

**Linear Regression**

* **Training RMSE**: 5.1703
* **Training R²**: 0.3522
* **Interpretation**:
  + The Linear Regression model has a relatively high RMSE, indicating a significant average error in its predictions.
  + The R² value is 0.3522, suggesting that only 35.22% of the variance in the **ESTIMATE** values is explained by the model. This indicates poor performance and suggests that a linear relationship might not adequately capture the complexity of the data.

**Decision Tree Regressor**

* **Training RMSE**: 0.2596
* **Training R²**: 0.9984
* **Top Features**:
  + **PANEL\_NUM**: 0.3283
  + **AGE\_NUM**: 0.2940
  + **YEAR\_NUM**: 0.1629
  + **STUB\_LABEL\_NUM**: 0.1419
  + **Sex\_Male**: 0.0629
  + **Race\_Hispanic\_or\_Latino**: 0.0051
  + **STUB\_NAME\_NUM**: 0.0049
  + **UNIT\_NUM**: 0.0000
* **Interpretation**:
  + The Decision Tree Regressor has a very low RMSE and a very high R², indicating excellent performance on the training data.
  + The model captures almost all the variance in the data, suggesting that it fits the training data very well.
  + However, the high R² could indicate overfitting, and the model's performance on unseen data should be validated.
  + The top features show that **PANEL\_NUM** and **AGE\_NUM** are the most important predictors.

**Random Forest Regressor**

* **Training RMSE**: 0.3903
* **Training R²**: 0.9963
* **Top Features**:
  + **PANEL\_NUM**: 0.3302
  + **AGE\_NUM**: 0.2697
  + **YEAR\_NUM**: 0.1769
  + **STUB\_LABEL\_NUM**: 0.1559
  + **Sex\_Male**: 0.0537
  + **STUB\_NAME\_NUM**: 0.0098
  + **Race\_Hispanic\_or\_Latino**: 0.0035
  + **UNIT\_NUM**: 0.0004
* **Interpretation**:
  + The Random Forest Regressor also shows very low RMSE and very high R², indicating excellent performance on the training data.
  + The model likely captures the underlying patterns well and is less prone to overfitting compared to a single decision tree due to its ensemble nature.
  + The top features are similar to those identified by the Decision Tree Regressor.

**Gradient Boosting Regressor**

* **Training RMSE**: 2.2985
* **Training R²**: 0.8720
* **Top Features**:
  + **PANEL\_NUM**: 0.4240
  + **AGE\_NUM**: 0.2564
  + **YEAR\_NUM**: 0.1715
  + **STUB\_LABEL\_NUM**: 0.1053
  + **Sex\_Male**: 0.0372
  + **STUB\_NAME\_NUM**: 0.0034
  + **Race\_Hispanic\_or\_Latino**: 0.0022
  + **UNIT\_NUM**: 0.0000
* **Interpretation**:
  + The Gradient Boosting Regressor has a higher RMSE and a lower R² compared to the Random Forest and Decision Tree models, indicating less overfitting and better generalization.
  + The model still explains a significant portion of the variance (87.20%) in the training data.
  + The top features are consistent, with **PANEL\_NUM** being the most important.

**Support Vector Regressor**

* **Training RMSE**: 5.2033
* **Training R²**: 0.3439
* **Interpretation**:
  + The Support Vector Regressor has a high RMSE and a low R², indicating poor performance on the training data.
  + The model does not capture the variance in the **ESTIMATE** values well and might not be suitable for this problem.

**K-Nearest Neighbors Regressor**

* **Training RMSE**: 3.6634
* **Training R²**: 0.6748
* **Interpretation**:
  + The K-Nearest Neighbors Regressor shows moderate performance with an RMSE of 3.6634 and an R² of 0.6748.
  + The model explains 67.48% of the variance in the training data, which is better than linear models but worse than ensemble methods.

**Neural Network (MLPRegressor)**

* **Training RMSE**: 3.0113
* **Training R²**: 0.7803
* **Interpretation**:
  + The Neural Network has a moderate RMSE and R², indicating it captures some patterns in the data but not as effectively as the Random Forest or Decision Tree models.
  + Neural networks typically require more data and tuning to perform optimally, which might explain the moderate performance.

**Summary**

| **Model** | **Training RMSE** | **Training R²** | **Top Features** |
| --- | --- | --- | --- |
| Linear Regression | 5.1703 | 0.3522 | - |
| Decision Tree Regressor | 0.2596 | 0.9984 | PANEL\_NUM, AGE\_NUM, YEAR\_NUM, etc. |
| Random Forest Regressor | 0.3903 | 0.9963 | PANEL\_NUM, AGE\_NUM, YEAR\_NUM, etc. |
| Gradient Boosting Regressor | 2.2985 | 0.8720 | PANEL\_NUM, AGE\_NUM, YEAR\_NUM, etc. |
| Support Vector Regressor | 5.2033 | 0.3439 | - |
| K-Nearest Neighbors | 3.6634 | 0.6748 | - |
| Neural Network | 3.0113 | 0.7803 | - |