# Health Information Data Breaches

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## Abstract

This paper describes the use of a visualization tool to enhance healthcare data security and protect patient data. This paper highlights two domain tasks for a healthcare organization, wherein their end goals consist of conducting a risk assessment and developing a data security strategy. The tool enables healthcare organizations to identify connections with regions of the United States that have experienced data breaches, which can help them assess potential risks and develop targeted data security strategies. By using the tool to conduct risk assessments and develop data security strategies, healthcare organizations can comply with privacy regulations, reduce reputational damage, and increase trust with their patients. In addition, the tool can also be useful for healthcare users who are choosing a healthcare entity in a specific state of the United States, as it allows them to view states that have been affected by data breaches or information exposure, and make an informed decision about where to entrust their data.

## 1 Introduction

Healthcare organizations face significant challenges in safeguarding patient data due to the constantly evolving threat of cyberattacks. A data breach could not only result in reputational damage and legal consequences, but also cause harm to patients. Healthcare organizations need to conduct regular risk assessments to identify potential vulnerabilities and threats to patient data security and develop data security strategies to mitigate those risks. The use of a visualization tool may be effective for healthcare organizations to enhance their security systems and safeguard patient data. This visualization tool will showcase health data breaches reported by the U.S. Department of Health and Human Services that are currently being investigated by the Office for Civil Rights. Attributes that will be visible are the name of the state, the state the breach occurred, the number of breaches by breach type, type of breach, location of breach information, and the year of breach. This can be used to identify connections with states that have experienced data breaches, allowing healthcare organizations to conduct more targeted risk assessments and develop more effective data security strategies.

This visualization will support two domain tasks. The first is conducting a risk assessment. Healthcare organizations need to conduct regular risk assessments to identify potential vulnerabilities and threats to patient data security. By using the visualization tool to identify connections with states that have experienced data breaches, the healthcare organization can conduct a more targeted risk assessment that focuses on specific areas of concern based on the type of data breach. This task requires specialized knowledge of healthcare data security and risk management principles, as well as the ability to analyze data and identify potential risks. Another domain task is developing a data security strategy. Once potential risks have been identified through the risk assessment, the healthcare organization needs to develop a data security strategy to mitigate those risks. This task requires a deep understanding of healthcare data security regulations and best practices, as well as the ability to develop and implement effective security measures. By using the visualization tool to identify connections with states that have experienced data breaches, the healthcare organization can develop a more targeted data security strategy that addresses specific areas of concern.

## 2 Related Work

A group of researchers wanted to examine the transition from paper health records to electric health records and the increase in data breaches [1]. They used public data to examine the nature and extent of data breaches from 2010 to 2017. The visualizations presented in this paper will be beneficial as a resource since similar data is used within our chosen dataset and cover various aspects of the data. In Figure 1, a line plot is created that shows the year vs. the number of breaches. There are three different lines that represent a HIPAA entity type which is shown in their own distinct colors. For our visualization, we could create a line plot that shows the covered entity type with the associated number of breaches and distinguish them with different colors. In Figure 2, a line plot is created that shows the year vs. the number of breaches. There are six different lines to represent the media location and breach data. This could be helpful for our dataset since we also work with similar data.

Researchers discusses how although digital healthcare services have made it easier and more accessible for patients to view their records and receive treatment, the present-day healthcare industry has been a prominent victim of internal and external breach attacks [2]. They performed an in-depth analysis of healthcare data breaches and drew inferences to improve healthcare data confidentiality. A visualization in this paper could be advantageous as a resource because of the way they incorporated channels to better envision their data. In Figure 5, the visualization compares the year vs. the number of associated data breaches using a grouped bar chart. Each bar for a certain year represents the type of breach location but is distinguished by its own distinct color. This concept allows readers to clearly see which breach was more popular to take place during a certain year or time period. For example, in 2019, a data breach via email was the most common breach while in 2010, it was one of the least common breaches. This shows the impact of how the increase in technology use has made companies and digital health platforms more at risk of data breaches.

## 3 Use Case

A healthcare organization is taking proactive steps to enhance their security system and safeguard patient data. They recognize that a data breach could not only result in reputational damage and legal consequences, but also cause harm to their patients. They plan to use a visualization tool to identify any connections with states in the United States that have experienced data breaches. By doing so, they can assess the potential impact on their own systems and procedures, and develop strategies to mitigate any risks. This would not only help them to comply with privacy regulations but also increase trust with their patients.

In addition to being a useful tool for healthcare organizations, the visualization tool could also be relevant to healthcare users who are choosing a healthcare entity in a region of the United States. They could use the tool to view the states that have been affected by data breaches or information exposure. By seeing this information, users could make an informed decision about whether they feel comfortable entrusting their data in an organization based in a specific state or whether they should consider an alternative option.

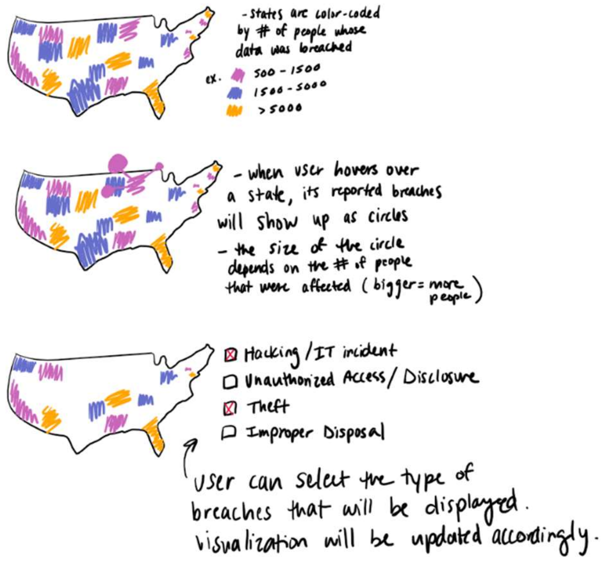
## 4 Data

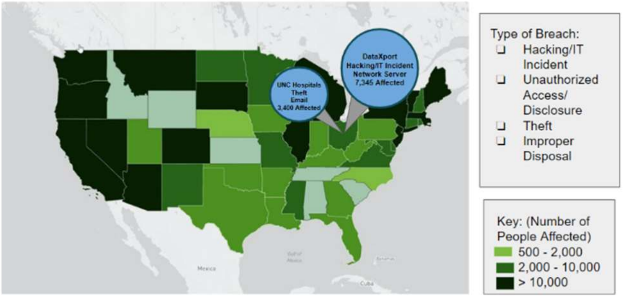
The data was collected by the U.S. Department of Health and Human Services that are currently being investigated by the Office for Civil Rights. The original dataset can be found in this link: https://ocrportal.hhs.gov/ocr/breach/breach_report.jsf. The U.S. Department of Health and Human Services is a sector of the United States government that promotes the well-being and health of all Americans by supporting services that emphasize the science behind medicine, public health, and social services. The data demonstrates a list of data breaches reported within the last 24 months that have affected 500 or more individuals with unsecured health information. It shows the name of the covered entity, also known as the organization or company that was affected by a data breach, the type of covered entity, and the type of breach. Additionally, the state, the date of the submitted breach, and the number of individuals affected are shown.

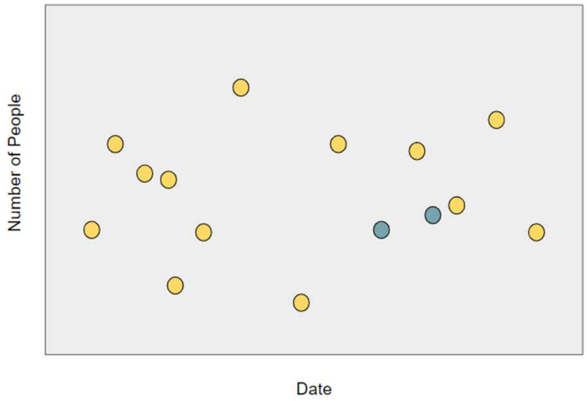
Since this data is directly submitted to the U.S. government, there should be no bias as it is information that should be neutralized without any preference. The data is covered from all places around the United States and does not only show one part of the country. The only aspect that is disadvantageous is the option of "Other" which is included in the "Type of Breach" column. This option does not fully specify what type of breach was committed. This information should be fully open about every type of data breach that exists to create more awareness among users of healthcare and allow readers of the data to see if a specific type was more common compared to other breaches or if it would have an impact on the statistics of the data.

The data doesn't have any missing or unexpected values. There are no outliers, and the data contains all the attributes we want to visualize. However, the values under "Name of Covered Entity" in the data are messy, containing characters that do not make logical sense, extraneous information, and inconsistent capitalization and formatting (ex. "doing business as" is written as "d/b/a", "dba", "doing business as"). In terms of data cleaning, there was an additional column included called "Web Description" that had no data, so this column was removed since it was not essential to our visualization. There were also white spaces towards the end of certain words which were eventually removed. All the data had consistent wording and spelling and did not require any change. There were no new, derived attributes added to the data.

## 5 Design Process


- States are color-coded by # of people whose data was breached
ex.
500 - 1500
1500 - 5000
> 5000
- when user hovers over a state, its reported breaches will show up as circles
- the size of the circle depends on the # of people that were affected (bigger = more people)
☒ Hacking / IT incident
☐ Unauthorized Access / Disclosure
☒ Theft
☐ Improper Disposal
user can select the type of breaches that will be displayed. visualization will be updated accordingly.





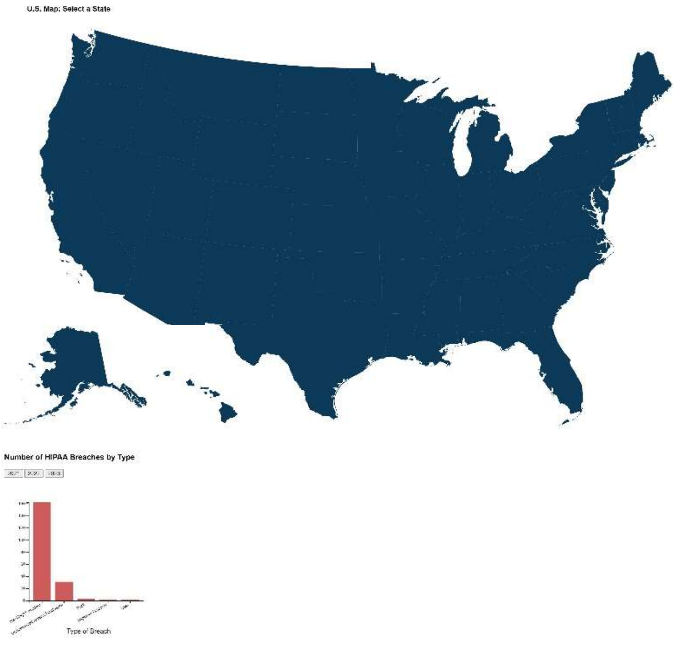
Breaches will be displayed geographically on a U.S. map. The states will be color-coded using a gradient to distinguish how many people were affected by breaches (the darker the hue is, the more people were affected, and vice versa). When a user hovers over a state, the state will highlight, and its individual breaches will pop-up and enlarge as circles with pointers to the state. Each circle will contain more details about the breach, such as the organization, the type of breach, what was breached, and the number of people affected. The size of these circles will reflect how many people were affected (the bigger the circle is, the more people were affected, and vice versa). The user can also select the type of breach they want to see, and the visualization will update accordingly.

A separate view will display a scatter plot plotting the date of breach and the number of people affected. When a user hovers over a state, the points on the scatter plot that coordinate with the breaches present in that state will change color.

The final visualization design continuously evolved during the implementation process. The bar chart was a new implementation. Instead of displaying data breaches as bubbles that show on hover on the U.S. map, the data displays on a bar chart after the user clicks on a state. This design choice allows the user to see the difference in the prevalence of a type of data breach more accurately. Moreover, a feature to filter by year was included. This allows the user to view the data on different timelines according to their interest. At the time of usability testing, only the bar chart was implemented. As a result, state by state data was not displayed. Participants were asked to find how many Hacking/IT Incidents there were in 2022. They were also asked to find what type of data breach was most prevalent in 2021. Because the target user is analyzing the prevalence of different types of data breaches, these tasks mimic how the target user would use the visualization. Participants' answers were collected and checked to see if they were correct. Based on the results, users were able to complete the given tasks with 100% accuracy. This ensured the bar chart was well-designed and easy to use.

In designing the U.S. state map, data breaches were removed from showing up on user hover and was no longer color-coded by the number of people affected. This design choice allows the user to select the desired state before seeing its relevant data. This change was a result of the target user already knowing the state they want to look at, so displaying data for all states was unnecessary.

## 6 Final Design



This visualization is designed to show the number of HIPAA data breaches in the United States from 2021-2023. It contains an interactive United States map that is linked to a bar chart that shows the number of HIPAA data breaches by the type of data breach which is either a hacking/IT incident, unauthorized access/disclosure, theft, improper disposal, and loss. The bar chart contains a filter that allows the user to click on a year from 2021-2023 to see the data for a state in that year. To use the visualization, the user would first need to click on a state in the United States map which will then be highlighted from blue to red. Once a state is selected, the user will scroll down to the bar chart and click on a year from the filter buttons. Once a filter button is selected, the user will be able to see the amount of data breaches by data breach type for that year for that specific state. Since the data is updated by year, the user can click on the other filter buttons to see the data for another year. If a user wanted to see the data for another state, they would go back to the United States map and click on another state. Once another state is selected, the user would repeat the steps by going to the bar chart and clicking on a filter button to see the data for the specific year. If a user would like to see the number of HIPAA breaches by type for the United States as a whole, the user could click on any whitespace or any spot outside of the United States map, scroll down to the bar chart, and click on a filter button. This would allow the user to see the number of HIPAA breaches by type for the United States in general for each year from 2021-2023.

Since the United States map is interactive and linked to the bar chart, the target user would be able to see the number of HIPAA breaches by type for that specific state for a chosen year. With the bar chart, the target user would create comparisons for the number of data breaches by the data breach type for a specific state throughout 2021-2023 to see any increases or decreases in the overall state of security of patient health data. Additionally, the target user could create comparisons for the amount of data breaches by data breach type for different states and see which states need to be prioritized to implement more secure data strategies within companies and organizations. The target user could also see how data breaches are affecting the states that are known to have a higher population and usage of digital health records compared to the states that do not use these resources.

## 7 Discussion

Our visualization tool provides a solution to our domain problem by presenting HIPAA data breaches by type throughout the United States from 2021-2023. Additionally, it allows the user to see the number of breaches that occurred in a certain year by each type. It shows foundational information that could potentially benefit health companies and organizations to create more security protocols and conduct risk assessments. However, certain features could have been included to demonstrate the importance of the domain problem and how much of a negative impact data breaches have on the protection and security of individual health data.

An additional feature that could be implemented is showing the number of people that were affected since a single data breach could impact thousands of people. To implement this feature, it would be beneficial to have a grouped bar chart with the same axis that we originally had. It would have one bar that represented the number of breaches that occurred as well as the number of people that were affected for each data breach type. For example, for the data breach type "Unauthorized Access/Disclosure", there would be two different colored bars where one bar represents the number of breaches that were of this data breach type as well as another bar that represented the number of people that were affected by this type of breach.

Another feature that could be implemented is showing the type of information that was released such as financial information, personal contact details, medical records, or other examples of sensitive data. This could be represented in another visual encoding that includes the bar chart and the United States map. To implement this feature, a user could click on a bar on the bar chart which would be linked to a pie chart that showed the percentages of sensitive information that was released by that type of data breach. These features would allow the user to see how much of a detrimental impact data breaches have had on the United States population and analyze what further steps could be taken to have more restrictive security measures. Additionally, the user can see what type of information needs to be prioritized in terms of security and protection to reduce harm to the data of health patients. To implement these features, we would have to do further research on other datasets since this information is not available in the dataset that we chose.

In terms of our current visualization, one improvement could be the layout of our filter buttons. To make the visualization more appealing and useful for the user, we could add a box that has a caption that says, "Press the following buttons to show the HIPAA data breaches for a certain year". The following buttons would be the buttons we have for the different labels which are labeled "2021", "2022", and "2023". Another improvement would be reducing the size of the United States map to have the bar chart be adjacent to the map. This would allow the user to see the entire visualization and the data presented simultaneously while interacting with the map instead of having to scroll down to see the data in the bar chart.

## 8 Conclusion

The creation of this visualization tool serves the purpose of bolstering healthcare data security and safeguard patient data. This visualization assists two domain tasks for healthcare organizations and companies - conducting a risk assessment and formulating data security strategies, ultimately aiming to achieve the reduction in reputational harm, the gaining of patients' trust, and regulatory compliance. This visualization may be effective for healthcare organizations to enhance their security systems and safeguard patient data in a particular region of the United States. Additionally, it can identify connections with states that have experienced data breaches, allowing healthcare organizations to conduct a more targeted risk assessment and develop more effective data security strategies.

We extracted data from health data breach reports from 2021 to 2023 collected by the U.S. Department of Health and Human Services. We created an interactive United States map that links to a bar chart that presents the number of HIPAA data breaches by data breach type. We included a filter for the years 2021, 2022, and 2023 to allow the user to see the health data breaches for a selected year for a specific state. We also included a feature for the user to see the number of data breaches by data breach type for the United States as a whole with the help of the filter buttons to show the data breaches for each year from 2021 to 2023.

## References

[1] McCoy, T. H., Jr, & Perlis, R. H. (2018). Temporal trends and characteristics of reportable health data breaches, 2010-2017. *JAMA*,*320*(12),1282–1284. https://doi.org/10.1001/jama.2018.9222

[2] Seh, A. H., Zarour, M., Alenezi, M., Sarkar, A. K., Agrawal, A., Kumar, R., & Ahmad Khan, R. (2020). Healthcare data breaches: Insights and implications. *Healthcare*, *8*(2), 133. https://doi.org/10.3390/healthcare8020133

## Appendix: Data Abstraction

Each row in the dataset represents an item. The column "Name of Covered Entity" is a categorical attribute. The column "State" is a categorical attribute. The column "Covered Entity Type" is a categorical attribute. The column "Individuals Affected" is a quantitative attribute which is sequential. The column "Breach Submission" is an ordered attribute which is cyclic. The column "Type of Breach" is a categorical attribute. The column "Location of Breach" is a categorical attribute. The column "Business Associate Present" is a categorical attribute.

## Appendix: Task Abstraction

- Conducting a risk assessment:
    - High-level: Discover; the visualization will need to be explored by the user to glean any valuable insights.
    - Medium-level: Browse; the location is already known (where the end user is located), but the target is unknown (are there any data breaches in the specified location?)
    - Low-level: Identify; to help the end user determine whether or not to conduct a risk assessment, the visualization will provide information about data breaches in the target location. If there are data breaches connected to the state, steps to develop a data security strategy may be pursued.
- Developing a data security strategy:
    - High-level: Discover; the visualization will need to be explored by the user to glean any valuable insights.
    - Medium-level: Browse; the location is already known (where the end user is located), but the target is unknown (are there any data breaches in the specified location?)
    - Low-level: Summarize; the visualization will provide information about data breaches by state and its associated information (organization that was breached, what kind of information was breached, when the data was breached) to help the end user develop a data security regulations and practices that are equipped to handle information that has been shown to be at higher risk.