistance



Data Integration and Risk Communication

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- Disease and behavior monitoring from heterogeneous data
- Using visualization to improve data communication; geospatial visualization
- Real-time decision support to optimize preparedness and response, Economic modeling
- Fusion of data-driven and model-driven approaches to more accurately understand disease dynamics
- Exploitation of traditional and non—traditional data streams to enhance model accuracy and forecasting

Our Tools Provide a Span of Capabilities

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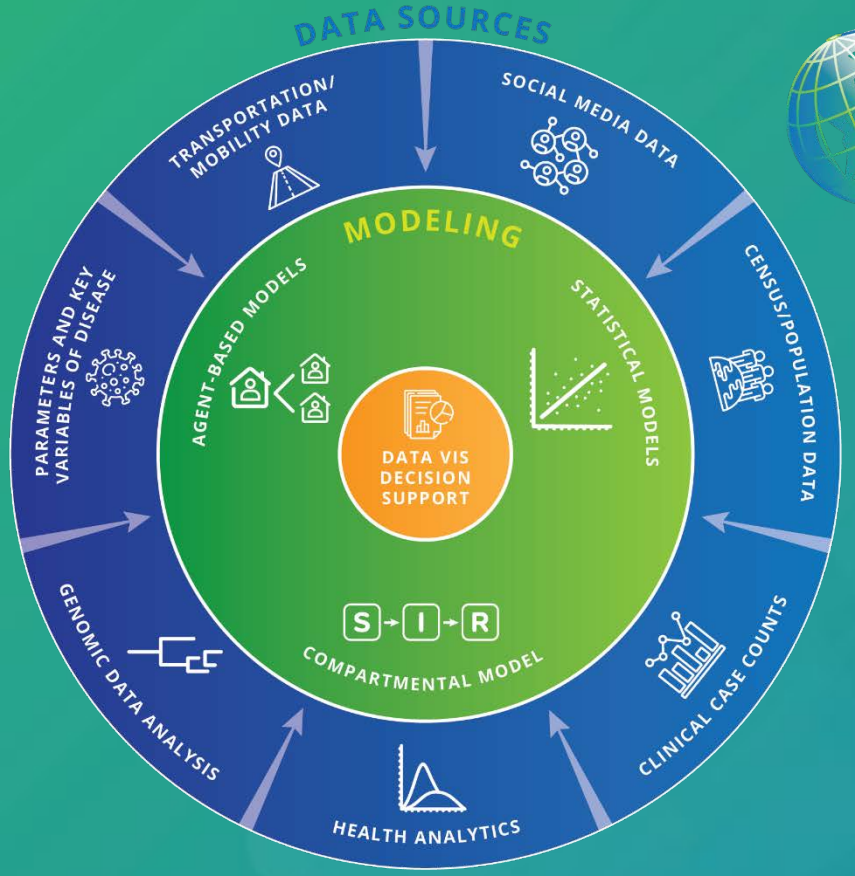
BIODEFENSE RESEARCH CENTER

Detect

Understand



GLOBAL DISEASE MODELING & FORECASTING CENTER

Model

Support Decisions

Unique Tools Developed at LANL

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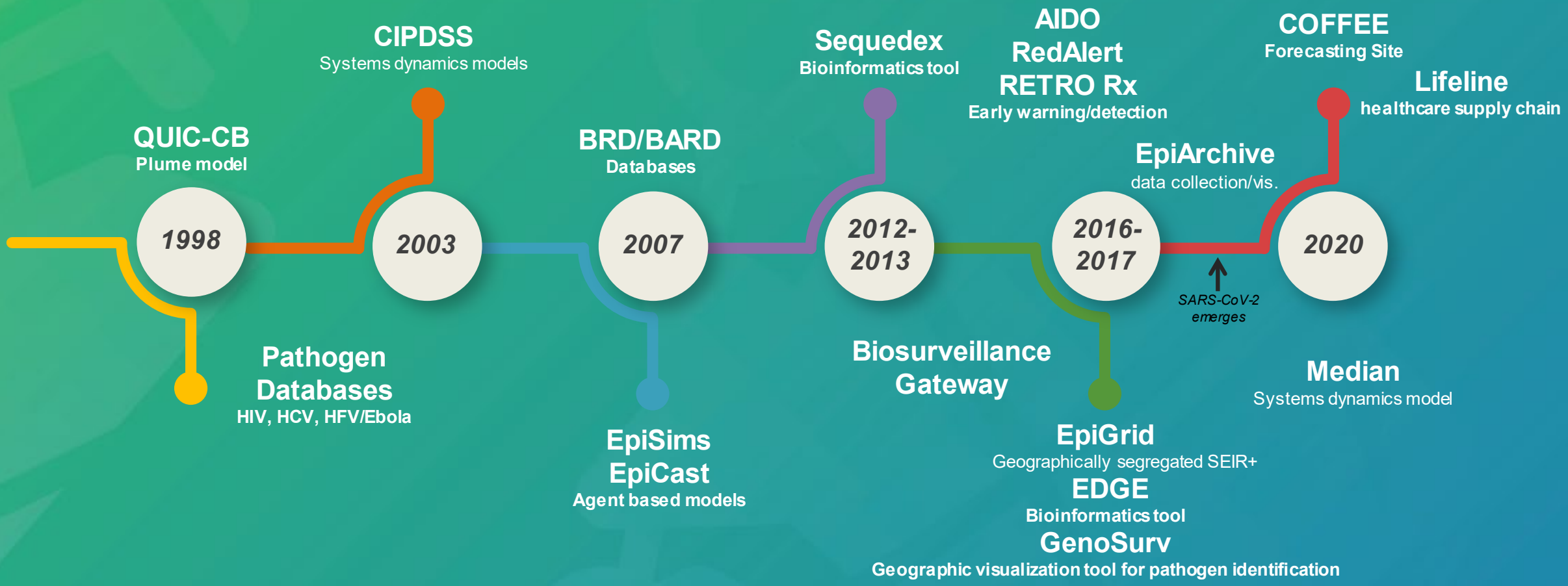

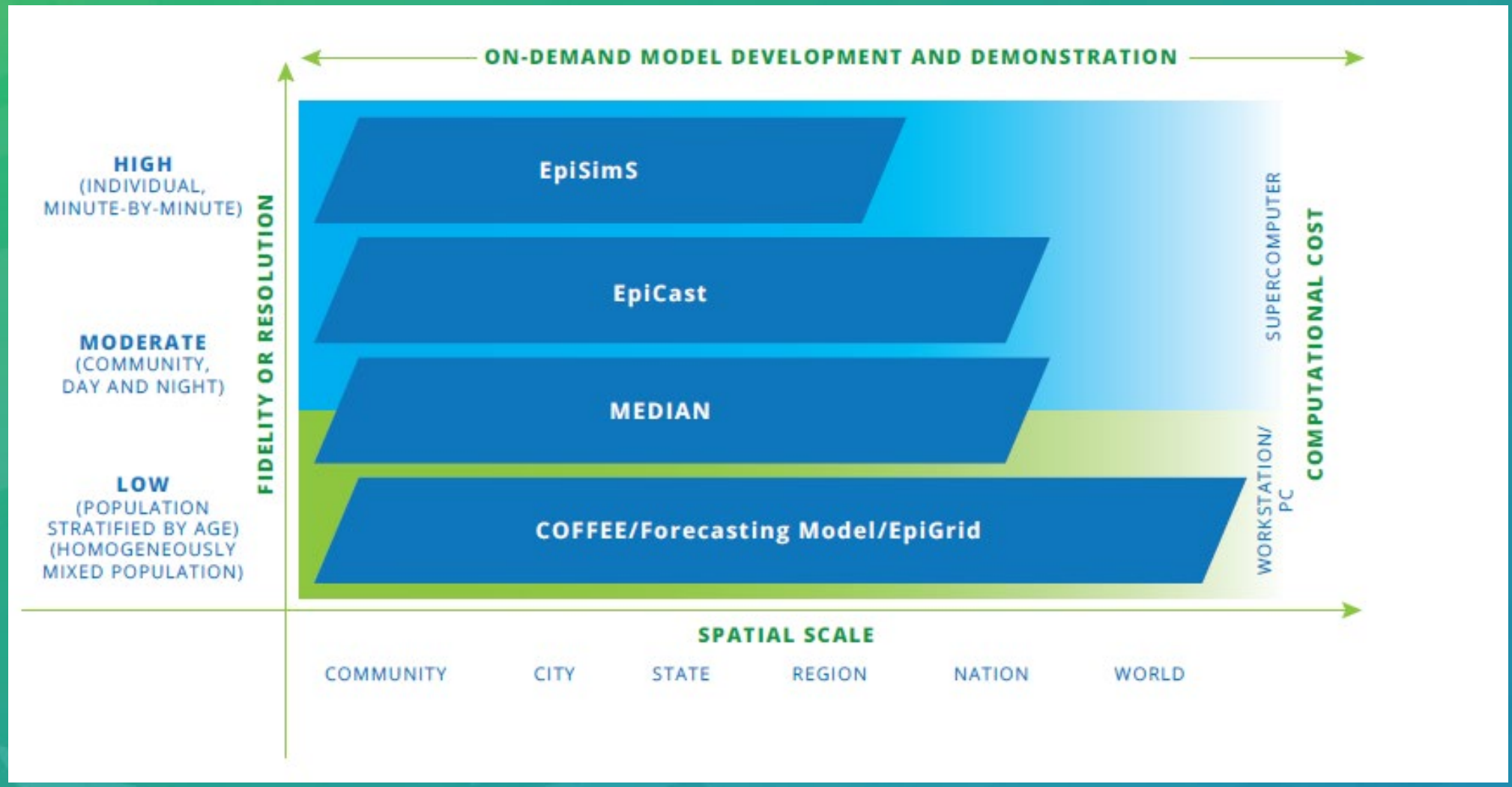
ON-DEMAND MODEL DEVELOPMENT AND DEMONSTRATION
HIGH
(INDIVIDUAL, MINUTE-BY-MINUTE)
MODERATE
(COMMUNITY, DAY AND NIGHT)
LOW
(POPULATION STRATIFIED BY AGE) (HOMOGENEOUSLY MIXED POPULATION)
FIDELITY OR RESOLUTION
EpiSimS
EpiCast
MEDIAN
COFFEE/Forecasting Model/EpiGrid
SUPERCOMPUTER
WORKSTATION/ PC
COMPUTATIONAL COST
SPATIAL SCALE
COMMUNITY
CITY
STATE
REGION
NATION
WORLD

Biosurveillance Resource Directory (BRD)

Facilitates obtaining disease surveillance information. Contains information on disease surveillance resources worldwide. Helps to rapidly select appropriate epidemiological models for infectious disease prediction, forecasting and monitoring. http://brd.bsvgateway.org

Epidemiological Information Collection Tool (Epi Archive)

A data collection and visualization tool for notifiable disease data from around the world. https://epiarchive.bsvgateway.org

Analytics for Investigation of Disease Outbreaks (AIDO)

Provides context and a frame of reference for disease surveillance information about an unfolding event, through matching of user input to a library of global historical disease outbreaks. http://aido.bsvgateway.org

Re-emergence infectious disease alert (RED Alert)

Provides early warning or detection of the re-emergence of an infectious disease at the *global* level, but through a regional lens. Facilitates long term public health planning. http://redalert.bsvgateway.org

RETRO Rx – Rapid, easy tools for responding to outbreaks and re-emergence events

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Bridging the gap between traditional epidemiological models and unanalyzed spreadsheets of data. Supports mitigation and prevention planning, outbreak forecasting and anomaly detection.
https://www.lanl.gov/science-innovation/science-videos1.php

EDGE is a highly adaptable bioinformatics platform that allows laboratories to quickly analyze and interpret genomic sequence data. The platform allows users to address a wide range of use cases including assay validation and the characterization of novel biological threats, clinical samples, and complex environmental samples.
https://bioedge.lanl.gov/ & https://covid19.edgebioinformatics.org/#/home

Genetic Surveillance (GenoSurv)

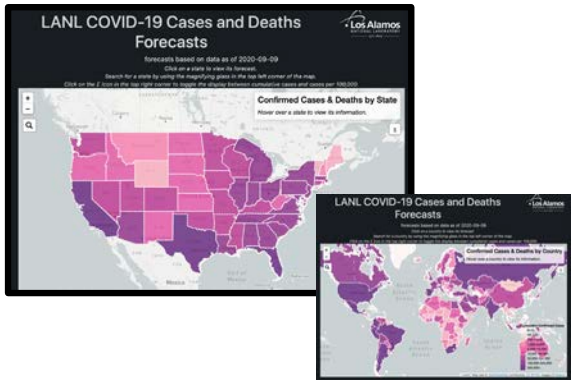
GenoSurv

Retrieves genomics data and displays summarized output from EDGE Bioinformatics. Sample metadata collected and global map visualization of pathogen identification provided.

SEQUEDEX

SEQUEDEX ...ATG

Analyzes collections of sequences in new ways, answering *who is doing what?* and bridging *molecular to ecological* scales of biology *via evolution*. Extremely fast and resource-sparing. Works for *reads as short as 30 bp* where other methods fail.



COFFEE: COVID-19 Forecasts using Forward Evaluation and Estimation

is LANL's COVID-19 confirmed cases and deaths forecasting model. COFFEE forecasts up to six weeks ahead for all US states and many countries. Forecasts are probabilistic, providing a range of possible future outbreak trajectories. https://covid-19.bsvgateway.org/

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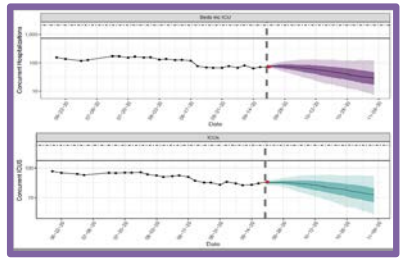
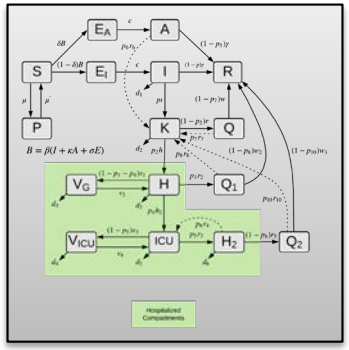


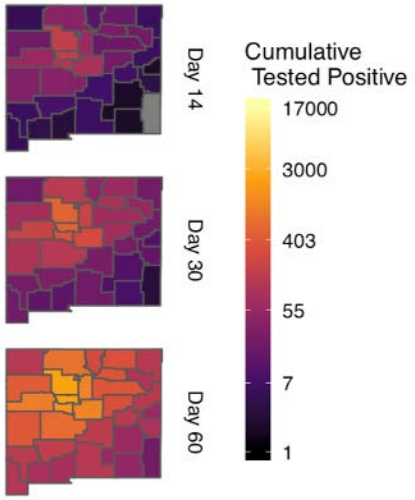
Forecasting Short-term Healthcare Needs

To provide forecasts of the number of beds, ICUs, and ventilators needed for four weeks into the future and to identify moments where needs exceed capacity numbers.



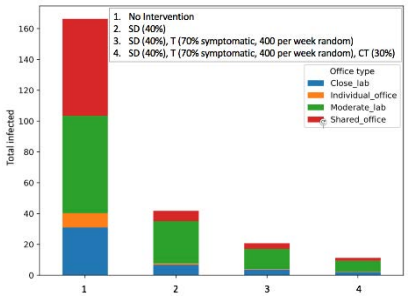
Deterministic Model of Hospital Resources and Within Hospital Transmission

A deterministic model was developed that captures COVID-19 transmission from all routes of infection, as well as patient interactions with the hospital system. Model hospital resources by incorporating understanding of patient movement within and between levels of care.



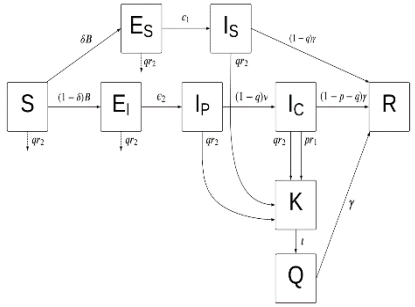
LANL Mitigation Model

Age-structured, deterministic ODE model. Identifying vulnerable and sentinel New Mexican counties and access Mitigation Strategies to provide guidance on aimed at reducing risk from out-of-state visitors. Testing the impact of split work schedules on LANL and the surrounding communities



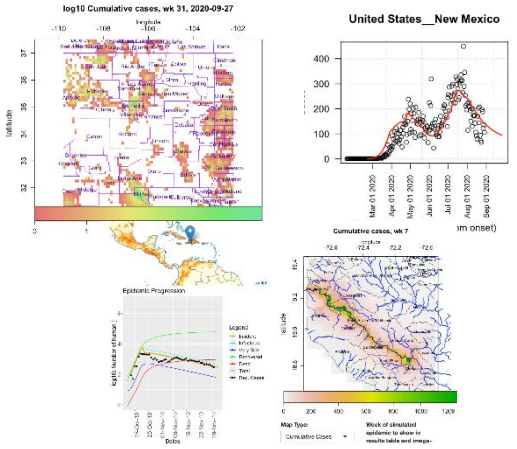
Agent-based Simulation

COVID-19 Spread within a Building and evaluate the effects of different intervention strategies.



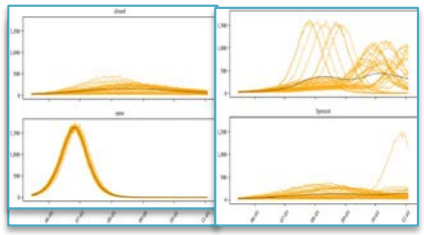
Mechanistic, deterministic SEIR-type model

To assess relative outcomes of COVID-19 mitigation strategies in New Mexico by running what-if scenarios for social distancing, comparing outcomes for closing schools versus closing businesses and evaluate the key parameters needed for speed, amount, and accuracy of testing. Identify a school reopening plan that protects children from a COVID-19 outbreak when an infection is introduced - K-12 Schools



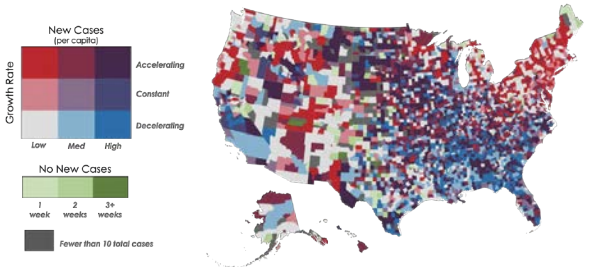
EpiGrid

A readily parameterized medium-grained model capturing disease progression, mitigations, epidemic spread, and geographical heterogeneity on equal footings in a fast-running analyst's tool. Geographical spread occurs by local contact, along roads, river, rail, and air transport. Mitigations capture vaccination, animal culling, early vs. less-timely epi and medical interventions in disease progression, and reductions in the contagious force of infection. A library of scenarios exists for the range of disease biology.



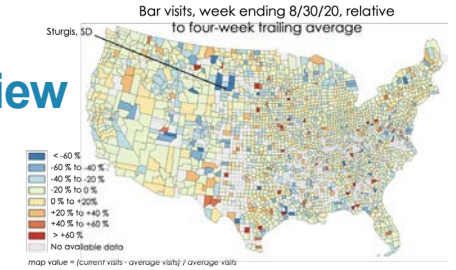
EpiCast

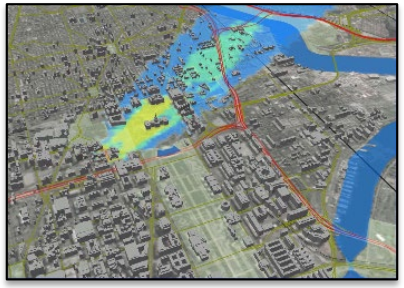
A fine-grained hybrid-agent epidemic model with diurnal agent travel and contagion allows the analysis of the importance of contact-networks, travel, and detailed intervention strategies for the control of outbreaks and epidemics.



Joint DOE Effort for Pandemic Modeling and Analysis Overview

ORNL, ANL, SNL, LANL





Quick Urban & Industrial Complex (QUIC CB)

QUIC is a fast response urban dispersion model that runs on a laptop. Chemical, biological, and radiological agent dispersion can be computed on building to neighborhood scales in tens of seconds to tens of minutes.

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MEDIAN
Modeling Epidemics for Decision support with Infrastructure ANalysis

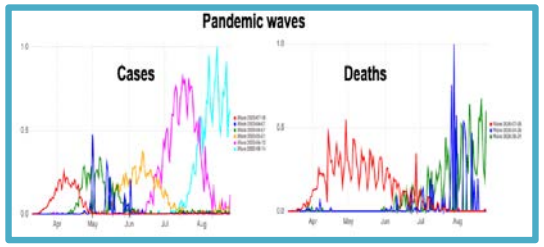
Modeling epidemics for decision support with infrastructure analysis (MEDIAN)

Systems dynamics models designed to understand interdependencies between critical infrastructures and uncertainty in the primary drivers of pandemic outcomes and mitigation impacts.

lifeline
Critical Healthcare Supply Chains Model

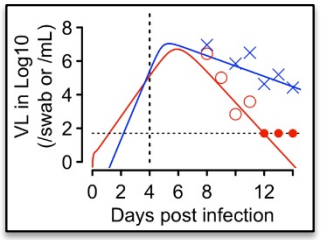
Lifeline

A healthcare supply chain tool to support policy decisions for production and distribution of critical supplies. It integrates epidemiological and hospitalizations models forecasts and predicts demand and shortages of critical supplies.



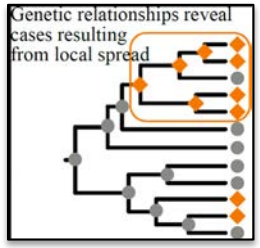
ML learning Tools: pattern detection of pandemic waves

Novel ML methods developed / patented at LANL are applied to process county-level pandemic data. The ML methods can detect the spatial and temporal patterns of pandemic cases and deaths, attributing patterns to various demographic variables.

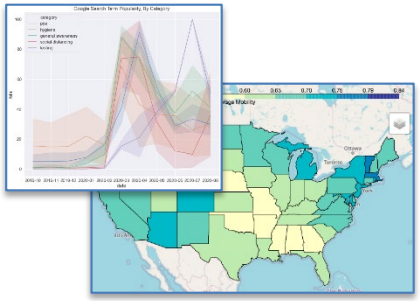


Modeling the dynamics of pathogens in infected hosts

Within-host modeling to understand pathogen dynamics and pathogenesis; Quantify the immune response; Study effect of therapeutic interventions on pathogen dynamics; Inform epidemiological models linking pathogen dynamics in the host with infectiousness

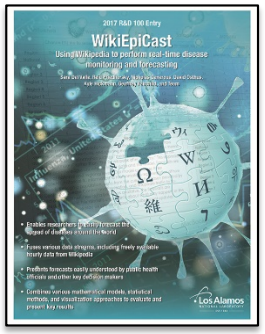


Phylodynamic methods for revealing transmission links and outbreak spread from pathogen genetic sequence data.



Nontraditional Data Mining to Measure Human Behavior

Analyze trends geospatially and over time using natural language processing (e.g., sentiment analysis, topic modeling) and machine learning



WikiEpiCast framework combines mathematical models with clinical surveillance data and readership traffic from Wikipedia to forecast the spread and severity of diseases around the world.