In [52]:
```
import pandas as pd
import numpy as np
```

In [53]:
```
df = pd.read_csv(r'C:\Users\hp\Downloads\insurance.csv')
df
```

Out[53]:

	age	sex	bmi	children	smoker	region	charges
0	19	female	27.900	0	yes	southwest	16884.92400
1	18	male	33.770	1	no	southeast	1725.55230
2	28	male	33.000	3	no	southeast	4449.46200
3	33	male	22.705	0	no	northwest	21984.47061
4	32	male	28.880	0	no	northwest	3866.85520
...	...	...	...	...	...	...	...
1333	50	male	30.970	3	no	northwest	10600.54830
1334	18	female	31.920	0	no	northeast	2205.98080
1335	18	female	36.850	0	no	southeast	1629.83350
1336	21	female	25.800	0	no	southwest	2007.94500
1337	61	female	29.070	0	yes	northwest	29141.36030

1338 rows × 7 columns

In [54]:
```
duplicates = df.duplicated().sum()
duplicates
```

Out[54]:
```
1
```

In [55]:
```
df.drop_duplicates(inplace=True)
df
```

Out[55]:

	age	sex	bmi	children	smoker	region	charges
0	19	female	27.900	0	yes	southwest	16884.92400
1	18	male	33.770	1	no	southeast	1725.55230
2	28	male	33.000	3	no	southeast	4449.46200
3	33	male	22.705	0	no	northwest	21984.47061
4	32	male	28.880	0	no	northwest	3866.85520
...	...	...	...	...	...	...	...
1333	50	male	30.970	3	no	northwest	10600.54830
1334	18	female	31.920	0	no	northeast	2205.98080
1335	18	female	36.850	0	no	southeast	1629.83350
1336	21	female	25.800	0	no	southwest	2007.94500
1337	61	female	29.070	0	yes	northwest	29141.36030

1337 rows × 7 columns

In [56]:

```
null_values = df.isnull().sum()
null_values
```

Out[56]:

```
age         0
sex         0
bmi         0
children    0
smoker      0
region      0
charges     0
dtype: int64
```

In [57]:

```
from sklearn.preprocessing import LabelEncoder
```

In [58]:

```
lab_encode = LabelEncoder()
```

In [59]:

```
for col in ['sex', 'smoker']:
    lab_encode.fit(df[col])
    df[col] = lab_encode.transform(df[col])
```

In [60]:

```
one_hot_encode = pd.get_dummies(df['region'])
```

In [61]:

```
one_hot_encode
```

Out[61]:

	northeast	northwest	southeast	southwest
0	0	0	0	1
1	0	0	1	0
2	0	0	1	0
3	0	1	0	0
4	0	1	0	0
...	...	...	...	...
1333	0	1	0	0
1334	1	0	0	0
1335	0	0	1	0
1336	0	0	0	1
1337	0	1	0	0

1337 rows × 4 columns

In [62]:
```
df1 = pd.concat([df, one_hot_encode], axis=1)
```

In [ ]:
```
```

In [63]:
```
df1.drop('region', axis=1, inplace=True)
```

In [64]:
```
from sklearn.model_selection import train_test_split
```

In [65]:
```
X = df1.drop('charges', axis=1)
```

In [66]:
```
y = df1['charges']
```

In [67]:
```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=
```

In [68]:
```
print(X_train.shape)
print(X_test.shape)
print(y_train.shape)
print(y_test.shape)
```

```
(1069, 9)
(268, 9)
(1069,)
(268,)
```

In [69]:
```
from sklearn.ensemble import RandomForestRegressor
from sklearn.model_selection import cross_val_score
```

In [70]:
```
rand_forest_model = RandomForestRegressor(n_estimators=50, n_jobs=2, random_state=42)
```

In [71]:
```
negative_mean_squared_error_scores = cross_val_score(rand_forest_model, X_train, y_tra
```

In [72]:
```
performance = np.sqrt(-negative_mean_squared_error_scores)
```

In [73]:
```
std = np.std(performance)
```

In [74]:
```
print(f"Performance: {performance.mean():.2f}")
print(f"Standard deviation: {std:.2f}")
```

```
Performance: 4960.71
Standard deviation: 586.88
```

In [81]:
```
rand_forest_model.fit(X_train, y_train)
```

Out[81]:
```
▾ RandomForestRegressor
RandomForestRegressor(n_estimators=50, n_jobs=2, random_state=42)
```

In [82]:
```
predictions = rand_forest_model.predict(X_test)
```

In [83]:
```
rounded_predictions = np.round(predictions, 2)
```

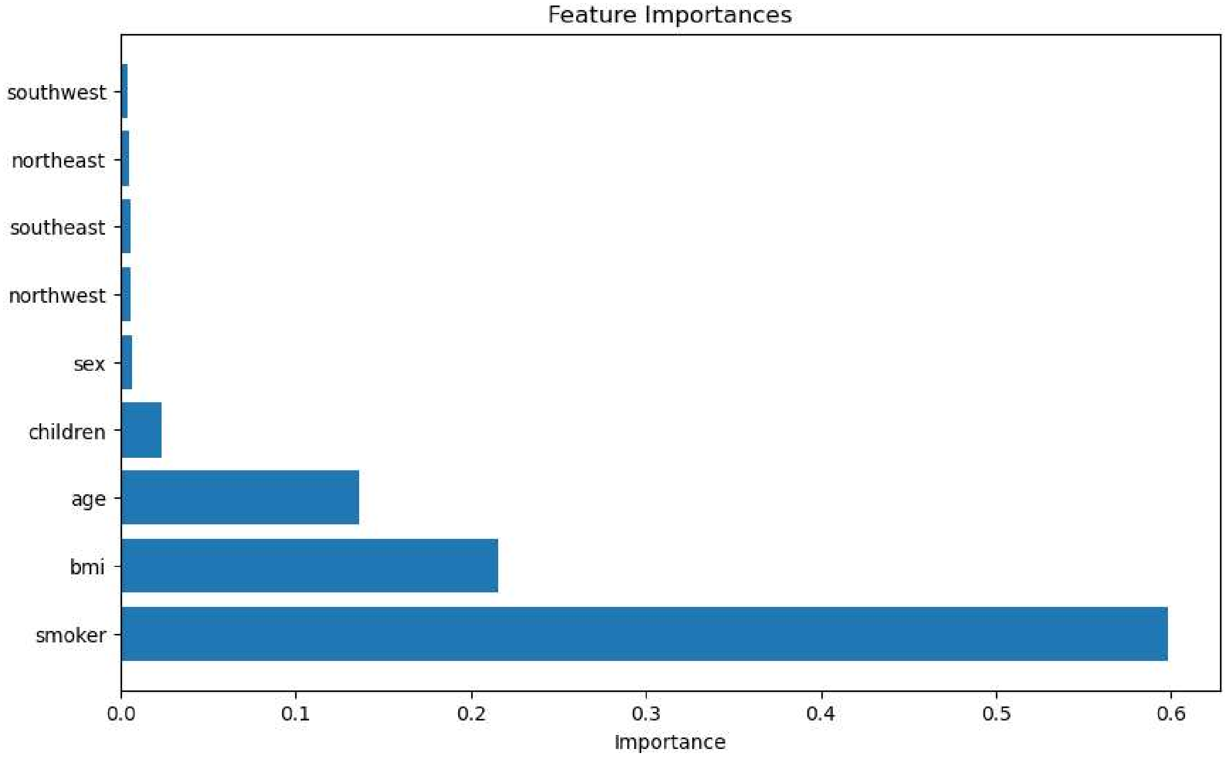
In [85]:
```
rounded_y_test = np.round(y_test.values, 2)
```

In [86]:
```
compare_data = {'Actual Charges': rounded_y_test, 'Predicted Charges': rounded_predict
compare = pd.DataFrame(compare_data)
```

In [87]:
```
print(compare.head(10))
```

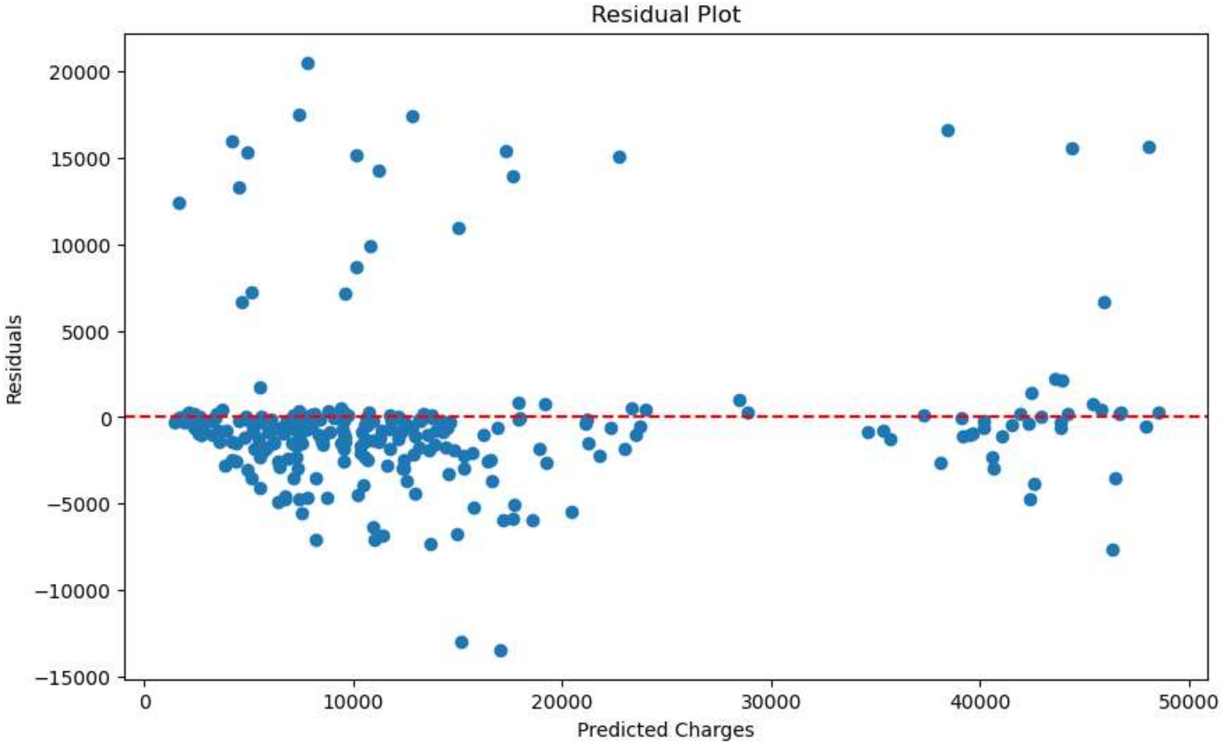
```
   Actual Charges  Predicted Charges
0         8688.86           10334.48
1         5708.87            6651.49
2        11436.74           12295.40
3        38746.36           42608.01
4         4463.21            6853.03
5         9304.70            9366.65
6        38511.63           39526.20
7         2150.47            2194.72
8         7345.73            8516.75
9        10264.44           10708.99
```

In [88]:
```
feature_importances = rand_forest_model.feature_importances_
feature_importance_df = pd.DataFrame({'Feature': X_train.columns, 'Importance': featur
feature_importance_df = feature_importance_df.sort_values(by='Importance', ascending=F
import matplotlib.pyplot as plt
plt.figure(figsize=(10, 6))
plt.barh(feature_importance_df['Feature'], feature_importance_df['Importance'])
plt.xlabel('Importance')
plt.title('Feature Importances')
plt.show()
```



In [89]:

```
residuals = y_test - predictions
plt.figure(figsize=(10, 6))
plt.scatter(predictions, residuals)
plt.axhline(y=0, color='r', linestyle='--')
plt.xlabel('Predicted Charges')
plt.ylabel('Residuals')
plt.title('Residual Plot')
plt.show()
```



In [90]:

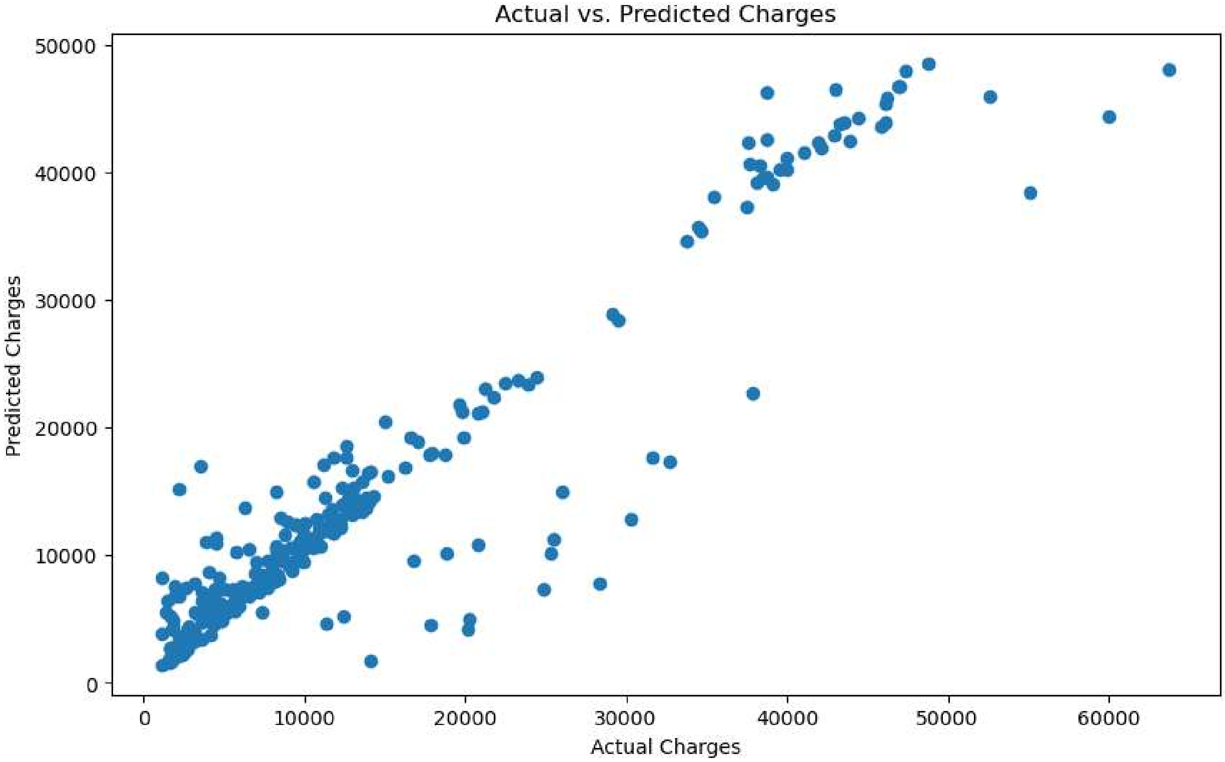
```
from sklearn.metrics import mean_absolute_error, r2_score
mae = mean_absolute_error(y_test, predictions)
```

```
r2 = r2_score(y_test, predictions)
print(f'Mean Absolute Error: {mae:.2f}')
print(f'R-squared: {r2:.2f}')
```

```
Mean Absolute Error: 2572.81
R-squared: 0.88
```

In [91]:

```
plt.figure(figsize=(10, 6))
plt.scatter(y_test, predictions)
plt.xlabel('Actual Charges')
plt.ylabel('Predicted Charges')
plt.title('Actual vs. Predicted Charges')
plt.show()
```

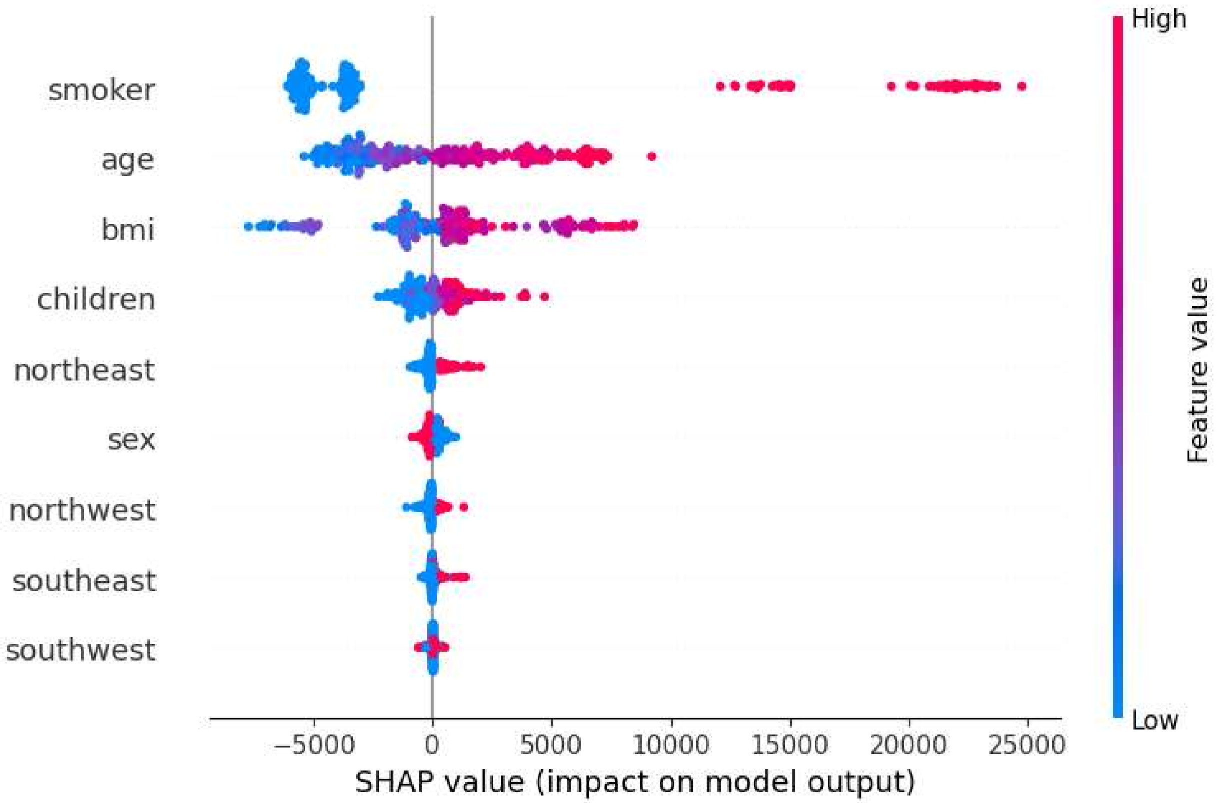


In [95]:

```
import shap
```

In [97]:

```
explainer = shap.TreeExplainer(rand_forest_model)
shap_values = explainer.shap_values(X_test)

shap.summary_plot(shap_values, X_test)
```



In [98]:
```
import matplotlib.pyplot as plt
from statsmodels.tsa.statespace.sarimax import SARIMAX
from statsmodels.tsa.arima.model import ARIMA
from sklearn.preprocessing import LabelEncoder
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error
```

In [99]:
```
df['sex'] = LabelEncoder().fit_transform(df['sex'])
df['smoker'] = LabelEncoder().fit_transform(df['smoker'])
df['region'] = LabelEncoder().fit_transform(df['region'])
```

In [100…
```
X = df[['age', 'sex', 'bmi', 'children', 'smoker', 'region']]
y = df['charges']
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=
```

In [101…
```
sarimax_model = SARIMAX(endog=y_train, exog=X_train, order=(1, 1, 1), seasonal_order=(
sarimax_result = sarimax_model.fit(disp=False)
```

```
An unsupported index was provided and will be ignored when e.g. forecasting.
An unsupported index was provided and will be ignored when e.g. forecasting.
Maximum Likelihood optimization failed to converge. Check mle_retvals
```

In [102…
```
sarimax_predictions = sarimax_result.get_forecast(steps=len(X_test), exog=X_test)
sarimax_mean = sarimax_predictions.predicted_mean
```

```
No supported index is available. Prediction results will be given with an integer ind
ex beginning at `start`.
```

In [103…
```
arimax_model = ARIMA(endog=y_train, exog=X_train, order=(1, 1, 1))
arimax_result = arimax_model.fit()
```

```
An unsupported index was provided and will be ignored when e.g. forecasting.
An unsupported index was provided and will be ignored when e.g. forecasting.
An unsupported index was provided and will be ignored when e.g. forecasting.
Maximum Likelihood optimization failed to converge. Check mle_retvals
```

In [104…

```
arimax_predictions = arimax_result.get_forecast(steps=len(X_test), exog=X_test)
arimax_mean = arimax_predictions.predicted_mean
```

```
No supported index is available. Prediction results will be given with an integer ind
ex beginning at `start`.
```

In [105…

```
mse_sarimax = mean_squared_error(y_test, sarimax_mean)
rmse_sarimax = np.sqrt(mse_sarimax)

mse_arimax = mean_squared_error(y_test, arimax_mean)
rmse_arimax = np.sqrt(mse_arimax)
```

In [106…

```
print(f"SARIMAX Root Mean Squared Error: {rmse_sarimax:.2f}")
print(f"ARIMAX Root Mean Squared Error: {rmse_arimax:.2f}")
```

```
SARIMAX Root Mean Squared Error: 6435.24
ARIMAX Root Mean Squared Error: 6018.36
```

In [107…

```
from sklearn.metrics import r2_score
```

In [109…

```
r2_sarimax = r2_score(y_test, sarimax_mean)
```

In [110…

```
r2_arimax = r2_score(y_test, arimax_mean)
```

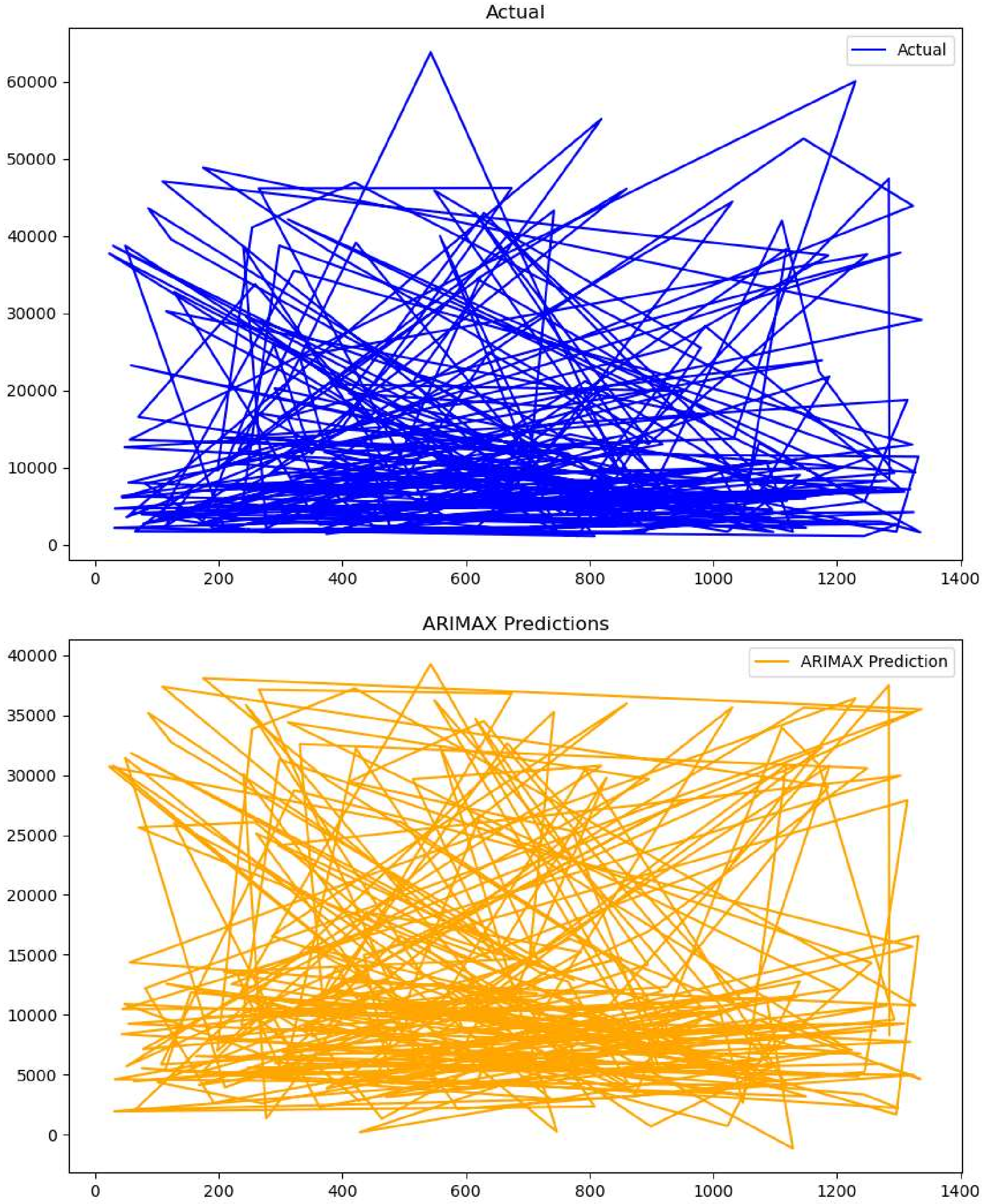
In [111…

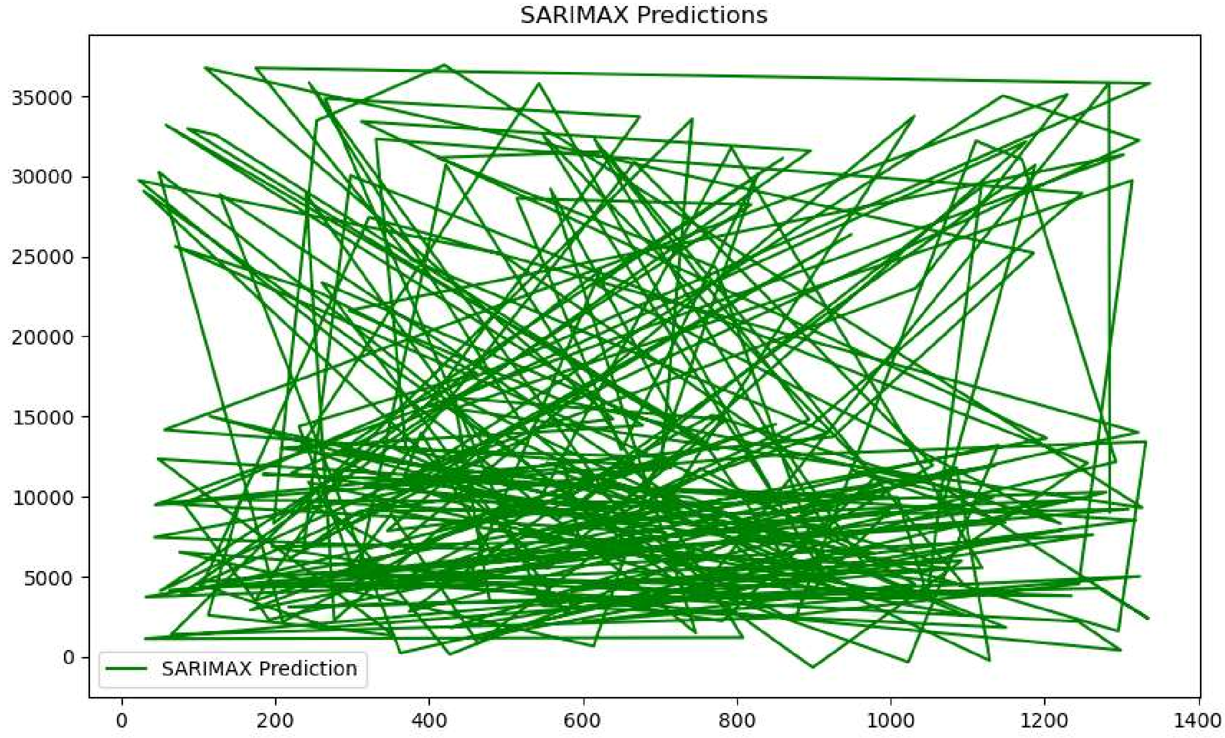
```
print(f"SARIMAX R-squared: {r2_sarimax:.2f}")
print(f"ARIMAX R-squared: {r2_arimax:.2f}")
```

```
SARIMAX R-squared: 0.77
ARIMAX R-squared: 0.80
```

In [117…

```
plt.figure(figsize=(10, 6))
plt.plot(y_test.index, y_test, label='Actual', color='blue')
plt.legend()
plt.title('Actual')
plt.show()

plt.figure(figsize=(10, 6))
plt.plot(y_test.index, arimax_mean, label='ARIMAX Prediction', color='orange')
plt.legend()
plt.title('ARIMAX Predictions')
plt.show()

plt.figure(figsize=(10, 6))
plt.plot(y_test.index, sarimax_mean, label='SARIMAX Prediction', color='green')
plt.legend()
plt.title('SARIMAX Predictions')
plt.show()
```


Actual
Actual
60000
50000
40000
30000
20000
10000
0
0
200
400
600
800
1000
1200
1400
ARIMAX Predictions
ARIMAX Prediction
40000
35000
30000
25000
20000
15000
10000
5000
0
0
200
400
600
800
1000
1200
1400

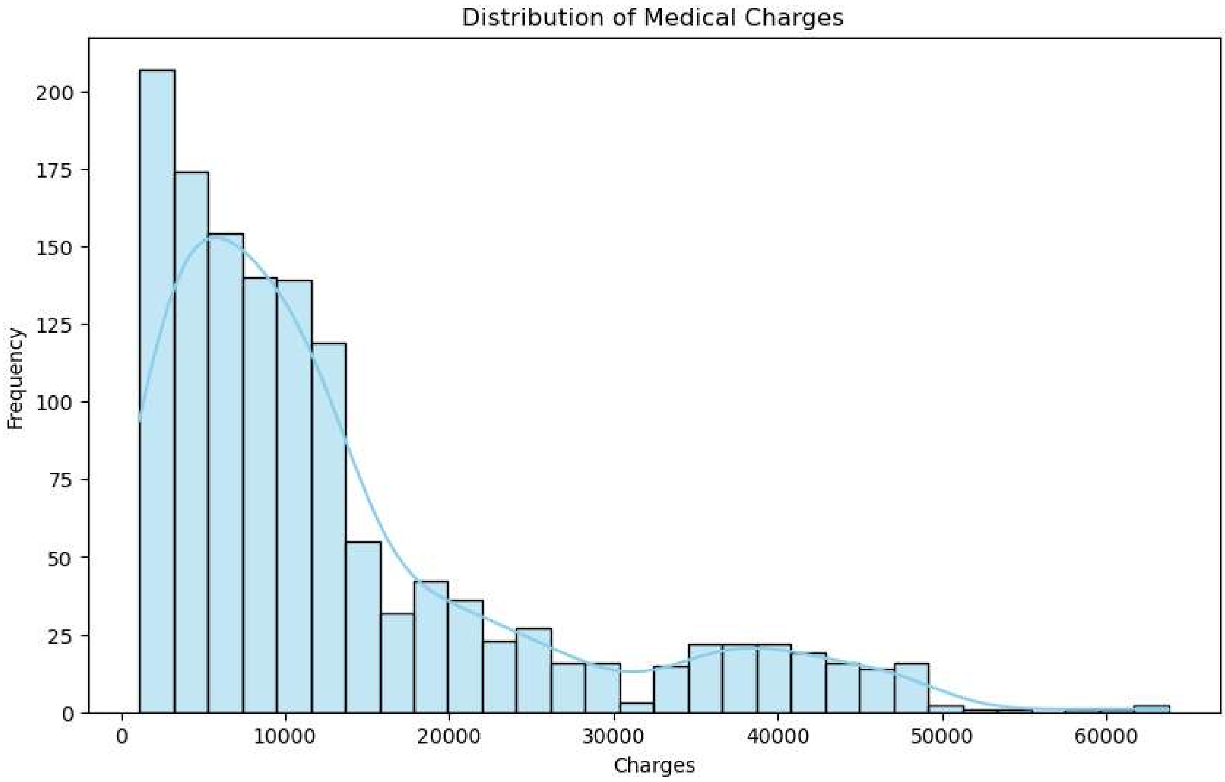


In [119…

```python
import seaborn as sns
```

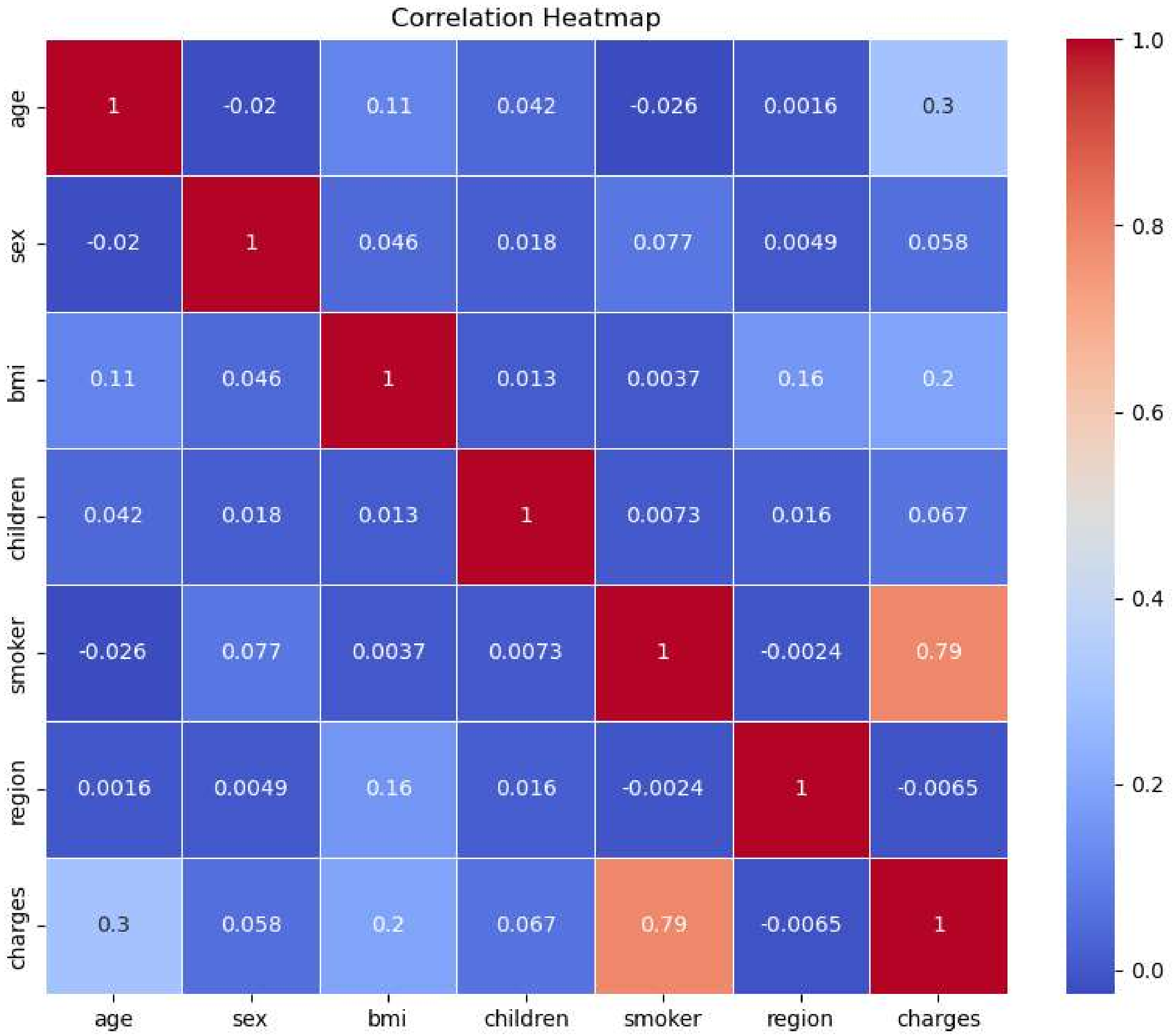
In [120…

```python
plt.figure(figsize=(10, 6))
sns.histplot(df['charges'], kde=True, bins=30, color='skyblue')
plt.title('Distribution of Medical Charges')
plt.xlabel('Charges')
plt.ylabel('Frequency')
plt.show()
```



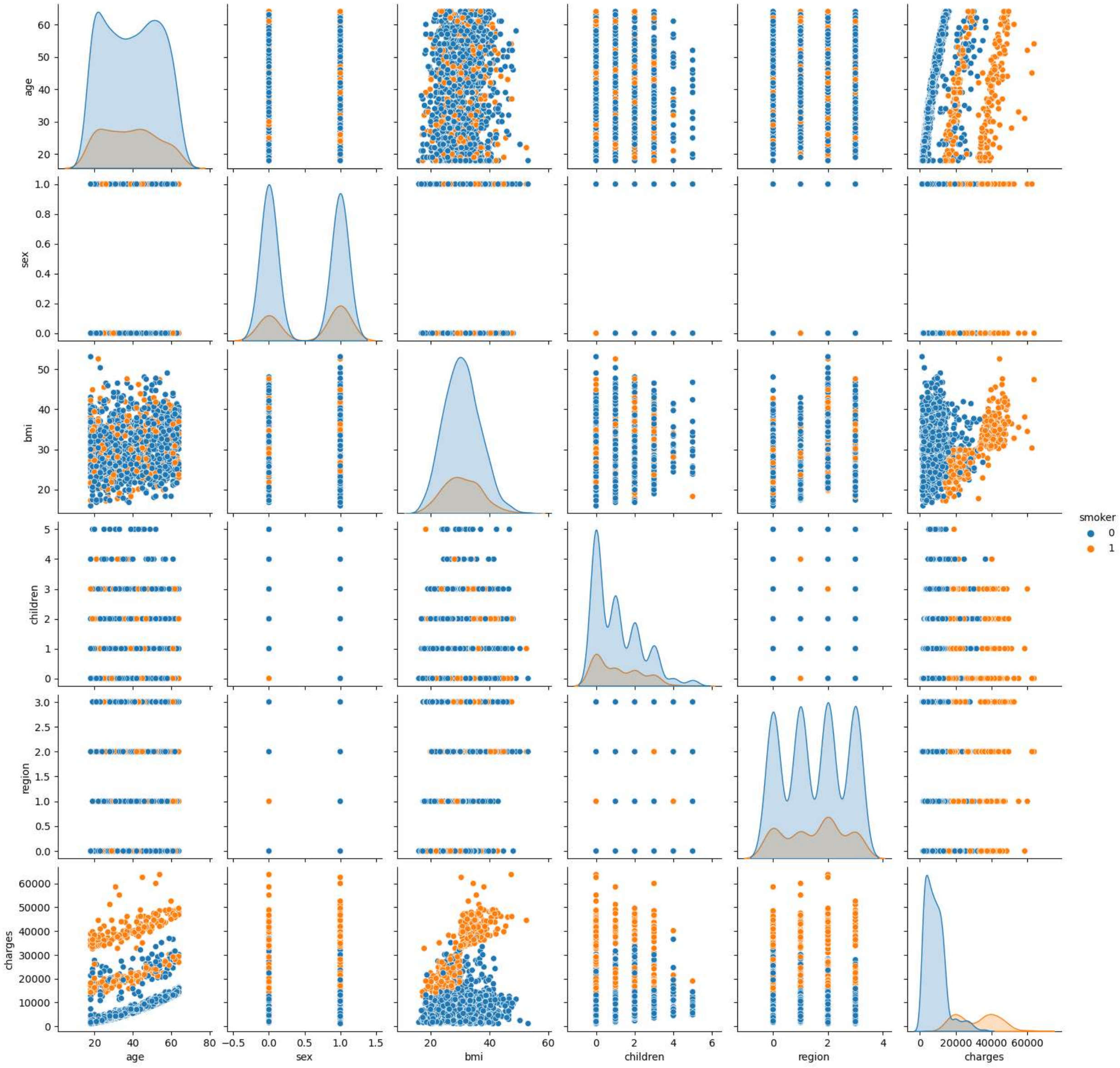
In [124…

```
plt.figure(figsize=(10, 8))
correlation_matrix = df.corr()
sns.heatmap(correlation_matrix, annot=True, cmap='coolwarm', linewidths=.5)
plt.title('Correlation Heatmap')
plt.show()
```



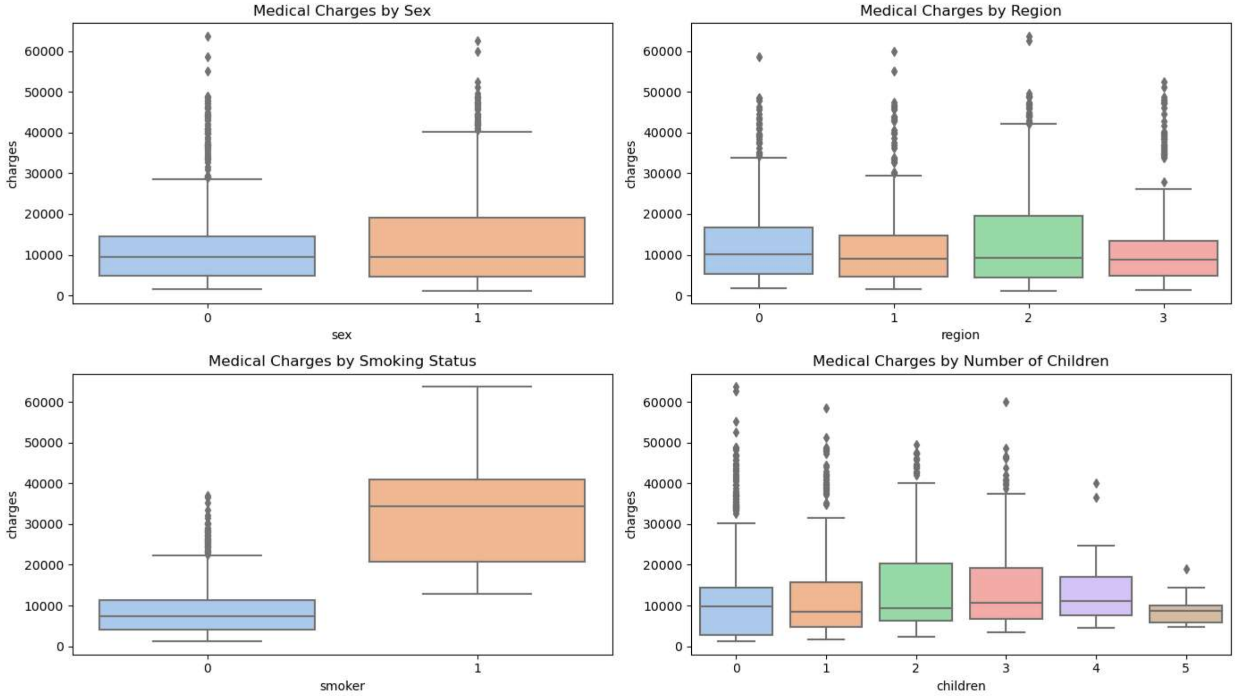
In [125…

```
sns.pairplot(df, hue='smoker', diag_kind='kde')
plt.show()
```



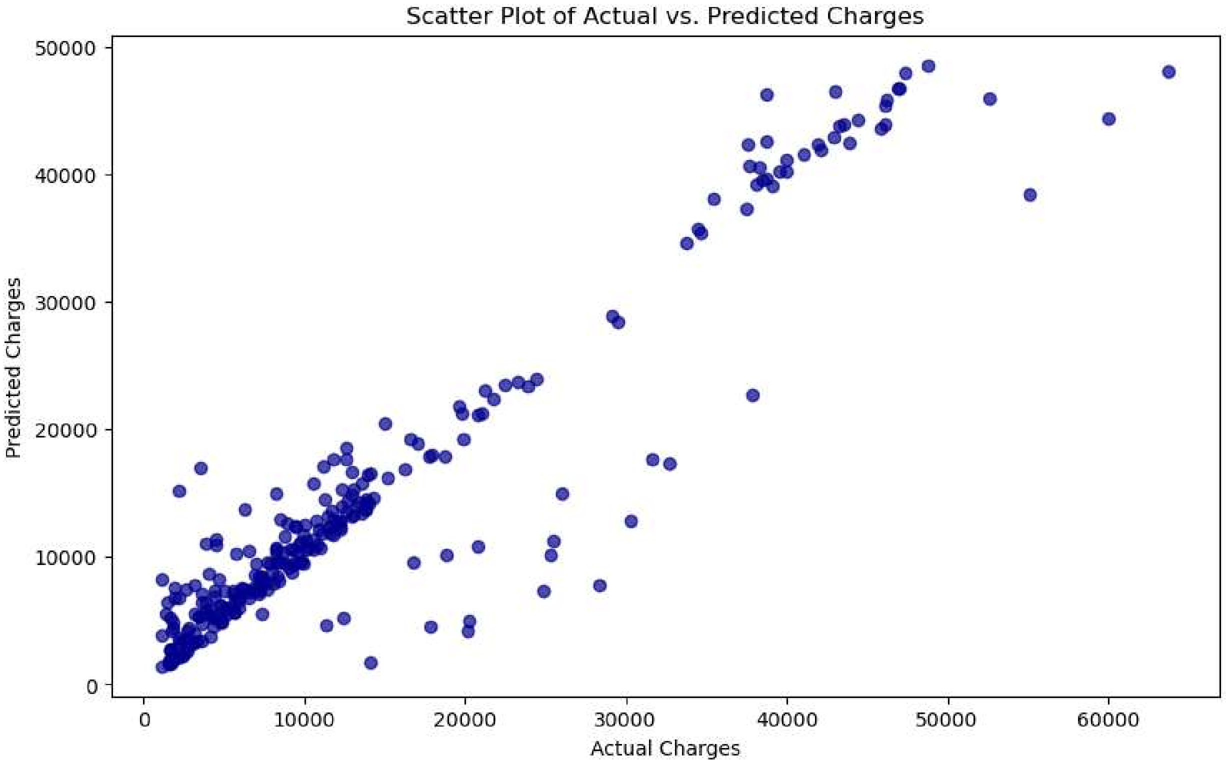
In [126…

```
plt.figure(figsize=(14, 8))
plt.subplot(2, 2, 1)
sns.boxplot(x='sex', y='charges', data=df, palette='pastel')
plt.title('Medical Charges by Sex')

plt.subplot(2, 2, 2)
sns.boxplot(x='region', y='charges', data=df, palette='pastel')
plt.title('Medical Charges by Region')

plt.subplot(2, 2, 3)
sns.boxplot(x='smoker', y='charges', data=df, palette='pastel')
plt.title('Medical Charges by Smoking Status')

plt.subplot(2, 2, 4)
sns.boxplot(x='children', y='charges', data=df, palette='pastel')
plt.title('Medical Charges by Number of Children')

plt.tight_layout()
plt.show()
```



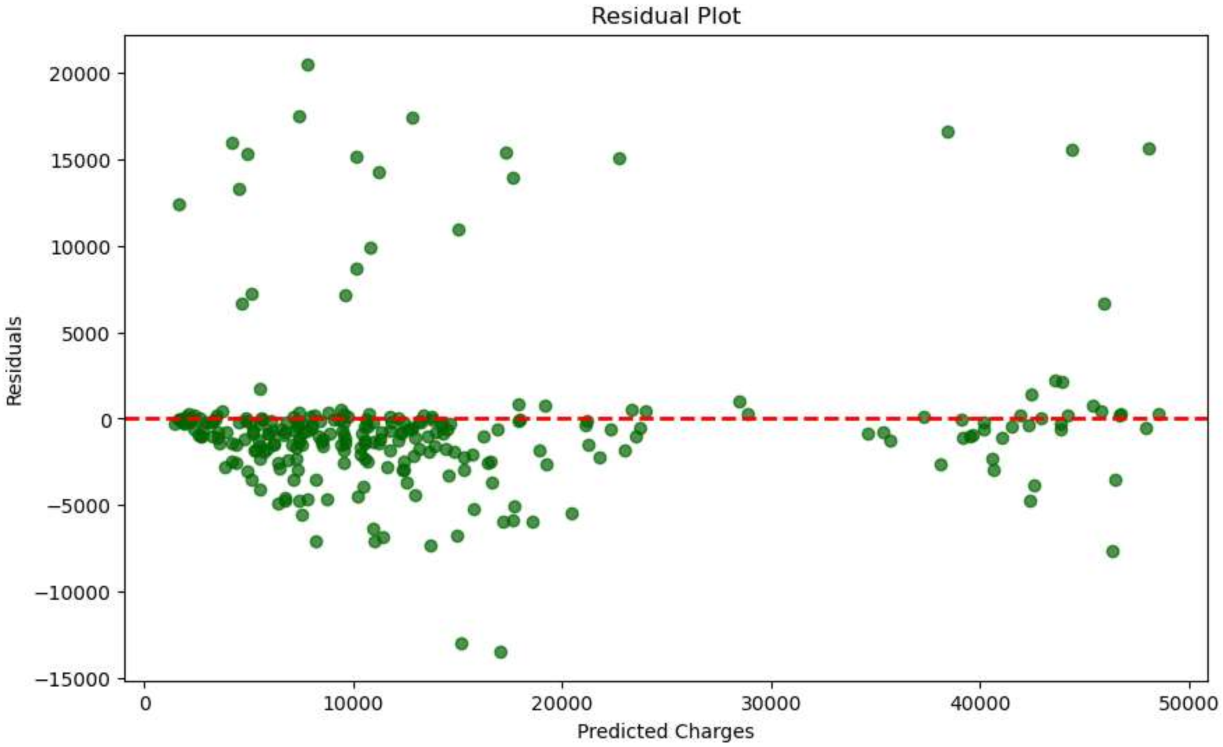
In [127…

```
plt.figure(figsize=(10, 6))
plt.scatter(y_test, predictions, alpha=0.7, color='darkblue')
plt.title('Scatter Plot of Actual vs. Predicted Charges')
plt.xlabel('Actual Charges')
plt.ylabel('Predicted Charges')
plt.show()
```



In [128…

```
residuals = y_test - predictions
plt.figure(figsize=(10, 6))
plt.scatter(predictions, residuals, alpha=0.7, color='darkgreen')
plt.title('Residual Plot')
plt.xlabel('Predicted Charges')
plt.ylabel('Residuals')
plt.axhline(0, color='red', linestyle='--', linewidth=2)
plt.show()
```


Residual Plot
Residuals
Predicted Charges