# Science files fraud detection

## О Проекте

Тестовое задание для специалиста по Data Science.

### Описание данных

Часть базы данных наблюдательного исследования (основные данные по визиту Скрининг) в формате Excel. В файле будет 2 вкладки: вкладка с описанием полей для сбора данных и вкладка с данными.

### Задача

Проверить имеющиеся данные на их возможную фальсификацию.

Если фальсификация будет обнаружена, то вам необходимо указать:

* какие именно данные, возможно, были сфальсифицированы;
* отметить номера пациентов, для которых данные, возможно, были сфальсифицированы.

### Выполнил

## Первоначальная стратегия

* Задача 1: Определение пациентов с фальсифицированными данными
  + Статистические методы:
    - Z-оценка: Подсчитать Z-оценку для каждого значения и идентифицировать значения, которые превышают порог (например, 3 или -3 для двухстороннего теста).
    - IQR (межквартильный размах): Вычислить IQR и определить значения за пределами 1.5\*IQR от квартилей.
  + Визуализация:
    - Ящик с усами (Boxplot): Визуализировать данные для каждого признака и искать выбросы.
    - Scatter plot: Построить график зависимостей между различными признаками и поискать необычные точки.
  + Машинное обучение:
  + Изолирующий лес (Isolation Forest): Алгоритм, основанный на деревьях решений, который изолирует выбросы.
  + Метод опорных векторов для одного класса (One-Class SVM): Определяет границу нормальных данных и выявляет выбросы.
  + DBSCAN или OPTICS: Алгоритмы кластеризации, которые могут обнаруживать выбросы как шум в данных.
* Задача 2: Определение сфальсифицированных признаков
  + Feature Importance:
    - Использование алгоритмов машинного обучения, таких как Random Forest или Gradient Boosting, для определения важности признаков, которые могут указывать на фальсификацию.
  + Анализ аномалий:
    - Использование алгоритмов детекции аномалий на уровне признаков для выявления необычных паттернов.
    - Ручная проверка:
    - Ручной аудит признаков с экспертами в соответствующей области для интерпретации подозрительных значений.
  + Correlation Analysis:
    - Провести корреляционный анализ для определения необычных связей между признаками, которые могут указывать на манипулирование данными.
  + Temporal Analysis:
    - Анализ изменений в данных со временем для выявления необычных паттернов, которые могут быть связаны с фальсификацией.

## Шаг 1. Импорты

import pandas as pd  
import seaborn as sns  
import numpy as np  
import plotly.express as px  
import scipy  
import matplotlib.pyplot as plt  
from scipy.stats import zscore  
import warnings  
from sklearn.cluster import DBSCAN  
from sklearn.linear\_model import LinearRegression  
warnings.filterwarnings('ignore')  
  
# кастомные функции  
from utils import df\_info # Функция для получения информации о датафрейме  
from utils import low\_information\_features # Функция для определения неинформативных признаков

# Загрузка данных  
df = pd.read\_excel('data/ProjectToOneFile\_for\_test.xlsx', sheet\_name=1)  
legend = pd.read\_excel('data/ProjectToOneFile\_for\_test.xlsx', sheet\_name=0)

# Описание полей  
legend

Код поля \  
0 SCR\_ICF\_SVDAT\_ICF   
1 SCR\_ICF\_SVDAT   
2 SCR\_ICF\_BRTHDAT   
3 SCR\_ICF\_AGE   
4 SCR\_ICF\_VSORRES\_HEIGHT   
5 SCR\_ICF\_VSORRES\_WEIGHT   
6 SCR\_ICF\_VSORRES\_BMI   
7 SCR\_LB\_SPERMOGR\_LBDAT\_SPERM   
8 SCR\_LB\_SPERMOGR\_LBORRES\_VOL\_EJACUL   
9 SCR\_LB\_SPERMOGR\_LBORRES\_TOTCONC\_SP   
10 SCR\_LB\_SPERMOGR\_LBORRES\_COCENTR\_SP   
11 SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP   
12 SCR\_LB\_SPERMOGR\_LBORRES\_PROGR\_MOBIL   
13 SCR\_LB\_SPERMOGR\_LBORRES\_PNONPROGR\_MOBIL   
14 SCR\_LB\_SPERMOGR\_LBORRES\_FIXED   
  
 Описание поля \  
0 Дата подписания ИС   
1 Дата визита 1   
2 Дата рождения   
3 Возраст, полных лет   
4 Рост, см   
5 Масса тела, кг   
6 Индекс массы тела, кг/м2   
7 Дата проведения исследования   
8 Объем эякулята, мл   
9 Общая концентрация сперматозоидов\nв эякуляте,...   
10 Концентрация сперматозоидов, млн/м\nл\   
11 Общая подвижность сперматозоидов,\n%   
12 Группа1. Прогрессивно-подвижные, %   
13 Группа 2. Непрогрессивно-подвижные,\n%   
14 Группа 3. Неподвижные, %   
  
 Всплывающая подсказка Тип поля   
0 Дата подписания ИС DATE   
1 Дата визита 1 DATE   
2 Дата рождения DATE   
3 Возраст, полных лет TEXTBOX   
4 Рост, см TEXTBOX   
5 Масса тела, кг TEXTBOX   
6 Индекс массы тела, кг/м2 TEXTBOX   
7 Дата проведения исследования DATE   
8 Объем эякулята, мл TEXTBOX   
9 Общая концентрация сперматозоидов\nв эякуляте,... TEXTBOX   
10 Концентрация сперматозоидов, млн/м\nл TEXTBOX   
11 Общая подвижность сперматозоидов,\n% TEXTBOX   
12 Группа1. Прогрессивно-подвижные (Быст\nрые про... TEXTBOX   
13 Группа 2. Непрогрессивно-подвижные,\n% TEXTBOX   
14 Группа 3. Неподвижные, % TEXTBOX

## Шаг 2. Исследовательский анализ данных

df\_info(df)

Количество записей: 602  
Количество столбцов: 18  
Явных дубликатов: 0  
Пропуски присутствуют в 13 столбцах из 18:

Пропущено %  
SCR\_ICF\_VSORRES\_HEIGHT 75.913621  
SCR\_ICF\_VSORRES\_WEIGHT 75.913621  
SCR\_ICF\_VSORRES\_BMI 75.913621  
SCR\_LB\_SPERMOGR\_LBORRES\_VOL\_EJACUL 15.614618  
SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP 8.471761  
SCR\_LB\_SPERMOGR\_LBORRES\_PROGR\_MOBIL 8.139535  
SCR\_LB\_SPERMOGR\_LBORRES\_PNONPROGR\_MOBIL 8.139535  
SCR\_LB\_SPERMOGR\_LBORRES\_FIXED 7.807309  
SCR\_LB\_SPERMOGR\_LBORRES\_TOTCONC\_SP 7.142857  
SCR\_LB\_SPERMOGR\_LBORRES\_COCENTR\_SP 6.976744  
SCR\_LB\_SPERMOGR\_LBDAT\_SPERM 3.654485  
SCR\_ICF\_BRTHDAT 0.498339  
SCR\_ICF\_AGE 0.498339

Обобщенная информация:  
<class 'pandas.core.frame.DataFrame'>  
RangeIndex: 602 entries, 0 to 601  
Columns: 18 entries, Screening # to SCR\_LB\_SPERMOGR\_LBORRES\_FIXED  
dtypes: float64(11), int64(1), object(6)  
memory usage: 84.8+ KB

None

Первые 3 строки:

Screening # Initials Site # SCR\_ICF\_SVDAT\_ICF SCR\_ICF\_SVDAT \  
0 001-001 РКВ 1 2023-06-26 2023-06-26   
1 001-002 КАД 1 2023-06-24 2023-06-24   
2 001-003 АДР 1 2023-10-23 2023-10-23   
  
 SCR\_ICF\_BRTHDAT SCR\_ICF\_AGE SCR\_ICF\_VSORRES\_HEIGHT \  
0 1986-04-12 37.0 183.0   
1 1993-09-09 29.0 184.0   
2 1983-01-09 40.0 173.0   
  
 SCR\_ICF\_VSORRES\_WEIGHT SCR\_ICF\_VSORRES\_BMI SCR\_LB\_SPERMOGR\_LBDAT\_SPERM \  
0 100.0 29.86 2023-06-21   
1 91.0 26.88 2023-05-27   
2 78.0 26.06 2023-10-23   
  
 SCR\_LB\_SPERMOGR\_LBORRES\_VOL\_EJACUL SCR\_LB\_SPERMOGR\_LBORRES\_TOTCONC\_SP \  
0 3.2 139.17   
1 0.4 15.20   
2 3.0 103.00   
  
 SCR\_LB\_SPERMOGR\_LBORRES\_COCENTR\_SP SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP \  
0 43.49 32.0   
1 38.00 41.0   
2 34.00 15.3   
  
 SCR\_LB\_SPERMOGR\_LBORRES\_PROGR\_MOBIL \  
0 32.53   
1 34.00   
2 3.63   
  
 SCR\_LB\_SPERMOGR\_LBORRES\_PNONPROGR\_MOBIL SCR\_LB\_SPERMOGR\_LBORRES\_FIXED   
0 11.83 55.64   
1 10.10 59.00   
2 11.66 84.70

### Анализ пропусков

# Общее количество пропусков в колонках  
df.isna().sum()

Screening # 0  
Initials 0  
Site # 0  
SCR\_ICF\_SVDAT\_ICF 0  
SCR\_ICF\_SVDAT 0  
SCR\_ICF\_BRTHDAT 3  
SCR\_ICF\_AGE 3  
SCR\_ICF\_VSORRES\_HEIGHT 457  
SCR\_ICF\_VSORRES\_WEIGHT 457  
SCR\_ICF\_VSORRES\_BMI 457  
SCR\_LB\_SPERMOGR\_LBDAT\_SPERM 22  
SCR\_LB\_SPERMOGR\_LBORRES\_VOL\_EJACUL 94  
SCR\_LB\_SPERMOGR\_LBORRES\_TOTCONC\_SP 43  
SCR\_LB\_SPERMOGR\_LBORRES\_COCENTR\_SP 42  
SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP 51  
SCR\_LB\_SPERMOGR\_LBORRES\_PROGR\_MOBIL 49  
SCR\_LB\_SPERMOGR\_LBORRES\_PNONPROGR\_MOBIL 49  
SCR\_LB\_SPERMOGR\_LBORRES\_FIXED 47  
dtype: int64

# Количество наблюжений хотя бы с одним пропуском  
df.isnull().any(axis=1).sum()

472

# Соотношение пропусков, %  
nans = 100 \* df.isnull().mean().sort\_values(ascending=False)[df.isnull().mean().sort\_values(ascending=False) > 0]  
  
fig = px.bar(x=nans.index, y=nans.values, title='Соотношение пропусков, %', height=500, width=800)  
fig.show()

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fig = px.imshow(df[nans.index].isnull(), title='Тепловая карта пропусков')  
fig.show()

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0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[255,255,255,0,0,0,0,0,0,0,0,0,0],[255,255,255,0,0,0,0,0,0,0,0,0,0],[255,255,255,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[255,255,255,0,0,0,0,0,0,0,0,0,0],[255,255,255,255,255,255,255,255,255,255,0,0,0],[255,255,255,255,255,255,255,255,255,255,0,0,0],[255,255,255,255,255,255,255,255,255,255,0,0,0],[255,255,255,255,255,255,255,255,255,255,0,0,0],[255,255,255,255,255,255,255,255,255,255,0,0,0],[255,255,255,255,255,255,255,255,255,255,0,0,0],[255,255,255,255,255,255,255,255,255,255,0,0,0],[255,255,255,255,255,255,255,255,255,255,0,0,0],[255,255,255,255,255,255,255,255,255,255,0,0,0],[255,255,255,255,255,255,255,255,255,255,0,0,0],[255,255,255,255,0,0,0,0,0,0,0,0,0],[255,255,255,255,0,0,0,0,0,0,0,0,0],[255,255,255,255,0,0,0,0,0,0,0,0,0],[255,255,255,255,0,0,0,0,0,0,0,0,0],[255,255,255,255,0,0,0,0,0,0,0,0,0],[255,255,255,255,0,0,0,0,0,0,0,0,0],[255,255,255,0,0,0,0,0,0,0,0,0,0],[255,255,255,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[255,255,255,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[255,255,255,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[0,0,0,0,0,0,0,0,0,0,0,0,0],[255,255,255,255,0,0,0,0,0,0,0,0,0],[255,255,255,255,0,0,0,0,0,0,0,0,0],[255,255,255,255,0,0,0,0,0,0,0,0,0],[255,255,255,255,0,0,0,0,0,0,0,0,0],[255,255,255,255,255,255,255,255,255,255,255,0,0],[255,255,255,255,255,255,255,255,255,255,255,0,0],[255,255,255,255,255,255,255,255,255,255,255,0,0],[0,0,0,255,255,255,255,255,255,255,255,0,0],[0,0,0,255,255,255,255,255,255,255,255,0,0],[0,0,0,255,255,255,255,255,255,255,255,0,0],[0,0,0,255,255,255,255,255,255,255,255,0,0],[0,0,0,255,255,255,255,255,255,255,255,0,0],[0,0,0,255,255,255,255,255,255,255,255,0,0],[0,0,0,255,255,255,255,255,255,255,255,0,0],[0,0,0,255,255,255,255,255,255,255,255,0,0],[0,0,0,255,255,255,255,255,255,255,255,0,0],[0,0,0,255,255,255,255,255,255,255,255,0,0],[0,0,0,255,255,255,255,255,255,255,255,0,0]],"yaxis":"y","xaxis":"x","coloraxis":"coloraxis","hovertemplate":"x: %{x}<br>y: %{y}<br>color: %{z}<extra></extra>","name":"0","x":["SCR\_ICF\_VSORRES\_BMI","SCR\_ICF\_VSORRES\_HEIGHT","SCR\_ICF\_VSORRES\_WEIGHT","SCR\_LB\_SPERMOGR\_LBORRES\_VOL\_EJACUL","SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP","SCR\_LB\_SPERMOGR\_LBORRES\_PNONPROGR\_MOBIL","SCR\_LB\_SPERMOGR\_LBORRES\_PROGR\_MOBIL","SCR\_LB\_SPERMOGR\_LBORRES\_FIXED","SCR\_LB\_SPERMOGR\_LBORRES\_TOTCONC\_SP","SCR\_LB\_SPERMOGR\_LBORRES\_COCENTR\_SP","SCR\_LB\_SPERMOGR\_LBDAT\_SPERM","SCR\_ICF\_AGE","SCR\_ICF\_BRTHDAT"],"type":"heatmap","y":[0,1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18,19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,47,48,49,50,51,52,53,54,55,56,57,58,59,60,61,62,63,64,65,66,67,68,69,70,71,72,73,74,75,76,77,78,79,80,81,82,83,84,85,86,87,88,89,90,91,92,93,94,95,96,97,98,99,100,101,102,103,104,105,106,107,108,109,110,111,112,113,114,115,116,117,118,119,120,121,122,123,124,125,126,127,128,129,130,131,132,133,134,135,136,137,138,139,140,141,142,143,144,145,146,147,148,149,150,151,152,153,154,155,156,157,158,159,160,161,162,163,164,165,166,167,168,169,170,171,172,173,174,175,176,177,178,179,180,181,182,183,184,185,186,187,188,189,190,191,192,193,194,195,196,197,198,199,200,201,202,203,204,205,206,207,208,209,210,211,212,213,214,215,216,217,218,219,220,221,222,223,224,225,226,227,228,229,230,231,232,233,234,235,236,237,238,239,240,241,242,243,244,245,246,247,248,249,250,251,252,253,254,255,256,257,258,259,260,261,262,263,264,265,266,267,268,269,270,271,272,273,274,275,276,277,278,279,280,281,282,283,284,285,286,287,288,289,290,291,292,293,294,295,296,297,298,299,300,301,302,303,304,305,306,307,308,309,310,311,312,313,314,315,316,317,318,319,320,321,322,323,324,325,326,327,328,329,330,331,332,333,334,335,336,337,338,339,340,341,342,343,344,345,346,347,348,349,350,351,352,353,354,355,356,357,358,359,360,361,362,363,364,365,366,367,368,369,370,371,372,373,374,375,376,377,378,379,380,381,382,383,384,385,386,387,388,389,390,391,392,393,394,395,396,397,398,399,400,401,402,403,404,405,406,407,408,409,410,411,412,413,414,415,416,417,418,419,420,421,422,423,424,425,426,427,428,429,430,431,432,433,434,435,436,437,438,439,440,441,442,443,444,445,446,447,448,449,450,451,452,453,454,455,456,457,458,459,460,461,462,463,464,465,466,467,468,469,470,471,472,473,474,475,476,477,478,479,480,481,482,483,484,485,486,487,488,489,490,491,492,493,494,495,496,497,498,499,500,501,502,503,504,505,506,507,508,509,510,511,512,513,514,515,516,517,518,519,520,521,522,523,524,525,526,527,528,529,530,531,532,533,534,535,536,537,538,539,540,541,542,543,544,545,546,547,548,549,550,551,552,553,554,555,556,557,558,559,560,561,562,563,564,565,566,567,568,569,570,571,572,573,574,575,576,577,578,579,580,581,582,583,584,585,586,587,588,589,590,591,592,593,594,595,596,597,598,599,600,601]}]}

### Анализ типов данных

df.dtypes

Screening # object  
Initials object  
Site # int64  
SCR\_ICF\_SVDAT\_ICF object  
SCR\_ICF\_SVDAT object  
SCR\_ICF\_BRTHDAT object  
SCR\_ICF\_AGE float64  
SCR\_ICF\_VSORRES\_HEIGHT float64  
SCR\_ICF\_VSORRES\_WEIGHT float64  
SCR\_ICF\_VSORRES\_BMI float64  
SCR\_LB\_SPERMOGR\_LBDAT\_SPERM object  
SCR\_LB\_SPERMOGR\_LBORRES\_VOL\_EJACUL float64  
SCR\_LB\_SPERMOGR\_LBORRES\_TOTCONC\_SP float64  
SCR\_LB\_SPERMOGR\_LBORRES\_COCENTR\_SP float64  
SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP float64  
SCR\_LB\_SPERMOGR\_LBORRES\_PROGR\_MOBIL float64  
SCR\_LB\_SPERMOGR\_LBORRES\_PNONPROGR\_MOBIL float64  
SCR\_LB\_SPERMOGR\_LBORRES\_FIXED float64  
dtype: object

### Анализ малоинформативных признаков

# Получение неинформативных признаков  
low\_information\_features(df)

Screening #: 100.0% уникальных значений

['Screening #']

### Выводы по EDA

При первичном анализе датасета на предмет пропусков обнаружены признаки с количеством пропусков более 70%. Так-же присутствует признак screenening - похоже это индекс пациента. Так-же часть данных, содержащих даты - не приведенf а нужному типу.

Поскольку у некоторых пациентов пропущены все значения в результатах - нет смысла оставлять их в датасете.

Исправим эти моменты, сохранив общее число наблюдений

df\_cleaned = df.copy()

# Удаление строк, где пропуски присутствуют во всех отобранных столбцах  
spermo\_columns = [col for col in df\_cleaned.columns if 'SCR\_LB\_SPERMOGR\_LBORRES' in col]  
df\_cleaned = df\_cleaned.dropna(subset=spermo\_columns, how='all')

# Устанавливаем столбец 'Screening #' в качестве индекса DataFrame  
df\_cleaned.set\_index('Screening #', inplace=True)  
  
# Определяем столбцы, содержащие строки с датами в формате 'YYYY-MM-DD'  
date\_cols = []  
for col in df\_cleaned.columns:  
 # Если хотя бы одно значение в столбце соответствует шаблону даты, добавляем его в список date\_cols  
 if df\_cleaned[col].astype(str).str.match(r'^\d{4}-\d{2}-\d{2}$').any():  
 date\_cols.append(col)  
  
# Конвертируем все обнаруженные столбцы с датами из строк в datetime  
for col in date\_cols:  
 df\_cleaned[col] = pd.to\_datetime(df\_cleaned[col])  
  
# Удаляем столбцы, где более 70% значений пропущены  
# Сначала рассчитываем порог: столбцы должны содержать минимум 30% непустых значений  
threshold = len(df\_cleaned) \* 0.3  
# Удаляем столбцы, не соответствующие порогу  
df\_cleaned.dropna(axis=1, thresh=threshold, inplace=True)  
  
# Приводим возраст к int - целому числу  
df\_cleaned['SCR\_ICF\_AGE'] = df\_cleaned['SCR\_ICF\_AGE'].astype(int, errors='ignore')

df\_info(df\_cleaned)

Количество записей: 560  
Количество столбцов: 14  
Явных дубликатов: 0  
Пропуски присутствуют в 9 столбцах из 14:

Пропущено %  
SCR\_LB\_SPERMOGR\_LBORRES\_VOL\_EJACUL 9.285714  
SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP 1.607143  
SCR\_LB\_SPERMOGR\_LBORRES\_PROGR\_MOBIL 1.250000  
SCR\_LB\_SPERMOGR\_LBORRES\_PNONPROGR\_MOBIL 1.250000  
SCR\_LB\_SPERMOGR\_LBORRES\_FIXED 0.892857  
SCR\_ICF\_BRTHDAT 0.535714  
SCR\_ICF\_AGE 0.535714  
SCR\_LB\_SPERMOGR\_LBDAT\_SPERM 0.357143  
SCR\_LB\_SPERMOGR\_LBORRES\_TOTCONC\_SP 0.178571

Обобщенная информация:  
<class 'pandas.core.frame.DataFrame'>  
Index: 560 entries, 001-001 to 071-004  
Columns: 14 entries, Initials to SCR\_LB\_SPERMOGR\_LBORRES\_FIXED  
dtypes: datetime64[ns](4), float64(8), int64(1), object(1)  
memory usage: 65.6+ KB

None

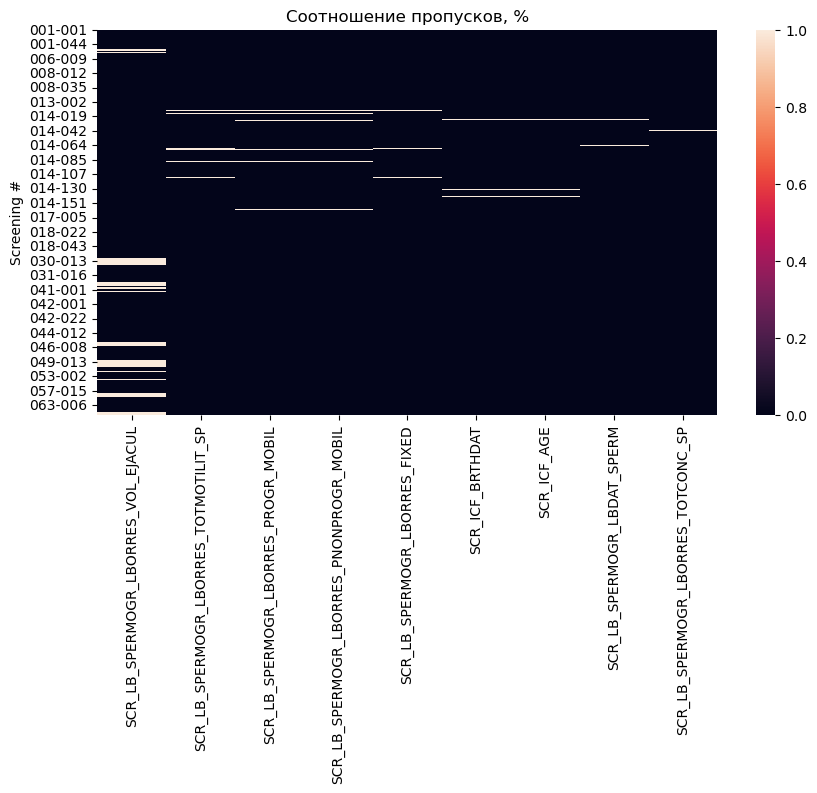
Первые 3 строки:

Initials Site # SCR\_ICF\_SVDAT\_ICF SCR\_ICF\_SVDAT SCR\_ICF\_BRTHDAT \  
Screening #   
001-001 РКВ 1 2023-06-26 2023-06-26 1986-04-12   
001-002 КАД 1 2023-06-24 2023-06-24 1993-09-09   
001-003 АДР 1 2023-10-23 2023-10-23 1983-01-09   
  
 SCR\_ICF\_AGE SCR\_LB\_SPERMOGR\_LBDAT\_SPERM \  
Screening #   
001-001 37.0 2023-06-21   
001-002 29.0 2023-05-27   
001-003 40.0 2023-10-23   
  
 SCR\_LB\_SPERMOGR\_LBORRES\_VOL\_EJACUL \  
Screening #   
001-001 3.2   
001-002 0.4   
001-003 3.0   
  
 SCR\_LB\_SPERMOGR\_LBORRES\_TOTCONC\_SP \  
Screening #   
001-001 139.17   
001-002 15.20   
001-003 103.00   
  
 SCR\_LB\_SPERMOGR\_LBORRES\_COCENTR\_SP \  
Screening #   
001-001 43.49   
001-002 38.00   
001-003 34.00   
  
 SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP \  
Screening #   
001-001 32.0   
001-002 41.0   
001-003 15.3   
  
 SCR\_LB\_SPERMOGR\_LBORRES\_PROGR\_MOBIL \  
Screening #   
001-001 32.53   
001-002 34.00   
001-003 3.63   
  
 SCR\_LB\_SPERMOGR\_LBORRES\_PNONPROGR\_MOBIL \  
Screening #   
001-001 11.83   
001-002 10.10   
001-003 11.66   
  
 SCR\_LB\_SPERMOGR\_LBORRES\_FIXED   
Screening #   
001-001 55.64   
001-002 59.00   
001-003 84.70

df\_cleaned.dtypes

Initials object  
Site # int64  
SCR\_ICF\_SVDAT\_ICF datetime64[ns]  
SCR\_ICF\_SVDAT datetime64[ns]  
SCR\_ICF\_BRTHDAT datetime64[ns]  
SCR\_ICF\_AGE float64  
SCR\_LB\_SPERMOGR\_LBDAT\_SPERM datetime64[ns]  
SCR\_LB\_SPERMOGR\_LBORRES\_VOL\_EJACUL float64  
SCR\_LB\_SPERMOGR\_LBORRES\_TOTCONC\_SP float64  
SCR\_LB\_SPERMOGR\_LBORRES\_COCENTR\_SP float64  
SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP float64  
SCR\_LB\_SPERMOGR\_LBORRES\_PROGR\_MOBIL float64  
SCR\_LB\_SPERMOGR\_LBORRES\_PNONPROGR\_MOBIL float64  
SCR\_LB\_SPERMOGR\_LBORRES\_FIXED float64  
dtype: object

# Визуализация соотношений пропусков  
nans = 100 \* df\_cleaned.isnull().mean().sort\_values(ascending=False)[df\_cleaned.isnull().mean().sort\_values(ascending=False) > 0]  
# Столбчатая диаграмма  
nans.plot(  
 kind='bar',   
 logy=False,  
 figsize=(10,5),  
 title='Соотношение пропусков, %');  
  
# Построение тепловой карты пропусков  
sns.heatmap(df\_cleaned[nans.index].isnull());



## Шаг 3 Поиск аномалий

## Задача 1: Определение пациентов с фальсифицированными данными

#### Проблемы с датами

# Пересчитаем возраст  
df\_cleaned['recalculated\_age'] = (df\_cleaned['SCR\_ICF\_SVDAT\_ICF'] - df\_cleaned['SCR\_ICF\_BRTHDAT']).dt.days / 365.25

# Выведем количество наблюдений с отклонением более 2 года  
  
# Вычисляем абсолютное отклонение возраста относительно колонки 'SCR\_ICF\_AGE'  
df\_cleaned['age\_deviation'] = (df\_cleaned['recalculated\_age'] - df\_cleaned['SCR\_ICF\_AGE']).abs()  
  
# Подсчитываем количество наблюдений с отклонением в 2 года и более  
deviation\_count = df\_cleaned[df\_cleaned['age\_deviation'] >= 2].shape[0]  
  
print(f"Количество наблюдений с отклонением в 2 года и более: {deviation\_count}")

Количество наблюдений с отклонением в 2 года и более: 0

# Переводим колонки с датами в формат datetime  
# df\_cleaned['SCR\_LB\_SPERMOGR\_LBDAT\_SPERM'] = pd.to\_datetime(df\_cleaned['SCR\_LB\_SPERMOGR\_LBDAT\_SPERM'])  
df\_cleaned['SCR\_ICF\_SVDAT'] = pd.to\_datetime(df\_cleaned['SCR\_ICF\_SVDAT'])  
  
# Фильтруем DataFrame, чтобы оставить только те наблюдения, где дата анализа спермограммы идет до даты визита  
observations\_before\_visit = df\_cleaned[df\_cleaned['SCR\_LB\_SPERMOGR\_LBDAT\_SPERM'] < df\_cleaned['SCR\_ICF\_SVDAT']]  
  
# Подсчитываем количество таких наблюдений  
count\_observations\_before\_visit = observations\_before\_visit.shape[0]  
  
print(f"Количество наблюдений, где анализ спермограммы был сделан до визита: {count\_observations\_before\_visit}")

Количество наблюдений, где анализ спермограммы был сделан до визита: 101

# Prepare a series of numbers to represent the y-axis in the scatter plot  
indices = range(len(df\_cleaned))  
  
# Creating scatter plots  
plt.figure(figsize=(12, 18))  
  
# Scatter plot for SCR\_ICF\_SVDAT\_ICF  
plt.subplot(3, 1, 1) # 3 rows, 1 column, 1st subplot  
plt.scatter(df\_cleaned['SCR\_ICF\_SVDAT\_ICF'], indices, color='blue', alpha=0.6, label='SCR\_ICF\_SVDAT\_ICF')  
plt.title('Дата подписания ИС')  
plt.xlabel('Date')  
plt.ylabel('Index')  
plt.legend()  
  
# Scatter plot for SCR\_ICF\_SVDAT  
plt.subplot(3, 1, 2) # 3 rows, 1 column, 2nd subplot  
plt.scatter(df\_cleaned['SCR\_ICF\_SVDAT'], indices, color='red', alpha=0.6, label='SCR\_ICF\_SVDAT')  
plt.title('Дата первого визита')  
plt.xlabel('Date')  
plt.ylabel('Index')  
plt.legend()  
  
# Scatter plot for SCR\_ICF\_BRTHDAT  
plt.subplot(3, 1, 3) # 3 rows, 1 column, 3rd subplot  
plt.scatter(df\_cleaned['SCR\_LB\_SPERMOGR\_LBDAT\_SPERM'], indices, color='green', alpha=0.6, label='SCR\_LB\_SPERMOGR\_LBDAT\_SPERM')  
plt.title('Дата лабораторного исследования')  
plt.xlabel('Date')  
plt.ylabel('Index')  
plt.legend()  
  
  
  
# Show the plots  
plt.tight\_layout()  
plt.show()

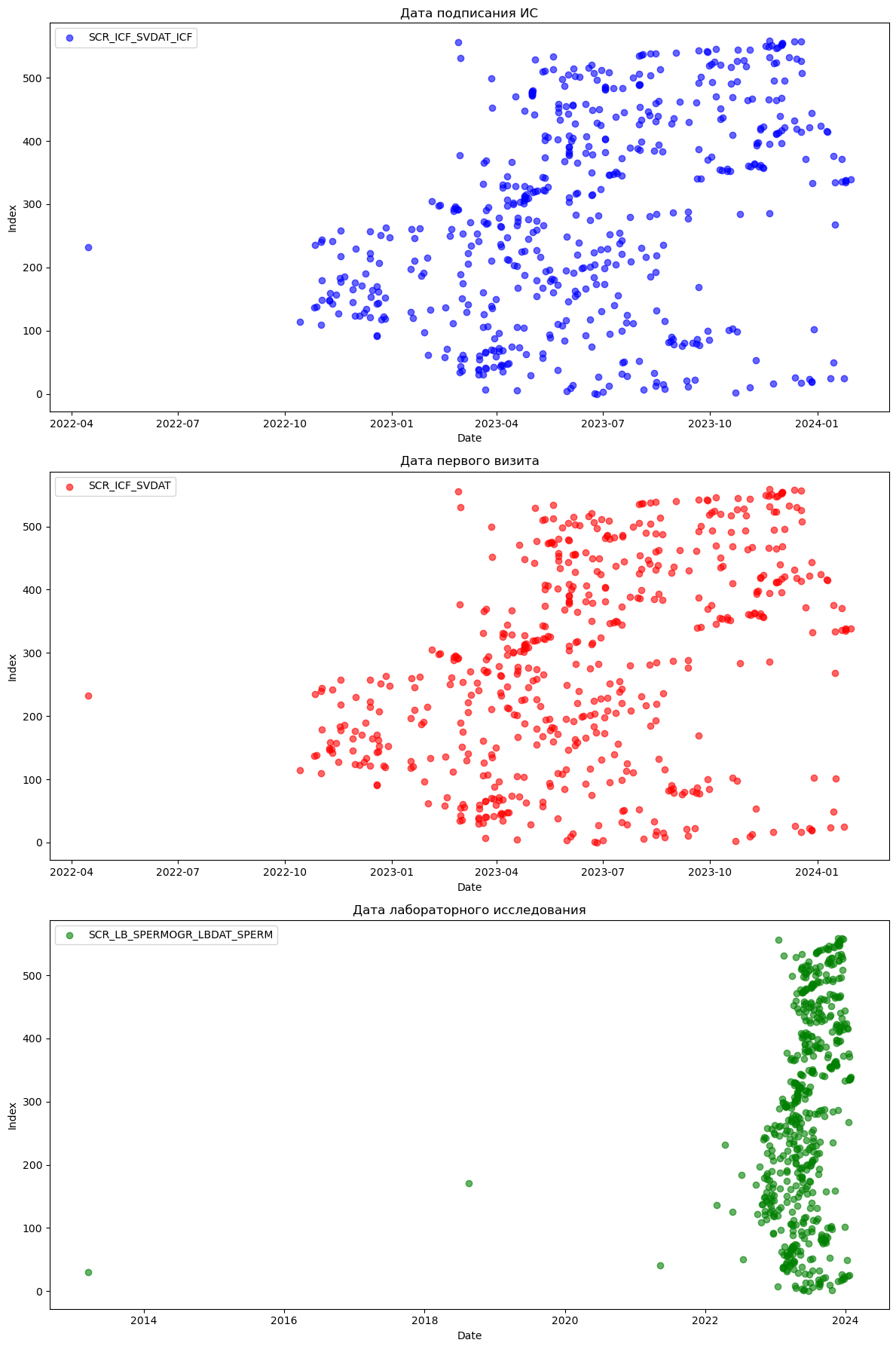


fig = px.histogram(  
 data\_frame=df\_cleaned,  
 x = 'SCR\_LB\_SPERMOGR\_LBDAT\_SPERM',  
 histnorm = 'percent',  
 marginal = 'box',  
 width = 700,  
 title = 'Распределение дат лабораторных исследований'  
   
)  
fig.show()

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fig.show()

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Screening #  
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'014-135'

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Initials СГА  
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recalculated\_age 0.457221  
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### Обзор распределений данных по лабораторным исследованиям

# Распределения по лабораторным исследованиям  
for col in spermo\_columns:  
 fig = px.histogram(  
 data\_frame=df\_cleaned,  
 x=col,  
 histnorm='percent',  
 marginal='box',  
 width=700,  
 title=f'Распределение признака {col}'  
 )  
 fig.show()

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# Find indices of rows where values exceed IQR by 10 times  
outlier\_indices = set()  
  
# Find indices of rows where values exceed IQR by 10 times  
for col in spermo\_columns:  
 q1 = df\_cleaned[col].quantile(0.25)  
 q3 = df\_cleaned[col].quantile(0.75)  
 iqr = q3 - q1  
   
 # Find outlier indices for the current column  
 outliers = df\_cleaned[(df\_cleaned[col] < q1 - 10 \* iqr) | (df\_cleaned[col] > q3 + 10 \* iqr)].index  
   
 # Update the set of all outlier indices  
 outlier\_indices.update(outliers)  
  
# Remove rows corresponding to outliers  
df\_cleaned\_filtered = df\_cleaned.drop(index=outlier\_indices)  
print(f'Удалены индексы с аномалиями: {outlier\_indices}')

Удалены индексы с аномалиями: {'024-001', '053-004', '014-127'}

# Calculate IQR for each column in spermo\_columns  
iqr\_values = {}  
for col in spermo\_columns:  
 q1 = df\_cleaned[col].quantile(0.25)  
 q3 = df\_cleaned[col].quantile(0.75)  
 iqr = q3 - q1  
 iqr\_values[col] = iqr  
  
# Find indices of rows where values exceed IQR by 10 times  
outlier\_indices = {}  
for col in spermo\_columns:  
 # Recalculate q1 and q3 for the current column  
 q1 = df\_cleaned[col].quantile(0.25)  
 q3 = df\_cleaned[col].quantile(0.75)  
 iqr = iqr\_values[col]  
 outliers = df\_cleaned[(df\_cleaned[col] < q1 - 10 \* iqr) | (df\_cleaned[col] > q3 + 10 \* iqr)].index  
 outlier\_indices[col] = outliers.tolist()  
  
# Find indices of rows where values exceed IQR by 10 times  
outlier\_results = []  
for col in spermo\_columns:  
 # Recalculate q1 and q3 for the current column  
 q1 = df\_cleaned[col].quantile(0.25)  
 q3 = df\_cleaned[col].quantile(0.75)  
 iqr = iqr\_values[col]  
  
 # Find outliers  
 outliers = df\_cleaned[(df\_cleaned[col] < q1 - 10 \* iqr) | (df\_cleaned[col] > q3 + 10 \* iqr)]  
  
 # Add outlier information to the results list  
 for index in outliers.index:  
 outlier\_results.append({'Patient ID': index, 'Feature': col, 'Value': outliers.at[index, col]})  
  
# Create a beautiful table with the results  
outlier\_table = pd.DataFrame(outlier\_results)  
print(outlier\_table)

Patient ID Feature Value  
0 053-004 SCR\_LB\_SPERMOGR\_LBORRES\_VOL\_EJACUL 74.0  
1 024-001 SCR\_LB\_SPERMOGR\_LBORRES\_TOTCONC\_SP 2400000.0  
2 024-001 SCR\_LB\_SPERMOGR\_LBORRES\_COCENTR\_SP 600000.0  
3 014-127 SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP 456.0

# Remove rows corresponding to outliers  
df\_cleaned = df\_cleaned.drop(index=(outlier\_table['Patient ID'].values))

df\_cleaned.shape

(557, 16)

# Распределения по лабораторным исследованиям  
for col in spermo\_columns:  
 fig = px.histogram(  
 data\_frame=df\_cleaned,  
 x=col,  
 histnorm='percent',  
 marginal='box',  
 width=700,  
 title=f'Распределение признака {col}'  
 )  
 fig.show()

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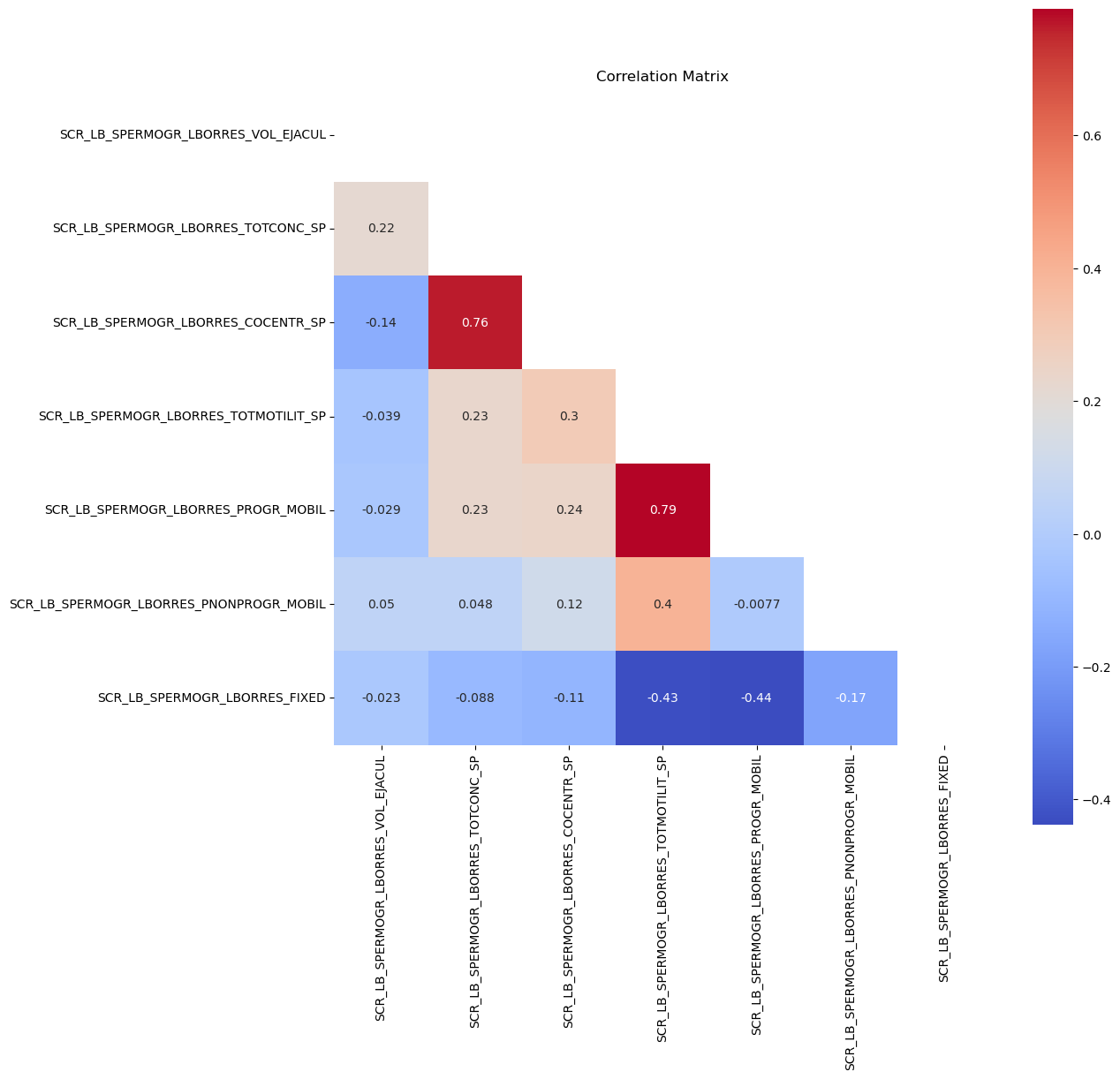
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49,45,33,47,73,68,88,55,98,98,44,64,52,55,58,48,60,51,60,53,58,91,46,51,69,56,38,45,56,64,79,58,43,40,99,18,28,84,0,0,0,0,45,78,77,67,80,80,59,65,63,72,70.2,68.2,73.4,68,63.2,76,50,33,80.5,72,50,25,59,80,65,64,65,85,74,44,10,50,60,51,66,62,65,11,58,66,47,69,12,48,64,11,83,100,48,30,63,18,24,58,50,49,100,60,47.83,33.33,77,66,5,71,45,13,17,67,26,15,47,75,0,2,5,5,10,15,16,20,66,1,81,66,86,68,77,55,60,70,56,53,53,58,55,60,41.7,94.6,71.4,0,46.7,45.3,54,22.9,67,15,100,72,14.7,37,96,37,19,31.1,17,5,8,5,8,5,5,5,5,5,9,81,42.86,35.29,41,28.13,52,79,63,23,20,92,59,21,81,75,73,50,83,59,97,60,23,18,23,45,38,50,33,25,52,33,45,80,50,78,70,80,40,69,55,100,0,52,48.1,0,43,47,41,30,39,40,36,38,64,28,40,48,100,70,86,19,62,36,29,0,31,72,90,73,72,56,60,96,17,58,79,73,76,19,59,60,72,79,63,76,77,65,79,91,81,44,69,62,39,60,56,84,76,78,26,75,0,0,64,63,36,38,64,50,58,69,51,35,25,71,0,0,46,66,61,56,42,52,55,62,56,28,48,28,50,93,69,44.7,55.44,0,58,71.84,37.75,28.43,88,85,57,69,57,65,78,44,44,29,41,43,35,35,43,48,39,42,33,29,33,33,67.76,49.4,40.11,91.07],"type":"box","legendgroup":""}]}

## Задача 2: Определение сфальсифицированных признаков

### Матрица корреляции признаков

# Select only the columns in spermo\_columns  
corr\_df = df\_cleaned[spermo\_columns]  
  
# Calculate the correlation matrix  
corr\_matrix = corr\_df.corr()  
  
# Create a mask to remove the upper triangle  
mask = np.triu(np.ones\_like(corr\_matrix, dtype=bool))  
  
# Create a beautiful correlation matrix plot  
plt.figure(figsize=(12, 12))  
sns.heatmap(corr\_matrix, annot=True, cmap='coolwarm', square=True, mask=mask)  
plt.title('Correlation Matrix')  
plt.show()  
# Get the top correlations  
top\_corr = corr\_matrix.unstack().sort\_values(ascending=False).drop\_duplicates()  
  
# Print the top correlations  
print('Топ корреляции показателей лабораторных результатов')  
print(top\_corr[top\_corr > 0.7])



Топ корреляции показателей лабораторных результатов  
SCR\_LB\_SPERMOGR\_LBORRES\_VOL\_EJACUL SCR\_LB\_SPERMOGR\_LBORRES\_VOL\_EJACUL 1.000000  
SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP SCR\_LB\_SPERMOGR\_LBORRES\_PROGR\_MOBIL 0.791283  
SCR\_LB\_SPERMOGR\_LBORRES\_TOTCONC\_SP SCR\_LB\_SPERMOGR\_LBORRES\_COCENTR\_SP 0.763382  
dtype: float64

Вывод: обнаружена пара высокоррелированных признаков

* SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP
* SCR\_LB\_SPERMOGR\_LBORRES\_PROGR\_MOBIL

### z-score

Z-score — это мера, которая описывает положение значения в выборке относительно среднего значения, измеренное в числе стандартных отклонений. Этот метод хорошо работает, если данные имеют нормальное распределение.

Часть наших данных на графиках выше - скошена влево.

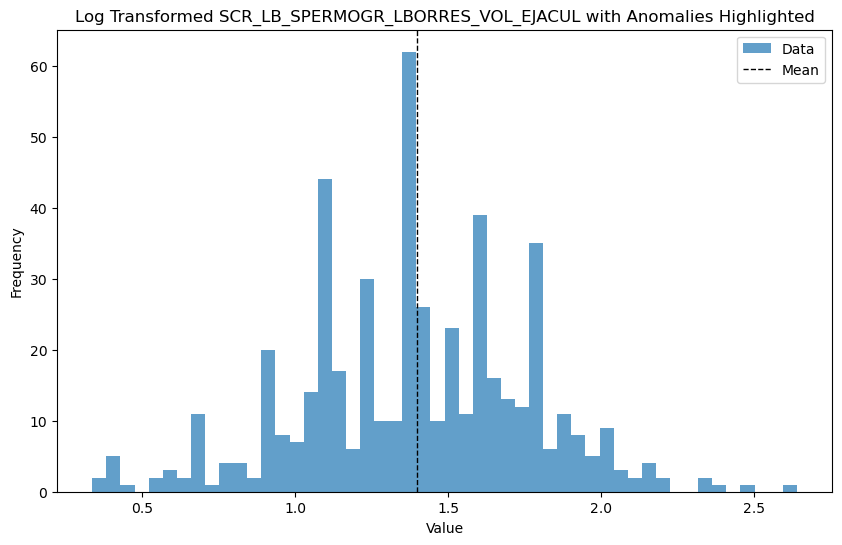
Если распределение данных скошено, то z-score может не быть лучшим способом обнаружения выбросов, поскольку оценки среднего и стандартного отклонения могут быть искажены.

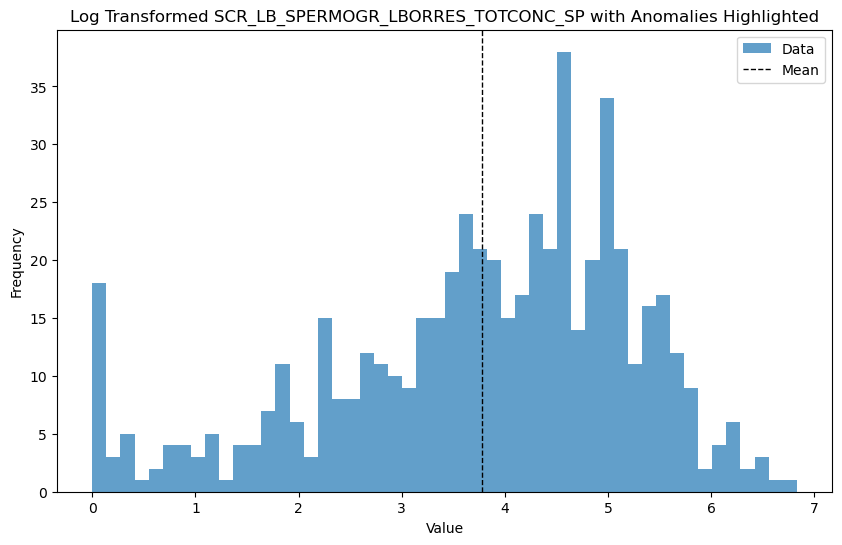
Один из способов обработки скошенных данных — преобразование данных для приближения к нормальному распределению. Примеры таких преобразований включают логарифмическое преобразование, квадратный корень, обратное преобразование и Box-Cox преобразование.

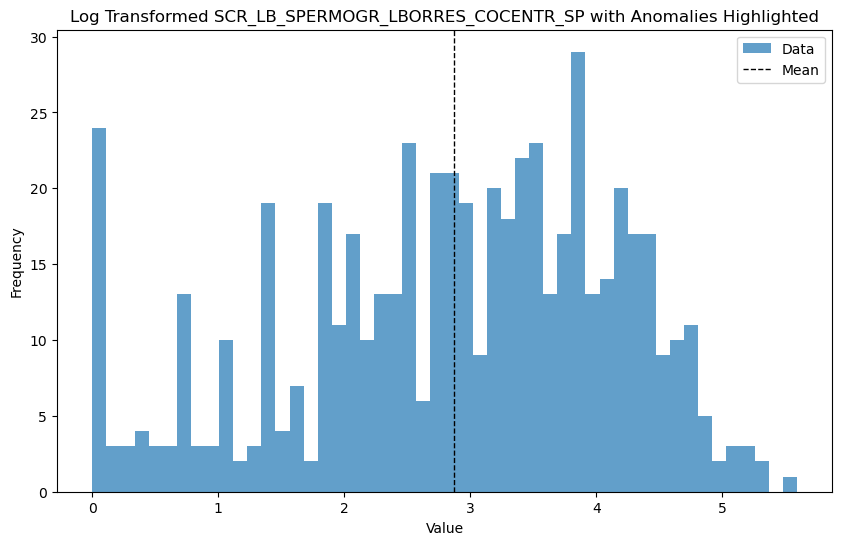
Этот код выведет список аномальных значений и создаст гистограммы логарифмированных признаков с выделенными аномалиями.

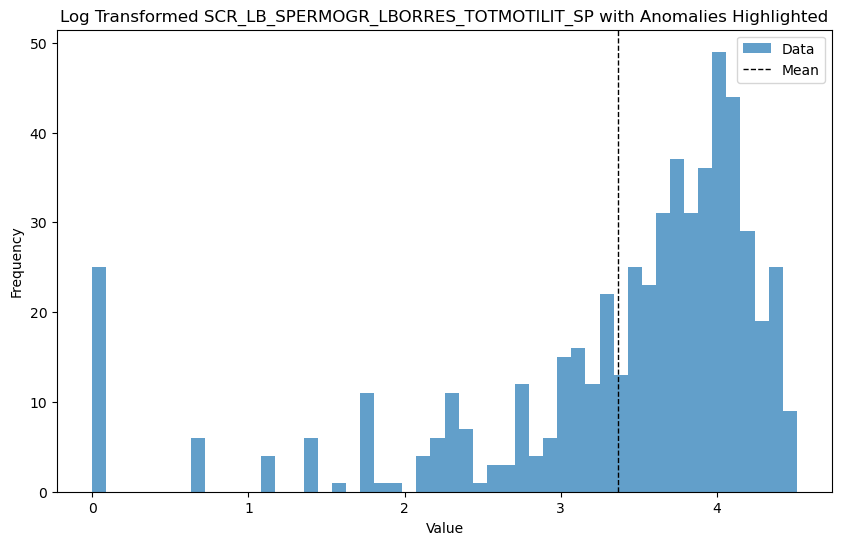
# Применяем логарифмическое преобразование и вычисляем z-score  
for col in spermo\_columns:  
 df\_cleaned[col + '\_log'] = np.log1p(df\_cleaned[col])  
 df\_cleaned[col + '\_log\_zscore'] = zscore(df\_cleaned[col + '\_log'])  
  
# Идентифицируем аномалии  
threshold\_zscore = 3  
anomalies = pd.DataFrame()  
  
for col in spermo\_columns:  
 z\_col = col + '\_log\_zscore'  
 anomalies\_col = df\_cleaned[(df\_cleaned[z\_col] > threshold\_zscore) | (df\_cleaned[z\_col] < -threshold\_zscore)]  
 anomalies\_col = anomalies\_col[[col, z\_col]]  
 anomalies\_col['Feature'] = col  
 anomalies\_col.rename(columns={col: 'Value', z\_col: 'Z-score'}, inplace=True)  
 anomalies = pd.concat([anomalies, anomalies\_col[['Feature', 'Value', 'Z-score']]])  
  
# Выводим список аномалий  
print(anomalies)  
  
# Визуализация аномалий  
for col in spermo\_columns:  
 plt.figure(figsize=(10, 6))  
 plt.hist(df\_cleaned[col + '\_log'], bins=50, alpha=0.7, label='Data')  
 plt.axvline(df\_cleaned[col + '\_log'].mean(), color='k', linestyle='dashed', linewidth=1, label='Mean')  
 # Подсветка аномалий  
 anomalies\_col = df\_cleaned[(df\_cleaned[col + '\_log\_zscore'] > threshold\_zscore) |   
 (df\_cleaned[col + '\_log\_zscore'] < -threshold\_zscore)]  
 if not anomalies\_col.empty:  
 plt.scatter(anomalies\_col[col + '\_log'], [0] \* anomalies\_col.shape[0], color='r', label='Anomalies')  
 plt.title(f'Log Transformed {col} with Anomalies Highlighted')  
 plt.xlabel('Value')  
 plt.ylabel('Frequency')  
 plt.legend()  
 plt.show()

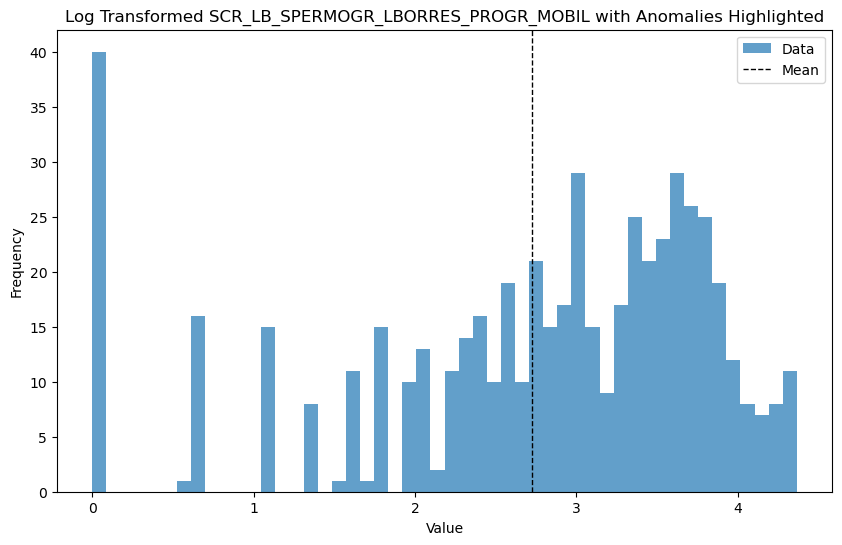
Empty DataFrame  
Columns: [Feature, Value, Z-score]  
Index: []

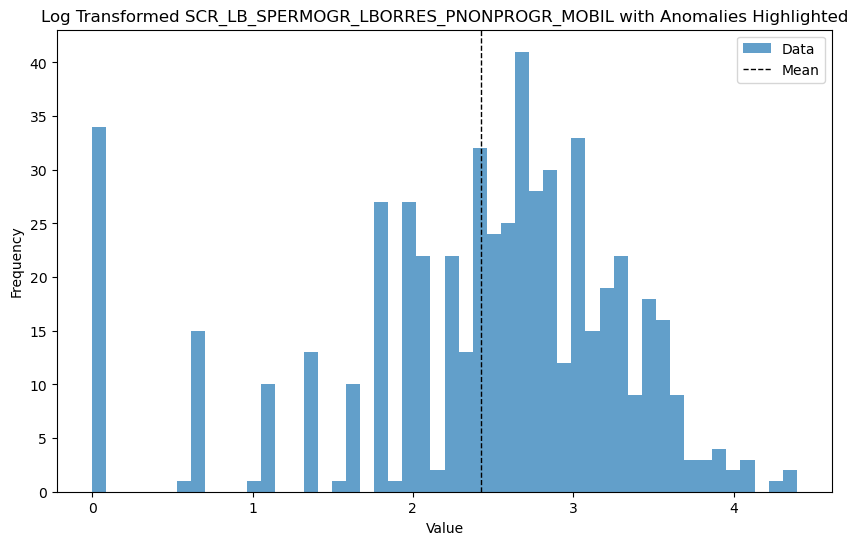


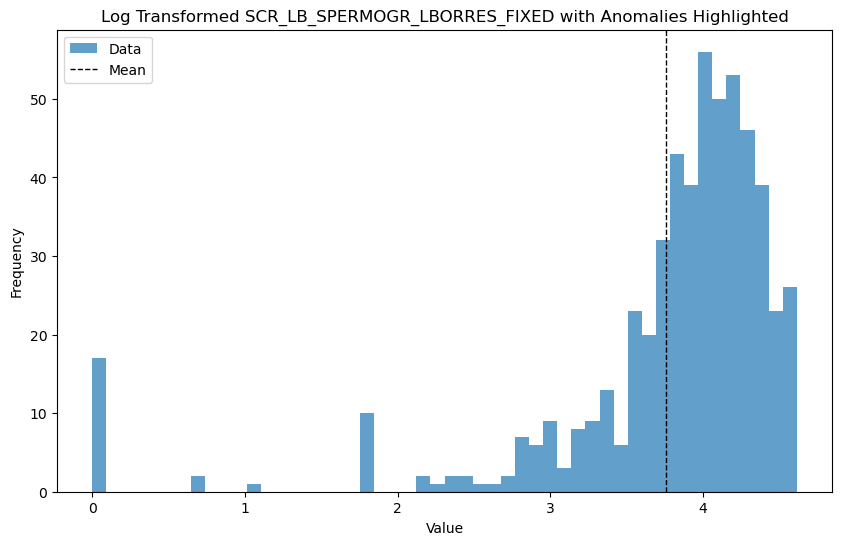








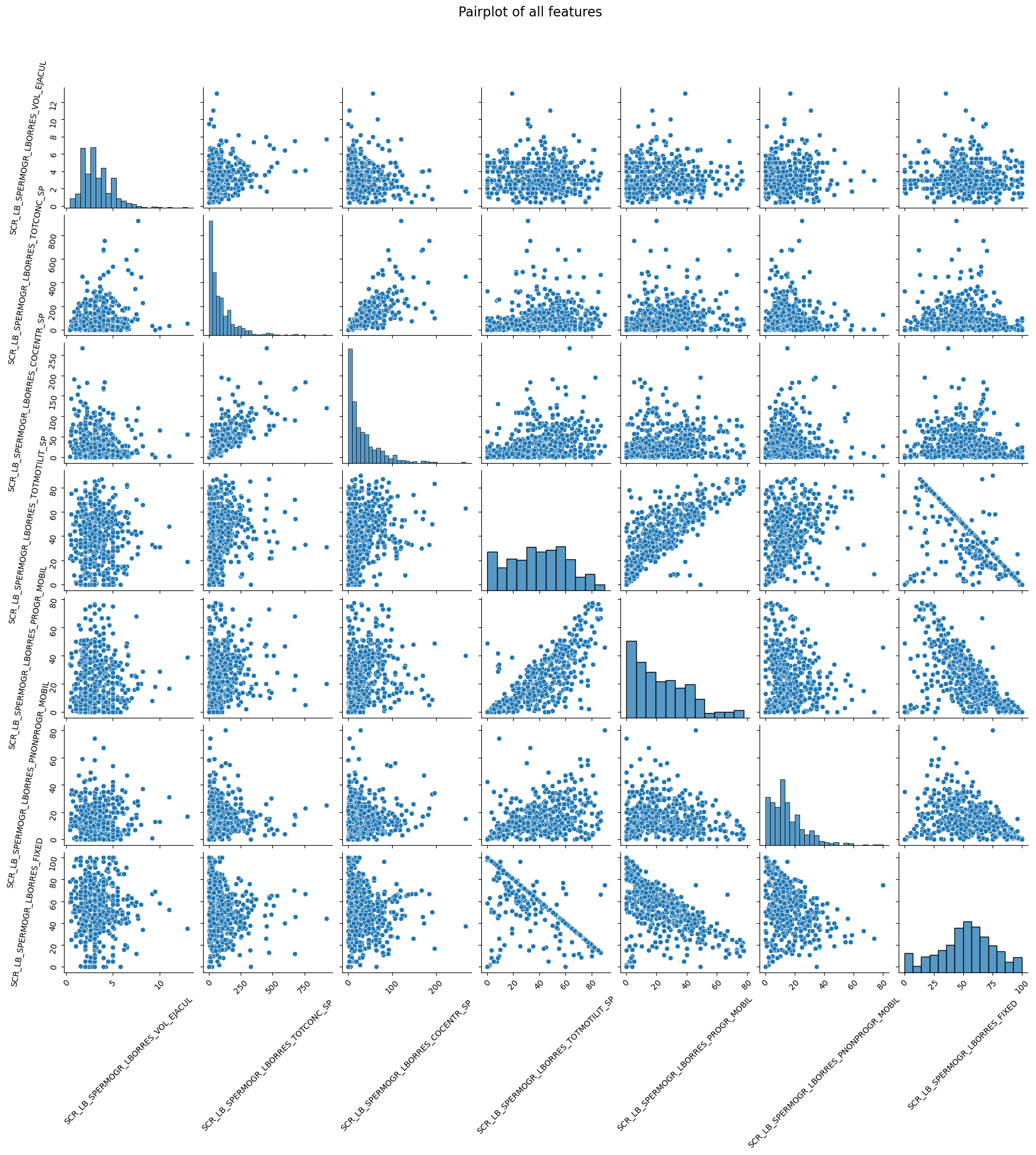




Вывод: методом z-score по логарифмированным данным выбросы и аномалии в сабсете по значениям лабораторных результатов - не обнаружены

### Pairplot

# Создаем pairplot для всех признаков в df\_cleaned  
g = sns.pairplot(df\_cleaned[spermo\_columns])  
  
# Поворачиваем метки на 45 градусов  
for ax in g.axes.flatten():  
 # Поворачиваем метки оси X  
 if ax is not None:  
 ax.set\_xlabel(ax.get\_xlabel(), rotation=45)  
 ax.set\_ylabel(ax.get\_ylabel(), rotation=80, labelpad=20)  
 # Поворачиваем текст меток  
 for label in ax.get\_xticklabels():  
 label.set\_rotation(45)  
 for label in ax.get\_yticklabels():  
 label.set\_rotation(80)  
  
# Устанавливаем заголовок для всей фигуры, а не для отдельных осей  
plt.subplots\_adjust(top=0.9) # Немного поднимаем заголовок, чтобы не перекрывать оси  
g.fig.suptitle('Pairplot of all features', fontsize=16)  
  
# Показываем pairplot  
plt.show()



Вывод: построение матрицы парных корреляций признаков указывает на аномальную связь одной пары признаков. Рассмотрим детальнее.

# Построение scatterplot  
fig = px.scatter(df\_cleaned, x='SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP', y='SCR\_LB\_SPERMOGR\_LBORRES\_FIXED')  
  
# Установка подписей осей и заголовка  
fig.update\_layout(  
 xaxis\_title='SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP',  
 yaxis\_title='SCR\_LB\_SPERMOGR\_LBORRES\_FIXED',  
 title='Scatterplot of TOTMOTILIT\_SP and FIXED'  
)  
  
# Показ графика  
fig.show()

{"layout":{"yaxis":{"domain":[0,1],"anchor":"x","title":{"text":"SCR\_LB\_SPERMOGR\_LBORRES\_FIXED"}},"xaxis":{"domain":[0,1],"anchor":"y","title":{"text":"SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP"}},"margin":{"t":60},"title":{"text":"Scatterplot of TOTMOTILIT\_SP and 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.33,77,66,5,71,45,13,17,67,26,15,47,75,0,2,5,5,10,15,16,20,66,1,81,66,86,68,77,55,60,70,56,53,53,58,55,60,41.7,94.6,71.4,0,46.7,45.3,54,22.9,67,15,100,72,14.7,37,96,37,19,31.1,17,5,8,5,8,5,5,5,5,5,9,81,42.86,35.29,41,28.13,52,79,63,23,20,92,59,21,81,75,73,50,83,59,97,60,23,18,23,45,38,50,33,25,52,33,45,80,50,78,70,80,40,69,55,100,0,52,48.1,0,43,47,41,30,39,40,36,38,64,28,40,48,100,70,86,19,62,36,29,0,31,72,90,73,72,56,60,96,17,58,79,73,76,19,59,60,72,79,63,76,77,65,79,91,81,44,69,62,39,60,56,84,76,78,26,75,0,0,64,63,36,38,64,50,58,69,51,35,25,71,0,0,46,66,61,56,42,52,55,62,56,28,48,28,50,93,69,44.7,55.44,0,58,71.84,37.75,28.43,88,85,57,69,57,65,78,44,44,29,41,43,35,35,43,48,39,42,33,29,33,33,67.76,49.4,40.11,91.07]}]}

Вывод: на диаграмме разброса четка видна обратная корреляция части данных.

### Машинное обучение для выявления аномалий

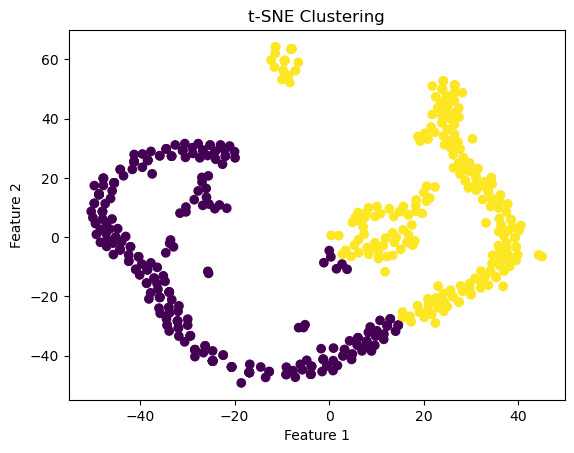
df\_anomaly = df\_cleaned[['SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP', 'SCR\_LB\_SPERMOGR\_LBORRES\_FIXED']].copy()  
df\_anomaly.shape

(557, 2)

# Удаление строк с NaN значениями для двух столбцов  
df\_anomaly = df\_anomaly.dropna()  
  
# Преобразуем данные в формат, подходящий для sklearn  
X = df\_anomaly['SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP'].values.reshape(-1, 1)  
y = df\_anomaly['SCR\_LB\_SPERMOGR\_LBORRES\_FIXED'].values  
  
# Создаем и обучаем модель  
model = LinearRegression().fit(X, y)  
  
# Вычисляем предсказанные значения  
y\_pred = model.predict(X)  
  
# Вычисляем ошибки (расстояния от точек до линии регрессии)  
errors = np.abs(y - y\_pred)  
  
# Определяем порог ошибки для определения "сильной" корреляции  
threshold = errors.mean() # Например, средняя ошибка  
  
# Получаем индексы пациентов с ошибкой ниже порога  
strong\_correlation\_indices = errors < threshold  
  
# Используем индексы DataFrame для получения id пациентов с сильной корреляцией  
patients\_with\_strong\_correlation = df\_anomaly.index[strong\_correlation\_indices]  
  
# Выводим список пациентов  
print(patients\_with\_strong\_correlation.tolist())

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from sklearn.manifold import TSNE  
from sklearn.cluster import KMeans  
import matplotlib.pyplot as plt  
  
# Perform t-SNE dimensionality reduction  
tsne = TSNE(n\_components=2, random\_state=42)  
tsne\_df = tsne.fit\_transform(df\_anomaly)  
  
# Perform K-Means clustering with 2 clusters  
kmeans = KMeans(n\_clusters=2, random\_state=42)  
kmeans\_labels = kmeans.fit\_predict(tsne\_df)  
  
# Plot the clusters  
plt.scatter(tsne\_df[:, 0], tsne\_df[:, 1], c=kmeans\_labels)  
plt.title('t-SNE Clustering')  
plt.xlabel('Feature 1')  
plt.ylabel('Feature 2')  
plt.show()



# Define the line equation: y = -x + 100  
def line\_eq(x):  
 return -x + 100  
  
# Calculate the y-values for the line  
x\_line = np.array([20, 80])  
y\_line = line\_eq(x\_line)  
  
# Create the main scatterplot  
fig = px.scatter(df\_cleaned, x='SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP', y='SCR\_LB\_SPERMOGR\_LBORRES\_FIXED',  
 color\_discrete\_sequence=['blue'], # синий цвет для основного слоя  
 title='Scatterplot of TOTMOTILIT\_SP and FIXED')  
  
# Add a line to the plot  
fig.add\_scatter(x=x\_line, y=y\_line, mode='lines', line=dict(color='black', width=2), name='Линия тренда')  
  
# Identify points in df\_anomaly that lie on the line with a tolerance of +- 1  
tolerance = 1  
df\_anomaly\_on\_line = df\_anomaly[np.abs(df\_anomaly['SCR\_LB\_SPERMOGR\_LBORRES\_FIXED'] - line\_eq(df\_anomaly['SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP'])) <= tolerance]  
  
# Save the patients who lie on the line to a list  
patients\_on\_line = df\_anomaly\_on\_line.index.tolist()  
  
# # Add yellow points for the points on the line  
# fig.add\_scatter(x=df\_anomaly\_on\_line['SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP'],  
# y=df\_anomaly\_on\_line['SCR\_LB\_SPERMOGR\_LBORRES\_FIXED'],  
# mode='markers', marker=dict(color='yellow'), name='Ручная привязка пациентов к линии тренда')  
  
# Add red points for patients with strong correlation  
fig.add\_scatter(x=df\_cleaned.loc[patients\_with\_strong\_correlation, 'SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP'],  
 y=df\_cleaned.loc[patients\_with\_strong\_correlation, 'SCR\_LB\_SPERMOGR\_LBORRES\_FIXED'],  
 mode='markers', marker=dict(color='red'), name='Linear Regression predict')  
  
  
# Show the plot  
fig.show()

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# Perform DBSCAN clustering with 2 clusters  
dbscan = DBSCAN(eps=0.7, min\_samples=2)  
dbscan\_labels = dbscan.fit\_predict(df\_anomaly)  
  
# Replace all cluster labels except -1 with 1  
dbscan\_labels\_binary = np.where(dbscan\_labels == -1, -1, 1)  
  
# Create a DataFrame with patient IDs and cluster assignments  
cluster\_assignments = pd.DataFrame({  
 'Patient ID': df\_anomaly.index,   
 'Cluster': dbscan\_labels\_binary})  
cluster\_assignments.set\_index('Patient ID', inplace=True)  
  
cluster\_assignments = cluster\_assignments.assign(  
 SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP=df\_cleaned['SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP'],  
 SCR\_LB\_SPERMOGR\_LBORRES\_FIXED=df\_cleaned['SCR\_LB\_SPERMOGR\_LBORRES\_FIXED']  
)

cluster\_assignments.Cluster.value\_counts()

Cluster  
 1 411  
-1 137  
Name: count, dtype: int64

# Define the line equation: y = -x + 100  
def line\_eq(x):  
 return -x + 100  
  
# Calculate the y-values for the line  
x\_line = np.array([20, 80])  
y\_line = line\_eq(x\_line)  
  
# Create the main scatterplot  
fig = px.scatter(df\_cleaned, x='SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP', y='SCR\_LB\_SPERMOGR\_LBORRES\_FIXED',  
 color\_discrete\_sequence=['blue'], # синий цвет для основного слоя  
 title='Scatterplot of TOTMOTILIT\_SP and FIXED')  
  
# Add a line to the plot  
fig.add\_scatter(x=x\_line, y=y\_line, mode='lines', line=dict(color='black', width=2), name='Линия тренда')  
  
  
# Add green points for patients from BDSCAN clusters == 1  
ca\_1 = cluster\_assignments[cluster\_assignments.Cluster == 1]  
fig.add\_scatter(x=ca\_1['SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP'],  
 y=ca\_1['SCR\_LB\_SPERMOGR\_LBORRES\_FIXED'],  
 mode='markers', marker=dict(color='green'), name='from DBSCAN clusters == 1 (Аномалии)')  
  
# Add black points for patients from BDSCAN clusters == -1  
ca\_norm = cluster\_assignments[cluster\_assignments.Cluster == -1]  
fig.add\_scatter(x=ca\_norm['SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP'],  
 y=ca\_norm['SCR\_LB\_SPERMOGR\_LBORRES\_FIXED'],  
 mode='markers', marker=dict(color='black'), name='from DBSCAN clusters == -1 (Норма)')  
  
# Show the plot  
fig.show()

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## Шаг 04 Общий вывод

### Какие именно данные, возможно, были сфальсифицированы

Список типов исследований с возможной фальсификацией

* 'SCR\_LB\_SPERMOGR\_LBORRES\_TOTMOTILIT\_SP',
* 'SCR\_LB\_SPERMOGR\_LBORRES\_FIXED'

print(f"Количество наблюдений, где анализ спермограммы был сделан до визита: {count\_observations\_before\_visit}")

Количество наблюдений, где анализ спермограммы был сделан до визита: 101

### Oтметить номера пациентов, для которых данные, возможно, были сфальсифицированы.

len(ca\_1), len(df\_anomaly\_on\_line)

(411, 401)

ca\_1.to\_csv('fraud\_by\_clustering.csv', index=True)  
df\_anomaly\_on\_line.to\_csv('fraud\_by\_visual.csv', index=True)