In [1]:
```
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
```

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]:

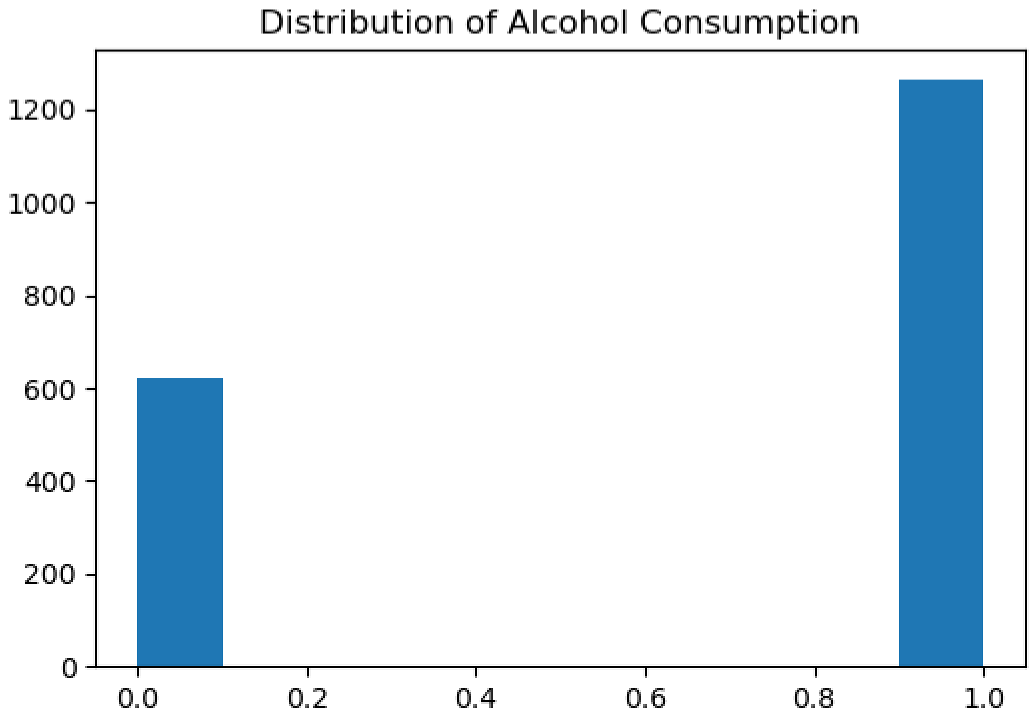
```
print(drugs_data.isna().values.any())
print(alc_output.isna().values.any())

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

```
False
False
```

Visualize Data

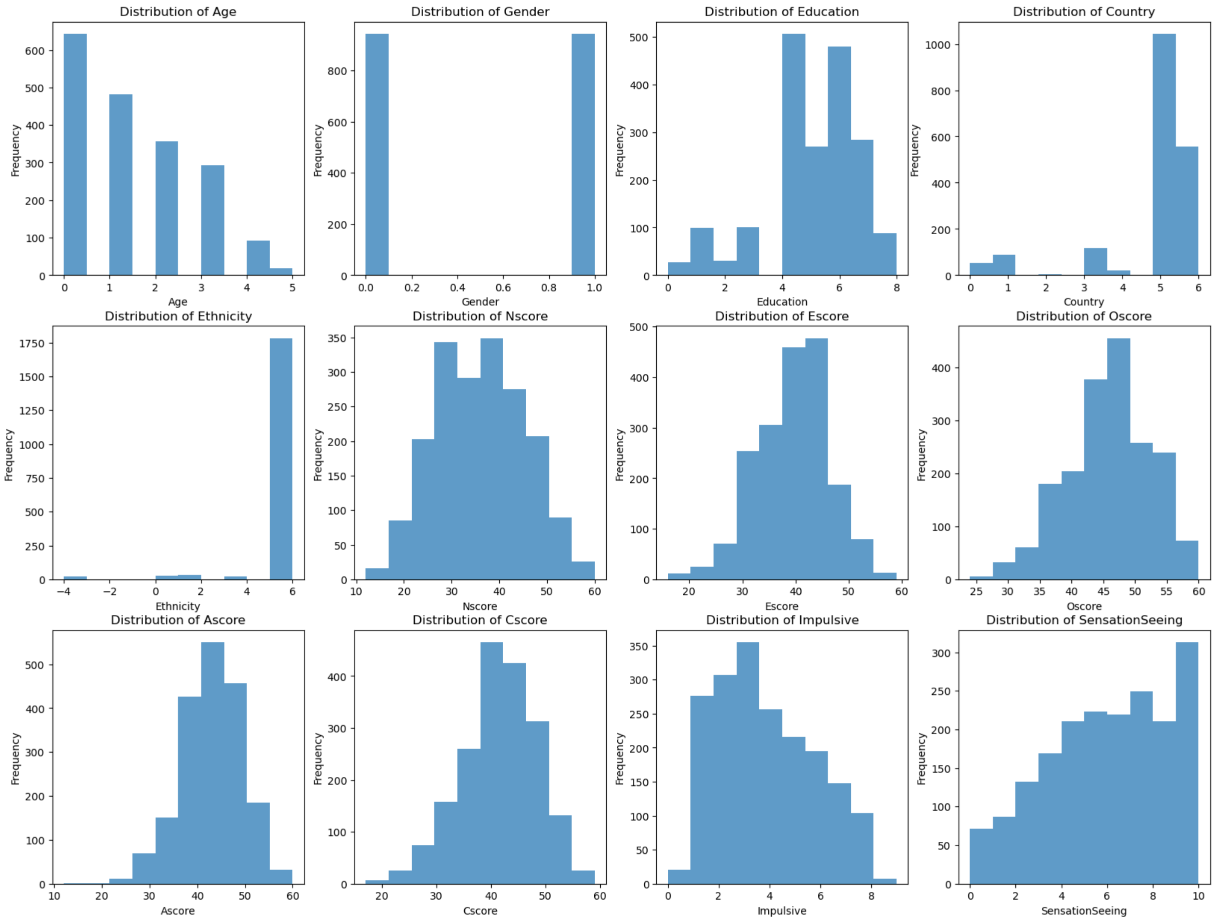
In [9]:

```
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]:

```
scaler = MinMaxScaler()

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

In [12]:

```
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]:

```
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)
2025-04-29 23:36:53.109615: I metal_plugin/src/device/metal_device.cc:1154]
Metal device set to: Apple M4
2025-04-29 23:36:53.109637: I metal_plugin/src/device/metal_device.cc:296] s
ystemMemory: 16.00 GB
2025-04-29 23:36:53.109642: I metal_plugin/src/device/metal_device.cc:313] m
axCacheSize: 5.33 GB
2025-04-29 23:36:53.109658: 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.
2025-04-29 23:36:53.109666: 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)
```

```
2025-04-29 23:36:53.251390: I tensorflow/core/grappler/optimizers/custom_gra
ph_optimizer_registry.cc:117] Plugin optimizer for device_type GPU is enable
d.
2025-04-29 23:36:53.251970: 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 0x302b61ca0>
```

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: 0.6505 - loss: 0.6228
Loss: 0.6122
Accuracy: 0.6711
```

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

In [19]:
```python
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]:
```python
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]:
```python
model.compile(loss= 'binary_crossentropy', optimizer = 'rmsprop', metrics =
```

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

Out[22]:
```
<keras.src.callbacks.history.History at 0x302804b30>
```

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

```
36/59 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.9931 - loss: 0.0179
2025-04-29 23:40:17.176505: 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: 0.9919 - loss: 0.0202
Loss: 0.0232
Accuracy: 0.9910
```

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_26987/2670385671.
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 0x30ad47800>
```

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: 0.6881 - loss: 0.6051
Loss: 0.6096
Accuracy: 0.6790
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.6509 - loss: 0.6311
Loss: 0.6301
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 0x321837800>
```

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: 0.6908 - loss: 0.5955
Loss: 0.5994
Accuracy: 0.6910
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6517 - loss: 0.6263
Loss: 0.6260
Accuracy: 0.6525
```

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,
```

```
2025-04-29 23:42:06.700575: 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 0x3027bb080>
```

```
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: 0.6854 - loss: 0.6124
Loss: 0.6177
Accuracy: 0.6804
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.6596 - loss: 0.6275
Loss: 0.6310
Accuracy: 0.6605
```

```
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 0x346b4f9b0>
```

```
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: 0.7191 - loss: 0.5733
Loss: 0.5801
Accuracy: 0.7049
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6651 - loss: 0.6312
Loss: 0.6251
Accuracy: 0.6658
```

```
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,
```

```
2025-04-29 23:44:00.938060: 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 0x32188b2c0>
```

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: 0.7364 - loss: 0.5560
Loss: 0.5637
Accuracy: 0.7235
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.6569 - loss: 0.6582
Loss: 0.6482
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,
```

```
2025-04-29 23:45:05.316689: 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 0x3079c8dd0>
```

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: 0.7643 - loss: 0.5001
Loss: 0.5046
Accuracy: 0.7606
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step - accuracy: 0.6309 - loss: 0.7327
Loss: 0.6944
Accuracy: 0.6499
```

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,
```

```
2025-04-29 23:46:11.707480: 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 0x307917800>
```

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: 0.8683 - loss: 0.3149
Loss: 0.3241
Accuracy: 0.8660
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 3ms/step - accuracy: 0.5883 - loss: 1.0777
Loss: 1.0776
Accuracy: 0.6101
```

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 [64]:

```
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
```

```
2025-04-30 17:24:22.238730: 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 3ms/step
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 4ms/step
Model 1 F1 score: 0.7837398373983739
Model 2 F1 score: 0.7848932676518884
Model 3 F1 score: 0.7928802588996764
Model 4 F1 score: 0.7927631578947368
Model 5 F1 score: 0.7711267605633803
Model 6 F1 score: 0.7617328519855595
Model 7 F1 score: 0.7123287671232876
```

Best Model

In [57]:
```
best_model_best = load_model('best_model.keras')
```

In [58]:
```
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 3ms/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]
 1/12 ━━━━━━━━━━━━━━━━━━━━ 1s 107ms/step - accuracy: 0.6875 - loss: 0.5767
2025-04-29 23:47:23.157469: 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: 0.6619 - loss: 0.6194
```

Out[58]:
```
[0.6176947355270386, 0.663129985332489]
```

In [59]:
```
print(len(best_pred))
alc_test_count = (alc_test == 1).sum().sum()
print(alc_test_count)
```

```
377
249
```

In [60]:
```
best_model_best.summary()
```

Model: "sequential_7"

Layer (type)	Output Shape	Par
dense_17 (Dense)	(None, 32)	
dense_18 (Dense)	(None, 16)	
dense_19 (Dense)	(None, 8)	
dense_20 (Dense)	(None, 1)	

```
Total params: 2,180 (8.52 KB)
Trainable params: 1,089 (4.25 KB)
Non-trainable params: 0 (0.00 B)
Optimizer params: 1,091 (4.27 KB)
```

In [61]:

```
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: 0.6815476190476191
Recall: 0.9196787148594378
F1: 0.7829059829059829
```

In [62]:

```
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_single(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 [63]:

```
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(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)
12/12 ━━━━━━━━━━━━━━━━━━━━ 0s 6ms/step - accuracy: 0.6518 - loss: 0.6474
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: 0.6466
 1/12 ━━━━━━━━━━━━━━━━━━━━ 0s 27ms/step
2025-04-29 23:49:13.712488: 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: 0.6557
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: 0.6345
 1/12 ━━━━━━━━━━━━━━━━━━━━ 0s 27ms/step
2025-04-29 23:51:06.666156: 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: 0.6460
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: 0.6448
 1/12 ━━━━━━━━━━━━━━━━━━━━ 0s 29ms/step
2025-04-29 23:52:56.414775: 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: 0.6339
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: 0.6495
 1/12 ━━━━━━━━━━━━━━━━━━━━ 0s 28ms/step
2025-04-29 23:54:46.469545: 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: 0.6481
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: 0.6475
 1/12 ━━━━━━━━━━━━━━━━━━━━ 0s 27ms/step
2025-04-29 23:56:38.696561: 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: 0.6463
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: 0.6394
 1/12 ━━━━━━━━━━━━━━━━━━━━ 0s 28ms/step
2025-04-29 23:58:27.522064: 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 [ ]:
```