

In [1]:

```
1 import pandas as pd
2 import numpy as np
3 import matplotlib.pyplot as plt
4 import seaborn as sns
5 from IPython import get_ipython
6 import warnings
7 warnings.filterwarnings("ignore")
```

In [2]:

```
1 fetal_data = pd.read_csv('fetal_health.csv')
```

In [3]:

```
1 fetal_data.head()
```

Out[3]:

	baseline value	accelerations	fetal_movement	uterine_contractions	light_decelerations	severe_dece
0	120	0.000	0.0	0.000	0.000	
1	132	0.006	0.0	0.006	0.003	
2	133	0.003	0.0	0.008	0.003	
3	134	0.003	0.0	0.008	0.003	
4	132	0.007	0.0	0.008	0.000	

5 rows × 22 columns

In [4]:

```
1 fetal_data.tail()
```

Out[4]:

	baseline value	accelerations	fetal_movement	uterine_contractions	light_decelerations	severe_c
2121	140	0.000	0.000	0.007	0.0	
2122	140	0.001	0.000	0.007	0.0	
2123	140	0.001	0.000	0.007	0.0	
2124	140	0.001	0.000	0.006	0.0	
2125	142	0.002	0.002	0.008	0.0	

5 rows × 22 columns

In [5]:



```
1 fetal_data.shape
```

Out[5]:

```
(2126, 22)
```

In [6]:



```
1 fetal_data.columns
```

Out[6]:

```
Index(['baseline value', 'accelerations', 'fetal_movement',  
      'uterine_contractions', 'light_decelerations', 'severe_deceleration  
s',  
      'prolongued_decelerations', 'abnormal_short_term_variability',  
      'mean_value_of_short_term_variability',  
      'percentage_of_time_with_abnormal_long_term_variability',  
      'mean_value_of_long_term_variability', 'histogram_width',  
      'histogram_min', 'histogram_max', 'histogram_number_of_peaks',  
      'histogram_number_of_zeroes', 'histogram_mode', 'histogram_mean',  
      'histogram_median', 'histogram_variance', 'histogram_tendency',  
      'fetal_health'],  
      dtype='object')
```

In [7]:



```
1 fetal_data.duplicated().sum()
```

Out[7]:

```
13
```

In [8]:



```
1 fetal_data = fetal_data.drop_duplicates()
```

In [9]:



```
1 fetal_data.shape
```

Out[9]:

```
(2113, 22)
```

In [10]:



```
1 fetal_data.isnull().sum()
```

Out[10]:

baseline value	0
accelerations	0
fetal_movement	0
uterine_contractions	0
light_decelerations	0
severe_decelerations	0
prolongued_decelerations	0
abnormal_short_term_variability	0
mean_value_of_short_term_variability	0
percentage_of_time_with_abnormal_long_term_variability	0
mean_value_of_long_term_variability	0
histogram_width	0
histogram_min	0
histogram_max	0
histogram_number_of_peaks	0
histogram_number_of_zeroes	0
histogram_mode	0
histogram_mean	0
histogram_median	0
histogram_variance	0
histogram_tendency	0
fetal_health	0
dtype: int64	

In [11]:



```
1 fetal_data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 2113 entries, 0 to 2125
Data columns (total 22 columns):
 #   Column                                Non-Null Count
---  ---
 0   baseline value                        2113 non-null
int64
 1   accelerations                        2113 non-null
float64
 2   fetal_movement                       2113 non-null
float64
 3   uterine_contractions                 2113 non-null
float64
 4   light_decelerations                 2113 non-null
float64
 5   severe_decelerations                2113 non-null
float64
 6   prolonged_decelerations             2113 non-null
float64
 7   abnormal_short_term_variability     2113 non-null
int64
 8   mean_value_of_short_term_variability 2113 non-null
float64
 9   percentage_of_time_with_abnormal_long_term_variability 2113 non-null
int64
10   mean_value_of_long_term_variability  2113 non-null
float64
11   histogram_width                      2113 non-null
int64
12   histogram_min                       2113 non-null
int64
13   histogram_max                      2113 non-null
int64
14   histogram_number_of_peaks           2113 non-null
int64
15   histogram_number_of_zeroes         2113 non-null
int64
16   histogram_mode                     2113 non-null
int64
17   histogram_mean                     2113 non-null
int64
18   histogram_median                   2113 non-null
int64
19   histogram_variance                 2113 non-null
int64
20   histogram_tendency                 2113 non-null
int64
21   fetal_health                       2113 non-null
int64
dtypes: float64(8), int64(14)
memory usage: 379.7 KB
```

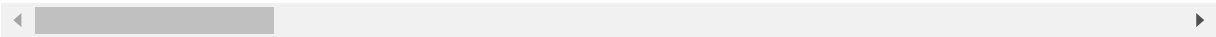
In [12]:

```
1 fetal_data.describe()
```

Out[12]:

	baseline value	accelerations	fetal_movement	uterine_contractions	light_decelerations	severe_decelerations
count	2113.000000	2113.000000	2113.000000	2113.000000	2113.000000	2113.000000
mean	133.304780	0.003188	0.009517	0.004387	0.001901	0.000000
std	9.837451	0.003871	0.046804	0.002941	0.002966	0.000000
min	106.000000	0.000000	0.000000	0.000000	0.000000	0.000000
25%	126.000000	0.000000	0.000000	0.002000	0.000000	0.000000
50%	133.000000	0.002000	0.000000	0.005000	0.000000	0.000000
75%	140.000000	0.006000	0.003000	0.007000	0.003000	0.000000
max	160.000000	0.019000	0.481000	0.015000	0.015000	0.000000

8 rows × 22 columns



In [13]:

```
1 fetal_data.nunique()
```

Out[13]:

baseline value	48
accelerations	20
fetal_movement	102
uterine_contractions	16
light_decelerations	16
severe_decelerations	2
prolongued_decelerations	6
abnormal_short_term_variability	75
mean_value_of_short_term_variability	57
percentage_of_time_with_abnormal_long_term_variability	87
mean_value_of_long_term_variability	249
histogram_width	154
histogram_min	109
histogram_max	86
histogram_number_of_peaks	18
histogram_number_of_zeroes	9
histogram_mode	88
histogram_mean	103
histogram_median	95
histogram_variance	133
histogram_tendency	3
fetal_health	3
dtype: int64	

In [14]:



```
1 fetal_data['fetal_health'].unique()
```

Out[14]:

```
array([2, 1, 3], dtype=int64)
```

In [15]:



```
1 fetal_data['fetal_health'].value_counts()
```

Out[15]:

```
1    1646
2     292
3     175
```

```
Name: fetal_health, dtype: int64
```

In [16]:

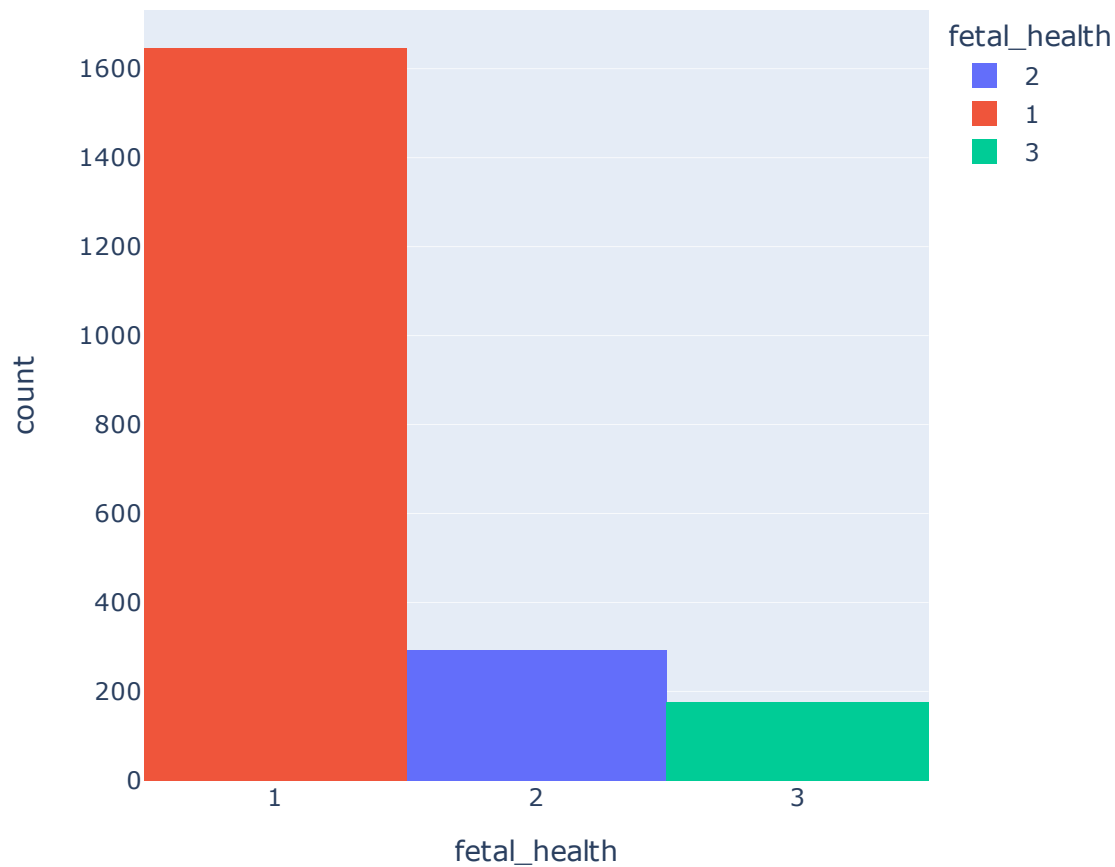


```
1 import plotly.express as px
```

In [17]:



```
1 fig1 = px.histogram(fetal_data, x = 'fetal_health',  
2                     color = 'fetal_health')  
3 fig1.show()
```



In [18]:

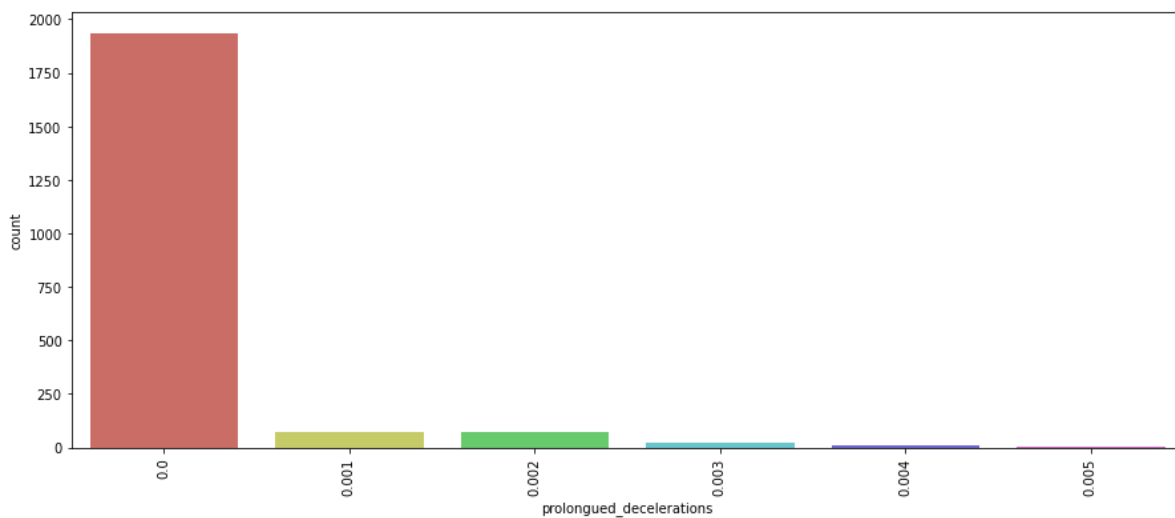
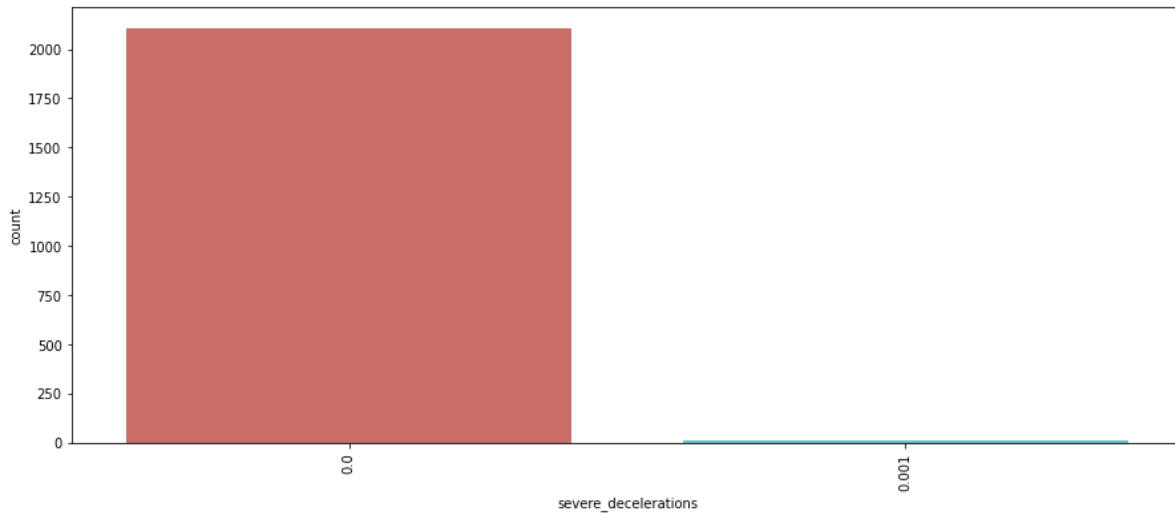


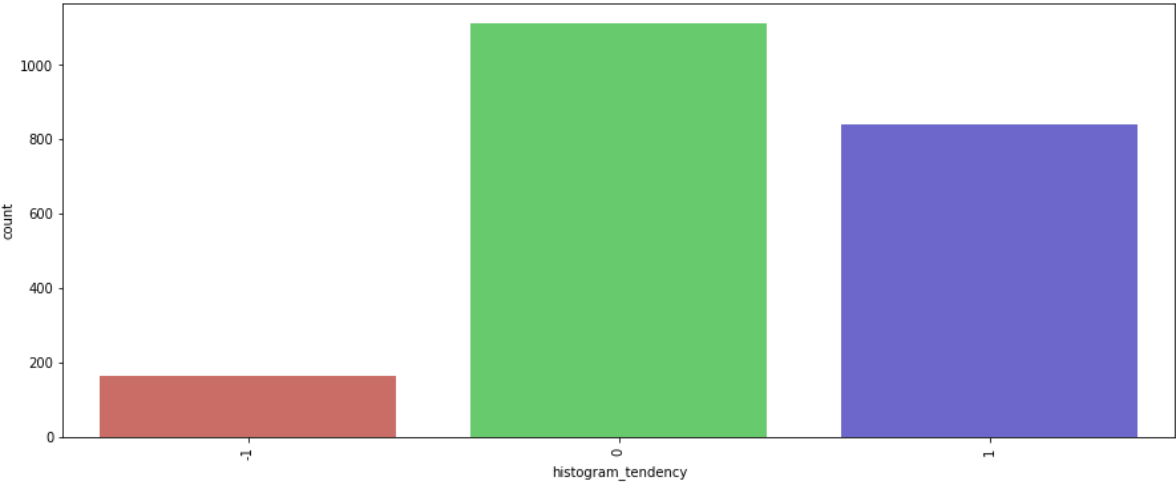
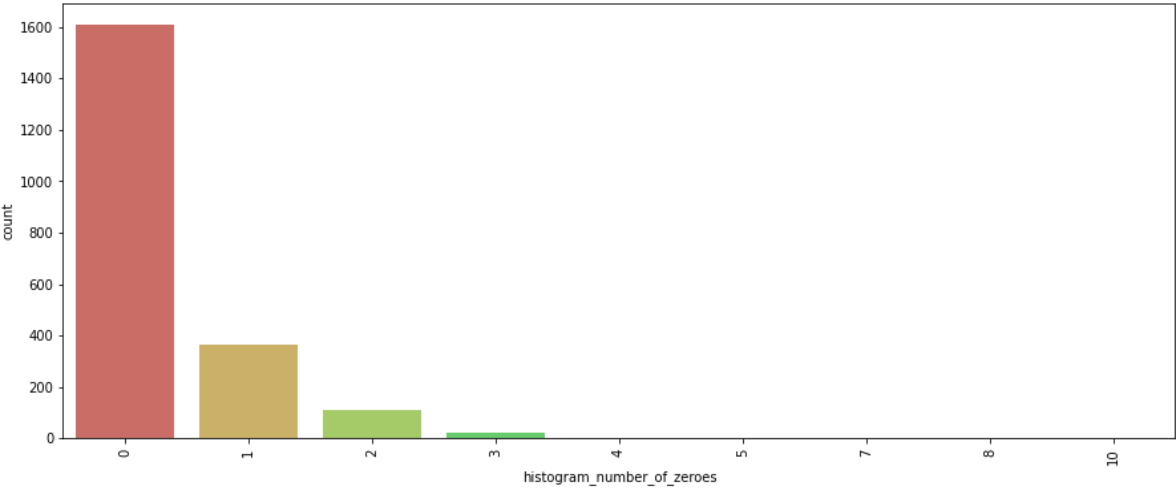
```
1 fetal_data_cat = fetal_data[['severe_decelerations', 'prolonged_decelerations',  
2                             'histogram_number_of_zeroes', 'histogram_tendency']]
```

In [19]:



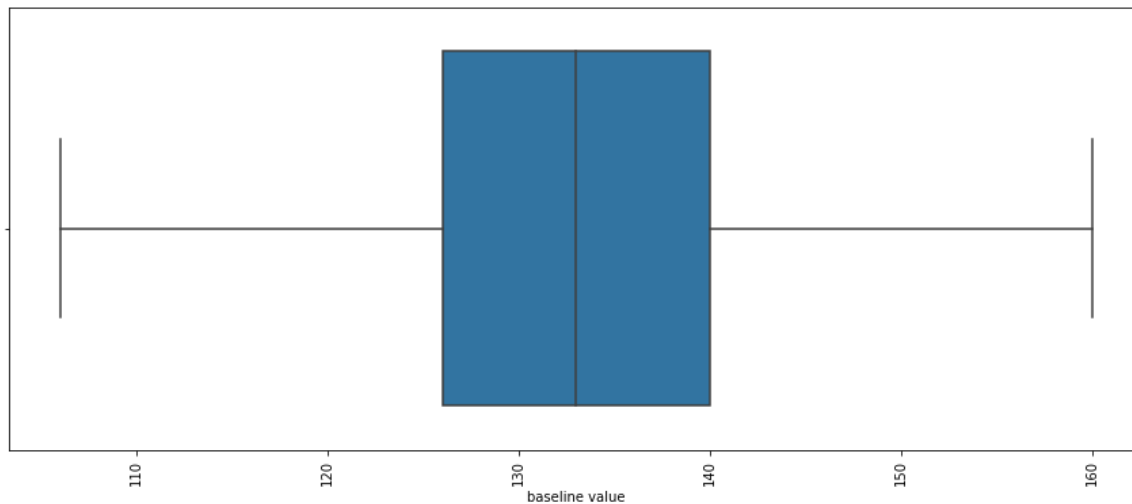
```
1 for i in fetal_data_cat.columns:
2     plt.figure(figsize=(15,6))
3     sns.countplot(fetal_data_cat[i], data = fetal_data_cat,
4                   palette='hls')
5     plt.xticks(rotation = 90)
6     plt.show()
```





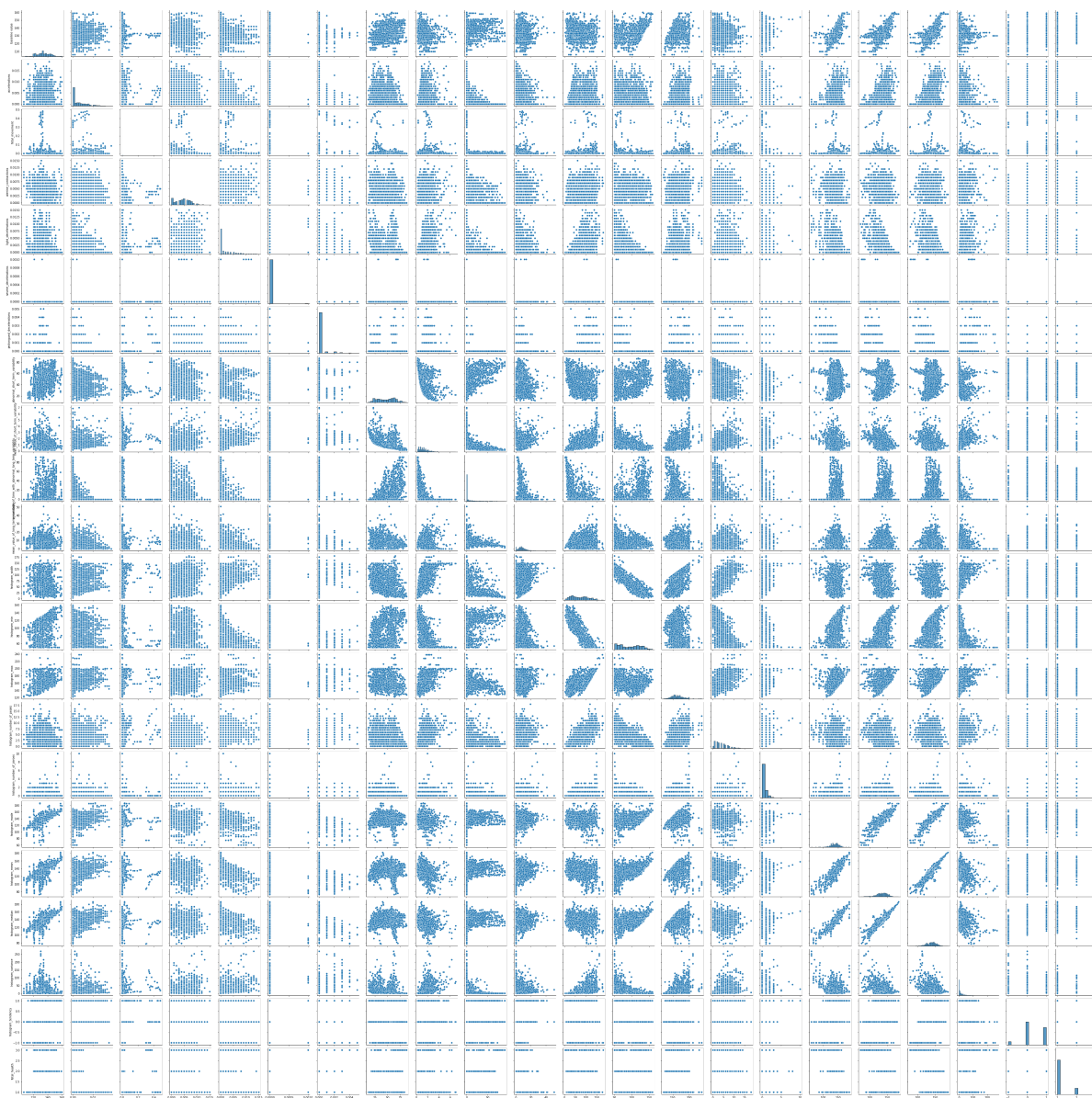
In [20]:

```
1 for i in fetal_data.columns:  
2     plt.figure(figsize=(15,6))  
3     sns.boxplot(fetal_data[i], data = fetal_data)  
4     plt.xticks(rotation = 90)  
5     plt.show()
```



In [21]:

```
1 sns.pairplot(fetal_data)
2 plt.show()
```



In [23]:

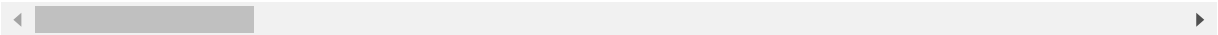


```
1 fetal_data.corr()
```

Out[23]:

	baseline value	accelerations	fetal_movement
baseline value	1.000000	-0.081885	-0.033949
accelerations	-0.081885	1.000000	0.048114
fetal_movement	-0.033949	0.048114	1.000000
uterine_contractions	-0.149587	0.086174	-0.069867
light_decelerations	-0.159836	-0.110595	0.048795
severe_decelerations	-0.053706	-0.043237	-0.011022
prolongued_decelerations	-0.105003	-0.128682	0.265802
abnormal_short_term_variability	0.303502	-0.280495	-0.104876
mean_value_of_short_term_variability	-0.278344	0.206762	0.121532
percentage_of_time_with_abnormal_long_term_variability	0.283918	-0.373507	-0.074900
mean_value_of_long_term_variability	-0.028901	-0.141413	0.011749
histogram_width	-0.147150	0.298350	0.162803
histogram_min	0.360129	-0.155306	-0.154297
histogram_max	0.273402	0.392684	0.099703
histogram_number_of_peaks	-0.113242	0.189209	0.164645
histogram_number_of_zeroes	-0.004807	-0.007360	-0.018122
histogram_mode	0.708074	0.243083	-0.061496
histogram_mean	0.722152	0.270266	-0.089938
histogram_median	0.788487	0.272507	-0.072676
histogram_variance	-0.134458	0.124433	0.179115
histogram_tendency	0.294412	0.030670	-0.001459
fetal_health	0.146077	-0.363947	0.088057

22 rows × 22 columns



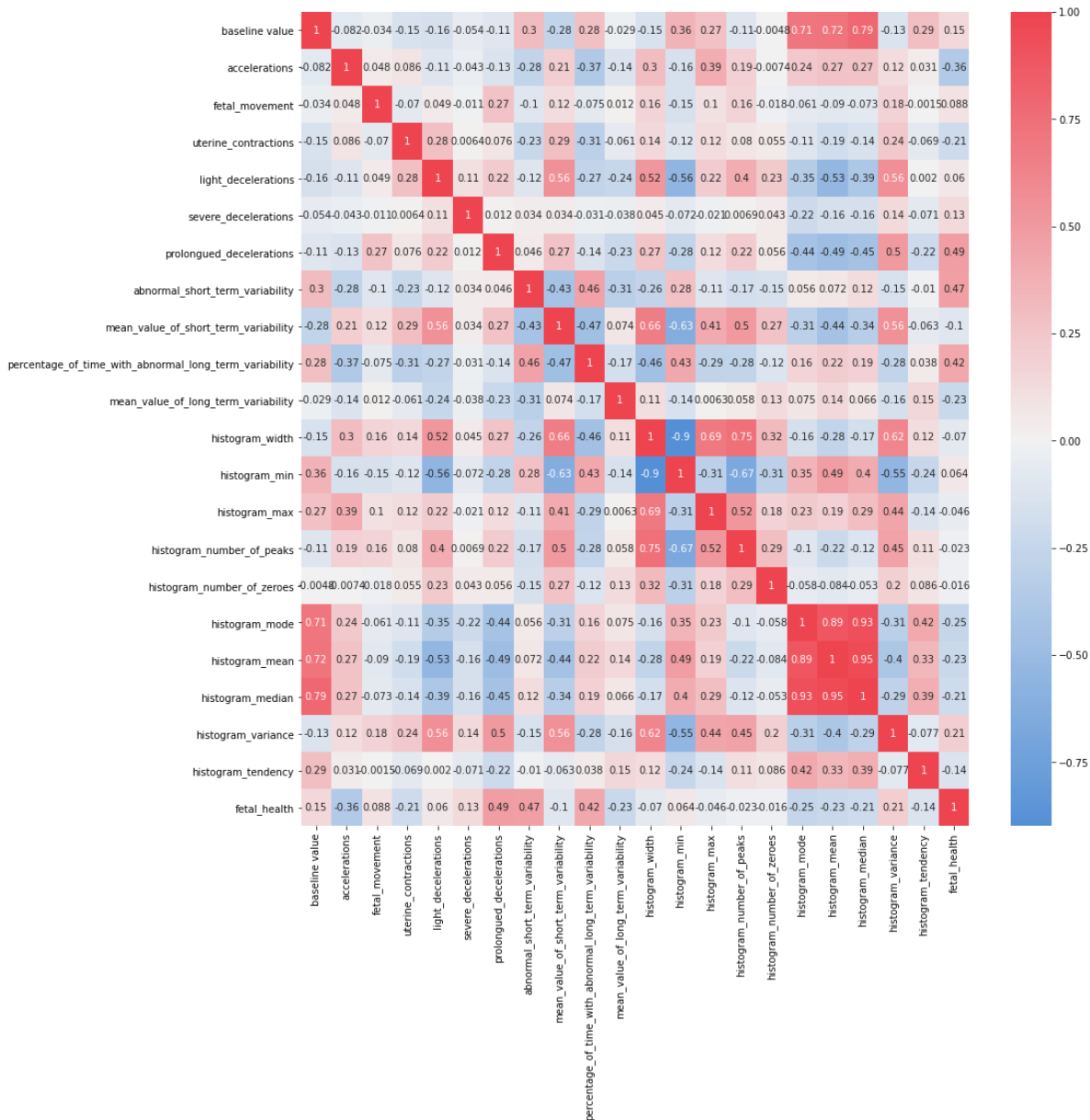
In [25]:



```

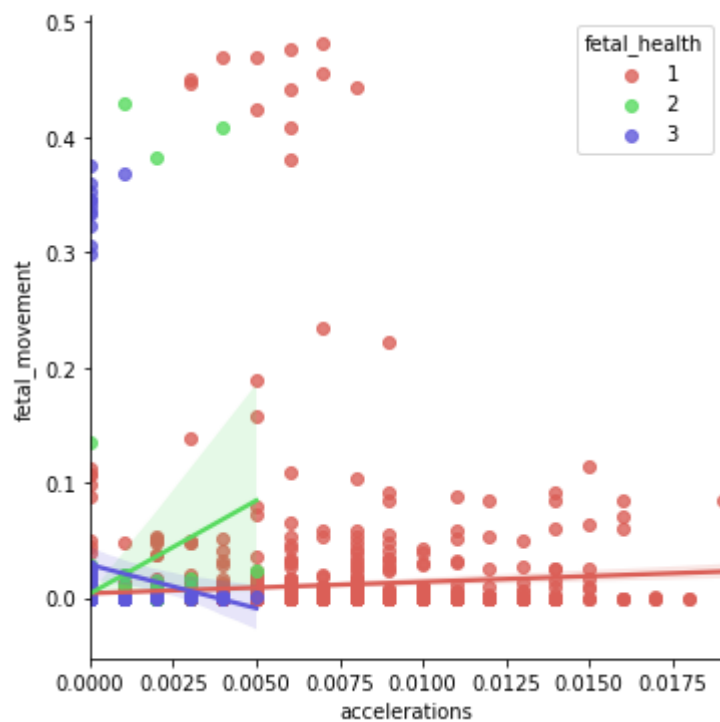
1 plt.figure(figsize=(15,15))
2 cmap = sns.diverging_palette(250, 10, s=80, l=55, n=9, as_cmap=True)
3 sns.heatmap(fetal_data.corr(),annot=True, cmap=cmap, center=0)
4 plt.show()

```



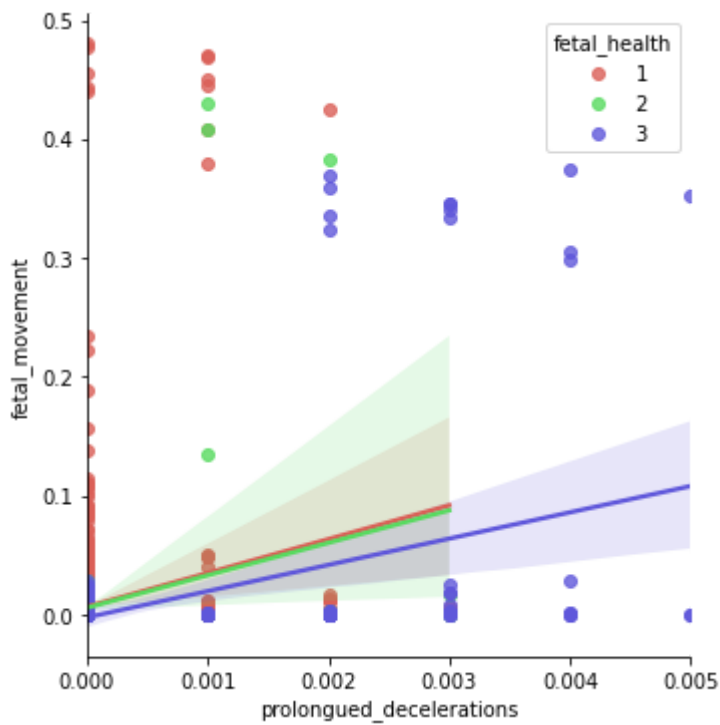
In [27]:

```
1 sns.lmplot(data = fetal_data,x="accelerations",y="fetal_movement",  
2           palette='hls', hue="fetal_health",legend_out=False)  
3 plt.show()
```



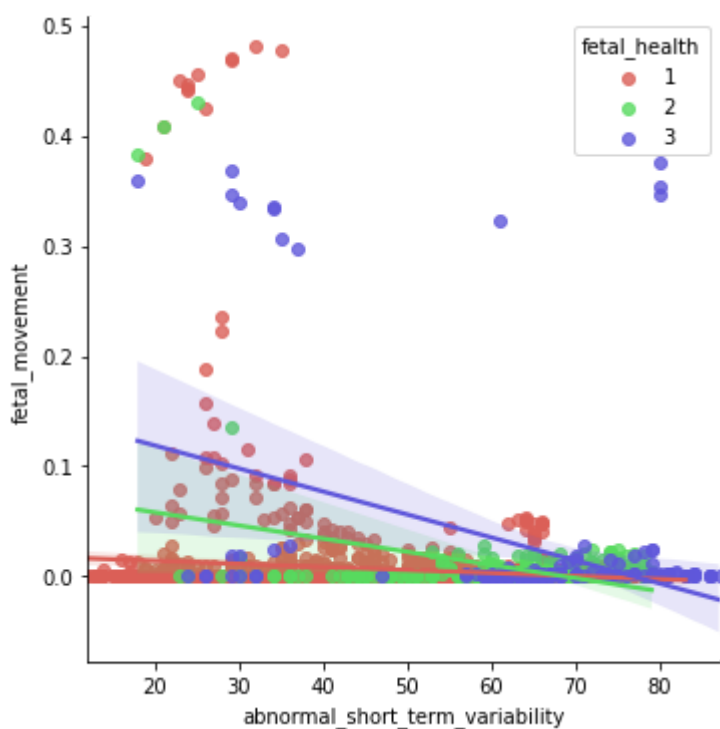
In [29]:

```
1 sns.lmplot(data = fetal_data,x="prolongued_decelerations",y="fetal_movement",
2           palette='hls', hue="fetal_health",legend_out=False)
3 plt.show()
```



In [30]:

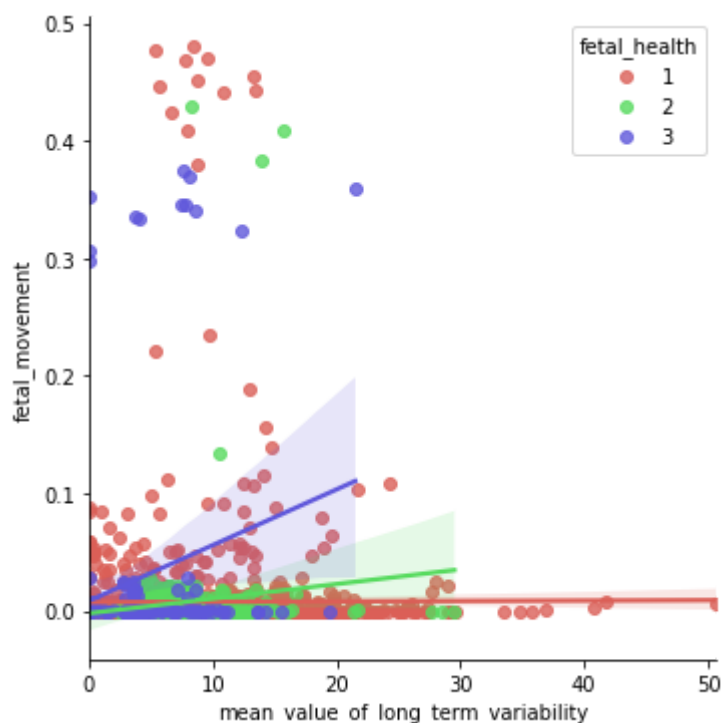
```
1 sns.lmplot(data = fetal_data,x="abnormal_short_term_variability",y="fetal_movement"
2           palette='hls', hue="fetal_health",legend_out=False)
3 plt.show()
```



In [31]:



```
1 sns.lmplot(data = fetal_data,x="mean_value_of_long_term_variability",y="fetal_movement",
2           palette='hls', hue="fetal_health",legend_out=False)
3 plt.show()
```



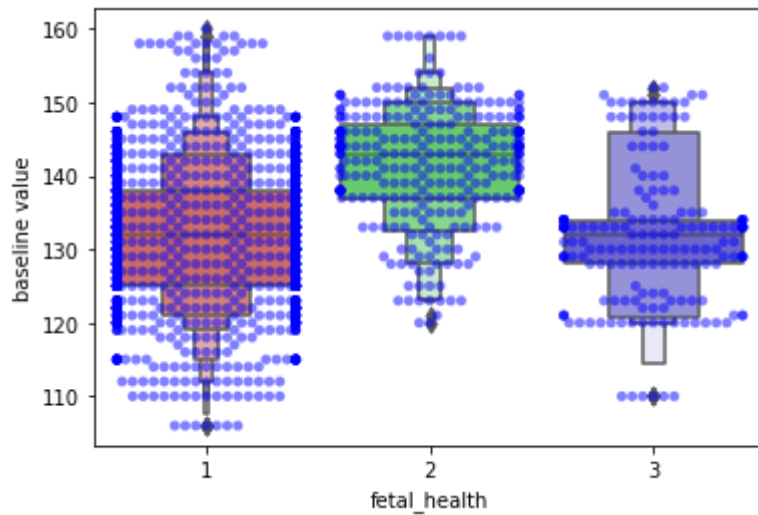
In [32]:



```
1 fetal_data_cols=['baseline value', 'accelerations', 'fetal_movement',
2                 'uterine_contractions', 'light_decelerations', 'severe_decelerations',
3                 'prolongued_decelerations', 'abnormal_short_term_variability',
4                 'mean_value_of_short_term_variability',
5                 'percentage_of_time_with_abnormal_long_term_variability',
6                 'mean_value_of_long_term_variability']
```

In [33]:

```
1 for i in fetal_data_cols:
2     sns.swarmplot(x=fetal_data["fetal_health"], y=fetal_data[i],
3                 color="blue", alpha=0.5 )
4     sns.boxenplot(x=fetal_data["fetal_health"], y=fetal_data[i],
5                 palette='hls')
6     plt.show()
```

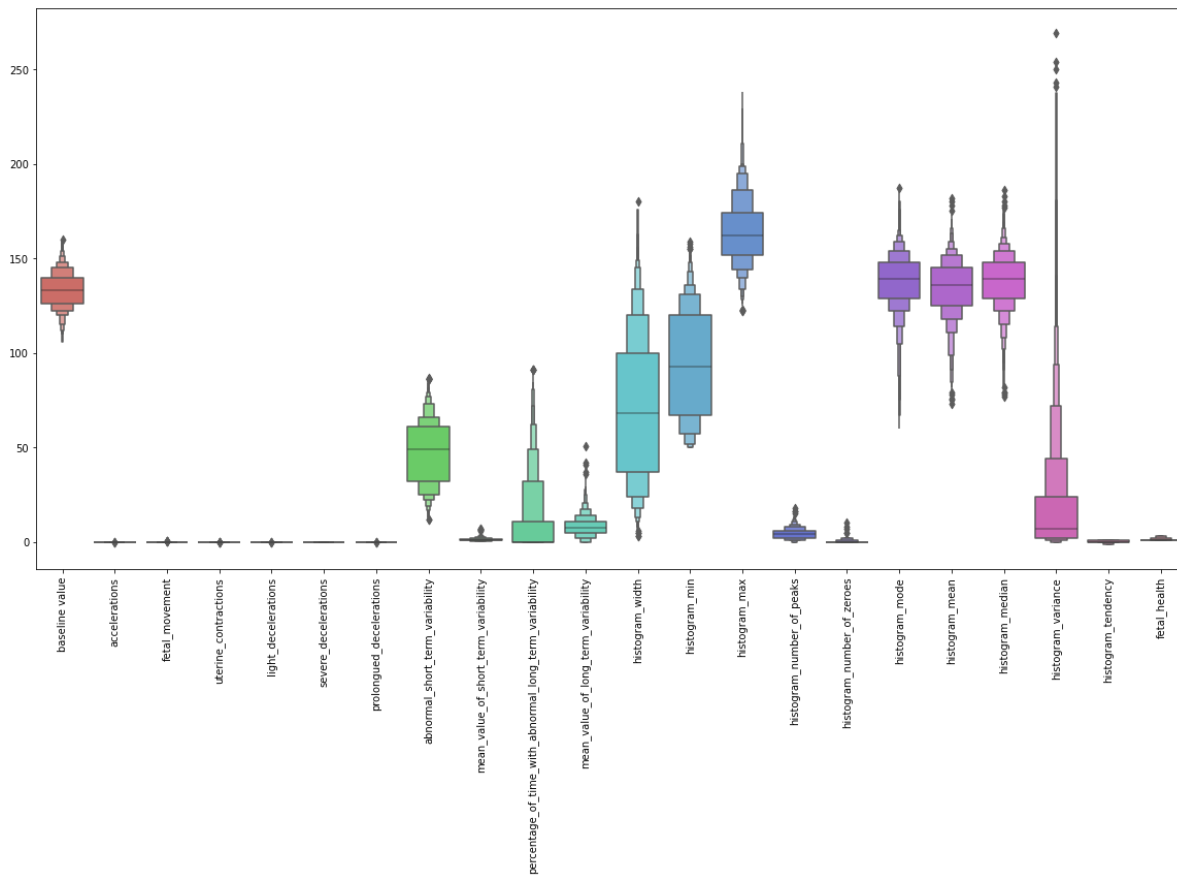


In [34]:

```

1 plt.figure(figsize=(20,10))
2 sns.boxenplot(data = fetal_data,palette = 'hls')
3 plt.xticks(rotation=90)
4 plt.show()

```



In [35]:

```

1 from sklearn.model_selection import train_test_split
2 from sklearn import preprocessing
3 from sklearn.preprocessing import StandardScaler
4 from sklearn.pipeline import Pipeline
5 from sklearn.linear_model import LogisticRegression
6 from sklearn.tree import DecisionTreeClassifier
7 from sklearn.ensemble import RandomForestClassifier
8 from sklearn.svm import SVC
9 from sklearn.svm import LinearSVC
10 from sklearn.model_selection import GridSearchCV
11 from sklearn.model_selection import cross_val_score
12 from sklearn.metrics import precision_score, recall_score, confusion_matrix, classification_report
13 from sklearn import metrics
14 from sklearn.metrics import roc_curve, auc, roc_auc_score
15 np.random.seed(0)

```

In [36]:

```

1 X=fetal_data.drop(["fetal_health"],axis=1)
2 y=fetal_data["fetal_health"]

```

In [37]:



```
1 X.shape
```

Out[37]:

```
(2113, 21)
```

In [38]:



```
1 y.shape
```

Out[38]:

```
(2113,)
```

In [39]:



```
1 col_names = list(X.columns)
2 s_scaler = preprocessing.StandardScaler()
3 X_df= s_scaler.fit_transform(X)
4 X_df = pd.DataFrame(X_df, columns=col_names)
5 X_df.describe().T
```

Out[39]:

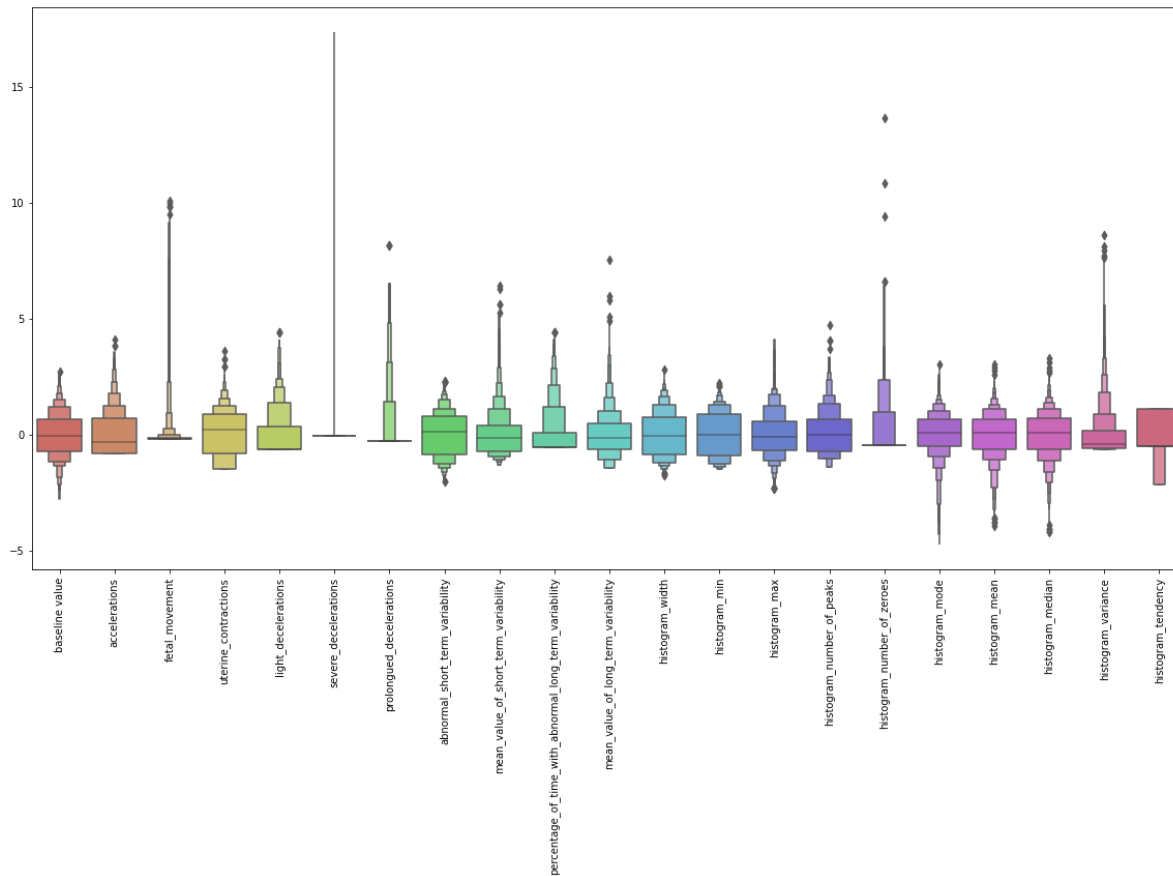
	count	mean	std	m
baseline value	2113.0	-1.143325e-15	1.000237	-2.77625
accelerations	2113.0	6.725440e-18	1.000237	-0.82377
fetal_movement	2113.0	-1.345088e-17	1.000237	-0.20339
uterine_contractions	2113.0	8.070528e-17	1.000237	-1.49224
light_decelerations	2113.0	-8.070528e-17	1.000237	-0.64120
severe_decelerations	2113.0	-6.725440e-18	1.000237	-0.05765
prolongued_decelerations	2113.0	4.035264e-17	1.000237	-0.26964
abnormal_short_term_variability	2113.0	-1.345088e-17	1.000237	-2.03764
mean_value_of_short_term_variability	2113.0	-4.035264e-17	1.000237	-1.28373
percentage_of_time_with_abnormal_long_term_variability	2113.0	2.690176e-17	1.000237	-0.53429
mean_value_of_long_term_variability	2113.0	1.076070e-16	1.000237	-1.45015
histogram_width	2113.0	5.044080e-17	1.000237	-1.73174
histogram_min	2113.0	1.042443e-16	1.000237	-1.47400
histogram_max	2113.0	3.127330e-16	1.000237	-2.34655
histogram_number_of_peaks	2113.0	0.000000e+00	1.000237	-1.38162
histogram_number_of_zeroes	2113.0	7.313916e-17	1.000237	-0.46015
histogram_mode	2113.0	-1.614106e-16	1.000237	-4.72336
histogram_mean	2113.0	3.497229e-16	1.000237	-3.94699
histogram_median	2113.0	3.497229e-16	1.000237	-4.22015
histogram_variance	2113.0	-6.725440e-17	1.000237	-0.65125
histogram_tendency	2113.0	2.690176e-17	1.000237	-2.15819

In [40]:

```

1 plt.figure(figsize=(20,10))
2 sns.boxenplot(data = X_df,palette = 'hls')
3 plt.xticks(rotation=90)
4 plt.show()

```



In [41]:

```

1 X_train, X_test, y_train,y_test = train_test_split(X_df,y,
2                                                    test_size=0.2,
3                                                    random_state=42)

```

In [42]:

```

1 pipeline_lr=Pipeline([('lr_classifier',LogisticRegression(random_state=42))])
2 pipeline_dt=Pipeline([ ('dt_classifier',DecisionTreeClassifier(random_state=42))])
3 pipeline_rf=Pipeline([('rf_classifier',RandomForestClassifier())])
4 pipeline_svc=Pipeline([('sv_classifier',SVC())])
5 pipelines = [pipeline_lr, pipeline_dt, pipeline_rf, pipeline_svc]
6 pipe_dict = {0: 'Logistic Regression', 1: 'Decision Tree',
7              2: 'RandomForest', 3: "SVC"}

```

In [43]:

```
1 for pipe in pipelines:
2     pipe.fit(X_train, y_train)
```

In [44]:

```
1 cv_results_accuracy = []
2 for i, model in enumerate(pipelines):
3     cv_score = cross_val_score(model, X_train, y_train, cv=10)
4     cv_results_accuracy.append(cv_score)
5     print("%s: %f" % (pipe_dict[i], cv_score.mean()))
```

Logistic Regression: 0.887574

Decision Tree: 0.915385

RandomForest: 0.937278

SVC: 0.904734

In [45]:

```
1 pred_rfc = pipeline_rf.predict(X_test)
```

In [46]:

```
1 print("Training Accuracy :", pipeline_rf.score(X_train, y_train))
2 print("Testing Accuracy :", pipeline_rf.score(X_test, y_test))
```

Training Accuracy : 0.9994082840236687

Testing Accuracy : 0.966903073286052

In [50]:

```
1 from sklearn.metrics import accuracy_score
```

In [51]:

```
1 print("Classification report for classifier %s:\n%s\n" % (pipeline_rf,
2                                                         metrics.classification_report(y_test, pred_rfc)))
```

Classification report for classifier Pipeline(steps=[('rf_classifier', RandomForestClassifier())]):

	precision	recall	f1-score	support
1	0.97	0.99	0.98	341
2	0.93	0.80	0.86	54
3	1.00	1.00	1.00	28
accuracy			0.97	423
macro avg	0.97	0.93	0.95	423
weighted avg	0.97	0.97	0.97	423

In [52]:

```
1 matrix = confusion_matrix(y_test, pred_rfc)
2 print('Confusion matrix : \n',matrix)
```

Confusion matrix :

```
[[338   3   0]
 [ 11  43   0]
 [  0   0  28]]
```

In [53]:

```
1 plt.subplots(figsize=(12,8))
2 sns.heatmap(matrix/np.sum(matrix), cmap=cmap,annot = True,
3             annot_kws = {'size':15})
4 plt.show()
```

