

# Comparative Analysis: Cybersecurity Breaches in Hospitals Nationwide

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# Overview

Cybersecurity is the practice of protecting networks and systems from digital attacks. Effective cybersecurity is designed to preserve the confidentiality, integrity, and availability of important data.

Cybersecurity breaches can have extremely damaging effects on individuals and/or organizations. In **2022, \$64.86 billion** was invested into cybersecurity in the U.S. alone! Its estimated that this cost is to increase to **\$113.8 billion** by the year **2028!**



# Recent Major Cybercrime Attacks

**HCA Healthcare:** This third-party storage breach leaked over 11 million patients personal information across 20 states. HCA did not use reasonable security procedures for its patients/customers and most personal information extracted from emails and calendar reminders.

**Medibank:** Russian hackers used a ransomware to steal 9.7 million users information and wanted 10 million dollars to return it. This affected high ranking politicians in Australia including the Prime Minister.

**Regal Medical Group:** In California from 2022 to early 2023, this medical group was targeted by a ransomware attack that affected 3.3 million patients. These patients were threatened to, in a sense, have their specific information held hostage. The attackers threatened to release addresses, DOB, diagnosis/treatment, Social Security number, test results, phone numbers, etc.



# Why is cybercrime a problem in healthcare?

- High volume and valuable datasets
- HIPAA Act of 1996 was created to increase standards across America to protect sensitive patient health information
  - This act has not stopped cyber attacks across the nation
- Demand and monetary value for information on the black market
  - Leaked patient portfolios can lead to a compromise of sensitive information
- Cybercrime can disrupt daily care, slow, or even stop treatment, and in worst cases cause death
- Hospitals can go under due to ransoms being paid
- Most hospitals use outdated technology



# Problem

There has been a huge increase (53%!) in data breaches across the United States in hospitals/healthcare in the past three years. These data breaches can affect anywhere between one patient to over millions of patients.

The HIPAA Act was created in order to protect hospitals from attacks, yet the number of breaches continue to climb with 2023 being the highest amount of security breaches in history. It is important to hospitals to figure out how to stop these attacks, as it could save them from paying a large sum of money for ransom and make sure the patient's private information is not leaked.



# Business Question

How do characteristics of hospitals affect the amount of patients falling victim of a Cyber Attack?



# Preprocessing

1. Pulled datasets from CMS health and US Dept. of Health and Human Services
2. Eliminate variables deemed unnecessary
3. Merged variables
4. Standardized variables
5. Change target variable to categorical
6. Split up data into 4 excel sheets sorted by severity



# Our Data

We took many variables into consideration in order to find the perfect answer to the business question stated before. We decided to check each hospital's:

- |  |  |                            |
|--|--|----------------------------|
| - Name                                   | - City   | - inpatient total charges  |
| - Street Address                         | - Rural vs. Urban                              | - Outpatient total charges |
| - CCN Facility Type                      | - FTE - Employees on payroll                   | - Total salaries           |
| - # of Interns and residents - # of beds |  | - Total Bed available      |
| - Depreciation cost                      | - Total cost                                   | - Cash on hand & Banks     |
| - Accounts receivable                    | - Total Current Assets                         | - Investments              |
| - Total Assets                           | - Total liabilities                            | - Total patient revenue    |
| - Total income                           | - Cost to Charge Ratio                         |                            |
| - Breach Intensity                       | - Size of breach/Individuals affected (Target) |                            |

Note: In summary, we will focus on financials, size of hospital, area of hospital, and the breaches that have occurred in this time table. Our information goes from 2011-2021.



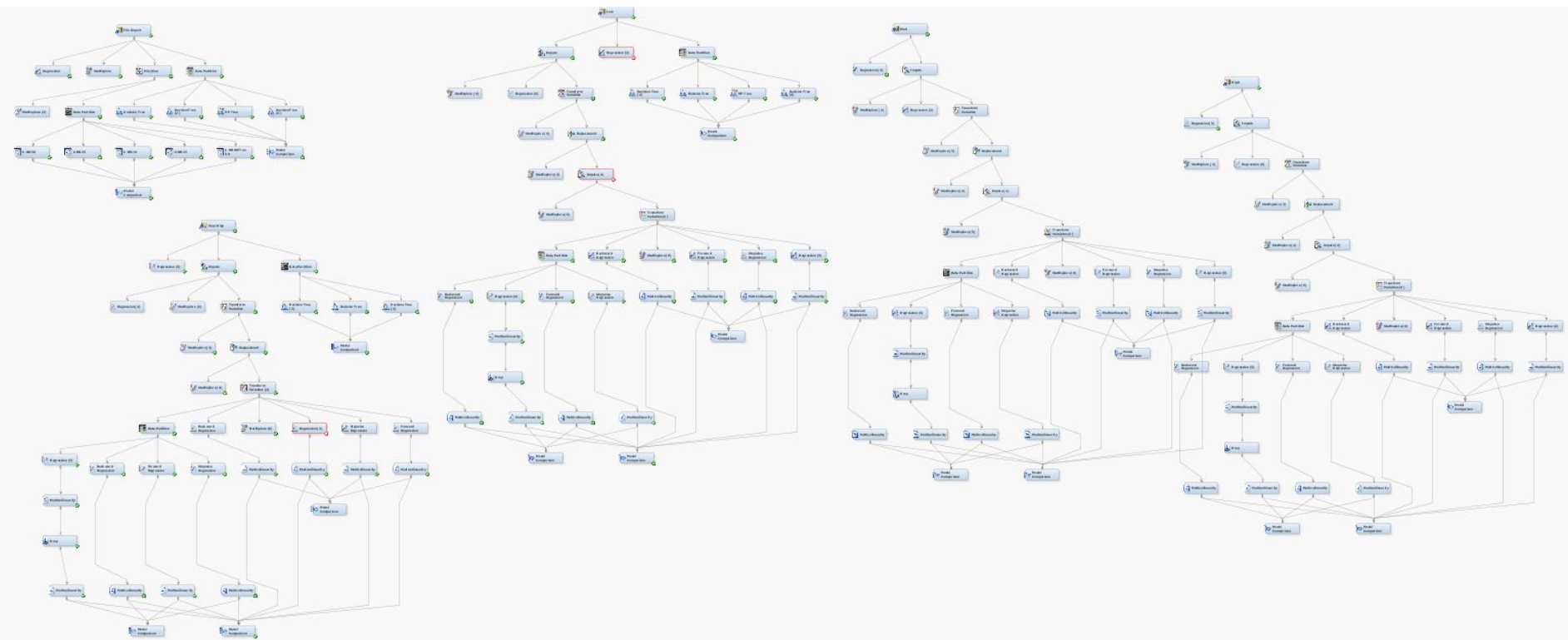


# Our Data

- The data is split up into 4 levels of severity
- 0-1,126 is low severity
- 1,127-3,000 is medium severity
- 3,000-12,486 is high severity
- 12,487+ is very high severity

Target Profile		
Ordered Value	Breach Intensity	Total Frequency
1	Very-High	402
2	Med	428
3	Low	387
4	High	374

# Process Flow





# Regression - Very High

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	t Value	Pr >  t
Intercept	1	283737	85607.5	3.31	0.0014
Accounts_Payable	1	-0.00025	0.000411	-0.62	0.5371
Accounts_Receivable	1	0.000041	0.000297	0.14	0.8905
Cash_on_Hand_and_in_Banks	1	0.000900	0.000540	1.67	0.0999
Depreciation_Cost	1	0.000810	0.00346	0.23	0.8157
FTE_Employees_on_Payroll	1	-75.5962	113.2	-0.67	0.5064
Inpatient_Revenue	1	0.000433	0.000583	0.74	0.4595
Inpatient_Total_Charges	1	-0.00042	0.000573	-0.73	0.4657
Investments	1	0.000282	0.000317	0.89	0.3756
Net_Income	1	0.000029	0.000936	0.03	0.9751
Number_of_Beds	1	1286.1	2797.0	0.46	0.6469
Number_of_Interns_and_Residents	1	561.6	487.5	1.15	0.2529
Outpatient_Revenue	1	0.000176	0.000332	0.53	0.5986
Outpatient_Total_Charges	1	-0.00022	0.000386	-0.57	0.5680
Total_Assets	1	-0.00028	0.000264	-1.05	0.2984
Total_Bed_Days_Available	1	-3.8107	7.4082	-0.51	0.6085
Total_Costs	1	0.000077	0.000439	0.17	0.8621
Total_Current_Assets	1	0.000214	0.000300	0.71	0.4773
Total_Current_Liabilities	1	-0.00007	0.000470	-0.15	0.8821
Total_Income	1	0.000673	0.00115	0.59	0.5585
Total_Liabilities	1	0.000027	0.000185	0.15	0.8844
Total_Patient_Revenue	0	0	.	.	.
Total_Salaries_adjusted_	1	0.000324	0.000946	0.34	0.7327

## Equation:

**Breach Total** = -0.00025 \* Account payable + 0.000041 \* Accounts Receivable + 0.0009 \* Cash on Hand in Banks + 0.00081 \* Depreciation Cost - 75.60 \* Employees on Payroll + 0.00043 \* Inpatient Revenue - 0.00042 \* Impatient Total Charges + 0.00028 \* Investments + 0.000029 \* Net Income + 1286.1 \* Number of Beds + 561.6 \* Number of interns and residents + 0.00018 \* Outpatient Revenue - 0.0002 \* Outpatient Total Charges - 0.00028 \* Total Assets - 3.8107 \* Total Bed Days Available + 0.000077 \* Total Costs + 0.000214 Total Current Assets - 0.00007 \* Total Current Liabilities + 0.000673 \* Total Income + 0.000027 \* Total Liabilities + 0.000324 \* Total Salaries Adjusted

# Regression - High

## Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	t Value	Pr >  t
Intercept	1	5224.9	726.9	7.19	<.0001
Accounts_Payable	1	7.716E-6	0.000019	0.40	0.6918
Accounts_Receivable	1	-1.79E-6	3.372E-6	-0.53	0.5976
Cash_on_Hand_and_in_Banks	1	-2.03E-6	7.165E-6	-0.28	0.7778
Depreciation_Cost	1	-0.00003	0.000026	-1.13	0.2620
FTE_Employees_on_Payroll	1	-0.4669	0.5026	-0.93	0.3560
Inpatient_Revenue	1	0.000016	7.538E-6	2.15	0.0346
Inpatient_Total_Charges	1	-0.00002	7.298E-6	-2.20	0.0307
Investments	1	-7.36E-7	2.505E-6	-0.29	0.7698
Net_Income	1	-3.24E-6	9.599E-6	-0.34	0.7364
Number_of_Beds	1	11.5224	19.4053	0.59	0.5545
Number_of_Interns_and_Residents	1	-2.5630	3.6757	-0.70	0.4879
Outpatient_Revenue	1	8.066E-6	6.114E-6	1.32	0.1913
Outpatient_Total_Charges	1	-8.58E-6	6.558E-6	-1.31	0.1947
Total_Assets	1	-1.73E-6	2.276E-6	-0.76	0.4498
Total_Bed_Days_Available	1	-0.0279	0.0520	-0.54	0.5928
Total_Costs	1	9.875E-6	4.49E-6	2.20	0.0311
Total_Current_Assets	1	1.341E-6	6.256E-6	0.21	0.8309
Total_Current_Liabilities	1	-2.43E-6	2.764E-6	-0.88	0.3828
Total_Income	1	-6.6E-6	0.000012	-0.57	0.5733
Total_Liabilities	1	2.694E-6	2.519E-6	1.07	0.2884
Total_Patient_Revenue	0	0	.	.	.
Total_Salaries_adjusted	1	-2.64E-6	6.395E-6	-0.41	0.6811

## Equation:

**Breach Total** = 5224.9 + 7.716E-6 \* Accounts\_Payable - 1.79E-6 \* Accounts\_Receivable - 2.03E-6 \* Cash\_on\_Hand\_and\_in\_Banks - 0.000003 \* Depreciation\_Cost - 0.4669 \* FTE\_Employees\_on\_Payroll + 0.000016 \* Inpatient\_Revenue - 0.000002 \* Inpatient\_Total\_Charges - 7.36E-7 \* Investments - 3.24E-6 \* Number\_of\_Beds - 2.5630 \* Number\_of\_Interns\_and\_Residents + 8.066E-6 \* Outpatient\_Revenue - 8.58E-6 \* Outpatient\_Total\_Charges - 1.73E-6 \* Total\_Assets - 0.0279 \* Total\_Bed\_Days\_Available + 9.875E-6 \* Total\_Costs + 1.341E-6 \* Total\_Current\_Assets - 2.43E-6 \* Total\_Current\_Liabilities - 6.6E-6 \* Total\_Income + 2.694E-6 \* Total\_Liabilities - 2.64E-6 \* Total\_Salaries\_adjusted



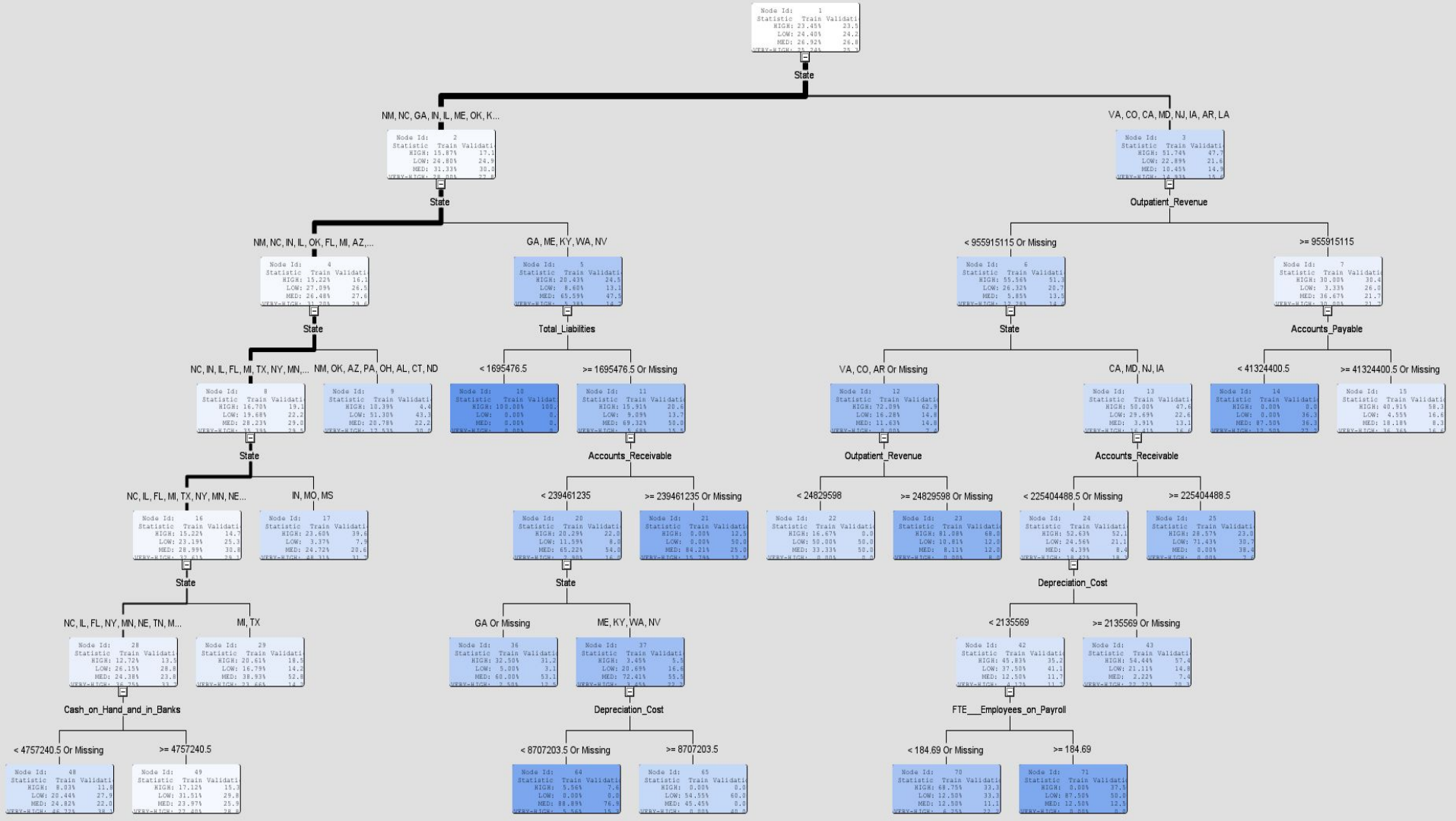
# Regression - Medium

Analysis of Maximum Likelihood Estimates

Parameter	DF	Estimate	Standard Error	t Value	Pr >  t
Intercept	1	1928.7	138.7	13.91	<.0001
Accounts_Payable	1	1.19E-6	1.678E-6	0.71	0.4801
Accounts_Receivable	1	7.737E-7	5.755E-7	1.34	0.1827
Cash_on_Hand_and_in_Banks	1	1.553E-6	8.652E-7	1.80	0.0764
Depreciation_Cost	1	9.878E-6	5.479E-6	1.80	0.0752
FTE_Employees_on_Payroll	1	0.2869	0.1538	1.87	0.0657
Inpatient_Revenue	1	1.018E-8	6.813E-7	0.01	0.9881
Inpatient_Total_Charges	1	-4.95E-8	6.786E-7	-0.07	0.9420
Investments	1	-2.19E-7	5.112E-7	-0.43	0.6699
Net_Income	1	-1.91E-6	1.546E-6	-1.24	0.2200
Number_of_Beds	1	9.3771	10.0238	0.94	0.3524
Number_of_Interns_and_Residents	1	-1.4437	0.9391	-1.54	0.1282
Outpatient_Revenue	1	-5.48E-8	6.258E-7	-0.09	0.9304
Outpatient_Total_Charges	1	-2.08E-7	7.084E-7	-0.29	0.7696
Total_Assets	1	-4.44E-7	4.806E-7	-0.92	0.3581
Total_Bed_Days_Available	1	-0.0280	0.0281	-1.00	0.3216
Total_Costs	1	1.53E-7	1.065E-6	0.14	0.8861
Total_Current_Assets	1	1.437E-8	7.299E-7	0.02	0.9843
Total_Current_Liabilities	1	1.704E-7	1.046E-6	0.16	0.8710
Total_Income	1	6.226E-7	1.281E-6	0.49	0.6283
Total_Liabilities	1	4.267E-7	5.212E-7	0.82	0.4155
Total_Patient_Revenue	0	0	.	.	.
Total_Salaries_adjusted	1	-2E-6	1.859E-6	-1.07	0.2863

## Equation:

**Breach Total** = 1928.7 + 1.19E-6 \* Accounts\_Payable + 7.737E-7 \* Accounts\_Receivable + 1.533E-6 \* Cash\_on\_Hand\_and\_in\_Banks + 9.878E-6 \* Depreciation\_Cost + 0.2869 \* FTE\_Employees\_on\_Payroll + 1.018E-3 \* Inpatient\_Revenue - 4.95E-3 \* Inpatient\_Total\_Charges - 2.19E-7 \* Investments - 1.91E-6 \* Number\_of\_Beds - 1.4437 \* Number\_of\_Interns\_and\_Residents - 5.48E-3 \* Outpatient\_Revenue - 2.08E-7 \* Outpatient\_Total\_Charges - 4.44E-7 \* Total\_Assets - 0.0200 \* Total\_Bed\_Days\_Available + 1.53E-7 \* Total\_Costs + 4.37E-3 \* Total\_Current\_Assets + 1.704E-7 \* Total\_Current\_Liabilities + 6.226E-7 \* Total\_Income + 4.267E-7 \* Total\_Liabilities - 2E-6 \* Total\_Salaries\_adjusted





# Decision Tree

```
if State IS ONE OF: NC, IL, FL, NY, MN, NE, TN, MA or MISSING  
AND Cash_on_Hand_and_in_Banks >= 4757241  
then
```

```
Tree Node Identifier    = 49  
Number of Observations = 146  
Predicted: Breach_Intensity=Very-High = 0.27  
Predicted: Breach_Intensity=Med = 0.24  
Predicted: Breach_Intensity=Low = 0.32  
Predicted: Breach_Intensity=High = 0.17
```

```
if State IS ONE OF: NC, IL, FL, NY, MN, NE, TN, MA or MISSING  
AND Cash_on_Hand_and_in_Banks < 4757241 or MISSING  
then
```

```
Tree Node Identifier    = 48  
Number of Observations = 137  
Predicted: Breach_Intensity=Very-High = 0.47  
Predicted: Breach_Intensity=Med = 0.25  
Predicted: Breach_Intensity=Low = 0.20  
Predicted: Breach_Intensity=High = 0.08
```

```
if State IS ONE OF: IN, MO, MS  
then
```

```
Tree Node Identifier    = 17  
Number of Observations = 89  
Predicted: Breach_Intensity=Very-High = 0.48  
Predicted: Breach_Intensity=Med = 0.25  
Predicted: Breach_Intensity=Low = 0.03  
Predicted: Breach_Intensity=High = 0.24
```



# Recommendations

- High Intensity cases where breach total is 12,487+ should be a focus
- Not all cases are made the same
- States NC, IL, FL, NY, MN, NE, TN, MA who have less than \$4,757,241 cash on hand or in the bank are very likely to be attacked
- States IN, MO, MS in general need to be ready for attacks





# Sources

<https://www.expressvpn.com/blog/cybersecurity-spending/> - \$64.86 billion invested in cybersecurity in 2022. \$113.8 billion expected in 2028

<https://www.upguard.com/blog/biggest-data-breaches-us> - largest cybercrime attacks in the US

<https://arcticwolf.com/resources/blog/top-healthcare-industry-cyberattacks/> Recent major breaches

<https://data.cms.gov/summary-statistics-on-use-and-payments/medicare-service-type-reports/medicare-telehealth-trends> - Hospital Information

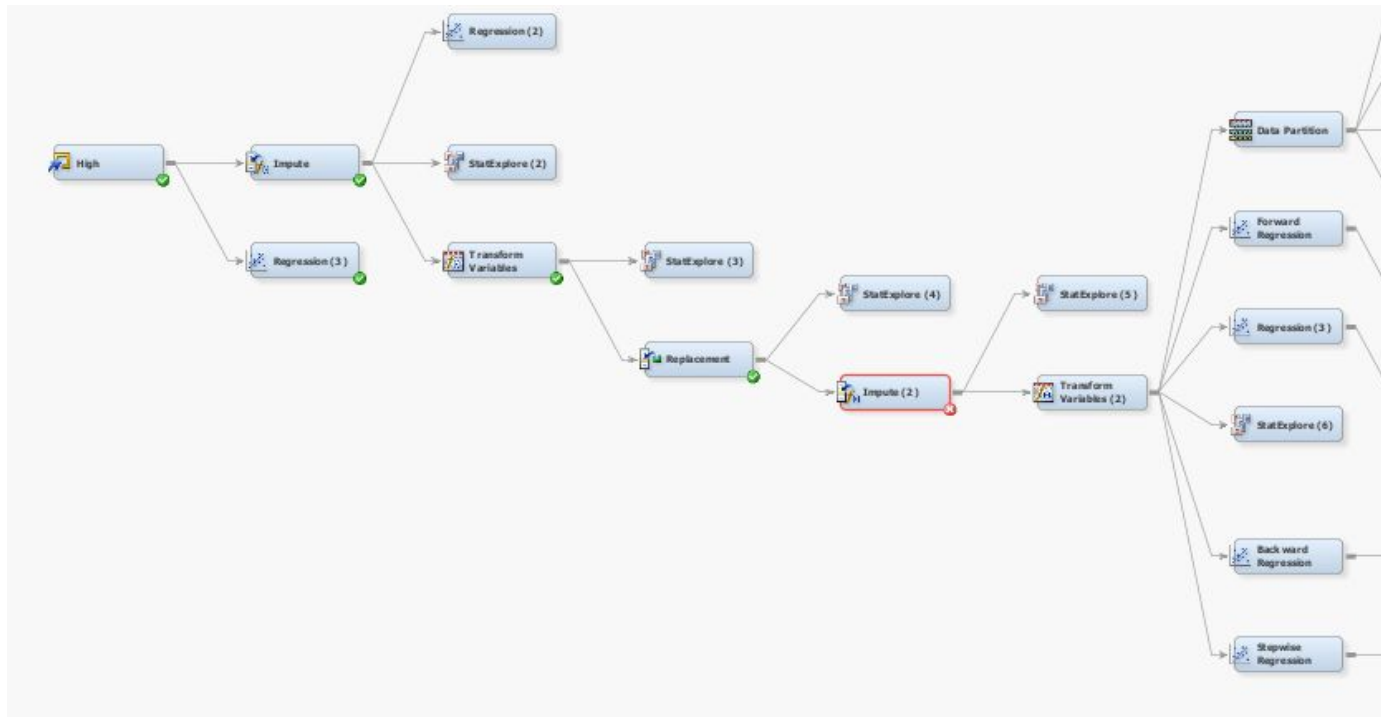
<https://www.definitivehc.com/resources/healthcare-insights/25-hospitals-highest-operating-budget-> Hospital Financials



# **Any Questions?**

Thank you for your time

# Appendix





# Appendix

## Variable Summary

Role	Measurement Level	Frequency Count
REJECTED	INTERVAL	22
TARGET	INTERVAL	1

## Interval Variable Summary Statistics (maximum 500 observations printed)

Data Role=TRAIN

Variable	Role	Mean	Standard Deviation	Non Missing	Missing	Minimum	Median	Maximum	Skewness	Kurtosis
Breach_Total	TARGET	76784.17	1256711	4438	1	500	3660	78800000	56.09928	3477.092