Loading Packages

```
import pandas as pd
from utils import custom_info
import numpy as np
import seaborn as sns
from scipy import stats
import matplotlib.pyplot as plt
import matplotlib.ticker as ticker
```

Part A: Load the endline data.

```
endline_df = pd.read_stata('endline.dta')
```

We can observe totformalborrow_24, totinformalborrow_24, hhinc parameters have Null Values

```
custom_info(endline_df)
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4160 entries, 0 to 4159
Data columns (total 7 columns):
                      Non-Null Count Null Count Unique Values    Dtype
Column
hhid                            4160          0          4160  float64
group_id                        4160          0           101  float32
totformalborrow_24              2939       1221           413   object
totinformalborrow_24            2621       1539           346   object
hhinc                           3916        244           802   object
hhnomembers                     4160          0            14     int8
survey_round                    4160          0             3   object
Total Rows                      4160
memory usage: 187328 bytes
```

```
endline_df
```

```
          hhid  group_id totformalborrow_24 totinformalborrow_24
hhinc  \
0         86.0       3.0             120000                69000
NaN
1        147.0      96.0                NaN               300000
10700
2        179.0       4.0              50000                96000
4300
3        192.0      76.0             140000                  NaN
NaN
4        261.0      14.0                NaN                  NaN
60000
...        ...       ...                ...                  ...    ..
```

```
.
4155  185874.0      30.0                   6000                     NaN
10750
4156  185875.0      44.0                    NaN                     NaN
7000
4157  185876.0      32.0                    NaN                     NaN
NaN
4158  185877.0     142.0                    NaN                     NaN
1000
4159  185878.0     152.0                    NaN                     NaN
500

      hhnomembers survey_round
0               4   Endline II
1               4   Endline II
2               5   Endline II
3               2   Endline II
4               7    Endline I
...           ...          ...
4155            3  Endline III
4156            4  Endline III
4157            3  Endline III
4158            2  Endline III
4159            1  Endline III

[4160 rows x 7 columns]
```

Part B: Recode household debt and income variables as numeric values instead of strings, and replace "None" with Zero

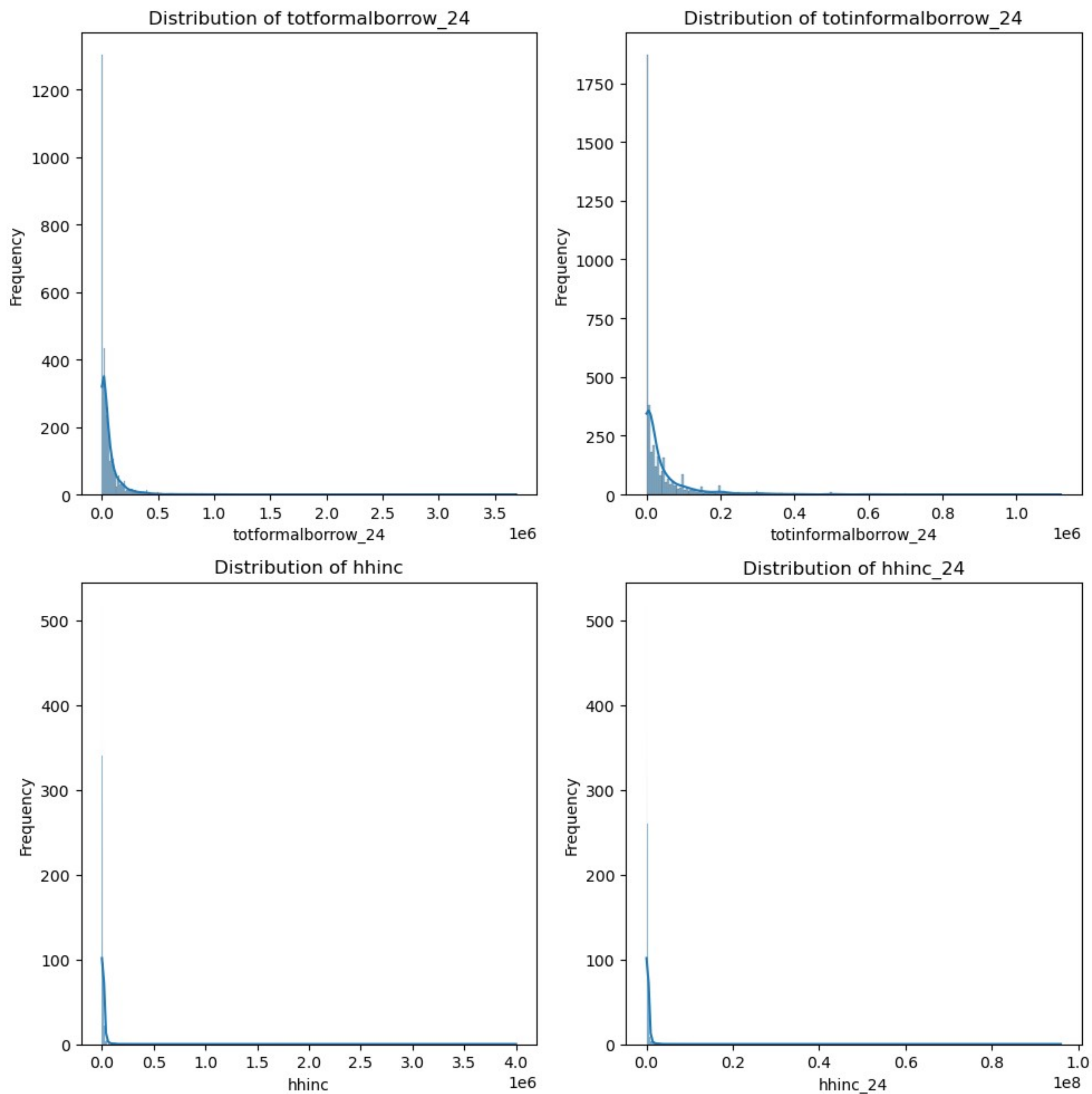
```
cols_to_convert = ['totformalborrow_24', 'totinformalborrow_24',
'hhinc']

for col in cols_to_convert:
    endline_df[col] = pd.to_numeric(endline_df[col], errors='coerce')
    endline_df[col] = endline_df[col].fillna(0).astype(int)

endline_df.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4160 entries, 0 to 4159
Data columns (total 7 columns):
 #   Column                Non-Null Count  Dtype
---  ------                --------------  -----
 0   hhid                  4160 non-null   float64
```

```
 1   group_id               4160 non-null   float32
 2   totformalborrow_24     4160 non-null   int64
 3   totinformalborrow_24   4160 non-null   int64
 4   hhinc                  4160 non-null   int64
 5   hhnomembers            4160 non-null   int8
 6   survey_round           4160 non-null   object
dtypes: float32(1), float64(1), int64(3), int8(1), object(1)
memory usage: 182.9+ KB
```

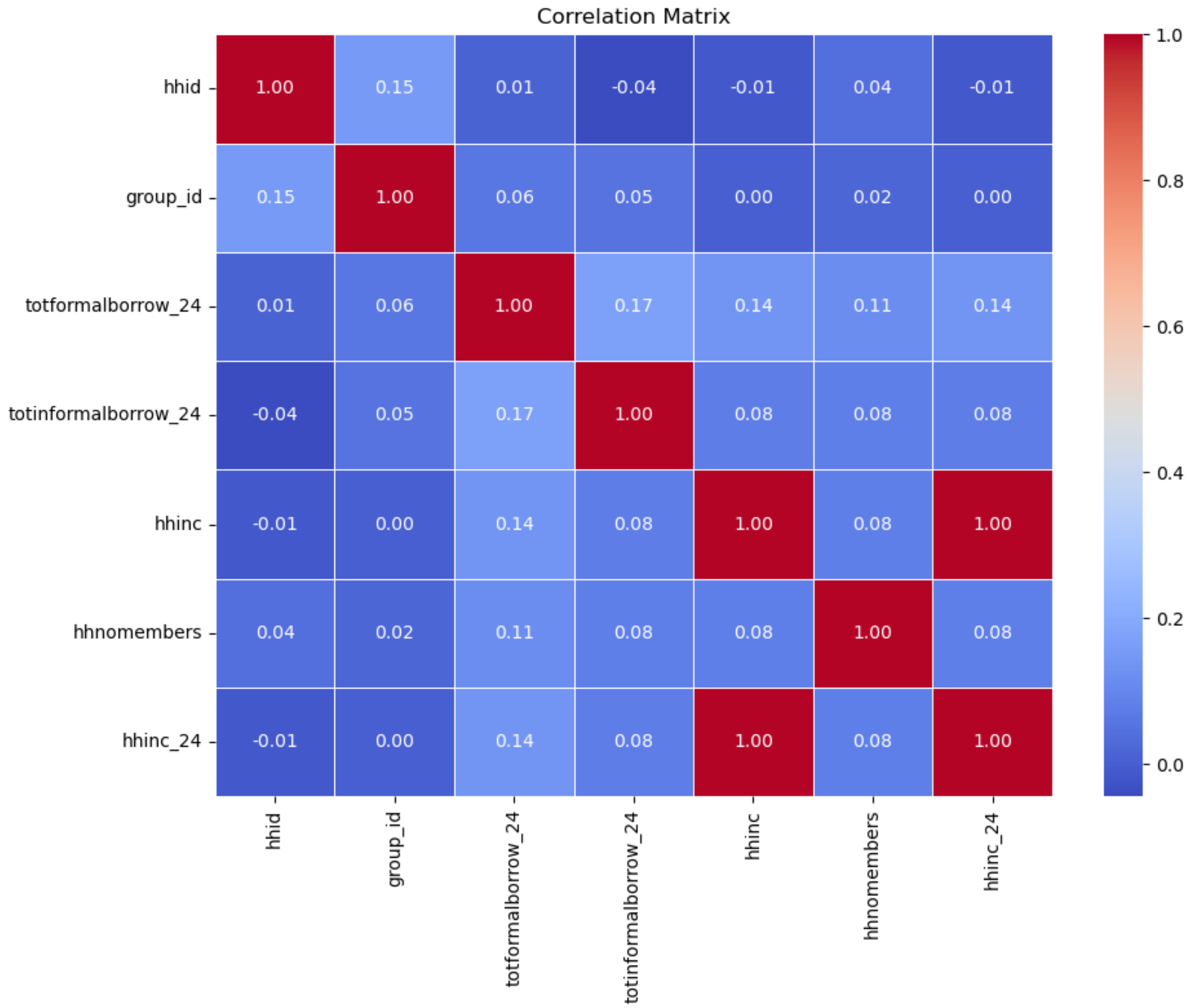
We can see hhinc, totformalborrow_24, totalinformalborrow_24 follow skewed distribution, hence replacing with median is the best option, and also adding a column called hhinc_24 for 24 months income of the family (Assuming per month (30 days = 1 month) remains constant for 24 months

```
endline_df['hhinc_24'] = endline_df['hhinc'].fillna(0) * 24

endline_df

          hhid  group_id  totformalborrow_24  totinformalborrow_24
hhinc  \
0         86.0       3.0              120000                 69000
0
1        147.0      96.0                   0                300000
10700
2        179.0       4.0               50000                 96000
4300
3        192.0      76.0              140000                     0
0
4        261.0      14.0                   0                     0
60000
...        ...       ...                 ...                   ...
...
4155  185874.0      30.0                6000                     0
10750
4156  185875.0      44.0                   0                     0
7000
4157  185876.0      32.0                   0                     0
0
4158  185877.0     142.0                   0                     0
1000
4159  185878.0     152.0                   0                     0
500

      hhnomembers survey_round  hhinc_24
0               4   Endline II         0
1               4   Endline II    256800
2               5   Endline II    103200
```

```
3                 2   Endline II         0
4                 7    Endline I   1440000
...             ...          ...       ...
4155              3  Endline III    258000
4156              4  Endline III    168000
4157              3  Endline III         0
4158              2  Endline III     24000
4159              1  Endline III     12000

[4160 rows x 8 columns]

numeric_features = ['totformalborrow_24', 'totinformalborrow_24',
'hhinc','hhinc_24']
num_rows = 2
num_cols = 2
fig, axes = plt.subplots(num_rows, num_cols, figsize=(10, 10))

axes = axes.flatten()

for i, feature in enumerate(numeric_features):
    sns.histplot(endline_df[feature], kde=True, ax=axes[i])
    axes[i].set_title(f'Distribution of {feature}')
    axes[i].set_xlabel(feature)
    axes[i].set_ylabel('Frequency')

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




```python
# Select only the numeric columns
numeric_cols = endline_df.select_dtypes(include=[np.number]).columns

# Create a new DataFrame with only the numeric columns
numeric_df = endline_df[numeric_cols]

plt.figure(figsize=(10, 8))
sns.heatmap(numeric_df.corr(), annot=True, cmap='coolwarm', fmt=".2f",
linewidths=0.5)
plt.title('Correlation Matrix')
plt.tight_layout()
plt.show()
```



Now we have dataset which has imputation with the median and extra column hhinc_24

```
endline_df = pd.read_stata('endline.dta')

# Columns to convert and handle missing values
cols_to_convert = ['totformalborrow_24', 'totinformalborrow_24',
'hhinc']

# Convert columns to numeric and replace missing values with the
median
for col in cols_to_convert:
    endline_df[col] = pd.to_numeric(endline_df[col], errors='coerce')
    median_value = endline_df[col].median()
    endline_df[col] = endline_df[col].fillna(median_value).astype(int)

# Create a new column 'hhinc_24' by multiplying 'hhinc' by 24
endline_df['hhinc_24'] = endline_df['hhinc'] * 24
```

```
custom_info(endline_df)
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4160 entries, 0 to 4159
Data columns (total 8 columns):
                      Non-Null Count Null Count Unique Values    Dtype
Column
hhid                            4160          0          4160  float64
group_id                        4160          0           101  float32
totformalborrow_24              4160          0           412    int64
totinformalborrow_24            4160          0           345    int64
hhinc                           4160          0           801    int64
hhnomembers                     4160          0            14     int8
survey_round                    4160          0             3   object
hhinc_24                        4160          0           801    int64
Total Rows                      4160
memory usage: 220608 bytes
```

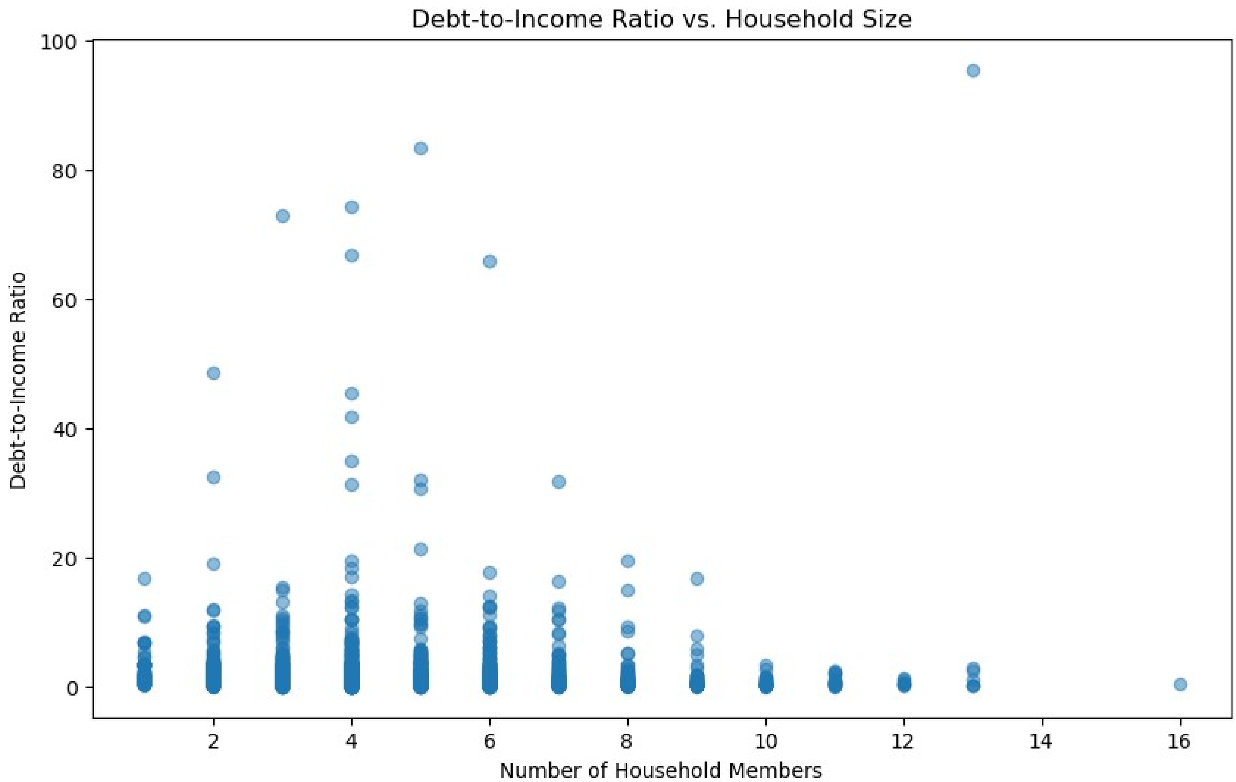
```
endline_df.describe()
```

```
                hhid     group_id  totformalborrow_24
totinformalborrow_24  \
count    4160.000000  4160.000000        4.160000e+03
4.160000e+03
mean   105520.079087   113.227402        7.904370e+04
5.200912e+04
std     47127.152425    53.617245        1.219337e+05
8.054436e+04
min        86.000000     1.000000        2.000000e+03
2.000000e+03
25%     78535.250000    76.000000        3.487500e+04
2.000000e+04
50%    114347.500000   133.000000        5.000000e+04
3.000000e+04
75%    125841.000000   159.000000        7.500000e+04
4.500000e+04
max    185878.000000   183.000000        3.690000e+06
1.120000e+06

              hhinc  hhnomembers      hhinc_24
count  4.160000e+03  4160.000000  4.160000e+03
mean   1.219746e+04     4.514423  2.927390e+05
std    6.737758e+04     1.855772  1.617062e+06
min    3.000000e+01     1.000000  7.200000e+02
25%    3.400000e+03     3.000000  8.160000e+04
50%    6.700000e+03     4.000000  1.608000e+05
75%    1.100000e+04     6.000000  2.640000e+05
max    4.000000e+06    16.000000  9.600000e+07
```

Part 3: Browse the variables in this dataset, and write a few sentences about the financial status of households in this sample, supported by this data. Feel free to use a table or figure to support your argument.

All households have a debt-to-income ratio greater than 1, indicating that their total borrowing over the past 24 months exceeds their total income over the same period. This suggests a high level of indebtedness relative to income, which could imply financial stress.

```
endline_df1 = endline_df.copy()

# Calculate total borrowed amount and normalize income to 24 months
endline_df1['total_borrowed'] = endline_df1['totformalborrow_24'] +
endline_df1['totinformalborrow_24']
endline_df1['normalized_income'] = endline_df1['hhinc_24']

# Calculate debt-to-income ratio
endline_df1['debt_to_income_ratio'] = endline_df1['total_borrowed'] /
endline_df1['normalized_income']

# Create a scatter plot of debt-to-income ratio vs. number of
household members
plt.figure(figsize=(10, 6))
plt.scatter(endline_df1['hhnomembers'],
endline_df1['debt_to_income_ratio'], alpha=0.5)
plt.xlabel('Number of Household Members')
plt.ylabel('Debt-to-Income Ratio')
plt.title('Debt-to-Income Ratio vs. Household Size')
plt.show()
```



The scatter plot provided illustrates the relationship between household size and the debt-to-income ratio for a sample of households. From the plot, we can observe several trends and points of interest:

1. **Decreasing Debt-to-Income Ratio with Larger Household Size**: There is a general trend where larger households, particularly those with 10 or more members, tend to have lower debt-to-income ratios. This could indicate that as households grow in size, they may benefit from economies of scale or have more potential income earners, which helps in managing and reducing relative debt levels.

2. **Variability in Smaller Households**: Smaller households, especially those with 2 to 6 members, display a wide range of debt-to-income ratios, with some households experiencing very high ratios, well above 20. This variability suggests that financial health in smaller households is less consistent and possibly more vulnerable to fluctuations in income or unexpected expenses.

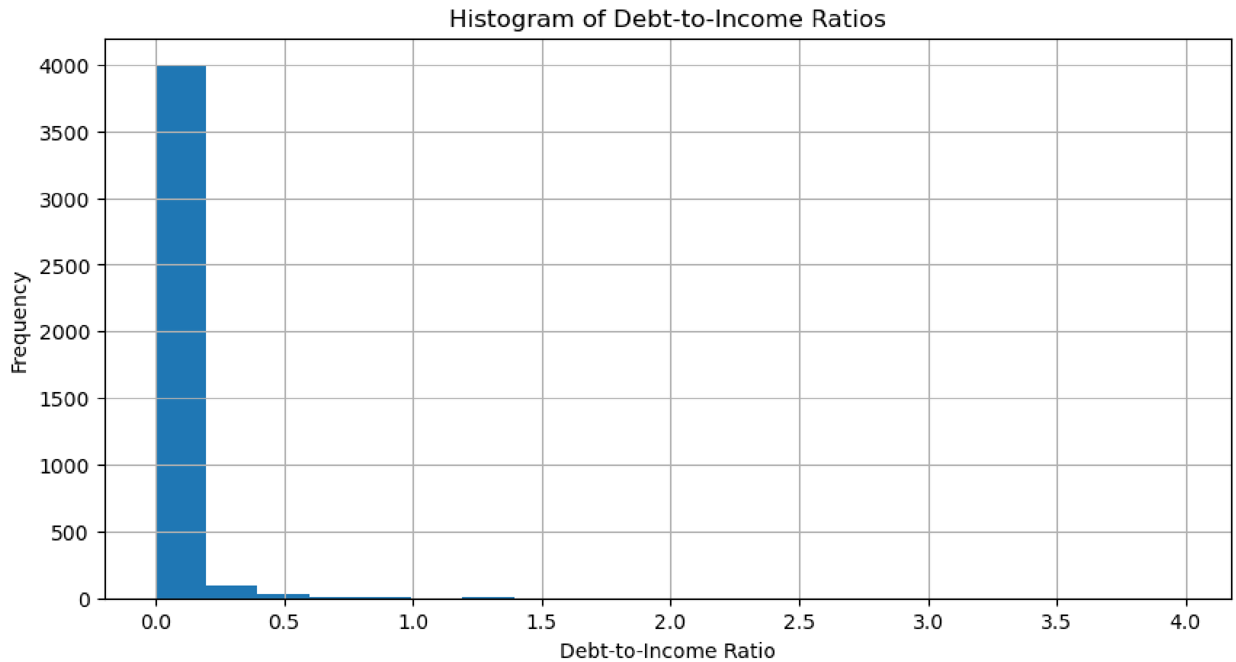
3. **Presence of High Debt-to-Income Ratios**: There are several outliers with extremely high debt-to-income ratios across different household sizes. These outliers indicate that some households, regardless of size, may be facing significant financial stress, with debt levels that are disproportionately high compared to their income.

4. **Overall Financial Health**: While larger households appear to have a more favorable financial status based on their lower debt-to-income ratios, the presence

of households with high ratios across all sizes indicates that financial challenges are not exclusive to any particular household size. It is important to consider that the debt-to-income ratio is just one aspect of financial health and other factors such as savings, assets, and expenses would also play a critical role in a comprehensive assessment.

```
def analyze_financial_status(df):
    df['totformalborrow_24'] = pd.to_numeric(df['totformalborrow_24'], 
errors='coerce')
    df['totinformalborrow_24'] = 
pd.to_numeric(df['totinformalborrow_24'], errors='coerce')
    df['hhinc_24'] = pd.to_numeric(df['hhinc_24'], errors='coerce')

    # Calculate total borrowed and adjust income for 24 months
    df['total_borrowed'] = df['totformalborrow_24'].fillna(0) + 
df['totinformalborrow_24'].fillna(0)
    df['adjusted_income'] = df['hhinc_24'].fillna(0) * 24

    # Calculate debt-to-income ratio
    df['debt_to_income_ratio'] = df['total_borrowed'] / 
df['adjusted_income'].replace(0, np.nan)

    num_ignored = df['debt_to_income_ratio'].isnull().sum()
    print(f"Number of values ignored while calculating debt-to-income 
ratio: {num_ignored}")


    # Summary statistics
    summary_stats = df[['debt_to_income_ratio', 
'hhnomembers']].describe()

    # Plotting
    plt.figure(figsize=(10, 5))
    df['debt_to_income_ratio'].hist(bins=20)
    plt.title('Histogram of Debt-to-Income Ratios')
    plt.xlabel('Debt-to-Income Ratio')
    plt.ylabel('Frequency')
    plt.show()

    return summary_stats


analyze_financial_status(endline_df1)
```

```
Number of values ignored while calculating debt-to-income ratio: 0
```




```
       debt_to_income_ratio  hhnomembers
count           4160.000000  4160.000000
mean               0.056169     4.514423
std                0.157901     1.855772
min                0.000100     1.000000
25%                0.012770     3.000000
50%                0.024034     4.000000
75%                0.052083     6.000000
max                3.975694    16.000000
```

The mean debt-to-income ratio is approximately 0.056, which suggests that, on average, households have a debt amount that is just 5.6% of their income. This indicates a relatively low level of indebtedness across the sample as a whole.

However, the standard deviation is about 0.158, which points to substantial variability in the financial burden among households. Some households have much higher debt-to-income ratios, which could signal financial stress.

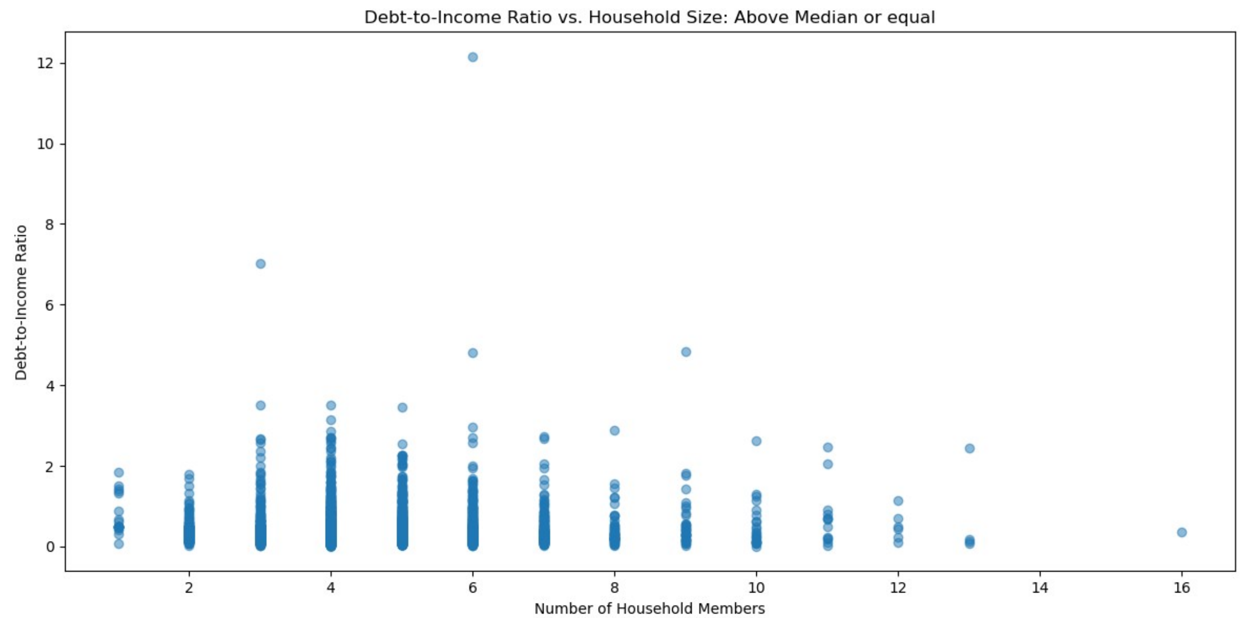
The minimum debt-to-income ratio is very close to zero, showing that some households have negligible debt. In contrast, the maximum ratio is nearly 4, indicating that at least one household has debt that is nearly four times its income, which is a sign of high financial distress.

The median household size is 4 members, with half of the households having between 3 and 6 members. This suggests that the sample includes many medium-sized households.

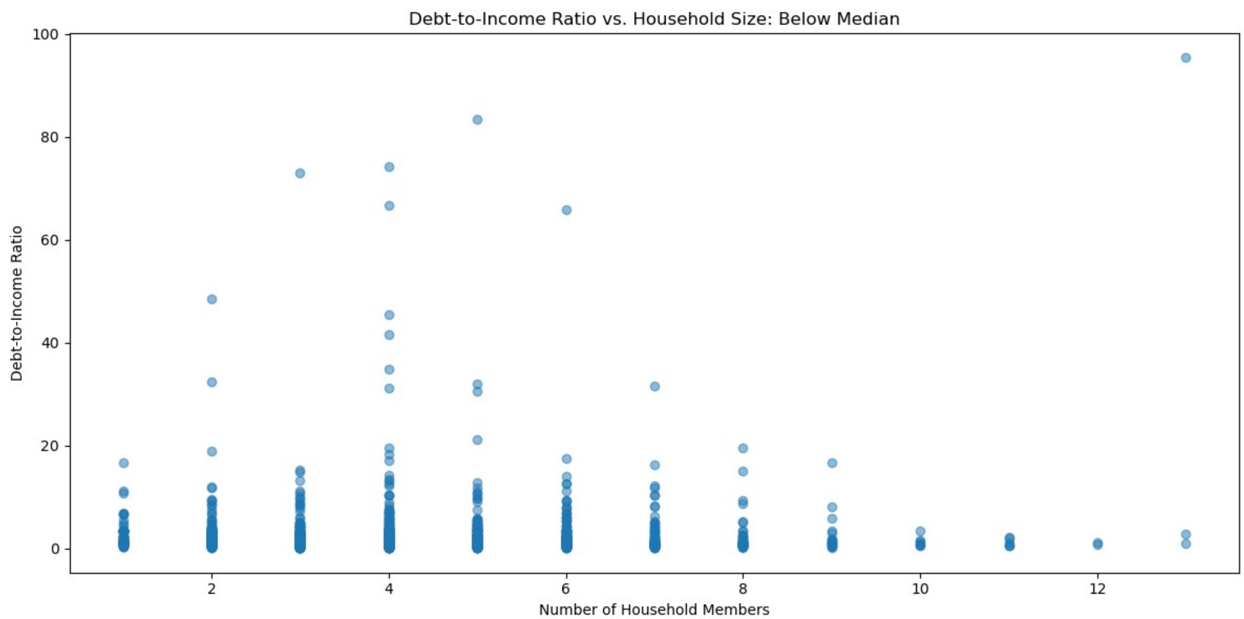
```
median_income = endline_df1['normalized_income'].median()
endline_df1['income_class'] =
endline_df1['normalized_income'].apply(lambda x: 'Above Median or
equal' if x >= median_income else 'Below Median')


num_rows = 2
num_cols = 1
fig, axes = plt.subplots(num_rows, num_cols, figsize=(12, 12))


axes = axes.flatten()


for i, income_class in enumerate(['Above Median or equal', 'Below
Median']):
    subset = endline_df1[endline_df1['income_class'] == income_class]
    axes[i].scatter(subset['hhnomembers'],
```

```
subset['debt_to_income_ratio'], alpha=0.5)
    axes[i].set_title(f'Debt-to-Income Ratio vs. Household Size:
{income_class}')
    axes[i].set_xlabel('Number of Household Members')
    axes[i].set_ylabel('Debt-to-Income Ratio')
    summary_stats = subset[['debt_to_income_ratio',
'hhnomembers']].describe()
    print(f"Summary Statistics for {income_class}:")
    print(summary_stats)
    print(f"Total number of households in {income_class}:
{len(subset)}\n")

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

```
Summary Statistics for Above Median or equal:
       debt_to_income_ratio  hhnomembers
count           2205.000000  2205.000000
mean               0.502004     4.798186
std                0.557768     1.818337
min                0.002396     1.000000
25%                0.204352     4.000000
50%                0.354167     5.000000
75%                0.588235     6.000000
max               12.157960    16.000000
Total number of households in Above Median or equal: 2205

Summary Statistics for Below Median:
       debt_to_income_ratio  hhnomembers
count           1955.000000  1955.000000
mean               2.302306     4.194373
std                5.338313     1.845925
min                0.057471     1.000000
25%                0.625000     3.000000
50%                1.111111     4.000000
75%                2.301136     5.000000
max               95.416667    13.000000
Total number of households in Below Median: 1955
```



Debt-to-Income Ratio vs. Household Size: Above Median or equal
Debt-to-Income Ratio
Number of Household Members



Debt-to-Income Ratio vs. Household Size: Below Median
Debt-to-Income Ratio
Number of Household Members

For households above or equal to the median size, the average debt-to-income ratio is 0.502, which suggests that on average, the debt is approximately half of the income. This group has a relatively lower mean debt-to-income ratio and a standard deviation of 0.558, indicating moderate variability in financial burden among these households. The median household size is 5 members, and the range extends up to 16 members, which is the largest household size observed in the sample.

In contrast, households below the median size have a significantly higher mean debt-to-income ratio of 2.302, indicating that on average, their debt is more than twice their income. This group exhibits a much higher standard deviation of 5.338, reflecting a greater disparity in the financial status among these households. The median household size is 4 members, with the range going up to 13 members.

The scatter plots reinforce these findings, showing that households above or equal to the median size tend to have a cluster of lower debt-to-income ratios, whereas households below the median size display a wider spread of ratios, including some extreme values.

larger households tend to have a more favorable financial status with lower debt relative to their income. In contrast, smaller households appear to face greater financial strain, with higher debt-to-income ratios indicating potential challenges in managing debt and maintaining financial stability.

Part 4 and 5: Top code household debt and income variables, replacing all values greater than three standard deviations above the mean with a value that is equal to three standard deviations and Label the new top-coded variables.

This process helps to manage outliers in my data that can skew analysis.

```
# Variables to top code
columns_to_top_code = ['totformalborrow_24', 'totinformalborrow_24',
'hhinc', 'hhinc_24']

for column in columns_to_top_code:
    mean = endline_df[column].mean()
    std_dev = endline_df[column].std()
    cutoff = mean + 3 * std_dev
    top_coded_label = column + '_top_coded'
    endline_df[top_coded_label] = np.where(endline_df[column] >
cutoff, cutoff, endline_df[column])

endline_df
```

```
          hhid  group_id  totformalborrow_24  totinformalborrow_24
hhinc  \
0         86.0       3.0              120000                 69000
6700
1        147.0      96.0               50000                300000
10700
2        179.0       4.0               50000                 96000
4300
3        192.0      76.0              140000                 30000
6700
4        261.0      14.0               50000                 30000
60000
...        ...       ...                 ...                   ...
...
4155  185874.0      30.0                6000                 30000
10750
4156  185875.0      44.0               50000                 30000
```

```
7000
4157  185876.0      32.0               50000                   30000
6700
4158  185877.0     142.0               50000                   30000
1000
4159  185878.0     152.0               50000                   30000
500

      hhnomembers survey_round  hhinc_24  totformalborrow_24_top_coded
\
0               4   Endline II    160800                      120000.0

1               4   Endline II    256800                       50000.0

2               5   Endline II    103200                       50000.0

3               2   Endline II    160800                      140000.0

4               7    Endline I   1440000                       50000.0

...           ...          ...       ...                           ...

4155            3  Endline III    258000                        6000.0

4156            4  Endline III    168000                       50000.0

4157            3  Endline III    160800                       50000.0

4158            2  Endline III     24000                       50000.0

4159            1  Endline III     12000                       50000.0


      totinformalborrow_24_top_coded  hhinc_top_coded
hhinc_24_top_coded
0                       69000.000000           6700.0
160800.0
1                      293642.188493          10700.0
256800.0
2                       96000.000000           4300.0
103200.0
3                       30000.000000           6700.0
160800.0
4                       30000.000000          60000.0
1440000.0
...                              ...              ...
...
4155                    30000.000000          10750.0
258000.0
4156                    30000.000000           7000.0
```

```
168000.0
4157                        30000.000000           6700.0
160800.0
4158                        30000.000000           1000.0
24000.0
4159                        30000.000000            500.0
12000.0

[4160 rows x 12 columns]
```

Usually z-score = 3 is considered as a cut-off value to set the limit. Therefore, any z-score greater than +3 or less than -3 is considered as outlier

```
numeric_features = ['totformalborrow_24', 'totinformalborrow_24',
'hhinc', 'hhinc_24',
                    'totformalborrow_24_top_coded',
'totinformalborrow_24_top_coded',
                    'hhinc_top_coded', 'hhinc_24_top_coded']

for feature in numeric_features:
    z_scores = stats.zscore(endline_df[feature])

    outliers = endline_df[(z_scores < -3) | (z_scores >= 3)]
    num_outliers = len(outliers)

    # Print the feature name and the number of outliers
    print(f"Feature: {feature}")
    print(f"Number of outliers: {num_outliers}")
    print("---")

Feature: totformalborrow_24
Number of outliers: 55
---
Feature: totinformalborrow_24
Number of outliers: 95
---
Feature: hhinc
Number of outliers: 9
---
Feature: hhinc_24
Number of outliers: 9
---
Feature: totformalborrow_24_top_coded
Number of outliers: 133
---
Feature: totinformalborrow_24_top_coded
Number of outliers: 145
---
```

```
Feature: hhinc_top_coded
Number of outliers: 69
---
Feature: hhinc_24_top_coded
Number of outliers: 69
---
```

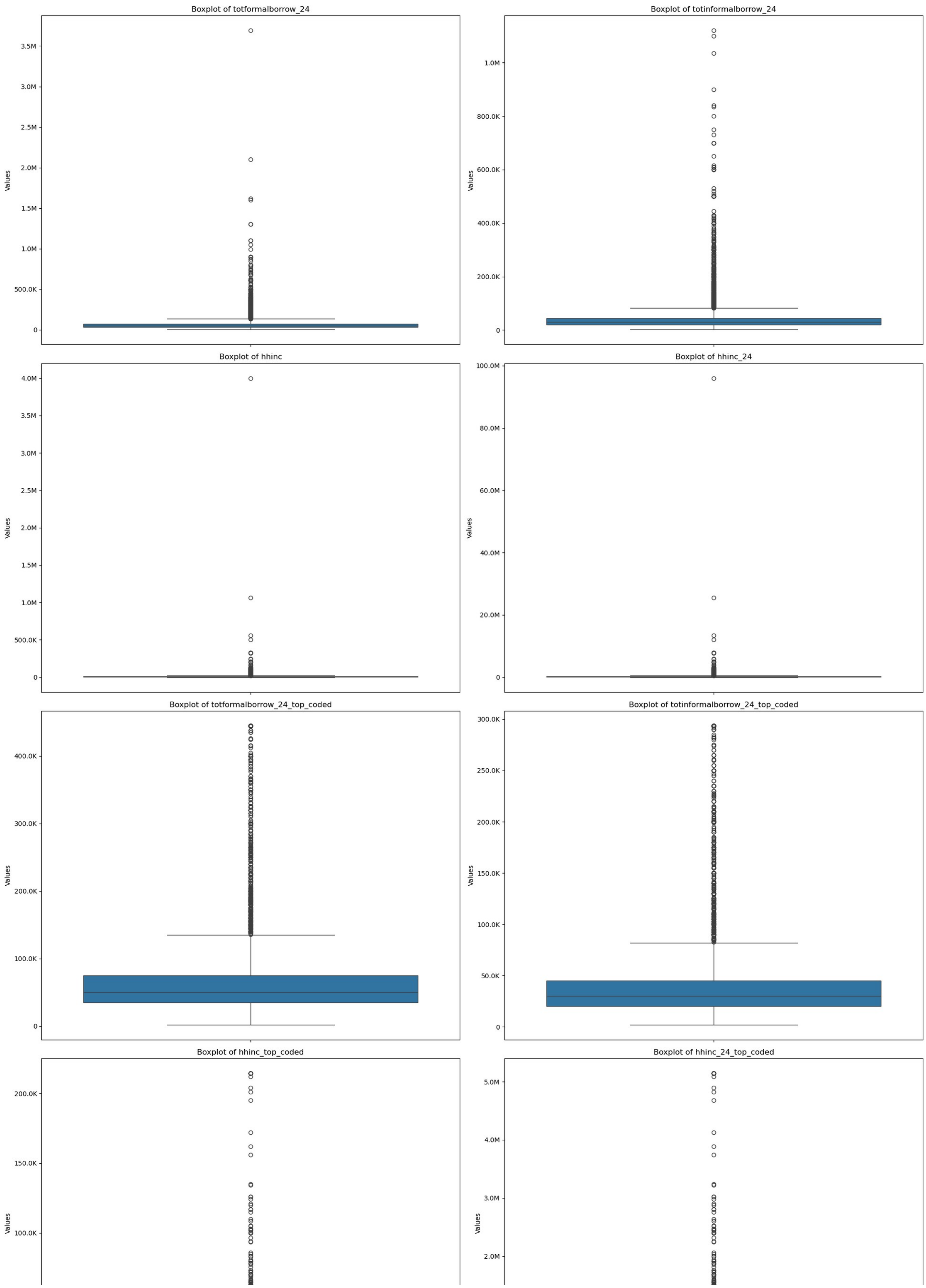
Part H: Write a few sentences about why we might want to top code these types of survey responses from households, and give an example of another data quality or cleaning check

1. **Check for Outliers:**
   - Identify outliers in numeric features using statistical methods (e.g., IQR, Z-score).
   - Decide on the appropriate treatment for outliers:
     - Remove outliers if they are deemed erroneous or influential.
     - Transform outliers using techniques like log transformation if they are not errors but affect model performance.

Reducing the impact of outliers: Extreme values, such as unusually high income or debt figures, can significantly skew statistical measures like the mean and standard deviation. By top coding these outliers, we can mitigate their influence on the overall analysis and obtain more representative results.

```python
numeric_features = ['totformalborrow_24', 'totinformalborrow_24',
'hhinc', 'hhinc_24', 'totformalborrow_24_top_coded',
'totinformalborrow_24_top_coded', 'hhinc_top_coded',
'hhinc_24_top_coded']

num_rows = (len(numeric_features) + 1) // 2
num_cols = 2

fig, axes = plt.subplots(num_rows, num_cols, figsize=(20, 30))

axes = axes.flatten()

def format_tick_labels(x, pos):
    if x >= 1e6:
        return f'{x / 1e6:.1f}M'
    elif x >= 1e3:
        return f'{x / 1e3:.1f}K'
    else:
```

```
        return f'{x:.0f}'

for i, feature in enumerate(numeric_features):
    sns.boxplot(data=endline_df[feature], ax=axes[i])
    axes[i].set_title(f'Boxplot of {feature}')
    axes[i].set_ylabel('Values')

axes[i].yaxis.set_major_formatter(ticker.FuncFormatter(format_tick_lab
els))

if len(numeric_features) % 2 != 0:
    fig.delaxes(axes[-1])

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


Boxplot of totformalborrow_24
Values
3.5M
3.0M
2.5M
2.0M
1.5M
1.0M
500.0K
0
Boxplot of totinformalborrow_24
Values
1.0M
800.0K
600.0K
400.0K
200.0K
0
Boxplot of hhinc
Values
4.0M
3.5M
3.0M
2.5M
2.0M
1.5M
1.0M
500.0K
0
Boxplot of hhinc_24
Values
100.0M
80.0M
60.0M
40.0M
20.0M
0
Boxplot of totformalborrow_24_top_coded
Values
400.0K
300.0K
200.0K
100.0K
0
Boxplot of totinformalborrow_24_top_coded
Values
300.0K
250.0K
200.0K
150.0K
100.0K
50.0K
0
Boxplot of hhinc_top_coded
Values
200.0K
150.0K
100.0K
Boxplot of hhinc_24_top_coded
Values
5.0M
4.0M
3.0M
2.0M

```
# Function to remove outliers based on IQR-score
def remove_outliers_iqr(data, numeric_features):
    outliers_indices = []
    for feature in numeric_features:
        Q1 = np.percentile(data[feature], 25)
        Q3 = np.percentile(data[feature], 75)
        IQR = Q3 - Q1
        lower_bound = Q1 - 1.5 * IQR
        upper_bound = Q3 + 1.5 * IQR
        outliers = data[(data[feature] < lower_bound) | (data[feature]
> upper_bound)]
        outliers_indices.extend(outliers.index)

    outliers_indices = list(set(outliers_indices))
    data_cleaned = data.drop(outliers_indices)
    return data_cleaned

data_cleaned = remove_outliers_iqr(endline_df.copy(),
numeric_features)

data_cleaned
```

```
          hhid  group_id  totformalborrow_24  totinformalborrow_24
hhinc  \
0         86.0       3.0              120000                 69000
6700
8        450.0      76.0               15000                 10000
1500
9        500.0     134.0               25000                 30000
8940
10       554.0     122.0               15000                 30000
10000
12      1129.0      57.0               16000                 26450
7000
...        ...       ...                 ...                   ...
...
4155  185874.0      30.0                6000                 30000
10750
4156  185875.0      44.0               50000                 30000
7000
4157  185876.0      32.0               50000                 30000
6700
4158  185877.0     142.0               50000                 30000
1000
4159  185878.0     152.0               50000                 30000
500

      hhnomembers survey_round  hhinc_24  totformalborrow_24_top_coded
\
0               4   Endline II    160800                      120000.0
```

```
8                6   Endline II     36000                             15000.0
9                6   Endline II    214560                             25000.0
10               5    Endline I    240000                             15000.0
12               3   Endline II    168000                             16000.0
...            ...          ...       ...                                 ...
4155             3  Endline III    258000                              6000.0
4156             4  Endline III    168000                             50000.0
4157             3  Endline III    160800                             50000.0
4158             2  Endline III     24000                             50000.0
4159             1  Endline III     12000                             50000.0

      totinformalborrow_24_top_coded  hhinc_top_coded
hhinc_24_top_coded
0                            69000.0           6700.0
160800.0
8                            10000.0           1500.0
36000.0
9                            30000.0           8940.0
214560.0
10                           30000.0          10000.0
240000.0
12                           26450.0           7000.0
168000.0
...                              ...              ...
...
4155                         30000.0          10750.0
258000.0
4156                         30000.0           7000.0
168000.0
4157                         30000.0           6700.0
160800.0
4158                         30000.0           1000.0
24000.0
4159                         30000.0            500.0
12000.0

[2969 rows x 12 columns]
```

PartG: Create a total borrowed amount variable that equals the sum of formal and informal borrowed amounts.

```
endline_df['total_borrowed_amount'] = endline_df['totformalborrow_24']
+ endline_df['totinformalborrow_24']

endline_df
```

```
           hhid  group_id  totformalborrow_24  totinformalborrow_24
hhinc  \
0          86.0       3.0              120000                 69000
6700
1         147.0      96.0               50000                300000
10700
2         179.0       4.0               50000                 96000
4300
3         192.0      76.0              140000                 30000
6700
4         261.0      14.0               50000                 30000
60000
...         ...       ...                 ...                   ...
...
4155  185874.0      30.0                6000                 30000
10750
4156  185875.0      44.0               50000                 30000
7000
4157  185876.0      32.0               50000                 30000
6700
4158  185877.0     142.0               50000                 30000
1000
4159  185878.0     152.0               50000                 30000
500

      hhnomembers survey_round  hhinc_24  totformalborrow_24_top_coded
\
0               4   Endline II    160800                      120000.0

1               4   Endline II    256800                       50000.0

2               5   Endline II    103200                       50000.0

3               2   Endline II    160800                      140000.0

4               7    Endline I   1440000                       50000.0

...           ...          ...       ...                           ...
```

```
4155           3  Endline III    258000                           6000.0

4156           4  Endline III    168000                          50000.0

4157           3  Endline III    160800                          50000.0

4158           2  Endline III     24000                          50000.0

4159           1  Endline III     12000                          50000.0


      totinformalborrow_24_top_coded  hhinc_top_coded
hhinc_24_top_coded  \
0                       69000.000000           6700.0
160800.0
1                      293642.188493          10700.0
256800.0
2                       96000.000000           4300.0
103200.0
3                       30000.000000           6700.0
160800.0
4                       30000.000000          60000.0
1440000.0
...                              ...              ...
...
4155                    30000.000000          10750.0
258000.0
4156                    30000.000000           7000.0
168000.0
4157                    30000.000000           6700.0
160800.0
4158                    30000.000000           1000.0
24000.0
4159                    30000.000000            500.0
12000.0

      total_borrowed_amount
0                    189000
1                    350000
2                    146000
3                    170000
4                     80000
...                     ...
4155                  36000
4156                  80000
4157                  80000
4158                  80000
4159                  80000

[4160 rows x 13 columns]
```

Part H: Merge the endline data with the treatment_status dataset to assign a treatment status for each household

```
# Read the treatment_status dataset
treatment_status_df = pd.read_csv("treatment_status.csv")

# Merge the endline DataFrame with the treatment_status DataFrame
merge_df = pd.merge(endline_df, treatment_status_df, on="group_id",
how="left")

merge_df
```

```
          hhid  group_id  totformalborrow_24  totinformalborrow_24  
hhinc  \
0         86.0       3.0              120000                 69000  
6700
1        147.0      96.0               50000                300000  
10700
2        179.0       4.0               50000                 96000  
4300
3        192.0      76.0              140000                 30000  
6700
4        261.0      14.0               50000                 30000  
60000
...        ...       ...                 ...                   ...  
...
4155  185874.0      30.0                6000                 30000  
10750
4156  185875.0      44.0               50000                 30000  
7000
4157  185876.0      32.0               50000                 30000  
6700
4158  185877.0     142.0               50000                 30000  
1000
4159  185878.0     152.0               50000                 30000  
500

      hhnomembers survey_round  hhinc_24  totformalborrow_24_top_coded  
\
0               4   Endline II    160800                      120000.0  

1               4   Endline II    256800                       50000.0  

2               5   Endline II    103200                       50000.0  

3               2   Endline II    160800                      140000.0  
```

```
4               7    Endline I   1440000                       50000.0

...           ...          ...       ...                           ...

4155            3  Endline III    258000                        6000.0

4156            4  Endline III    168000                       50000.0

4157            3  Endline III    160800                       50000.0

4158            2  Endline III     24000                       50000.0

4159            1  Endline III     12000                       50000.0


      totinformalborrow_24_top_coded  hhinc_top_coded
hhinc_24_top_coded  \
0                       69000.000000           6700.0
160800.0
1                      293642.188493          10700.0
256800.0
2                       96000.000000           4300.0
103200.0
3                       30000.000000           6700.0
160800.0
4                       30000.000000          60000.0
1440000.0
...                              ...              ...
...
4155                    30000.000000          10750.0
258000.0
4156                    30000.000000           7000.0
168000.0
4157                    30000.000000           6700.0
160800.0
4158                    30000.000000           1000.0
24000.0
4159                    30000.000000            500.0
12000.0

      total_borrowed_amount  pair_id  treated
0                    189000       31        1
1                    350000       14        0
2                    146000       31        0
3                    170000        5        0
4                     80000        1        0
...                     ...      ...      ...
4155                  36000       28        1
4156                  80000       28        0
4157                  80000       32        1
```

```
4158                      80000        36         0
4159                      80000        36         1

[4160 rows x 15 columns]
```

Part i: Create a dummy variable for households that are below the poverty line using a daily per capita poverty line of 26.995 INR (which was equivalent to 1.90 USD at the time of data collection). Use the endline top coded "hhinc" variable, which contains self-reported household income over the past 30 days, in order to do this

```
poverty_line_per_day_per_person = 26.995

# Calculate daily household income from 'hhinc_top_coded' and divide
by 'hhnomembers' to get per capita income
merge_df['daily_per_capita_income'] = (merge_df['hhinc_top_coded'] /
30) / merge_df['hhnomembers']

# Create a dummy variable for households below the poverty line # 0 -
below poverty, 1 - above poverty
merge_df['below_poverty_line'] = (merge_df['daily_per_capita_income']
>= poverty_line_per_day_per_person).astype(int)

merge_df

          hhid  group_id  totformalborrow_24  totinformalborrow_24
hhinc  \
0         86.0       3.0              120000                 69000
6700
1        147.0      96.0               50000                300000
10700
2        179.0       4.0               50000                 96000
4300
3        192.0      76.0              140000                 30000
6700
4        261.0      14.0               50000                 30000
60000
...        ...       ...                 ...                   ...
```

```
...
4155  185874.0      30.0                6000                     30000
10750
4156  185875.0      44.0               50000                     30000
7000
4157  185876.0      32.0               50000                     30000
6700
4158  185877.0     142.0               50000                     30000
1000
4159  185878.0     152.0               50000                     30000
500

      hhnomembers survey_round  hhinc_24  totformalborrow_24_top_coded
\
0               4   Endline II    160800                      120000.0

1               4   Endline II    256800                       50000.0

2               5   Endline II    103200                       50000.0

3               2   Endline II    160800                      140000.0

4               7    Endline I   1440000                       50000.0

...           ...          ...       ...                           ...

4155            3  Endline III    258000                        6000.0

4156            4  Endline III    168000                       50000.0

4157            3  Endline III    160800                       50000.0

4158            2  Endline III     24000                       50000.0

4159            1  Endline III     12000                       50000.0


      totinformalborrow_24_top_coded  hhinc_top_coded
hhinc_24_top_coded  \
0                       69000.000000           6700.0
160800.0
1                      293642.188493          10700.0
256800.0
2                       96000.000000           4300.0
103200.0
3                       30000.000000           6700.0
160800.0
4                       30000.000000          60000.0
1440000.0
...                              ...              ...
```

```
...
4155                    30000.000000          10750.0
258000.0
4156                    30000.000000           7000.0
168000.0
4157                    30000.000000           6700.0
160800.0
4158                    30000.000000           1000.0
24000.0
4159                    30000.000000            500.0
12000.0

      total_borrowed_amount  pair_id  treated  daily_per_capita_income  \
0                    189000       31        1                55.833333

1                    350000       14        0                89.166667

2                    146000       31        0                28.666667

3                    170000        5        0               111.666667

4                     80000        1        0               285.714286

...                     ...      ...      ...                      ...

4155                  36000       28        1               119.444444

4156                  80000       28        0                58.333333

4157                  80000       32        1                74.444444

4158                  80000       36        0                16.666667

4159                  80000       36        1                16.666667


      below_poverty_line
0                      1
1                      1
2                      1
3                      1
4                      1
...                  ...
4155                   1
4156                   1
4157                   1
4158                   0
4159                   0

[4160 rows x 17 columns]
```

Part J: Write a few sentences about the strengths and limitations of using the dummy you created to assess a household's poverty status. If you were able to collect more data from these households, what types of additional questions might you ask?

Strengths of Using the Poverty Line Dummy Variable

The dummy variable for poverty status based on a daily per capita income threshold simplifies the analysis by converting a continuous income measure into a binary indicator, which is easy to interpret and use in statistical models. Using a standardized poverty line allows for comparisons across different studies and geographical areas. This can be particularly useful in policy analysis and international development research. The dummy variable directly addresses economic vulnerability and can be immediately useful for targeting and evaluating poverty alleviation programs. It helps in identifying the households most in need of support.

Limitations of Using the Poverty Line Dummy Variable

The dummy variable does not capture the depth or severity of poverty. Households significantly below the poverty line are treated the same as those just below it. It can be the case a rich household can be under huge debt whereas a poor household in very less debt.

Additional Data Collection Suggestions

1. **Expenditure Details**: What are the major areas of household expenditure? Understanding where money is spent can provide insights into household priorities and needs.

2. **Asset Ownership**: What assets (e.g., land, livestock, vehicles, appliances) does the household own? Assets are a critical component of household wealth and can provide a buffer against economic shocks which can tell their net worth.

3. **Access to Services**: Does the household have access to essential services such as clean water, sanitation, electricity, healthcare, and education? These factors are crucial for understanding living standards and well-being.

4. **Employment and Labor Information**: What types of employment do household members engage in? Are these jobs stable or seasonal? Information about employment can help assess economic stability and vulnerability.

5. **Education Levels**: What are the education levels of household members? Education is a key factor in long-term economic prospects and social mobility.

Part K: Merge your working data with the baseline controls dataset, and save the merged data. If you need to make decisions about dropping mismatched values, please justify them in notes.

```
baseline_df = pd.read_stata('baseline_controls.dta')

baseline_df
```

```
          hhid  group_id hhnomembers  gender_hoh age_hoh  \
0         73.0      35.0           5  Female (0)    30.0
1         86.0       3.0           4    Male (1)    55.0
2        179.0       4.0           5    Male (1)    51.0
3        192.0      76.0           2    Male (1)    57.0
4        261.0      14.0           7    Male (1)    46.0
...        ...       ...         ...         ...     ...
4061  185362.0     120.0           4    Male (1)    39.0
4062  185417.0     120.0           4  Female (0)    45.0
4063  185436.0     120.0           4  Female (0)    34.0
4064  185452.0     120.0           5  Female (0)    51.0
4065  185460.0     120.0           5  Female (0)    50.0

                   educyears_hoh  readwrite_hoh  noclasspassed_hoh  \
0                       10 years            1.0                0.0
1                       10 years            1.0                0.0
2                        8 years            1.0                0.0
3                       12 years            1.0                0.0
4     19+ years (Post-graduate)            1.0                0.0
...                          ...            ...                ...
4061    3-7 years (Classes 1-5)            1.0                0.0
4062                     0 years            0.0                1.0
4063    14 years (Class 12/HSC)            1.0                0.0
4064                     0 years            0.0                1.0
4065                     0 years            0.0                1.0

      higheduc_hoh  hhnomembers_above18  hhnomembers_below18
```

```
hhreg_muslim  \
0               0.0                   2.0                   3.0
0.0
1               0.0                   4.0                   0.0
0.0
2               0.0                   5.0                   0.0
0.0
3               0.0                   2.0                   0.0
0.0
4               1.0                   4.0                   3.0
0.0
...             ...                   ...                   ...
...
4061            0.0                   2.0                   2.0
0.0
4062            0.0                   2.0                   2.0
0.0
4063            0.0                   2.0                   2.0
0.0
4064            0.0                   5.0                   0.0
0.0
4065            0.0                   3.0                   2.0
0.0

      hhreg_christian  hhcaste_fc  hhcaste_bc  hhcaste_mbc
hhcaste_sc_st
0                 0.0         0.0         0.0          1.0
0.0
1                 0.0         0.0         1.0          0.0
0.0
2                 0.0         0.0         0.0          0.0
1.0
3                 0.0         0.0         1.0          0.0
0.0
4                 0.0         0.0         0.0          0.0
1.0
...               ...         ...         ...          ...
...
4061              0.0         0.0         0.0          1.0
0.0
4062              0.0         0.0         0.0          1.0
0.0
4063              0.0         0.0         1.0          0.0
0.0
4064              0.0         0.0         0.0          1.0
0.0
4065              0.0         0.0         0.0          1.0
0.0
```

```
[4066 rows x 17 columns]

common_columns = merge_df.columns.intersection(baseline_df.columns)
print("Common Columns:", common_columns)

Common Columns: Index(['hhid', 'group_id', 'hhnomembers'],
dtype='object')

merged_data_inner = pd.merge(merge_df, baseline_df , on='hhid',
how='inner')
```

The inner join (how='inner') will keep only the rows that have matching 'hhid' values in both datasets. This means that if there are any 'hhid' values present in one dataset but not in the other, those rows will be excluded from the merged result. The common attribute between them is hhid

```
merged_data_inner

          hhid  group_id_x  totformalborrow_24  totinformalborrow_24
hhinc  \
0         86.0         3.0              120000                 69000
6700
1        179.0         4.0               50000                 96000
4300
2        192.0        76.0              140000                 30000
6700
3        261.0        14.0               50000                 30000
60000
4        268.0        96.0              120000                 30000
26000
...        ...         ...                 ...                   ...
...
3797  185314.0       120.0                3500                 30000
1500
3798  185362.0       120.0               20000                  4000
20000
3799  185417.0       120.0               90000                200000
10000
3800  185452.0       120.0               60000                370000
4000
3801  185460.0       120.0               50000                 30000
13500

      hhnomembers_x survey_round  hhinc_24
totformalborrow_24_top_coded  \
0                 4   Endline II    160800
120000.0
```

```
1                  5   Endline II    103200
50000.0
2                  2   Endline II    160800
140000.0
3                  7    Endline I   1440000
50000.0
4                  5   Endline II    624000
120000.0
...              ...          ...       ...                            .
..
3797               4  Endline III     36000
3500.0
3798               4  Endline III    480000
20000.0
3799               4  Endline III    240000
90000.0
3800               5  Endline III     96000
60000.0
3801               5  Endline III    324000
50000.0

      totinformalborrow_24_top_coded  ...  noclasspassed_hoh
higheduc_hoh  \
0                       69000.000000  ...                0.0
0.0
1                       96000.000000  ...                0.0
0.0
2                       30000.000000  ...                0.0
0.0
3                       30000.000000  ...                0.0
1.0
4                       30000.000000  ...                1.0
0.0
...                              ...  ...                ...
...
3797                    30000.000000  ...                0.0
0.0
3798                     4000.000000  ...                0.0
0.0
3799                   200000.000000  ...                1.0
0.0
3800                   293642.188493  ...                1.0
0.0
3801                    30000.000000  ...                1.0
0.0

      hhnomembers_above18  hhnomembers_below18  hhreg_muslim
hhreg_christian  \
0                     4.0                  0.0           0.0
```

```
0.0
1                     5.0                    0.0           0.0
0.0
2                     2.0                    0.0           0.0
0.0
3                     4.0                    3.0           0.0
0.0
4                     5.0                    0.0           0.0
0.0
...                   ...                    ...           ...
...
3797                  2.0                    2.0           0.0
0.0
3798                  2.0                    2.0           0.0
0.0
3799                  2.0                    2.0           0.0
0.0
3800                  5.0                    0.0           0.0
0.0
3801                  3.0                    2.0           0.0
0.0

      hhcaste_fc  hhcaste_bc hhcaste_mbc hhcaste_sc_st
0            0.0         1.0         0.0           0.0
1            0.0         0.0         0.0           1.0
2            0.0         1.0         0.0           0.0
3            0.0         0.0         0.0           1.0
4            0.0         0.0         1.0           0.0
...          ...         ...         ...           ...
3797         0.0         1.0         0.0           0.0
3798         0.0         0.0         1.0           0.0
3799         0.0         0.0         1.0           0.0
3800         0.0         0.0         1.0           0.0
3801         0.0         0.0         1.0           0.0

[3802 rows x 33 columns]
```

As the inner join was performed on hhid, I checked if there were any mismatched on the other common columns - group_id and hhnomembers, I dropped rows if any mismatches were there

```
mismatch_mask = merged_data_inner['group_id_x'] !=
merged_data_inner['group_id_y']

# Count the number of mismatches
mismatch_count = mismatch_mask.sum()

# Print the number of mismatches
if mismatch_count > 0:
```

```
    print(f"There are {mismatch_count} mismatches between 'group_id_x' 
and 'group_id_y'.")
else:
    print("The values in 'group_id_x' and 'group_id_y' are always 
equal for all rows.")

# Optional: Display rows where mismatches occur
if mismatch_count > 0:
    print("Displaying rows with mismatches:")
    ff = merged_data_inner[mismatch_mask]
    print(ff[['hhid',"group_id_x","group_id_y"]])
```

```
There are 2 mismatches between 'group_id_x' and 'group_id_y'.
Displaying rows with mismatches:
          hhid  group_id_x  group_id_y
1577  106131.0       148.0       152.0
1601  106360.0       148.0       152.0
```

```
mismatch_mask = merged_data_inner['hhnomembers_x'] != 
merged_data_inner['hhnomembers_y']

# Count the number of mismatches
mismatch_count = mismatch_mask.sum()

# Print the number of mismatches
if mismatch_count > 0:
    print(f"There are {mismatch_count} mismatches between 'group_id_x' 
and 'group_id_y'.")
else:
    print("The values in 'hhnomembers_x' and 'hhnomembers_y' are 
always equal for all rows.")

# Optional: Display rows where mismatches occur
if mismatch_count > 0:
    print("Displaying rows with mismatches:")
    ff = merged_data_inner[mismatch_mask]
    print(ff[['hhid',"hhnomembers_x","hhnomembers_y"]])
```

```
The values in 'hhnomembers_x' and 'hhnomembers_y' are always equal for 
all rows.
```

```
hhids_to_drop = [106131.0, 106360.0]

# Find the index of rows with these hhids
indexes_to_drop = 
merged_data_inner[merged_data_inner['hhid'].isin(hhids_to_drop)].index

# Drop these rows
merged_data_inner.drop(indexes_to_drop, inplace=True)
```

```
merged_data_inner =
merged_data_inner.drop(['group_id_y','hhnomembers_y'], axis=1)

merged_data_inner
```

```
          hhid  group_id_x  totformalborrow_24  totinformalborrow_24
hhinc  \
0         86.0         3.0              120000                 69000
6700
1        179.0         4.0               50000                 96000
4300
2        192.0        76.0              140000                 30000
6700
3        261.0        14.0               50000                 30000
60000
4        268.0        96.0              120000                 30000
26000
...        ...         ...                 ...                   ...
...
3797  185314.0       120.0                3500                 30000
1500
3798  185362.0       120.0               20000                  4000
20000
3799  185417.0       120.0               90000                200000
10000
3800  185452.0       120.0               60000                370000
4000
3801  185460.0       120.0               50000                 30000
13500

      hhnomembers_x survey_round  hhinc_24
totformalborrow_24_top_coded  \
0                 4   Endline II    160800
120000.0
1                 5   Endline II    103200
50000.0
2                 2   Endline II    160800
140000.0
3                 7    Endline I   1440000
50000.0
4                 5   Endline II    624000
120000.0
...             ...          ...       ...                            .
..
3797              4  Endline III     36000
3500.0
3798              4  Endline III    480000
20000.0
3799              4  Endline III    240000
90000.0
```

```
3800              5  Endline III     96000
60000.0
3801              5  Endline III    324000
50000.0

      totinformalborrow_24_top_coded  ...  noclasspassed_hoh
higheduc_hoh  \
0                       69000.000000  ...                0.0
0.0
1                       96000.000000  ...                0.0
0.0
2                       30000.000000  ...                0.0
0.0
3                       30000.000000  ...                0.0
1.0
4                       30000.000000  ...                1.0
0.0
...                              ...  ...                ...
...
3797                    30000.000000  ...                0.0
0.0
3798                     4000.000000  ...                0.0
0.0
3799                   200000.000000  ...                1.0
0.0
3800                   293642.188493  ...                1.0
0.0
3801                    30000.000000  ...                1.0
0.0

      hhnomembers_above18  hhnomembers_below18  hhreg_muslim
hhreg_christian  \
0                     4.0                  0.0           0.0
0.0
1                     5.0                  0.0           0.0
0.0
2                     2.0                  0.0           0.0
0.0
3                     4.0                  3.0           0.0
0.0
4                     5.0                  0.0           0.0
0.0
...                   ...                  ...           ...
...
3797                  2.0                  2.0           0.0
0.0
3798                  2.0                  2.0           0.0
0.0
3799                  2.0                  2.0           0.0
```

```
0.0
3800                 5.0                  0.0           0.0
0.0
3801                 3.0                  2.0           0.0
0.0

      hhcaste_fc hhcaste_bc hhcaste_mbc hhcaste_sc_st
0            0.0        1.0         0.0           0.0
1            0.0        0.0         0.0           1.0
2            0.0        1.0         0.0           0.0
3            0.0        0.0         0.0           1.0
4            0.0        0.0         1.0           0.0
...          ...        ...         ...           ...
3797         0.0        1.0         0.0           0.0
3798         0.0        0.0         1.0           0.0
3799         0.0        0.0         1.0           0.0
3800         0.0        0.0         1.0           0.0
3801         0.0        0.0         1.0           0.0

[3800 rows x 31 columns]
```

```
custom_info(merged_data_inner)
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 3800 entries, 0 to 3799
Data columns (total 31 columns):
                                Non-Null Count Null Count Unique
Values  \
Column

hhid                                      3800          0
3800
group_id_x                                3800          0
101
totformalborrow_24                        3800          0
400
totinformalborrow_24                      3800          0
330
hhinc                                     3800          0
760
hhnomembers_x                             3800          0
14
survey_round                              3800          0
3
hhinc_24                                  3800          0
760
totformalborrow_24_top_coded              3800          0
360
totinformalborrow_24_top_coded            3800          0
283
```

```
hhinc_top_coded                                    3800          0
753
hhinc_24_top_coded                                 3800          0
753
total_borrowed_amount                              3800          0
612
pair_id                                            3800          0
50
treated                                            3800          0
2
daily_per_capita_income                            3800          0
1139
below_poverty_line                                 3800          0
2
gender_hoh                                         3800          0
2
age_hoh                                            3800          0
72
educyears_hoh                                      3800          0
12
readwrite_hoh                                      3800          0
2
noclasspassed_hoh                                  3800          0
2
higheduc_hoh                                       3800          0
2
hhnomembers_above18                                3800          0
13
hhnomembers_below18                                3800          0
9
hhreg_muslim                                       3798          2
2
hhreg_christian                                    3798          2
2
hhcaste_fc                                         3799          1
2
hhcaste_bc                                         3799          1
2
hhcaste_mbc                                        3799          1
2
hhcaste_sc_st                                      3799          1
2
Total Rows                                         3800


                                          Dtype
Column
hhid                                     object
group_id_x                              float32
```

```
totformalborrow_24                   int64
totinformalborrow_24                 int64
hhinc                                int64
hhnomembers_x                         int8
survey_round                        object
hhinc_24                             int64
totformalborrow_24_top_coded       float64
totinformalborrow_24_top_coded     float64
hhinc_top_coded                    float64
hhinc_24_top_coded                 float64
total_borrowed_amount                int64
pair_id                              int64
treated                              int64
daily_per_capita_income            float64
below_poverty_line                   int64
gender_hoh                        category
age_hoh                           category
educyears_hoh                     category
readwrite_hoh                      float32
noclasspassed_hoh                  float32
higheduc_hoh                       float32
hhnomembers_above18                float32
hhnomembers_below18                float32
hhreg_muslim                       float32
hhreg_christian                    float32
hhcaste_fc                         float32
hhcaste_bc                         float32
hhcaste_mbc                        float32
hhcaste_sc_st                      float32
Total Rows
memory usage: 687200 bytes

merged_data_inner.to_csv("Merge.csv")
```