```python
# Cell 1: Import Required Libraries
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from collections import Counter
import warnings

warnings.filterwarnings('ignore')
plt.style.use('seaborn-v0_8-darkgrid')
sns.set_palette("husl")

%matplotlib inline

print("✅ All libraries imported successfully!")
```

```
✅ All libraries imported successfully!
```

```python
# Cell 2: Load Kaggle Dataset
data_path =
'../data/raw/Lifestyle_and_Health_Risk_Prediction_Synthetic_Dataset
Kaggle.csv'

df_kaggle = pd.read_csv(data_path)

print("="*70)
print(" " * 20 + "KAGGLE DATASET LOADED SUCCESSFULLY")
print("="*70)
print(f"Total Records: {len(df_kaggle):,}")
print(f"Total Columns: {len(df_kaggle.columns)}")
print(f"\nColumn Names:")
print(df_kaggle.columns.tolist())
```

```
======================================================================
                    KAGGLE DATASET LOADED SUCCESSFULLY
======================================================================
Total Records: 5,000
Total Columns: 12

Column Names:
['age', 'weight', 'height', 'exercise', 'sleep', 'sugar_intake',
'smoking', 'alcohol', 'married', 'profession', 'bmi', 'health_risk']
```

```python
# Cell 3: Dataset Overview
print("="*70)
print(" " * 25 + "DATASET OVERVIEW")
print("="*70)

print("\nFirst 10 Rows:")
print(df_kaggle.head(10))
```

```python
print("\n" + "="*70)
print("Last 5 Rows:")
print(df_kaggle.tail())

print("\n" + "="*70)
print("Random Sample (5 rows):")
print(df_kaggle.sample(5))
```

```
======================================================================
                        DATASET OVERVIEW
======================================================================

First 10 Rows:
   age  weight  height exercise  sleep sugar_intake smoking alcohol
married  \
0   56      67     195      low    6.1       medium     yes     yes
yes
1   69      76     170     high    6.9         high      no      no
no
2   46     106     153     high    6.6          low     yes      no
no
3   32      54     186   medium    8.5       medium      no      no
no
4   60      98     195     high    8.0          low      no      no
yes
5   25      96     160   medium    3.8       medium      no      no
yes
6   78      64     168   medium    9.9         high      no      no
yes
7   38      76     194      low    6.6       medium     yes      no
yes
8   56      58     158   medium    9.6       medium      no      no
yes
9   75      94     147     none    8.1       medium     yes      no
no

      profession   bmi health_risk
0  office_worker  17.6        high
1        teacher  26.3        high
2         artist  45.3        high
3         artist  15.6         low
4        teacher  25.8        high
5         farmer  37.5        high
6         artist  22.7        high
7         driver  20.2        high
8  office_worker  23.2         low
9         farmer  43.5        high

======================================================================
Last 5 Rows:
```

```
      age  weight  height exercise  sleep sugar_intake smoking alcohol
\
4995   42      75     187   medium    7.2          low      no      no

4996   39      86     183      low    7.4          low      no      no

4997   48      56     194     none    7.2         high     yes     yes

4998   34     109     148   medium    9.9       medium      no      no

4999   72      47     149     high    6.3       medium      no      no


     married profession   bmi health_risk
4995     yes     driver  21.4         low
4996     yes   engineer  25.7        high
4997     yes   engineer  14.9        high
4998     yes     doctor  49.8         low
4999     yes     driver  21.2         low

======================================================================
Random Sample (5 rows):
      age  weight  height exercise  sleep sugar_intake smoking alcohol
\
2786   77      49     186      low    9.8       medium      no      no

4880   20     103     163      low    6.8       medium      no      no

1160   78      76     162   medium    7.1         high      no      no

2135   37     105     165   medium    9.0          low      no      no

1375   72      91     161   medium    6.1       medium      no      no


     married profession   bmi health_risk
2786      no     doctor  14.2        high
4880      no   engineer  38.8        high
1160     yes     artist  29.0        high
2135     yes     doctor  38.6         low
1375      no     farmer  35.1        high
```

```
# Cell 4: Data Types and Structure
print("="*70)
print(" " * 25 + "DATA TYPES & INFO")
print("="*70)

print("\nDataFrame Info:")
print(df_kaggle.info())

print("\n" + "="*70)
```

```python
print("Data Types Summary:")
print(df_kaggle.dtypes)

print("\n" + "="*70)
print("Dataset Shape:")
print(f"  Rows: {df_kaggle.shape[0]:,}")
print(f"  Columns: {df_kaggle.shape[1]}")

print("\n" + "="*70)
print("Memory Usage:")
print(f"  {df_kaggle.memory_usage(deep=True).sum() / 1024**2:.2f} MB")
```

```
======================================================================
                        DATA TYPES & INFO
======================================================================

DataFrame Info:
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 5000 entries, 0 to 4999
Data columns (total 12 columns):
 #   Column        Non-Null Count  Dtype  
---  ------        --------------  -----  
 0   age           5000 non-null   int64  
 1   weight        5000 non-null   int64  
 2   height        5000 non-null   int64  
 3   exercise      5000 non-null   object 
 4   sleep         5000 non-null   float64
 5   sugar_intake  5000 non-null   object 
 6   smoking       5000 non-null   object 
 7   alcohol       5000 non-null   object 
 8   married       5000 non-null   object 
 9   profession    5000 non-null   object 
 10  bmi           5000 non-null   float64
 11  health_risk   5000 non-null   object 
dtypes: float64(2), int64(3), object(7)
memory usage: 468.9+ KB
None

======================================================================
Data Types Summary:
age              int64
weight           int64
height           int64
exercise        object
sleep          float64
sugar_intake    object
smoking         object
alcohol         object
married         object
profession      object
```

```
bmi              float64
health_risk       object
dtype: object

======================================================================
Dataset Shape:
  Rows: 5,000
  Columns: 12

======================================================================
Memory Usage:
  2.22 MB
```

```
# Cell 5: Missing Values Analysis
print("="*70)
print(" " * 25 + "MISSING VALUES ANALYSIS")
print("="*70)

missing_values = df_kaggle.isnull().sum()
missing_percentage = (missing_values / len(df_kaggle)) * 100

missing_df = pd.DataFrame({
    'Column': missing_values.index,
    'Missing_Count': missing_values.values,
    'Percentage': missing_percentage.values
})

missing_df = missing_df[missing_df['Missing_Count'] >
0].sort_values('Missing_Count', ascending=False)

if len(missing_df) > 0:
    print("\nMissing Values Found:")
    print(missing_df.to_string(index=False))

    # Visualization
    plt.figure(figsize=(12, 6))
    plt.barh(missing_df['Column'], missing_df['Percentage'],
color='coral')
    plt.xlabel('Missing Percentage (%)', fontsize=12)
    plt.ylabel('Column Name', fontsize=12)
    plt.title('Missing Values by Column', fontsize=14,
fontweight='bold')
    plt.gca().invert_yaxis()
    plt.tight_layout()
    plt.savefig('../reports/kaggle_missing_values.png', dpi=300,
bbox_inches='tight')
    plt.show()
else:
    print("\n No missing values found!")
    print("   Dataset is complete and ready for analysis.")
```

```
======================================================================
                        MISSING VALUES ANALYSIS
======================================================================

 No missing values found!
   Dataset is complete and ready for analysis.
```

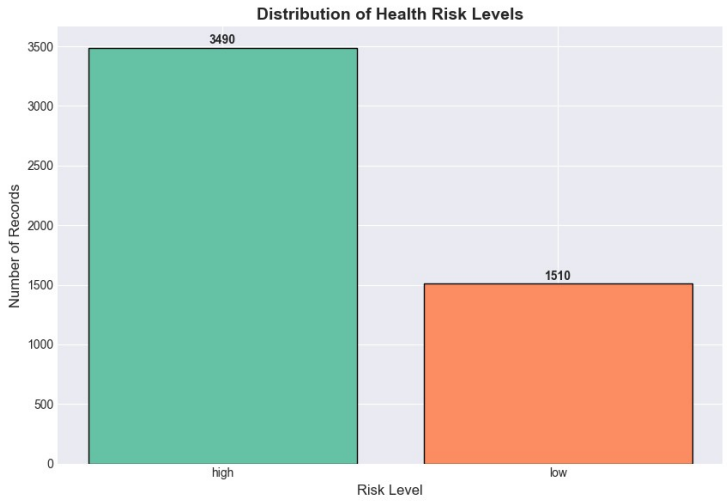
```python
# Cell 6: Statistical Summary
print("="*70)
print(" " * 25 + "STATISTICAL SUMMARY")
print("="*70)

print("\nNumerical Features Summary:")
print(df_kaggle.describe())

print("\n" + "="*70)
print("Categorical Features Summary:")
categorical_cols = df_kaggle.select_dtypes(include=['object']).columns
if len(categorical_cols) > 0:
    print(df_kaggle[categorical_cols].describe())
else:
    print("No categorical columns found.")
```

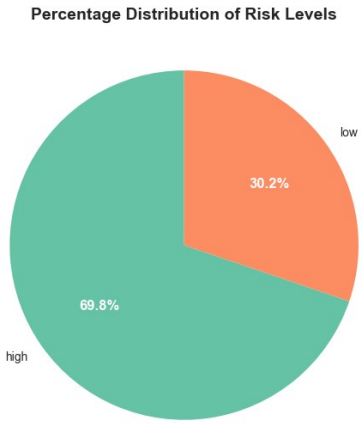
```
======================================================================
                        STATISTICAL SUMMARY
======================================================================

Numerical Features Summary:
                age       weight       height        sleep          bmi
count  5000.000000  5000.000000  5000.000000  5000.000000  5000.00000
mean     48.805600    77.359200   171.933200     6.997060    26.84388
std      17.906991    18.714567    15.822225     1.432849     8.25249
min      18.000000    45.000000   145.000000     3.000000    11.40000
25%      34.000000    61.000000   158.000000     6.000000    20.30000
50%      49.000000    77.000000   171.500000     7.000000    26.00000
75%      64.000000    94.000000   186.000000     8.000000    32.40000
max      79.000000   109.000000   199.000000    10.000000    51.40000

======================================================================
Categorical Features Summary:
       exercise sugar_intake smoking alcohol married profession
health_risk
count      5000         5000    5000    5000    5000       5000
5000
unique        4            3       2       2       2          8
2
top      medium       medium      no      no     yes    student
high
freq       1985         2511    4023    3741    3018        644
3490
```

```
# Cell 7: Target Variable Distribution
print("="*70)
print(" " * 20 + "TARGET VARIABLE: health_risk")
print("="*70)

# Identify target column (adjust name if different)
target_col = 'health_risk'  # Change if your target column has a
different name

if target_col in df_kaggle.columns:

    # Value counts
    risk_counts = df_kaggle[target_col].value_counts()
    risk_percentage = (risk_counts / len(df_kaggle)) * 100

    risk_df = pd.DataFrame({
        'Risk_Level': risk_counts.index,
        'Count': risk_counts.values,
        'Percentage': risk_percentage.values
    })

    print("\nRisk Level Distribution:")
    print(risk_df.to_string(index=False))

    # Visualizations
    fig, axes = plt.subplots(1, 2, figsize=(16, 6))

    # Bar chart
    axes[0].bar(risk_counts.index, risk_counts.values,
                color=sns.color_palette("Set2", len(risk_counts)),
edgecolor='black')
    axes[0].set_xlabel('Risk Level', fontsize=12)
    axes[0].set_ylabel('Number of Records', fontsize=12)
    axes[0].set_title('Distribution of Health Risk Levels',
fontsize=14, fontweight='bold')
    for i, v in enumerate(risk_counts.values):
        axes[0].text(i, v + 10, str(v), ha='center', va='bottom',
fontweight='bold')

    # Pie chart
    colors = sns.color_palette("Set2", len(risk_counts))
    wedges, texts, autotexts = axes[1].pie(risk_counts.values,
labels=risk_counts.index,
                                           autopct='%1.1f%%',
startangle=90, colors=colors)
    axes[1].set_title('Percentage Distribution of Risk Levels',
fontsize=14, fontweight='bold')

    for autotext in autotexts:
        autotext.set_color('white')
```

```
        autotext.set_fontweight('bold')
        autotext.set_fontsize(12)

    plt.tight_layout()
    plt.savefig('../reports/kaggle_risk_distribution.png', dpi=300,
bbox_inches='tight')
    plt.show()

    # Check class balance
    min_class = risk_counts.min()
    max_class = risk_counts.max()
    balance_ratio = min_class / max_class

    print(f"\n Class Balance Analysis:")
    print(f"   Smallest class: {min_class:,} samples")
    print(f"   Largest class: {max_class:,} samples")
    print(f"   Balance ratio: {balance_ratio:.3f}")

    if balance_ratio < 0.5:
        print("   ⚠  Warning: Class imbalance detected!")
        print("   → Consider using stratified sampling or SMOTE")
    else:
        print("    Classes are reasonably balanced")

else:
    print(f"⚠  Column '{target_col}' not found!")
    print(f"   Available columns: {df_kaggle.columns.tolist()}")
```

```
======================================================================
                    TARGET VARIABLE: health_risk
======================================================================

Risk Level Distribution:
Risk_Level  Count  Percentage
      high   3490        69.8
       low   1510        30.2
```



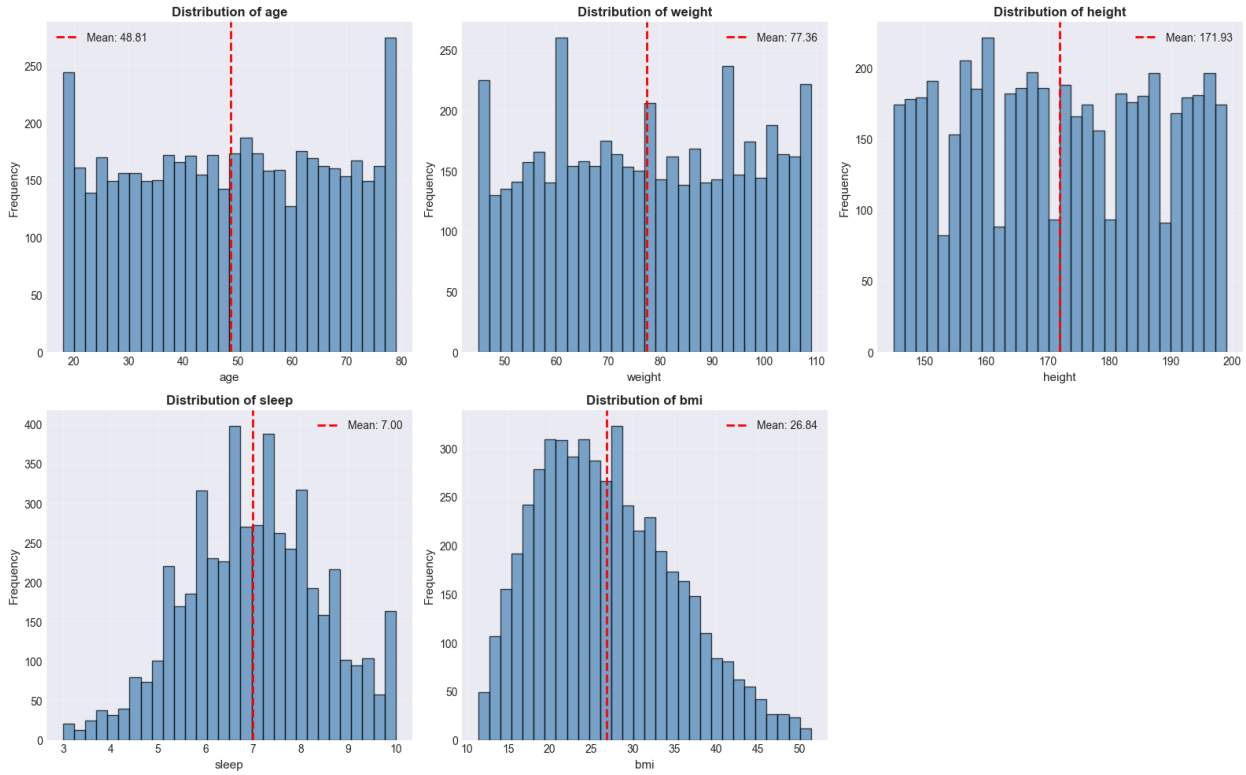



```
 Class Balance Analysis:
   Smallest class: 1,510 samples
   Largest class: 3,490 samples
   Balance ratio: 0.433
   ⚠  Warning: Class imbalance detected!
   → Consider using stratified sampling or SMOTE
```

```
# Cell 8: Numerical Features Analysis
print("="*70)
print(" " * 25 + "NUMERICAL FEATURES ANALYSIS")
print("="*70)

numerical_cols =
df_kaggle.select_dtypes(include=[np.number]).columns.tolist()

# Remove target if it's numerical
if target_col in numerical_cols and df_kaggle[target_col].nunique() <=
10:
    numerical_cols.remove(target_col)

print(f"\nNumerical Features ({len(numerical_cols)}):")
for col in numerical_cols:
    print(f"  - {col}")

# Distribution plots
if len(numerical_cols) > 0:
    n_cols = 3
    n_rows = (len(numerical_cols) + n_cols - 1) // n_cols

    fig, axes = plt.subplots(n_rows, n_cols, figsize=(16, 5 * n_rows))
    axes = axes.flatten() if n_rows > 1 else [axes] if n_cols == 1
else axes
```

```
    for idx, col in enumerate(numerical_cols):
        axes[idx].hist(df_kaggle[col].dropna(), bins=30,
color='steelblue',
                       edgecolor='black', alpha=0.7)
        axes[idx].set_xlabel(col, fontsize=11)
        axes[idx].set_ylabel('Frequency', fontsize=11)
        axes[idx].set_title(f'Distribution of {col}', fontsize=12,
fontweight='bold')
        axes[idx].grid(True, alpha=0.3)

        # Add mean line
        mean_val = df_kaggle[col].mean()
        axes[idx].axvline(mean_val, color='red', linestyle='--',
linewidth=2,
                          label=f'Mean: {mean_val:.2f}')
        axes[idx].legend()

    # Hide unused subplots
    for idx in range(len(numerical_cols), len(axes)):
        axes[idx].axis('off')

    plt.tight_layout()
    plt.savefig('../reports/kaggle_numerical_distributions.png',
dpi=300, bbox_inches='tight')
    plt.show()

    print(f"\n Saved visualization:
kaggle_numerical_distributions.png")
else:
    print("\nNo numerical features to visualize.")
```

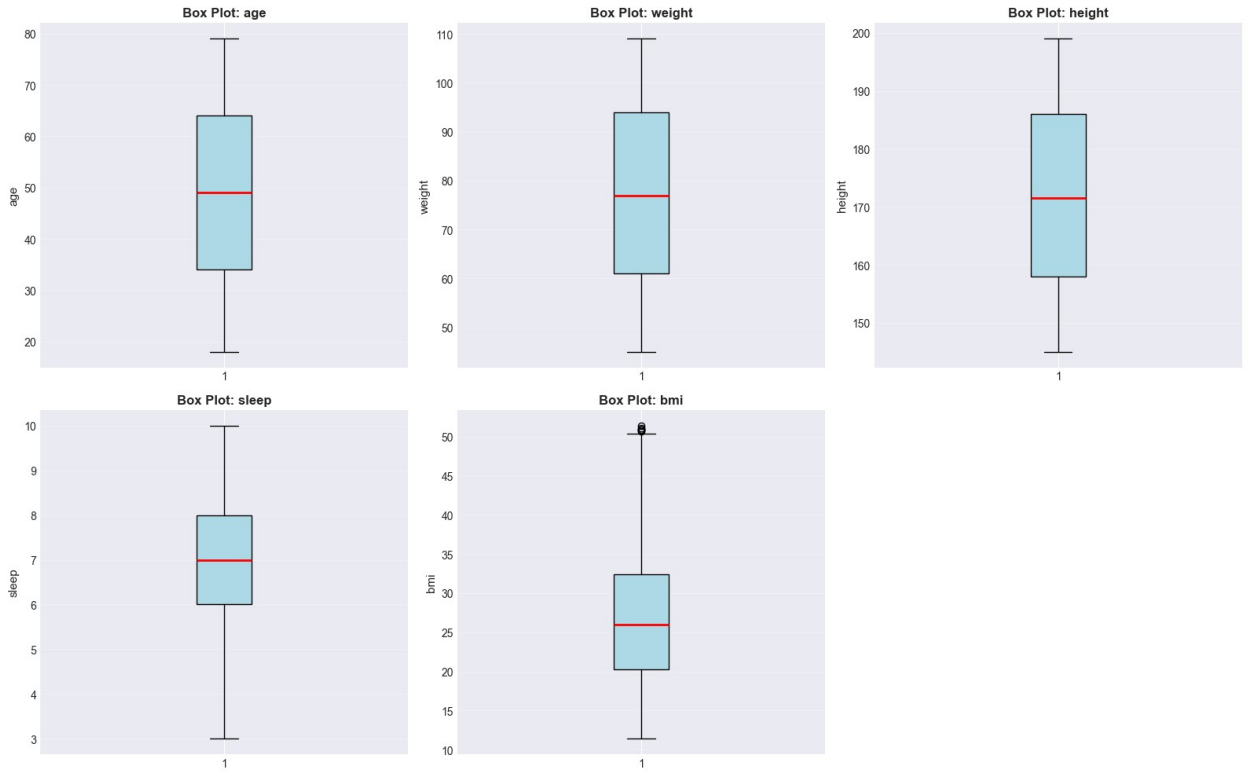
```
================================================================================
                          NUMERICAL FEATURES ANALYSIS
================================================================================

Numerical Features (5):
  - age
  - weight
  - height
  - sleep
  - bmi
```




```
✅ Saved visualization: kaggle_numerical_distributions.png

# Cell 9: Box Plots for Numerical Features
print("="*70)
print(" " * 20 + "BOX PLOTS - OUTLIER DETECTION")
print("="*70)

if len(numerical_cols) > 0:
    n_cols = 3
    n_rows = (len(numerical_cols) + n_cols - 1) // n_cols

    fig, axes = plt.subplots(n_rows, n_cols, figsize=(16, 5 * n_rows))
    axes = axes.flatten() if n_rows > 1 else [axes] if n_cols == 1
else axes

    for idx, col in enumerate(numerical_cols):
        axes[idx].boxplot(df_kaggle[col].dropna(), vert=True,
patch_artist=True,
                          boxprops=dict(facecolor='lightblue',
color='black'),
                          medianprops=dict(color='red', linewidth=2),
                          whiskerprops=dict(color='black'),
                          capprops=dict(color='black'))
        axes[idx].set_ylabel(col, fontsize=11)
        axes[idx].set_title(f'Box Plot: {col}', fontsize=12,
```

```
fontweight='bold')
        axes[idx].grid(True, alpha=0.3, axis='y')

    # Hide unused subplots
    for idx in range(len(numerical_cols), len(axes)):
        axes[idx].axis('off')

    plt.tight_layout()
    plt.savefig('../reports/kaggle_boxplots.png', dpi=300,
bbox_inches='tight')
    plt.show()

    print(f"\n Saved visualization: kaggle_boxplots.png")
```

```
======================================================================
                    BOX PLOTS - OUTLIER DETECTION
======================================================================
```



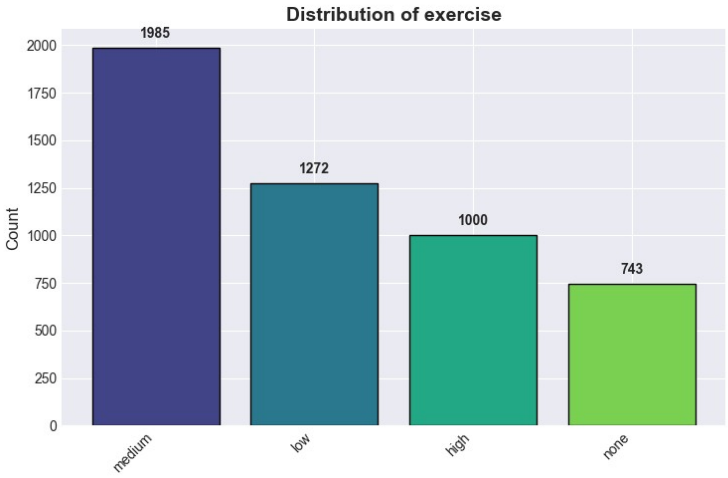

```
 Saved visualization: kaggle_boxplots.png
```

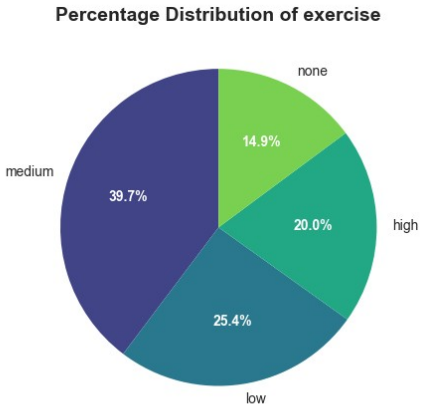
```
# Cell 10: Categorical Features Analysis
print("="*70)
print(" " * 25 + "CATEGORICAL FEATURES ANALYSIS")
print("="*70)
```

```
categorical_cols =
df_kaggle.select_dtypes(include=['object']).columns.tolist()

# Remove target if it's categorical
if target_col in categorical_cols:
    categorical_cols.remove(target_col)

print(f"\nCategorical Features ({len(categorical_cols)}):")
for col in categorical_cols:
    print(f"  - {col}")

# Value counts and visualizations
if len(categorical_cols) > 0:
    for col in categorical_cols:
        print(f"\n{'-'*70}")
        print(f"Feature: {col.upper()}")
        print(f"{'-'*70}")

        value_counts = df_kaggle[col].value_counts()
        value_percentage = (value_counts / len(df_kaggle)) * 100

        result_df = pd.DataFrame({
            'Value': value_counts.index,
            'Count': value_counts.values,
            'Percentage': value_percentage.values
        })

        print(result_df.to_string(index=False))

        # Visualization
        fig, axes = plt.subplots(1, 2, figsize=(14, 5))

        # Bar chart
        axes[0].bar(range(len(value_counts)), value_counts.values,
                    color=sns.color_palette("viridis",
len(value_counts)), edgecolor='black')
        axes[0].set_xticks(range(len(value_counts)))
        axes[0].set_xticklabels(value_counts.index, rotation=45,
ha='right')
        axes[0].set_ylabel('Count', fontsize=12)
        axes[0].set_title(f'Distribution of {col}', fontsize=14,
fontweight='bold')
        for i, v in enumerate(value_counts.values):
            axes[0].text(i, v + max(value_counts.values)*0.02, str(v),

                         ha='center', va='bottom', fontweight='bold')

        # Pie chart
        colors = sns.color_palette("viridis", len(value_counts))
        wedges, texts, autotexts = axes[1].pie(value_counts.values,
```

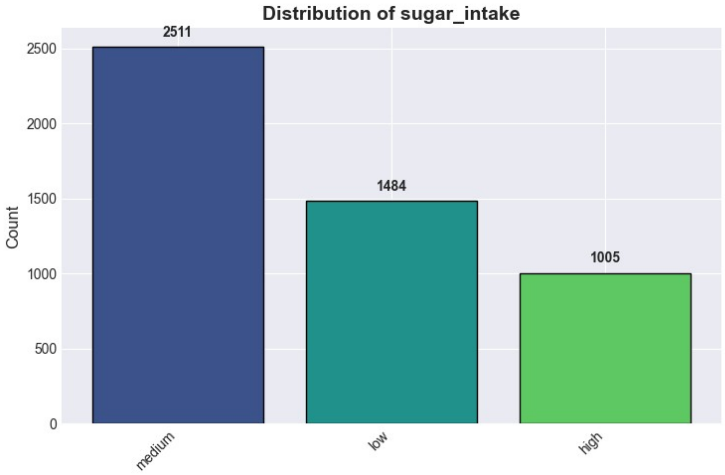
```
labels=value_counts.index,
                                                    autopct='%1.1f%%',
startangle=90, colors=colors)
        axes[1].set_title(f'Percentage Distribution of {col}',
fontsize=14, fontweight='bold')

        for autotext in autotexts:
            autotext.set_color('white')
            autotext.set_fontweight('bold')

        plt.tight_layout()
        plt.savefig(f'../reports/kaggle_categorical_{col}.png',
dpi=300, bbox_inches='tight')
        plt.show()

        print(f"\n Saved visualization:
kaggle_categorical_{col}.png")
else:
    print("\nNo categorical features to analyze.")
```

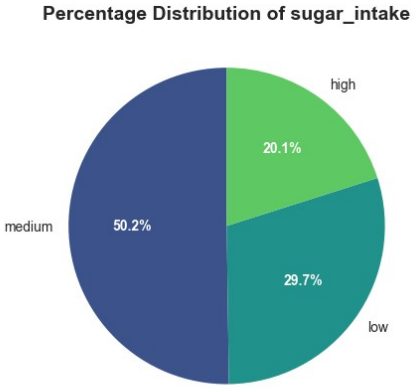
```
================================================================================
                          CATEGORICAL FEATURES ANALYSIS
================================================================================

Categorical Features (6):
  - exercise
  - sugar_intake
  - smoking
  - alcohol
  - married
  - profession

--------------------------------------------------------------------------------
Feature: EXERCISE
--------------------------------------------------------------------------------
 Value  Count  Percentage
medium   1985       39.70
   low   1272       25.44
  high   1000       20.00
  none    743       14.86
```





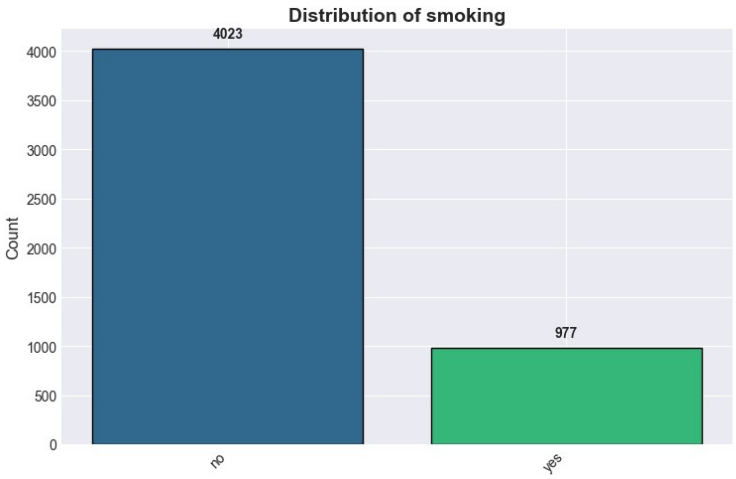

```
✅ Saved visualization: kaggle_categorical_exercise.png

--------------------------------------------------------------------------------
Feature: SUGAR_INTAKE
--------------------------------------------------------------------------------
 Value  Count  Percentage
medium   2511       50.22
   low   1484       29.68
  high   1005       20.10
```

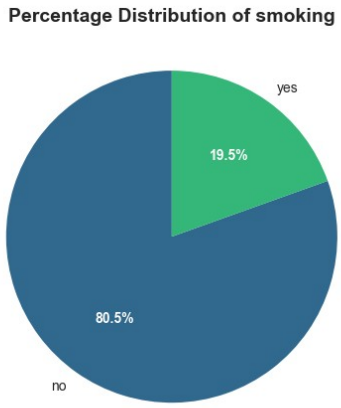




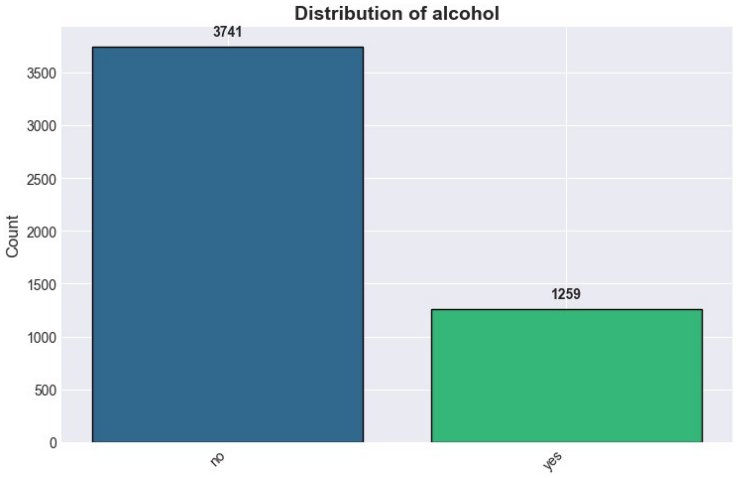

```
✅ Saved visualization: kaggle_categorical_sugar_intake.png

--------------------------------------------------------------------------------
Feature: SMOKING
--------------------------------------------------------------------------------
Value  Count  Percentage
```

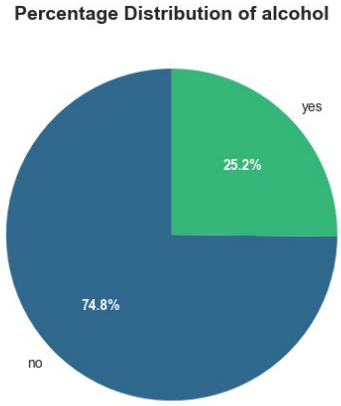
```
   no    4023       80.46
  yes     977       19.54
```





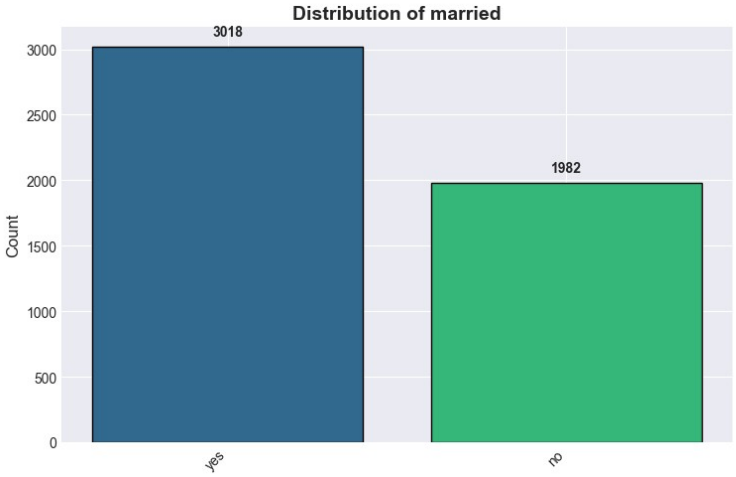

```
 Saved visualization: kaggle_categorical_smoking.png

--------------------------------------------------------------------------------
Feature: ALCOHOL
--------------------------------------------------------------------------------
Value  Count  Percentage
   no   3741       74.82
  yes   1259       25.18
```

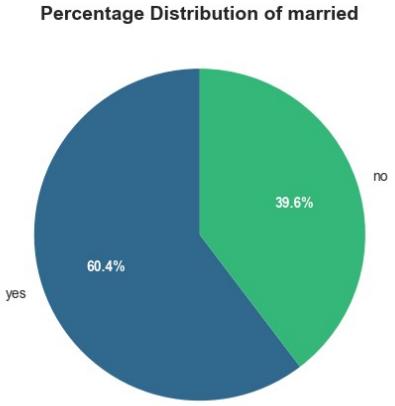




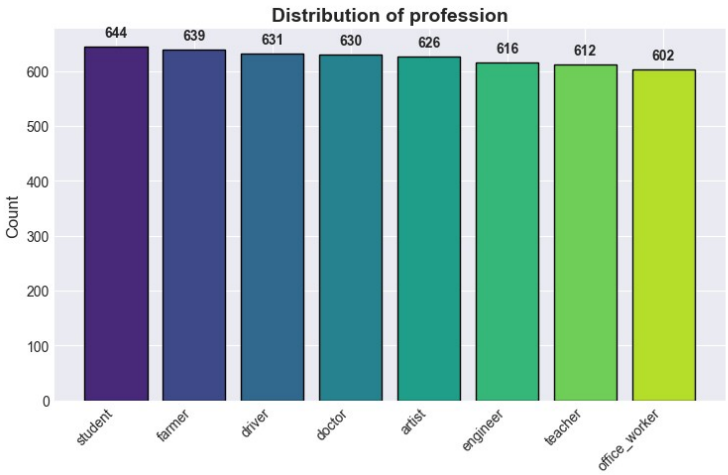

```
 Saved visualization: kaggle_categorical_alcohol.png

--------------------------------------------------------------------------------
Feature: MARRIED
--------------------------------------------------------------------------------
```

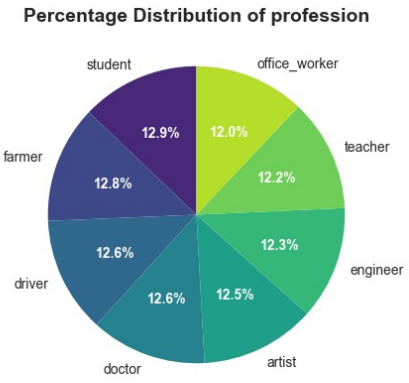
```
Value  Count  Percentage
  yes   3018       60.36
   no   1982       39.64
```






```
 Saved visualization: kaggle_categorical_married.png

--------------------------------------------------------------------------------
Feature: PROFESSION
--------------------------------------------------------------------------------
        Value  Count  Percentage
      student    644       12.88
       farmer    639       12.78
       driver    631       12.62
       doctor    630       12.60
       artist    626       12.52
     engineer    616       12.32
      teacher    612       12.24
office_worker    602       12.04
```



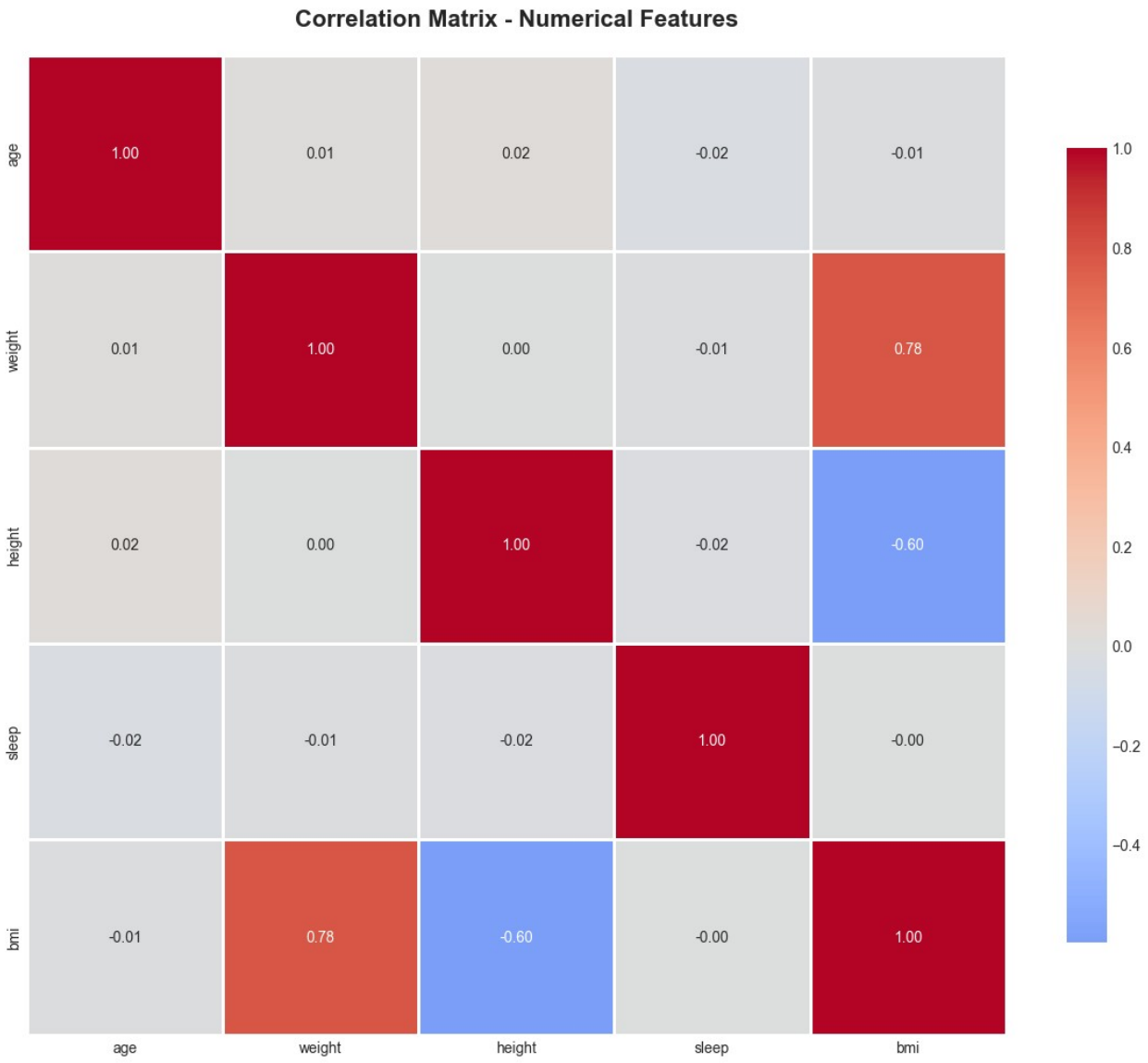


```
 Saved visualization: kaggle_categorical_profession.png
```

```
# Cell 11: Correlation Matrix
print("="*70)
print(" " * 25 + "CORRELATION ANALYSIS")
print("="*70)

if len(numerical_cols) > 1:
    # Calculate correlation matrix
    correlation_matrix = df_kaggle[numerical_cols].corr()

    print("\nCorrelation Matrix:")
    print(correlation_matrix)

    # Heatmap
    plt.figure(figsize=(12, 10))
    sns.heatmap(correlation_matrix, annot=True, fmt='.2f',
cmap='coolwarm',
                center=0, square=True, linewidths=1,
cbar_kws={"shrink": 0.8})
    plt.title('Correlation Matrix - Numerical Features', fontsize=16,
fontweight='bold', pad=20)
    plt.tight_layout()
    plt.savefig('../reports/kaggle_correlation_matrix.png', dpi=300,
bbox_inches='tight')
    plt.show()

    print(f"\n Saved visualization: kaggle_correlation_matrix.png")

    # Find highly correlated pairs
    print("\n" + "="*70)
    print("Highly Correlated Feature Pairs (|correlation| > 0.7):")
    print("="*70)

    high_corr = []
    for i in range(len(correlation_matrix.columns)):
        for j in range(i+1, len(correlation_matrix.columns)):
            if abs(correlation_matrix.iloc[i, j]) > 0.7:
                high_corr.append({
                    'Feature_1': correlation_matrix.columns[i],
                    'Feature_2': correlation_matrix.columns[j],
                    'Correlation': correlation_matrix.iloc[i, j]
                })

    if len(high_corr) > 0:
        high_corr_df =
pd.DataFrame(high_corr).sort_values('Correlation',
                                                    key=abs,
ascending=False)
```

```
        print(high_corr_df.to_string(index=False))
        print("\n⚠️  High correlation detected - consider feature
selection/engineering")
    else:
        print("✅ No highly correlated features found")
else:
    print("\nInsufficient numerical features for correlation
analysis.")
```

```
================================================================================
                          CORRELATION ANALYSIS
================================================================================

Correlation Matrix:
             age    weight    height     sleep       bmi
age     1.000000  0.010220  0.020501 -0.022504 -0.011407
weight  0.010220  1.000000  0.001637 -0.012756  0.784869
height  0.020501  0.001637  1.000000 -0.016776 -0.596046
sleep  -0.022504 -0.012756 -0.016776  1.000000 -0.001544
bmi    -0.011407  0.784869 -0.596046 -0.001544  1.000000
```

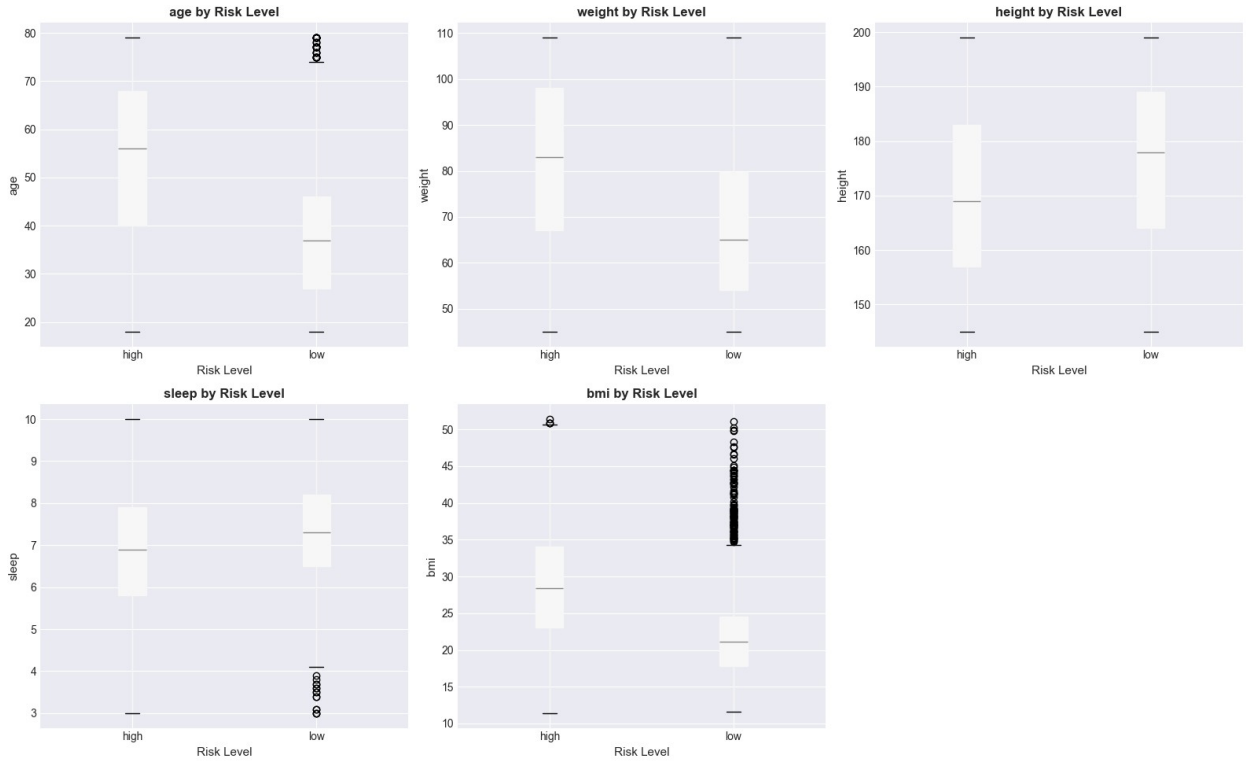



```
✓ Saved visualization: kaggle_correlation_matrix.png

======================================================================
Highly Correlated Feature Pairs (|correlation| > 0.7):
======================================================================
Feature_1 Feature_2  Correlation
   weight       bmi     0.784869

⚠  High correlation detected - consider feature selection/engineering
```

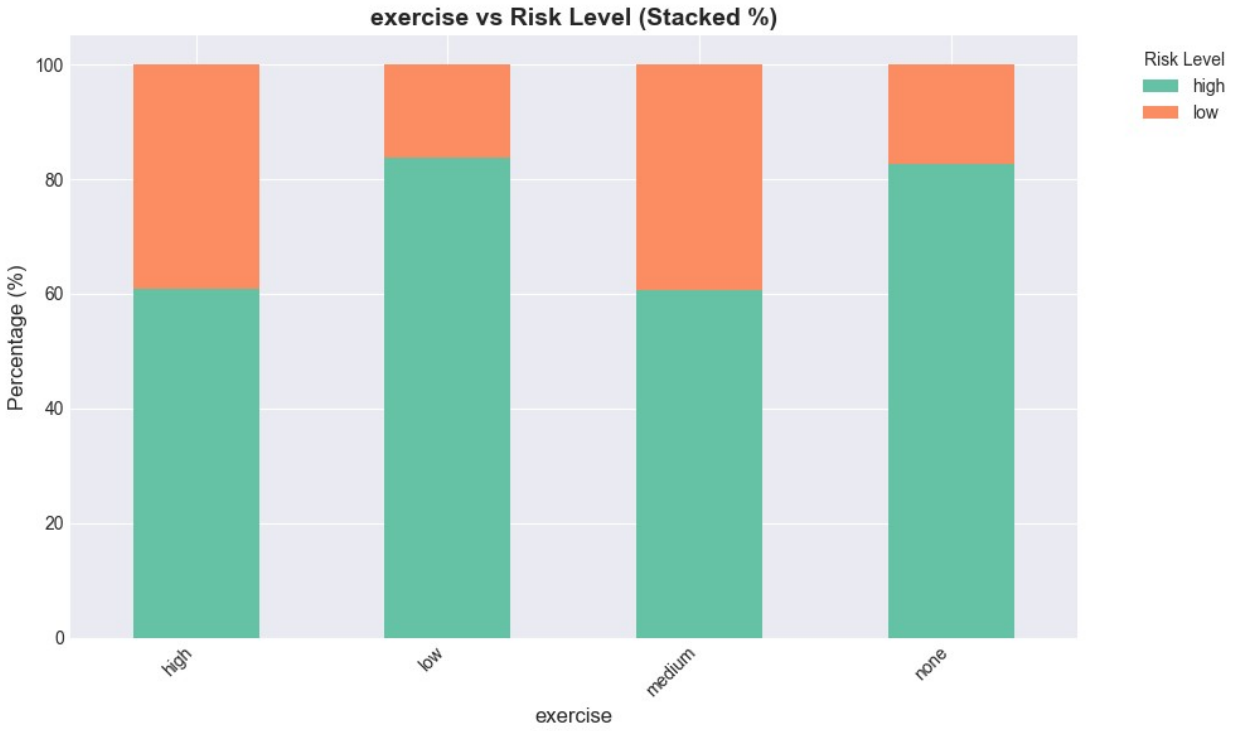
```python
# Cell 12: Features vs Target Analysis
print("="*70)
print(" " * 20 + "FEATURES vs TARGET ANALYSIS")
print("="*70)
```

```
if target_col in df_kaggle.columns:

    # Numerical features vs Target
    if len(numerical_cols) > 0:
        print("\n" + "="*70)
        print("NUMERICAL FEATURES vs RISK LEVEL")
        print("="*70)

        n_cols = 3
        n_rows = (len(numerical_cols) + n_cols - 1) // n_cols

        fig, axes = plt.subplots(n_rows, n_cols, figsize=(16, 5 *
n_rows))
        axes = axes.flatten() if n_rows > 1 else [axes] if n_cols == 1
else axes

        for idx, col in enumerate(numerical_cols):
            df_kaggle.boxplot(column=col, by=target_col, ax=axes[idx],
patch_artist=True)
            axes[idx].set_xlabel('Risk Level', fontsize=11)
            axes[idx].set_ylabel(col, fontsize=11)
            axes[idx].set_title(f'{col} by Risk Level', fontsize=12,
fontweight='bold')
            axes[idx].get_figure().suptitle('')

        # Hide unused subplots
        for idx in range(len(numerical_cols), len(axes)):
            axes[idx].axis('off')

        plt.tight_layout()
        plt.savefig('../reports/kaggle_features_vs_target.png',
dpi=300, bbox_inches='tight')
        plt.show()

        print(f"\n Saved visualization:
kaggle_features_vs_target.png")

    # Categorical features vs Target
    if len(categorical_cols) > 0:
        print("\n" + "="*70)
        print("CATEGORICAL FEATURES vs RISK LEVEL")
        print("="*70)

        for col in categorical_cols:
            print(f"\n{col.upper()} vs RISK LEVEL:")
            crosstab = pd.crosstab(df_kaggle[col],
df_kaggle[target_col], margins=True)
            print(crosstab)
```

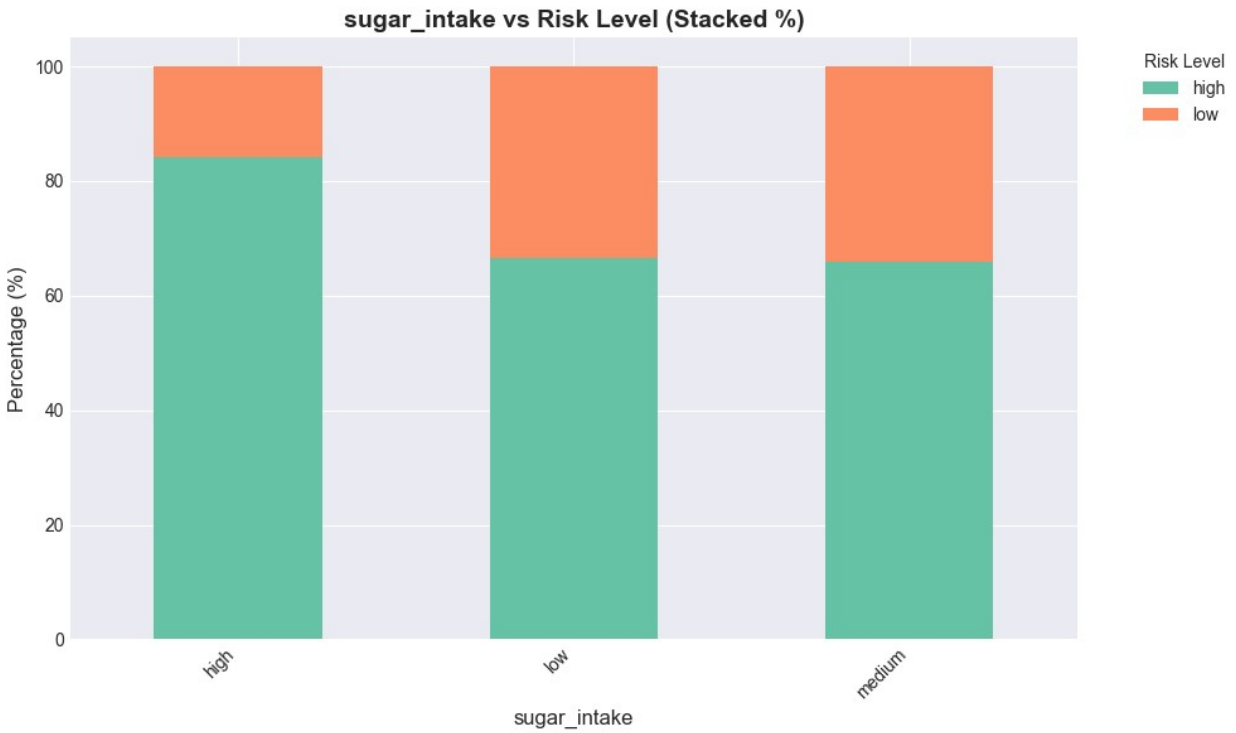
```
            # Stacked bar chart
            crosstab_no_margins = pd.crosstab(df_kaggle[col],
df_kaggle[target_col], normalize='index') * 100

            fig, ax = plt.subplots(figsize=(10, 6))
            crosstab_no_margins.plot(kind='bar', stacked=True, ax=ax,
                                     color=sns.color_palette("Set2",
len(df_kaggle[target_col].unique())))
            ax.set_xlabel(col, fontsize=12)
            ax.set_ylabel('Percentage (%)', fontsize=12)
            ax.set_title(f'{col} vs Risk Level (Stacked %)',
fontsize=14, fontweight='bold')
            ax.legend(title='Risk Level', bbox_to_anchor=(1.05, 1),
loc='upper left')
            plt.xticks(rotation=45, ha='right')
            plt.tight_layout()
            plt.savefig(f'../reports/kaggle_{col}_vs_target.png',
dpi=300, bbox_inches='tight')
            plt.show()

            print(f"\n Saved visualization:
kaggle_{col}_vs_target.png")

================================================================================
                    FEATURES vs TARGET ANALYSIS
================================================================================

================================================================================
NUMERICAL FEATURES vs RISK LEVEL
================================================================================
```



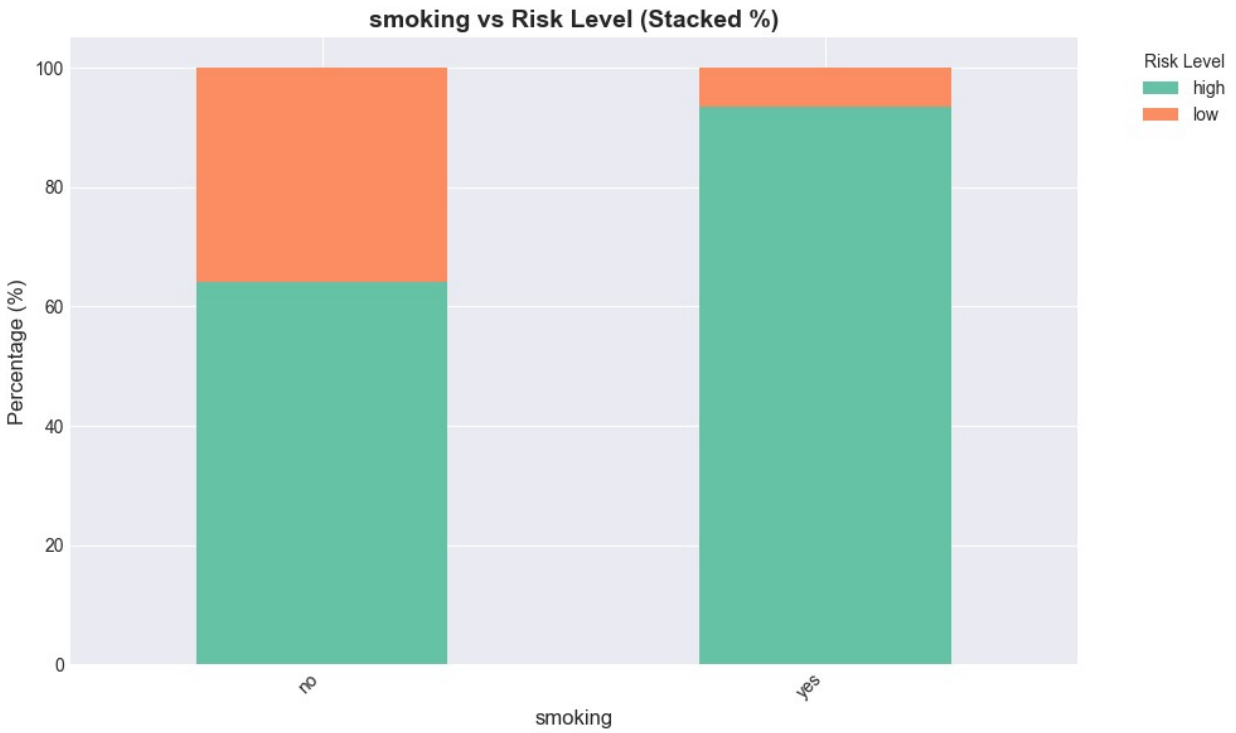

```
✅ Saved visualization: kaggle_features_vs_target.png

======================================================================
CATEGORICAL FEATURES vs RISK LEVEL
======================================================================

EXERCISE vs RISK LEVEL:
health_risk  high   low   All
exercise
high          609   391  1000
low          1065   207  1272
medium       1202   783  1985
none          614   129   743
All          3490  1510  5000
```



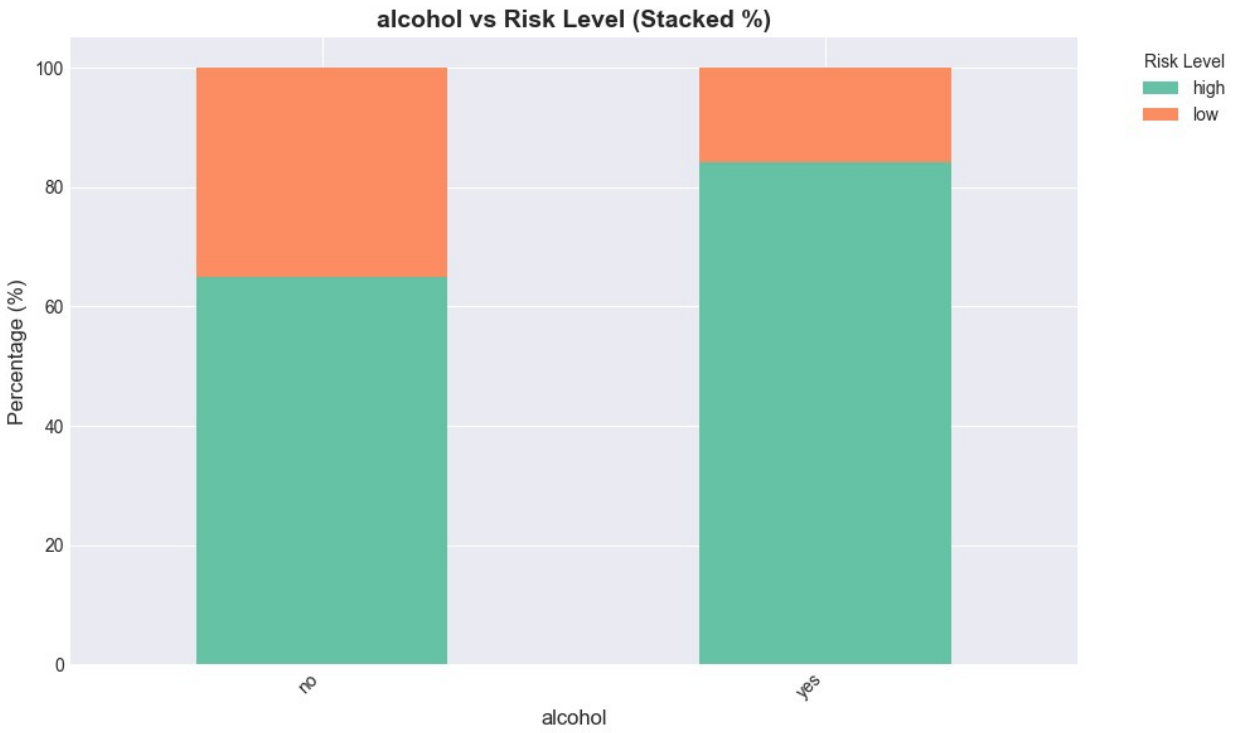

```
 Saved visualization: kaggle_exercise_vs_target.png

SUGAR_INTAKE vs RISK LEVEL:
health_risk   high   low   All
sugar_intake
high           845   160  1005
low            989   495  1484
medium        1656   855  2511
All           3490  1510  5000
```



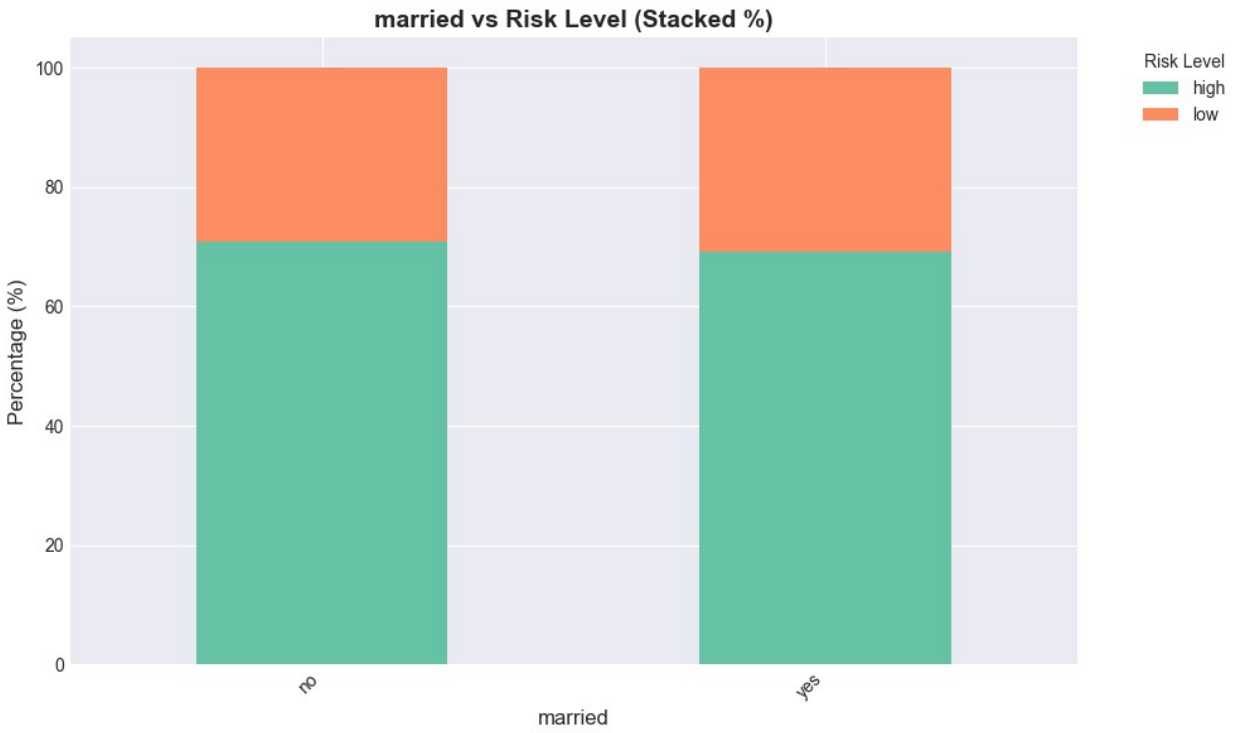

```
 Saved visualization: kaggle_sugar_intake_vs_target.png

SMOKING vs RISK LEVEL:
health_risk  high   low   All
smoking
no           2578  1445  4023
yes           912    65   977
All          3490  1510  5000
```



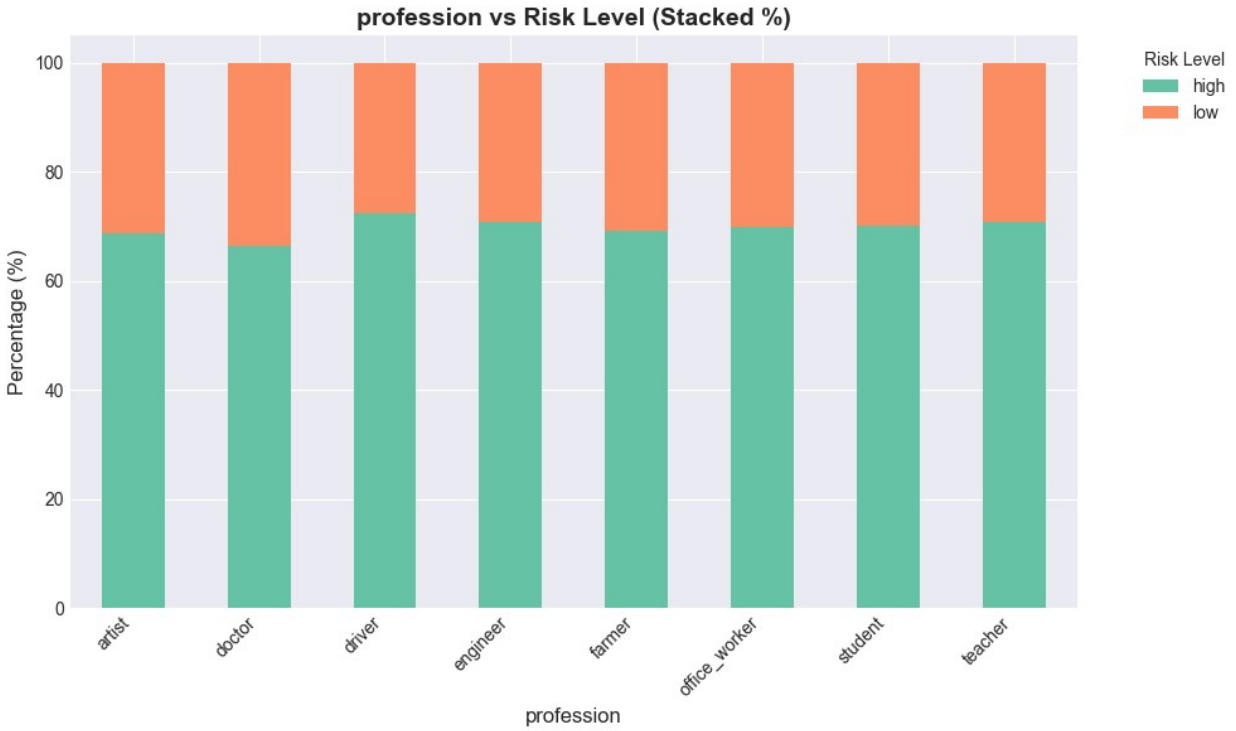

```
✅ Saved visualization: kaggle_smoking_vs_target.png

ALCOHOL vs RISK LEVEL:
health_risk  high   low   All
alcohol
no           2431  1310  3741
yes          1059   200  1259
All          3490  1510  5000
```




```
 Saved visualization: kaggle_alcohol_vs_target.png

MARRIED vs RISK LEVEL:
health_risk  high   low   All
married
no           1405   577  1982
yes          2085   933  3018
All          3490  1510  5000
```




```
✅ Saved visualization: kaggle_married_vs_target.png

PROFESSION vs RISK LEVEL:
health_risk    high   low   All
profession
artist          430   196   626
doctor          419   211   630
driver          457   174   631
engineer        437   179   616
farmer          442   197   639
office_worker   421   181   602
student         451   193   644
teacher         433   179   612
All            3490  1510  5000
```




```
□ Saved visualization: kaggle_profession_vs_target.png
```

```python
# Cell 13: Data Quality Summary
print("="*70)
print(" " * 25 + "DATA QUALITY SUMMARY")
print("="*70)

print("\n□ DUPLICATES:")
print("-" * 70)
duplicates = df_kaggle.duplicated().sum()
print(f"  Total duplicate rows: {duplicates}")
if duplicates > 0:
    print(f"  Percentage: {duplicates/len(df_kaggle)*100:.2f}%")
    print("  ⚠  Consider removing duplicates before modeling")
else:
    print("  □ No duplicates found")

print("\n□ UNIQUE VALUES PER COLUMN:")
print("-" * 70)
for col in df_kaggle.columns:
    unique_count = df_kaggle[col].nunique()
    unique_pct = (unique_count / len(df_kaggle)) * 100
    print(f"  {col:25s}: {unique_count:6,} unique values
({unique_pct:6.2f}%)")

print("\n□ DATA TYPES SUMMARY:")
```

```
print("-" * 70)
dtype_summary = df_kaggle.dtypes.value_counts()
for dtype, count in dtype_summary.items():
    print(f"  {str(dtype):15s}: {count} columns")
```

```
======================================================================
                        DATA QUALITY SUMMARY
======================================================================

 DUPLICATES:
----------------------------------------------------------------------
  Total duplicate rows: 0
   No duplicates found

 UNIQUE VALUES PER COLUMN:
----------------------------------------------------------------------
  age                       :     62 unique values (  1.24%)
  weight                    :     65 unique values (  1.30%)
  height                    :     55 unique values (  1.10%)
  exercise                  :      4 unique values (  0.08%)
  sleep                     :     71 unique values (  1.42%)
  sugar_intake              :      3 unique values (  0.06%)
  smoking                   :      2 unique values (  0.04%)
  alcohol                   :      2 unique values (  0.04%)
  married                   :      2 unique values (  0.04%)
  profession                :      8 unique values (  0.16%)
  bmi                       :    383 unique values (  7.66%)
  health_risk               :      2 unique values (  0.04%)

 DATA TYPES SUMMARY:
----------------------------------------------------------------------
  object         : 7 columns
  int64          : 3 columns
  float64        : 2 columns
```

```
# Cell 14: Feature Engineering Suggestions
print("="*70)
print(" " * 20 + "FEATURE ENGINEERING SUGGESTIONS")
print("="*70)

suggestions = []

# Check for potential BMI calculation
if 'height' in df_kaggle.columns and 'weight' in df_kaggle.columns and
'bmi' not in df_kaggle.columns:
    suggestions.append(" Create BMI: weight / (height/100)^2")

# Check for age groups
if 'age' in df_kaggle.columns:
    suggestions.append(" Create age groups: Young (<30), Adult (30-
```

```
50), Senior (>50)")

# Check for binary features
for col in categorical_cols:
    if df_kaggle[col].nunique() == 2:
        suggestions.append(f"□ Convert '{col}' to binary (0/1)")

# Check for exercise/activity combinations
if 'exercise' in df_kaggle.columns and 'sleep' in df_kaggle.columns:
    suggestions.append("□ Create lifestyle score: combine exercise +
sleep quality")

# Check for substance use flags
substance_cols = [col for col in df_kaggle.columns if any(x in
col.lower() for x in ['smoking', 'alcohol', 'drug'])]
if len(substance_cols) > 1:
    suggestions.append(f"□ Create substance_use_flag: combine {',
'.join(substance_cols)}")

if len(suggestions) > 0:
    print("\n□ Recommended Feature Engineering:")
    for idx, suggestion in enumerate(suggestions, 1):
        print(f"  {idx}. {suggestion}")
else:
    print("\n□ Dataset appears well-featured. No immediate engineering
needed.")
```

```
================================================================================
                    FEATURE ENGINEERING SUGGESTIONS
================================================================================

□ Recommended Feature Engineering:
  1. □ Create age groups: Young (<30), Adult (30-50), Senior (>50)
  2. □ Convert 'smoking' to binary (0/1)
  3. □ Convert 'alcohol' to binary (0/1)
  4. □ Convert 'married' to binary (0/1)
  5. □ Create lifestyle score: combine exercise + sleep quality
  6. □ Create substance_use_flag: combine smoking, alcohol
```

```
# Cell 15: Final EDA Summary Report
print("="*80)
print(" " * 25 + "KAGGLE DATASET - EDA SUMMARY")
print("="*80)

print("\n□ DATASET OVERVIEW:")
print("-" * 80)
print(f"  Total Records: {len(df_kaggle):,}")
print(f"  Total Features: {len(df_kaggle.columns)}")
print(f"  Numerical Features: {len(numerical_cols)}")
print(f"  Categorical Features: {len(categorical_cols)}")
```

```
print(f"  Memory Usage: {df_kaggle.memory_usage(deep=True).sum() /
1024**2:.2f} MB")

print("\n DATA QUALITY:")
print("-" * 80)
missing_total = df_kaggle.isnull().sum().sum()
print(f"  Missing Values: {missing_total}
({missing_total/(len(df_kaggle)*len(df_kaggle.columns))*100:.2f}%)")
print(f"  Duplicate Rows: {df_kaggle.duplicated().sum()}")

if target_col in df_kaggle.columns:
    print(f"\n TARGET VARIABLE ({target_col}):")
    print("-" * 80)
    print(f"  Unique Values: {df_kaggle[target_col].nunique()}")
    for value, count in df_kaggle[target_col].value_counts().items():
        pct = count / len(df_kaggle) * 100
        print(f"    {value:15s}: {count:6,} ({pct:5.1f}%)")

print("\n VISUALIZATIONS GENERATED:")
print("-" * 80)
visualizations = [
    "kaggle_risk_distribution.png",
    "kaggle_numerical_distributions.png",
    "kaggle_boxplots.png",
    "kaggle_correlation_matrix.png",
    "kaggle_features_vs_target.png"
]
for viz in visualizations:
    print(f"  {viz}")

print("\n NEXT STEPS:")
print("-" * 80)
print("  1. Handle missing values (if any)")
print("  2. Remove duplicates (if any)")
print("  3. Engineer new features (see suggestions)")
print("  4. Encode categorical variables")
print("  5. Split data (train/test)")
print("  6. Scale numerical features")
print("  7. Train baseline models")

print("\n" + "="*80)
print(" " * 25 + "KAGGLE EDA COMPLETED SUCCESSFULLY! ")
print("="*80)
```

```
================================================================================
                          KAGGLE DATASET - EDA SUMMARY
================================================================================
```

```
 DATASET OVERVIEW:
--------------------------------------------------------------------------------
  Total Records: 5,000
  Total Features: 12
  Numerical Features: 5
  Categorical Features: 6
  Memory Usage: 2.22 MB

 DATA QUALITY:
--------------------------------------------------------------------------------
  Missing Values: 0 (0.00%)
  Duplicate Rows: 0

 TARGET VARIABLE (health_risk):
--------------------------------------------------------------------------------
  Unique Values: 2
    high           :  3,490 ( 69.8%)
    low            :  1,510 ( 30.2%)

 VISUALIZATIONS GENERATED:
--------------------------------------------------------------------------------
  ✓ kaggle_risk_distribution.png
  ✓ kaggle_numerical_distributions.png
  ✓ kaggle_boxplots.png
  ✓ kaggle_correlation_matrix.png
  ✓ kaggle_features_vs_target.png

 NEXT STEPS:
--------------------------------------------------------------------------------
  1. Handle missing values (if any)
  2. Remove duplicates (if any)
  3. Engineer new features (see suggestions)
  4. Encode categorical variables
  5. Split data (train/test)
  6. Scale numerical features
  7. Train baseline models

================================================================================
                          KAGGLE EDA COMPLETED SUCCESSFULLY! 
================================================================================
```