In [19]:
```
# Dataset & file handling
from ucimlrepo import fetch_ucirepo
import pandas as pd
import os

# Visualization
import matplotlib.pyplot as plt
import seaborn as sns

# Experiment tracking
import mlflow
import mlflow.sklearn

# ML utilities
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import cross_validate
from sklearn.linear_model import LogisticRegression
from sklearn.pipeline import Pipeline
from sklearn.preprocessing import StandardScaler
from sklearn.compose import ColumnTransformer
from sklearn.pipeline import Pipeline
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
from sklearn.impute import SimpleImputer
```

In [2]:
```
# Create data directory
os.makedirs("data", exist_ok=True)

# Fetch Heart Disease dataset from UCI
heart_disease = fetch_ucirepo(id=45)

# Extract features and target
X = heart_disease.data.features
y = heart_disease.data.targets

# Convert target to 1D
y = y.iloc[:, 0]

# Combine features and target
df = pd.concat([X, y], axis=1)

# Rename target column
df.rename(columns={y.name: "target"}, inplace=True)

# Convert to binary classification
df["target"] = df["target"].apply(lambda x: 1 if x > 0 else 0)

# Save dataset
df.to_csv("data/heart.csv", index=False)

print("Heart Disease dataset downloaded and saved successfully")
```

```
Heart Disease dataset downloaded and saved successfully
```

In [3]:
```
# Load saved dataset
df = pd.read_csv("data/heart.csv")
df.head()
```

Out[3]:

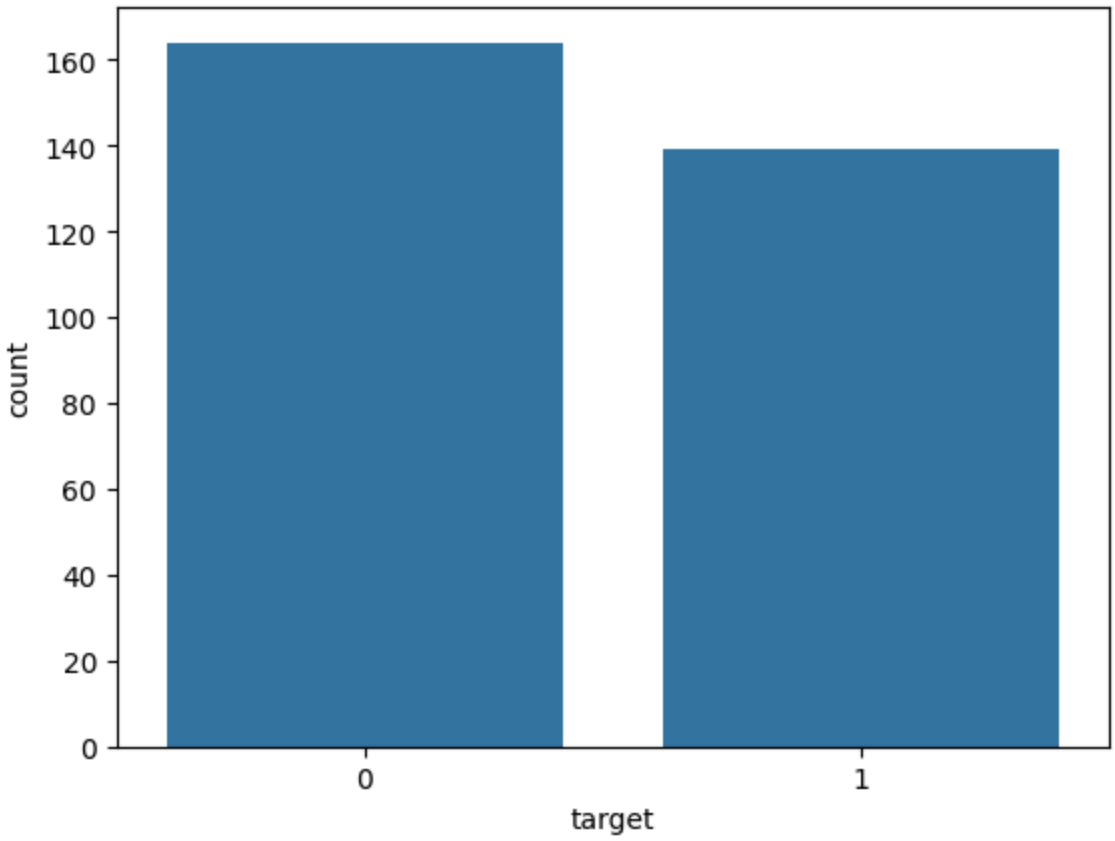
	age	sex	cp	trestbps	chol	fbs	restecg	thalach	exang	oldpeak	slope	ca	thal	t
0	63	1	1	145	233	1	2	150	0	2.3	3	0.0	6.0	
1	67	1	4	160	286	0	2	108	1	1.5	2	3.0	3.0	
2	67	1	4	120	229	0	2	129	1	2.6	2	2.0	7.0	
3	37	1	3	130	250	0	0	187	0	3.5	3	0.0	3.0	
4	41	0	2	130	204	0	2	172	0	1.4	1	0.0	3.0	

In [4]:
```
# Shape, schema and missing values
df.shape
df.info()
df.isnull().sum()
```

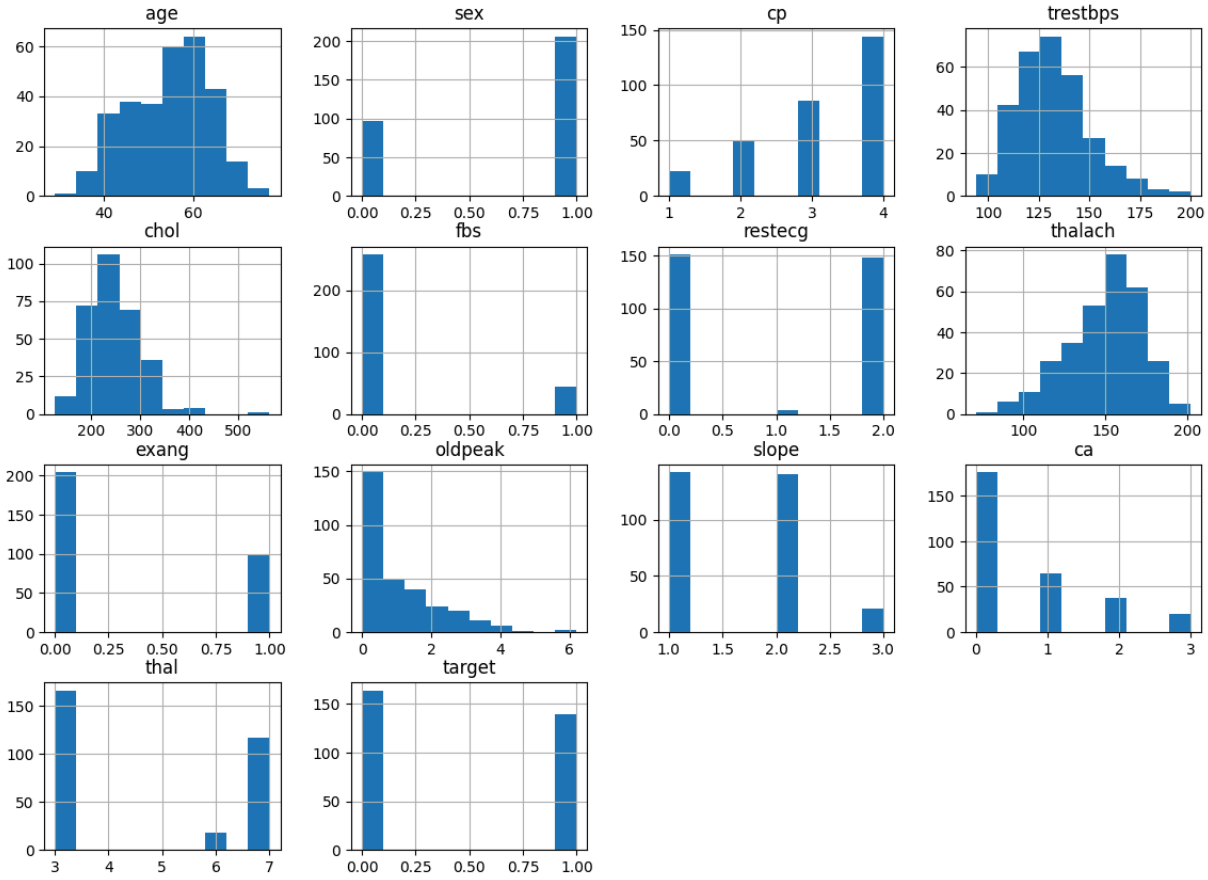
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 303 entries, 0 to 302
Data columns (total 14 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       303 non-null    int64  
 1   sex       303 non-null    int64  
 2   cp        303 non-null    int64  
 3   trestbps  303 non-null    int64  
 4   chol      303 non-null    int64  
 5   fbs       303 non-null    int64  
 6   restecg   303 non-null    int64  
 7   thalach   303 non-null    int64  
 8   exang     303 non-null    int64  
 9   oldpeak   303 non-null    float64
 10  slope     303 non-null    int64  
 11  ca        299 non-null    float64
 12  thal      301 non-null    float64
 13  target    303 non-null    int64  
dtypes: float64(3), int64(11)
memory usage: 33.3 KB
```

Out[4]:
```
age         0
sex         0
cp          0
trestbps    0
chol        0
fbs         0
restecg     0
thalach     0
exang       0
oldpeak     0
slope       0
ca          4
thal        2
target      0
dtype: int64
```

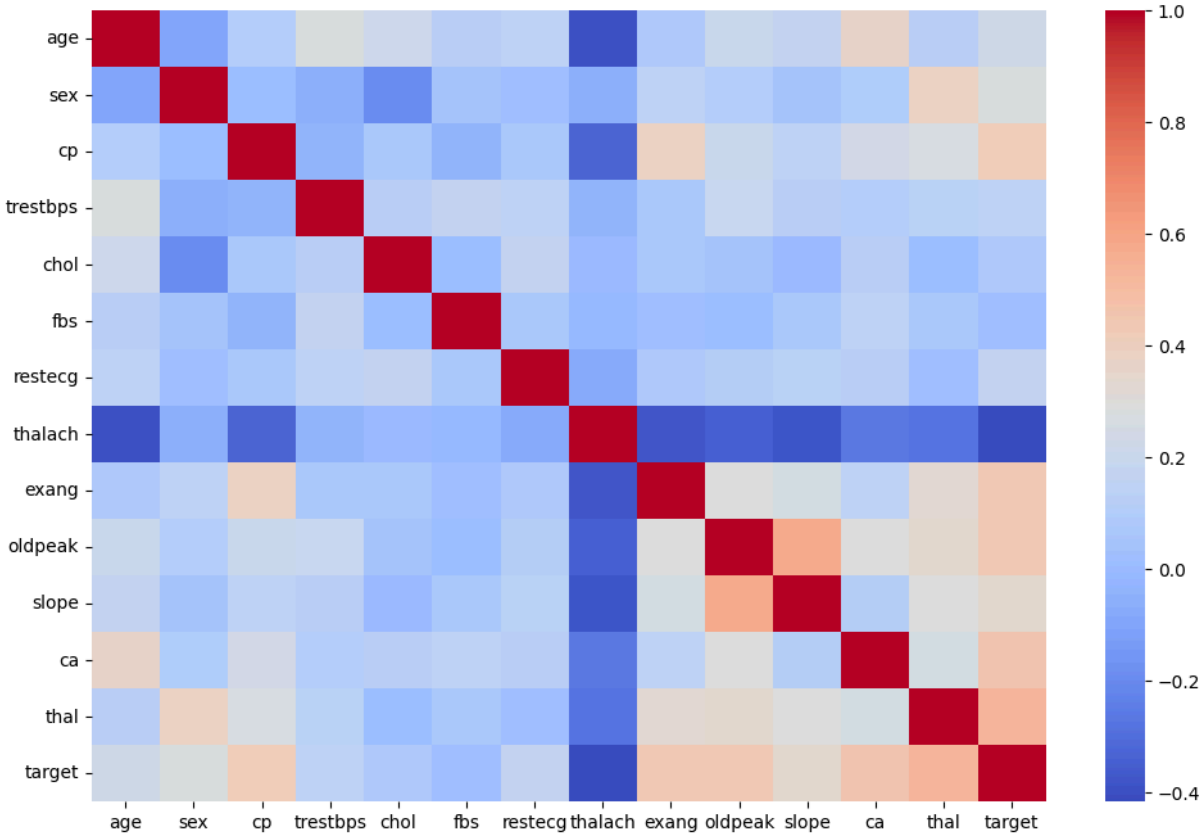
In [5]:
```
# Class balance
sns.countplot(x="target", data=df)
plt.show()
```



In [6]:
```
# Distribution of numerical features
df.hist(figsize=(14, 10))
plt.show()
```



In [7]:
```
# Feature correlation
plt.figure(figsize=(12, 8))
sns.heatmap(df.corr(), cmap="coolwarm")
plt.show()
```



In [8]:
```
# Split features and label
X = df.drop("target", axis=1)
y = df["target"]
```

In [9]:
```
# Scale numerical features
numeric_features = X.columns.tolist()

# Handle missing values + scale features
preprocessor = ColumnTransformer(
    transformers=[
        ("num", Pipeline([
            ("imputer", SimpleImputer(strategy="median")),
            ("scaler", StandardScaler())
        ]), numeric_features)
    ]
)
```

In [10]:
```
# Set MLflow experiment
mlflow.set_experiment("Heart Disease Prediction")
```

```
2026/01/06 10:29:24 INFO mlflow.store.db.utils: Creating initial MLflow database tab
les...
2026/01/06 10:29:24 INFO mlflow.store.db.utils: Updating database tables
2026/01/06 10:29:24 INFO alembic.runtime.migration: Context impl SQLiteImpl.
2026/01/06 10:29:24 INFO alembic.runtime.migration: Will assume non-transactional DD
L.
2026/01/06 10:29:24 INFO alembic.runtime.migration: Context impl SQLiteImpl.
2026/01/06 10:29:24 INFO alembic.runtime.migration: Will assume non-transactional DD
L.
```

Out[10]:
```
<Experiment: artifact_location='file:c:/Users/sonaa/OneDrive/Documents/ML OPS/mlop
s_code/mlruns/1', creation_time=1766903558773, experiment_id='1', last_update_time
=1766903558773, lifecycle_stage='active', name='Heart Disease Prediction', tags={}
>
```

In [20]:
```
# Logistic Regression pipeline
lr_pipeline = Pipeline([
    ("preprocessing", preprocessor),
    ("model", LogisticRegression(max_iter=1000))
])

# Cross-validation with multiple metrics
lr_scores = cross_validate(
    lr_pipeline,
    X,
    y,
    cv=5,
    scoring={
        "accuracy": "accuracy",
        "precision": "precision",
        "recall": "recall",
        "roc_auc": "roc_auc"
    }
)

# Mean scores
print("Logistic Regression Performance:")
print("Accuracy:", lr_scores["test_accuracy"].mean())
print("Precision:", lr_scores["test_precision"].mean())
print("Recall:", lr_scores["test_recall"].mean())
print("ROC-AUC:", lr_scores["test_roc_auc"].mean())
```

```
Logistic Regression Performance:
Accuracy: 0.8282513661202184
Precision: 0.8361948292715813
Recall: 0.7838624338624338
ROC-AUC: 0.9011639209555877
```

In [21]:
```
# Random Forest pipeline
rf_pipeline = Pipeline([
    ("preprocessing", preprocessor),
    ("model", RandomForestClassifier(
        n_estimators=100,
        random_state=42
    ))
])

# Cross-validation with multiple metrics
rf_scores = cross_validate(
    rf_pipeline,
    X,
    y,
    cv=5,
    scoring={
        "accuracy": "accuracy",
        "precision": "precision",
```

```
        "recall": "recall",
        "roc_auc": "roc_auc"
    }
)

# Mean scores
print("Random Forest Performance:")
print("Accuracy:", rf_scores["test_accuracy"].mean())
print("Precision:", rf_scores["test_precision"].mean())
print("Recall:", rf_scores["test_recall"].mean())
print("ROC-AUC:", rf_scores["test_roc_auc"].mean())
```

```
Random Forest Performance:
Accuracy: 0.8181967213114755
Precision: 0.8210396825396824
Recall: 0.7767195767195767
ROC-AUC: 0.9000519831248998
```

In [26]:
```
# Train final selected model
rf_pipeline.fit(X, y)

# Save best model locally in MLflow format
os.makedirs("models", exist_ok=True)

mlflow.sklearn.save_model(
    sk_model=rf_pipeline,
    path="models/final_model"
)
```

In [27]:
```
print("EDA, model training, and MLflow tracking completed")
```

```
EDA, model training, and MLflow tracking completed
```