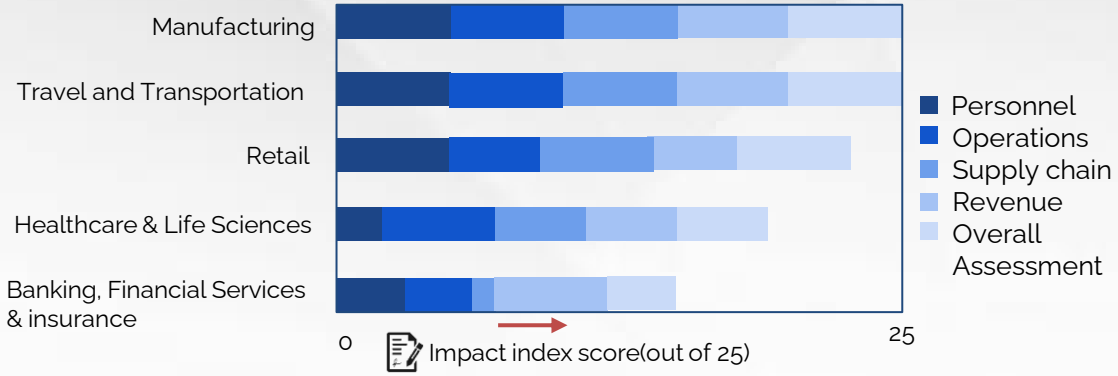
Estimate of outbreak in future will help implementing strategic measures today.

- Pandemic impacted:
  - ➢ Consumer behavior
  - ➢ Creating enormous disruption
  - ➢ **Uncertainty** in many industries operations.
- Companies have seen demand surge, plummet, or sometimes both.

Impact of pandemic on different sector



- Manufacturing, and Transportation shows largest impact. (GDP growth level - **6.3%** for 2020)
  - Inefficient operations and supply chain.
  - Increased wastage due to lack of Monitoring (lost around **561,000** jobs).
- Operations are most affected in Healthcare
  - Increased usage rate of current supply
  - Inefficient **vaccine supply chain**

Model suggested

- **Answering questions**
  - When COVID-19 outbreak will peak?
  - How long outbreak will last?
  - How many people will eventually be infected ?
- Allows the managers to **develop strategic planning.**
  - Setting up **health centre.**
  - Stocking medical necessities
  - Spreading awareness
  - Avoid possible epidemics

Unfolding the model development process to understand the data better.

Team NOOB

COVID-19 Dataset

Data Cleaning
- ✓ Identifying and **Handling missing values**
- ✓ Data Formatting

Feature Engineering
- ✓ Drop irrelevant columns
- ✓ Adding new columns
- ✓ **Normalization**

Training Data

Testing Data

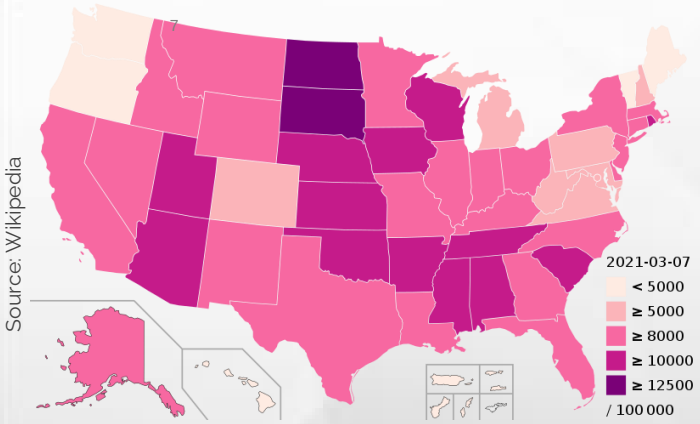
Learning Algorithm
- ✓ **LSTM**

Trained Model

Predictions

Evaluation Parameters
- ✓ R^2 score
- ✓ MAE
- ✓ RMSE

Understanding and insights from data

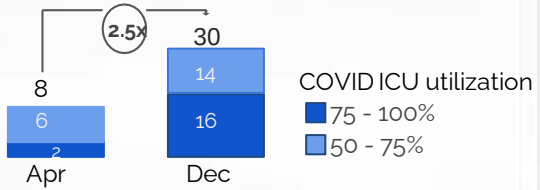


Source: Wikipedia

COVID-19 cases per 100,000 people by state, as of March 7.

1 **US health system** under immense pressure

Number of US states reporting intensive care unit (ICU) utilization >50%



2 Correlation with output (cases)
- Positive: **85%**
- Negative: **10%**
- Zero: **5%**

3 Variables types:
- Continuous: **85%**
- Discrete or other: **15%**
- Target takes continuous value.

4 **~3x** Higher exposure in communities of color compared to White, non-Hispanic persons in the US.

5 **90x** Higher death rate for those older than 65 and/or with undelying conditions (roughly 30% of US population) vs. healthy young adults (18-29 years).

Data preprocessing for the Machine learning algorithms to produce meaningful results.

Data cleaning

- Data Formatting
  - ✓ Renaming of columns
  - ✓ All column values to numeric
- Filling **null values** by **mean** value of column
  - ➢ Why mean?

Google Mobility → Filling with zero, regresssion imputation etc..

Google Mobility → Filling with average → ✓ Better result
➢ **Most counties same trend**

Feature Engineering

- **9+** Hand-crafted new features

New Columns	Combinations
Electricity sales	Sum of sales from all sector (transportation , commercial etc ..)
Onset_covid_inpatient_per_hospital	'hospital_onset_covid_SD']/ 'hospital_onset_covid_coverage_SD'
Total_flight	Domestic Flights + International flights

- Too much null values
  - ➢ Dropped columns with more than **80% null.**
- Normalization
  - ➢ **Min-max normalization** → exact same scale.
  - ➢ Normalize training and testing data with same scale.

Preparing training and testing data

Supervised Regression problem:

Last **20 days data and population information** → Predict → Number of confirmed **cases on 21th day.**

Variables

Temporal, **Demographic**

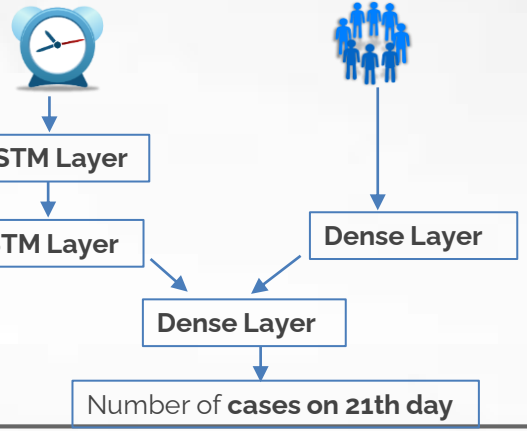
Training and Testing data

- Training (**90%**) , Testing (**10%**)
  - ➢ Temporal input **trend for 20 days**
  - ➢ Demographic input
  - ➢ Confirmed **cases on 21th day**

Finding right parameters for model will be crucial for accurate predictions, hence effective strategic planning.

Team NOOB

Model Development



Model Evaluation

- Comparison of actual difference between the estimated and the measured value.
  - **Mean Absolute Error:** 209.59
  - **Root Mean Square Error:** 4305.11
- R^2 metric provides an indication of goodness of fit of predictions to the actual values.
  - ✓ R2 score of 0.73 obtained on testing set.

Variable and correlation with confirmed cases

Hospital staff and Infrastructure

Adult ICU bed covid utilization	**0.89**
Critical staffing shortage	**0.85**
Total adult patients hospitalized	**0.56**

Others

Electricity Sales	**0.78**
Test count	**0.63**
County total population	**0.63**
Monthly Total Labour Force and Employed population	**0.58**

Insights

- **Hospital Infrastructure and facilities** related parameters shows very **high correlation** with covid cases.
- Improvement in these parameters could significantly help to deal with situation.

Additional Features for Model Improvement

Vaccine count
Value: People vaccinated
Reason: Cases decline at rate of 2000(approx. Per day)

Wind Speed
Value: Wind speed(m/s) and sunshine hours
Reason: Low wind speed and sunshine hrs.significantly correlated with higher Covid cases.

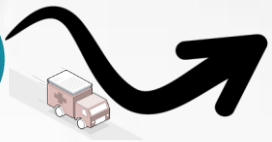
Service provider
Sales of home service provider and **Rating** (out of **10**) indicating how they are following covid regulation countywise.

Mask
Number of new **mask production per day county-wise**.
Rating(out of **100**) on the basis of willingness of people to wear mask.

Making vaccine, reach people in a cost effective way through an efficient supply chain.

Team NOOB

Manufacturer



Logistics Service Provider(LSP)

Vaccination Centre

Why Logistics Service Provider?

- Increased Efficiency
- Focussed Specialization
- Reduced costs
- Streamlined vaccine supply chain

2 LSP MODEL

OUTSOURCING MODEL

National Delivery	Procurement and Import	Cross Docking and storage
Regional delivery	Sub-national distribution	Last mile delivery

AVOIDING WASTAGE

Insights

25% **Vaccines** go waste in transit.

Vaccine can **no longer be 100% efficient** due to interrupted cold chain

Recommendations

QUALITY MANAGEMENT

- ❑ **End to End** temperature logging
- ❑ Real time **monitoring** and reporting
- ❑ Automated **scanners**.

This will give us **instant update** and also gives time for remedial action.

ENHANCING SUPPLY CHAIN

Insights

40% **of chains** have risked **product integrity.**

- Poor inventory visibility
- Data arrive **too late**.

Recommendations

END TO END INVENTORY VISIBILITY

- ❑ Data on **tags** on vaccine batches.
- ❑ Stocks identified by manufacturer and **expiry date**.

Gives complete picture of **volume of vaccines**.

ENSURING PRODUCT INTEGRITY

- ❑ **Chain of custody** reported through smart **IoT devices**.
- ❑ Auto detection of anomaly and **automated alerts**.

CUSTOMIZING SITES

- ❑ Population **Density**
- ❑ **Distance** of target population must travel
- ❑ **Trained worker**
- ❑ Confirmed **Cases**

COMPLIANCE MANAGEMENT

Insights

~10% **decreased performance if not assessed.**

Compromised quality if not monitored

Recommendations

PERFORMANCE METER

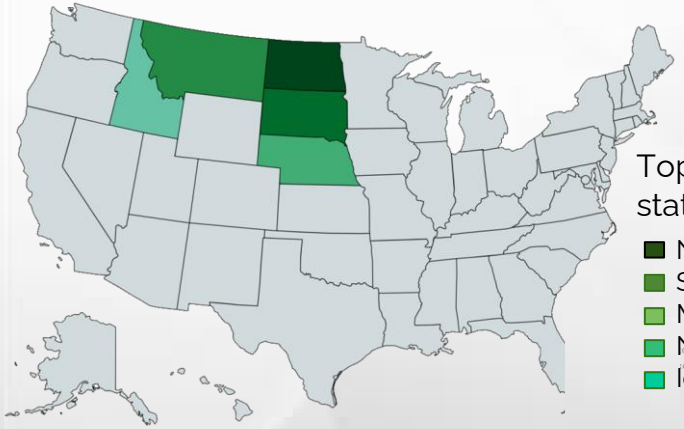
- ❑ **KPI** Chart (Key Performance Indicator)
- ❑ Logistics Tracking **Dashboard**
- ❑ **Reviews** on daily, weekly and monthly basis

So that we can **recalibrate supply** to meet the changing demand

Finding the root problems to manage the situation in a constructive way

Team NOOB

RANK 1	NORTH DAKOTA	RANK 2	SOUTH DAKOTA	RANK 3	MONTANA	RANK 46	NEW YORK
Population	■□□□□	Population	■■□□□	Population	■■■□□	Population	■■■■■
Area	■■□□□	Area	■■■□□	Area	■■■■■	Area	■□□□□
Awareness	■■□□□	Awareness	■■□□□	Awareness	■■■□□	Awareness	■■■■□
Healthcare	4.5	Healthcare	7.8	Healthcare	5.7	Healthcare	9.7
Labour force	8.0	Labour force	7.1	Labour force	7.3	Labour force	6.5
Covid cases	9.5	Covid cases	8.0	Covid cases	6.4	Covid cases	4.8
Mobility	7.8	Mobility	8.9	Mobility	8.3	Mobility	4.2
Overall		Overall		Overall		Overall	
Electric Sales	9.8	Electric Sales	9.3	Electric Sales	7.2	Electric Sales	5.8



Top affected states

- North Dakota
- South Dakota
- Montana
- Nebraska
- Idaho

Source: Dataset given in Round 1

RECOMMENDATIONS

NORTH DAKOTA	SOUTH DAKOTA	MONTANA
• Immediate support on healthcare **staffing shortage**. • Increased **initial claims** to labour force.	• Strict restrictions on **public gathering and rallies**. • Restrictions on some **inessential commerce.**	• Support on healthcare **infrastructure**. • **Roll out outings** to deal with pandemic fatigue .

All the top affected states are **adjacent** and **far from capital region.**

SPECIALISED CENTER

~2x Execution and reachability

Problem | Methodology | Insights | Preprocessing | Evaluation | Transportation | Analysis

Appendix- Country Stats

State	July 2019 Estimate	Area (square miles, including water)	State	July 2019 Estimate	Area (square miles, including water)	State	July 2019 Estimate	Area (square miles, including water)
Alabama	49,03,185	52,419 sq mi	Kentucky	44,67,673	40,410 sq mi	North Dakota	7,62,062	70,700 sq mi
Alaska	7,31,545	663,267 sq mi	Louisiana	46,48,794	51,840 sq mi	Ohio	1,16,89,100	44,825 sq mi
Arizona	72,78,717	113,998 sq mi	Maine	13,44,212	35,385 sq mi	Oklahoma	39,56,971	69,899 sq mi
Arkansas	30,17,825	53,179 sq mi	Maryland	60,45,680	12,407 sq mi	Oregon	42,17,737	98,380 sq mi
California	3,95,12,223	163,695 sq mi	Massachusetts	69,49,503	10,555 sq mi	Pennsylvania	1,28,01,989	46,056 sq mi
Colorado	57,58,736	104,093 sq mi	Michigan	99,86,857	96,716 sq mi	Rhode Island	10,59,361	1,545 sq mi
Connecticut	35,65,287	5,544 sq mi	Minnesota	56,39,632	86,938 sq mi	South Carolina	51,48,714	32,020 sq mi
DC	7,05,749	2,489 sq mi	Mississippi	29,76,149	48,431 sq mi	South Dakota	8,84,659	77,121 sq mi
Delaware	9,73,764	68.25 sq mi	Missouri	61,37,428	69,704 sq mi	Tennessee	68,33,174	42,144 sq mi
Florida	2,14,77,737	65,755 sq mi	Montana	10,68,778	147,042 sq mi	Texas	2,89,95,881	268,580 sq mi
Georgia	1,06,17,423	59,425 sq mi	Nebraska	19,34,408	77,358 sq mi	Utah	32,05,958	84,898 sq mi
Hawaii	14,15,872	10,931 sq mi	Nevada	30,80,156	110,560 sq mi	Vermont	6,23,989	9,615 sq mi
Idaho	17,87,065	83,570 sq mi	New Hampshire	13,59,711	9,350 sq mi	Virginia	85,35,519	42,774 sq mi
Illinois	1,26,71,821	57,914 sq mi	New Jersey	88,82,190	8,722 sq mi	Washington	76,14,893	71,300 sq mi
Indiana	67,32,219	36,418 sq mi	New Mexico	20,96,829	121,589 sq mi	West Virginia	17,92,147	24,230 sq mi
Iowa	31,55,070	56,271 sq mi	New York	1,94,53,561	54,556 sq mi	Wisconsin	58,22,434	65,498 sq mi
Kansas	29,13,314	82,276 sq mi	North Carolina	1,04,88,084	53,818 sq mi	Wyoming	5,78,759	97,813 sq mi

Source: Infoplease and Dataset given in Round 1

Appendix- Outsourcing Stats

Benefits of outsourcing the vaccine distribution process in the United States.

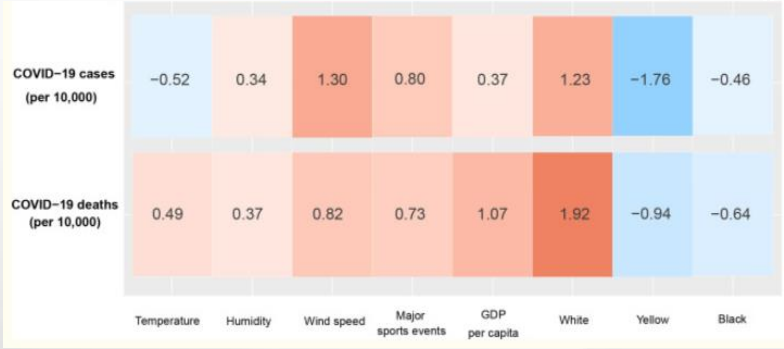
	1994	2008
Public-sector cost	US$200 million	US$3 billion
Number of vaccines	6	12
Funds allocation	64 lines of credit	One centralized account
Distribution	64 independent distribution systems operating their own storage depots (430 nationwide)	One company distributes vaccines with a few depots and guarantees performance
Delivery	Up to 4 weeks	3 to 8 days

Source: WHO

The comparative benefits of outsourcing in South Africa and Thailand.

	South Africa	Thailand
In-house supply chain cost (percentage of vaccine cost)	28%*	31%
Outsourced supply chain cost (percentage of vaccine cost)	6%	5%

Source: WHO



Source: https://doi.org/10.1016/j.puhe.2020.11.008