Problema de Machine Learning de Classificação: Diagnóstico de Diabetes

1 - Definindo o problema de negócio

Você foi contratado por um hospital para desenvolver um modelo de machine learning que possa ajudar os médicos no diagnóstico precoce de diabetes em pacientes. O hospital deseja melhorar a eficiência dos diagnósticos, permitindo uma intervenção mais rápida e precisa para os pacientes em risco de desenvolver diabetes.

2 - Decisões

O problema de negócio já informa que é requerido um modelo de Machine Learning. No dataset, temos a coluna “Outcome” que é a variável que queremos prever. Desta forma, iremos utilizar aprendizagem supervisionada.

3 - Versão python e import dos pacotes utilizados

In [1]:
```
# Versão da Linguagem Python
from platform import python_version
print('Versão da Linguagem Python Usada Neste Jupyter Notebook:', python_version())
```

```
Versão da Linguagem Python Usada Neste Jupyter Notebook: 3.9.13
```

In [2]:
```
# Para atualizar um pacote, execute o comando abaixo no terminal ou prompt de comar
# pip install -U nome_pacote

# Para instalar a versão exata de um pacote, execute o comando abaixo no terminal c
#!pip install nome_pacote==versão_desejada

# Depois de instalar ou atualizar o pacote, reinicie o jupyter notebook.

# Instala o pacote watermark.
# Esse pacote é usado para gravar as versões de outros pacotes usados neste jupyter
#!pip install -q -U watermark
```

In [3]:
```
# Imports
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import sklearn
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import GridSearchCV
```

```python
from sklearn.model_selection import train_test_split
from sklearn.feature_selection import RFE
from sklearn.preprocessing import StandardScaler
from imblearn.under_sampling import RandomUnderSampler
from sklearn.linear_model import LogisticRegression
from sklearn.ensemble import RandomForestClassifier
from sklearn.svm import SVC
from sklearn.neural_network import MLPClassifier
from xgboost import XGBClassifier
from lightgbm import LGBMClassifier
from sklearn.metrics import classification_report
from sklearn.metrics import roc_curve, auc, roc_auc_score, confusion_matrix
from sklearn.metrics import accuracy_score
%matplotlib inline
import warnings
warnings.filterwarnings("ignore", category=FutureWarning)
```

In [4]:
```python
# Versões dos pacotes usados neste jupyter notebook
%reload_ext watermark
%watermark -a "Danilo Temerloglou de Abreu" --iversions
```

```
Author: Danilo Temerloglou de Abreu

sklearn   : 1.2.1
seaborn   : 0.12.2
matplotlib: 3.7.1
numpy     : 1.23.5
pandas    : 1.3.4
```

4 - Dicionário de dados

In [5]:
```python
#Pregnancies - Número de vezes grávida
#Glucose - Concentração de glicose no plasma
#BloodPressure - Pressão sanguínea diastólica
#SkinThickness - Espessura da dobra da pele do tríceps
#Insulin - Nível de insulina sérica
#BMI - Índice de massa corporal (IMC)
#DiabetesPedigreeFunction - Função de pedigree de diabetes
#Age - Idade
#Outcome - Variável de classe (0 ou 1, indicando a presença ou ausência de diabetes
```

5 - Carregando o Conjunto de dados

In [6]:
```python
# Carrega o dataset
df = pd.read_csv('diabetes.csv')
```

6 - EDA Análise Exploratória de Dados

In [7]:
```python
# Shape
df.shape
```

Out[7]:
```
(768, 9)
```

In [8]:
```python
#nomes das colunas
df.columns
```

Out[8]:
```
Index(['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insulin',
       'BMI', 'DiabetesPedigreeFunction', 'Age', 'Outcome'],
      dtype='object')
```

In [9]:
```
# Info
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 768 entries, 0 to 767
Data columns (total 9 columns):
 #   Column                    Non-Null Count  Dtype  
---  ------                    --------------  -----  
 0   Pregnancies               768 non-null    int64  
 1   Glucose                   768 non-null    int64  
 2   BloodPressure             768 non-null    int64  
 3   SkinThickness             768 non-null    int64  
 4   Insulin                   768 non-null    int64  
 5   BMI                       768 non-null    float64
 6   DiabetesPedigreeFunction  768 non-null    float64
 7   Age                       768 non-null    int64  
 8   Outcome                   768 non-null    int64  
dtypes: float64(2), int64(7)
memory usage: 54.1 KB
```

In [10]:
```
# Amostra
df.sample(5)
```

Out[10]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction
415	3	173	84	33	474	35.7	0.258
9	8	125	96	0	0	0.0	0.232
437	5	147	75	0	0	29.9	0.434
223	7	142	60	33	190	28.8	0.687
399	3	193	70	31	0	34.9	0.241

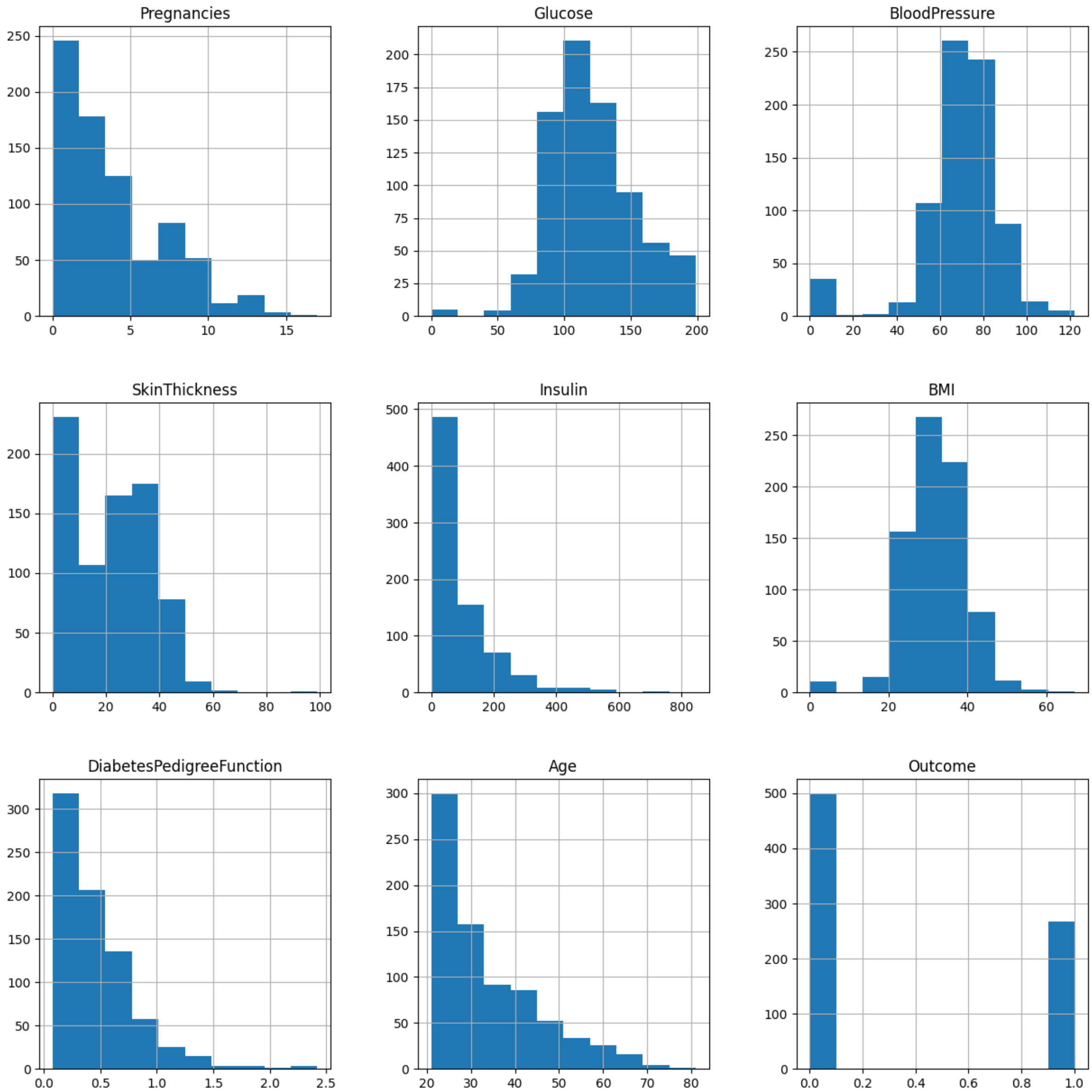
Exploração das variáveis numéricas

In [11]:
```
df.describe()
```

Out[11]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPe
count	768.000000	768.000000	768.000000	768.000000	768.000000	768.000000	
mean	3.845052	120.894531	69.105469	20.536458	79.799479	31.992578	
std	3.369578	31.972618	19.355807	15.952218	115.244002	7.884160	
min	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	
25%	1.000000	99.000000	62.000000	0.000000	0.000000	27.300000	
50%	3.000000	117.000000	72.000000	23.000000	30.500000	32.000000	
75%	6.000000	140.250000	80.000000	32.000000	127.250000	36.600000	
max	17.000000	199.000000	122.000000	99.000000	846.000000	67.100000	

In [12]:
```
# Plot
df.hist(figsize = (15,15), bins = 10)
plt.show()
```



In [13]:
```
# Insighs:
# Predomínio de grávidas maioira até 4 filhos
# Concentração de glicose no plasma maioria de 100 a 130 (Os níveis normais de glic
# Pressão sanguínea diastólica maioria entre 60 e 85 (Seu valor para uma pessoa sau
# Espessura da dobra da pele do tríceps maioria até 40
# Nível de insulina sérica maioria até 100 (IMC de até 25: 2 a 13 mU/L de insulina.
# Índice de massa corporal (IMC) maioria de 20 a 40 (Menor que 18,5     Baixo peso,
# Função de pedigree de diabetes maioria até 0,75 (Função que pontua a probabilidad
# Idade maioria até 55 anos
# Saída maioria dos casos sem diabetes
```

In [14]:
```
# Correlação (tabela)
df.corr()
```

Out[14]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BM
Pregnancies	1.000000	0.129459	0.141282	-0.081672	-0.073535	0.01768
Glucose	0.129459	1.000000	0.152590	0.057328	0.331357	0.22107
BloodPressure	0.141282	0.152590	1.000000	0.207371	0.088933	0.28180
SkinThickness	-0.081672	0.057328	0.207371	1.000000	0.436783	0.39257
Insulin	-0.073535	0.331357	0.088933	0.436783	1.000000	0.19785
BMI	0.017683	0.221071	0.281805	0.392573	0.197859	1.00000
DiabetesPedigreeFunction	-0.033523	0.137337	0.041265	0.183928	0.185071	0.14064
Age	0.544341	0.263514	0.239528	-0.113970	-0.042163	0.03624
Outcome	0.221898	0.466581	0.065068	0.074752	0.130548	0.29269

In [15]:

```
#A variável Outcome (que é a que queremos prever) tem melhor correlação com as vari
# As variáveis preditoras Glucose e Insulin tem alta correlação entre si o que não
# As variáveis preditoras Age e Pregnancies tem alta correlação entre si o que não
# As variáveis preditoras SkinThickness e BMI tem alta correlação entre si o que nã
```

In [16]:

```
df['Outcome'].value_counts()
```

Out[16]:

```
0    500
1    268
Name: Outcome, dtype: int64
```

In [17]:

```
# A variável Outcome (que é a que queremos prever) está desbalanceada. Isso é ruim
```

Verificando a relação entre atributos

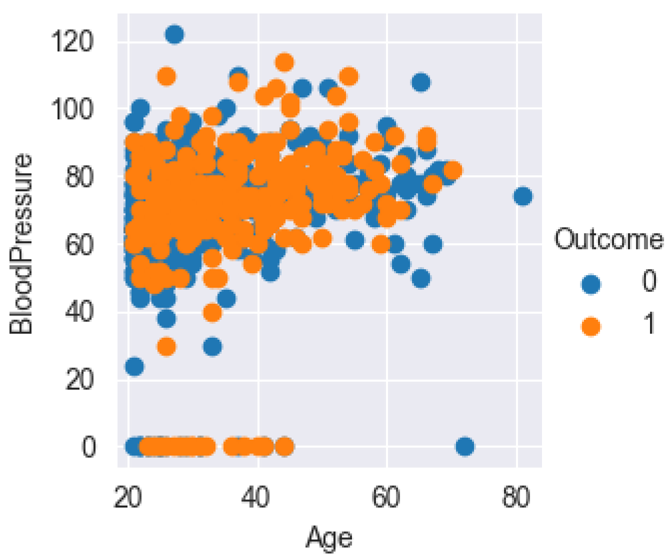
In [18]:

```
# Define o estilo do background
sns.set_style('darkgrid')

# Facetgrid
sns.FacetGrid(df, hue = 'Outcome').map(plt.scatter, 'Age', 'BloodPressure').add_leg
```

Out[18]:

```
<seaborn.axisgrid.FacetGrid at 0x20592d8c6d0>
```



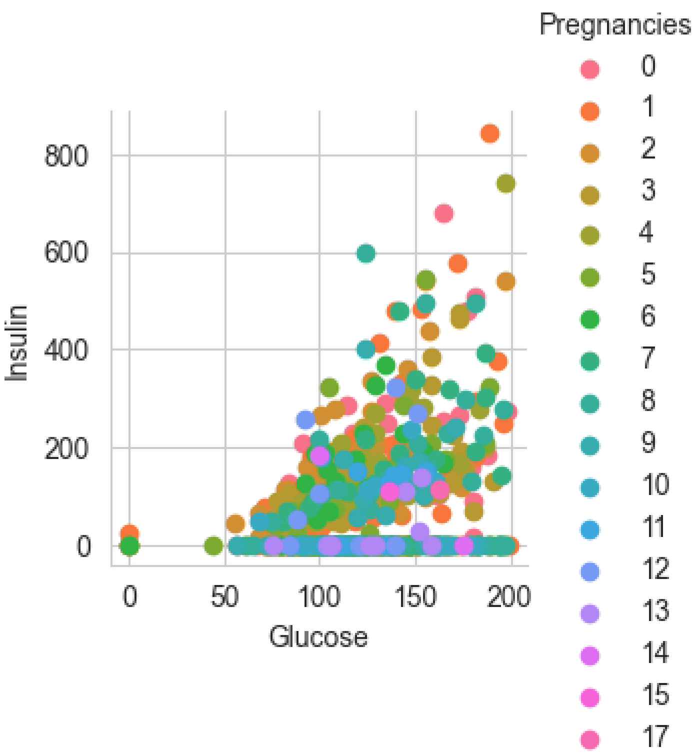
Observando os histogramas, podemos ver que os dados estão normalmente distribuídos (seguem uma distribuição normal).

Observando o gráfico de dispersão, não parece haver correlação entre as duas variáveis. Vamos confirmar calculando o coeficiente de correlação entre elas.

In [19]:
```
# Define o estilo do background
sns.set_style('whitegrid')

# Facetgrid
sns.FacetGrid(df, hue = 'Pregnancies').map(plt.scatter, 'Glucose', 'Insulin').add_l
```

Out[19]: <seaborn.axisgrid.FacetGrid at 0x20592e98910>



7 - Pré-Processamento de Dados Para Construção de Modelos de Machine Learning

In [20]:
```
df.shape
```

Out[20]: (768, 9)

In [21]:
```
# Verificando valores ausentes
numero_ausentes = df.isnull().sum()
print('A quantidade de valores ausentes em cada coluna é:\n', numero_ausentes)
```

```
A quantidade de valores ausentes em cada coluna é:
 Pregnancies                 0
Glucose                     0
BloodPressure               0
SkinThickness               0
Insulin                     0
BMI                         0
DiabetesPedigreeFunction    0
Age                         0
Outcome                     0
dtype: int64
```

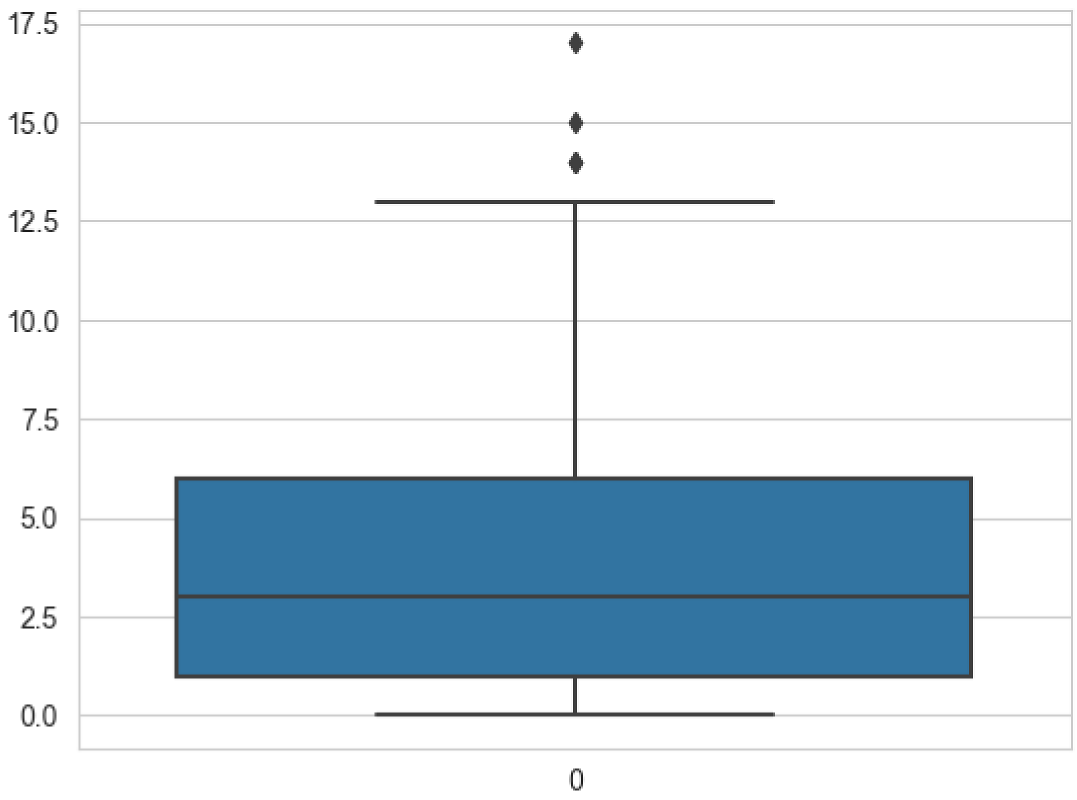
In [22]:
```
# Verifica registros duplicados (remove uma das duplicatas)
numero_duplicados = df.duplicated().sum()
print('A quantidade de valores duplicados é: ', numero_duplicados)
```

```
A quantidade de valores duplicados é:  0
```

In [23]:
```
#Tratamento de outliers
```

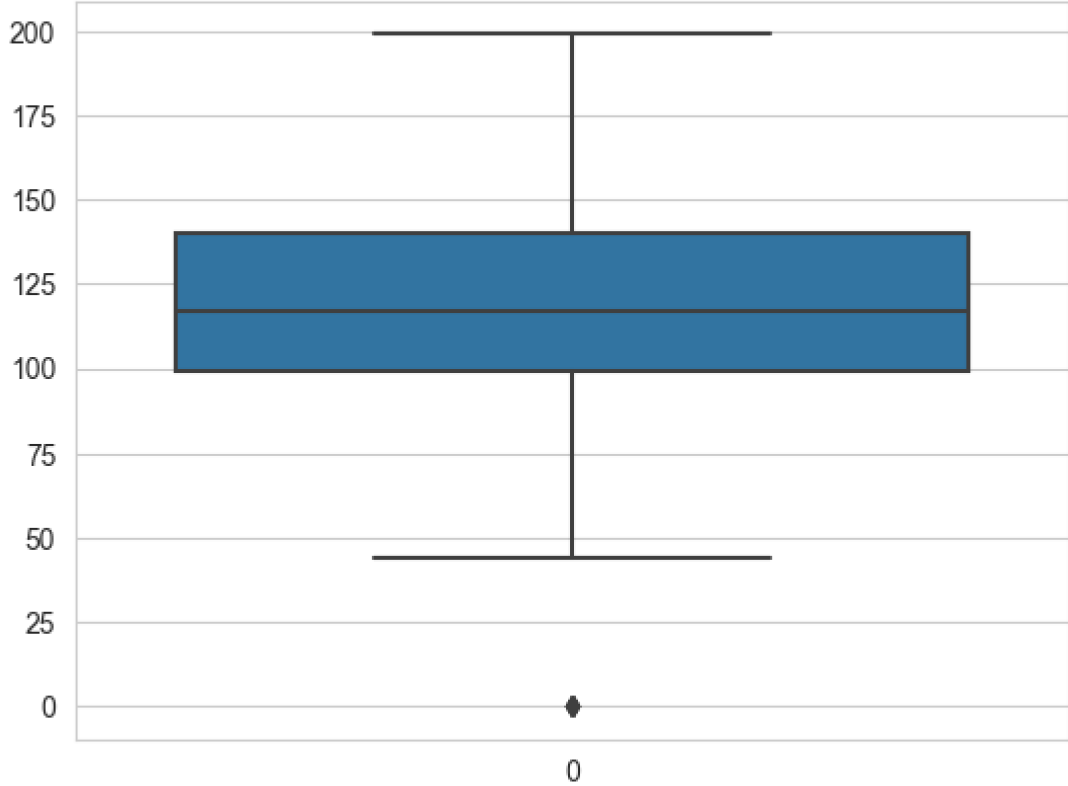
In [24]:
```
# Boxplot
sns.boxplot(df.Pregnancies)
```

Out[24]: <Axes: >



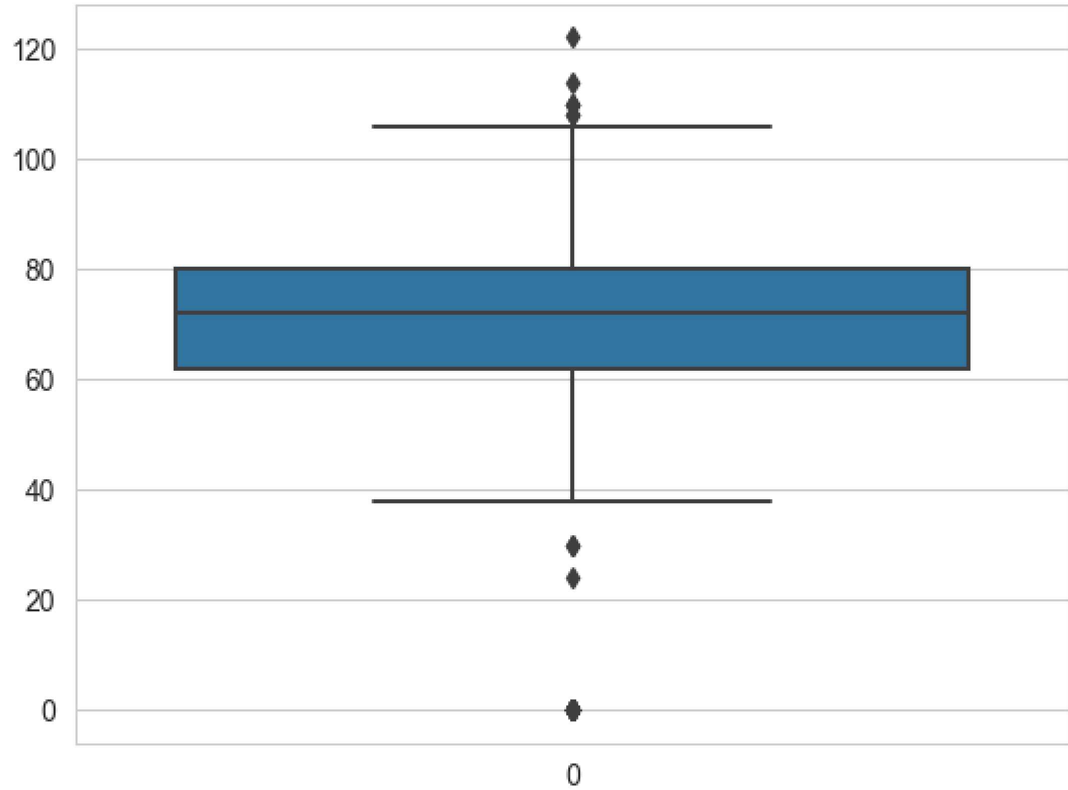
In [25]:
```
# Boxplot
sns.boxplot(df.Glucose)
```

Out[25]: <Axes: >



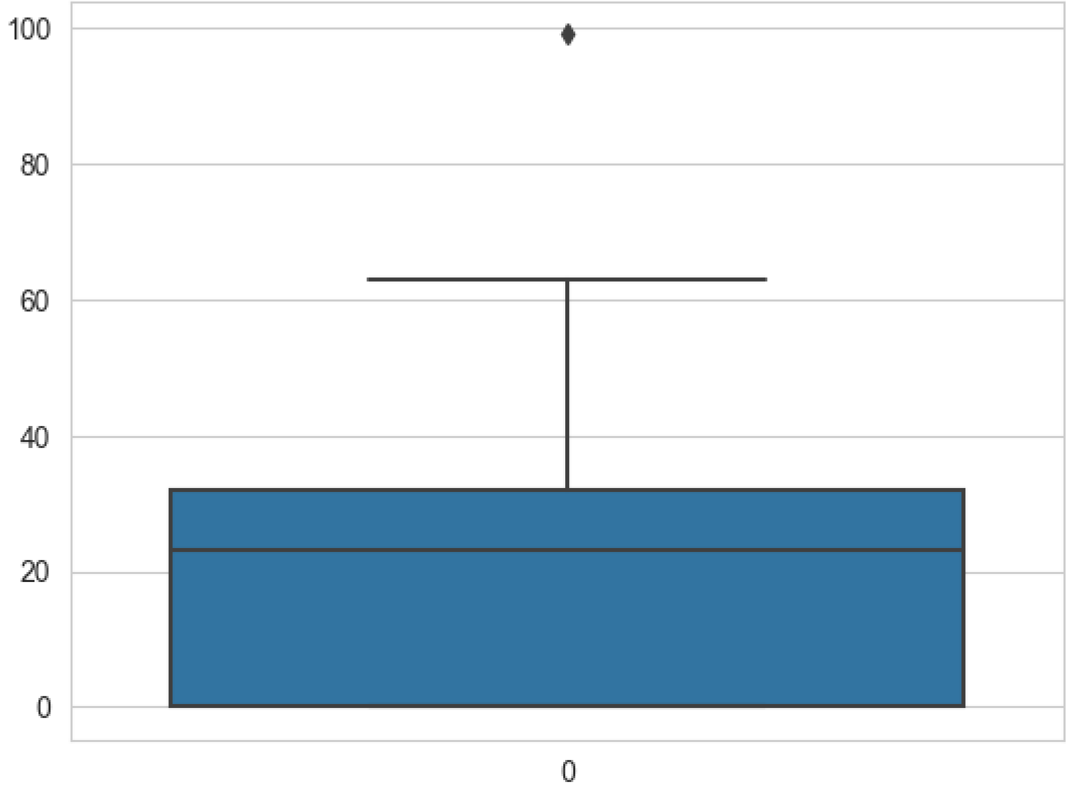
In [26]:
```
# Boxplot
sns.boxplot(df.BloodPressure )
```

Out[26]:
```
<Axes: >
```



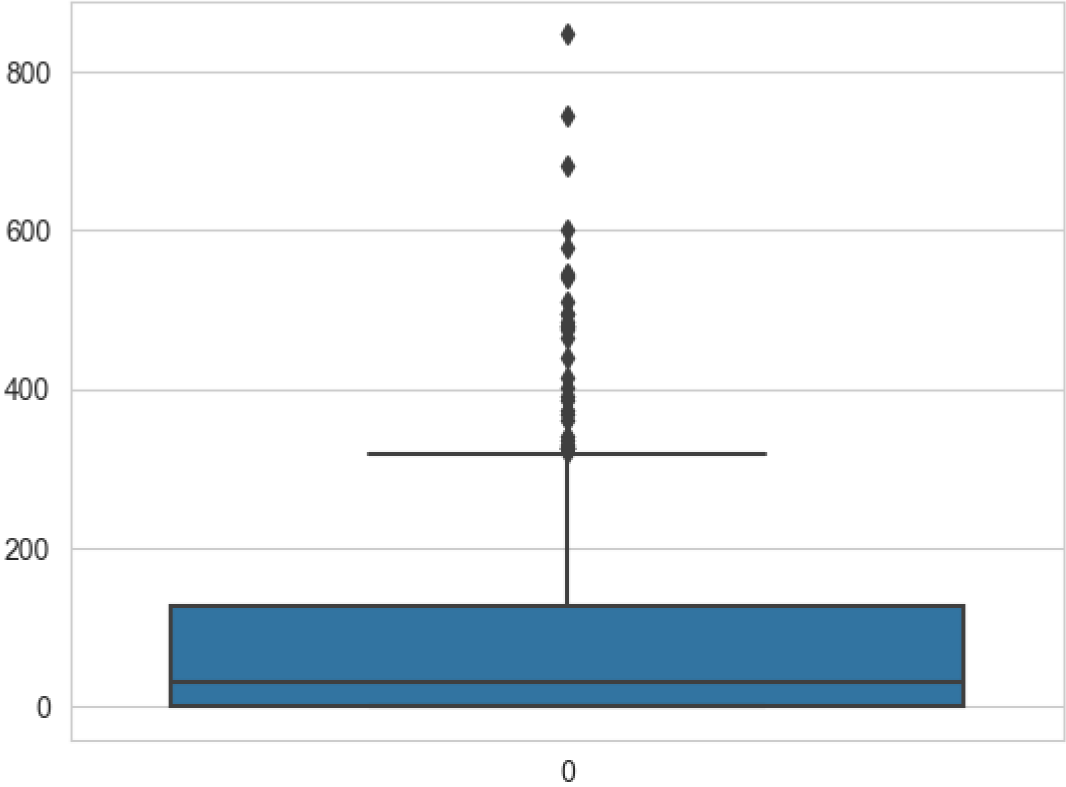
In [27]:
```
# Boxplot
sns.boxplot(df.SkinThickness)
```

Out[27]:
```
<Axes: >
```



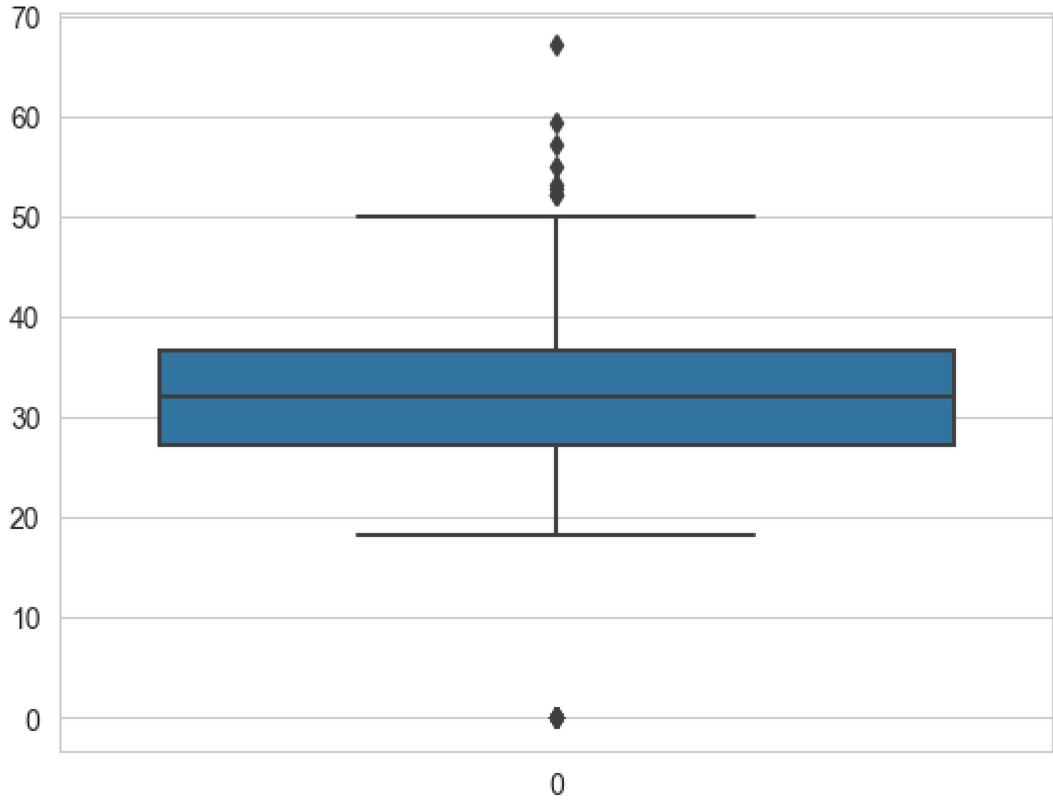
In [28]:
```
# Boxplot
sns.boxplot(df.Insulin )
```

Out[28]: <Axes: >



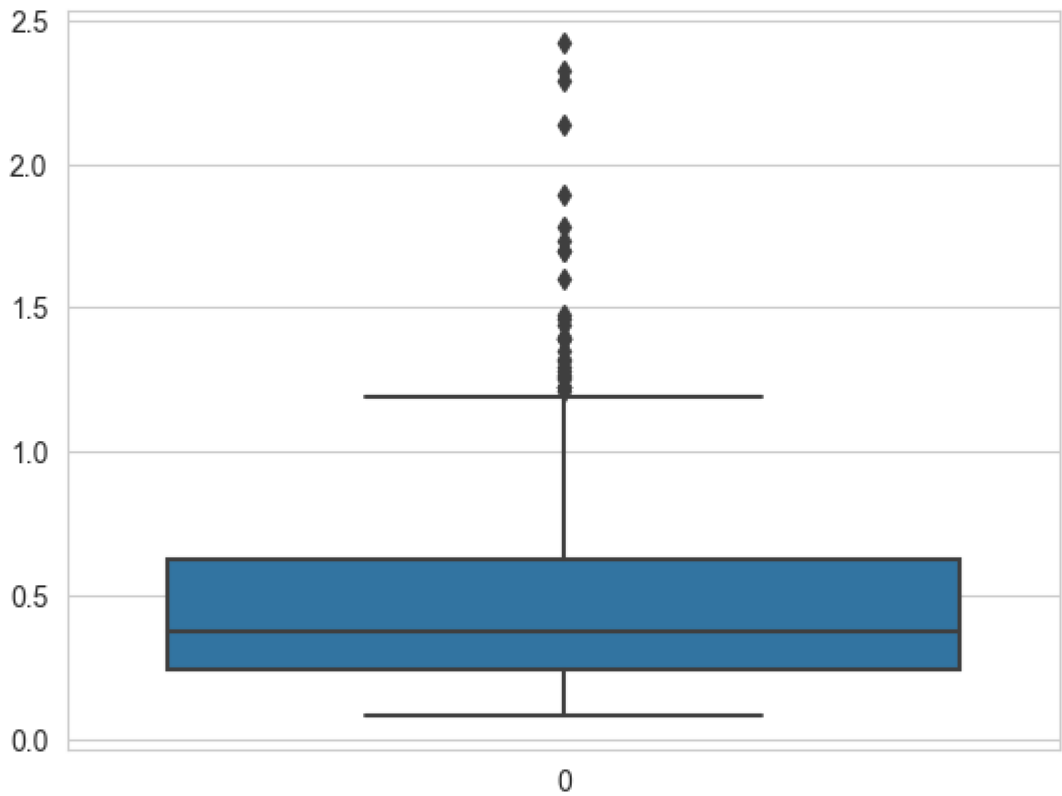
In [29]:
```
# Boxplot
sns.boxplot(df.BMI   )
```

Out[29]: <Axes: >



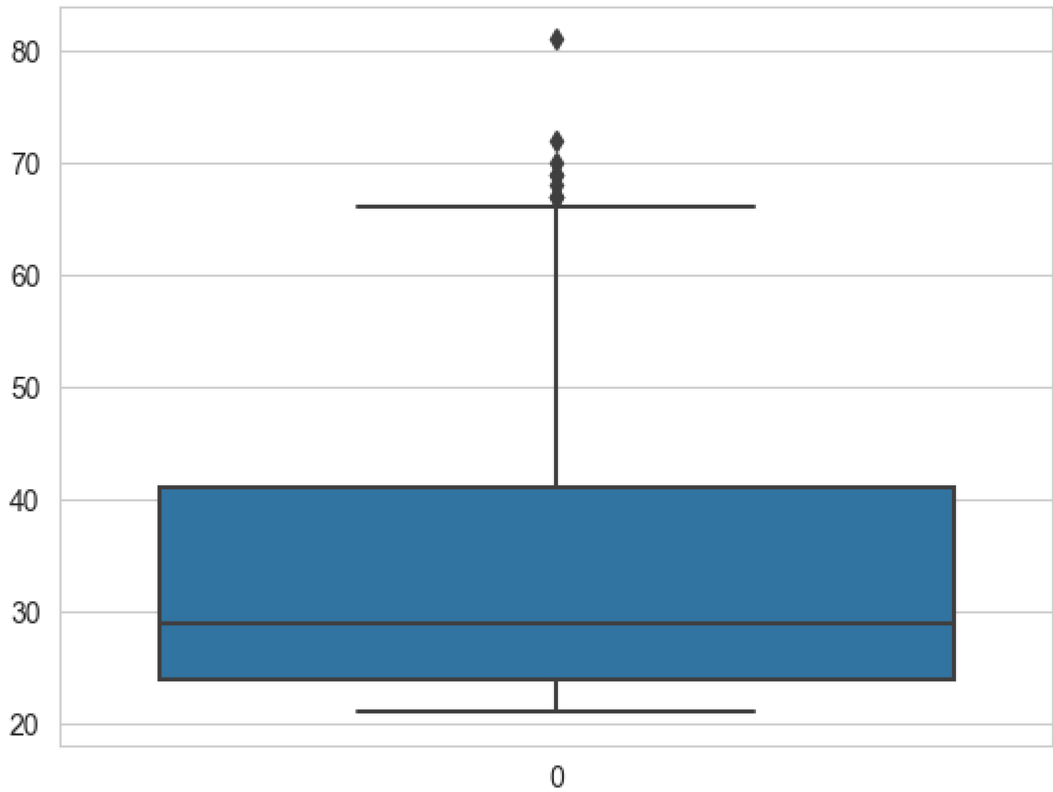
In [30]:
```
# Boxplot
sns.boxplot(df.DiabetesPedigreeFunction)
```

Out[30]: <Axes: >



In [31]:
```
# Boxplot
sns.boxplot(df.Age)
```

Out[31]: <Axes: >



In [32]:
```
#outliers - variável Pregnancies
# Calcular os quartis
Q1 = df['Pregnancies'].quantile(0.25)
Q3 = df['Pregnancies'].quantile(0.75)

# Calcular o intervalo interquartil (IQR)
IQR = Q3 - Q1

# Definir limites para identificar outliers
limite_inferior = Q1 - 1.5 * IQR
limite_superior = Q3 + 1.5 * IQR

# Identificar outliers
outliers_inferiores = df[df['Pregnancies'] < limite_inferior]
outliers_superiores = df[df['Pregnancies'] > limite_superior]

# Contar a quantidade de outliers inferiores e superiores
quantidade_outliers_inferiores = len(outliers_inferiores)
quantidade_outliers_superiores = len(outliers_superiores)

print("Quantidade de outliers inferiores:", quantidade_outliers_inferiores)
print("Quantidade de outliers superiores:", quantidade_outliers_superiores)
```

```
Quantidade de outliers inferiores: 0
Quantidade de outliers superiores: 4
```

In [33]:
```
# Decisão: Manter os outliers
```

In [34]:
```
#outliers - variável Glucose
# Calcular os quartis
Q1 = df['Glucose'].quantile(0.25)
Q3 = df['Glucose'].quantile(0.75)

# Calcular o intervalo interquartil (IQR)
IQR = Q3 - Q1

# Definir limites para identificar outliers
```

```
limite_inferior = Q1 - 1.5 * IQR
limite_superior = Q3 + 1.5 * IQR

# Identificar outliers
outliers_inferiores = df[df['Glucose'] < limite_inferior]
outliers_superiores = df[df['Glucose'] > limite_superior]

# Contar a quantidade de outliers inferiores e superiores
quantidade_outliers_inferiores = len(outliers_inferiores)
quantidade_outliers_superiores = len(outliers_superiores)

print("Quantidade de outliers inferiores:", quantidade_outliers_inferiores)
print("Quantidade de outliers superiores:", quantidade_outliers_superiores)
```

```
Quantidade de outliers inferiores: 5
Quantidade de outliers superiores: 0
```

In [35]:

```
# Decisão: Manter os outliers
```

In [36]:

```
#outliers - variável BloodPressure
# Calcular os quartis
Q1 = df['BloodPressure'].quantile(0.25)
Q3 = df['BloodPressure'].quantile(0.75)

# Calcular o intervalo interquartil (IQR)
IQR = Q3 - Q1

# Definir limites para identificar outliers
limite_inferior = Q1 - 1.5 * IQR
limite_superior = Q3 + 1.5 * IQR

# Identificar outliers
outliers_inferiores = df[df['BloodPressure'] < limite_inferior]
outliers_superiores = df[df['BloodPressure'] > limite_superior]

# Contar a quantidade de outliers inferiores e superiores
quantidade_outliers_inferiores = len(outliers_inferiores)
quantidade_outliers_superiores = len(outliers_superiores)

print("Quantidade de outliers inferiores:", quantidade_outliers_inferiores)
print("Quantidade de outliers superiores:", quantidade_outliers_superiores)
```

```
Quantidade de outliers inferiores: 38
Quantidade de outliers superiores: 7
```

In [37]:

```
# Decisão: Manter os outliers
```

In [38]:

```
#outliers - variável SkinThickness
# Calcular os quartis
Q1 = df['SkinThickness'].quantile(0.25)
Q3 = df['SkinThickness'].quantile(0.75)

# Calcular o intervalo interquartil (IQR)
IQR = Q3 - Q1

# Definir limites para identificar outliers
limite_inferior = Q1 - 1.5 * IQR
limite_superior = Q3 + 1.5 * IQR

# Identificar outliers
outliers_inferiores = df[df['SkinThickness'] < limite_inferior]
outliers_superiores = df[df['SkinThickness'] > limite_superior]

# Contar a quantidade de outliers inferiores e superiores
```

```
quantidade_outliers_inferiores = len(outliers_inferiores)
quantidade_outliers_superiores = len(outliers_superiores)

print("Quantidade de outliers inferiores:", quantidade_outliers_inferiores)
print("Quantidade de outliers superiores:", quantidade_outliers_superiores)
```

```
Quantidade de outliers inferiores: 0
Quantidade de outliers superiores: 1
```

In [39]:
```
# Decisão: Manter o outlier
```

In [40]:
```
#outliers - variável Insulin
# Calcular os quartis
Q1 = df['Insulin'].quantile(0.25)
Q3 = df['Insulin'].quantile(0.75)

# Calcular o intervalo interquartil (IQR)
IQR = Q3 - Q1

# Definir limites para identificar outliers
limite_inferior = Q1 - 1.5 * IQR
limite_superior = Q3 + 1.5 * IQR

# Identificar outliers
outliers_inferiores = df[df['Insulin'] < limite_inferior]
outliers_superiores = df[df['Insulin'] > limite_superior]

# Contar a quantidade de outliers inferiores e superiores
quantidade_outliers_inferiores = len(outliers_inferiores)
quantidade_outliers_superiores = len(outliers_superiores)

print("Quantidade de outliers inferiores:", quantidade_outliers_inferiores)
print("Quantidade de outliers superiores:", quantidade_outliers_superiores)
```

```
Quantidade de outliers inferiores: 0
Quantidade de outliers superiores: 34
```

In [41]:
```
 # Decisão: Manter os outliers
```

In [42]:
```
#outliers - variável BMI
# Calcular os quartis
Q1 = df['BMI'].quantile(0.25)
Q3 = df['BMI'].quantile(0.75)

# Calcular o intervalo interquartil (IQR)
IQR = Q3 - Q1

# Definir limites para identificar outliers
limite_inferior = Q1 - 1.5 * IQR
limite_superior = Q3 + 1.5 * IQR

# Identificar outliers
outliers_inferiores = df[df['BMI'] < limite_inferior]
outliers_superiores = df[df['BMI'] > limite_superior]

# Contar a quantidade de outliers inferiores e superiores
quantidade_outliers_inferiores = len(outliers_inferiores)
quantidade_outliers_superiores = len(outliers_superiores)

print("Quantidade de outliers inferiores:", quantidade_outliers_inferiores)
print("Quantidade de outliers superiores:", quantidade_outliers_superiores)
```

```
Quantidade de outliers inferiores: 11
Quantidade de outliers superiores: 8
```

In [43]:
```
# Decisão: Manter os outliers
```

In [44]:
```
#outliers - variável DiabetesPedigreeFunction
# Calcular os quartis
Q1 = df['DiabetesPedigreeFunction'].quantile(0.25)
Q3 = df['DiabetesPedigreeFunction'].quantile(0.75)

# Calcular o intervalo interquartil (IQR)
IQR = Q3 - Q1

# Definir limites para identificar outliers
limite_inferior = Q1 - 1.5 * IQR
limite_superior = Q3 + 1.5 * IQR

# Identificar outliers
outliers_inferiores = df[df['DiabetesPedigreeFunction'] < limite_inferior]
outliers_superiores = df[df['DiabetesPedigreeFunction'] > limite_superior]

# Contar a quantidade de outliers inferiores e superiores
quantidade_outliers_inferiores = len(outliers_inferiores)
quantidade_outliers_superiores = len(outliers_superiores)

print("Quantidade de outliers inferiores:", quantidade_outliers_inferiores)
print("Quantidade de outliers superiores:", quantidade_outliers_superiores)
```

```
Quantidade de outliers inferiores: 0
Quantidade de outliers superiores: 29
```

In [45]:
```
# Decisão: Manter os outliers
```

In [46]:
```
#outliers - variável Age
# Calcular os quartis
Q1 = df['Age'].quantile(0.25)
Q3 = df['Age'].quantile(0.75)

# Calcular o intervalo interquartil (IQR)
IQR = Q3 - Q1

# Definir limites para identificar outliers
limite_inferior = Q1 - 1.5 * IQR
limite_superior = Q3 + 1.5 * IQR

# Identificar outliers
outliers_inferiores = df[df['Age'] < limite_inferior]
outliers_superiores = df[df['Age'] > limite_superior]

# Contar a quantidade de outliers inferiores e superiores
quantidade_outliers_inferiores = len(outliers_inferiores)
quantidade_outliers_superiores = len(outliers_superiores)

print("Quantidade de outliers inferiores:", quantidade_outliers_inferiores)
print("Quantidade de outliers superiores:", quantidade_outliers_superiores)
```

```
Quantidade de outliers inferiores: 0
Quantidade de outliers superiores: 9
```

In [47]:
```
# Decisão: Manter os outliers
```

Balanceando os dados de saída

In [48]:
```
# Vamos fazer o Under sampling para este balanceamento

# Separar features e target
X = df.drop('Outcome', axis=1)
y = df['Outcome']

# Criar o objeto RandomUnderSampler para balancear as classes
rus = RandomUnderSampler(random_state=42)

# Aplicar o undersampling aos dados
X_resampled, y_resampled = rus.fit_resample(X, y)

# Converter os dados balanceados de volta para DataFrame
df_balanceado = pd.DataFrame(X_resampled, columns=X.columns)
df_balanceado['Outcome'] = y_resampled

# Visualizar o DataFrame balanceado
#print(df_balanceado)

# novo shape após balanceamento
df_balanceado.shape
```

Out[48]:
```
(536, 9)
```

In [49]:
```
# Quantidade de respostas com e sem diabetes balanceada
df_balanceado['Outcome'].value_counts()
```

Out[49]:
```
0    268
1    268
Name: Outcome, dtype: int64
```

8 - Construção, Treinamento e Avaliação do Modelo 1 com Regressão Logística (Benchmark)

In [50]:
```
# Preparando os dados de treino e teste
# X = df.drop(columns='Outcome')
# y = df['Outcome']

X = df_balanceado.drop(columns='Outcome')
y = df_balanceado['Outcome']
X_treino, X_teste, y_treino, y_teste = train_test_split(X, y, test_size=0.2, randon
```

Padronização

In [51]:
```
scaler = StandardScaler()
```

In [52]:
```
scaler.fit(X_treino)
```

Out[52]:
```
▾ StandardScaler
StandardScaler()
```

In [53]:
```
X_treino = scaler.transform(X_treino)
```

In [54]:
```
X_teste = scaler.transform(X_teste)
```

In [55]:
```
X_treino[:5]
```

Out[55]:
```
array([[ 0.85591446, -0.55980992,  0.25421671, -1.24039822, -0.68454544,
        -0.36678014, -0.67948254, -0.2685443 ],
       [-1.15216677,  1.662925  , -0.13524101,  1.10840803, -0.68454544,
         1.20939441,  3.73085429, -0.78318741],
       [-0.57842927, -1.13832996, -0.52469873,  0.32547261, -0.551268  ,
        -0.51931316,  0.69824318, -1.04050896],
       [-0.86529802,  1.17575022,  0.64367443,  1.34931124, -0.12644619,
         0.03997458, -0.4453768 ,  1.36115887],
       [-0.86529802, -0.19442883, -1.20624974,  1.59021444, -0.15976554,
         0.38317388, -0.6095199 , -0.78318741]])
```

In [56]:
```
X_teste[:5]
```

Out[56]:
```
array([[ 0.56904572, -0.43801622, -0.23260544,  1.10840803, -0.68454544,
         0.21792977, -0.66333731, -0.86896126],
       [-1.15216677, -1.26012366, -0.23260544,  0.08456941, -0.13477603,
         0.42130713,  0.10356079, -1.12628281],
       [-0.86529802,  0.07960698,  0.93576772,  1.10840803,  0.23173691,
         0.51028473,  1.48128651,  0.24609881],
       [-0.29156053, -1.3210205 ,  0.05948785, -1.24039822, -0.68454544,
        -1.44722237, -0.31621501, -0.78318741],
       [ 1.14278321,  1.69337342, -0.03787658,  0.92773063,  3.43872514,
        -0.30322472,  0.29192173,  2.21889738]])
```

8.1 - Modelo de Regressão Logística

In [57]:
```
# Cria o modelo
modelo_v1 = LogisticRegression()
```

In [58]:
```
# Treinamento
modelo_v1.fit(X_treino, y_treino)
```

Out[58]:
```
▾ LogisticRegression
LogisticRegression()
```

In [59]:
```
# Avaliação do Modelo

Previsao = modelo_v1.predict(X_teste)
print('Matriz Confusão: \n', confusion_matrix(y_teste, Previsao), '\n')
```

```
Matriz Confusão:
 [[40 10]
 [17 41]]
```

In [60]:
```
# Métricas de Classificação - Relatório de Classificação
print('Relatório de Classificação - Regressão Logistica: \n', classification_report
```

```
Relatório de Classificação - Regressão Logistica:
               precision    recall  f1-score   support

           0       0.70      0.80      0.75        50
           1       0.80      0.71      0.75        58

    accuracy                           0.75       108
   macro avg       0.75      0.75      0.75       108
weighted avg       0.76      0.75      0.75       108
```

In [61]:
```
# Previsão Balanceada
print('Score (Treino): ', round(modelo_v1.score(X_treino, y_treino), 2))
print('Score (Teste): ', round(modelo_v1.score(X_teste, y_teste), 2))
```

```
Score (Treino):  0.76
Score (Teste):  0.75
```

In [62]:
```
# Fazer previsões no conjunto de teste
y_pred = modelo_v1.predict(X_teste)
```

In [63]:
```
# Avaliar a precisão do modelo
accuracy_v1 = accuracy_score(y_teste, y_pred)
print("Accuracy:", accuracy_v1)
```

```
Accuracy: 0.75
```

8.2 - Modelo de Random Forest

In [64]:
```
# Cria o modelo
modelo_v2 = RandomForestClassifier(max_depth=3)
```

In [65]:
```
# Treinamento
modelo_v2.fit(X_treino, y_treino)
```

Out[65]:
```
▾ RandomForestClassifier
RandomForestClassifier(max_depth=3)
```

In [66]:
```
# Avaliação do modelo
Previsao_forest = modelo_v2.predict(X_teste)
print('Relatório de Classificação - Random Forest: \n', classification_report(y_tes
```

```
Relatório de Classificação - Random Forest:
               precision    recall  f1-score   support

           0       0.67      0.74      0.70        50
           1       0.75      0.69      0.72        58

    accuracy                           0.71       108
   macro avg       0.71      0.71      0.71       108
weighted avg       0.72      0.71      0.71       108
```

In [67]:
```
# Fazer previsões no conjunto de teste
y_pred = modelo_v2.predict(X_teste)
```

In [68]:
```
# Avaliar a precisão do modelo
accuracy_v2 = accuracy_score(y_teste, y_pred)
print("Accuracy:", accuracy_v2)
```

```
Accuracy: 0.7129629629629629
```

8.3 - Modelo de SVM

In [69]:
```
# Cria o modelo
modelo_v3 = SVC(kernel='linear')
```

In [70]:
```
# Treinamento
modelo_v3.fit(X_treino, y_treino)
```

Out[70]:
```
SVC
SVC(kernel='linear')
```

In [71]:
```
# Avaliação do modelo
Previsao_svm = modelo_v3.predict(X_teste)
print('Relatório de Classificação - SVM: \n', classification_report(y_teste, Previs
```

```
Relatório de Classificação - SVM:
               precision    recall  f1-score   support

           0       0.69      0.82      0.75        50
           1       0.82      0.69      0.75        58

    accuracy                           0.75       108
   macro avg       0.76      0.75      0.75       108
weighted avg       0.76      0.75      0.75       108
```

In [72]:
```
# Fazer previsões no conjunto de teste
y_pred = modelo_v3.predict(X_teste)
```

In [73]:
```
# Avaliar a precisão do modelo
accuracy_v3 = accuracy_score(y_teste, y_pred)
print("Accuracy:", accuracy_v3)
```

```
Accuracy: 0.75
```

8.4 - Modelo de Rede Neural

In [74]:
```
# Criar o modelo
modelo_v4 = MLPClassifier(hidden_layer_sizes=(100, 50), max_iter=500, activation='r
```

In [75]:
```
# Treinamento
modelo_v4.fit(X_treino, y_treino)
```

```
C:\Users\Chilov\anaconda3\lib\site-packages\sklearn\neural_network\_multilayer_per
ceptron.py:684: ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500)
reached and the optimization hasn't converged yet.
  warnings.warn(
```

Out[75]:
```
MLPClassifier
MLPClassifier(hidden_layer_sizes=(100, 50), max_iter=500, random_state=4
2)
```

In [76]:
```
# Avaliação do modelo
Previsao_rn = modelo_v4.predict(X_teste)
print('Relatório de Classificação - Rede Neural: \n', classification_report(y_teste
```

```
Relatório de Classificação - Rede Neural:
              precision    recall  f1-score   support

           0       0.72      0.78      0.75        50
           1       0.80      0.74      0.77        58

    accuracy                           0.76       108
   macro avg       0.76      0.76      0.76       108
weighted avg       0.76      0.76      0.76       108
```

In [77]:
```
# Treinamento
modelo_v4.fit(X_treino, y_treino)
```

```
C:\Users\Chilov\anaconda3\lib\site-packages\sklearn\neural_network\_multilayer_perceptron.py:684: ConvergenceWarning: Stochastic Optimizer: Maximum iterations (500) reached and the optimization hasn't converged yet.
  warnings.warn(
```

Out[77]:

MLPClassifier

```
MLPClassifier(hidden_layer_sizes=(100, 50), max_iter=500, random_state=42)
```

In [78]:
```
# Fazer previsões no conjunto de teste
y_pred = modelo_v4.predict(X_teste)
```

In [79]:
```
# Avaliar a precisão do modelo
accuracy_v4 = accuracy_score(y_teste, y_pred)
print("Accuracy:", accuracy_v4)
```

```
Accuracy: 0.7592592592592593
```

8.5 - Modelo de XGBOOST

In [80]:
```
# Criar o modelo
modelo_v5 = XGBClassifier(learning_rate=0.01, n_estimators=1000, max_depth=3, rando
```

In [81]:
```
# Treinamento
modelo_v5.fit(X_treino, y_treino)
```

Out[81]:

XGBClassifier

```
XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
              colsample_bytree=None, device=None, early_stopping_rounds=None,
              enable_categorical=False, eval_metric=None, feature_types=None,
              gamma=None, grow_policy=None, importance_type=None,
              interaction_constraints=None, learning_rate=0.01, max_bin=None,
              max_cat_threshold=None, max_cat_to_onehot=None,
              max_delta_step=None, max_depth=3, max_leaves=None,
```

In [82]:
```
# Fazer previsões no conjunto de teste
y_pred = modelo_v5.predict(X_teste)
```

In [83]:
```
# Avaliação do modelo
Previsao_xgboost = modelo_v5.predict(X_teste)
print('Relatório de Classificação - XGBOOST: \n', classification_report(y_teste, Pr
```

```
Relatório de Classificação - XGBOOST:
               precision    recall  f1-score   support

           0       0.70      0.74      0.72        50
           1       0.76      0.72      0.74        58

    accuracy                           0.73       108
   macro avg       0.73      0.73      0.73       108
weighted avg       0.73      0.73      0.73       108
```

In [84]:
```
# Avaliar a precisão do modelo
accuracy_v5 = accuracy_score(y_teste, y_pred)
print("Accuracy:", accuracy_v5)
```

```
Accuracy: 0.7314814814814815
```

8.6 - Modelo de LIGHTGBM

In [85]:
```
# Criar o modelo
modelo_v6 = LGBMClassifier(learning_rate=0.01, n_estimators=1000, max_depth=3, ranc
```

In [86]:
```
# Treinamento
modelo_v6.fit(X_treino, y_treino)
```

```
C:\Users\Chilov\anaconda3\lib\site-packages\joblib\externals\loky\backend\context.
py:110: UserWarning: Could not find the number of physical cores for the following
reason:
found 0 physical cores < 1
Returning the number of logical cores instead. You can silence this warning by set
ting LOKY_MAX_CPU_COUNT to the number of cores you want to use.
  warnings.warn(
  File "C:\Users\Chilov\anaconda3\lib\site-packages\joblib\externals\loky\backend
\context.py", line 217, in _count_physical_cores
    raise ValueError(
```

```
[LightGBM] [Info] Number of positive: 210, number of negative: 218
[LightGBM] [Info] Auto-choosing col-wise multi-threading, the overhead of testing
was 0.000239 seconds.
You can set `force_col_wise=true` to remove the overhead.
[LightGBM] [Info] Total Bins 532
[LightGBM] [Info] Number of data points in the train set: 428, number of used feat
ures: 8
[LightGBM] [Info] [binary:BoostFromScore]: pavg=0.490654 -> initscore=-0.037388
[LightGBM] [Info] Start training from score -0.037388
[LightGBM] [Warning] No further splits with positive gain, best gain: -inf
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```

Out[86]:

```
LGBMClassifier
LGBMClassifier(learning_rate=0.01, max_depth=3, n_estimators=1000,
               random_state=42)
```

In [87]:

```
# Fazer previsões no conjunto de teste
y_pred = modelo_v6.predict(X_teste)
```

In [88]:

```
# Avaliação do modelo
Previsao_lightGBM = modelo_v6.predict(X_teste)
print('Relatório de Classificação - XGBOOST: \n', classification_report(y_teste, Pr
```

```
Relatório de Classificação - XGBOOST:
               precision    recall  f1-score   support

           0       0.67      0.78      0.72        50
           1       0.78      0.67      0.72        58

    accuracy                           0.72       108
   macro avg       0.73      0.73      0.72       108
weighted avg       0.73      0.72      0.72       108
```

In [89]:

```
# Avaliar a precisão do modelo
accuracy_v6 = accuracy_score(y_teste, y_pred)
print("Accuracy:", accuracy_v6)
```

```
Accuracy: 0.7222222222222222
```

In [90]:

```
print('A acurácia do modelo_v1 (Regressão Logística) é:\n', accuracy_v1)
print('A acurácia do modelo_v2 (Random Forest) é:\n', accuracy_v2)
print('A acurácia do modelo_v3 (SVM) é:\n', accuracy_v3)
print('A acurácia do modelo_v4 (Rede Neural) é:\n', accuracy_v4)
print('A acurácia do modelo_v5 (XGBOOST) é:\n', accuracy_v5)
print('A acurácia do modelo_v5 (LIGHTBGM) é:\n', accuracy_v6)
```

```
A acurácia do modelo_v1 (Regressão Logística) é:
 0.75
A acurácia do modelo_v2 (Random Forest) é:
 0.7129629629629629
A acurácia do modelo_v3 (SVM) é:
 0.75
A acurácia do modelo_v4 (Rede Neural) é:
 0.7592592592592593
A acurácia do modelo_v5 (XGBOOST) é:
 0.7314814814814815
A acurácia do modelo_v5 (LIGHTBGM) é:
 0.7222222222222222
```

Seleção do Modelo

Os melhores modelos são v1 e v3. Neste caso, devemos procurar o modelo mais simples. Então seguiremos com o modelo_v1 Regressão Logística

8.6 - Otimização do modelo

8.6.1 - Otimização somente com mudança de hiperparâmetro

In [91]:
```
#obtem variáveis preditoras
X = df_balanceado.drop(columns='Outcome')
y = df_balanceado['Outcome']

# Dividir os dados em conjuntos de treinamento e teste
X_treino, X_teste, y_treino, y_teste = train_test_split(X, y, test_size=0.2, random

# Inicializar o classificador (Random Forest)
clf = RandomForestClassifier()

# Inicializar o seletor de características (RFE) com o classificador e o número de
rfe = RFE(estimator=clf, n_features_to_select=3, step=1)

# Ajustar o seletor de características aos dados de treinamento
rfe.fit(X_treino, y_treino)

# Obter as características selecionadas
selected_features = rfe.support_

# Imprimir as características selecionadas
print("Características selecionadas:")
for i in range(len(selected_features)):
    if selected_features[i]:
        print(f"Feature {i}: {X.columns[i]}")
```

```
Características selecionadas:
Feature 1: Glucose
Feature 5: BMI
Feature 7: Age
```

In [92]:
```
#vamos novamente treinar só com estas variáveis
df.columns
```

Out[92]:
```
Index(['Pregnancies', 'Glucose', 'BloodPressure', 'SkinThickness', 'Insulin',
       'BMI', 'DiabetesPedigreeFunction', 'Age', 'Outcome'],
      dtype='object')
```

In [93]:
```
#X = df_balanceado.drop(columns=['Pregnancies','BloodPressure', 'SkinThickness', 'I
X = df_balanceado[['Glucose', 'BMI', 'DiabetesPedigreeFunction']]
y = df_balanceado['Outcome']
X_treino, X_teste, y_treino, y_teste = train_test_split(X, y, test_size=0.2, random
```

In [94]:
```
# Padronização
scaler = StandardScaler()
scaler.fit(X_treino)
X_treino = scaler.transform(X_treino)
X_teste = scaler.transform(X_teste)
```

In [95]:
```
# Cria o modelo
modelo_v7 = LogisticRegression()
# Treinamento
modelo_v7.fit(X_treino, y_treino)
```

Out[95]:
```
▾ LogisticRegression
LogisticRegression()
```

In [96]:
```
# Avaliação do Modelo
Previsao = modelo_v7.predict(X_teste)
print('Matriz Confusão: \n', confusion_matrix(y_teste, Previsao), '\n')
```

```
Matriz Confusão:
 [[41  9]
 [19 39]]
```

In [97]:
```
# Métricas de Classificação - Relatório de Classificação
print('Relatório de Classificação - Regressão Logistica: \n', classification_report
```

```
Relatório de Classificação - Regressão Logistica:
               precision    recall  f1-score   support

           0       0.68      0.82      0.75        50
           1       0.81      0.67      0.74        58

    accuracy                           0.74       108
   macro avg       0.75      0.75      0.74       108
weighted avg       0.75      0.74      0.74       108
```

In [98]:
```
# Fazer previsões no conjunto de teste
y_pred = modelo_v7.predict(X_teste)
# Avaliar a precisão do modelo
accuracy_v7 = accuracy_score(y_teste, y_pred)
print("Accuracy:", accuracy_v7)
```

```
Accuracy: 0.7407407407407407
```

In [99]:
```
# tive uma acurácia um pouco menor com um modelo com menos variáveis preditoras, ou
```

In [100…
```
# Define lista de hiperparâmetros
tuned_params_v8 = {'C': [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000],
                   'penalty': ['l1', 'l2']}
```

In [101…
```
# Criaremos o modelo com GridSearch
# Vários modelos serão criados com diferentes combinações de hiperparâmetros
modelo_v8 = GridSearchCV(LogisticRegression(),
                         tuned_params_v8,
                         scoring = 'accuracy',
                         n_jobs = -1)
```

In [102…
```
# Treinamento do modelo
modelo_v8.fit(X_treino, y_treino)
```

```
C:\Users\Chilov\anaconda3\lib\site-packages\sklearn\model_selection\_validation.p
y:378: FitFailedWarning:
45 fits failed out of a total of 90.
The score on these train-test partitions for these parameters will be set to nan.
If these failures are not expected, you can try to debug them by setting error_sco
re='raise'.

Below are more details about the failures:
--------------------------------------------------------------------------------
45 fits failed with the following error:
Traceback (most recent call last):
  File "C:\Users\Chilov\anaconda3\lib\site-packages\sklearn\model_selection\_valid
ation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\Chilov\anaconda3\lib\site-packages\sklearn\linear_model\_logisti
c.py", line 1162, in fit
    solver = _check_solver(self.solver, self.penalty, self.dual)
  File "C:\Users\Chilov\anaconda3\lib\site-packages\sklearn\linear_model\_logisti
c.py", line 54, in _check_solver
    raise ValueError(
ValueError: Solver lbfgs supports only 'l2' or 'none' penalties, got l1 penalty.

  warnings.warn(some_fits_failed_message, FitFailedWarning)
C:\Users\Chilov\anaconda3\lib\site-packages\sklearn\model_selection\_search.py:95
2: UserWarning: One or more of the test scores are non-finite: [        nan 0.51168
263        nan 0.73376197        nan 0.74787962
        nan 0.74314637        nan 0.74785226        nan 0.74785226
        nan 0.74785226        nan 0.74785226        nan 0.74785226]
  warnings.warn(
```

Out[102]:

```
▸ GridSearchCV
▸ estimator: LogisticRegression
  ▸ LogisticRegression
```

In [103…

```
# Selecionamos o melhor modelo
modelo_v8.best_estimator_
```

Out[103]:

```
▾ LogisticRegression
LogisticRegression(C=0.01)
```

In [104…

```
# Previsões com dados de teste
y_pred_v8 = modelo_v8.predict(X_teste)
```

In [105…

```
# Mostra as 10 primeiras previsões
y_pred_v8[:10]
```

Out[105]:

```
array([0, 0, 1, 0, 1, 0, 0, 0, 0, 0], dtype=int64)
```

In [106…

```
# Obtemos as previsões no formato de probabilidade para cada classe
y_pred_proba_v8 = modelo_v8.predict_proba(X_teste)
```

In [107…

```
# Mostra as 10 primeiras previsões
y_pred_proba_v8[:10]
```

Out[107]:
```
array([[0.56429416, 0.43570584],
       [0.62198388, 0.37801612],
       [0.41778668, 0.58221332],
       [0.75769115, 0.24230885],
       [0.3285916 , 0.6714084 ],
       [0.64310392, 0.35689608],
       [0.57421192, 0.42578808],
       [0.62734546, 0.37265454],
       [0.74740611, 0.25259389],
       [0.68575121, 0.31424879]])
```

In [108…
```
# Obtemos as previsões no formato de probabilidade filtrando para a classe positivo
# Precisamos disso para calcula a Curva ROC
y_pred_proba_v8 = modelo_v8.predict_proba(X_teste)[:,1]
```

In [109…
```
# Mostra as 10 primeiras previsões
y_pred_proba_v8[:10]
```

Out[109]:
```
array([0.43570584, 0.37801612, 0.58221332, 0.24230885, 0.6714084 ,
       0.35689608, 0.42578808, 0.37265454, 0.25259389, 0.31424879])
```

In [110…
```
# Matriz de confusão
confusion_matrix(y_teste, y_pred_v8)
```

Out[110]:
```
array([[41,  9],
       [19, 39]], dtype=int64)
```

In [111…
```
# Extraindo cada valor da CM
tn, fp, fn, tp = confusion_matrix(y_teste, y_pred_v8).ravel()
```

In [112…
```
# Calcula a métrica global AUC (Area Under The Curve) com dados reais e previsões e
roc_auc_v8 = roc_auc_score(y_teste, y_pred_v8)
print(roc_auc_v8)
```

```
0.7462068965517242
```

In [113…
```
# Calcula a curva ROC com dados e previsões em teste
fpr_v8, tpr_v8, thresholds = roc_curve(y_teste, y_pred_proba_v8)
```

In [114…
```
# AUC em teste
auc_v8 = auc(fpr_v8, tpr_v8)
print(auc_v8)
```

```
0.8437931034482758
```

In [115…
```
# Acurácia em teste
acuracia_v8 = accuracy_score(y_teste, y_pred_v8)
print(acuracia_v8)
```

```
0.7407407407407407
```

8.6.2 - Otimização excluindo outliers e buscando melhor hiperparâmetro

In [116…
```
# Remover outliers - variável Glucose
Q1 = df['Glucose'].quantile(0.25)
Q3 = df['Glucose'].quantile(0.75)
IQR = Q3 - Q1
limite_inferior = Q1 - 1.5 * IQR
limite_superior = Q3 + 1.5 * IQR
df = df[(df['Glucose'] >= limite_inferior) & (df['Glucose'] <= limite_superior)]
```

In [117…

```
# Remover outliers - variável BMI
Q1 = df['BMI'].quantile(0.25)
Q3 = df['BMI'].quantile(0.75)
IQR = Q3 - Q1
limite_inferior = Q1 - 1.5 * IQR
limite_superior = Q3 + 1.5 * IQR
df = df[(df['BMI'] >= limite_inferior) & (df['BMI'] <= limite_superior)]
```

In [118…

```
# Remover outliers - variável DiabetesPedigreeFunction
Q1 = df['DiabetesPedigreeFunction'].quantile(0.25)
Q3 = df['DiabetesPedigreeFunction'].quantile(0.75)
IQR = Q3 - Q1
limite_inferior = Q1 - 1.5 * IQR
limite_superior = Q3 + 1.5 * IQR
df_sem_outliers = df[(df['DiabetesPedigreeFunction'] >= limite_inferior) & (df['Dia
```

In [119…

```
df_sem_outliers.shape
```

Out[119]:

```
(717, 9)
```

In [120…

```
df_sem_outliers['Outcome'].value_counts()
```

Out[120]:

```
0    475
1    242
Name: Outcome, dtype: int64
```

In [121…

```
# Vamos fazer o Under sampling para este balanceamento

# Separar features e target
X = df_sem_outliers.drop('Outcome', axis=1)
y = df_sem_outliers['Outcome']

# Criar o objeto RandomUnderSampler para balancear as classes
rus = RandomUnderSampler(random_state=42)

# Aplicar o undersampling aos dados
X_resampled, y_resampled = rus.fit_resample(X, y)

# Converter os dados balanceados de volta para DataFrame
df_balanceado = pd.DataFrame(X_resampled, columns=X.columns)
df_balanceado['Outcome'] = y_resampled

# Visualizar o DataFrame balanceado
#print(df_balanceado)

# novo shape após balanceamento
df_balanceado.shape
```

Out[121]:

```
(484, 9)
```

In [122…

```
#X = df_balanceado.drop(columns=['Pregnancies','BloodPressure', 'SkinThickness', 'I
X = df_balanceado[['Glucose', 'BMI', 'DiabetesPedigreeFunction']]
y = df_balanceado['Outcome']
X_treino, X_teste, y_treino, y_teste = train_test_split(X, y, test_size=0.2, randon
```

In [123…

```
# Padronização
scaler = StandardScaler()
scaler.fit(X_treino)
X_treino = scaler.transform(X_treino)
X_teste = scaler.transform(X_teste)
```

In [124…

```
# Define lista de hiperparâmetros
tuned_params_v9 = {'C': [0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000],
                   'penalty': ['l1', 'l2']}
```

In [125…

```
# Criaremos o modelo com GridSearch
# Vários modelos serão criados com diferentes combinações de hiperparâmetros
modelo_v9 = GridSearchCV(LogisticRegression(),
                         tuned_params_v9,
                         scoring = 'accuracy',
                         n_jobs = -1)
```

In [126…

```
# Treinamento do modelo
modelo_v9.fit(X_treino, y_treino)
```

```
C:\Users\Chilov\anaconda3\lib\site-packages\sklearn\model_selection\_validation.p
y:378: FitFailedWarning:
45 fits failed out of a total of 90.
The score on these train-test partitions for these parameters will be set to nan.
If these failures are not expected, you can try to debug them by setting error_sco
re='raise'.

Below are more details about the failures:
--------------------------------------------------------------------------------
45 fits failed with the following error:
Traceback (most recent call last):
  File "C:\Users\Chilov\anaconda3\lib\site-packages\sklearn\model_selection\_valid
ation.py", line 686, in _fit_and_score
    estimator.fit(X_train, y_train, **fit_params)
  File "C:\Users\Chilov\anaconda3\lib\site-packages\sklearn\linear_model\_logisti
c.py", line 1162, in fit
    solver = _check_solver(self.solver, self.penalty, self.dual)
  File "C:\Users\Chilov\anaconda3\lib\site-packages\sklearn\linear_model\_logisti
c.py", line 54, in _check_solver
    raise ValueError(
ValueError: Solver lbfgs supports only 'l2' or 'none' penalties, got l1 penalty.

  warnings.warn(some_fits_failed_message, FitFailedWarning)
C:\Users\Chilov\anaconda3\lib\site-packages\sklearn\model_selection\_search.py:95
2: UserWarning: One or more of the test scores are non-finite: [        nan 0.56360
306        nan 0.74159174        nan 0.74408924
        nan 0.74665335        nan 0.74662005        nan 0.74662005
        nan 0.74405594        nan 0.74405594        nan 0.74405594]
  warnings.warn(
```

Out[126]:

```
▸ GridSearchCV
▸ estimator: LogisticRegression
    ▸ LogisticRegression
```

In [127…

```
# Selecionamos o melhor modelo
modelo_v9.best_estimator_
# Previsões com dados de teste
y_pred_v9 = modelo_v9.predict(X_teste)
# Obtemos as previsões no formato de probabilidade filtrando para a classe positiva
# Precisamos disso para calcula a Curva ROC
y_pred_proba_v9 = modelo_v9.predict_proba(X_teste)[:,1]
# Matriz de confusão
confusion_matrix(y_teste, y_pred_v9)
# Extraindo cada valor da CM
tn, fp, fn, tp = confusion_matrix(y_teste, y_pred_v9).ravel()
```

In [128…
```
# Calcula a métrica global AUC (Area Under The Curve) com dados reais e previsões e
roc_auc_v9 = roc_auc_score(y_teste, y_pred_v9)
print(roc_auc_v9)
```

```
0.6804255319148935
```

In [129…
```
# Calcula a curva ROC com dados e previsões em teste
fpr_v9, tpr_v9, thresholds = roc_curve(y_teste, y_pred_proba_v9)
```

In [130…
```
# AUC em teste
auc_v9 = auc(fpr_v9, tpr_v9)
print(auc_v9)
```

```
0.8038297872340425
```

In [131…
```
# Acurácia em teste
acuracia_v9 = accuracy_score(y_teste, y_pred_v9)
print(acuracia_v9)
```

```
0.6804123711340206
```

Conclusão

O modelo_V8 foi o melhor utilizando somente as variáveis 'Glucose', 'BMI', 'DiabetesPedigreeFunction' como preditoras com uma acurácia de 74% que é aceitável diante da pouca quantidade de dados.

Fim