In [67]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from tensorflow.keras.models import Sequential, load_model
from tensorflow.keras.layers import Dense
from tensorflow.keras.callbacks import ModelCheckpoint
from sklearn.preprocessing import MinMaxScaler
from sklearn.model_selection import train_test_split
from sklearn.metrics import precision_score, recall_score, f1_score, roc_auc
```

In [2]:
```
drugs_df = pd.read_csv('drug_use_revised.csv').sample(frac=1, random_state=4
```

In [3]:
```
drugs_df.head()
```

Out[3]:

	ID	Age	Gender	Education	Country	Ethnicity	Nscore	Escore	Oscore	Ascore
0	310	2	0	7	5	6	28	41	45	47
1	385	3	1	6	5	6	37	38	43	50
2	465	0	1	6	5	6	39	34	53	48
3	1745	4	1	4	5	6	31	33	36	46
4	921	0	0	3	1	6	38	49	58	41

In [4]:
```
alc_output = drugs_df.iloc[:, [-1]]
drugs_data = drugs_df.iloc[:, 1:13]
drugs_data.head()
```

Out[4]:

	Age	Gender	Education	Country	Ethnicity	Nscore	Escore	Oscore	Ascore	Csc
0	2	0	7	5	6	28	41	45	47	
1	3	1	6	5	6	37	38	43	50	
2	0	1	6	5	6	39	34	53	48	
3	4	1	4	5	6	31	33	36	46	
4	0	0	3	1	6	38	49	58	41	

In [5]:
```
alc_output.head()
```

Out[5]:

	Alcohol
0	1
1	1
2	1
3	0
4	1

In [6]:
```
print(alc_output.shape)
print(drugs_data.shape)
```

```
(1885, 1)
(1885, 12)
```

In [7]:
```
print(drugs_data.isnull().values.any())
print(alc_output.isnull().values.any())
```

```
False
False
```

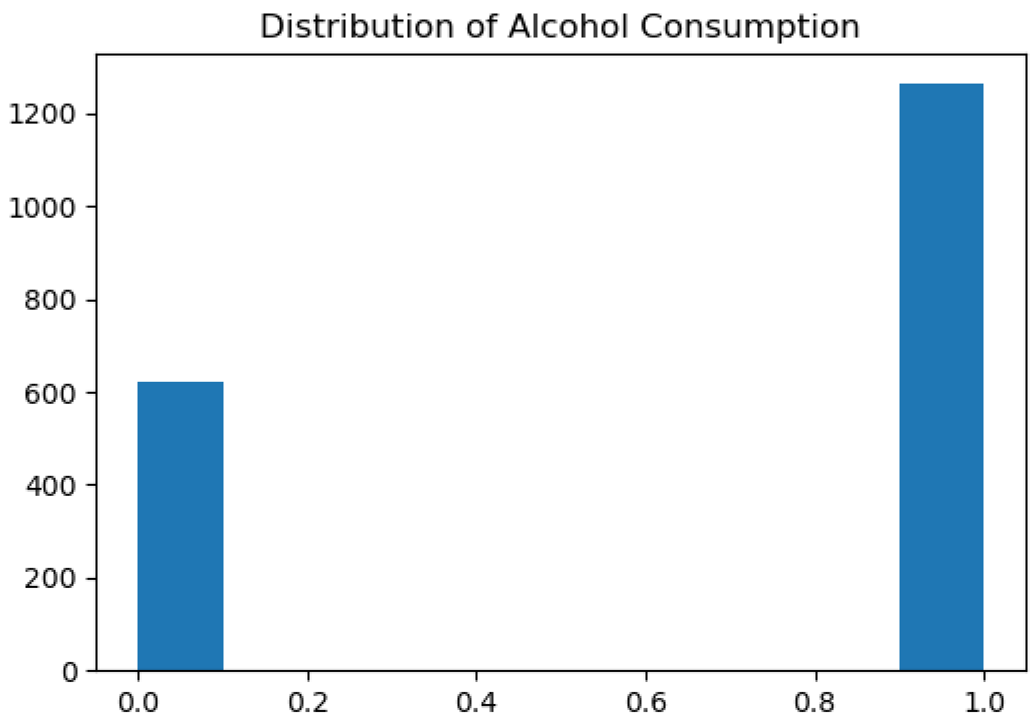
In [8]:
```
print(drugs_data.isna().values.any())
print(alc_output.isna().values.any())

drugs_data = drugs_data.astype('float32')
alc_output = alc_output.astype('float32')
```

```
False
False
```

Visualize Data

In [9]:
```
plt.figure(figsize=(6,4))
plt.hist(x = 'Alcohol', data = alc_output)
plt.title('Distribution of Alcohol Consumption')
plt.savefig('output_distribution.png')
plt.show()
```

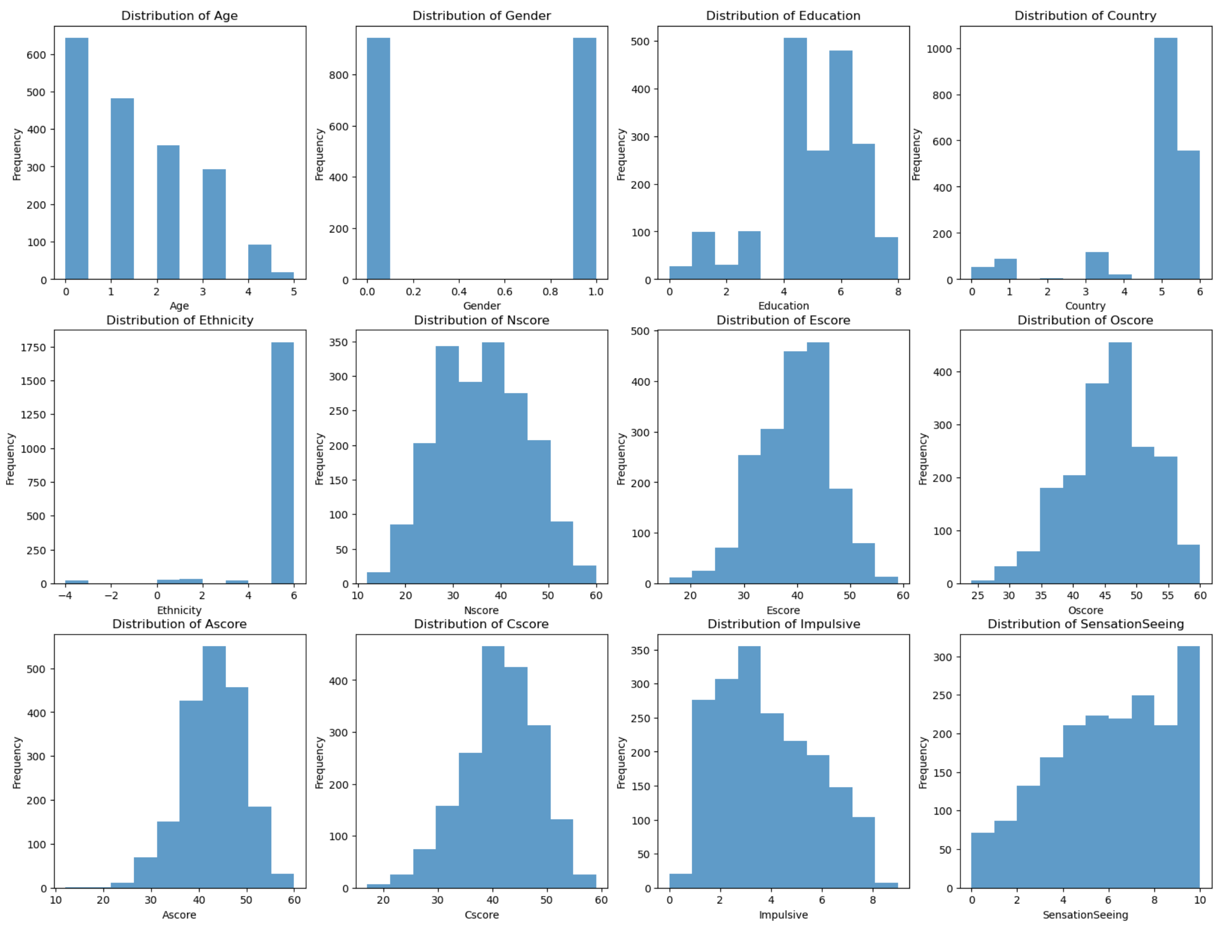


In [10]:
```
num_features = drugs_data.shape[1]
num_cols = 4
num_rows = (num_features + num_cols - 1) // num_cols

fig, axes = plt.subplots(num_rows, num_cols, figsize = (20, 5 * num_rows))
axes = axes.flatten()

for i, col in enumerate(drugs_data.columns):
    ax = axes[i]
    ax.hist(drugs_data[col], alpha=0.7)
    ax.set_title(f'Distribution of {col}', fontsize=12)
    ax.set_xlabel(col)
    ax.set_ylabel('Frequency')

plt.savefig('object_distribution.png')
plt.show()
```



Scale the Data

In [11]:
```python
scaler = MinMaxScaler()

drugs_data.iloc[:, :13] = scaler.fit_transform(drugs_data.iloc[:, :13])
alc_output.iloc[:, :] = scaler.fit_transform(alc_output.iloc[:, :])
```

In [12]:
```python
drugs_data.tail()
```

Out[12]:

	Age	Gender	Education	Country	Ethnicity	Nscore	Escore	Oscore
1880	0.2	0.0	0.875	0.333333	1.0	0.625000	0.441860	0.638889
1881	0.0	0.0	0.500	1.000000	0.9	0.416667	0.558140	0.722222
1882	0.0	0.0	0.750	0.833333	1.0	0.500000	0.534884	0.583333
1883	0.2	0.0	0.875	0.833333	1.0	0.520833	0.581395	0.527778
1884	0.0	0.0	0.500	1.000000	1.0	0.708333	0.209302	0.472222

In [13]:
```python
alc_output.head()
```

Out[13]:

	Alcohol
0	1.0
1	1.0
2	1.0
3	0.0
4	1.0

In [14]:
```
model_reg = Sequential()
model_reg.add(Dense(1, input_dim = drugs_data.shape[1], activation = 'sigmoi
```

```
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
2025-05-10 23:35:56.780107: I metal_plugin/src/device/metal_device.cc:1154]
Metal device set to: Apple M4
2025-05-10 23:35:56.780136: I metal_plugin/src/device/metal_device.cc:296] s
ystemMemory: 16.00 GB
2025-05-10 23:35:56.780141: I metal_plugin/src/device/metal_device.cc:313] m
axCacheSize: 5.33 GB
2025-05-10 23:35:56.780419: I tensorflow/core/common_runtime/pluggable_devic
e/pluggable_device_factory.cc:305] Could not identify NUMA node of platform
GPU ID 0, defaulting to 0. Your kernel may not have been built with NUMA sup
port.
2025-05-10 23:35:56.780428: I tensorflow/core/common_runtime/pluggable_devic
e/pluggable_device_factory.cc:271] Created TensorFlow device (/job:localhos
t/replica:0/task:0/device:GPU:0 with 0 MB memory) -> physical PluggableDevic
e (device: 0, name: METAL, pci bus id: <undefined>)
```

In [15]:
```
model_reg.compile(loss = 'binary_crossentropy', optimizer= 'rmsprop', metric
```

In [16]:
```
model_reg.fit(drugs_data, alc_output, epochs = 256, verbose = 0)
```

```
2025-05-10 23:35:57.001805: I tensorflow/core/grappler/optimizers/custom_gra
ph_optimizer_registry.cc:117] Plugin optimizer for device_type GPU is enable
d.
2025-05-10 23:35:57.003858: E tensorflow/core/grappler/optimizers/meta_optim
izer.cc:961] PluggableGraphOptimizer failed: INVALID_ARGUMENT: Failed to des
erialize the `graph_buf`.
```

Out[16]:
```
<keras.src.callbacks.history.History at 0x17b130fb0>
```

In [17]:
```
loss, acc = model_reg.evaluate(drugs_data, alc_output)
print(f'Loss: {loss:.4f}')
print(f'Accuracy: {acc:.4f}')
```

```
59/59 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.6507 - loss: 0.6236
Loss: 0.6127
Accuracy: 0.6732
```

In [18]:
```
model = Sequential()
```

In [19]:
```
model.add(Dense(128, input_dim = drugs_data.shape[1], activation= 'relu'))
model.add(Dense(64, activation= 'relu'))
model.add(Dense(32, activation= 'relu'))
model.add(Dense(16, activation= 'relu'))
model.add(Dense(8, activation= 'relu'))
model.add(Dense(1, activation= 'sigmoid'))
```

```
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

In [20]:
```
model.summary()
```

Model: "sequential_1"

Layer (type)	Output Shape	Par
dense_1 (Dense)	(None, 128)	1
dense_2 (Dense)	(None, 64)	8
dense_3 (Dense)	(None, 32)	2
dense_4 (Dense)	(None, 16)	
dense_5 (Dense)	(None, 8)	
dense_6 (Dense)	(None, 1)	

```
Total params: 12,673 (49.50 KB)
Trainable params: 12,673 (49.50 KB)
Non-trainable params: 0 (0.00 B)
```

In [21]:
```
model.compile(loss= 'binary_crossentropy', optimizer = 'rmsprop', metrics =
```

In [22]:
```
model.fit(x = drugs_data, y = alc_output, epochs = 512, verbose = 0)
```

Out[22]:
```
<keras.src.callbacks.history.History at 0x17c297e00>
```

In [23]:
```
loss, acc = model.evaluate(drugs_data, alc_output)
print(f'Loss: {loss:.4f}')
print(f'Accuracy: {acc:.4f}')
```

```
35/59 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.9945 - loss: 0.0244
2025-05-10 23:39:22.379323: E tensorflow/core/grappler/optimizers/meta_optim
izer.cc:961] PluggableGraphOptimizer failed: INVALID_ARGUMENT: Failed to des
erialize the `graph_buf`.
59/59 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.9947 - loss: 0.0227
Loss: 0.0186
Accuracy: 0.9952
```

Phase 3

In [24]:
```
drugs_data = drugs_data.sample(frac = 1, random_state = 50).reset_index(drop
alc_output = alc_output.sample(frac = 1, random_state = 50).reset_index(drop

drugs_data.iloc[:, :13] = scaler.fit_transform(drugs_data.iloc[:, :13])
alc_output.iloc[:, :] = scaler.fit_transform(alc_output.iloc[:, :])
```

In [25]:
```
checkpoint = ModelCheckpoint(
    filepath='best_model.keras',
    monitor='val_loss',
    save_best_only=True,
    mode = min,
    verbose = 0
)
```

```
/var/folders/dj/8cd2dqkx2bbb8rmfr739gtd80000gn/T/ipykernel_63851/2670385671.
py:1: UserWarning: ModelCheckpoint mode '<built-in function min>' is unknow
n, fallback to auto mode.
  checkpoint = ModelCheckpoint(
```

In [26]:
```
drugs_train = drugs_data.iloc[:1508, :]
drugs_test = drugs_data.iloc[1508:, :]
alc_train = alc_output.iloc[:1508, :]
alc_test = alc_output.iloc[1508:, :]
```

In [27]:
```
model_train = Sequential()
```

In [28]:
```
model_train.add(Dense(1, input_dim = drugs_train.shape[1], activation= 'sigm
```

```
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

In [29]:
```
model_train.compile(loss= 'binary_crossentropy', optimizer = 'rmsprop', metr
```

In [30]:
```
model_train.fit(x = drugs_train, y = alc_train, epochs = 256, verbose = 0, v
```

Out[30]:
```
<keras.src.callbacks.history.History at 0x319c9d250>
```

In [31]:
```
loss, acc = model_train.evaluate(drugs_train, alc_train)
print(f'Loss: {loss:.4f}')
print(f'Accuracy: {acc:.4f}')

loss, acc = model_train.evaluate(drugs_test, alc_test)
print(f'Loss: {loss:.4f}')
print(f'Accuracy: {acc:.4f}')
```

```
48/48 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.6914 - loss: 0.6041
Loss: 0.6099
Accuracy: 0.6790
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.6511 - loss: 0.6358
Loss: 0.6330
Accuracy: 0.6472
```

In [32]:
```
model_train_2 = Sequential()
model_train_2.add(Dense(2, input_dim = drugs_train.shape[1], activation = 'r
model_train_2.add(Dense(1, activation = 'sigmoid'))
```

```
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

In [33]:
```
model_train_2.compile(loss = 'binary_crossentropy', optimizer = 'rmsprop', m
```

In [34]:
```
model_train_2.fit(x = drugs_train, y = alc_train, epochs = 256, verbose = 0,
```

Out[34]:
```
<keras.src.callbacks.history.History at 0x30806af60>
```

In [35]:
```
loss_2, acc_2 = model_train_2.evaluate(drugs_train, alc_train)
print(f'Loss: {loss_2:.4f}')
print(f'Accuracy: {acc_2:.4f}')

loss_2, acc_2 = model_train_2.evaluate(drugs_test, alc_test)
print(f'Loss: {loss_2:.4f}')
print(f'Accuracy: {acc_2:.4f}')
```

```
48/48 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.6964 - loss: 0.6008
Loss: 0.6061
Accuracy: 0.6837
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.6680 - loss: 0.6285
Loss: 0.6266
Accuracy: 0.6578
```

In [36]:
```
model_train_3 = Sequential()
model_train_3.add(Dense(4, input_dim = drugs_train.shape[1], activation = 'r
model_train_3.add(Dense(1, activation = 'sigmoid'))
```

```
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

In [37]:
```
model_train_3.compile(loss = 'binary_crossentropy', optimizer = 'rmsprop', m
```

In [38]:
```
model_train_3.fit(x = drugs_train, y = alc_train, epochs = 256, verbose = 0,
```

```
2025-05-10 23:41:11.795978: E tensorflow/core/grappler/optimizers/meta_optim
izer.cc:961] PluggableGraphOptimizer failed: INVALID_ARGUMENT: Failed to des
erialize the `graph_buf`.
```

```
Out[38]: <keras.src.callbacks.history.History at 0x10785bf20>
```

```
In [39]: loss_3, acc_3 = model_train_3.evaluate(drugs_train, alc_train)
         print(f'Loss: {loss_3:.4f}')
         print(f'Accuracy: {acc_3:.4f}')

         loss_3, acc_3 = model_train_3.evaluate(drugs_test, alc_test)
         print(f'Loss: {loss_3:.4f}')
         print(f'Accuracy: {acc_3:.4f}')
```

```
48/48 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.6977 - loss: 0.5922
Loss: 0.5984
Accuracy: 0.6883
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.6738 - loss: 0.6286
Loss: 0.6337
Accuracy: 0.6552
```

```
In [40]: model_train_4 = Sequential()
         model_train_4.add(Dense(8, input_dim = drugs_train.shape[1], activation = 'r
         model_train_4.add(Dense(1, activation = 'sigmoid'))
```

```
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

```
In [41]: model_train_4.compile(loss = 'binary_crossentropy', optimizer = 'rmsprop', m
```

```
In [42]: model_train_4.fit(x = drugs_train, y = alc_train, epochs=256, verbose = 0, v
```

```
Out[42]: <keras.src.callbacks.history.History at 0x17f80b260>
```

```
In [43]: loss_4, acc_4 = model_train_4.evaluate(drugs_train, alc_train)
         print(f'Loss: {loss_4:.4f}')
         print(f'Accuracy: {acc_4:.4f}')

         loss_4, acc_4 = model_train_4.evaluate(drugs_test, alc_test)
         print(f'Loss: {loss_4:.4f}')
         print(f'Accuracy: {acc_4:.4f}')
```

```
48/48 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.7044 - loss: 0.5905
Loss: 0.5958
Accuracy: 0.6910
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.6526 - loss: 0.6331
Loss: 0.6275
Accuracy: 0.6525
```

```
In [44]: model_train_5 = Sequential()
         model_train_5.add(Dense(16, input_dim = drugs_train.shape[1], activation = '
         model_train_5.add(Dense(8, activation = 'relu'))
         model_train_5.add(Dense(1, activation = 'sigmoid'))
```

```
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

In [45]:
```
model_train_5.compile(loss = 'binary_crossentropy', optimizer = 'rmsprop', m
```

In [46]:
```
model_train_5.fit(x = drugs_train, y = alc_train, epochs = 256, verbose = 0,
```

```
2025-05-10 23:43:05.563423: E tensorflow/core/grappler/optimizers/meta_optim
izer.cc:961] PluggableGraphOptimizer failed: INVALID_ARGUMENT: Failed to des
erialize the `graph_buf`.
```

Out[46]:
```
<keras.src.callbacks.history.History at 0x17f8a8290>
```

In [47]:
```
loss_5, acc_5 = model_train_5.evaluate(drugs_train, alc_train)
print(f'Loss: {loss_5:.4f}')
print(f'Accuracy: {acc_5:.4f}')

loss_5, acc_5 = model_train_5.evaluate(drugs_test, alc_test)
print(f'Loss: {loss_5:.4f}')
print(f'Accuracy: {acc_5:.4f}')
```

```
48/48 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.7271 - loss: 0.5674
Loss: 0.5756
Accuracy: 0.7115
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6506 - loss: 0.6393
Loss: 0.6406
Accuracy: 0.6552
```

In [48]:
```
model_train_6 = Sequential()
model_train_6.add(Dense(32, input_dim = drugs_train.shape[1], activation='re
model_train_6.add(Dense(16, activation='relu'))
model_train_6.add(Dense(8, activation='relu'))
model_train_6.add(Dense(1, activation='sigmoid'))
```

```
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

In [49]:
```
model_train_6.compile(loss = 'binary_crossentropy', optimizer='rmsprop', met
```

In [50]:
```
model_train_6.fit(x = drugs_train, y = alc_train, epochs = 256, verbose = 0,
```

```
2025-05-10 23:44:09.438109: E tensorflow/core/grappler/optimizers/meta_optim
izer.cc:961] PluggableGraphOptimizer failed: INVALID_ARGUMENT: Failed to des
erialize the `graph_buf`.
```

Out[50]:
```
<keras.src.callbacks.history.History at 0x17f8a9340>
```

In [51]:
```
loss_6, acc_6 = model_train_6.evaluate(drugs_train, alc_train)
print(f'Loss: {loss_6:.4f}')
print(f'Accuracy: {acc_6:.4f}')
```

```
loss_6, acc_6 = model_train_6.evaluate(drugs_test, alc_test)
print(f'Loss: {loss_6:.4f}')
print(f'Accuracy: {acc_6:.4f}')
```

```
48/48 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.7517 - loss: 0.5130
Loss: 0.5253
Accuracy: 0.7407
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6796 - loss: 0.6996
Loss: 0.6908
Accuracy: 0.6790
```

In [52]:
```
model_train_7 = Sequential()
model_train_7.add(Dense(64, input_dim = drugs_train.shape[1], activation='re
model_train_7.add(Dense(32, activation='relu'))
model_train_7.add(Dense(16, activation='relu'))
model_train_7.add(Dense(8, activation = 'relu'))
model_train_7.add(Dense(1, activation='sigmoid'))
```

```
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

In [53]:
```
model_train_7.compile(loss='binary_crossentropy', optimizer='rmsprop', metri
```

In [54]:
```
model_train_7.fit(x = drugs_train, y = alc_train, epochs = 256, verbose = 0,
```

```
2025-05-10 23:45:16.792956: E tensorflow/core/grappler/optimizers/meta_optim
izer.cc:961] PluggableGraphOptimizer failed: INVALID_ARGUMENT: Failed to des
erialize the `graph_buf`.
```

Out[54]:
```
<keras.src.callbacks.history.History at 0x3751c0410>
```

In [55]:
```
loss_7, acc_7 = model_train_7.evaluate(drugs_train, alc_train)
print(f'Loss: {loss_7:.4f}')
print(f'Accuracy: {acc_7:.4f}')

loss_7, acc_7 = model_train_7.evaluate(drugs_test, alc_test)
print(f'Loss: {loss_7:.4f}')
print(f'Accuracy: {acc_7:.4f}')
```

```
48/48 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.8417 - loss: 0.3837
Loss: 0.4000
Accuracy: 0.8362
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6368 - loss: 1.5658
Loss: 1.3551
Accuracy: 0.6472
```

In [56]:
```
count_ones_train = (alc_train == 1.0).sum()
print(f'Baseline Percentage: {(count_ones_train/len(alc_train))}')

count_ones_test = (alc_test == 1.0).sum()
print(f'Baseline Percentage: {(count_ones_test/len(alc_test))}')
```

```
Baseline Percentage: Alcohol    0.673077
dtype: float64
Baseline Percentage: Alcohol    0.660477
dtype: float64
```

F1 Score check

In [57]:
```
model_1_pred_prob = model_train.predict(drugs_test)
model_2_pred_prob = model_train_2.predict(drugs_test)
model_3_pred_prob = model_train_3.predict(drugs_test)
model_4_pred_prob = model_train_4.predict(drugs_test)
model_5_pred_prob = model_train_5.predict(drugs_test)
model_6_pred_prob = model_train_6.predict(drugs_test)
model_7_pred_prob = model_train_7.predict(drugs_test)

model_1_pred = (model_1_pred_prob > 0.5).astype(int).flatten()
model_2_pred = (model_2_pred_prob > 0.5).astype(int).flatten()
model_3_pred = (model_3_pred_prob > 0.5).astype(int).flatten()
model_4_pred = (model_4_pred_prob > 0.5).astype(int).flatten()
model_5_pred = (model_5_pred_prob > 0.5).astype(int).flatten()
model_6_pred = (model_6_pred_prob > 0.5).astype(int).flatten()
model_7_pred = (model_7_pred_prob > 0.5).astype(int).flatten()

model_1_f1 = f1_score(alc_test, model_1_pred)
model_2_f1 = f1_score(alc_test, model_2_pred)
model_3_f1 = f1_score(alc_test, model_3_pred)
model_4_f1 = f1_score(alc_test, model_4_pred)
model_5_f1 = f1_score(alc_test, model_5_pred)
model_6_f1 = f1_score(alc_test, model_6_pred)
model_7_f1 = f1_score(alc_test, model_7_pred)

print(f'Model 1 F1 score: {model_1_f1}')
print(f'Model 2 F1 score: {model_2_f1}')
print(f'Model 3 F1 score: {model_3_f1}')
print(f'Model 4 F1 score: {model_4_f1}')
print(f'Model 5 F1 score: {model_5_f1}')
print(f'Model 6 F1 score: {model_6_f1}')
print(f'Model 7 F1 score: {model_7_f1}')
```

```
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 2ms/step
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step
 1/12 ━━━━━━━━━━━━━━━━━━━━ 0s 16ms/step
2025-05-10 23:46:29.795756: E tensorflow/core/grappler/optimizers/meta_optim
izer.cc:961] PluggableGraphOptimizer failed: INVALID_ARGUMENT: Failed to des
erialize the `graph_buf`.
```

```
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
Model 1 F1 score: 0.7837398373983739
Model 2 F1 score: 0.7881773399014779
Model 3 F1 score: 0.7804054054054054
Model 4 F1 score: 0.7848932676518884
Model 5 F1 score: 0.7703180212014135
Model 6 F1 score: 0.7917383820998278
Model 7 F1 score: 0.7662565905096661
```

Best Model

In [58]:
```
best_model_best = load_model('best_model.keras')
```

In [59]:
```
best_pred_prob = best_model_best.predict(drugs_test)
best_pred = (best_pred_prob > 0.5).astype(int).flatten()
print(alc_test)
best_model_best.evaluate(drugs_test, alc_test)
```

```
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
      Alcohol
1508      0.0
1509      1.0
1510      1.0
1511      0.0
1512      0.0
...       ...
1880      1.0
1881      1.0
1882      1.0
1883      1.0
1884      0.0

[377 rows x 1 columns]
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.6618 - loss: 0.6193
```

Out[59]:
```
[0.6148596405982971, 0.6604774594306946]
```

In [60]:
```
print(len(best_pred))
alc_test_count = (alc_test == 1).sum().sum()
print(alc_test_count)
```

```
377
249
```

In [61]:
```
best_model_best.summary()
```

Model: "sequential_8"

Layer (type)	Output Shape	Par
dense_21 (Dense)	(None, 64)	
dense_22 (Dense)	(None, 32)	2
dense_23 (Dense)	(None, 16)	
dense_24 (Dense)	(None, 8)	
dense_25 (Dense)	(None, 1)	

```
Total params: 7,172 (28.02 KB)
Trainable params: 3,585 (14.00 KB)
Non-trainable params: 0 (0.00 B)
Optimizer params: 3,587 (14.02 KB)
```

In [62]:
```
precision = precision_score(alc_test, best_pred)
recall = recall_score(alc_test, best_pred)
f1 = f1_score(alc_test, best_pred)

print(f'Precision: {precision}')
print(f'Recall: {recall}')
print(f'F1: {f1}')
```

```
Precision: 0.6795252225519288
Recall: 0.9196787148594378
F1: 0.7815699658703071
```

In [78]:
```
def build_model_single(x, y):
    model = Sequential()
    model.add(Dense(32, input_dim = 1, activation = 'relu'))
    model.add(Dense(16, activation='relu'))
    model.add(Dense(8, activation='relu'))
    model.add(Dense(1, activation = 'sigmoid'))
    model.compile(loss = 'binary_crossentropy', optimizer = 'rmsprop', metri
    model.fit(x = x, y = y, epochs = 256, verbose = 0)
    return model

def eval_model(model, x, y):
    model.evaluate(x, y)
    model_pred_prob = model.predict(x)
    model_pred = (model_pred_prob > 0.5).astype(int).flatten()

    precision = precision_score(y, model_pred)
    recall = recall_score(y, model_pred)
    f1 = f1_score(y, model_pred)

    print(f'Precision: {precision}')
    print(f'Recall: {recall}')
    print(f'F1: {f1}')
```

In [79]:
```
for i in range(12):
    single_train = drugs_train.iloc[:, i]
    single_test = drugs_test.iloc[:, i]
    single_model = build_model_single(single_train, alc_train)
    eval_model(single_model, single_test, alc_test)
```

```
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
2025-05-11 19:10:13.084052: E tensorflow/core/grappler/optimizers/meta_optim
izer.cc:961] PluggableGraphOptimizer failed: INVALID_ARGUMENT: Failed to des
erialize the `graph_buf`.
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.6518 - loss: 0.6495
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
Precision: 0.6604774535809018
Recall: 1.0
F1: 0.7955271565495208
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.6518 - loss: 0.6471
 1/12 ━━━━━━━━━━━━━━━━━━━━ 0s 27ms/step
2025-05-11 19:12:01.317906: E tensorflow/core/grappler/optimizers/meta_optim
izer.cc:961] PluggableGraphOptimizer failed: INVALID_ARGUMENT: Failed to des
erialize the `graph_buf`.
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
Precision: 0.6604774535809018
Recall: 1.0
F1: 0.7955271565495208
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.6518 - loss: 0.6572
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
Precision: 0.6604774535809018
Recall: 1.0
F1: 0.7955271565495208
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 10ms/step - accuracy: 0.6518 - loss: 0.6474
2025-05-11 19:13:52.321096: E tensorflow/core/grappler/optimizers/meta_optim
izer.cc:961] PluggableGraphOptimizer failed: INVALID_ARGUMENT: Failed to des
erialize the `graph_buf`.
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 5ms/step
Precision: 0.6604774535809018
Recall: 1.0
F1: 0.7955271565495208
```

```
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.6596 - loss: 0.6408
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
Precision: 0.6675824175824175
Recall: 0.9759036144578314
F1: 0.7928221859706363
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step - accuracy: 0.6518 - loss: 0.6491
 1/12 ━━━━━━━━━━━━━━━━━━━━ 0s 28ms/step
2025-05-11 19:15:43.569921: E tensorflow/core/grappler/optimizers/meta_optim
izer.cc:961] PluggableGraphOptimizer failed: INVALID_ARGUMENT: Failed to des
erialize the `graph_buf`.
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
Precision: 0.6604774535809018
Recall: 1.0
F1: 0.7955271565495208
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step - accuracy: 0.6518 - loss: 0.6359
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
Precision: 0.6604774535809018
Recall: 1.0
F1: 0.7955271565495208
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step - accuracy: 0.6518 - loss: 0.6494
 1/12 ━━━━━━━━━━━━━━━━━━━━ 0s 28ms/step
2025-05-11 19:17:34.536444: E tensorflow/core/grappler/optimizers/meta_optim
izer.cc:961] PluggableGraphOptimizer failed: INVALID_ARGUMENT: Failed to des
erialize the `graph_buf`.
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
Precision: 0.6604774535809018
Recall: 1.0
F1: 0.7955271565495208
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

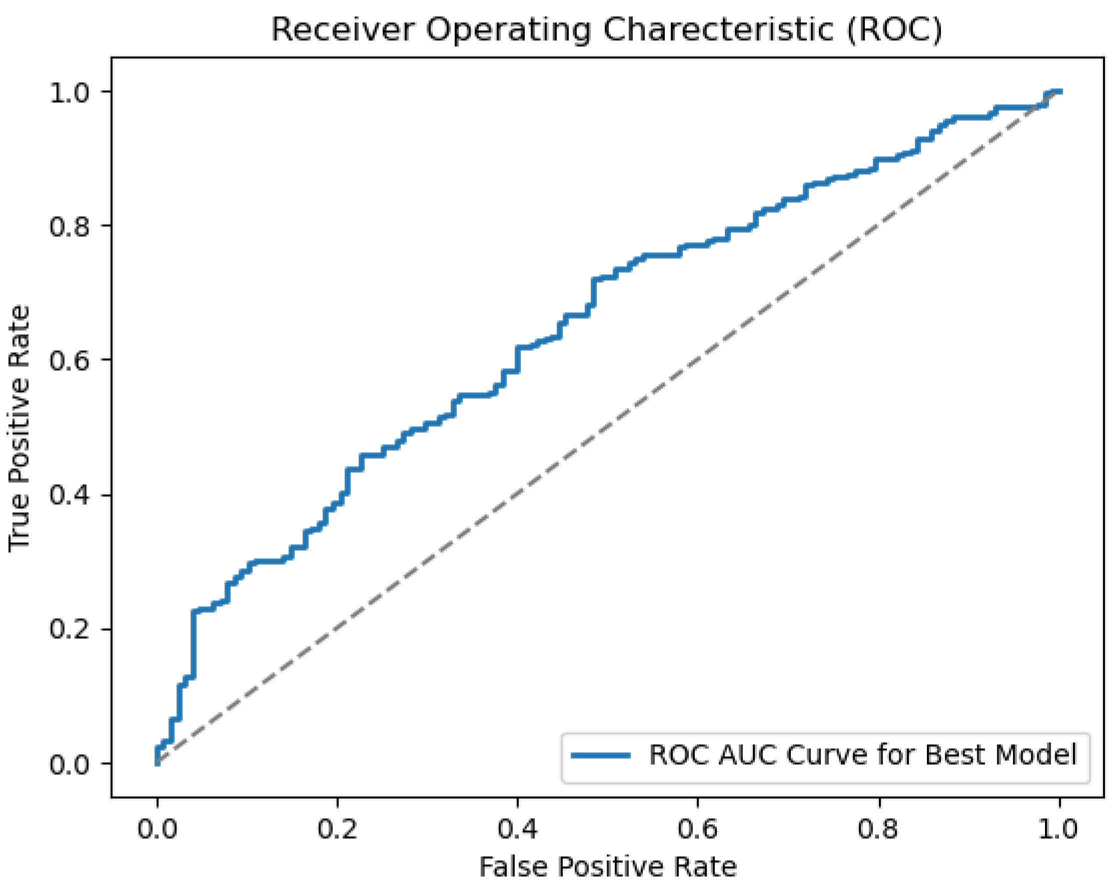
```
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.6518 - loss: 0.6478
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
Precision: 0.6604774535809018
Recall: 1.0
F1: 0.7955271565495208
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step - accuracy: 0.6518 - loss: 0.6482
 1/12 ━━━━━━━━━━━━━━━━━━━━ 0s 28ms/step
2025-05-11 19:19:27.218439: E tensorflow/core/grappler/optimizers/meta_optim
izer.cc:961] PluggableGraphOptimizer failed: INVALID_ARGUMENT: Failed to des
erialize the `graph_buf`.
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
Precision: 0.6604774535809018
Recall: 1.0
F1: 0.7955271565495208
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 7ms/step - accuracy: 0.6518 - loss: 0.6478
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
Precision: 0.6604774535809018
Recall: 1.0
F1: 0.7955271565495208
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.6518 - loss: 0.6398
 1/12 ━━━━━━━━━━━━━━━━━━━━ 0s 27ms/step
2025-05-11 19:21:19.307333: E tensorflow/core/grappler/optimizers/meta_optim
izer.cc:961] PluggableGraphOptimizer failed: INVALID_ARGUMENT: Failed to des
erialize the `graph_buf`.
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
Precision: 0.6604774535809018
Recall: 1.0
F1: 0.7955271565495208
```

In [80]:

```python
fpr, tpr, thresholds = roc_curve(alc_test, best_pred_prob)
roc_auc = roc_auc_score(alc_test, best_pred_prob)
```

In [81]:

```python
plt.plot(fpr, tpr, lw = 2, label = 'ROC AUC Curve for Best Model')
plt.plot([0, 1], [0, 1], color='gray', linestyle='--')
plt.title('Receiver Operating Charecteristic (ROC)')
plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.legend(loc = 'lower right')
plt.savefig('roc_auc_curve.png')
plt.show()
```



In [82]:
```
drugs_data_reduced = drugs_data.iloc[:, 6:13]
drugs_data_reduced_train = drugs_data_reduced.iloc[:1508, :]
drugs_data_reduced_test = drugs_data_reduced.iloc[1508:, :]
```

In [83]:
```
model = Sequential()
model.add(Dense(32, input_dim = drugs_data_reduced_train.shape[1], activatio
model.add(Dense(16, activation='relu'))
model.add(Dense(8, activation='relu'))
model.add(Dense(1, activation = 'sigmoid'))
model.compile(loss = 'binary_crossentropy', optimizer = 'rmsprop', metrics =
model.fit(x = drugs_data_reduced_train, y = alc_train, epochs = 256, verbose
```

```
/opt/anaconda3/lib/python3.12/site-packages/keras/src/layers/core/dense.py:8
7: UserWarning: Do not pass an `input_shape`/`input_dim` argument to a laye
r. When using Sequential models, prefer using an `Input(shape)` object as th
e first layer in the model instead.
  super().__init__(activity_regularizer=activity_regularizer, **kwargs)
```

Out[83]:
```
<keras.src.callbacks.history.History at 0x314493da0>
```

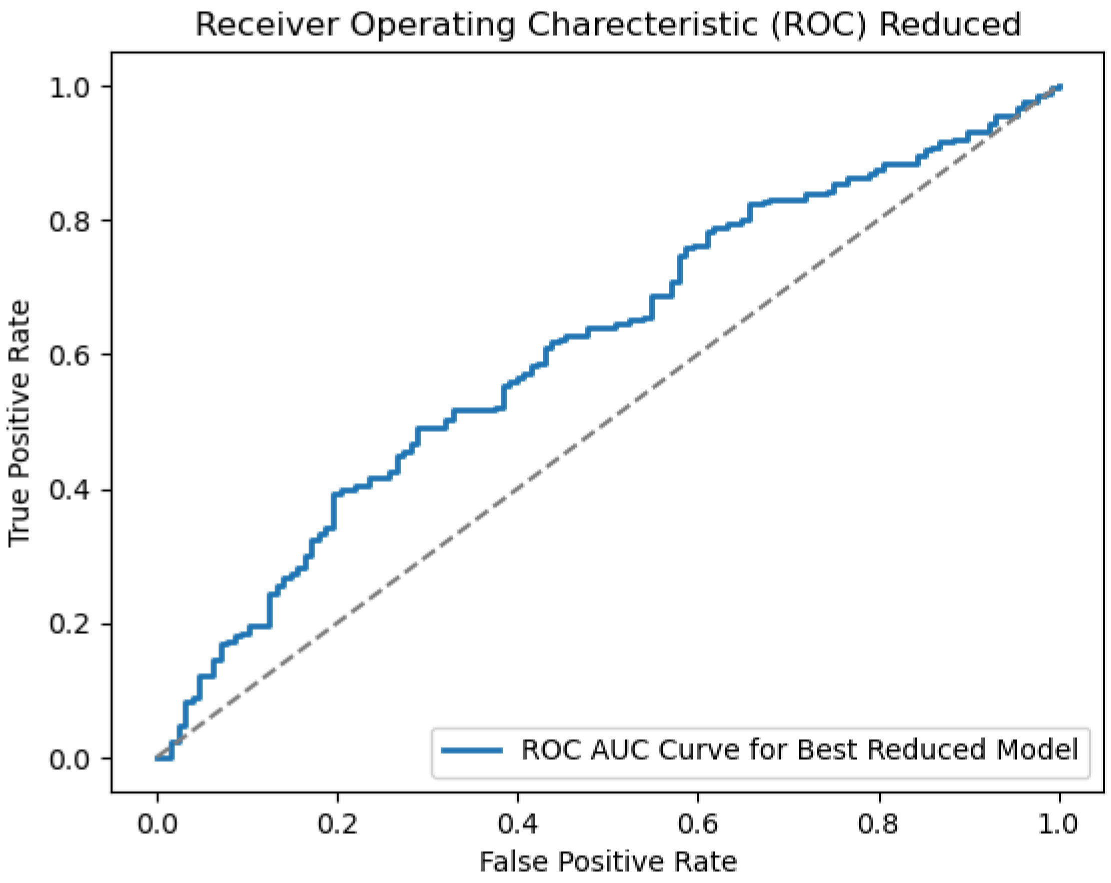
In [86]:
```
best_pred_reduced_prob = model.predict(drugs_data_reduced_test)
best_pred = (best_pred_reduced_prob > 0.5).astype(int).flatten()
model.evaluate(drugs_data_reduced_test, alc_test)
```

```
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6302 - loss: 0.6442
```

```
Out[86]: [0.6350504159927368, 0.6498673558235168]
```

```
In [87]: fpr, tpr, thresholds = roc_curve(alc_test, best_pred_reduced_prob)
         roc_auc = roc_auc_score(alc_test, best_pred_reduced_prob)
```

```
In [88]: plt.plot(fpr, tpr, lw = 2, label = 'ROC AUC Curve for Best Reduced Model')
         plt.plot([0, 1], [0, 1], color='gray', linestyle='--')
         plt.title('Receiver Operating Charecteristic (ROC) Reduced')
         plt.xlabel('False Positive Rate')
         plt.ylabel('True Positive Rate')
         plt.legend(loc = 'lower right')
         plt.savefig('roc_auc_curve_reduced.png')
         plt.show()
```



```
In [ ]:
```