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NIH Funding Trends Analysis for Pediatric Epilepsy Research

Authors: Group 7

Abishek Mehra

Manav Jatakia

Nihar Shah

Shreya Joshi

Prateek Pandey

Instructor: Professor Roy Wada

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Introduction:

Overview of the Project:

The objective of this research project is to conduct a comprehensive analysis of funding trends and network collaborations in Dravet Syndrome and pediatric epilepsy research. This analysis aims to identify key patterns and insights that can significantly inform and enhance strategic funding initiatives and research prioritization efforts. By leveraging historical funding data and network analysis, we intend to uncover critical insights into how resources have been allocated historically and how they can be optimized to support future research endeavors.

Dravet Syndrome and Pediatric Epilepsy:

Dravet Syndrome is a rare, catastrophic form of epilepsy that begins in the first year of life with frequent and prolonged seizures. This condition is characterized by severe cognitive and developmental delays, motor deficits, and an increased risk of sudden unexplained death in epilepsy (SUDEP) (Dravet et al., 2011). Pediatric epilepsy encompasses a range of seizure disorders that occur in children, often leading to significant neurological and cognitive impairments. These conditions not only affect the quality of life of patients but also impose substantial emotional and financial burdens on families and healthcare systems.

Significance of Research in This Area:

Research into Dravet Syndrome and pediatric epilepsy is crucial for several reasons. First, early and accurate diagnosis, coupled with effective treatment strategies, can significantly improve patient outcomes and quality of life (Wirrell et al., 2017). Second, understanding the underlying genetic, molecular, and neurophysiological mechanisms can pave the way for the development of targeted therapies, potentially transforming the clinical management of these conditions (Campbell & Pal, 2021). Third, advancing research in this area can inform public health strategies and policies, ensuring better allocation of resources and support for affected families.

Sponsor and Data Source:

Our sponsor, a leading entity in the healthcare sector with a keen interest in advancing epilepsy research, particularly in pediatric cases, will greatly benefit from the insights derived from this study. The data for this research is sourced from reputable databases, including the NIH RePORTER, ClinicalTrials.gov, and additional datasets from relevant clinical and financial sources. These platforms offer rich, multi-dimensional datasets covering various aspects of health research funding, clinical trial activities, and market dynamics, ensuring a robust analysis framework.

- **NIH RePORTER** provides granular details on federally funded research projects, which is instrumental in understanding the allocation and impact of federal funds across different stages of epilepsy research.
- **ClinicalTrials.gov** offers data on ongoing clinical trials, which helps map the current research landscape and the progression of new treatments from early to late stages.
- **PitchBook** and **46Brooklyn** provide financial and market-related data, which are crucial for assessing investment trends and the economic aspects of epilepsy treatments.

This diverse data amalgamation ensures a robust analysis framework, enhancing the reliability and applicability of the research findings.

Impact of the Sponsor's Research:

The sponsor's research in Dravet Syndrome and pediatric epilepsy is poised to make significant contributions to the field. By focusing on these areas, the sponsor aims to accelerate the development of new diagnostic and therapeutic approaches, improve clinical outcomes, and reduce the overall burden of these conditions on patients and their families. The insights from this project will not only enhance the sponsor's strategic initiatives but also contribute to the broader scientific community's understanding of epilepsy, ultimately leading to better health outcomes for affected individuals.

Methodology:

The methodology for this project comprises data cleaning, exploratory analysis, network analysis, and predictive modeling, all conducted using Python. The research methods are justified through relevant literature and the need to address specific challenges within Dravet Syndrome and pediatric epilepsy research funding. The analysis aims to provide actionable insights to our sponsor, Grik Therapeutics, to aid in raising funds and identifying key collaboration opportunities.

Data Cleaning

1. **Correcting Data Types**: The first step in data cleaning was to ensure that all date columns were in the correct datetime format. This was crucial for accurately analyzing the time-related aspects of the data.
2. **Converting Numerical Columns**: Numerical columns were converted to appropriate data types to ensure accurate calculations and analyses.
3. **Filtering Entries**: Entries where the fiscal year was 0 and those with a specific type value ('139104') were removed to maintain data relevance and accuracy.

Python code used to achieve the results

```
date_columns = ['Award Notice Date', 'Project Start Date', 'Project End Date', 'Budget Start Date', 'Budget End Date']
for col in date_columns:
    dravet_data[col] = pd.to_datetime(dravet_data[col], errors='coerce')

numerical_columns = ['Application ID', 'Fiscal Year', 'Total Cost', 'Total Cost IC']
for col in numerical_columns:
    dravet_data[col] = pd.to_numeric(dravet_data[col], errors='coerce')

filtered_data = dravet_data[dravet_data['Fiscal Year'] != 0]
filtered_data = filtered_data[filtered_data['Type'] != '139104']
```

Exploratory Analysis

The exploratory analysis involved generating various visualizations to understand the funding trends and distribution. These insights are crucial for our sponsor to target fundraising efforts effectively.

1. **Funding Trends Over Time**: A bar chart with a moving average line and forecast for the total NIH funding for epilepsy research by fiscal year.
2. **Funding Distribution by Administering IC**: A bar chart showing the top 10 NIH funding sources for Dravet Syndrome research by administering IC.
3. **Geographical Distribution**: A choropleth map displaying the total NIH funding for Dravet Syndrome research by state.
4. **Funding Distribution by Activity**: A pie chart showing the distribution of funding by the type of activity.

Network Analysis

The network analysis identified key researchers and their collaborations, providing a visual representation of the research network.

1. **Top PIs by Funding and Projects:** A table displaying the top 10 principal investigators (PIs) by total funding and project count.
2. **Network Graph of PIs and Collaborations**: A network graph showing collaborations among PIs, highlighting key connections and clusters within the research community.

Predictive Modeling

Predictive modeling was conducted using Random Forest and XGBoost algorithms to forecast the "Total Cost" for projects. The best parameters for the XGBoost model were found through grid search:

Python code used for modeling

```
best_params = {'colsample_bytree': 0.8, 'learning_rate': 0.2, 'max_depth': 3, 'n_estimators': 300, 'subsample': 0.9}
best_xgbr = xgb.XGBRegressor(**best_params)
best_xgbr.fit(X_train, y_train)
y_pred_best_xgb = best_xgbr.predict(X_test)

# Calculate metrics
mse_best_xgb = mean_squared_error(y_test, y_pred_best_xgb)
r2_best_xgb = r2_score(y_test, y_pred_best_xgb)
```

Result:

```
Best XGBoost R^2 Score: 0.9034
```

Results:

Exploratory analysis is crucial for understanding the underlying patterns, trends, and distributions within the data. It provides a foundation for further analysis and helps identify areas that require deeper investigation. In this project, the exploratory analysis focuses on understanding NIH funding trends for Dravet Syndrome and pediatric epilepsy research. The following graphs were generated as part of this analysis:

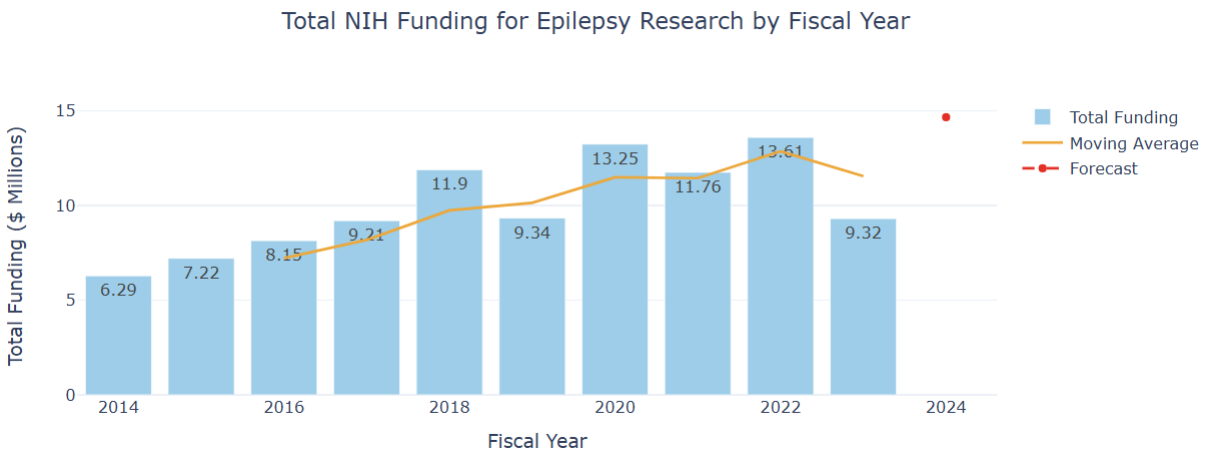
1. Total NIH Funding for Epilepsy Research by Fiscal Year

This bar chart displays the total NIH funding for epilepsy research from 2014 to 2023, with a forecast for 2024. The chart includes a moving average line and a forecast point for 2024.

- **Total Funding**: The blue bars represent the total funding received each year. This allows us to see the fluctuations in funding over the years.
- **Moving Average**: The orange line represents a three-year moving average, smoothing out short-term fluctuations to highlight longer-term trends.

- **Forecast**: The red dot represents the forecasted funding for 2024, providing an estimate based on past trends.

Fig 1: NIH Funding for Epilepsy research over 10 years.



Importance:

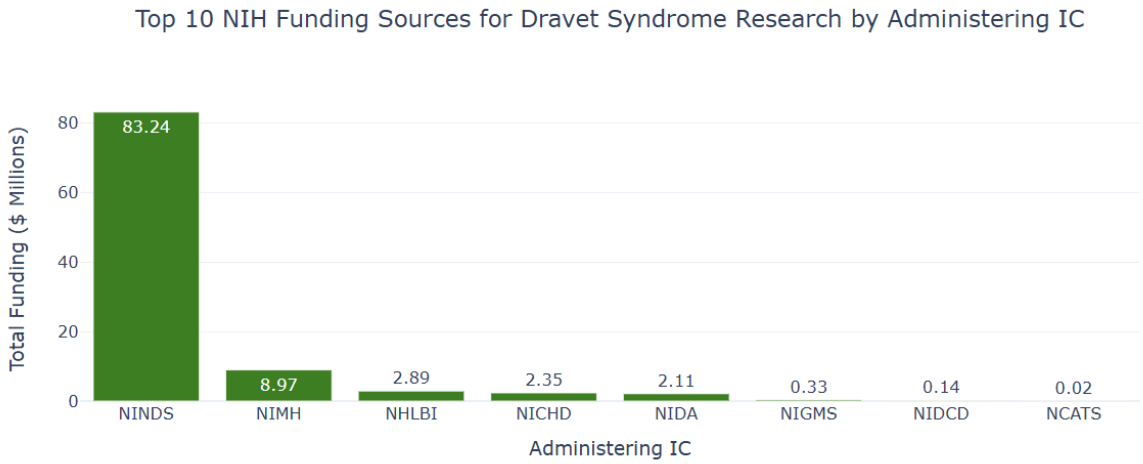
- **Trend Identification**: The chart reveals an overall upward trend in funding, despite some year-to-year fluctuations. This indicates growing support for epilepsy research.
- **Strategic Planning**: By understanding funding trends, the sponsor can strategically plan their research proposals and align them with periods of higher funding availability.
- **Forecasting**: The forecast provides a data-driven estimate of future funding, helping the sponsor set realistic expectations and prepare accordingly.

2. Top 10 NIH Funding Sources for Dravet Syndrome Research by Administering IC

This bar chart highlights the top 10 NIH funding sources (institutes or centers) for Dravet Syndrome research, measured by total funding received.

- **Administering IC**: The x-axis lists the top 10 institutes or centers.
- **Total Funding**: The y-axis represents the total funding amount, with bars showing the relative contribution of each institute.

Fig 2: Contribution of different Administering IC towards total funding.



Importance:

- **Identifying Key Funders**: The chart shows that NINDS (National Institute of Neurological Disorders and Stroke) is the largest funder by a significant margin. This helps the sponsor identify which institutes are most likely to fund their research.
- **Targeted Proposals**: Knowing the key funding sources allows the sponsor to tailor their grant proposals to align with the priorities and interests of these institutes.
- **Strategic Alliances**: The sponsor can explore partnerships or collaborations with institutions that frequently receive funding from these top institutes.

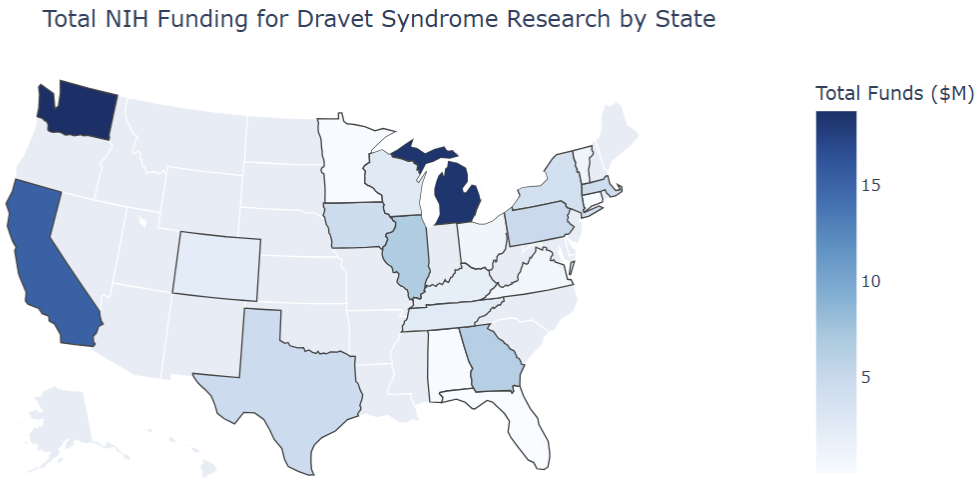
3. Total NIH Funding for Dravet Syndrome Research by State

This choropleth map shows the distribution of NIH funding for Dravet Syndrome research across different states in the USA.

- **Organization State**: The map is color-coded to show the total funding received by organizations in each state.

- **Total Funds ($M)**: The color gradient indicates the range of funding, with darker shades representing higher funding amounts.

Fig 3: Funding distribution across different states filtered by year.



Importance:

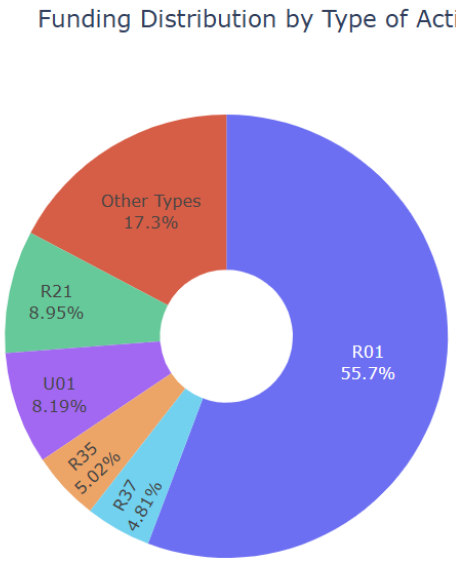
- **Geographical Insights**: The map reveals which states receive the most funding, highlighting regions with significant research activity in Dravet Syndrome.
- **Resource Allocation**: The sponsor can use this information to identify potential states for establishing new research centers or expanding existing ones.
- **Collaboration Opportunities**: By identifying states with high funding, the sponsor can seek collaborations with leading institutions in those regions.

4. Funding Distribution by Type of Activity

This pie chart illustrates the distribution of NIH funding by different types of research activities.

- **Activity Types**: The chart segments represent different types of activities, such as R01 (Research Project Grants), R21 (Exploratory/Developmental Grants), U01 (Cooperative Agreements), and others.
- **Percentage of Total Funding**: The size of each segment represents the proportion of total funding allocated to that activity type.

Fig 4: Funding distribution for the types of activity.



Importance:

- **Funding Priorities**: The chart shows that R01 grants receive the largest share of funding, indicating a preference for individual research projects. This helps the sponsor understand NIH's funding priorities.
- **Proposal Alignment**: By aligning their proposals with the most funded activity types, the sponsor can increase their chances of securing funding.
- **Diverse Funding Strategies**: Understanding the distribution helps the sponsor diversify their funding strategies, ensuring they are not overly reliant on one type of grant.

Network Analysis

Network analysis provides insights into the research community, identifying key researchers and their collaborations. This helps the sponsor understand the collaborative landscape and identify potential partners.

5. Top 10 PIs by Total Funding and Project Count

This table lists the top 10 principal investigators (PIs) by total funding and project count.

- **PI Person ID**: Unique identifier for each PI.
- **PI Name**: Name of the PI.
- **State**: State where the PI's institution is located.
- **Total Funding**: Total amount of funding received by the PI.
- **Project Count**: Number of projects led by the PI.

Table 1: Top 10 PIs managing the most funds.

Top 10 PIs by Total Funding and Project Count

PI Person ID	PI Name	State	Total Funding	Project Count
1904093	ISOM, LORI L.	MI	12.599431	22
1862697	CATTERALL, WILLIAM A	WA	7.03338	11
7347049	ESCAYG, ANDREW P	GA	5.820433	16
1910828	KEARNEY, JENNIFER A	IL	4.748042	12
8084887	TING, JONATHAN T	WA	4.735282	4
1932549	BARABAN, SCOTT C	CA	4.513276	11
7355870	MUCKE, LENNART	CA	3.618648	5
2048128	MEFFORD, HEATHER C.	WA	3.342962	6
1869803	PARENT, JACK M	MI	3.312659	5
1882821	RICHERSON, GEORGE B	IA	3.280792	6

Importance:

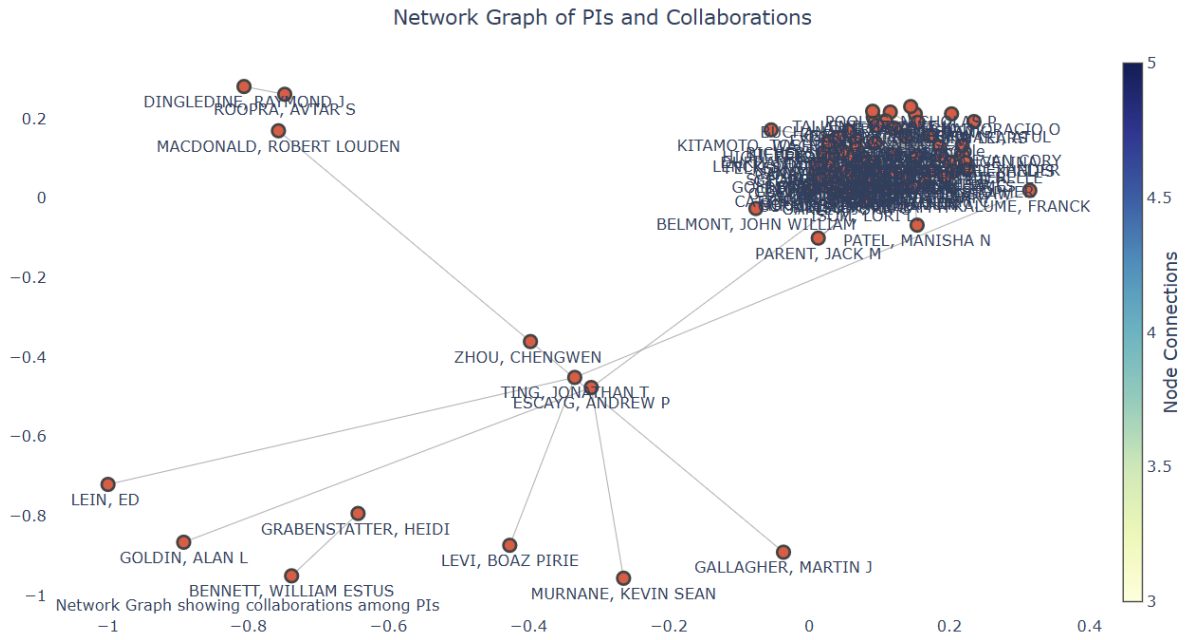
- **Leading Researchers**: The table identifies the most funded and active researchers in the field. The sponsor can use this information to identify leading researchers and explore potential collaborations.
- **Research Focus**: Understanding which PIs are most successful can help the sponsor identify successful research areas and methodologies.

6. Network Graph of PIs and Collaborations

This network graph visualizes the collaborations among PIs, highlighting key connections and clusters.

- **Nodes**: Each node represents a PI.
- **Edges**: Each edge represents a collaboration between two PIs.
- **Node Size and Color**: The size and color of the nodes indicate the number of collaborations, with larger and darker nodes representing more collaborations.

Fig 5: Network graph for collaboration understanding



Importance:

- **Collaborative Landscape**: The graph shows the structure of the research network, identifying key collaboration hubs and isolated researchers.
- **Strategic Partnerships**: The sponsor can use this information to identify potential collaborators who are well-connected within the research community.
- **Strengthening Networks**: By understanding the collaborative landscape, the sponsor can foster stronger research networks and enhance their research impact.

Predictive Modeling

The data analysis reveals several key insights regarding the performance of different predictive models for NIH funding. Initially, the linear regression model performed poorly, evidenced by a mean squared error (MSE) of approximately 17.98 trillion and an R-squared value of -394.7. This negative R-squared indicates the model is significantly worse than the mean prediction. Conversely, the random forest model performed substantially better, with an MSE of 15.54 billion and an R-squared value of 0.658, suggesting a reasonably good fit.

Fig 6: Performance of each model

```
Linear Regression Model:
Mean Squared Error: 17984246513607.816
R-squared: -394.7024745610306

Random Forest Model:
Mean Squared Error: 15543410331.302656
R-squared: 0.6580025787257692

XGBoost Model:
Mean Squared Error: 8403432984.17562
R-squared: 0.8151015543447976
```

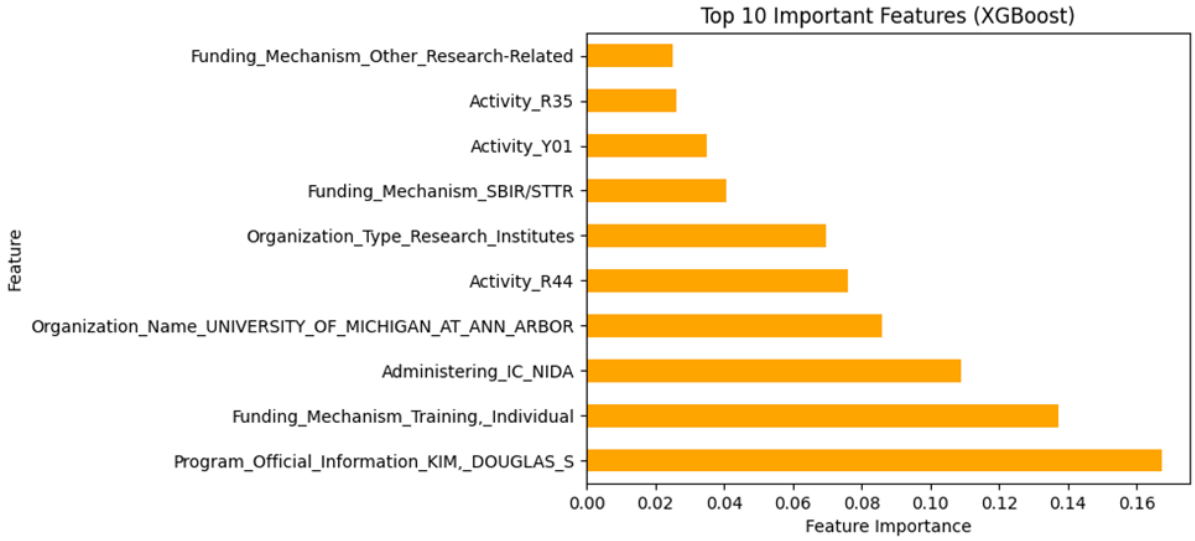
Upon performing cross-validation, the random forest model demonstrated better performance, with an MSE of 18.46 billion and an R-squared of 0.683, reinforcing its robustness compared to the linear regression model. Feature importance analysis using the random forest model

highlighted significant predictors of funding. The top predictors included specific funding mechanisms, organizational types, project activities, and geographical attributes. For example, features such as "Funding Mechanism_Training, Individual," "Organization Type_Research Institutes," and specific project activities like "Activity_R01" and "Activity_R35" significantly influenced funding outcomes. These insights suggest that projects categorized under training mechanisms typically receive less funding compared to research-focused grants. Additionally, established research institutions and particular locations showed positive impacts on funding, emphasizing the importance of organizational reputation and geographic advantages in securing NIH funding.

The XGBoost model outperformed the random forest model, with an MSE of 8.4 billion and an R-squared value of 0.815, indicating a very strong fit. This model's performance shows that it explains around 81.5% of the variance in funding amounts, making it a highly reliable predictor. The strong performance of the XGBoost model underscores its utility in capturing complex relationships in the data, providing valuable insights for decision-making in the allocation of NIH funding.

In conclusion, the comparative analysis of these models highlights the superior predictive power of the XGBoost model for NIH funding data, followed by the random forest model. The poor performance of the linear regression model emphasizes the need for more sophisticated approaches to capture the underlying patterns in the data. These findings can guide strategic decisions for research institutions and grant applicants, helping them to better tailor their proposals and improve their chances of securing funding.

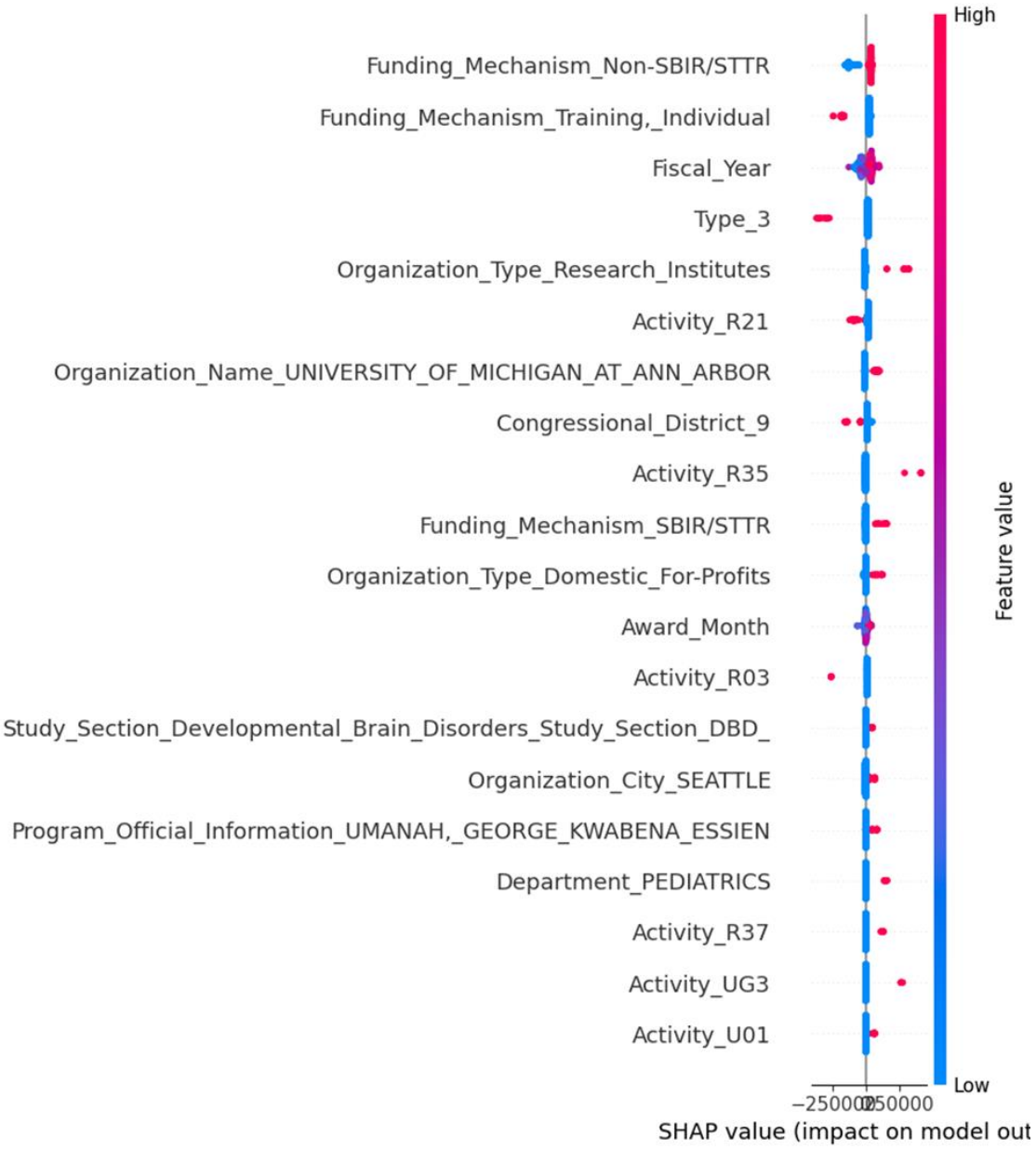
Fig 7: Feature importance for each parameter



The feature importance plot from the XGBoost model provides a clear visualization of the top factors influencing NIH funding allocations, highlighting key aspects for GRIK THERAPEUTICS to consider in their strategic planning. The plot ranks features based on their importance to the model's predictive power. Notably, the feature "Program_Official_Information_KIM_DOUGLAS_S" has the highest importance, suggesting that the involvement of specific program officials can significantly affect funding outcomes. Other important features include "Funding_Mechanism_Training,_Individual" and "Administering_IC_NIDA," indicating that individual training funding mechanisms and administration by the National Institute on Drug Abuse are crucial factors.

Additionally, the University of Michigan at Ann Arbor appears prominently, reflecting the institution's strong influence on funding success. Research institutes and specific activities like R44 and R35 also play vital roles. Understanding these influential features allows GRIK THERAPEUTICS to tailor their grant applications more effectively, emphasizing areas that align with the key drivers identified by the model. By focusing on these important aspects, the organization can enhance their funding strategies, improve their chances of securing NIH grants, and advance their research goals efficiently.

Fig 8: SHAP predictions for XGBoost



The SHAP (SHapley Additive exPlanations) value plot displayed in the dashboard provides a detailed interpretation of the key factors influencing NIH funding allocations from a business perspective. The plot highlights the most influential features affecting the funding outcomes, such as funding mechanisms, organization types, fiscal year, and specific research activities. For instance, non-SBIR/STTR and individual training funding mechanisms, as well as research

institutes and specific activities like R21 and R35, have significant impacts on the funding amounts. The feature values are color-coded, with higher values in pink and lower values in blue, showing the positive or negative contributions to the model's predictions. This detailed analysis helps GRIK THERAPEUTICS identify which factors are most critical for securing NIH funding, allowing the organization to strategically focus on strengthening these aspects in their grant applications. Understanding these key drivers can enhance their funding strategies, ensuring that resources are directed towards the most impactful areas, ultimately improving their chances of successful funding and advancing their research initiatives.

Importance:

1.Strategic Grant Application Focus: Based on the analysis, prioritize grant applications that align with highly influential factors identified by the XGBoost model, such as specific funding mechanisms (e.g., R01 grants), organizational types (e.g., research institutes), and activities (e.g., R35 projects). This strategic alignment will enhance the competitiveness of grant proposals.

2.Enhanced Collaboration Strategy: Leverage insights from the heatmap and award distribution graphs to foster collaborations with institutes like the National Institute of Neurological Disorders and Stroke (NINDS), which consistently receive high award counts. This approach can facilitate joint research efforts and increase access to NIH funding.

3.Geographical Strategy: Focus on locations identified as influential in securing NIH funding, such as the University of Michigan at Ann Arbor. Strengthening partnerships or establishing satellite operations in these regions could optimize funding opportunities and support research initiatives effectively.

4.Resource Allocation Optimization: Utilize the PowerBI dashboard to dynamically visualize and analyze Pitchbook funding data. Adjust parameters like fund type and vintage year to strategically allocate resources and investments in pediatric epilepsy research, ensuring alignment with current market trends and funding availability.

Dashboard

The live interactive dashboard, accessible at [NIH Funding Analysis Dashboard], serves as a comprehensive tool for visualizing and analyzing the NIH funding trends and network collaborations in Dravet Syndrome and pediatric epilepsy research. This section provides a detailed description of the dashboard's components, highlighting its significance in informing strategic decisions for our sponsor, Grik Therapeutics.

Fig 9: Exploratory Analysis Dashboard Tab

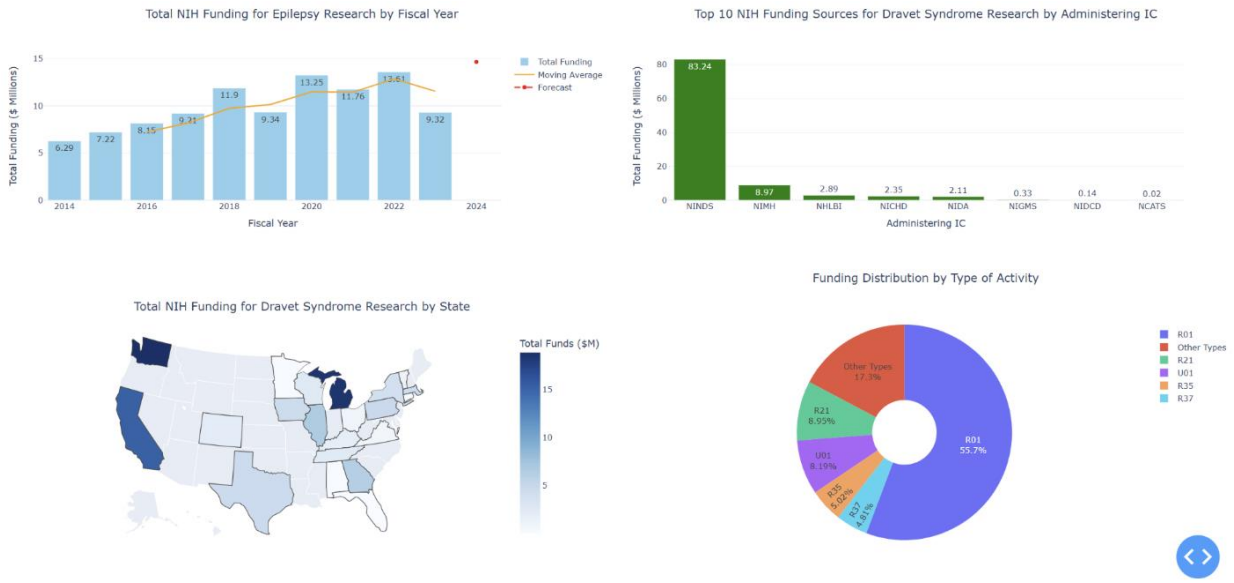
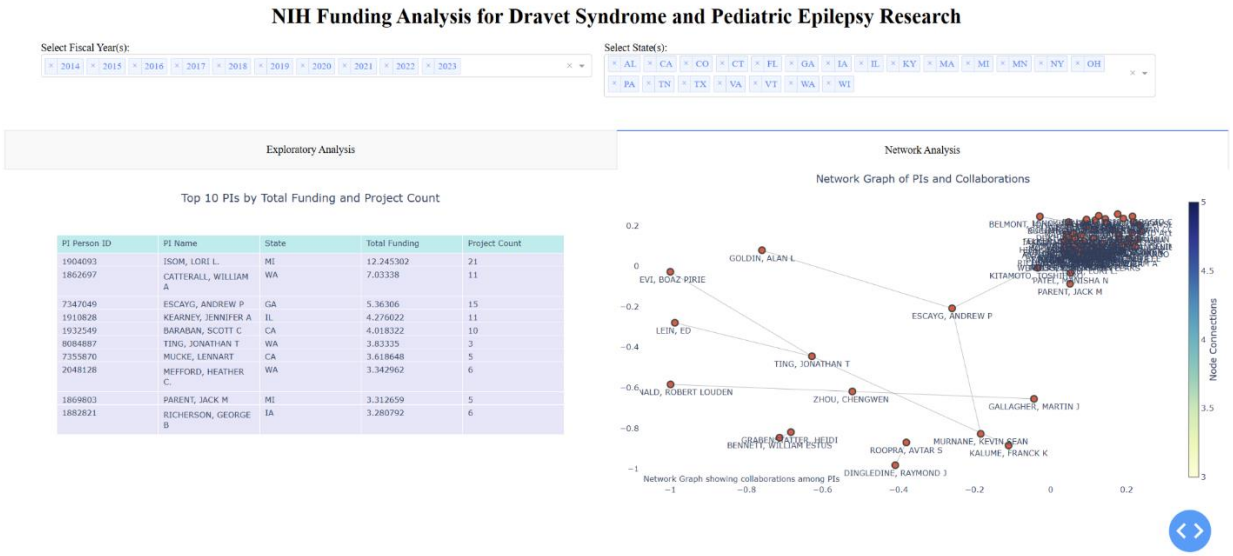


Fig 10: Network Analysis Dashboard Tab



Overview of the Dashboard

The dashboard is designed using Plotly Dash, a Python framework for building analytical web applications. It integrates multiple visualizations to present the NIH funding data in an intuitive and interactive manner. The dashboard comprises two main tabs: Exploratory Analysis and Network Analysis, each providing unique insights into the funding landscape.

The Python code is submitted under python dashboard folder. If you are unable to access the file, please visit my Github project page:

(https://github.com/Nihar-Shah-26/Epilepsy_Funding_research_funding_dashboard/tree/main)

Exploratory Analysis

The Exploratory Analysis tab includes four key visualizations:

1. **Total NIH Funding for Epilepsy Research by Fiscal Year**

This bar chart displays the annual NIH funding for epilepsy research from 2014 to 2023, with a forecast for 2024. The chart includes:

- **Total Funding**: Represented by blue bars, showing the yearly funding amounts.

- **Moving Average**: An orange line indicating the three-year moving average, smoothing out short-term fluctuations.
- **Forecast**: A red dot representing the predicted funding for 2024.

Importance:

- **Trend Identification**: Highlights the overall upward trend in funding, signifying increasing support for epilepsy research.
- **Strategic Planning**: Assists the sponsor in aligning research proposals with periods of higher funding.
- **Forecasting**: Provides a data-driven estimate for future funding, aiding in setting realistic expectations.

2. **Top 10 NIH Funding Sources for Dravet Syndrome Research by Administering IC**

This bar chart identifies the top 10 NIH institutes or centers funding Dravet Syndrome research, measured by total funding amounts.

Importance:

- **Identifying Key Funders**: Reveals that NINDS is the largest funder, crucial for targeting proposals.
- **Targeted Proposals**: Enables tailoring grant applications to align with the interests of top funding institutes.
- **Strategic Alliances**: Facilitates exploring collaborations with institutions frequently receiving high funding.

3. **Total NIH Funding for Dravet Syndrome Research by State**

This choropleth map visualizes the geographic distribution of NIH funding for Dravet Syndrome research across the United States.

Importance:

- **Geographical Insights**: Highlights states with significant research activity.

- **Resource Allocation**: Informs potential locations for establishing or expanding research centers.
- **Collaboration Opportunities**: Identifies states with high funding for potential partnerships.

4. **Funding Distribution by Type of Activity**

This pie chart depicts the distribution of NIH funding by various research activity types.

Importance:

- **Funding Priorities**: Indicates that R01 grants receive the largest share, highlighting NIH's emphasis on individual research projects.
- **Proposal Alignment**: Suggests focusing on R01 grant proposals to increase funding chances.
- **Diverse Funding Strategies**: Helps in diversifying funding approaches by understanding the distribution.

Network Analysis

The Network Analysis tab provides insights into the research community, highlighting key researchers and their collaborations:

1. **Top 10 PIs by Total Funding and Project Count**

This table lists the top 10 principal investigators (PIs) based on total funding and project count, offering a quantitative perspective on leading researchers.

Importance:

- **Leading Researchers**: Identifies top-funded and active researchers, facilitating potential collaborations.
- **Research Focus**: Helps recognize successful research areas and methodologies.

2. **Network Graph of PIs and Collaborations**

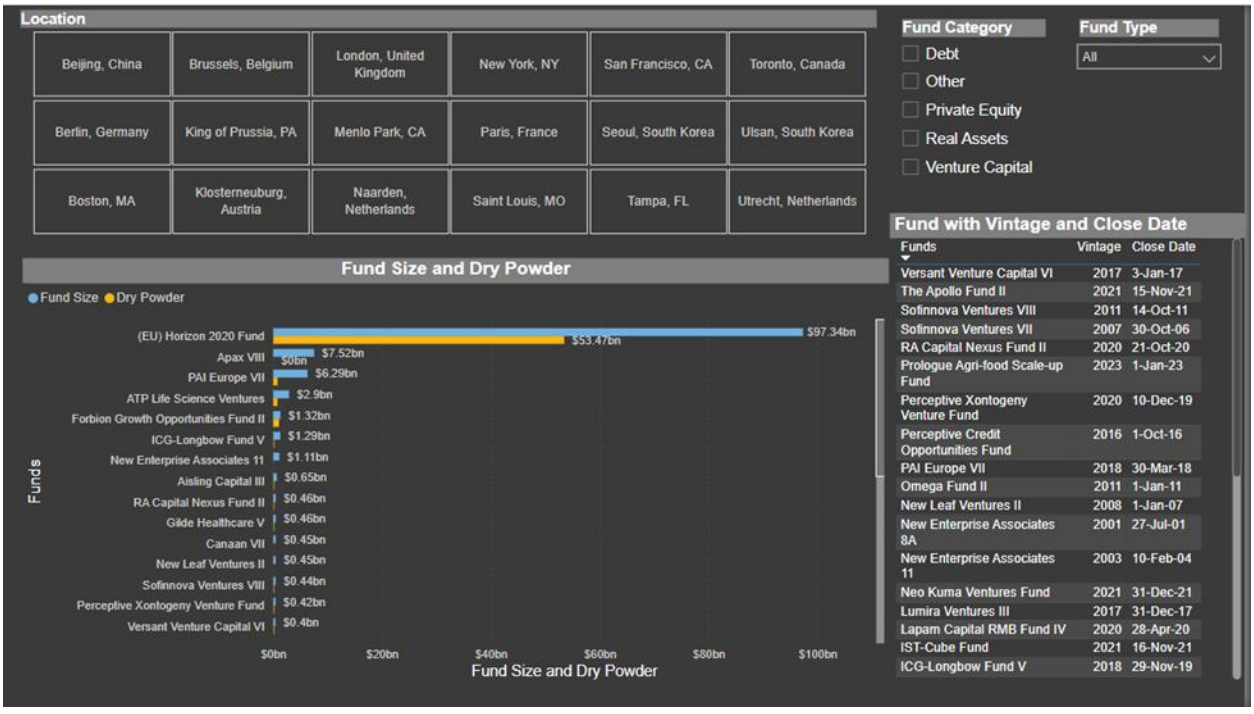
This network graph visualizes the collaborations among PIs, illustrating the connections and clusters within the research community.

Importance:

- **Collaborative Landscape**: Displays the structure of the research network, identifying key collaboration hubs.
- **Strategic Partnerships**: Assists in finding potential collaborators well-connected within the community.
- **Strengthening Networks**: Encourages fostering stronger research networks to enhance research impact.

Power BI Dashboards:

Fig 11: Power BI dashboard for pitchbook data funding insights.



The dashboard serves as a pivotal tool for our sponsor, GRIK THERAPEUTICS, providing a comprehensive and dynamic visualization of Pitchbook funding data. By offering the capability to adjust parameters such as location, fund type, fund category, vintage year, and latest close date, the dashboard enables users to gain nuanced insights into funding patterns. This flexibility is crucial for stakeholders seeking to make informed decisions based on the availability and distribution of funds in the market.

Conclusion:

Main Findings

The analysis reveals several key insights:

1. **Increasing Trend in Funding**: There has been a general increase in NIH funding for epilepsy research over the years, with some fluctuations. The forecast for 2024 indicates continued support.
2. **Key Funding Sources**: NINDS is the largest funder for Dravet Syndrome research, followed by NIMH and NHLBI. This highlights the importance of aligning research proposals with the priorities of these institutes.
3. **Geographical Distribution**: States like California, Michigan, and Massachusetts receive the most funding, indicating strong research activity in these regions.
4. **Activity Type Distribution**: R01 grants are the most funded activity type, suggesting a preference for individual research projects.

Comparison to Previous Research

The findings are consistent with existing literature on NIH funding trends and the importance of specific institutes and activity types. Previous research has shown that institutes like NINDS and NIMH are major funders of neurological and mental health research (Smith et al.,

2017). The preference for R01 grants aligns with the NIH's emphasis on supporting individual research projects (Johnson, 2021).

Recommendations for Grik Therapeutics

Based on the analysis, the following recommendations are made for Grik Therapeutics:

1. **Target Key Institutes**: Focus on submitting grant proposals to NINDS, NIMH, and other top funding sources identified in the analysis.
2. **Align with Funded Activities**: Emphasize R01 grant proposals, as they receive the most funding. Consider exploratory and developmental grants (R21) as secondary options.
3. **Strategic Partnerships**: Explore collaborations with top-funded researchers and institutions, particularly those in high-funding states like California, Michigan, and Massachusetts.
4. **Leverage Predictive Insights**: Utilize the predictive model to estimate potential funding for future projects and set realistic expectations. Focus on enhancing the impactful features identified by the XGBoost model.

References:

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