In [32]:
```
import pandas as pd
import xlrd
```

In [33]:
```
workbook = pd.read_stata('lawschs1_1.dta')
```

In [34]:
```
workbook
```

Out[34]:

	lsat	gpa	race	resident	college	year	gender	admit	black	hispanic	asian
0	156.0	3.71	White	0.0	Arizona State	2006	0.0	1.0	0.0	0.0	0
1	161.0	3.85	White	0.0	Arizona State	2006	0.0	1.0	0.0	0.0	0
2	160.0	3.20	White	0.0	Arizona State	2006	1.0	0.0	0.0	0.0	0
3	132.0	2.95		1.0	Arizona State	2006	1.0	0.0	0.0	0.0	0
4	159.0	3.49	White	0.0	Arizona State	2006	1.0	0.0	0.0	0.0	0
...	...	...	...	...	...	...	...	...	...	...	...
124552	179.0	3.72	White	1.0	Washington	2006	0.0	1.0	0.0	0.0	0
124553	179.0	3.96	Asian	1.0	Washington	2006	0.0	1.0	0.0	0.0	1
124554	179.0	3.97	White	0.0	Washington	2006	0.0	1.0	0.0	0.0	0
124555	180.0	3.29	White	0.0	Washington	2006	1.0	1.0	0.0	0.0	0
124556	180.0	3.53	White	1.0	Washington	2006	1.0	1.0	0.0	0.0	0

124557 rows × 15 columns

In [35]:
```
workbook = workbook.replace(r'^\s*$', '*', regex=True)
```

In [36]:
```
workbook = workbook.drop(['black','hispanic','asian','white','missingr
```

In [37]:
```
workbook.fillna('*').to_csv('lawschs1_1.csv')
```

In [38]:
```
workbook
```

Out[38]:

	lsat	gpa	race	resident	college	year	gender	admit
0	156.0	3.71	White	0.0	Arizona State	2006	0.0	1.0
1	161.0	3.85	White	0.0	Arizona State	2006	0.0	1.0
2	160.0	3.20	White	0.0	Arizona State	2006	1.0	0.0
3	132.0	2.95	*	1.0	Arizona State	2006	1.0	0.0
4	159.0	3.49	White	0.0	Arizona State	2006	1.0	0.0
...	...	...	...	...	...	...	...	...
124552	179.0	3.72	White	1.0	Washington	2006	0.0	1.0
124553	179.0	3.96	Asian	1.0	Washington	2006	0.0	1.0
124554	179.0	3.97	White	0.0	Washington	2006	0.0	1.0
124555	180.0	3.29	White	0.0	Washington	2006	1.0	1.0
124556	180.0	3.53	White	1.0	Washington	2006	1.0	1.0

124557 rows × 8 columns

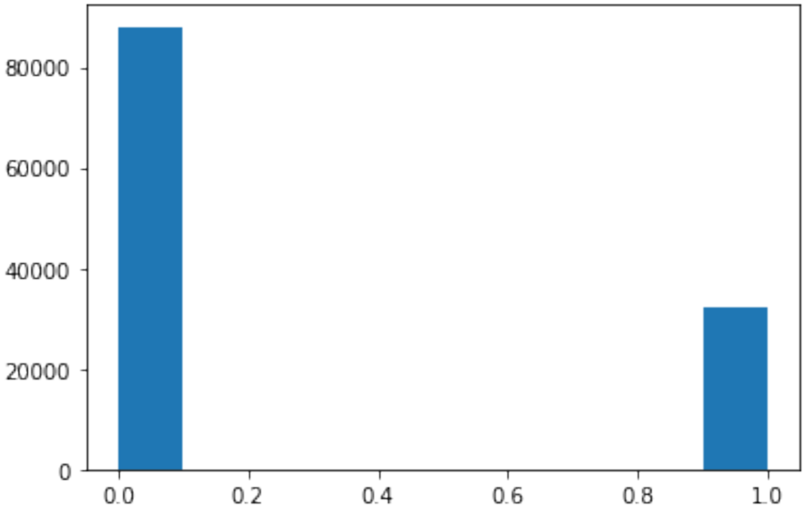
In [39]:

```
import matplotlib.pyplot as plt
plt.hist(workbook['admit'])
```

```
/usr/local/lib/python3.7/site-packages/numpy/lib/histograms.py:839: R
untimeWarning: invalid value encountered in greater_equal
  keep = (tmp_a >= first_edge)
/usr/local/lib/python3.7/site-packages/numpy/lib/histograms.py:840: R
untimeWarning: invalid value encountered in less_equal
  keep &= (tmp_a <= last_edge)
```

Out[39]:

```
(array([88033.,     0.,     0.,     0.,     0.,     0.,     0.,     0
.,
            0., 32229.]),
 array([0. , 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1. ]),
 <a list of 10 Patch objects>)
```



In [40]:

```
from fcit import fcit


def nonparametric_fcit_test(X, Y, Z, data):
    """
    X and Y are names of variables.
    Z is a list of names of variables.
    data is a pandas data frame.

    Return a float corresponding to the p-value computed from FCIT.
    """

    # implement code here
    data_X = np.asmatrix(data[[X]].to_numpy())
    data_Y = np.asmatrix(data[[Y]].to_numpy())
    data_Z = np.asmatrix(data[Z].to_numpy())
    return fcit.test(data_X, data_Y, data_Z)
```

In [41]:

```python
import numpy as np
```

In [42]:

```python
import statsmodels.api as sm
import pandas as pd
import numpy as np
from scipy.special import expit


def odds_ratio(X, Y, Z, data):
    """
    Compute the odds ratio OR(X, Y | Z).
    X, Y are names of variables
    in the data frame. Z is a list of names of variables.

    Return float OR for the odds ratio OR(X, Y | Z)
    """

    # Implement your code here:
    Xtrain = data[[Y] + Z]
    Xtrain.insert(0, 'Ones', 1)
    ytrain = data[[X]]
    log_reg = sm.Logit(ytrain, Xtrain).fit(disp=0)
    beta_1 = log_reg.params.values[1]
    OR = np.exp(beta_1)

    return OR
```

In [134]:

```python
race = list(workbook[['race']])
admit = list(workbook[['admit']])
lsat = list(workbook[['lsat']])
gpa = list(workbook[['gpa']])
```

In [130]:

```python
for i in range(len(race)):
    if i == len(race):
        break

    if race[i] == "White":
        race[i] = 1
    elif race[i] == '*':
        race[i] = 0
    elif race[i] == "Asian":
        race[i] = 2
    elif race[i] == "Black":
        race[i] = 3
    elif race[i] == "Hispanic":
        race[i] = 4
```

In [131]:

```
i = 0
while i < len(race):
    if pd.isna(admit[i][0]):
        print()
        del admit[i]
        del race[i]
        del lsat[i]
        del gpa[i]
    else:
        i = i+1
```

In [162]:

```
import math
data = {'lsat': [], 'gpa': [], 'race':[], 'admit':[]}
data = pd.DataFrame(columns=('lsat', 'gpa', 'race', 'admit'))

for index, row in workbook.iterrows():
    if math.isnan(row[0]) or math.isnan(row[1]) or math.isnan(row[7]):
        continue
    else:
        new_row = row
        if row[2] == '*':
            new_row[2] = 0
        elif row[2] == 'White':
            new_row[2] = 1
        elif row[2] == 'Asian':
            new_row[2] = 2
        elif row[2] == 'Black':
            new_row[2] = 3
        elif row[2] == 'Hispanic':
            new_row[2] = 4
        data.loc[index] = new_row
```

In [163]:

```
data
```

Out[163]:

	lsat	gpa	race	admit
0	156.0	3.71	1	1.0
1	161.0	3.85	1	1.0
2	160.0	3.20	1	0.0
3	132.0	2.95	0	0.0
4	159.0	3.49	1	0.0
...	...	...	...	...
124552	179.0	3.72	1	1.0
124553	179.0	3.96	2	1.0
124554	179.0	3.97	1	1.0
124555	180.0	3.29	1	1.0
124556	180.0	3.53	1	1.0

118246 rows × 4 columns

In [175]:

```
data['race'] = data['race'] * 0.25
```

In [176]:
```
data
```

Out[176]:

	lsat	gpa	race	admit
0	156.0	3.71	0.25	1.0
1	161.0	3.85	0.25	1.0
2	160.0	3.20	0.25	0.0
3	132.0	2.95	0	0.0
4	159.0	3.49	0.25	0.0
...	...	...	...	...
124552	179.0	3.72	0.25	1.0
124553	179.0	3.96	0.5	1.0
124554	179.0	3.97	0.25	1.0
124555	180.0	3.29	0.25	1.0
124556	180.0	3.53	0.25	1.0

118246 rows × 4 columns

In [178]:
```
odds_ratio("race", "admit", [], data.astype(float))
```

Out[178]:
```
0.9059681854213831
```

In [179]:
```
odds_ratio("race", "admit", ["gpa"], data.astype(float))
```

Out[179]:
```
1.0151255557984287
```

In [180]:
```
odds_ratio("race", "admit", ["lsat"], data.astype(float))
```

Out[180]:
```
1.1871617843528481
```

In [181]:
```
odds_ratio("race", "admit", ["lsat", "gpa"], data.astype(float))
```

Out[181]:
```
1.2294002430115953
```

In [182]:

```
def compute_confidence_intervals(X, Y, Z, data, num_bootstraps=200, al
    """
    Compute confidence intervals through bootstrap

    Returns tuple (q_low, q_up) for the lower and upper quantiles of t
    """

    Ql = alpha/2
    Qu = 1 - alpha/2
    estimates = []
    data_length = data.shape[0]

    for i in range(num_bootstraps):

        # Implement your code here:
        resampled_data = data.sample(n=data_length, replace=True)
        estimates.append(odds_ratio(X, Y, Z, resampled_data))

    q_low = np.quantile(estimates, Ql)
    q_up = np.quantile(estimates, Qu)

    return q_low, q_up
```

In [185]:

```
print("OR(race, admit)", odds_ratio("race", "admit", [], data.astype(f
print("OR(race, admit | gpa)", odds_ratio("race", "admit", ["gpa"], da
print("OR(race, admit | lsat)", odds_ratio("race", "admit", ["lsat"],
print("OR(race, admit | gpa,lsat)", odds_ratio("race", "admit", ["gpa"
```

```
OR(race, admit) 0.9059681854213831 (0.8930397941261121, 0.91665693477
90962)
OR(race, admit | gpa) 1.0151255557984287 (1.0019035147089632, 1.02879
07321584313)
OR(race, admit | lsat) 1.1871617843528481 (1.1690079026808833, 1.2051
835872100738)
OR(race, admit | gpa,lsat) 1.2294002430115951 (1.209370420517068, 1.2
4554553624103)
```