Import Libraries

In [33]:

```
!pip install MultiColumnLabelEncoder
```

```
Collecting MultiColumnLabelEncoder
  Downloading MultiColumnLabelEncoder-1.1.3-py3-none-any.whl (14 kB)
Installing collected packages: MultiColumnLabelEncoder
Successfully installed MultiColumnLabelEncoder-1.1.3
```

In [1]:

```python
# Importing important libraries
import pandas as pd
import numpy as np
from scipy import stats
from prettytable import PrettyTable
import pickle
#import pyforest
from lazypredict.Supervised import LazyRegressor
from pandas.plotting import scatter_matrix

# Scikit-learn packages
from sklearn.linear_model import LinearRegression, Ridge, Lasso, ElasticNet
from sklearn.preprocessing import PolynomialFeatures
from sklearn.preprocessing import StandardScaler, LabelEncoder
from sklearn.model_selection import train_test_split
from sklearn.metrics import mean_squared_error, mean_absolute_error,r2_score

# Neural Network packages
from tensorflow.keras.models import Model, load_model, Sequential
from tensorflow.keras.layers import Dense, Flatten
from tensorflow.keras.optimizers import Adam, SGD
from tensorflow.keras.callbacks import ModelCheckpoint

# Hide warnings
import warnings
```

```
warnings.filterwarnings("ignore")

# plotting
import seaborn as sns
import matplotlib.pyplot as plt
from matplotlib import style
from matplotlib.gridspec import GridSpec
%matplotlib inline
```

Load Dataset

In [2]:

```
df = pd.read_csv("D:/Freelancing/Mortality Detection/Dataset/Mortality-5.csv")
df.head(20)
```

Out[2]:

	Country	Admin1	SubDiv	Year	List	Cause	Sex	Frmat	IM_Frmat	Deaths1	...	Deaths21	Deaths22
0	4303	nan	NaN	2017	101	1000	1	1	8	281784	...	43174.00	29856.00
1	4303	nan	NaN	2017	101	1000	2	1	8	292339	...	56037.00	52655.00
2	4303	nan	NaN	2017	101	1001	1	1	8	6198	...	62.00	36.00
3	4303	nan	NaN	2017	101	1001	2	1	8	2516	...	86.00	45.00
4	4303	nan	NaN	2017	101	1002	1	1	8	0	...	0.00	0.00
5	4303	nan	NaN	2017	101	1002	2	1	8	0	...	0.00	0.00
6	4303	nan	NaN	2017	101	1003	1	1	8	1	...	0.00	0.00
7	4303	nan	NaN	2017	101	1003	2	1	8	1	...	0.00	1.00
8	4303	nan	NaN	2017	101	1004	1	1	8	18	...	1.00	0.00

In [3]:

```
#check for datatypes and null values
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 610184 entries, 0 to 610183
Data columns (total 39 columns):
 #   Column       Non-Null Count   Dtype
---  ------       --------------   -----
 0   Country      610184 non-null  int64
 1   Admin1       0 non-null       float64
 2   SubDiv       3931 non-null    object
 3   Year         610184 non-null  int64
 4   List         610184 non-null  int64
 5   Cause        610184 non-null  object
 6   Sex          610184 non-null  int64
 7   Frmat        610184 non-null  int64
 8   IM_Frmat     610184 non-null  int64
 9   Deaths1      610184 non-null  int64
 10  Deaths2      608592 non-null  float64
 11  Deaths3      608592 non-null  float64
 12  Deaths4      594046 non-null  float64
 13  Deaths5      594046 non-null  float64
 14  Deaths6      594046 non-null  float64
 15  Deaths7      608592 non-null  float64
```

```
 16  Deaths8     608194 non-null  float64
 17  Deaths9     608592 non-null  float64
 18  Deaths10    608194 non-null  float64
 19  Deaths11    608592 non-null  float64
 20  Deaths12    608194 non-null  float64
 21  Deaths13    608592 non-null  float64
 22  Deaths14    608194 non-null  float64
 23  Deaths15    608592 non-null  float64
 24  Deaths16    608194 non-null  float64
 25  Deaths17    608592 non-null  float64
 26  Deaths18    608194 non-null  float64
 27  Deaths19    608592 non-null  float64
 28  Deaths20    608194 non-null  float64
 29  Deaths21    608592 non-null  float64
 30  Deaths22    607847 non-null  float64
 31  Deaths23    607847 non-null  float64
 32  Deaths24    540474 non-null  float64
 33  Deaths25    540474 non-null  float64
 34  Deaths26    608592 non-null  float64
 35  IM_Deaths1  608592 non-null  float64
 36  IM_Deaths2  516532 non-null  float64
 37  IM_Deaths3  522331 non-null  float64
 38  IM_Deaths4  522331 non-null  float64
dtypes: float64(30), int64(7), object(2)
memory usage: 181.6+ MB
```

In [4]:

```
# check data type of each columns for further processing
df.dtypes
```

Out[4]:

```
Country        int64
Admin1       float64
SubDiv        object
Year           int64
List           int64
Cause         object
Sex            int64
Frmat          int64
IM_Frmat       int64
Deaths1        int64
Deaths2      float64
Deaths3      float64
Deaths4      float64
Deaths5      float64
Deaths6      float64
Deaths7      float64
Deaths8      float64
Deaths9      float64
Deaths10     float64
```

```
Deaths11       float64
Deaths12       float64
Deaths13       float64
Deaths14       float64
Deaths15       float64
Deaths16       float64
Deaths17       float64
Deaths18       float64
Deaths19       float64
Deaths20       float64
Deaths21       float64
Deaths22       float64
Deaths23       float64
Deaths24       float64
Deaths25       float64
Deaths26       float64
IM_Deaths1     float64
IM_Deaths2     float64
IM_Deaths3     float64
IM_Deaths4     float64
dtype: object
```

In [5]:

```python
# check unique values for each feature vector and output
df.nunique()
```

Out[5]:

```
Country          99
Admin1            0
SubDiv            2
Year              4
List              3
Cause         10073
Sex               3
Frmat             6
IM_Frmat          4
Deaths1        5894
Deaths2         766
Deaths3         247
Deaths4         179
Deaths5         151
Deaths6         140
Deaths7         266
Deaths8         280
Deaths9         460
Deaths10        557
Deaths11        627
```

```
Deaths12         702
Deaths13         800
Deaths14         911
Deaths15        1070
Deaths16        1266
Deaths17        1500
Deaths18        1714
Deaths19        1875
Deaths20        1918
Deaths21        2156
Deaths22        2365
Deaths23        2531
Deaths24        1805
Deaths25        1243
Deaths26         216
IM_Deaths1       472
IM_Deaths2       341
IM_Deaths3       307
IM_Deaths4       418
dtype: int64
```

In [6]:

```
df = df.drop(columns= ['Admin1','Cause'], axis = 1)
df.head(20)
```

Out[6]:

	Country	SubDiv	Year	List	Sex	Frmat	IM_Frmat	Deaths1	Deaths2	Deaths3	...	D
0	4303	NaN	2017	101	1	1	8	281784	1608.00	133.00	...	4
1	4303	NaN	2017	101	2	1	8	292339	1178.00	99.00	...	5
2	4303	NaN	2017	101	1	1	8	6198	41.00	11.00	...	
3	4303	NaN	2017	101	2	1	8	2516	29.00	7.00	...	
4	4303	NaN	2017	101	1	1	8	0	0.00	0.00	...	
5	4303	NaN	2017	101	2	1	8	0	0.00	0.00	...	
6	4303	NaN	2017	101	1	1	8	1	0.00	0.00	...	
7	4303	NaN	2017	101	2	1	8	1	0.00	0.00	...	
8	4303	NaN	2017	101	1	1	8	18	6.00	0.00	...	
9	4303	NaN	2017	101	2	1	8	4	1.00	0.00	...	
10	4303	NaN	2017	101	1	1	8	1864	1.00	0.00	...	

	Country	SubDiv	Year	List	Sex	Frmat	IM_Frmat	Deaths1	Deaths2	Deaths3	...	D
11	4303	NaN	2017	101	2	1	8	417	0.00	0.00	...	
12	4303	NaN	2017	101	1	1	8	1186	0.00	0.00	...	
13	4303	NaN	2017	101	2	1	8	268	1.00	1.00	...	
14	4303	NaN	2017	101	1	1	8	0	0.00	0.00	...	
15	4303	NaN	2017	101	2	1	8	0	0.00	0.00	...	
16	4303	NaN	2017	101	1	1	8	1	0.00	0.00	...	
17	4303	NaN	2017	101	2	1	8	4	0.00	0.00	...	
18	4303	NaN	2017	101	1	1	8	0	0.00	0.00	...	
19	4303	NaN	2017	101	2	1	8	0	0.00	0.00	...	

20 rows × 37 columns

In [7]:

```python
# general overview of dataset characteristics
df.describe().T
```

Out[7]:

	count	mean	std	min	25%	50%	75%	max
Country	610184.00	3372.06	969.38	1125.00	2310.00	4010.00	4210.00	5198.00
Year	610184.00	2018.15	0.99	2017.00	2017.00	2018.00	2019.00	2020.00
List	610184.00	103.92	0.32	101.00	104.00	104.00	104.00	104.00
Sex	610184.00	1.50	0.67	1.00	1.00	1.00	2.00	9.00
Frmat	610184.00	0.16	0.63	0.00	0.00	0.00	0.00	9.00
IM_Frmat	610184.00	2.02	2.46	1.00	1.00	1.00	1.00	9.00
Deaths1	610184.00	201.33	7401.58	0.00	1.00	3.00	13.00	1473823.00
Deaths2	608592.00	2.50	110.72	0.00	0.00	0.00	0.00	20964.00
Deaths3	608592.00	0.26	11.90	0.00	0.00	0.00	0.00	2663.00
Deaths4	594046.00	0.15	6.99	0.00	0.00	0.00	0.00	1519.00
Deaths5	594046.00	0.11	4.94	0.00	0.00	0.00	0.00	1119.00

	count	mean	std	min	25%	50%	75%	max
Deaths6	594046.00	0.09	4.00	0.00	0.00	0.00	0.00	873.00
Deaths7	608592.00	0.33	14.70	0.00	0.00	0.00	0.00	2982.00
Deaths8	608194.00	0.37	15.81	0.00	0.00	0.00	0.00	2828.00
Deaths9	608592.00	0.96	51.11	0.00	0.00	0.00	0.00	17763.00
Deaths10	608194.00	1.48	78.95	0.00	0.00	0.00	0.00	24445.00
Deaths11	608592.00	1.83	91.10	0.00	0.00	0.00	0.00	21425.00
Deaths12	608194.00	2.37	113.20	0.00	0.00	0.00	0.00	25135.00
Deaths13	608592.00	3.09	141.96	0.00	0.00	0.00	0.00	34168.00
Deaths14	608194.00	3.91	168.98	0.00	0.00	0.00	0.00	40125.00
Deaths15	608592.00	5.29	215.27	0.00	0.00	0.00	0.00	44424.00
Deaths16	608194.00	7.52	300.88	0.00	0.00	0.00	1.00	63581.00
Deaths17	608592.00	11.07	454.88	0.00	0.00	0.00	1.00	98387.00
Deaths18	608194.00	14.64	595.65	0.00	0.00	0.00	1.00	130870.00
Deaths19	608592.00	17.89	696.98	0.00	0.00	0.00	1.00	150938.00
Deaths20	608194.00	19.15	717.37	0.00	0.00	0.00	1.00	169309.00
Deaths21	608592.00	24.12	900.68	0.00	0.00	0.00	1.00	176496.00
Deaths22	607847.00	28.42	1055.30	0.00	0.00	0.00	1.00	185065.00

	count	mean	std	min	25%	50%	75%	max
Deaths23	607847.00	32.94	1325.49	0.00	0.00	0.00	1.00	268423.00
Deaths24	540474.00	17.83	822.92	0.00	0.00	0.00	1.00	202170.00
Deaths25	540474.00	8.40	474.17	0.00	0.00	0.00	0.00	128337.00
Deaths26	608592.00	0.19	13.85	0.00	0.00	0.00	0.00	3560.00
IM_Deaths1	608592.00	1.01	60.52	0.00	0.00	0.00	0.00	19846.00
IM_Deaths2	516532.00	0.51	23.73	0.00	0.00	0.00	0.00	5676.00
IM_Deaths3	522331.00	0.41	22.23	0.00	0.00	0.00	0.00	5954.00
IM_Deaths4	522331.00	0.83	44.53	-1.00	0.00	0.00	0.00	10658.00

Data Visualization and Preprocessing

Look for Missing and NAN Values

In [8]:

```python
# check for null or missing values
df.isnull().sum()
```

Out[8]:

```
Country           0
SubDiv       606253
Year              0
List              0
Sex               0
Frmat             0
IM_Frmat          0
Deaths1           0
Deaths2        1592
Deaths3        1592
Deaths4       16138
Deaths5       16138
Deaths6       16138
Deaths7        1592
Deaths8        1990
Deaths9        1592
Deaths10       1990
Deaths11       1592
Deaths12       1990
Deaths13       1592
```

```
Deaths14         1990
Deaths15         1592
Deaths16         1990
Deaths17         1592
Deaths18         1990
Deaths19         1592
Deaths20         1990
Deaths21         1592
Deaths22         2337
Deaths23         2337
Deaths24        69710
Deaths25        69710
Deaths26         1592
IM_Deaths1       1592
IM_Deaths2      93652
IM_Deaths3      87853
IM_Deaths4      87853
dtype: int64
```

There are several columns that have missing values. We will replace these values with zero

In [9]:

```
df.columns.isna()
```

Out[9]:

```
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])
```

In [10]:

```
# inplace
df.replace(np.nan, 0, inplace=True)
df.head(30)
```

Out[10]:

	Country	SubDiv	Year	List	Sex	Frmat	IM_Frmat	Deaths1	Deaths2	Deaths3	...	Death
0	4303	0	2017	101	1	1	8	281784	1608.00	133.00	...	43174
1	4303	0	2017	101	2	1	8	292339	1178.00	99.00	...	56037
2	4303	0	2017	101	1	1	8	6198	41.00	11.00	...	62
3	4303	0	2017	101	2	1	8	2516	29.00	7.00	...	86
4	4303	0	2017	101	1	1	8	0	0.00	0.00	...	0
5	4303	0	2017	101	2	1	8	0	0.00	0.00	...	0
6	4303	0	2017	101	1	1	8	1	0.00	0.00	...	0
7	4303	0	2017	101	2	1	8	1	0.00	0.00	...	0
8	4303	0	2017	101	1	1	8	18	6.00	0.00	...	1
9	4303	0	2017	101	2	1	8	4	1.00	0.00	...	0
10	4303	0	2017	101	1	1	8	1864	1.00	0.00	...	27

	Country	SubDiv	Year	List	Sex	Frmat	IM_Frmat	Deaths1	Deaths2	Deaths3	...	Death
11	4303	0	2017	101	2	1	8	417	0.00	0.00	...	33
12	4303	0	2017	101	1	1	8	1186	0.00	0.00	...	18
13	4303	0	2017	101	2	1	8	268	1.00	1.00	...	11
14	4303	0	2017	101	1	1	8	0	0.00	0.00	...	0
15	4303	0	2017	101	2	1	8	0	0.00	0.00	...	0
16	4303	0	2017	101	1	1	8	1	0.00	0.00	...	0
17	4303	0	2017	101	2	1	8	4	0.00	0.00	...	1
18	4303	0	2017	101	1	1	8	0	0.00	0.00	...	0
19	4303	0	2017	101	2	1	8	0	0.00	0.00	...	0
20	4303	0	2017	101	1	1	8	1	1.00	0.00	...	0
21	4303	0	2017	101	2	1	8	1	1.00	0.00	...	0
22	4303	0	2017	101	1	1	8	32	11.00	8.00	...	0
23	4303	0	2017	101	2	1	8	17	4.00	1.00	...	0
24	4303	0	2017	101	1	1	8	250	10.00	3.00	...	7
25	4303	0	2017	101	2	1	8	160	11.00	3.00	...	14
26	4303	0	2017	101	1	1	8	12	0.00	0.00	...	0
27	4303	0	2017	101	2	1	8	3	0.00	0.00	...	0

	Country	SubDiv	Year	List	Sex	Frmat	IM_Frmat	Deaths1	Deaths2	Deaths3	...	Death
28	4303	0	2017	101	1	1	8	0	0.00	0.00	...	0
29	4303	0	2017	101	2	1	8	0	0.00	0.00	...	0

30 rows × 37 columns

In [11]:

```
# check for null or missing values
df.isnull().sum()
```

Out[11]:

```
Country      0
SubDiv       0
Year         0
List         0
Sex          0
Frmat        0
IM_Frmat     0
Deaths1      0
Deaths2      0
Deaths3      0
Deaths4      0
Deaths5      0
Deaths6      0
Deaths7      0
Deaths8      0
Deaths9      0
Deaths10     0
Deaths11     0
Deaths12     0
Deaths13     0
```

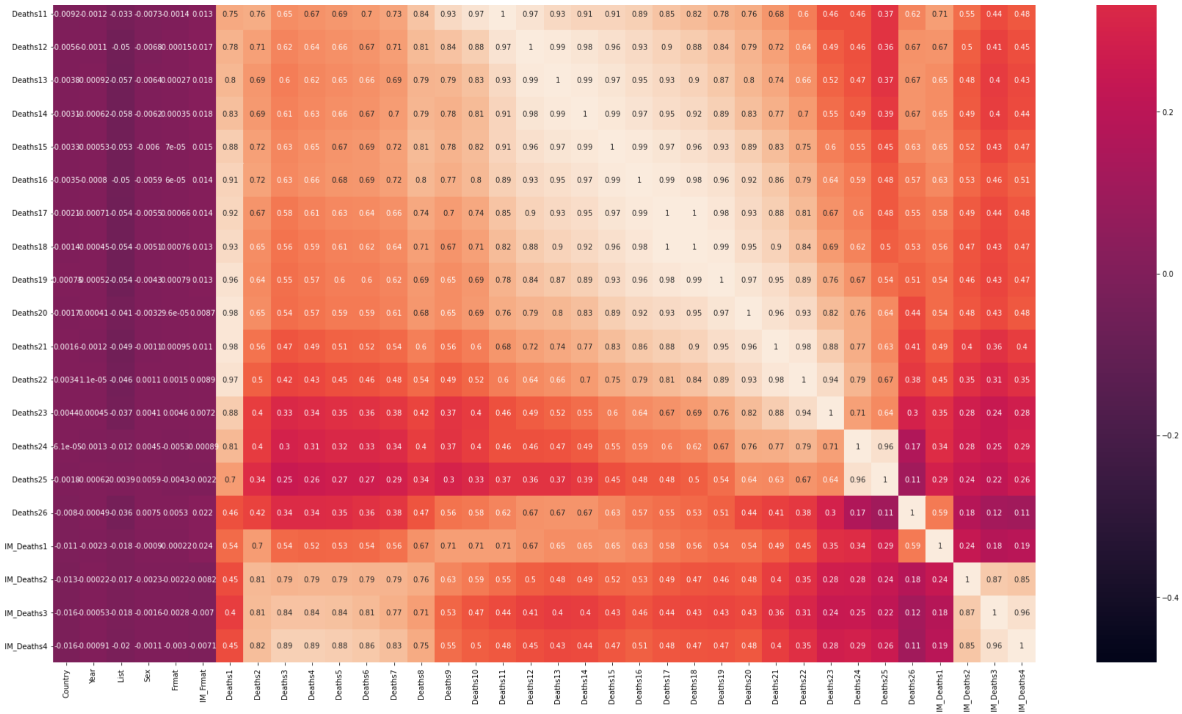
```
Deaths14      0
Deaths15      0
Deaths16      0
Deaths17      0
Deaths18      0
Deaths19      0
Deaths20      0
Deaths21      0
Deaths22      0
Deaths23      0
Deaths24      0
Deaths25      0
Deaths26      0
IM_Deaths1    0
IM_Deaths2    0
IM_Deaths3    0
IM_Deaths4    0
dtype: int64
```

In [12]:

```
#heatmap
plt.figure(figsize=(30,30))
cor_map = df.corr()
sns.heatmap(cor_map, annot=True)
```

Out[12]:

```
<AxesSubplot:>
```


Deaths11
Deaths12
Deaths13
Deaths14
Deaths15
Deaths16
Deaths17
Deaths18
Deaths19
Deaths20
Deaths21
Deaths22
Deaths23
Deaths24
Deaths25
Deaths26
IM_Deaths1
IM_Deaths2
IM_Deaths3
IM_Deaths4
Country
Year
List
Sex
Frmat
IM_Frmat
Deaths1
Deaths2
Deaths3
Deaths4
Deaths5
Deaths6
Deaths7
Deaths8
Deaths9
Deaths10
Deaths11
Deaths12
Deaths13
Deaths14
Deaths15
Deaths16
Deaths17
Deaths18
Deaths19
Deaths20
Deaths21
Deaths22
Deaths23
Deaths24
Deaths25
Deaths26
IM_Deaths1
IM_Deaths2
IM_Deaths3
IM_Deaths4
0.2
0.0
−0.2
−0.4

In [13]:

```python
# check data type of each columns for further processing
df.dtypes
```

Out[13]:

```
Country         int64
SubDiv         object
Year            int64
List            int64
Sex             int64
Frmat           int64
IM_Frmat        int64
Deaths1         int64
Deaths2       float64
Deaths3       float64
Deaths4       float64
Deaths5       float64
Deaths6       float64
Deaths7       float64
Deaths8       float64
Deaths9       float64
Deaths10      float64
Deaths11      float64
Deaths12      float64
Deaths13      float64
```

```
Deaths14       float64
Deaths15       float64
Deaths16       float64
Deaths17       float64
Deaths18       float64
Deaths19       float64
Deaths20       float64
Deaths21       float64
Deaths22       float64
Deaths23       float64
Deaths24       float64
Deaths25       float64
Deaths26       float64
IM_Deaths1     float64
IM_Deaths2     float64
IM_Deaths3     float64
IM_Deaths4     float64
dtype: object
```

Heatmap shows correlation of each attribute values amonst each other.

In [14]:

```
output_columns=['Deaths1','Deaths2','Deaths3','Deaths4','Deaths5','Deaths6','Deaths7','Deat
       'Deaths11','Deaths12','Deaths13','Deaths14','Deaths15','Deaths16','Deaths17','Deaths
       'Deaths21','Deaths22','Deaths23','Deaths24','Deaths25','Deaths26']
```

In [15]:

```
numerical_features = [features for features in df.columns if len(df[features].unique())!=3]
categorical_features = [features for features in df.columns if features not in numerical_fe
```

In [16]:

```
numerical_features
```

Out[16]:

```
['Country',
 'Year',
 'Frmat',
 'IM_Frmat',
 'Deaths1',
 'Deaths2',
 'Deaths3',
 'Deaths4',
 'Deaths5',
 'Deaths6',
 'Deaths7',
 'Deaths8',
 'Deaths9',
 'Deaths10',
 'Deaths11',
 'Deaths12',
 'Deaths13',
 'Deaths14',
 'Deaths15',
 'Deaths16',
 'Deaths17',
```

```
 'Deaths18',
 'Deaths19',
 'Deaths20',
 'Deaths21',
 'Deaths22',
 'Deaths23',
 'Deaths24',
 'Deaths25',
 'Deaths26',
 'IM_Deaths1',
 'IM_Deaths2',
 'IM_Deaths3',
 'IM_Deaths4']
```

In [17]:

```
categorical_features
```

Out[17]:

```
['SubDiv', 'List', 'Sex']
```

Split Dataset into Train and Test Set

In [18]:

```
# split dataset into train and test set
X = df.drop(columns=output_columns, axis = 1)
Y = df[output_columns]
X.head()
```

Out[18]:

	Country	SubDiv	Year	List	Sex	Frmat	IM_Frmat	IM_Deaths1	IM_Deaths2	IM_Deaths3	I
0	4303	0	2017	101	1	1	8	1608.00	0.00	0.00	
1	4303	0	2017	101	2	1	8	1178.00	0.00	0.00	
2	4303	0	2017	101	1	1	8	41.00	0.00	0.00	
3	4303	0	2017	101	2	1	8	29.00	0.00	0.00	
4	4303	0	2017	101	1	1	8	0.00	0.00	0.00	

In [19]:

```
Y.head()
```

Out[19]:

	Deaths1	Deaths2	Deaths3	Deaths4	Deaths5	Deaths6	Deaths7	Deaths8	Deaths9	Deaths
0	281784	1608.00	133.00	87.00	77.00	60.00	214.00	254.00	633.00	1492.(
1	292339	1178.00	99.00	59.00	47.00	36.00	177.00	148.00	257.00	416.(
2	6198	41.00	11.00	7.00	4.00	7.00	7.00	7.00	10.00	41.(
3	2516	29.00	7.00	4.00	5.00	3.00	6.00	5.00	13.00	27.(
4	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.(

5 rows × 26 columns

In [20]:

```
# Dataset is split into 80:20 ratio in which 80% of the total is allocated for training set
X_train, X_test, y_train, y_test = train_test_split(X, Y, test_size=0.2, random_state=24)
```

In [21]:

```
X_train.dtypes
```

Out[21]:

```
Country         int64
SubDiv         object
Year            int64
List            int64
Sex             int64
Frmat           int64
IM_Frmat        int64
IM_Deaths1    float64
IM_Deaths2    float64
IM_Deaths3    float64
IM_Deaths4    float64
dtype: object
```

le = MultiColumnLabelEncoder() encoded_dataframe = le.fit_transform(dataframe)

[Note: columns argument can also be passed if we want encoding only for certain columns. By default it will be none and it will encode all the categorical columns]

In [22]:

```python
class MultiColumnLabelEncoder:
    def __init__(self,columns = None):
        self.columns = columns

    def fit(self,X,y=None):
        return self

    def transform(self,X):
        output = X.copy()
        if self.columns is not None:
            for col in self.columns:
                output[col] = LabelEncoder().fit_transform(output[col])
        else:
            for colname,col in output.iteritems():
                output[colname] = LabelEncoder().fit_transform(col)
        return output

    def fit_transform(self,X,y=None):
        return self.fit(X,y).transform(X)
```

In [23]:

```
#MultiColumnLabelEncoder(columns = ['SubDiv','Cause']).fit_transform(X_train)
```

In [24]:

```
# Normalize input feature vector using standard scalar
le = LabelEncoder()
X_train['SubDiv'] = le.fit_transform(X_train['SubDiv'].astype(str))
X_test['SubDiv'] = le.fit_transform(X_test['SubDiv'].astype(str))
```

In [25]:

```
# Normalize input feature vector using standard scalar
scalar = StandardScaler()
X_train = scalar.fit_transform(X_train)
X_test = scalar.fit_transform(X_test)
```

In [26]:

```
X_train = np.array(X_train)
y_train = np.array(y_train)
X_test = np.array(X_test)
y_test = np.array(y_test)

# print shape
print("x train Shape",X_train.shape)
print("y train Shape",y_train.shape)
print("x test Shape",X_test.shape)
print("y test Shape",y_test.shape)
```

```
x train Shape (488147, 11)
y train Shape (488147, 26)
x test Shape (122037, 11)
y test Shape (122037, 26)
```

Train Linear Regression Model

In [27]:

```
x_train = X_train
x_test = X_test
```

In [28]:

```
## Train Linear Regression Model

linear_model = LinearRegression()
linear_model.fit(x_train,y_train)
pred = linear_model.predict(x_train)

print("Performace of trained model on Training Data")
print("=============================================")

mse_linear =  mean_squared_error(y_train,pred)
print("MSE: ",np.round(mse_linear,2))

rmse_linear = np.sqrt(mean_squared_error(y_train, pred))
print("RMSE: ",np.round(rmse_linear,2))

mae_linear = mean_absolute_error(y_train,pred)
print("MAE: ",np.round(mae_linear,2))

r2_linear = r2_score(y_train,pred)
print ("R2: ",np.round(r2_linear,2))

print ("Score (train): ",np.round(linear_model.score(x_train, y_train),2))
```

```
Performace of trained model on Training Data
```

```
=============================================
MSE:  1349387.55
RMSE:  1161.63
MAE:  27.85
R2:  0.58
Score (train):  0.58
```

In [30]:

```
pred = linear_model.predict(x_test)
print("Performace of trained model on Testing Data")
print("===========================================")

mse_linear =  mean_squared_error(y_test,pred)
print("MSE: ",np.round(mse_linear,2))

rmse_linear = np.sqrt(mean_squared_error(y_test, pred))
print("RMSE: ",np.round(rmse_linear,2))

mae_linear = mean_absolute_error(y_test,pred)
print("MAE: ",np.round(mae_linear,2))

r2_linear = r2_score(y_test,pred)
print ("R2: ",np.round(r2_linear,2))

print ("Score (test): ",np.round(linear_model.score(x_test, y_test),2))
```

```
Performace of trained model on Testing Data
===========================================
MSE:  1336808.71
RMSE:  1156.2
MAE:  27.8
R2:  0.59
Score (test):  0.59
```

Train GradientBoosting Regressor

In [33]:

```
from sklearn.ensemble import GradientBoostingRegressor
from sklearn.multioutput import MultiOutputRegressor
## Train GradientBoosting Regression Model

gbr_model = GradientBoostingRegressor()
gbr_model=MultiOutputRegressor(gbr_model)
gbr_model.fit(x_train,y_train)
pred = gbr_model.predict(x_train)

print("Performace of trained model on Training Data")
print("==============================================")

mse_gbr =  mean_squared_error(y_train,pred)
print("MSE: ",np.round(mse_gbr,2))

rmse_gbr = np.sqrt(mean_squared_error(y_train, pred))
print("RMSE: ",np.round(rmse_gbr,2))

mae_gbr = mean_absolute_error(y_train,pred)
print("MAE: ",np.round(mae_gbr,2))

r2_gbr = r2_score(y_train,pred)
print ("R2: ",np.round(r2_gbr,2))

print ("Score (train): ",np.round(gbr_model.score(x_train, y_train),2))
```

```
Performace of trained model on Training Data
=============================================
MSE:  238888.23
RMSE:  488.76
MAE:  15.39
R2:  0.92
Score (train):  0.92
```

In [34]:

```
pred = gbr_model.predict(x_test)

print("Performace of trained model on Testing Data")
print("============================================")

mse_gbr =  mean_squared_error(y_test,pred)
print("MSE: ",np.round(mse_gbr,2))

rmse_gbr = np.sqrt(mean_squared_error(y_test, pred))
print("RMSE: ",np.round(rmse_gbr,2))

mae_gbr = mean_absolute_error(y_test,pred)
print("MAE: ",np.round(mae_gbr,2))

r2_gbr = r2_score(y_test,pred)
print ("R2: ",np.round(r2_gbr,2))

print ("Score (test): ",np.round(gbr_model.score(x_test, y_test),2))
```

```
Performace of trained model on Testing Data
============================================
MSE:  366270.29
RMSE:  605.2
MAE:  16.96
```

```
R2:  0.79
Score (test):  0.79
```

In [35]:

```
# set path to save model here

pickle.dump(gbr_model,open('D:/Freelancing/Mortality Detection/Saved Model/gbr.pkl','wb'))
```

Train Ridge Regression Model

In [36]:

```
ridge_model = Ridge()
ridge_model.fit(x_train,y_train)
pred = ridge_model.predict(x_train)

print("Performace of trained model on Training Data")
print("=============================================")

mse_ridge =  mean_squared_error(y_train,pred)
print("MSE: ",np.round(mse_ridge,2))

rmse_ridge = np.sqrt(mean_squared_error(y_train, pred))
print("RMSE: ",np.round(rmse_ridge,2))

mae_ridge = mean_absolute_error(y_train,pred)
print("MAE: ",np.round(mae_ridge,2))

r2_ridge = r2_score(y_train,pred)
print ("R2: ",np.round(r2_ridge,2))

print ("Score (train): ",np.round(ridge_model.score(x_train, y_train),2))
```

```
Performace of trained model on Training Data
=============================================
MSE:  1349387.55
```

```
RMSE:  1161.63
MAE:  27.85
R2:  0.58
Score (train):  0.58
```

In [37]:

```
pred = ridge_model.predict(x_test)

print("Performace of trained model on Testing Data")
print("============================================")

mse_gbr =  mean_squared_error(y_test,pred)
print("MSE: ",np.round(mse_gbr,2))

rmse_gbr = np.sqrt(mean_squared_error(y_test, pred))
print("RMSE: ",np.round(rmse_gbr,2))

mae_gbr = mean_absolute_error(y_test,pred)
print("MAE: ",np.round(mae_gbr,2))

r2_gbr = r2_score(y_test,pred)
print ("R2: ",np.round(r2_gbr,2))

print ("Score (test): ",np.round(ridge_model.score(x_test, y_test),2))
```

```
Performace of trained model on Testing Data
============================================
MSE:  1336810.4
RMSE:  1156.21
MAE:  27.8
```

```
R2:  0.59
Score (test):  0.59
```

Train Lasso Regression Model

In [38]:

```python
lasso_model = Lasso()
lasso_model.fit(x_train,y_train)
pred = lasso_model.predict(x_train)

print("Performace of trained model on Training Data")
print("=============================================")

mse_lasso =  mean_squared_error(y_train,pred)
print("MSE: ",np.round(mse_lasso,2))

rmse_lasso = np.sqrt(mean_squared_error(y_train, pred))
print("RMSE: ",np.round(rmse_lasso,2))

mae_lasso = mean_absolute_error(y_train,pred)
print("MAE: ",np.round(mae_lasso,2))

r2_lasso = r2_score(y_train,pred)
print ("R2: ",np.round(r2_lasso,2))

print ("Score (train): ",np.round(lasso_model.score(x_train, y_train),2))
```

```
Performace of trained model on Training Data
=============================================
MSE:  1349428.81
```

```
RMSE:  1161.65
MAE:  26.8
R2:  0.57
Score (train):  0.57
```

In [39]:

```python
pred = lasso_model.predict(x_test)

print("Performace of trained model on Testing Data")
print("============================================")

mse_gbr =  mean_squared_error(y_test,pred)
print("MSE: ",np.round(mse_gbr,2))

rmse_gbr = np.sqrt(mean_squared_error(y_test, pred))
print("RMSE: ",np.round(rmse_gbr,2))

mae_gbr = mean_absolute_error(y_test,pred)
print("MAE: ",np.round(mae_gbr,2))

r2_gbr = r2_score(y_test,pred)
print ("R2: ",np.round(r2_gbr,2))

print ("Score (test): ",np.round(lasso_model.score(x_test, y_test),2))
```

```
Performace of trained model on Testing Data
============================================
MSE:  1337422.39
RMSE:  1156.47
MAE:  26.78
```

```
R2:  0.58
Score (test):  0.58
```

Train Random Forest Regressor

In [42]:

```python
from sklearn.ensemble import RandomForestRegressor

rf_model = RandomForestRegressor(n_estimators = 300)
rf_model.fit(x_train,y_train)
pred = rf_model.predict(x_train)

print("Performace of trained model on Training Data")
print("=============================================")

mse_rf =  mean_squared_error(y_train,pred)
print("MSE: ",np.round(mse_rf,2))

rmse_rf = np.sqrt(mean_squared_error(y_train, pred))
print("RMSE: ",np.round(rmse_rf,2))

mae_rf = mean_absolute_error(y_train,pred)
print("MAE: ",np.round(mae_rf,2))

r2_rf = r2_score(y_train,pred)
print ("R2: ",np.round(r2_rf,2))

print ("Score (train): ",np.round(rf_model.score(x_train, y_train),2))
```

```
Performace of trained model on Training Data
```

```
==============================================
MSE:  103814.92
RMSE:  322.2
MAE:  11.58
R2:  0.95
Score (train):  0.95
```

In [43]:

```
pred = rf_model.predict(x_test)

print("Performace of trained model on Testing Data")
print("============================================")

mse_gbr =  mean_squared_error(y_test,pred)
print("MSE: ",np.round(mse_gbr,2))

rmse_gbr = np.sqrt(mean_squared_error(y_test, pred))
print("RMSE: ",np.round(rmse_gbr,2))

mae_gbr = mean_absolute_error(y_test,pred)
print("MAE: ",np.round(mae_gbr,2))

r2_gbr = r2_score(y_test,pred)
print ("R2: ",np.round(r2_gbr,2))

print ("Score (test): ",np.round(rf_model.score(x_test, y_test),2))
```

```
Performace of trained model on Testing Data
============================================
MSE:  428002.18
RMSE:  654.22
MAE:  15.88
```

```
R2:  0.74
Score (test):  0.74
```

In [45]:

```
# set path to save model here

pickle.dump(rf_model,open('D:/Freelancing/Mortality Detection/Saved Model/rf.pkl','wb'))
```

Train Decision Tree Regressor

In [46]:

```python
from sklearn.tree import DecisionTreeRegressor

dt_model = DecisionTreeRegressor()
dt_model.fit(x_train,y_train)
pred = dt_model.predict(x_train)

print("Performace of trained model on Training Data")
print("==============================================")

mse_rf =  mean_squared_error(y_train,pred)
print("MSE: ",np.round(mse_rf,2))

rmse_rf = np.sqrt(mean_squared_error(y_train, pred))
print("RMSE: ",np.round(rmse_rf,2))

mae_rf = mean_absolute_error(y_train,pred)
print("MAE: ",np.round(mae_rf,2))

r2_rf = r2_score(y_train,pred)
print ("R2: ",np.round(r2_rf,2))

print ("Score (train): ",np.round(dt_model.score(x_train, y_train),2))
```

```
Performace of trained model on Training Data
```

```
=============================================
MSE:  65196.21
RMSE:  255.34
MAE:  9.94
R2:  0.98
Score (train):  0.98
```

In [47]:

```
pred = dt_model.predict(x_test)

print("Performace of trained model on Testing Data")
print("============================================")

mse_dt =  mean_squared_error(y_test,pred)
print("MSE: ",np.round(mse_dt,2))

rmse_dt = np.sqrt(mean_squared_error(y_test, pred))
print("RMSE: ",np.round(rmse_dt,2))

mae_dt = mean_absolute_error(y_test,pred)
print("MAE: ",np.round(mae_dt,2))

r2_dt = r2_score(y_test,pred)
print ("R2: ",np.round(r2_dt,2))

print ("Score (test): ",np.round(dt_model.score(x_test, y_test),2))
```

```
Performace of trained model on Testing Data
============================================
MSE:  651022.45
RMSE:  806.86
MAE:  16.47
```

```
R2:  0.62
Score (test):  0.62
```

Train Extra Tree Regressor

In [49]:

```
from sklearn.ensemble import ExtraTreesRegressor

et_model = ExtraTreesRegressor()
et_model.fit(x_train,y_train)
pred = et_model.predict(x_train)

print("Performace of trained model on Training Data")
print("==============================================")

mse_et =  mean_squared_error(y_train,pred)
print("MSE: ",np.round(mse_et,2))

rmse_et = np.sqrt(mean_squared_error(y_train, pred))
print("RMSE: ",np.round(rmse_et,2))

mae_et = mean_absolute_error(y_train,pred)
print("MAE: ",np.round(mae_et,2))

r2_et = r2_score(y_train,pred)
print ("R2: ",np.round(r2_et,2))

print ("Score (train): ",np.round(et_model.score(x_train, y_train),2))
```

```
Performace of trained model on Training Data
```

```
=============================================
MSE:  65196.21
RMSE:  255.34
MAE:  9.94
R2:  0.98
Score (train):  0.98
```

In [51]:

```python
pred = et_model.predict(x_test)

print("Performace of trained model on Testing Data")
print("============================================")

mse_et =  mean_squared_error(y_test,pred)
print("MSE: ",np.round(mse_et,2))

rmse_et = np.sqrt(mean_squared_error(y_test, pred))
print("RMSE: ",np.round(rmse_et,2))

mae_et = mean_absolute_error(y_test,pred)
print("MAE: ",np.round(mae_et,2))

r2_et = r2_score(y_test,pred)
print ("R2: ",np.round(r2_et,2))

print ("Score (test): ",np.round(et_model.score(x_test, y_test),2))
```

```
Performace of trained model on Testing Data
============================================
MSE:  526791.79
RMSE:  725.8
MAE:  15.75
```

```
R2:  0.83
Score (test):  0.83
```

In [52]:

```
# set path to save model here

pickle.dump(et_model,open('D:/Freelancing/Mortality Detection/Saved Model/et.pkl','wb'))
```

Application Phase

In [57]:

```
# Take input from the user
country = int (input("Enter country: "))
subDiV = input ("Enter SubDiV: ")
cause = input ("Cause of death: ")
year = int (input("Enter Year (Year to which data refer): "))
List = int (input("Enter List of ICD revision used : "))
gender = int (input("Enter Gender (1 male, 2 female and 9 sex unspecified): "))
Frmat = int (input ("Enter Frmat (Age-group format for breakdown of deaths at 0-95+ yrs): "
IM_Frmat = int (input ("Enter IM_Frmat (Age format for breakdown of infant deaths (0 year))
IM_deaths1 = float(input ("Enter Number of Infant deaths at age 0 day: "))
IM_deaths2 = float(input ("Enter Number of Infant deaths at age 1-6 day: "))
IM_deaths3 = float(input ("Enter Number of Infant deaths at age 7-27 day: "))
IM_deaths4 = float(input ("Enter Number of Infant deaths at age 28-364 day: "))
```

```
Enter country: 4303
Enter SubDiV: 0
Cause of death: 1000
Enter Year (Year to which data refer): 2017
Enter List of ICD revision used : 101
Enter Gender (1 male, 2 female and 9 sex unspecified): 1
Enter Frmat (Age-group format for breakdown of deaths at 0-95+ yrs): 1
Enter IM_Frmat (Age format for breakdown of infant deaths (0 year)): 8
Enter Number of Infant deaths at age 0 day: 20
```

```
Enter Number of Infant deaths at age 1-6 day: 10
Enter Number of Infant deaths at age 7-27 day: 5
Enter Number of Infant deaths at age 28-364 day: 2
```

In [58]:

```
# convert into pandas dataframe

user_input = pd.DataFrame({ 'Country': [country],'SubDiV': [subDiV],'Year': [year],'List':
                          ,'Frmat': [Frmat],'IM_Frmat': [IM_Frmat],'IM_Deaths1': [IM_deaths
                          'IM_Deaths3': [IM_deaths3],'IM_Deaths4': [IM_deaths4]})

print("\n\nUser Input Feature Vector:")
print("==========================\n")
print(user_input)
```

```
User Input Feature Vector:
==========================

   Country SubDiV  Year  List  Sex  Frmat  IM_Frmat  IM_Deaths1  IM_Deaths2  \
0     4303      0  2017   101    1      1         8       20.00       10.00

   IM_Deaths3  IM_Deaths4
0        5.00        2.00
```

In [59]:

```
user_input.dtypes
```

Out[59]:

```
Country          int64
SubDiV          object
Year             int64
List             int64
Sex              int64
Frmat            int64
IM_Frmat         int64
IM_Deaths1     float64
IM_Deaths2     float64
IM_Deaths3     float64
IM_Deaths4     float64
dtype: object
```

In [60]:

```
# load trained model

model = pickle.load(open('D:/Freelancing/Mortality Detection/Saved Model/et.pkl','rb')) # s
```

In [62]:

```
#le = LabelEncoder()
user_input['SubDiV'] = le.transform(user_input['SubDiV'].astype(str))
```

In [63]:

```
# convert into numpy arrays
user_input = np.array(user_input)
```

In [64]:

```
pred = model.predict(user_input)

print("Predicted Values: ")
print("====================\n")
print("Deaths 1 = ",pred[0][0])
print("Deaths 2 = ",pred[0][1])
print("Deaths 3 = ",pred[0][2])
print("Deaths 4 = ",pred[0][3])
print("Deaths 5 = ",pred[0][4])
print("Deaths 6 = ",pred[0][5])
print("Deaths 7 = ",pred[0][6])
print("Deaths 8 = ",pred[0][7])
print("Deaths 9 = ",pred[0][8])
print("Deaths 10 = ",pred[0][9])
print("Deaths 11 = ",pred[0][10])
print("Deaths 12 = ",pred[0][11])
print("Deaths 13 = ",pred[0][12])
print("Deaths 14 = ",pred[0][13])
print("Deaths 15 = ",pred[0][14])
print("Deaths 16 = ",pred[0][15])
print("Deaths 17 = ",pred[0][16])
print("Deaths 18 = ",pred[0][17])
print("Deaths 19 = ",pred[0][18])
print("Deaths 20 = ",pred[0][19])
print("Deaths 21 = ",pred[0][20])
```

```python
print("Deaths 22 = ",pred[0][21])
print("Deaths 23 = ",pred[0][22])
print("Deaths 24 = ",pred[0][23])
print("Deaths 25 = ",pred[0][24])
print("Deaths 26 = ",pred[0][25])
```

```
Predicted Values:
====================

Deaths 1 =  151866.48
Deaths 2 =  1109.07
Deaths 3 =  83.67
Deaths 4 =  37.56
Deaths 5 =  29.45
Deaths 6 =  20.98
Deaths 7 =  95.98
Deaths 8 =  102.85
Deaths 9 =  231.08
Deaths 10 =  392.78
Deaths 11 =  582.49
Deaths 12 =  850.64
Deaths 13 =  1180.75
Deaths 14 =  1592.06
Deaths 15 =  2355.79
Deaths 16 =  3725.59
Deaths 17 =  5903.05
Deaths 18 =  8097.23
```

```
Deaths 19 =  10819.33
Deaths 20 =  13095.52
Deaths 21 =  19587.78
Deaths 22 =  24903.24
Deaths 23 =  41795.13
Deaths 24 =  9941.38
Deaths 25 =  5330.45
Deaths 26 =  2.63
```

In [67]:

```
# Use pretty table to show detail analysis
x = PrettyTable()
print("\nDetailed Performance of all Models")
print("==================================\n")
x.field_names=["Model","MSE", "MAE", "RMSE", "R2"]
x.add_row(["Linear Regression",np.round(mse_linear,2), np.round(mae_linear,2), np.round(rms
x.add_row(["Gadient Boosting Regression",366270.29, 605.2, 16.96, 0.79])
x.add_row(["Ridge Regression",np.round(mse_ridge,2), np.round(mae_ridge,2), np.round(rmse_r
x.add_row(["Lasso Regression",np.round(mse_lasso,2), np.round(mae_lasso,2), np.round(rmse_l
x.add_row(["Random Forest Regression",428002.18, 654.22, 15.88, 0.74])
x.add_row(["Decision Tree Regression",np.round(mse_dt,2), np.round(mae_dt,2), np.round(rmse
x.add_row(["Extra Regression",np.round(mse_et,2), np.round(mae_et,2), np.round(rmse_et,2),

print(x)

print("\nBest Model")
print("==========\n")
y = PrettyTable()
y.field_names=["Model","MSE", "MAE", "RMSE", "R2"]
y.add_row(["Extra Regression",np.round(mse_et,2), np.round(mae_et,2), np.round(rmse_et,2),
print(y)
```

Detailed Performance of all Models
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Model	MSE	MAE	RMSE	R2
Linear Regression	1336808.71	27.8	1156.2	0.59
Gadient Boosting Regression	366270.29	605.2	16.96	0.79
Ridge Regression	1349387.55	27.85	1161.63	0.58
Lasso Regression	1349428.81	26.8	1161.65	0.57
Random Forest Regression	428002.18	654.22	15.88	0.74
Decision Tree Regression	651022.45	16.47	806.86	0.62
Extra Regression	526791.79	15.75	725.8	0.83

Best Model
============

Model	MSE	MAE	RMSE	R2
Extra Regression	526791.79	15.75	725.8	0.83