In [841]:

```
import seaborn
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
import json
import requests
from collections import Counter
from sklearn.impute import KNNImputer
import numpy as np
from sklearn.datasets import make_blobs
from sklearn.preprocessing import StandardScaler
import matplotlib.pyplot as plt
import seaborn as sn
import matplotlib.pyplot as plt
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from bioinfokit.analys import stat
from sklearn import metrics
from sklearn.metrics import confusion_matrix
from sklearn.svm import SVC
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.preprocessing import StandardScaler
from sklearn.decomposition import PCA
from sklearn.linear_model import LogisticRegression

pd.set_option('display.max_columns', 500)
df = pd.read_csv('Pima.csv')
df
```

Out[841]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFun
0	6	148	72	35	0	33.6	(
1	1	85	66	29	0	26.6	(
2	8	183	64	0	0	23.3	(
3	1	89	66	23	94	28.1	(
4	0	137	40	35	168	43.1	2
...	...	...	...	...	...	...	
763	10	101	76	48	180	32.9	(
764	2	122	70	27	0	36.8	(
765	5	121	72	23	112	26.2	(
766	1	126	60	0	0	30.1	(
767	1	93	70	31	0	30.4	(

768 rows × 9 columns

Overall understanding of the data

In [836]:
```
df.head()
```

Out[836]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFuncti
0	6	148	72	35	0	33.6	0.6
1	1	85	66	29	0	26.6	0.3
2	8	183	64	0	0	23.3	0.6
3	1	89	66	23	94	28.1	0.1
4	0	137	40	35	168	43.1	2.2

In [842]:
```
df.dtypes
```

Out[842]:
```
Pregnancies                   int64
Glucose                       int64
BloodPressure                 int64
SkinThickness                 int64
Insulin                       int64
BMI                         float64
DiabetesPedigreeFunction    float64
Age                           int64
Outcome                       int64
dtype: object
```

In [843]:
```
df.describe()
```

Out[843]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	Diabe
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 [844]:
```
#print the shape of dataframe
df.shape
```

Out[844]: (768, 9)

Handle missing values. There is no standard procedure of missing value imputation. For simplicity, follow the procedure below:

- Remove the rows containing the missing values if less than 5% of values are missing in a c

- If the percentage of missing values is between 5 % and 30%, fill the missing data with the Remove the feature if more than 30% of its values are missing

In [845]:
```
df[['Glucose ','BloodPressure','SkinThickness','Insulin ','BMI']] =  df[['Glu
print(df.isnull().sum())
```

```
Pregnancies                   0
Glucose                       5
BloodPressure                35
SkinThickness               227
Insulin                     374
BMI                          11
DiabetesPedigreeFunction      0
Age                           0
Outcome                       0
dtype: int64
```

In [846]:
```
p=df.isnull().sum() / df.shape[0]
p
```

Out[846]:
```
Pregnancies                 0.000000
Glucose                     0.006510
BloodPressure               0.045573
SkinThickness               0.295573
Insulin                     0.486979
BMI                         0.014323
DiabetesPedigreeFunction    0.000000
Age                         0.000000
Outcome                     0.000000
dtype: float64
```

From the result above we note that these features have more than 05% missing data -Remove the rows containing the missing values if less than 5% of values are missing in a column, the column Bloodpressure and BMI has less than 5% missing , So we will proceed to delete those missing rows

In [847]:
```
df = df.dropna(subset=['BloodPressure'])
df = df.dropna(subset=['BMI'])
df = df.dropna(subset=['Glucose '])
```

Use KNN to input the missing data

In [848]:

```
# define imputer
imputer = KNNImputer()
# fit on the dataset
imputer.fit(df)
# transform the dataset
df_filled = imputer.transform(df)
df_filled = pd.DataFrame(df_filled)
#df_filled.info()
df2 = df_filled.rename({0: 'Pregnancies', 1: 'Glucose',2:'BloodPressure',3:'S
#BMI    DiabetesPedigreeFunction    Age Outcome
df2.head()
# print total missing
df2.isnull().sum()
```

Out[848]:

```
Pregnancies      0
Glucose          0
BloodPressure    0
SkinThickness    0
Insulin          0
BMI              0
DBF              0
Age              0
Outcome          0
dtype: int64
```

Find outliers in data

In [849]:

```
plt.figure(figsize=(18,35))

plt.subplot(8,2,3)
sns.distplot(df2['Glucose'])
plt.subplot(8,2,4)
sns.boxplot(df2['Glucose'])
plt.subplot(8,2,5) #histogram
sns.distplot(df2['BloodPressure'])
plt.subplot(8,2,6)
sns.boxplot(df2['BloodPressure'])
plt.subplot(8,2,7) #histogram
sns.distplot(df2['SkinThickness'])
plt.subplot(8,2,8)
sns.boxplot(df2['SkinThickness'])
plt.subplot(8,2,9) #histogram
sns.distplot(df2['Insulin'])
plt.subplot(8,2,10)
sns.boxplot(df2['Insulin'])
plt.subplot(8,2,11) #histogram
sns.distplot(df2['BMI'])
plt.subplot(8,2,12)
sns.boxplot(df2['BMI'])
plt.subplot(8,2,13) #histogram
sns.distplot(df2['DBF'])
plt.subplot(8,2,14)
sns.boxplot(df2['DBF'])
plt.show()
```

```
C:\Users\merie\anaconda3\lib\site-packages\seaborn\distributions.py:2557:
FutureWarning: `distplot` is a deprecated function and will be removed in
a future version. Please adapt your code to use either `displot` (a figur
e-level function with similar flexibility) or `histplot` (an axes-level f
unction for histograms).
  warnings.warn(msg, FutureWarning)
C:\Users\merie\anaconda3\lib\site-packages\seaborn\_decorators.py:36: Fut
ureWarning: Pass the following variable as a keyword arg: x. From version
0.12, the only valid positional argument will be `data`, and passing othe
r arguments without an explicit keyword will result in an error or misint
erpretation.
  warnings.warn(
C:\Users\merie\anaconda3\lib\site-packages\seaborn\distributions.py:2557:
FutureWarning: `distplot` is a deprecated function and will be removed in
a future version. Please adapt your code to use either `displot` (a figur
e-level function with similar flexibility) or `histplot` (an axes-level f
unction for histograms).
  warnings.warn(msg, FutureWarning)
C:\Users\merie\anaconda3\lib\site-packages\seaborn\_decorators.py:36: Fut
```

In [850]:

```
from collections import Counter
def detect_outliers(df2,features):
    outlier_indices = []

    for c in features:
        # 1st quartile
        Q1 = np.percentile(df2[c],25)
        # 3rd quartile
        Q3 = np.percentile(df2[c],75)
        # IQR
        IQR = Q3 - Q1
        # Outlier step
        outlier_step = IQR * 1.5
        # detect outlier and their indeces
        outlier_list_col = df2[(df2[c] < Q1 - outlier_step) | (df2[c] > Q3 +
        # store indeces
        outlier_indices.extend(outlier_list_col)

    outlier_indices = Counter(outlier_indices)
    multiple_outliers = list(i for i, v in outlier_indices.items() if v > 2)

    return multiple_outliers
```

In [851]:

```
df2.loc[detect_outliers(df2,[ 'Pregnancies','Glucose', 'BloodPressure', 'Skir
```

Out[851]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DBF	Age	Outcome
418	0.0	180.0	78.0	63.0	14.0	59.4	2.42	25.0	1.0

In [852]:

```
df2 = df2.drop(detect_outliers(df2,[ 'Pregnancies','Glucose', 'BloodPressure'
```

In [853]:

```
df2.drop(df2.index[df2['Insulin'] > 400.0], inplace = True)
df2
```

Out[853]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DBF	Age	Outcom
0	6.0	148.0	72.0	35.0	169.0	33.6	0.627	50.0	1.
1	1.0	85.0	66.0	29.0	58.6	26.6	0.351	31.0	0.
2	8.0	183.0	64.0	25.8	164.6	23.3	0.672	32.0	1.
3	1.0	89.0	66.0	23.0	94.0	28.1	0.167	21.0	0.
4	0.0	137.0	40.0	35.0	168.0	43.1	2.288	33.0	1.
...	...	...	...	...	...	...	...	...	.
718	10.0	101.0	76.0	48.0	180.0	32.9	0.171	63.0	0.
719	2.0	122.0	70.0	27.0	165.0	36.8	0.340	27.0	0.
720	5.0	121.0	72.0	23.0	112.0	26.2	0.245	30.0	0.
721	1.0	126.0	60.0	35.2	134.2	30.1	0.349	47.0	1.
722	1.0	93.0	70.0	31.0	66.6	30.4	0.315	23.0	0.

702 rows × 9 columns

In [854]:

```
df2.drop(df2.index[df2['DBF'] > 1.0], inplace = True)
#df2
```

Out[854]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DBF	Age	Outcom
0	6.0	148.0	72.0	35.0	169.0	33.6	0.627	50.0	1.
1	1.0	85.0	66.0	29.0	58.6	26.6	0.351	31.0	0.
2	8.0	183.0	64.0	25.8	164.6	23.3	0.672	32.0	1.
3	1.0	89.0	66.0	23.0	94.0	28.1	0.167	21.0	0.
5	5.0	116.0	74.0	20.6	102.8	25.6	0.201	30.0	0.
...	...	...	...	...	...	...	...	...	.
718	10.0	101.0	76.0	48.0	180.0	32.9	0.171	63.0	0.
719	2.0	122.0	70.0	27.0	165.0	36.8	0.340	27.0	0.
720	5.0	121.0	72.0	23.0	112.0	26.2	0.245	30.0	0.
721	1.0	126.0	60.0	35.2	134.2	30.1	0.349	47.0	1.
722	1.0	93.0	70.0	31.0	66.6	30.4	0.315	23.0	0.

656 rows × 9 columns

In [855]:

```
df2.drop(df2.index[df2['SkinThickness'] > 50], inplace = True)
#df2
```

In [856]:
```
df2.drop(df2.index[df2['BMI'] > 50], inplace = True)
#df2
```

In [857]:
```
df2.describe()
```

Out[857]:

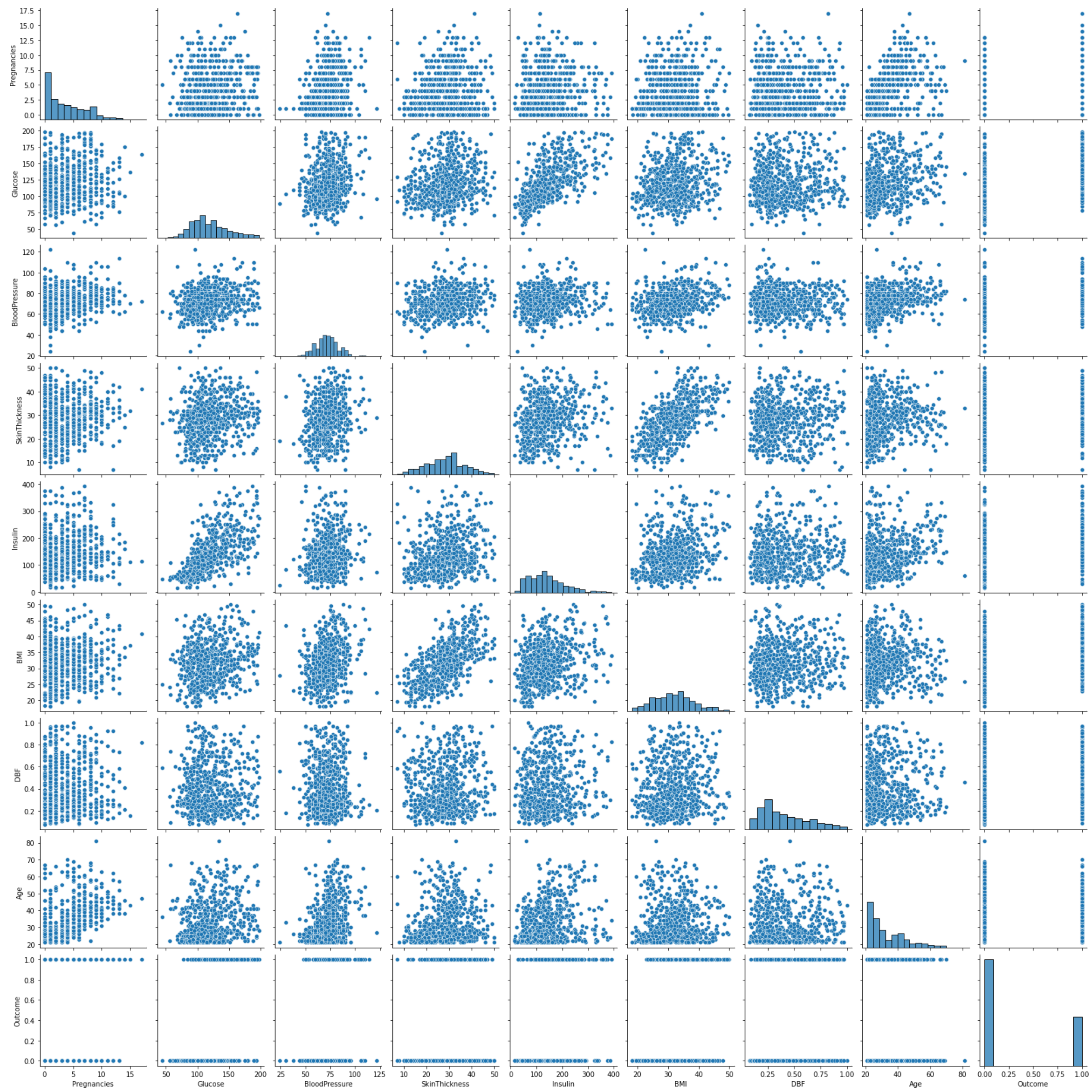
	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	
count	644.000000	644.00000	644.000000	644.000000	644.000000	644.000000	644.00
mean	3.900621	119.76087	72.049689	28.339441	141.493478	31.876708	0.40
std	3.331279	29.55121	12.166318	8.612862	73.210924	6.345578	0.21
min	0.000000	44.00000	24.000000	7.000000	15.000000	18.200000	0.07
25%	1.000000	99.00000	64.000000	22.700000	87.450000	27.300000	0.23
50%	3.000000	114.00000	72.000000	29.000000	130.000000	32.000000	0.34
75%	6.000000	138.00000	80.000000	33.450000	181.850000	35.800000	0.55
max	17.000000	198.00000	122.000000	50.000000	392.000000	50.000000	0.99

In [ ]:

Relevant Feature

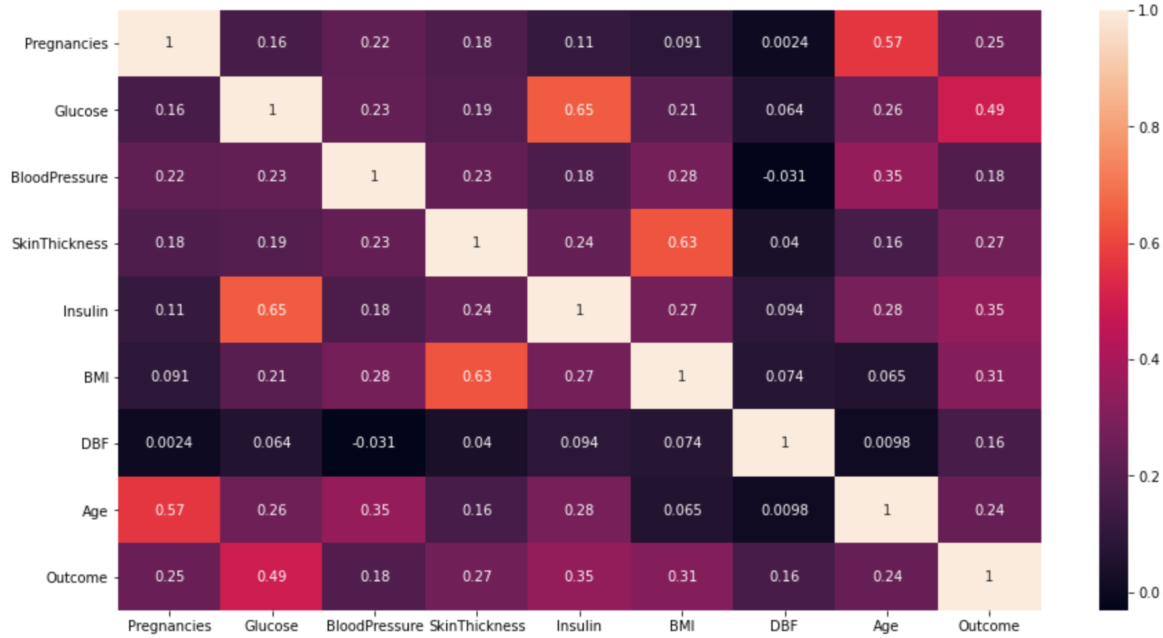
In [858]:

```
seaborn.pairplot(df2)
plt.show()
```



Correlation

In [959]:
```
fig = plt.figure(figsize=(15, 8))
corrMatrix = df2.corr()
sn.heatmap(corrMatrix, annot=True)

plt.show()
```



Null Hypothesis

Most of the studies related on the correlation coeffecient, the chi square is processed in my analysis to wether follow the reuslt of the coeffecient or not of the less correlated variables : preganancies , Blood pressure, Age , sckinthickness

In [861]:

```
cross=pd.crosstab(df2.Outcome,df2.BloodPressure)
res = stat ()
res.chisq(df=cross)
print(res.summary)
```

```
Chi-squared test for independence

Test              Df    Chi-square    P-value
--------------  ----  ------------  ---------
Pearson           43       52.0125  0.163052
Log-likelihood    43       62.0722  0.0298755
```

In [862]:

```
cross=pd.crosstab(df2.Outcome,df2.Age )
res = stat ()
res.chisq(df=cross)
print(res.summary)
```

```
Chi-squared test for independence

Test              Df    Chi-square      P-value
--------------  ----  ------------  -----------
Pearson           50       130.895  3.61438e-09
Log-likelihood    50       136.389  6.08482e-10
```

In [863]:

```
cross=pd.crosstab(df2.Outcome,df2.Pregnancies )
res = stat ()
res.chisq(df=cross)
print(res.summary)
```

```
Chi-squared test for independence

Test              Df    Chi-square      P-value
--------------  ----  ------------  -----------
Pearson           16       59.8596  5.52651e-07
Log-likelihood    16       60.2529  4.7443e-07
```

In [864]:

```
cross=pd.crosstab(df2.Outcome,df2.SkinThickness )
res = stat ()
res.chisq(df=cross)
print(res.summary)
```

```
Chi-squared test for independence

Test              Df    Chi-square    P-value
--------------  ----  ------------  ---------
Pearson          114       137.378  0.0671977
Log-likelihood   114       164.052  0.0014982
```

In [865]:

```
cross=pd.crosstab(df2.Outcome,df2.DBF )
res = stat ()
res.chisq(df=cross)
print(res.summary)
```

```
Chi-squared test for independence

Test              Df    Chi-square     P-value
--------------  ----  ------------  ----------
Pearson          431       438.384  0.392521
Log-likelihood   431       552.502  6.5304e-05
```

if chi_square > critical_value: conclusion = "Null Hypothesis is rejected."

From the above data we can see that most of the data has outliers except Glucose

In [960]:

```
X = df2[[ 'Glucose', 'Pregnancies', 'Age','Insulin', 'BMI']]
y = df2['Outcome']
```

In [961]:

```
X.describe()
```

Out[961]:

	Glucose	Pregnancies	Age	Insulin	BMI
count	644.00000	644.000000	644.000000	644.000000	644.000000
mean	119.76087	3.900621	33.133540	141.493478	31.876708
std	29.55121	3.331279	11.749228	73.210924	6.345578
min	44.00000	0.000000	21.000000	15.000000	18.200000
25%	99.00000	1.000000	24.000000	87.450000	27.300000
50%	114.00000	3.000000	29.000000	130.000000	32.000000
75%	138.00000	6.000000	40.250000	181.850000	35.800000
max	198.00000	17.000000	81.000000	392.000000	50.000000

In [872]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.2,rar
```

Model on imbalanced Dataset without any scaling

Logistique regression

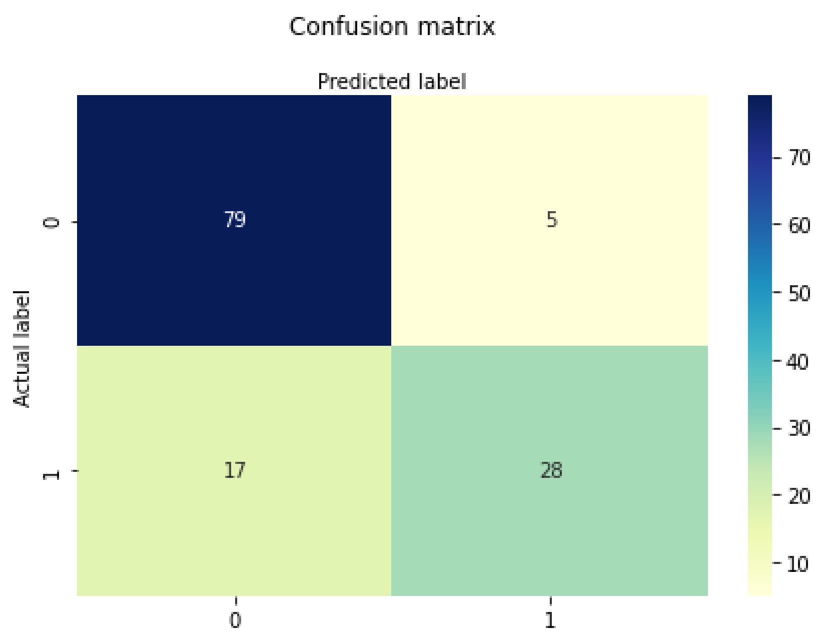
In [873]:
```
from sklearn.linear_model import LogisticRegression

# instantiate the model (using the default parameters)
logreg = LogisticRegression()

# fit the model with data
logreg.fit(X_train,y_train)

#
y_pred=logreg.predict(X_test)
```

In [874]:
```

cnf_matrix = metrics.confusion_matrix(y_test, y_pred)
cnf_matrix
```

Out[874]:
```
array([[79,  5],
       [17, 28]], dtype=int64)
```

In [875]:
```
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

Out[875]:
```
Text(0.5, 257.44, 'Predicted label')
```

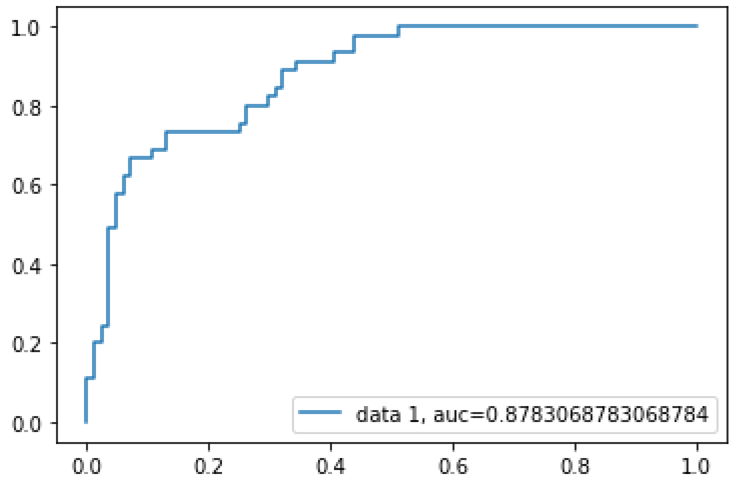


In [876]:
```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred))
print("Precision:",metrics.precision_score(y_test, y_pred))
print("Recall:",metrics.recall_score(y_test, y_pred))
```

```
Accuracy: 0.8294573643410853
Precision: 0.8484848484848485
Recall: 0.6222222222222222
```

In [877]:

```
y_pred_proba = logreg.predict_proba(X_test)[::,1]
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba)
auc = metrics.roc_auc_score(y_test, y_pred_proba)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```



SVM

In [878]:

```
from sklearn.svm import SVC
classifier1 = SVC(random_state=0, kernel='rbf')
classifier1.fit(X_train, y_train)
```

Out[878]: SVC(random_state=0)

In [879]:

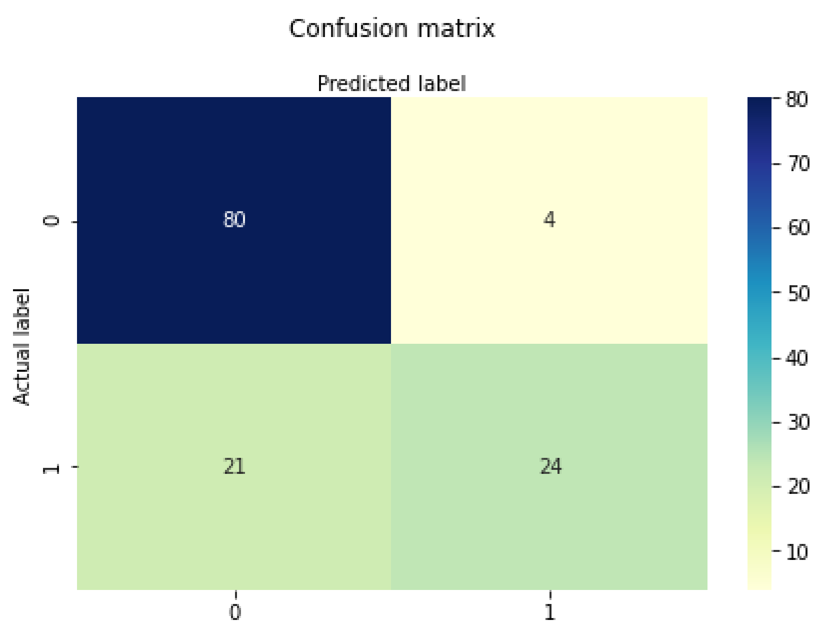
```
# fit the model with data
classifier1.fit(X_train,y_train)
#
y_pred1=classifier.predict(X_test)
```

In [880]:
```
cm1 = confusion_matrix(y_test, y_pred1)
print (cm)
```

```
[[80  4]
 [21 24]]
```

In [881]:
```
cnf_matrix1 = metrics.confusion_matrix(y_test, y_pred1)
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

Out[881]: `Text(0.5, 257.44, 'Predicted label')`

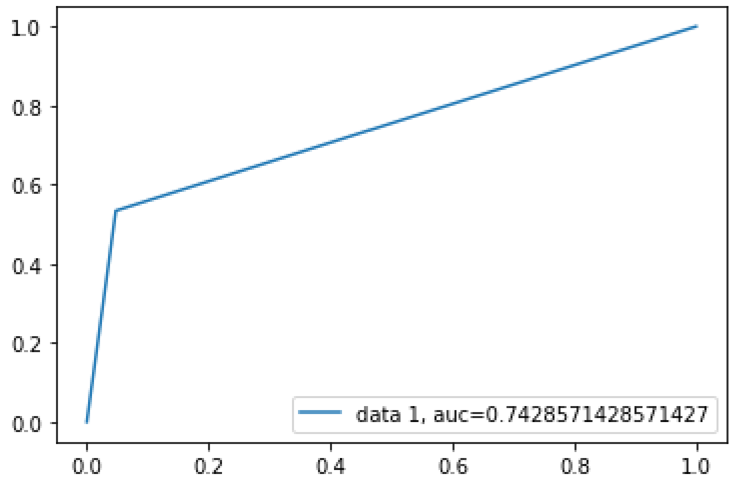


In [882]:
```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred1))
print("Precision:",metrics.precision_score(y_test, y_pred1))
print("Recall:",metrics.recall_score(y_test, y_pred1))
```

```
Accuracy: 0.8062015503875969
Precision: 0.8571428571428571
Recall: 0.5333333333333333
```

In [883]:

```
y_pred_proba1 =classifier1.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba1)
auc = metrics.roc_auc_score(y_test, y_pred_proba1)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```



Decision tree

In [884]:

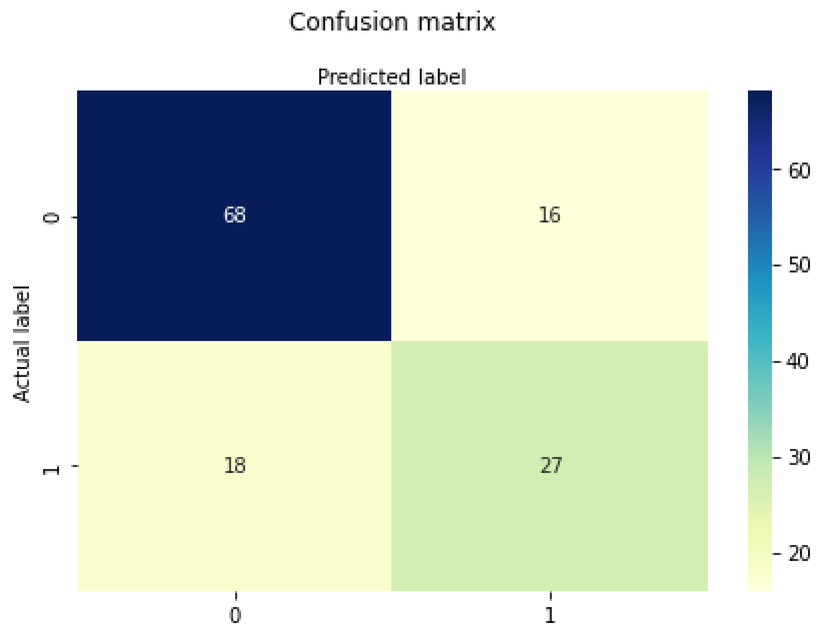
```

classifier2 = DecisionTreeClassifier(random_state=0)
classifier2.fit(X_train, y_train)
y_pred2 = classifier.predict(X_test)
```

In [885]:

```
cnf_matrix2 = metrics.confusion_matrix(y_test, y_pred2)
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

Out[885]:

```
Text(0.5, 257.44, 'Predicted label')
```

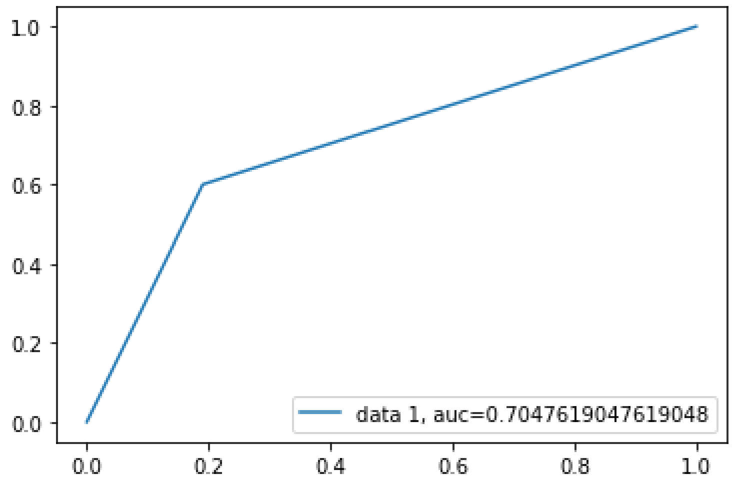


In [886]:

```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred2))
print("Precision:",metrics.precision_score(y_test, y_pred2))
print("Recall:",metrics.recall_score(y_test, y_pred2))
```

```
Accuracy: 0.7364341085271318
Precision: 0.627906976744186
Recall: 0.6
```

In [887]:
```
y_pred_proba2 =classifier.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba2)
auc = metrics.roc_auc_score(y_test, y_pred_proba2)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```

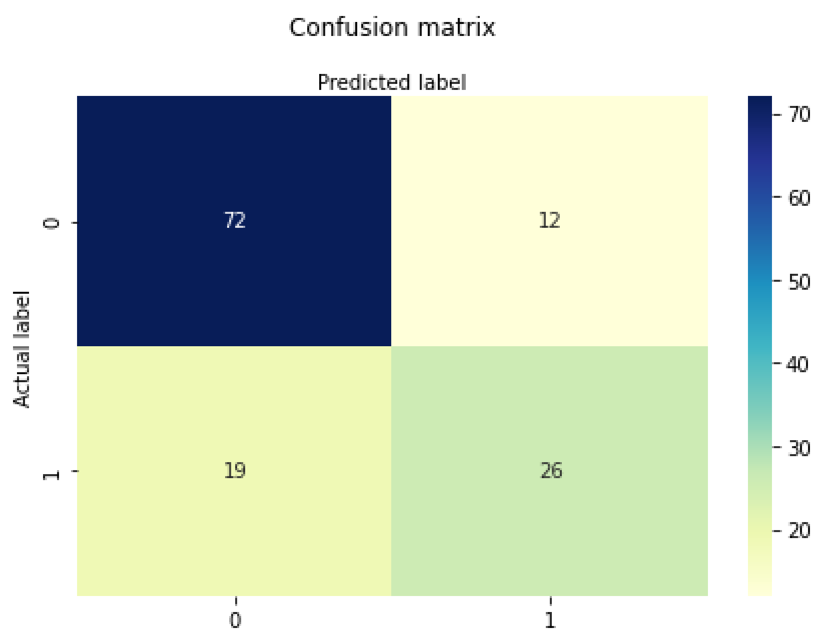


Random Forest

In [888]:
```
#Create a Gaussian Classifier
classifier3=RandomForestClassifier(n_estimators=100)

#Train the model using the training sets y_pred=clf.predict(X_test)
classifier3.fit(X_train,y_train)

y_pred3=classifier3.predict(X_test)
```

In [889]:
```
cnf_matrix3 = metrics.confusion_matrix(y_test, y_pred3)
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

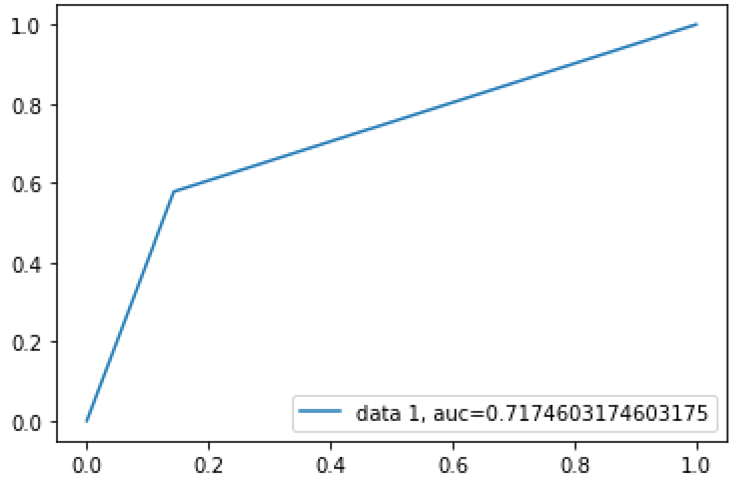
Out[889]: Text(0.5, 257.44, 'Predicted label')



In [890]:
```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred3))
print("Precision:",metrics.precision_score(y_test, y_pred3))
print("Recall:",metrics.recall_score(y_test, y_pred3))
```

```
Accuracy: 0.7596899224806202
Precision: 0.6842105263157895
Recall: 0.5777777777777777
```

In [891]:
```
y_pred_proba3 =classifier.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba3)
auc = metrics.roc_auc_score(y_test, y_pred_proba)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```



Scaling the data

In [892]:
```
X = df2[[ 'Glucose', 'Pregnancies', 'Age','Insulin', 'BMI']]
y = df2['Outcome']
```

In [893]:
```
Scaler=StandardScaler()
Scaler.fit(X)
```

Out[893]:
```
StandardScaler()
```

In [894]:
```
X= Scaler.transform(X)
X
```

Out[894]:
```
array([[ 0.95634261,  0.63069197,  1.4366536 ,  0.37600813,  0.27178476],
       [-1.17720695, -0.87139985, -0.18173099, -1.1331357 , -0.83220308],
       [ 2.14164792,  1.23152869, -0.09655286,  0.31586109, -1.35265449],
       ...,
       [ 0.04196423,  0.3302736 , -0.26690913, -0.40316939, -0.8952881 ],
       [ 0.21129356, -0.87139985,  1.18111919, -0.09970025, -0.28020916],
       [-0.90628002, -0.87139985, -0.86315608, -1.02377745, -0.23289539]])
```

In [895]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.2,rar
```

Model on imbalanced Dataset with scaling

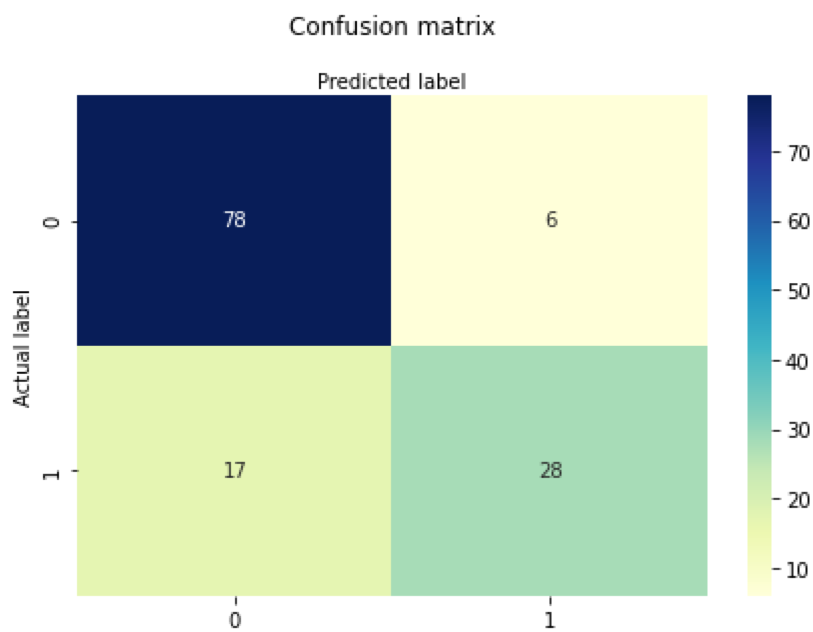
Logisitique regression on imbalanced dataset

with scaling

In [896]:
```
# instantiate the model (using the default parameters)
classifier4 = LogisticRegression()

# fit the model with data
classifier4.fit(X_train,y_train)

#
y_pred4=classifier4.predict(X_test)
```

In [897]:
```
cnf_matrix4 = metrics.confusion_matrix(y_test, y_pred4)
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

Out[897]:
```
Text(0.5, 257.44, 'Predicted label')
```

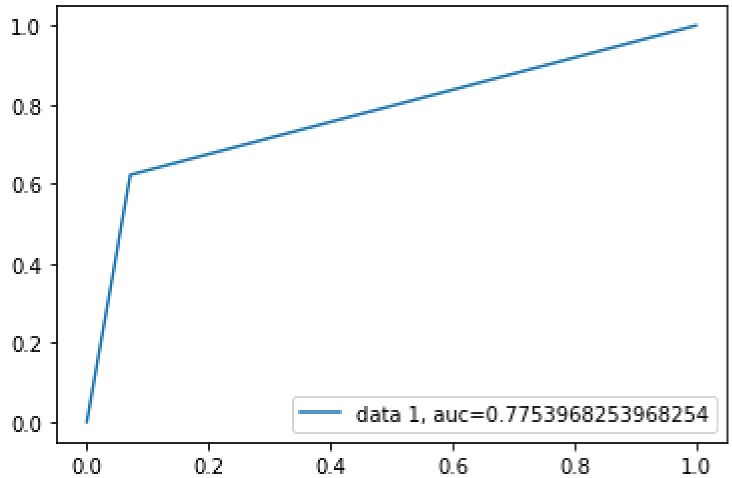


In [899]:
```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred4))
print("Precision:",metrics.precision_score(y_test, y_pred4))
print("Recall:",metrics.recall_score(y_test, y_pred4))
```

```
Accuracy: 0.8217054263565892
Precision: 0.8235294117647058
Recall: 0.6222222222222222
```

In [900]:

```
y_pred_proba4 =classifier.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba4)
auc = metrics.roc_auc_score(y_test, y_pred_proba4)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```



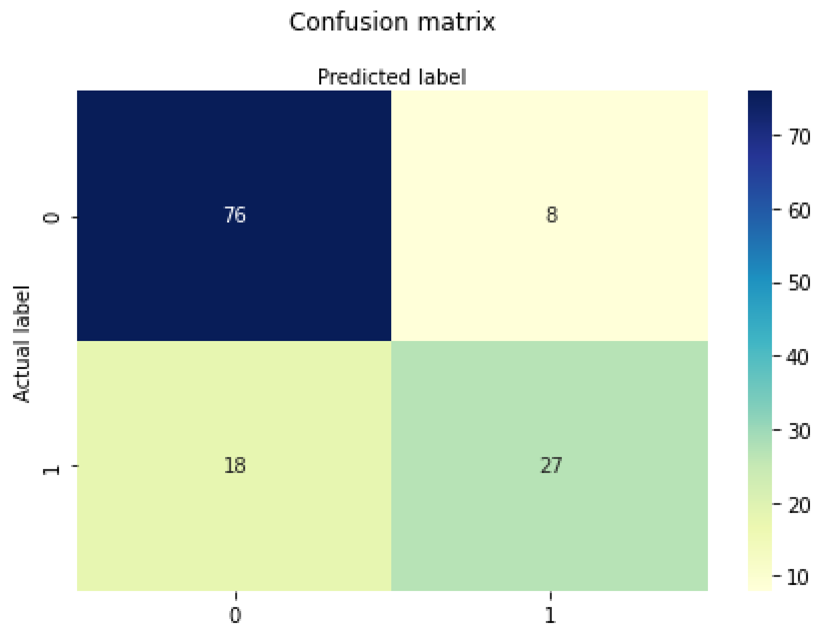
SVM

In [901]:

```
classifier5 = SVC(random_state=0, kernel='rbf')
classifier5.fit(X_train, y_train)
y_pred5=classifier5.predict(X_test)
```

In [902]:
```
cnf_matrix5 = metrics.confusion_matrix(y_test, y_pred5)
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

Out[902]:
```
Text(0.5, 257.44, 'Predicted label')
```

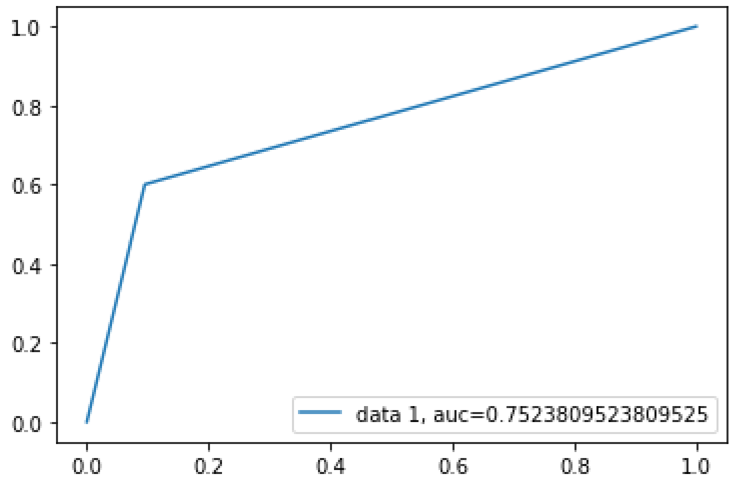


In [903]:
```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred5))
print("Precision:",metrics.precision_score(y_test, y_pred5))
print("Recall:",metrics.recall_score(y_test, y_pred5))
```

```
Accuracy: 0.7984496124031008
Precision: 0.7714285714285715
Recall: 0.6
```

In [904]:

```
y_pred_proba5 =classifier.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba5)
auc = metrics.roc_auc_score(y_test, y_pred_proba5)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```



Decision Tree

In [905]:

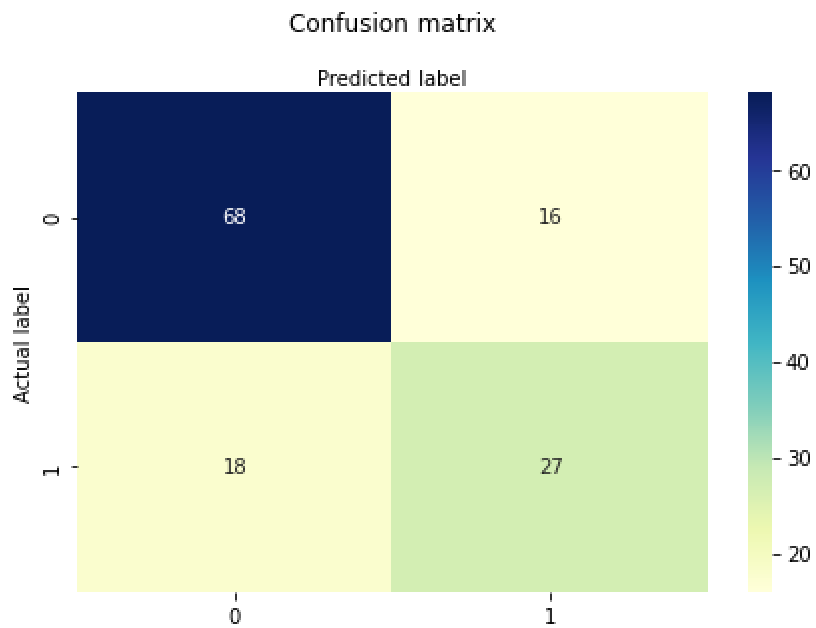
```
classifier6 = DecisionTreeClassifier(random_state=0)
classifier6.fit(X_train, y_train)
y_pred6=classifier6.predict(X_test)
```

In [906]:

```
cnf_matrix6 = metrics.confusion_matrix(y_test, y_pred6)
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

Out[906]:

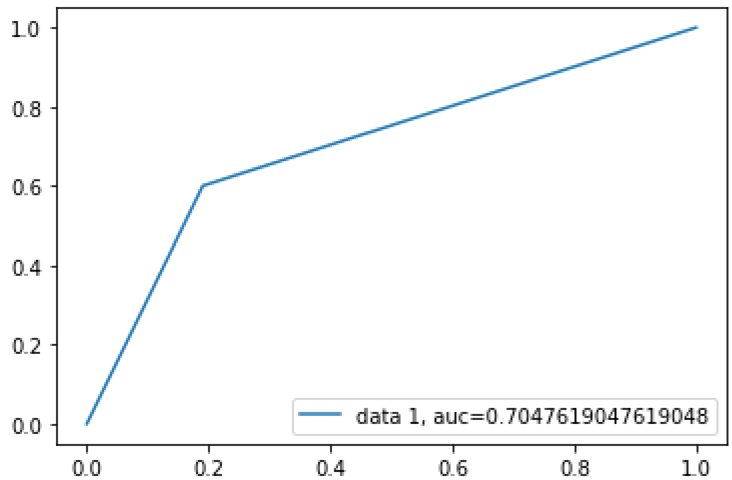
```
Text(0.5, 257.44, 'Predicted label')
```



In [907]:
```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred6))
print("Precision:",metrics.precision_score(y_test, y_pred6))
print("Recall:",metrics.recall_score(y_test, y_pred6))
```

```
Accuracy: 0.7364341085271318
Precision: 0.627906976744186
Recall: 0.6
```

In [908]:
```
y_pred_proba6 =classifier.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba6)
auc = metrics.roc_auc_score(y_test, y_pred_proba6)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```



Random Forest

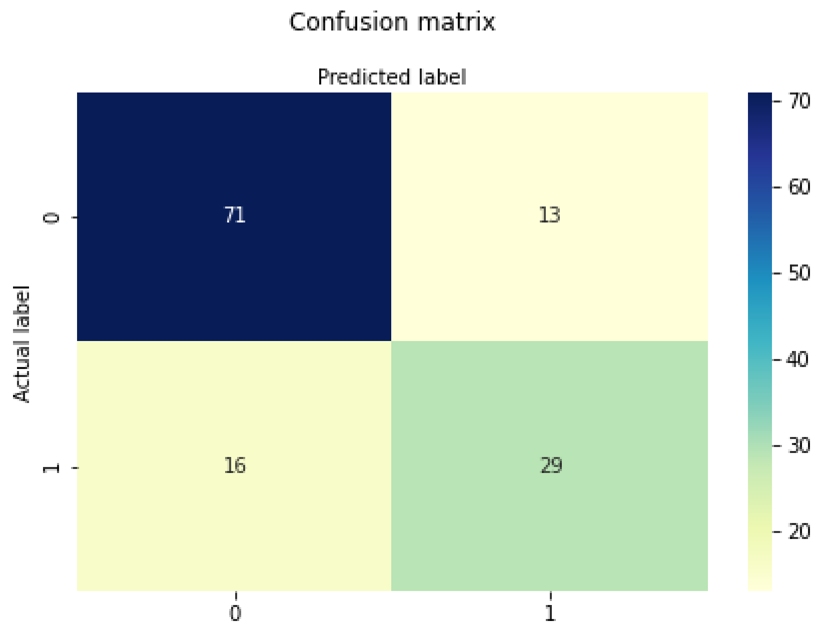
In [909]:
```
classifier7=RandomForestClassifier(n_estimators=100)

#Train the model using the training sets y_pred=clf.predict(X_test)
classifier7.fit(X_train,y_train)

y_pred7=classifier7.predict(X_test)
```

In [910]:

```
cnf_matrix = metrics.confusion_matrix(y_test, y_pred7)
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

Out[910]:

```
Text(0.5, 257.44, 'Predicted label')
```



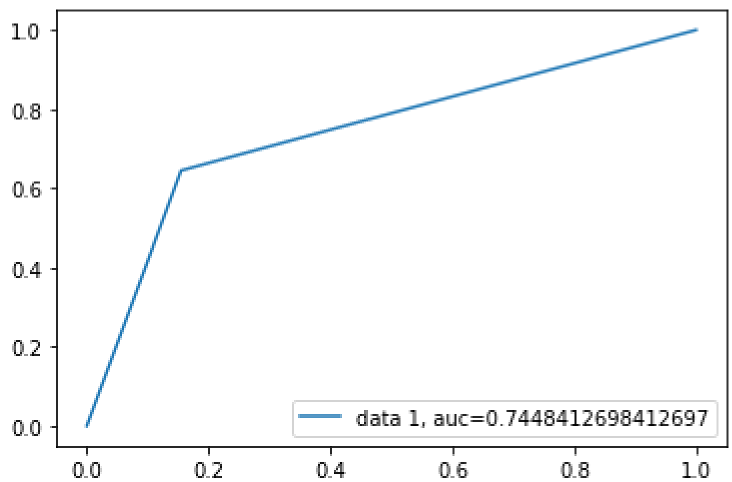
In [911]:

```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred7))
print("Precision:",metrics.precision_score(y_test, y_pred7))
print("Recall:",metrics.recall_score(y_test, y_pred7))
```

```
Accuracy: 0.7751937984496124
Precision: 0.6904761904761905
Recall: 0.6444444444444445
```

In [912]:

```
y_pred_proba7 =classifier7.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba7)
auc = metrics.roc_auc_score(y_test, y_pred_proba7)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```



Balancing the dataset with the undersampling technique

In [962]:

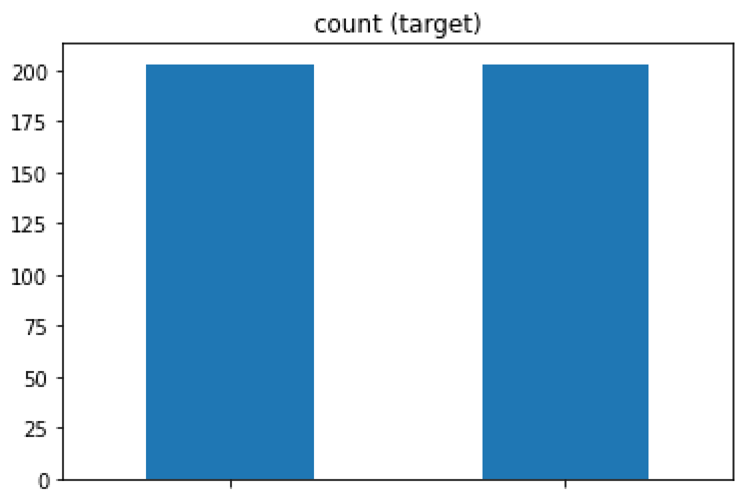
```
# class count
class_count_0, class_count_1 = df2['Outcome'].value_counts()

# Separate class
class_0 = df2[df2['Outcome'] == 0]
class_1 = df2[df2['Outcome'] == 1]# print the shape of the class
print('class 0:', class_0.shape)
print('class 1:', class_1.shape)
```

```
class 0: (441, 9)
class 1: (203, 9)
```

In [914]:
```
class_0_under = class_0.sample(class_count_1)

test_under = pd.concat([class_0_under, class_1], axis=0)

print("total class of 1 and0:",test_under['Outcome'].value_counts())# plot th
test_under['Outcome'].value_counts().plot(kind='bar', title='count (target)')
```

```
total class of 1 and0: 0.0    203
1.0    203
Name: Outcome, dtype: int64
```

Out[914]: <AxesSubplot:title={'center':'count (target)'}>



Models on balanced Dataset with unscaled data

In [921]:
```
X = test_under[[ 'Glucose', 'Pregnancies', 'Age','Insulin', 'BMI']]
y = test_under['Outcome']
```

In [922]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.2,ran
```

Logistique regression

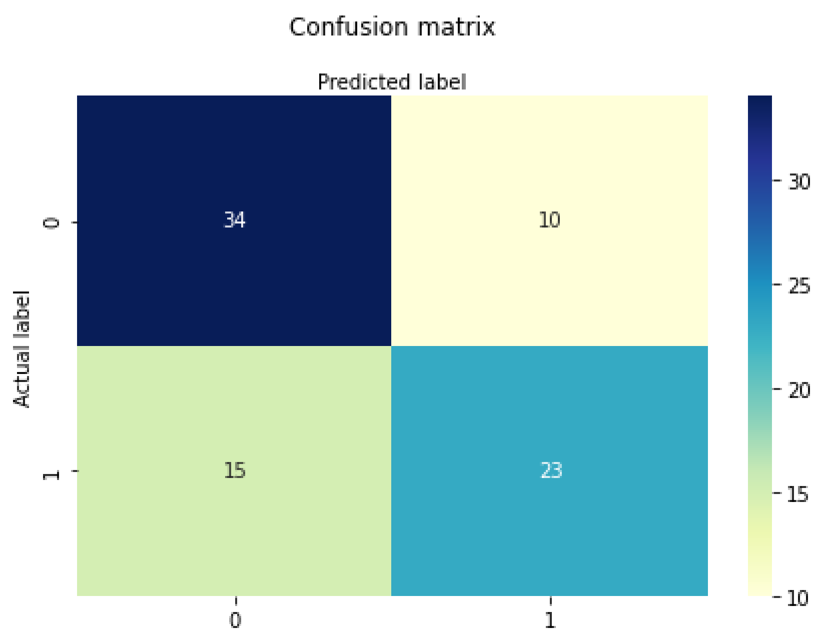
In [923]:
```
# instantiate the model (using the default parameters)
classifier8 = LogisticRegression()

# fit the model with data
classifier8.fit(X_train,y_train)

#
y_pred8=classifier8.predict(X_test)
```

In [924]:

```
cnf_matrix8 = metrics.confusion_matrix(y_test, y_pred8)
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

Out[924]:

```
Text(0.5, 257.44, 'Predicted label')
```



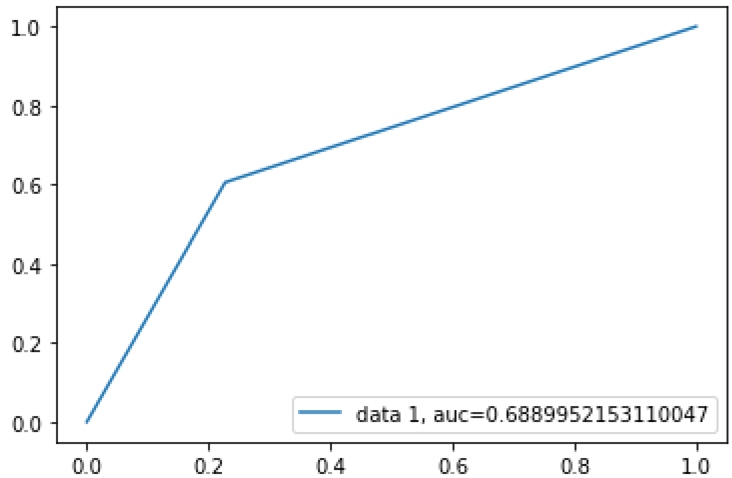
In [925]:

```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred8))
print("Precision:",metrics.precision_score(y_test, y_pred8))
print("Recall:",metrics.recall_score(y_test, y_pred8))
```

```
Accuracy: 0.6951219512195121
Precision: 0.696969696969697
Recall: 0.6052631578947368
```

In [926]:

```
y_pred_proba8 =classifier.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba8)
auc = metrics.roc_auc_score(y_test, y_pred_proba8)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```



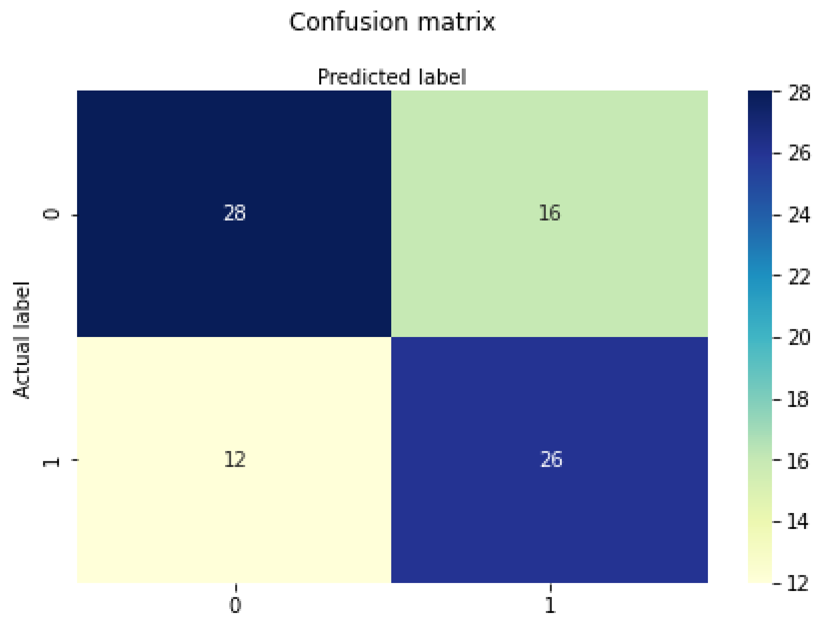
SVM

In [927]:

```
classifier9 = SVC(random_state=0, kernel='rbf')
classifier9.fit(X_train, y_train)
y_pred9=classifier9.predict(X_test)
```

In [928]:
```
cnf_matrix9 = metrics.confusion_matrix(y_test, y_pred9)
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

Out[928]:
```
Text(0.5, 257.44, 'Predicted label')
```



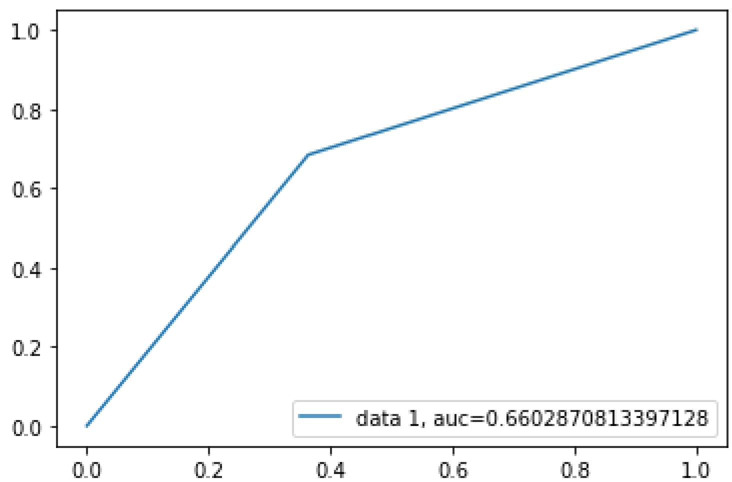
In [929]:

```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred9))
print("Precision:",metrics.precision_score(y_test, y_pred9))
print("Recall:",metrics.recall_score(y_test, y_pred9))
```

```
Accuracy: 0.6585365853658537
Precision: 0.6190476190476191
Recall: 0.6842105263157895
```

In [930]:

```
y_pred_proba9 =classifier9.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba9)
auc = metrics.roc_auc_score(y_test, y_pred_proba9)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```



Decision tree

In [931]:

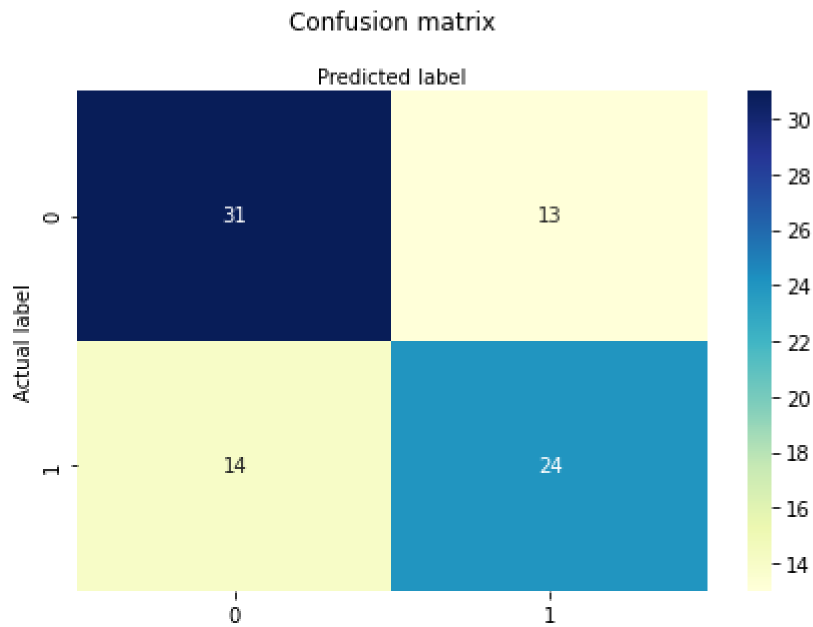
```

classifier10 = DecisionTreeClassifier(random_state=0)
classifier10.fit(X_train, y_train)
y_pred10 = classifier10.predict(X_test)
```

In [932]:

```
cnf_matrix10 = metrics.confusion_matrix(y_test, y_pred10)
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

Out[932]:

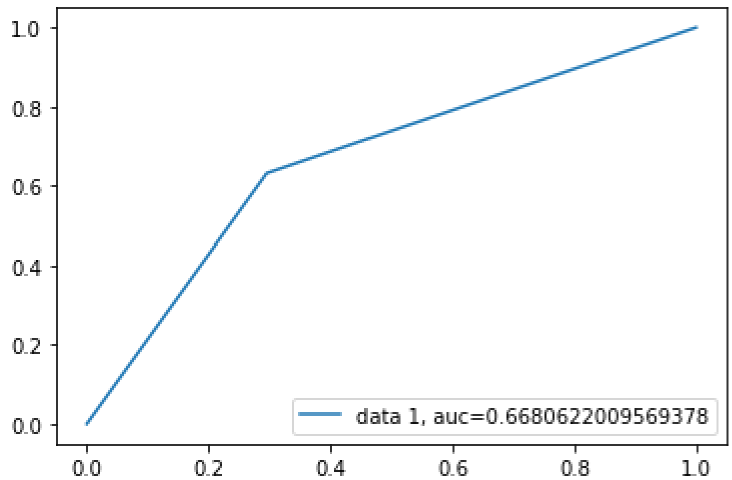
```
Text(0.5, 257.44, 'Predicted label')
```



In [933]:
```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred10))
print("Precision:",metrics.precision_score(y_test, y_pred10))
print("Recall:",metrics.recall_score(y_test, y_pred10))
```

```
Accuracy: 0.6707317073170732
Precision: 0.6486486486486487
Recall: 0.631578947368421
```

In [934]:
```
y_pred_proba10 =classifier.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba10)
auc = metrics.roc_auc_score(y_test, y_pred_proba10)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```



Random Forest

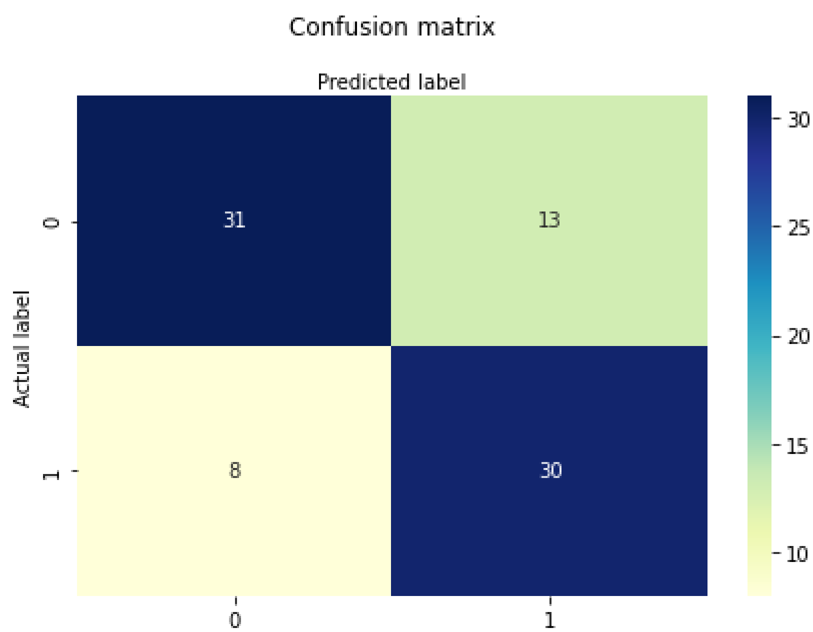
In [935]:
```
#Create a Gaussian Classifier
classifier11=RandomForestClassifier(n_estimators=100)

#Train the model using the training sets y_pred=clf.predict(X_test)
classifier11.fit(X_train,y_train)

y_pred11=classifier11.predict(X_test)
```

In [936]:

```
cnf_matrix11 = metrics.confusion_matrix(y_test, y_pred11)
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

Out[936]:

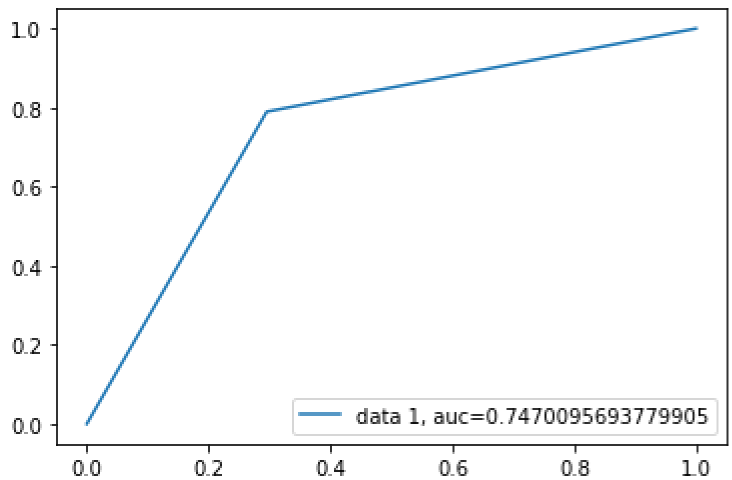
```
Text(0.5, 257.44, 'Predicted label')
```



In [937]:
```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred11))
print("Precision:",metrics.precision_score(y_test, y_pred11))
print("Recall:",metrics.recall_score(y_test, y_pred11))
```

```
Accuracy: 0.7439024390243902
Precision: 0.6976744186046512
Recall: 0.7894736842105263
```

In [938]:
```
y_pred_proba11 =classifier.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba11)
auc = metrics.roc_auc_score(y_test, y_pred_proba11)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```



Undersampling on scaled data

In [939]:
```
X = test_under[[ 'Glucose', 'Pregnancies', 'Age','Insulin', 'BMI']]
y = test_under['Outcome']
```

In [940]:
```
Scaler=StandardScaler()
Scaler.fit(X)
```

Out[940]:
```
StandardScaler()
```

In [941]:
```
X= Scaler.transform(X)
X
```

Out[941]:
```
array([[-0.52135248, -0.62612848, -0.64709258, -0.37114263, -0.04246523],
       [-0.55439996, -0.90702147, -0.73385598, -0.43786416, -1.51889436],
       [-1.54582435, -0.90702147, -1.08090959, -1.54544159, -1.15375597],
       ...,
       [ 2.12244589,  0.49744351,  2.73668016,  0.98997662,  0.44967782],
       [ 1.4614963 ,  1.3401225 ,  0.74112188,  1.15277716,  1.7991023 ],
       [ 0.00740719, -0.90702147,  1.0881755 , -0.24837501, -0.40760362]])
```

In [ ]:

In [942]:
```
from sklearn.model_selection import train_test_split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.2,rar
```

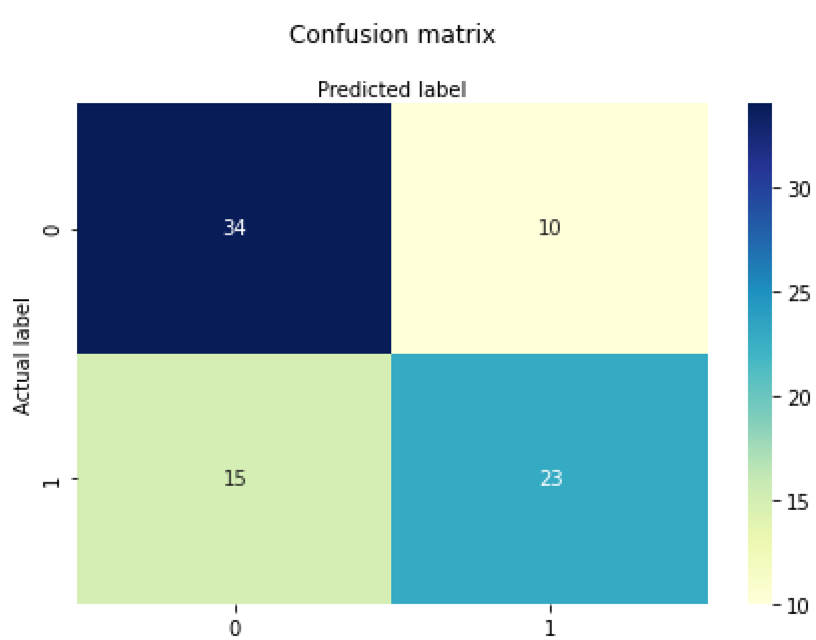
Models on balanced Dataset with scaled data

Logistique regression , undersampling and scaled

In [943]:
```
classifier12 = LogisticRegression()

# fit the model with data
classifier12.fit(X_train,y_train)

#
y_pred12=classifier12.predict(X_test)
```

In [944]:
```
cnf_matrix12 = metrics.confusion_matrix(y_test, y_pred12)
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

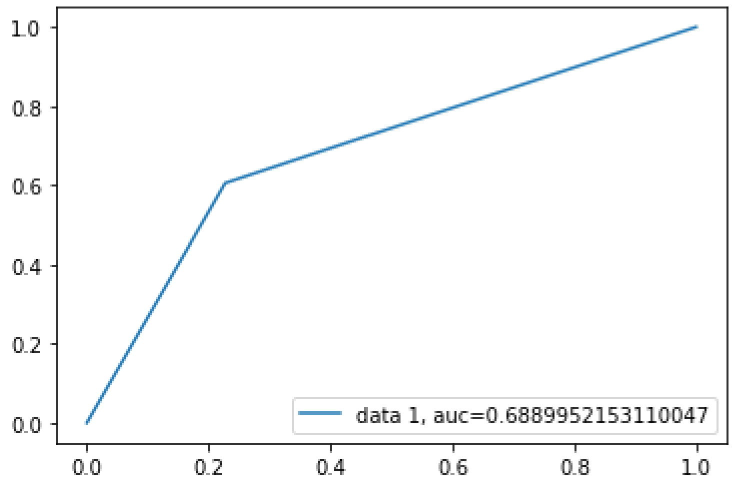
Out[944]:
```
Text(0.5, 257.44, 'Predicted label')
```



In [945]:
```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred12))
print("Precision:",metrics.precision_score(y_test, y_pred12))
print("Recall:",metrics.recall_score(y_test, y_pred12))
```

```
Accuracy: 0.6951219512195121
Precision: 0.696969696969697
Recall: 0.6052631578947368
```

In [946]:
```
y_pred_proba12 =classifier12.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba12)
auc = metrics.roc_auc_score(y_test, y_pred_proba12)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```

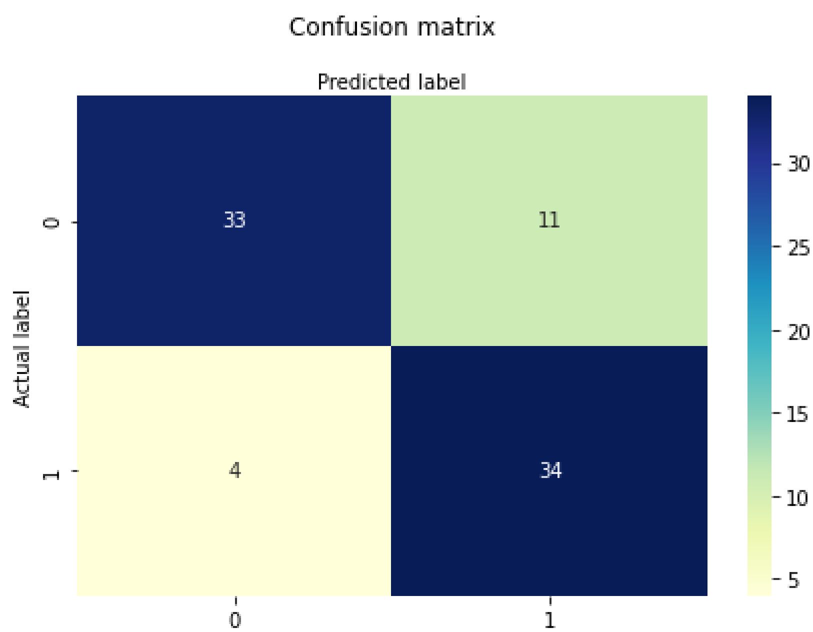


SVM , undersampling and scaled

In [947]:
```
classifier13 = SVC(random_state=0, kernel='rbf')
classifier13.fit(X_train, y_train)
y_pred13=classifier13.predict(X_test)
```

In [948]:
```
cnf_matrix13 = metrics.confusion_matrix(y_test, y_pred13)
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

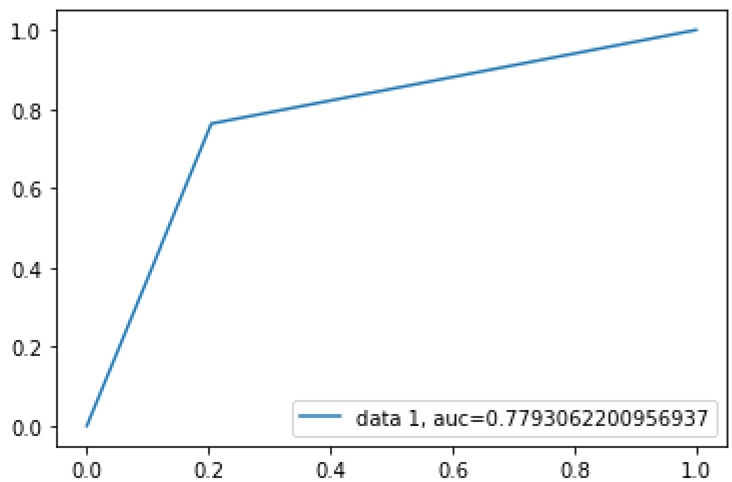
Out[948]:
```
Text(0.5, 257.44, 'Predicted label')
```



In [949]:
```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred13))
print("Precision:",metrics.precision_score(y_test, y_pred13))
print("Recall:",metrics.recall_score(y_test, y_pred13))
```

```
Accuracy: 0.8170731707317073
Precision: 0.7555555555555555
Recall: 0.8947368421052632
```

In [826]:
```
y_pred_proba13 =classifier13.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba13)
auc = metrics.roc_auc_score(y_test, y_pred_proba)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```

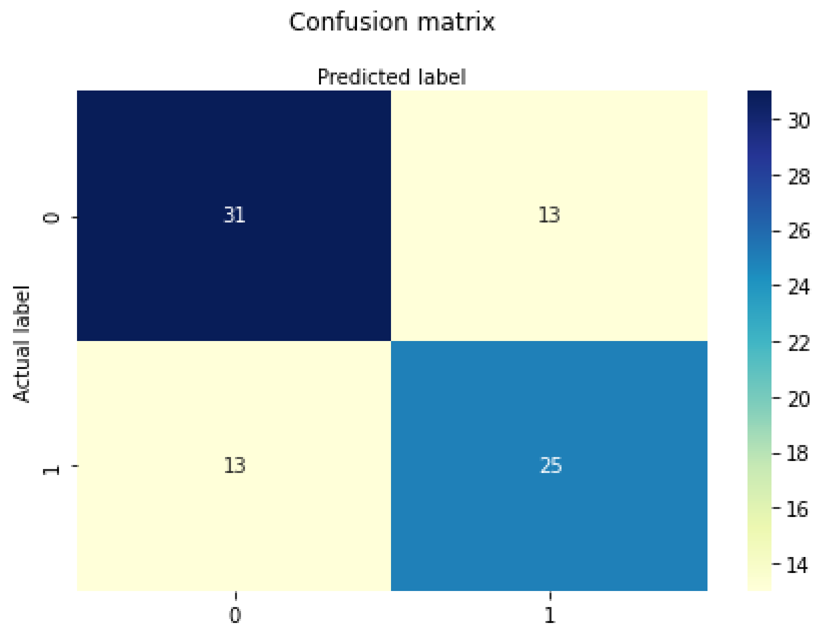


Decision tree

In [950]:
```
classifier14 = DecisionTreeClassifier(random_state=0)
classifier14.fit(X_train, y_train)
y_pred14 = classifier.predict(X_test)
```

In [951]:
```
cnf_matrix = metrics.confusion_matrix(y_test, y_pred14)
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

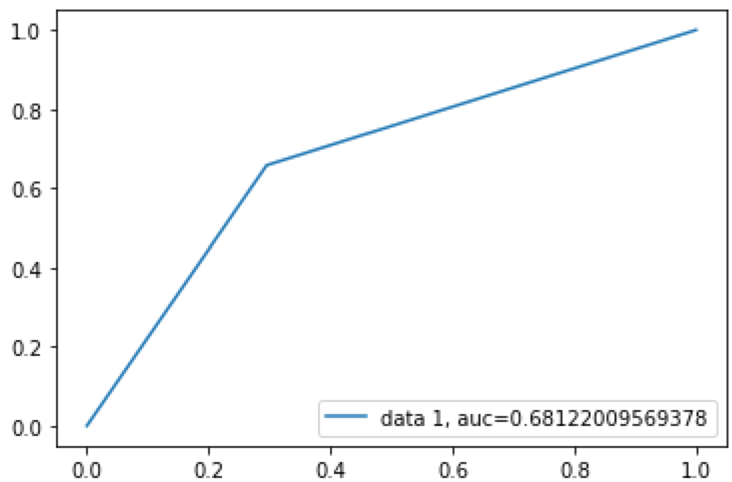
Out[951]:
```
Text(0.5, 257.44, 'Predicted label')
```



In [952]:
```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred14))
print("Precision:",metrics.precision_score(y_test, y_pred14))
print("Recall:",metrics.recall_score(y_test, y_pred14))
```

```
Accuracy: 0.6829268292682927
Precision: 0.6578947368421053
Recall: 0.6578947368421053
```

In [953]:
```
y_pred_proba14 =classifier.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba14)
auc = metrics.roc_auc_score(y_test, y_pred_proba)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```



Random Forest

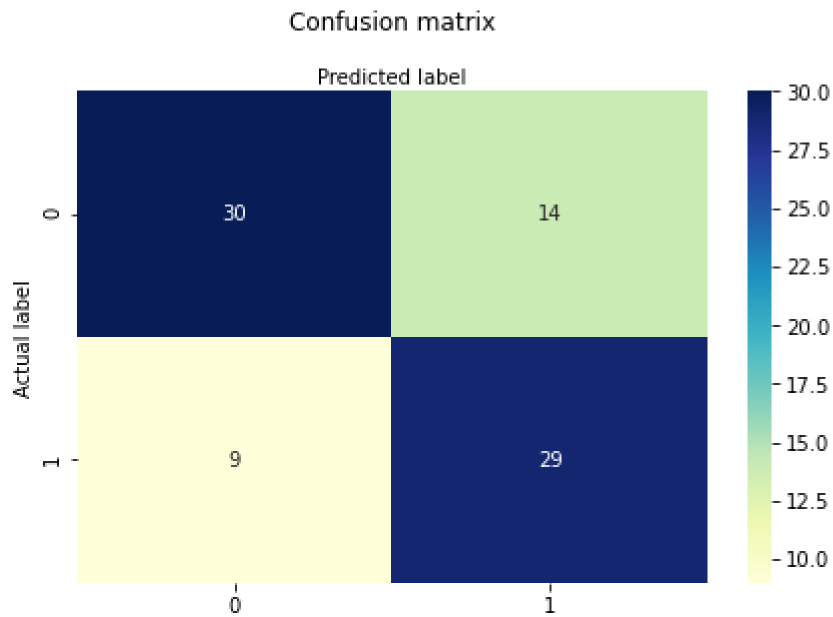
In [954]:
```
#Create a Gaussian Classifier
classifier15=RandomForestClassifier(n_estimators=100)

#Train the model using the training sets y_pred=clf.predict(X_test)
classifier15.fit(X_train,y_train)

y_pred15=classifier15.predict(X_test)
```

In [955]:

```
cnf_matrix15 = metrics.confusion_matrix(y_test, y_pred15)
class_names=[0,1] # name  of classes
fig, ax = plt.subplots()
tick_marks = np.arange(len(class_names))
plt.xticks(tick_marks, class_names)
plt.yticks(tick_marks, class_names)
# create heatmap
sns.heatmap(pd.DataFrame(cnf_matrix), annot=True, cmap="YlGnBu" ,fmt='g')
ax.xaxis.set_label_position("top")
plt.tight_layout()
plt.title('Confusion matrix', y=1.1)
plt.ylabel('Actual label')
plt.xlabel('Predicted label')
```

Out[955]:

```
Text(0.5, 257.44, 'Predicted label')
```



In [956]:

```
print("Accuracy:",metrics.accuracy_score(y_test, y_pred15))
print("Precision:",metrics.precision_score(y_test, y_pred15))
print("Recall:",metrics.recall_score(y_test, y_pred15))
```

```
Accuracy: 0.7195121951219512
Precision: 0.6744186046511628
Recall: 0.7631578947368421
```

In [957]:

```
y_pred_proba15 =classifier.predict(X_test)
fpr, tpr, _ = metrics.roc_curve(y_test,  y_pred_proba15)
auc = metrics.roc_auc_score(y_test, y_pred_proba15)
plt.plot(fpr,tpr,label="data 1, auc="+str(auc))
plt.legend(loc=4)
plt.show()
```