In [22]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
from sklearn.model_selection import train_test_split
from sklearn.naive_bayes import GaussianNB
from sklearn.metrics import (
    confusion_matrix, accuracy_score,
    precision_score, recall_score, f1_score, ConfusionMatrixDisplay)
```

In [23]:
```
# Load the dataset
df = pd.read_csv("diabetes.csv")

# Display first few rows
df.head(10)
```

Out[23]:

	Pregnancies	Glucose	BloodPressure	SkinThickness	Insulin	BMI	DiabetesPedigreeFunction	Age	Outcome
0	6	148	72	35	0	33.6	0.627	50	1
1	1	85	66	29	0	26.6	0.351	31	0
2	8	183	64	0	0	23.3	0.672	32	1
3	1	89	66	23	94	28.1	0.167	21	0
4	0	137	40	35	168	43.1	2.288	33	1
5	5	116	74	0	0	25.6	0.201	30	0
6	3	78	50	32	88	31.0	0.248	26	1
7	10	115	0	0	0	35.3	0.134	29	0
8	2	197	70	45	543	30.5	0.158	53	1
9	8	125	96	0	0	0.0	0.232	54	1

In [24]:
```
# Display basic info
df.info()
print("\n----------------- Dataset Summary -----------------")
print(df.describe())

print("\n Missing Values:", df.isnull().sum())

print("\n Dataset Shape:", df.shape)
```

```
<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

----------------- Dataset Summary -----------------
       Pregnancies     Glucose  BloodPressure  SkinThickness     Insulin  \
count   768.000000  768.000000     768.000000     768.000000  768.000000   
mean      3.845052  120.894531      69.105469      20.536458   79.799479   
std       3.369578   31.972618      19.355807      15.952218  115.244002   
min       0.000000    0.000000       0.000000       0.000000    0.000000   
25%       1.000000   99.000000      62.000000       0.000000    0.000000   
50%       3.000000  117.000000      72.000000      23.000000   30.500000   
75%       6.000000  140.250000      80.000000      32.000000  127.250000   
max      17.000000  199.000000     122.000000      99.000000  846.000000   

              BMI  DiabetesPedigreeFunction         Age     Outcome  
count  768.000000                768.000000  768.000000  768.000000  
mean    31.992578                  0.471876   33.240885    0.348958  
std      7.884160                  0.331329   11.760232    0.476951  
min      0.000000                  0.078000   21.000000    0.000000  
25%     27.300000                  0.243750   24.000000    0.000000  
50%     32.000000                  0.372500   29.000000    0.000000  
75%     36.600000                  0.626250   41.000000    1.000000  
max     67.100000                  2.420000   81.000000    1.000000  

 Missing Values: Pregnancies                0
Glucose                     0
BloodPressure               0
SkinThickness               0
Insulin                     0
BMI                         0
DiabetesPedigreeFunction    0
Age                         0
Outcome                     0
dtype: int64

 Dataset Shape: (768, 9)
```

In [25]:
```
# Selecting features and target variable
X = df.iloc[:, :-1]  # Feature columns
y = df.iloc[:, -1]   # Target column

# Splitting the dataset into training (70%) and testing (30%) sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=42)

# Create and train the Naïve Bayes model
model = GaussianNB()
model.fit(X_train, y_train)

# Make predictions on the test set
y_pred = model.predict(X_test)

# Compute the Confusion Matrix
cm = confusion_matrix(y_test, y_pred, labels=np.unique(y))
print("Confusion Matrix:")
print(cm)
```

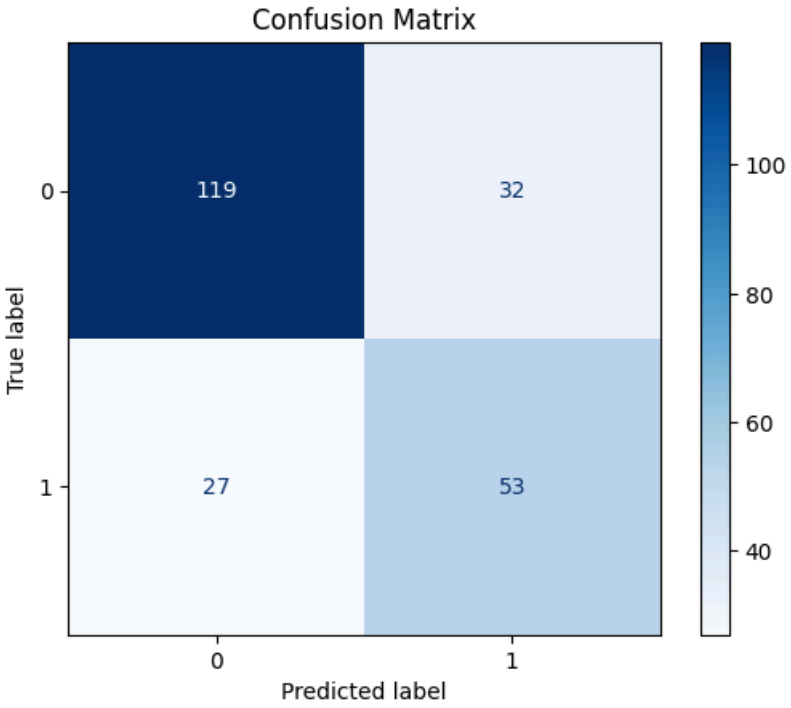
```
Confusion Matrix:
[[119  32]
 [ 27  53]]
```

In [26]:
```
# Extract True Positives (TP), False Positives (FP), False Negatives (FN), and True Negatives (TN)
TP = np.diag(cm)                     # Diagonal values are True Positives for each class
```

```
FP = np.sum(cm, axis=0) - TP           # Column sum minus TP gives False Positives
FN = np.sum(cm, axis=1) - TP           # Row sum minus TP gives False Negatives
TN = np.sum(cm) - (TP + FP + FN)       # Remaining values are True Negatives

# Compute evaluation metrics
accuracy = accuracy_score(y_test, y_pred)
precision = precision_score(y_test, y_pred, average='macro')
recall = recall_score(y_test, y_pred, average='macro')
f1 = f1_score(y_test, y_pred, average='macro')
error_rate = 1 - accuracy

# Display evaluation results
print(f"\nAccuracy: {accuracy:.4f}")
print(f"\nError Rate: {error_rate:.4f}")
print(f"\nPrecision (macro): {precision:.4f}")
print(f"\nRecall (macro): {recall:.4f}")
print(f"\nF1-Score (macro): {f1:.4f}")
print(f"\nTrue Positives: {TP}")
print(f"\nFalse Positives: {FP}")
print(f"\nTrue Negatives: {TN}")
print(f"\nFalse Negatives: {FN} \n")
```

```
Accuracy: 0.7446

Error Rate: 0.2554

Precision (macro): 0.7193

Recall (macro): 0.7253

F1-Score (macro): 0.7219

True Positives: [119  53]

False Positives: [27 32]

True Negatives: [ 53 119]

False Negatives: [32 27]
```

In [27]:
```
# Plot the Confusion Matrix
display_labels = model.classes_
cm_display = ConfusionMatrixDisplay(confusion_matrix=cm, display_labels=display_labels)
cm_display.plot(cmap=plt.cm.Blues)
plt.title("Confusion Matrix")
plt.show()
```



In [28]:
```
# Show probability estimates for the first 5 rows in the test set
probabilities = model.predict_proba(X_test[:5])
print("\nProbability Estimates for the First 5 Rows:")
print(probabilities)
```

```
Probability Estimates for the First 5 Rows:
[[0.73815858 0.26184142]
 [0.94027894 0.05972106]
 [0.97242831 0.02757169]
 [0.82840069 0.17159931]
 [0.47153473 0.52846527]]
```