In [1]:

```
pip install ucimlrepo
```

```
Collecting ucimlrepo
  Downloading ucimlrepo-0.0.6-py3-none-any.whl (8.0 kB)
Installing collected packages: ucimlrepo
Successfully installed ucimlrepo-0.0.6
```

In [2]:

```
from ucimlrepo import fetch_ucirepo

# fetch dataset
cervical_cancer_risk_factors = fetch_ucirepo(id=383)

# data (as pandas dataframes)
X = cervical_cancer_risk_factors.data.features
y = cervical_cancer_risk_factors.data.targets

# metadata
print(cervical_cancer_risk_factors.metadata)

# variable information
print(cervical_cancer_risk_factors.variables)
```

```
{'uci_id': 383, 'name': 'Cervical Cancer (Risk Factors)', 'repository_url': 'https://archive.ics.uci.edu/dat
aset/383/cervical+cancer+risk+factors', 'data_url': 'https://archive.ics.uci.edu/static/public/383/data.cs
v', 'abstract': 'This dataset focuses on the prediction of indicators/diagnosis of cervical cancer. The feat
ures cover demographic information, habits, and historic medical records.', 'area': 'Health and Medicine',
'tasks': ['Classification'], 'characteristics': ['Multivariate'], 'num_instances': 858, 'num_features': 36,
'feature_types': ['Integer', 'Real'], 'demographics': ['Age', 'Other'], 'target_col': None, 'index_col': Non
e, 'has_missing_values': 'yes', 'missing_values_symbol': 'NaN', 'year_of_dataset_creation': 2017, 'last_upda
ted': 'Sun Mar 10 2024', 'dataset_doi': '10.24432/C5Z310', 'creators': ['Kelwin Fernandes', 'Jaime Cardoso',
'Jessica Fernandes'], 'intro_paper': {'title': 'Transfer Learning with Partial Observability Applied to Cerv
ical Cancer Screening', 'authors': 'Kelwin Fernandes, Jaime S. Cardoso, Jessica C. Fernandes', 'published_i
n': 'Iberian Conference on Pattern Recognition and Image Analysis', 'year': 2017, 'url': 'https://www.semant
icscholar.org/paper/Transfer-Learning-with-Partial-Observability-to-Fernandes-Cardoso/1c02438ba4dfa775399ba4
14508e9cd335b69012', 'doi': None}, 'additional_info': {'summary': "The dataset was collected at 'Hospital Un
iversitario de Caracas' in Caracas, Venezuela. The dataset comprises demographic information, habits, and hi
storic medical records of 858 patients. Several patients decided not to answer some of the questions because
of privacy concerns (missing values).", 'purpose': None, 'funded_by': None, 'instances_represent': None, 're
commended_data_splits': None, 'sensitive_data': None, 'preprocessing_description': None, 'variable_info':
'(int) Age\r\n(int) Number of sexual partners\r\n(int) First sexual intercourse (age)\r\n(int) Num of pregna
ncies\r\n(bool) Smokes\r\n(bool) Smokes (years)\r\n(bool) Smokes (packs/year)\r\n(bool) Hormonal Contracepti
ves\r\n(int) Hormonal Contraceptives (years)\r\n(bool) IUD\r\n(int) IUD (years)\r\n(bool) STDs\r\n(int) STDs
(number)\r\n(bool) STDs:condylomatosis\r\n(bool) STDs:cervical condylomatosis\r\n(bool) STDs:vaginal condylo
matosis\r\n(bool) STDs:vulvo-perineal condylomatosis\r\n(bool) STDs:syphilis\r\n(bool) STDs:pelvic inflammat
ory disease\r\n(bool) STDs:genital herpes\r\n(bool) STDs:molluscum contagiosum\r\n(bool) STDs:AIDS\r\n(bool)
STDs:HIV\r\n(bool) STDs:Hepatitis B\r\n(bool) STDs:HPV\r\n(int) STDs: Number of diagnosis\r\n(int) STDs: Tim
e since first diagnosis\r\n(int) STDs: Time since last diagnosis\r\n(bool) Dx:Cancer\r\n(bool) Dx:CIN\r\n(bo
ol) Dx:HPV\r\n(bool) Dx\r\n(bool) Hinselmann: target variable\r\n(bool) Schiller: target variable\r\n(bool)
Cytology: target variable\r\n(bool) Biopsy: target variable', 'citation': None}}
```

```
                                  name     role        type demographic  \
0                                  Age  Feature     Integer         Age   
1             Number of sexual partners  Feature  Continuous       Other   
2            First sexual intercourse  Feature  Continuous        None   
3                  Num of pregnancies  Feature  Continuous        None   
4                              Smokes  Feature  Continuous        None   
5                      Smokes (years)  Feature  Continuous        None   
6                 Smokes (packs/year)  Feature  Continuous        None   
7              Hormonal Contraceptives  Feature  Continuous        None   
8      Hormonal Contraceptives (years)  Feature  Continuous        None   
9                                 IUD  Feature  Continuous        None   
10                        IUD (years)  Feature  Continuous        None   
11                               STDs  Feature  Continuous        None   
12                     STDs (number)  Feature  Continuous        None   
13                STDs:condylomatosis  Feature  Continuous        None   
14       STDs:cervical condylomatosis  Feature  Continuous        None   
```

```
15         STDs:vaginal condylomatosis  Feature  Continuous        None
16  STDs:vulvo-perineal condylomatosis  Feature  Continuous        None
17                       STDs:syphilis  Feature  Continuous        None
18    STDs:pelvic inflammatory disease  Feature  Continuous        None
19                 STDs:genital herpes  Feature  Continuous        None
20          STDs:molluscum contagiosum  Feature  Continuous        None
21                           STDs:AIDS  Feature  Continuous        None
22                            STDs:HIV  Feature  Continuous        None
23                    STDs:Hepatitis B  Feature  Continuous        None
24                            STDs:HPV  Feature  Continuous        None
25           STDs: Number of diagnosis  Feature     Integer        None
26    STDs: Time since first diagnosis  Feature  Continuous        None
27     STDs: Time since last diagnosis  Feature  Continuous        None
28                           Dx:Cancer  Feature     Integer        None
29                              Dx:CIN  Feature     Integer        None
30                              Dx:HPV  Feature     Integer        None
31                                  Dx  Feature     Integer        None
32                          Hinselmann  Feature     Integer        None
33                            Schiller  Feature     Integer        None
34                            Citology  Feature     Integer        None
35                              Biopsy  Feature     Integer        None

   description units missing_values
0         None  None             no
1         None  None            yes
2         None  None            yes
3         None  None            yes
4         None  None            yes
5         None  None            yes
6         None  None            yes
7         None  None            yes
8         None  None            yes
9         None  None            yes
10        None  None            yes
11        None  None            yes
12        None  None            yes
13        None  None            yes
14        None  None            yes
15        None  None            yes
16        None  None            yes
17        None  None            yes
18        None  None            yes
19        None  None            yes
```

```
20        None  None           yes
21        None  None           yes
22        None  None           yes
23        None  None           yes
24        None  None           yes
25        None  None            no
26        None  None           yes
27        None  None           yes
28        None  None            no
29        None  None            no
30        None  None            no
31        None  None            no
32        None  None            no
33        None  None            no
34        None  None            no
35        None  None            no
```

In [3]:

```
X.head()
```

Out[3]:

	Age	Number of sexual partners	First sexual intercourse	Num of pregnancies	Smokes	Smokes (years)	Smokes (packs/year)	Hormonal Contraceptives	Hormonal Contraceptives (years)	IUD	...	STDs: Time since first diagnosis	STD Tir since la diagnos
0	18	4.0	15.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	...	NaN	Na
1	15	1.0	14.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	...	NaN	Na
2	34	1.0	NaN	1.0	0.0	0.0	0.0	0.0	0.0	0.0	...	NaN	Na
3	52	5.0	16.0	4.0	1.0	37.0	37.0	1.0	3.0	0.0	...	NaN	Na
4	46	3.0	21.0	4.0	0.0	0.0	0.0	1.0	15.0	0.0	...	NaN	Na

5 rows × 36 columns

In [4]:

```
y
```

In [5]:

```
cervix_df = X.copy()
cervix_df.head()
```

Out[5]:

	Age	Number of sexual partners	First sexual intercourse	Num of pregnancies	Smokes	Smokes (years)	Smokes (packs/year)	Hormonal Contraceptives	Hormonal Contraceptives (years)	IUD	...	STDs: Time since first diagnosis	STD Tir since la diagnos
0	18	4.0	15.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	...	NaN	Na
1	15	1.0	14.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	...	NaN	Na
2	34	1.0	NaN	1.0	0.0	0.0	0.0	0.0	0.0	0.0	...	NaN	Na
3	52	5.0	16.0	4.0	1.0	37.0	37.0	1.0	3.0	0.0	...	NaN	Na
4	46	3.0	21.0	4.0	0.0	0.0	0.0	1.0	15.0	0.0	...	NaN	Na

5 rows × 36 columns

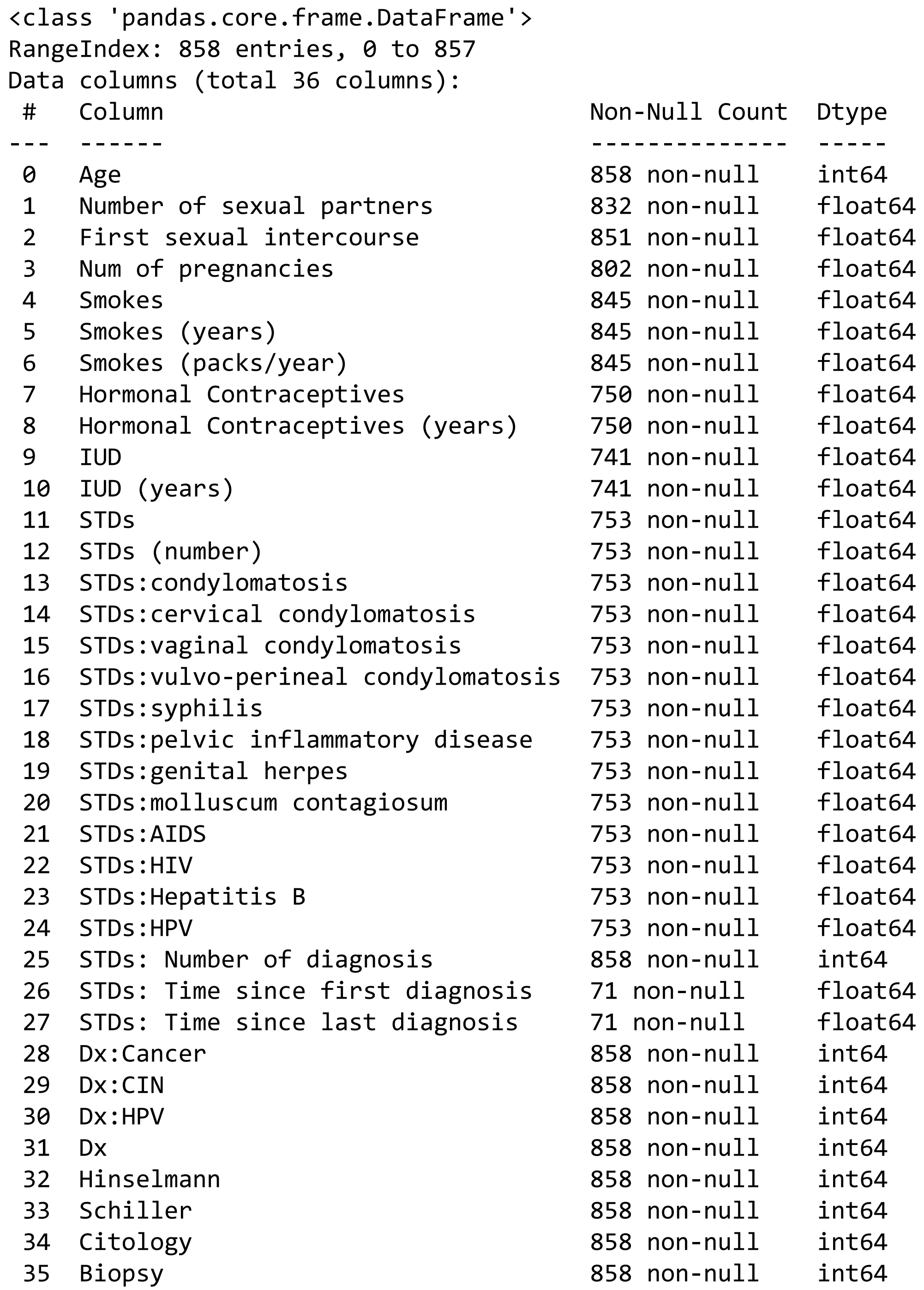
In [6]:

```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
```

EDA and Data Wrangling

In [7]:

```
cervix_df.info()
```



```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 858 entries, 0 to 857
Data columns (total 36 columns):
 #   Column                              Non-Null Count  Dtype
---  ------                              --------------  -----
 0   Age                                 858 non-null    int64
 1   Number of sexual partners           832 non-null    float64
 2   First sexual intercourse            851 non-null    float64
 3   Num of pregnancies                  802 non-null    float64
 4   Smokes                              845 non-null    float64
 5   Smokes (years)                      845 non-null    float64
 6   Smokes (packs/year)                 845 non-null    float64
 7   Hormonal Contraceptives             750 non-null    float64
 8   Hormonal Contraceptives (years)     750 non-null    float64
 9   IUD                                 741 non-null    float64
 10  IUD (years)                         741 non-null    float64
 11  STDs                                753 non-null    float64
 12  STDs (number)                       753 non-null    float64
 13  STDs:condylomatosis                 753 non-null    float64
 14  STDs:cervical condylomatosis        753 non-null    float64
 15  STDs:vaginal condylomatosis         753 non-null    float64
 16  STDs:vulvo-perineal condylomatosis  753 non-null    float64
 17  STDs:syphilis                       753 non-null    float64
 18  STDs:pelvic inflammatory disease    753 non-null    float64
 19  STDs:genital herpes                 753 non-null    float64
 20  STDs:molluscum contagiosum          753 non-null    float64
 21  STDs:AIDS                           753 non-null    float64
 22  STDs:HIV                            753 non-null    float64
 23  STDs:Hepatitis B                    753 non-null    float64
 24  STDs:HPV                            753 non-null    float64
 25  STDs: Number of diagnosis           858 non-null    int64
 26  STDs: Time since first diagnosis    71 non-null     float64
 27  STDs: Time since last diagnosis     71 non-null     float64
 28  Dx:Cancer                           858 non-null    int64
 29  Dx:CIN                              858 non-null    int64
 30  Dx:HPV                              858 non-null    int64
 31  Dx                                  858 non-null    int64
 32  Hinselmann                          858 non-null    int64
 33  Schiller                            858 non-null    int64
 34  Citology                            858 non-null    int64
 35  Biopsy                              858 non-null    int64
```

```
dtypes: float64(26), int64(10)
memory usage: 241.4 KB
```

In [8]:

```
cervix_df.describe()
```

Out[8]:

	Age	Number of sexual partners	First sexual intercourse	Num of pregnancies	Smokes	Smokes (years)	Smokes (packs/year)	Hormonal Contraceptives	Hormonal Contraceptives (years)	I
count	858.000000	832.000000	851.000000	802.000000	845.000000	845.000000	845.000000	750.000000	750.000000	741.0000
mean	26.820513	2.527644	16.995300	2.275561	0.145562	1.219721	0.453144	0.641333	2.256419	0.1120
std	8.497948	1.667760	2.803355	1.447414	0.352876	4.089017	2.226610	0.479929	3.764254	0.3155
min	13.000000	1.000000	10.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
25%	20.000000	2.000000	15.000000	1.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.0000
50%	25.000000	2.000000	17.000000	2.000000	0.000000	0.000000	0.000000	1.000000	0.500000	0.0000
75%	32.000000	3.000000	18.000000	3.000000	0.000000	0.000000	0.000000	1.000000	3.000000	0.0000
max	84.000000	28.000000	32.000000	11.000000	1.000000	37.000000	37.000000	1.000000	30.000000	1.0000

8 rows × 36 columns

Changing each columns to their corresponding datatypes.

In [13]:

```
column_data_types = {
    "Smokes": bool,
    "Smokes (years)": bool,
    "Smokes (packs/year)": bool,
    "Hormonal Contraceptives": bool,
    "IUD": bool,
    "STDs": bool,
    "STDs:condylomatosis": bool,
    "STDs:cervical condylomatosis": bool,
    "STDs:vaginal condylomatosis": bool,
    "STDs:vulvo-perineal condylomatosis": bool,
    "STDs:syphilis": bool,
    "STDs:pelvic inflammatory disease": bool,
    "STDs:genital herpes": bool,
    "STDs:molluscum contagiosum": bool,
    "STDs:AIDS": bool,
    "STDs:HIV": bool,
    "STDs:Hepatitis B": bool,
    "STDs:HPV": bool,
    "Dx:Cancer": bool,
    "Dx:CIN": bool,
    "Dx:HPV": bool,
    "Dx": bool,
    "Hinselmann": bool,
    "Schiller": bool,
    "Citology": bool,
    "Biopsy": bool
}

# converting datatypes
cervix_df = cervix_df.astype(column_data_types)
```

In [14]:

```
cervix_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 858 entries, 0 to 857
Data columns (total 36 columns):
 #   Column                              Non-Null Count  Dtype  
---  ------                              --------------  -----  
 0   Age                                 858 non-null    int64  
 1   Number of sexual partners           832 non-null    float64
 2   First sexual intercourse            851 non-null    float64
 3   Num of pregnancies                  802 non-null    float64
 4   Smokes                              858 non-null    bool   
 5   Smokes (years)                      858 non-null    bool   
 6   Smokes (packs/year)                 858 non-null    bool   
 7   Hormonal Contraceptives             858 non-null    bool   
 8   Hormonal Contraceptives (years)     750 non-null    float64
 9   IUD                                 858 non-null    bool   
 10  IUD (years)                         741 non-null    float64
 11  STDs                                858 non-null    bool   
 12  STDs (number)                       753 non-null    float64
 13  STDs:condylomatosis                 858 non-null    bool   
 14  STDs:cervical condylomatosis        858 non-null    bool   
 15  STDs:vaginal condylomatosis         858 non-null    bool   
 16  STDs:vulvo-perineal condylomatosis  858 non-null    bool   
 17  STDs:syphilis                       858 non-null    bool   
 18  STDs:pelvic inflammatory disease    858 non-null    bool   
 19  STDs:genital herpes                 858 non-null    bool   
 20  STDs:molluscum contagiosum          858 non-null    bool   
 21  STDs:AIDS                           858 non-null    bool   
 22  STDs:HIV                            858 non-null    bool   
 23  STDs:Hepatitis B                    858 non-null    bool   
 24  STDs:HPV                            858 non-null    bool   
 25  STDs: Number of diagnosis           858 non-null    int64  
 26  STDs: Time since first diagnosis    71 non-null     float64
 27  STDs: Time since last diagnosis     71 non-null     float64
 28  Dx:Cancer                           858 non-null    bool   
 29  Dx:CIN                              858 non-null    bool   
 30  Dx:HPV                              858 non-null    bool   
 31  Dx                                  858 non-null    bool   
 32  Hinselmann                          858 non-null    bool   
 33  Schiller                            858 non-null    bool   
 34  Citology                            858 non-null    bool   
 35  Biopsy                              858 non-null    bool   
```

```
dtypes: bool(26), float64(8), int64(2)
memory usage: 88.9 KB
```

In [15]:

```
cervix_df.head()
```

Out[15]:

	Age	Number of sexual partners	First sexual intercourse	Num of pregnancies	Smokes	Smokes (years)	Smokes (packs/year)	Hormonal Contraceptives	Hormonal Contraceptives (years)	IUD	...	STDs: Time since first diagnosis	ST T since diagn
0	18	4.0	15.0	1.0	False	False	False	False	0.0	False	...	NaN	I
1	15	1.0	14.0	1.0	False	False	False	False	0.0	False	...	NaN	I
2	34	1.0	NaN	1.0	False	False	False	False	0.0	False	...	NaN	I
3	52	5.0	16.0	4.0	True	True	True	True	3.0	False	...	NaN	I
4	46	3.0	21.0	4.0	False	False	False	True	15.0	False	...	NaN	I

5 rows × 36 columns

Handling missing values

In [16]:
```
cervix_df.isnull().sum()
```

Out[16]:
```
Age                                     0
Number of sexual partners              26
First sexual intercourse                7
Num of pregnancies                     56
Smokes                                  0
Smokes (years)                          0
Smokes (packs/year)                     0
Hormonal Contraceptives                 0
Hormonal Contraceptives (years)       108
IUD                                     0
IUD (years)                           117
STDs                                    0
STDs (number)                         105
STDs:condylomatosis                     0
STDs:cervical condylomatosis            0
STDs:vaginal condylomatosis             0
STDs:vulvo-perineal condylomatosis      0
STDs:syphilis                           0
STDs:pelvic inflammatory disease        0
STDs:genital herpes                     0
STDs:molluscum contagiosum              0
STDs:AIDS                               0
STDs:HIV                                0
STDs:Hepatitis B                        0
STDs:HPV                                0
STDs: Number of diagnosis               0
STDs: Time since first diagnosis      787
STDs: Time since last diagnosis       787
Dx:Cancer                               0
Dx:CIN                                  0
Dx:HPV                                  0
Dx                                      0
Hinselmann                              0
Schiller                                0
Citology                                0
Biopsy                                  0
dtype: int64
```

In [17]:

```
# STDs: Time since first diagnosis and STDs: Time since last diagnosis have the highest amount of missing val
cervix_df = cervix_df.drop(columns = ['STDs: Time since first diagnosis','STDs: Time since last diagnosis'])
cervix_df.head()
```

Out[17]:

	Age	Number of sexual partners	First sexual intercourse	Num of pregnancies	Smokes	Smokes (years)	Smokes (packs/year)	Hormonal Contraceptives	Hormonal Contraceptives (years)	IUD	...	STDs:HPV	S Nur diagn
0	18	4.0	15.0	1.0	False	False	False	False	0.0	False	...	False	
1	15	1.0	14.0	1.0	False	False	False	False	0.0	False	...	False	
2	34	1.0	NaN	1.0	False	False	False	False	0.0	False	...	False	
3	52	5.0	16.0	4.0	True	True	True	True	3.0	False	...	False	
4	46	3.0	21.0	4.0	False	False	False	True	15.0	False	...	False	

5 rows × 34 columns

In [18]:

```
cervix_df.mean()
```

Out[18]:

```
Age                                   26.820513
Number of sexual partners              2.527644
First sexual intercourse              16.995300
Num of pregnancies                     2.275561
Smokes                                 0.158508
Smokes (years)                         0.158508
Smokes (packs/year)                    0.158508
Hormonal Contraceptives                0.686480
Hormonal Contraceptives (years)        2.256419
IUD                                    0.233100
IUD (years)                            0.514804
STDs                                   0.214452
STDs (number)                          0.176627
STDs:condylomatosis                    0.173660
STDs:cervical condylomatosis           0.122378
STDs:vaginal condylomatosis            0.127040
STDs:vulvo-perineal condylomatosis     0.172494
STDs:syphilis                          0.143357
STDs:pelvic inflammatory disease       0.123543
STDs:genital herpes                    0.123543
STDs:molluscum contagiosum             0.123543
STDs:AIDS                              0.122378
STDs:HIV                               0.143357
STDs:Hepatitis B                       0.123543
STDs:HPV                               0.124709
STDs: Number of diagnosis              0.087413
Dx:Cancer                              0.020979
Dx:CIN                                 0.010490
Dx:HPV                                 0.020979
Dx                                     0.027972
Hinselmann                             0.040793
Schiller                               0.086247
Citology                               0.051282
Biopsy                                 0.064103
dtype: float64
```

In [19]:

```
# replacing NaN values with the mean value of each column
cervix_df = cervix_df.fillna(cervix_df.mean())
cervix_df.head()
```

Out[19]:

	Age	Number of sexual partners	First sexual intercourse	Num of pregnancies	Smokes	Smokes (years)	Smokes (packs/year)	Hormonal Contraceptives	Hormonal Contraceptives (years)	IUD	...	STDs:HPV	S Nur diagn
0	18	4.0	15.0000	1.0	False	False	False	False	0.0	False	...	False	
1	15	1.0	14.0000	1.0	False	False	False	False	0.0	False	...	False	
2	34	1.0	16.9953	1.0	False	False	False	False	0.0	False	...	False	
3	52	5.0	16.0000	4.0	True	True	True	True	3.0	False	...	False	
4	46	3.0	21.0000	4.0	False	False	False	True	15.0	False	...	False	

5 rows × 34 columns

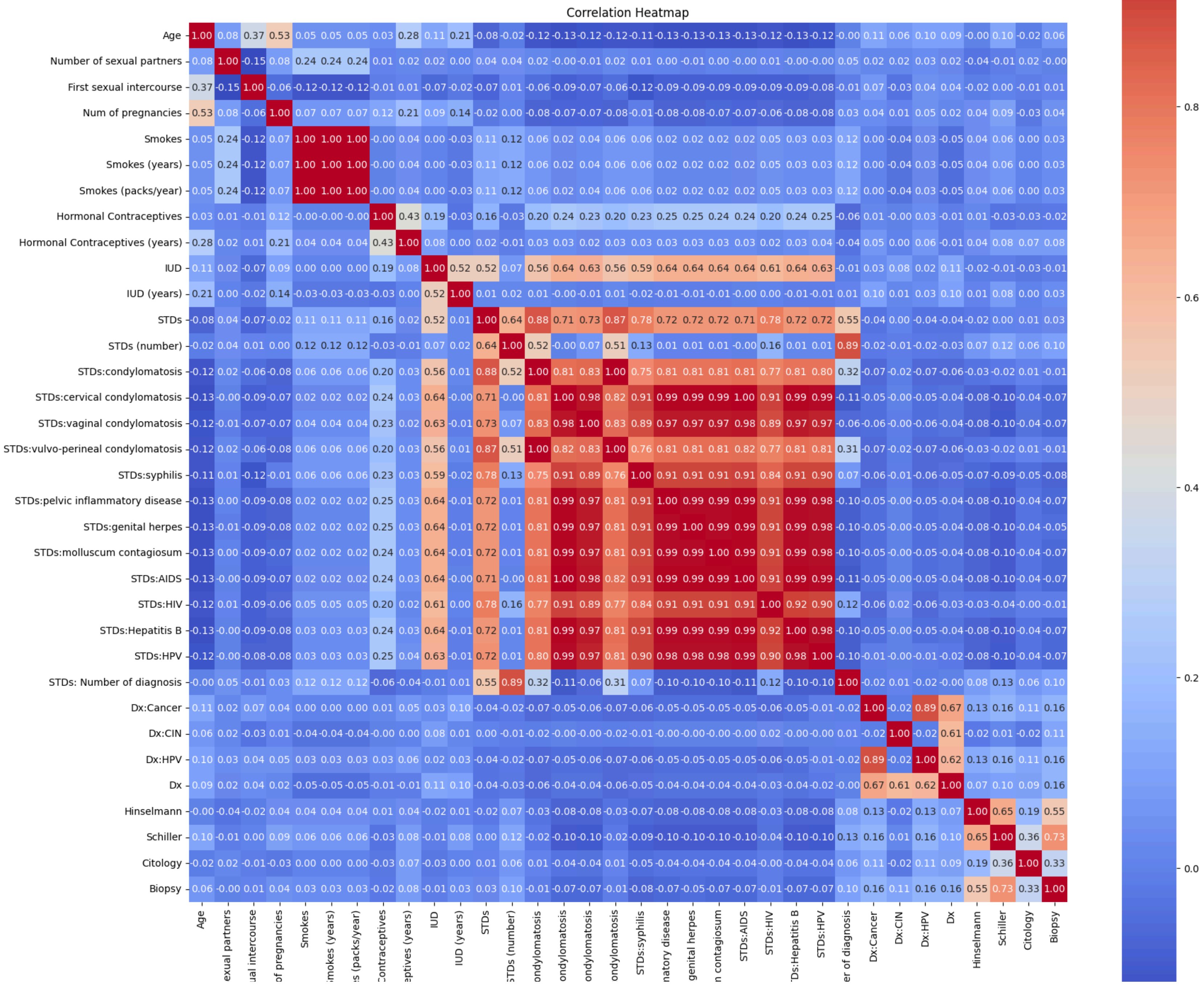
In [20]:
```
cervix_df.isnull().sum()
```

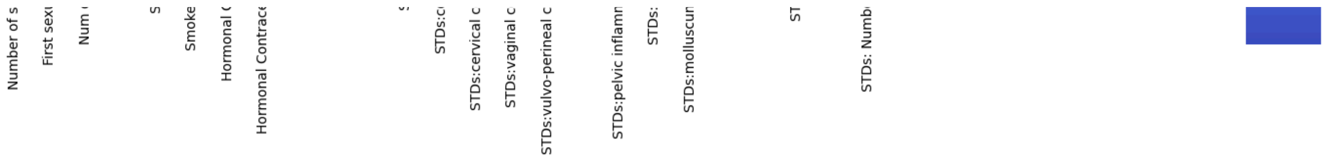
Out[20]:
```
Age                                   0
Number of sexual partners             0
First sexual intercourse              0
Num of pregnancies                    0
Smokes                                0
Smokes (years)                        0
Smokes (packs/year)                   0
Hormonal Contraceptives               0
Hormonal Contraceptives (years)       0
IUD                                   0
IUD (years)                           0
STDs                                  0
STDs (number)                         0
STDs:condylomatosis                   0
STDs:cervical condylomatosis          0
STDs:vaginal condylomatosis           0
STDs:vulvo-perineal condylomatosis    0
STDs:syphilis                         0
STDs:pelvic inflammatory disease      0
STDs:genital herpes                   0
STDs:molluscum contagiosum            0
STDs:AIDS                             0
STDs:HIV                              0
STDs:Hepatitis B                      0
STDs:HPV                              0
STDs: Number of diagnosis             0
Dx:Cancer                             0
Dx:CIN                                0
Dx:HPV                                0
Dx                                    0
Hinselmann                            0
Schiller                              0
Citology                              0
Biopsy                                0
dtype: int64
```

In [21]:

```
# correlation of variables
correlation_matrix = cervix_df.corr()

plt.figure(figsize=(20, 20))
sns.heatmap(correlation_matrix, annot=True, fmt='.2f', cmap='coolwarm', square=True)
plt.title('Correlation Heatmap')
plt.show()
```


Correlation Heatmap
Age 1.00 0.08 0.37 0.53 0.05 0.05 0.05 0.03 0.28 0.11 0.21 -0.08 -0.02 -0.12 -0.13 -0.12 -0.12 -0.11 -0.13 -0.13 -0.13 -0.13 -0.12 -0.13 -0.12 -0.00 0.11 0.06 0.10 0.09 -0.00 0.10 -0.02 0.06
Number of sexual partners 0.08 1.00 -0.15 0.08 0.24 0.24 0.24 0.01 0.02 0.02 0.00 0.04 0.04 0.02 -0.00 -0.01 0.02 0.01 0.00 -0.01 0.00 -0.00 0.01 -0.00 -0.00 0.05 0.02 0.02 0.03 0.02 -0.04 -0.01 0.02 -0.00
First sexual intercourse 0.37 -0.15 1.00 -0.06 -0.12 -0.12 -0.12 -0.01 0.01 -0.07 -0.02 -0.07 0.01 -0.06 -0.09 -0.07 -0.06 -0.12 -0.09 -0.09 -0.09 -0.09 -0.09 -0.09 -0.08 -0.01 0.07 -0.03 0.04 0.04 -0.02 0.00 -0.01 0.01
Num of pregnancies 0.53 0.08 -0.06 1.00 0.07 0.07 0.07 0.12 0.21 0.09 0.14 -0.02 0.00 -0.08 -0.07 -0.07 -0.08 -0.01 -0.08 -0.08 -0.07 -0.07 -0.06 -0.08 -0.08 0.03 0.04 0.01 0.05 0.02 0.04 0.09 -0.03 0.04
Smokes 0.05 0.24 -0.12 0.07 1.00 1.00 1.00 -0.00 0.04 0.00 -0.03 0.11 0.12 0.06 0.02 0.04 0.06 0.06 0.02 0.02 0.02 0.02 0.05 0.03 0.03 0.12 0.00 -0.04 0.03 -0.05 0.04 0.06 0.00 0.03
Smokes (years) 0.05 0.24 -0.12 0.07 1.00 1.00 1.00 -0.00 0.04 0.00 -0.03 0.11 0.12 0.06 0.02 0.04 0.06 0.06 0.02 0.02 0.02 0.02 0.05 0.03 0.03 0.12 0.00 -0.04 0.03 -0.05 0.04 0.06 0.00 0.03
Smokes (packs/year) 0.05 0.24 -0.12 0.07 1.00 1.00 1.00 -0.00 0.04 0.00 -0.03 0.11 0.12 0.06 0.02 0.04 0.06 0.06 0.02 0.02 0.02 0.02 0.05 0.03 0.03 0.12 0.00 -0.04 0.03 -0.05 0.04 0.06 0.00 0.03
Hormonal Contraceptives 0.03 0.01 -0.01 0.12 -0.00 -0.00 -0.00 1.00 0.43 0.19 -0.03 0.16 -0.03 0.20 0.24 0.23 0.20 0.23 0.25 0.25 0.24 0.24 0.20 0.24 0.25 -0.06 0.01 -0.00 0.03 -0.01 0.01 -0.03 -0.03 -0.02
Hormonal Contraceptives (years) 0.28 0.02 0.01 0.21 0.04 0.04 0.04 0.43 1.00 0.08 0.00 0.02 -0.01 0.03 0.03 0.02 0.03 0.03 0.03 0.03 0.03 0.03 0.02 0.03 0.04 -0.04 0.05 0.00 0.06 -0.01 0.04 0.08 0.07 0.08
IUD 0.11 0.02 -0.07 0.09 0.00 0.00 0.00 0.19 0.08 1.00 0.52 0.52 0.07 0.56 0.64 0.63 0.56 0.59 0.64 0.64 0.64 0.64 0.61 0.64 0.63 -0.01 0.03 0.08 0.02 0.11 -0.02 -0.01 -0.03 -0.01
IUD (years) 0.21 0.00 -0.02 0.14 -0.03 -0.03 -0.03 -0.03 0.00 0.52 1.00 0.01 0.02 0.01 -0.00 -0.01 0.01 -0.02 -0.01 -0.01 -0.01 -0.00 0.00 -0.01 -0.01 0.01 0.10 0.01 0.03 0.10 0.01 0.08 0.00 0.03
STDs -0.08 0.04 -0.07 -0.02 0.11 0.11 0.11 0.16 0.02 0.52 0.01 1.00 0.64 0.88 0.71 0.73 0.87 0.78 0.72 0.72 0.72 0.71 0.78 0.72 0.72 0.55 -0.04 0.00 -0.04 -0.04 -0.02 0.00 0.01 0.03
STDs (number) -0.02 0.04 0.01 0.00 0.12 0.12 0.12 -0.03 -0.01 0.07 0.02 0.64 1.00 0.52 -0.00 0.07 0.51 0.13 0.01 0.01 0.01 -0.00 0.16 0.01 0.01 0.89 -0.02 -0.01 -0.02 -0.03 0.07 0.12 0.06 0.10
STDs:condylomatosis -0.12 0.02 -0.06 -0.08 0.06 0.06 0.06 0.20 0.03 0.56 0.01 0.88 0.52 1.00 0.81 0.83 1.00 0.75 0.81 0.81 0.81 0.81 0.77 0.81 0.80 0.32 -0.07 -0.02 -0.07 -0.06 -0.03 -0.02 0.01 -0.01
STDs:cervical condylomatosis -0.13 -0.00 -0.09 -0.07 0.02 0.02 0.02 0.24 0.03 0.64 -0.00 0.71 -0.00 0.81 1.00 0.98 0.82 0.91 0.99 0.99 0.99 1.00 0.91 0.99 0.99 -0.11 -0.05 -0.00 -0.05 -0.04 -0.08 -0.10 -0.04 -0.07
STDs:vaginal condylomatosis -0.12 -0.01 -0.07 -0.07 0.04 0.04 0.04 0.23 0.02 0.63 -0.01 0.73 0.07 0.83 0.98 1.00 0.83 0.89 0.97 0.97 0.97 0.98 0.89 0.97 0.97 -0.06 -0.06 -0.00 -0.06 -0.04 -0.08 -0.10 -0.04 -0.07
STDs:vulvo-perineal condylomatosis -0.12 0.02 -0.06 -0.08 0.06 0.06 0.06 0.20 0.03 0.56 0.01 0.87 0.51 1.00 0.82 0.83 1.00 0.76 0.81 0.81 0.81 0.82 0.77 0.81 0.81 0.31 -0.07 -0.02 -0.07 -0.06 -0.03 -0.02 0.01 -0.01
STDs:syphilis -0.11 0.01 -0.12 -0.01 0.06 0.06 0.06 0.23 0.03 0.59 -0.02 0.78 0.13 0.75 0.91 0.89 0.76 1.00 0.91 0.91 0.91 0.91 0.84 0.91 0.90 0.07 -0.06 -0.01 -0.06 -0.05 -0.07 -0.09 -0.05 -0.08
STDs:pelvic inflammatory disease -0.13 0.00 -0.09 -0.08 0.02 0.02 0.02 0.25 0.03 0.64 -0.01 0.72 0.01 0.81 0.99 0.97 0.81 0.91 1.00 0.99 0.99 0.99 0.91 0.99 0.98 -0.10 -0.05 -0.00 -0.05 -0.04 -0.08 -0.10 -0.04 -0.07
STDs:genital herpes -0.13 -0.01 -0.09 -0.08 0.02 0.02 0.02 0.25 0.03 0.64 -0.01 0.72 0.01 0.81 0.99 0.97 0.81 0.91 0.99 1.00 0.99 0.99 0.91 0.99 0.98 -0.10 -0.05 -0.00 -0.05 -0.04 -0.08 -0.10 -0.04 -0.05
STDs:molluscum contagiosum -0.13 0.00 -0.09 -0.07 0.02 0.02 0.02 0.24 0.03 0.64 -0.01 0.72 0.01 0.81 0.99 0.97 0.81 0.91 0.99 0.99 1.00 0.99 0.91 0.99 0.98 -0.10 -0.05 -0.00 -0.05 -0.04 -0.08 -0.10 -0.04 -0.07
STDs:AIDS -0.13 -0.00 -0.09 -0.07 0.02 0.02 0.02 0.24 0.03 0.64 -0.00 0.71 -0.00 0.81 1.00 0.98 0.82 0.91 0.99 0.99 0.99 1.00 0.91 0.99 0.99 -0.11 -0.05 -0.00 -0.05 -0.04 -0.08 -0.10 -0.04 -0.07
STDs:HIV -0.12 0.01 -0.09 -0.06 0.05 0.05 0.05 0.20 0.02 0.61 0.00 0.78 0.16 0.77 0.91 0.89 0.77 0.84 0.91 0.91 0.91 0.91 1.00 0.92 0.90 0.12 -0.06 0.02 -0.06 -0.03 -0.03 -0.04 -0.00 -0.01
STDs:Hepatitis B -0.13 -0.00 -0.09 -0.08 0.03 0.03 0.03 0.24 0.03 0.64 -0.01 0.72 0.01 0.81 0.99 0.97 0.81 0.91 0.99 0.99 0.99 0.99 0.92 1.00 0.98 -0.10 -0.05 -0.00 -0.05 -0.04 -0.08 -0.10 -0.04 -0.07
STDs:HPV -0.12 -0.00 -0.08 -0.08 0.03 0.03 0.03 0.25 0.04 0.63 -0.01 0.72 0.01 0.80 0.99 0.97 0.81 0.90 0.98 0.98 0.98 0.99 0.90 0.98 1.00 -0.10 -0.01 -0.00 -0.01 -0.02 -0.08 -0.10 -0.04 -0.07
STDs: Number of diagnosis -0.00 0.05 -0.01 0.03 0.12 0.12 0.12 -0.06 -0.04 -0.01 0.01 0.55 0.89 0.32 -0.11 -0.06 0.31 0.07 -0.10 -0.10 -0.10 -0.11 0.12 -0.10 -0.10 1.00 -0.02 0.01 -0.02 -0.00 0.08 0.13 0.06 0.10
Dx:Cancer 0.11 0.02 0.07 0.04 0.00 0.00 0.00 0.01 0.05 0.03 0.10 -0.04 -0.02 -0.07 -0.05 -0.06 -0.07 -0.06 -0.05 -0.05 -0.05 -0.05 -0.06 -0.05 -0.01 -0.02 1.00 -0.02 0.89 0.67 0.13 0.16 0.11 0.16
Dx:CIN 0.06 0.02 -0.03 0.01 -0.04 -0.04 -0.04 -0.00 0.00 0.08 0.01 0.00 -0.01 -0.02 -0.00 -0.00 -0.02 -0.01 -0.00 -0.00 -0.00 -0.00 0.02 -0.00 -0.00 0.01 -0.02 1.00 -0.02 0.61 -0.02 0.01 -0.02 0.11
Dx:HPV 0.10 0.03 0.04 0.05 0.03 0.03 0.03 0.03 0.06 0.02 0.03 -0.04 -0.02 -0.07 -0.05 -0.06 -0.07 -0.06 -0.05 -0.05 -0.05 -0.05 -0.06 -0.05 -0.01 -0.02 0.89 -0.02 1.00 0.62 0.13 0.16 0.11 0.16
Dx 0.09 0.02 0.04 0.02 -0.05 -0.05 -0.05 -0.01 -0.01 0.11 0.10 -0.04 -0.03 -0.06 -0.04 -0.04 -0.06 -0.05 -0.04 -0.04 -0.04 -0.04 -0.03 -0.04 -0.02 -0.00 0.67 0.61 0.62 1.00 0.07 0.10 0.09 0.16
Hinselmann -0.00 -0.04 -0.02 0.04 0.04 0.04 0.04 0.01 0.04 -0.02 0.01 -0.02 0.07 -0.03 -0.08 -0.08 -0.03 -0.07 -0.08 -0.08 -0.08 -0.08 -0.03 -0.08 -0.08 0.08 0.13 -0.02 0.13 0.07 1.00 0.65 0.19 0.55
Schiller 0.10 -0.01 0.00 0.09 0.06 0.06 0.06 -0.03 0.08 -0.01 0.08 0.00 0.12 -0.02 -0.10 -0.10 -0.02 -0.09 -0.10 -0.10 -0.10 -0.10 -0.04 -0.10 -0.10 0.13 0.16 0.01 0.16 0.10 0.65 1.00 0.36 0.73
Citology -0.02 0.02 -0.01 -0.03 0.00 0.00 0.00 -0.03 0.07 -0.03 0.00 0.01 0.06 0.01 -0.04 -0.04 0.01 -0.05 -0.04 -0.04 -0.04 -0.04 -0.00 -0.04 -0.04 0.06 0.11 -0.02 0.11 0.09 0.19 0.36 1.00 0.33
Biopsy 0.06 -0.00 0.01 0.04 0.03 0.03 0.03 -0.02 0.08 -0.01 0.03 0.03 0.10 -0.01 -0.07 -0.07 -0.01 -0.08 -0.07 -0.05 -0.07 -0.07 -0.01 -0.07 -0.07 0.10 0.16 0.11 0.16 0.16 0.55 0.73 0.33 1.00
Age
exual partners
ual intercourse
of pregnancies
Smokes
mokes (years)
s (packs/year)
Contraceptives
eptives (years)
IUD
IUD (years)
STDs
TDs (number)
ondylomatosis
ondylomatosis
ondylomatosis
ondylomatosis
STDs:syphilis
natory disease
genital herpes
n contagiosum
STDs:AIDS
STDs:HIV
TDs:Hepatitis B
STDs:HPV
er of diagnosis
Dx:Cancer
Dx:CIN
Dx:HPV
Dx
Hinselmann
Schiller
Citology
Biopsy
1.0
0.8
0.6
0.4
0.2
0.0


Number of s
First sexu
Num
S
Smoke
Hormonal C
Hormonal Contrac
S
STDs:c
STDs:cervical c
STDs:vaginal c
STDs:vulvo-perineal c
STDs:pelvic inflamm
STDs:
STDs:molluscun
ST
STDs: Numb

In [22]:

```
correlation_matrix
```

Out[22]:

	Age	Number of sexual partners	First sexual intercourse	Num of pregnancies	Smokes	Smokes (years)	Smokes (packs/year)	Hormonal Contraceptives	Hormonal Contraceptives (years)
Age	1.000000	0.084896	0.369168	0.526137	0.045244	0.045244	0.045244	0.029201	0.277181
Number of sexual partners	0.084896	1.000000	-0.147937	0.076719	0.241673	0.241673	0.241673	0.005771	0.018552
First sexual intercourse	0.369168	-0.147937	1.000000	-0.058223	-0.119364	-0.119364	-0.119364	-0.009233	0.008000
Num of pregnancies	0.526137	0.076719	-0.058223	1.000000	0.068466	0.068466	0.068466	0.118860	0.207839
Smokes	0.045244	0.241673	-0.119364	0.068466	1.000000	1.000000	1.000000	-0.002485	0.036849
Smokes (years)	0.045244	0.241673	-0.119364	0.068466	1.000000	1.000000	1.000000	-0.002485	0.036849
Smokes (packs/year)	0.045244	0.241673	-0.119364	0.068466	1.000000	1.000000	1.000000	-0.002485	0.036849
Hormonal Contraceptives	0.029201	0.005771	-0.009233	0.118860	-0.002485	-0.002485	-0.002485	1.000000	0.433573
Hormonal Contraceptives (years)	0.277181	0.018552	0.008000	0.207839	0.036849	0.036849	0.036849	0.433573	1.000000
IUD	0.107725	0.023182	-0.070207	0.091457	0.002252	0.002252	0.002252	0.194324	0.079862
IUD (years)	0.205886	0.004215	-0.024803	0.143642	-0.026532	-0.026532	-0.026532	-0.033394	0.000455
STDs	-0.084916	0.035939	-0.073416	-0.022581	0.107566	0.107566	0.107566	0.163352	0.024324
STDs (number)	-0.015488	0.039359	0.006487	0.001706	0.123340	0.123340	0.123340	-0.027045	-0.006468
STDs:condylomatosis	-0.119277	0.018207	-0.057674	-0.083053	0.062190	0.062190	0.062190	0.197063	0.031559
STDs:cervical condylomatosis	-0.128618	-0.002320	-0.089871	-0.074901	0.022948	0.022948	0.022948	0.244691	0.033223
STDs:vaginal condylomatosis	-0.124629	-0.011049	-0.073367	-0.073965	0.035673	0.035673	0.035673	0.227629	0.024709
STDs:vulvo-perineal condylomatosis	-0.118207	0.019247	-0.055621	-0.082667	0.063695	0.063695	0.063695	0.195504	0.032746
STDs:syphilis	-0.113142	0.008980	-0.123280	-0.010497	0.059224	0.059224	0.059224	0.226274	0.031918
STDs:pelvic inflammatory disease	-0.125518	0.000866	-0.089500	-0.080359	0.021318	0.021318	0.021318	0.246090	0.031571
STDs:genital herpes	-0.130940	-0.005608	-0.086961	-0.077826	0.021318	0.021318	0.021318	0.246090	0.031068

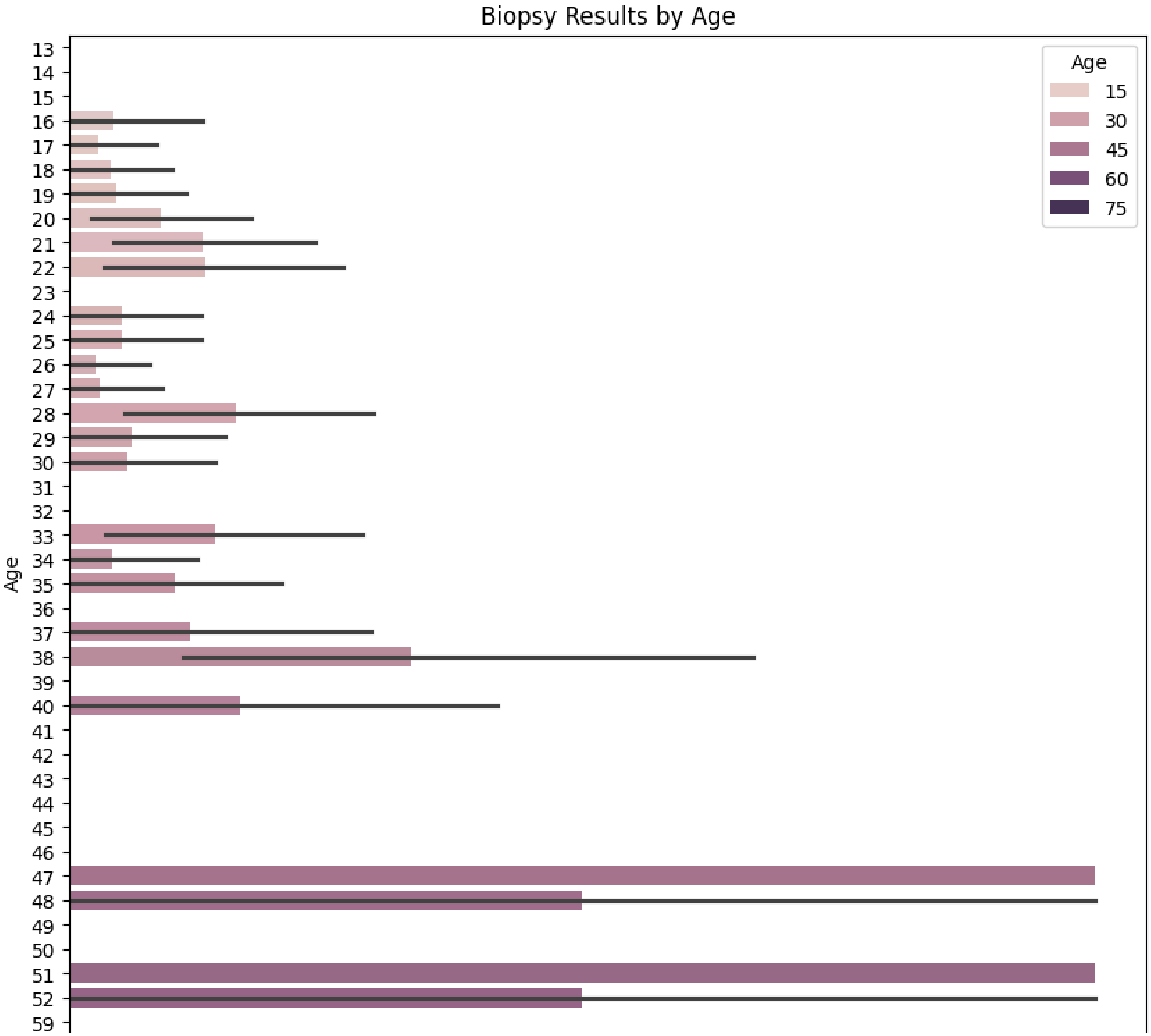
	Age	Number of sexual partners	First sexual intercourse	Num of pregnancies	Smokes	Smokes (years)	Smokes (packs/year)	Hormonal Contraceptives	Hormonal Contraceptives (years)
STDs:molluscum contagiosum	-0.128020	0.000866	-0.090769	-0.070229	0.021318	0.021318	0.021318	0.238455	0.030816
STDs:AIDS	-0.128618	-0.002320	-0.089871	-0.074901	0.022948	0.022948	0.022948	0.244691	0.033223
STDs:HIV	-0.118233	0.005996	-0.087521	-0.064539	0.050118	0.050118	0.050118	0.197598	0.015842
STDs:Hepatitis B	-0.130940	-0.003450	-0.088231	-0.077826	0.031016	0.031016	0.031016	0.238455	0.030816
STDs:HPV	-0.121616	-0.000271	-0.084077	-0.078209	0.029360	0.029360	0.029360	0.247484	0.040465
STDs: Number of diagnosis	-0.001606	0.051559	-0.013327	0.033514	0.117277	0.117277	0.117277	-0.062199	-0.037219
Dx:Cancer	0.110340	0.022309	0.067283	0.035123	0.003270	0.003270	0.003270	0.011278	0.054627
Dx:CIN	0.061443	0.015691	-0.032626	0.007344	-0.044686	-0.044686	-0.044686	-0.004397	0.003086
Dx:HPV	0.101722	0.027264	0.043966	0.046753	0.025538	0.025538	0.025538	0.028808	0.061394
Dx	0.092635	0.022982	0.035750	0.019025	-0.054271	-0.054271	-0.054271	-0.007245	-0.012865
Hinselmann	-0.003967	-0.039273	-0.016546	0.038685	0.039562	0.039562	0.039562	0.012360	0.038825
Schiller	0.103283	-0.008899	0.003493	0.087687	0.059913	0.059913	0.059913	-0.034002	0.078707
Citology	-0.016862	0.021839	-0.010971	-0.029656	0.000371	0.000371	0.000371	-0.025116	0.074324
Biopsy	0.055956	-0.001429	0.007262	0.043460	0.029733	0.029733	0.029733	-0.018015	0.078995

34 rows × 34 columns

In [23]:

```
plt.figure(figsize=(10, 10))
sns.barplot(x="Biopsy", y="Age", data=cervix_df, orient="h", hue="Age", dodge=False)

plt.xlabel("Total Instances")
plt.ylabel("Age")
plt.title("Biopsy Results by Age")
plt.show()
```


Biopsy Results by Age
Age
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
59
Age
15
30
45
60
75

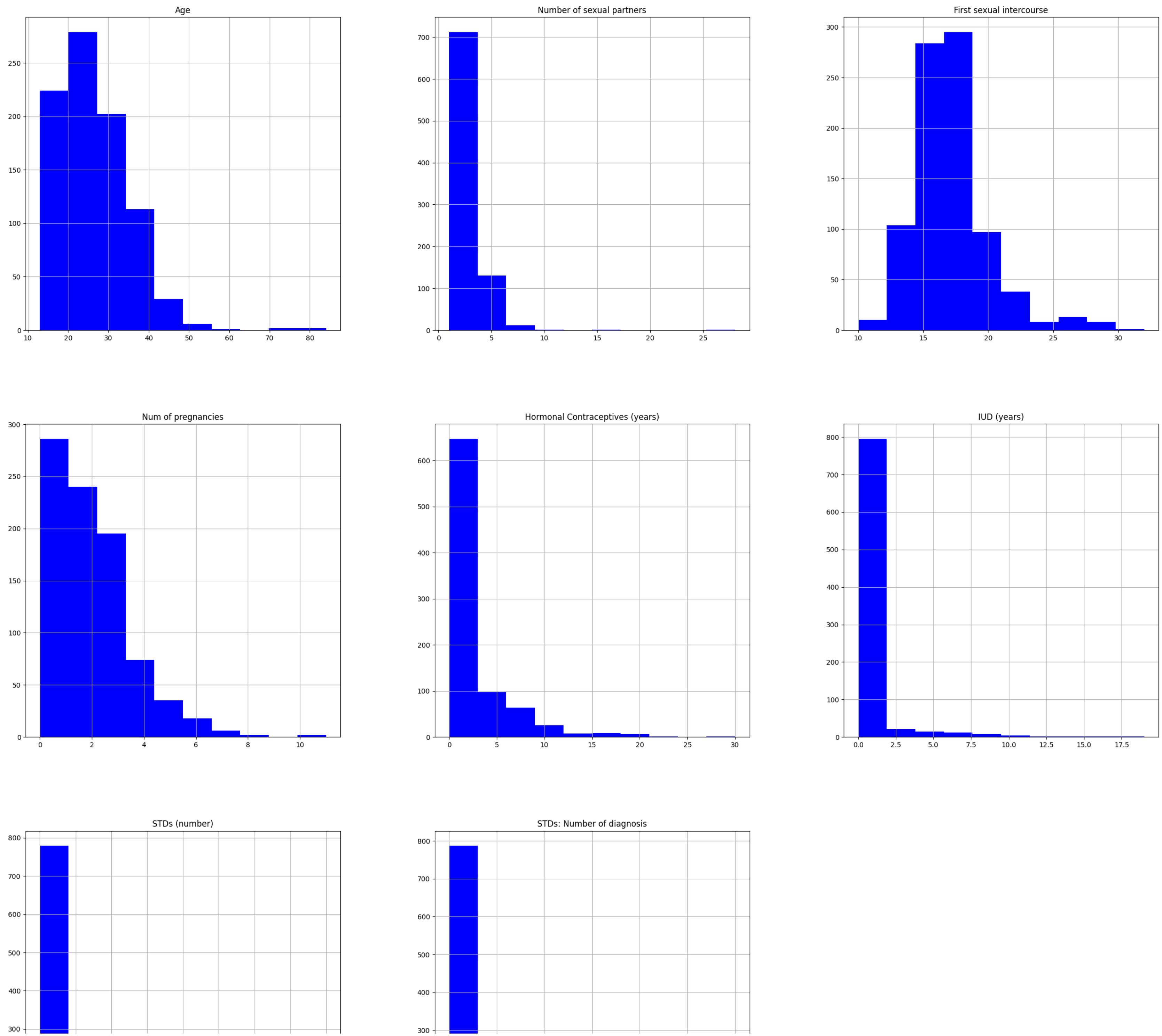
70
79
84
0.0
0.2
0.4
0.6
0.8
1.0
Total Instances

In [24]:

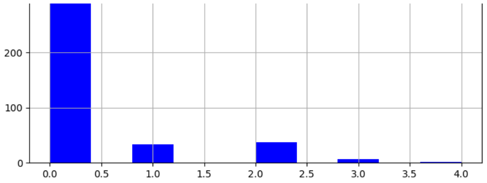
```python
# histogram
cervix_df.hist(bins = 10, figsize = (30,30), color = 'b')
```

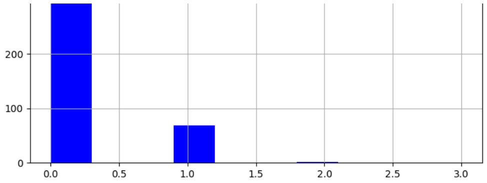
Out[24]:

```
array([[<Axes: title={'center': 'Age'}>,
        <Axes: title={'center': 'Number of sexual partners'}>,
        <Axes: title={'center': 'First sexual intercourse'}>],
       [<Axes: title={'center': 'Num of pregnancies'}>,
        <Axes: title={'center': 'Hormonal Contraceptives (years)'}>,
        <Axes: title={'center': 'IUD (years)'}>],
       [<Axes: title={'center': 'STDs (number)'}>,
        <Axes: title={'center': 'STDs: Number of diagnosis'}>, <Axes: >]],
      dtype=object)
```



Age
0
50
100
150
200
250
10
20
30
40
50
60
70
80
Number of sexual partners
0
100
200
300
400
500
600
700
0
5
10
15
20
25
First sexual intercourse
0
50
100
150
200
250
300
10
15
20
25
30
Num of pregnancies
0
50
100
150
200
250
300
0
2
4
6
8
10
Hormonal Contraceptives (years)
0
100
200
300
400
500
600
0
5
10
15
20
25
30
IUD (years)
0
100
200
300
400
500
600
700
800
0.0
2.5
5.0
7.5
10.0
12.5
15.0
17.5
STDs (number)
300
400
500
600
700
800
STDs: Number of diagnosis
300
400
500
600
700
800





Logistic Regression

In [25]:
```
cervix_df.columns
```

Out[25]:
```
Index(['Age', 'Number of sexual partners', 'First sexual intercourse',
       'Num of pregnancies', 'Smokes', 'Smokes (years)', 'Smokes (packs/year)',
       'Hormonal Contraceptives', 'Hormonal Contraceptives (years)', 'IUD',
       'IUD (years)', 'STDs', 'STDs (number)', 'STDs:condylomatosis',
       'STDs:cervical condylomatosis', 'STDs:vaginal condylomatosis',
       'STDs:vulvo-perineal condylomatosis', 'STDs:syphilis',
       'STDs:pelvic inflammatory disease', 'STDs:genital herpes',
       'STDs:molluscum contagiosum', 'STDs:AIDS', 'STDs:HIV',
       'STDs:Hepatitis B', 'STDs:HPV', 'STDs: Number of diagnosis',
       'Dx:Cancer', 'Dx:CIN', 'Dx:HPV', 'Dx', 'Hinselmann', 'Schiller',
       'Citology', 'Biopsy'],
      dtype='object')
```

In [28]:
```
# df with the target variables
target_df = cervix_df[['Hinselmann', 'Schiller', 'Citology', 'Biopsy']].copy()
target_df.head()
```

Out[28]:

	Hinselmann	Schiller	Citology	Biopsy
0	False	False	False	False
1	False	False	False	False
2	False	False	False	False
3	False	False	False	False
4	False	False	False	False

In [31]:

```
# df with feature variables
feature_df = cervix_df.drop(['Hinselmann', 'Schiller', 'Citology', 'Biopsy'], axis=1)
feature_df.head()
```

Out[31]:

	Age	Number of sexual partners	First sexual intercourse	Num of pregnancies	Smokes	Smokes (years)	Smokes (packs/year)	Hormonal Contraceptives	Hormonal Contraceptives (years)	IUD	...	STDs:molluscum contagiosum
0	18	4.0	15.0000	1.0	False	False	False	False	0.0	False	...	False
1	15	1.0	14.0000	1.0	False	False	False	False	0.0	False	...	False
2	34	1.0	16.9953	1.0	False	False	False	False	0.0	False	...	False
3	52	5.0	16.0000	4.0	True	True	True	True	3.0	False	...	False
4	46	3.0	21.0000	4.0	False	False	False	True	15.0	False	...	False

5 rows × 30 columns

Hinselmann vs Features

In [32]:

```
X = feature_df.copy()
```

In [33]:

```
y = target_df['Hinselmann']
y.head()
```

Out[33]:

```
0    False
1    False
2    False
3    False
4    False
Name: Hinselmann, dtype: bool
```

In [34]:

```
from sklearn.model_selection import train_test_split
```

```
In [35]: X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = 0.3, random_state = 21)
```

```
In [36]: X_train.shape
```

```
Out[36]: (600, 30)
```

```
In [38]: X_test.shape
```

```
Out[38]: (258, 30)
```

```
In [39]: y_train.shape
```

```
Out[39]: (600,)
```

```
In [40]: y_test.shape
```

```
Out[40]: (258,)
```

```
In [42]: from sklearn.preprocessing import StandardScaler
```

```
In [43]: scaler = StandardScaler()
```

```
In [44]: X_train_scaled =scaler.fit_transform(X_train)
```

```
In [45]: X_test_scaled =scaler.transform(X_test)
```

In [46]:
```
X_train_scaled
```

Out[46]:
```
array([[-1.26599668,  0.34370508, -1.1071669 , ..., -0.11624764,
        -0.13665914, -0.16552118],
       [ 1.18394314,  0.01852349,  0.40692371, ..., -0.11624764,
        -0.13665914, -0.16552118],
       [ 1.76726214, -0.34472007,  1.16396902, ..., -0.11624764,
        -0.13665914, -0.16552118],
       ...,
       [-1.03266908,  3.0974057 , -1.1071669 , ..., -0.11624764,
        -0.13665914, -0.16552118],
       [ 1.06727934, -0.34472007,  3.81362759, ..., -0.11624764,
        -0.13665914, -0.16552118],
       [-0.09935867,  0.34370508,  0.40692371, ..., -0.11624764,
        -0.13665914, -0.16552118]])
```

In [47]:
```
X_test_scaled
```

Out[47]:
```
array([[-0.21602247, -0.34472007,  0.02840106, ..., -0.11624764,
        -0.13665914, -0.16552118],
       [ 0.25063273, -0.34472007,  0.02840106, ..., -0.11624764,
        -0.13665914, -0.16552118],
       [-1.26599668, -1.03314523, -0.72864425, ..., -0.11624764,
        -0.13665914, -0.16552118],
       ...,
       [ 0.01730513,  1.03213024, -0.35012159, ..., -0.11624764,
        -0.13665914, -0.16552118],
       [ 2.46724495,  1.03213024, -0.35012159, ..., -0.11624764,
        -0.13665914, -0.16552118],
       [-1.14933288, -0.34472007, -1.48568955, ..., -0.11624764,
        -0.13665914, -0.16552118]])
```

In [48]:
```
from sklearn.linear_model import LogisticRegression
```

In [49]:
```
# model training
log_reg = LogisticRegression(random_state=0).fit(X_train_scaled, y_train)
```

In [50]:

```
log_reg.predict(X_train_scaled)
```

```
Out[50]: array([False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False, False, False, False,
                False, False, False, False, False, False])
```

In [53]:
```
# accuracy score
log_reg.score(X_train_scaled, y_train)
```

Out[53]:
```
0.96
```

In [54]:
```
# accuracy score (test data)
log_reg.score(X_test_scaled, y_test)
```

Out[54]:
```
0.9573643410852714
```

The accuracy scores are pretty high which means the model is quite strong.

```
In [67]: # adding more parameters in the training model
         log_reg1 = LogisticRegression(random_state=0,
                                       C = 0.1, # penalize the extreme values (C=1, default)
                                       fit_intercept = True
                                       ).fit(X_train_scaled, y_train)
```

```
In [68]: # accuracy score
         log_reg1.score(X_train_scaled, y_train)
```

```
Out[68]: 0.96
```

```
In [69]: # accuracy score (test data)
         log_reg1.score(X_test_scaled, y_test)
```

```
Out[69]: 0.9573643410852714
```

Changing the parameters didn't change the performance of the model.