



GPR-SPC Analyzer

User Manual

Statistical Process Control for Gamma Passing Rate Analysis

Aspasia E Evgeneia

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1 Introduction

This manual provides step-by-step instructions on how to use the GPR-SPC Analyzer application for Gamma Passing Rate (GPR) analysis. The tool supports data import and overview, statistical analysis, normality testing, SPC I-charts for normal and non-normal distributions, and an outlier elimination workflow based on the Identify – Eliminate – Recalculate technique.

2 Getting Started

2.1 Launching the Application

macOS

To open the application on macOS for the first time:

1. Right-click (or Ctrl-click) on `GPR-SPC Analyzer.app`.
2. Select **Open**.
3. If macOS displays a security warning, click **Open**.

If the application does not open or no **Open** button appears, use the following method:

1. Try to open the application once (double-click or right-click → Open). This registers it with macOS Gatekeeper.
2. Open **System Settings** and go to **Privacy & Security**.
3. Scroll down to the message: "*GPR-SPC Analyzer.app was blocked from use because it is not from an identified developer.*"
4. Click **Open Anyway**.
5. Confirm by clicking **Open** in the final dialog.

Windows

When launching the application on Windows for the first time, the Microsoft Defender SmartScreen may block it because it is not digitally signed. This is normal for locally built executables.

1. Double-click on `GPR-SPC Analyzer.exe`.
2. If Windows shows the message "*Windows protected your PC*", click on **More info**.

3. A new button labelled **Run anyway** will appear. Click on it.
4. The application will now launch normally.

2.2 Loading a File

To start using the application, you must load a file that follows the **recommended template** to avoid conflicts (see Section 6). Click the **Load File** button and select the file you want to analyze.

All other tabs and subtabs remain disabled until a correctly formatted file is loaded.

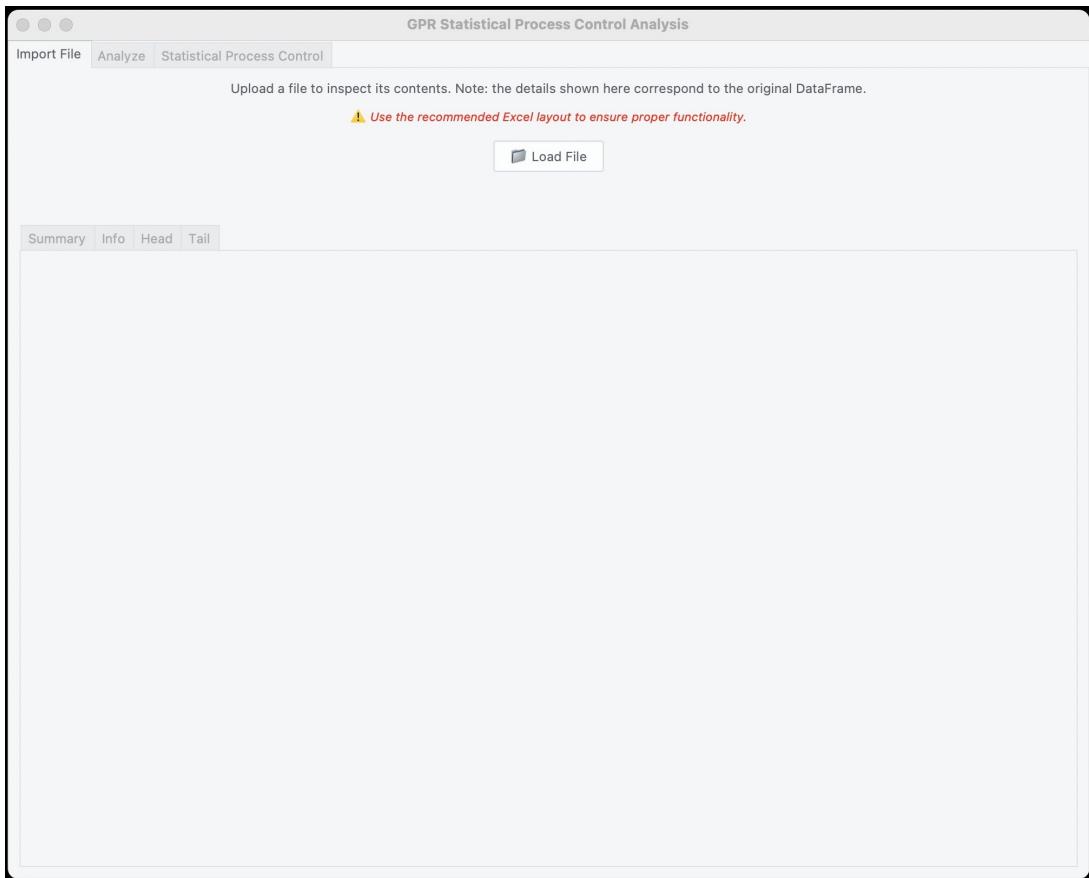


Figure 1: Main application interface before loading a file.

3 File Overview

Once you successfully load a file, you can review its contents to ensure that you have selected the correct dataset. The **Import File** tab contains several subtabs that help you inspect the structure and correctness of your data.

Note: If the displayed content exceeds the visible area, you can scroll vertically or horizontally to access all information.

3.1 Summary

The **Summary** subtab provides an initial overview of the loaded dataset. Here you can quickly verify that the file has been read correctly and that the data structure matches your expectations.

This section displays:

- the sites of cancer appearing in the file,
- the shape of the loaded DataFrame,
- the QA date range,
- the automatically applied ascending sorting by QA date,
- all available columns in the file,
- and the parameters that will be included in the SPC analysis.

The screenshot shows the 'GPR Statistical Process Control Analysis' application window. At the top, there are three colored circles (red, yellow, green) and a title bar. Below the title bar are tabs: 'Import File', 'Analyze', and 'Statistical Process Control'. The 'Analyze' tab is selected. A central message says 'Upload a file to inspect its contents. Note: the details shown here correspond to the original DataFrame.' Below this is a 'Load File' button with a folder icon. Underneath, it says 'Loaded: prostate_template.xlsx'. There are three tabs at the top of the main area: 'Summary' (selected), 'Info', 'Head', and 'Tail'. The 'Summary' tab contains the following information:

- Site(s) of Cancer: Prostate
- Shape: 57 rows x 25 columns
- Date Range: 2019-04-01 → 2023-10-12
- QA Date Sorting: Data is sorted by 'QA Date'!

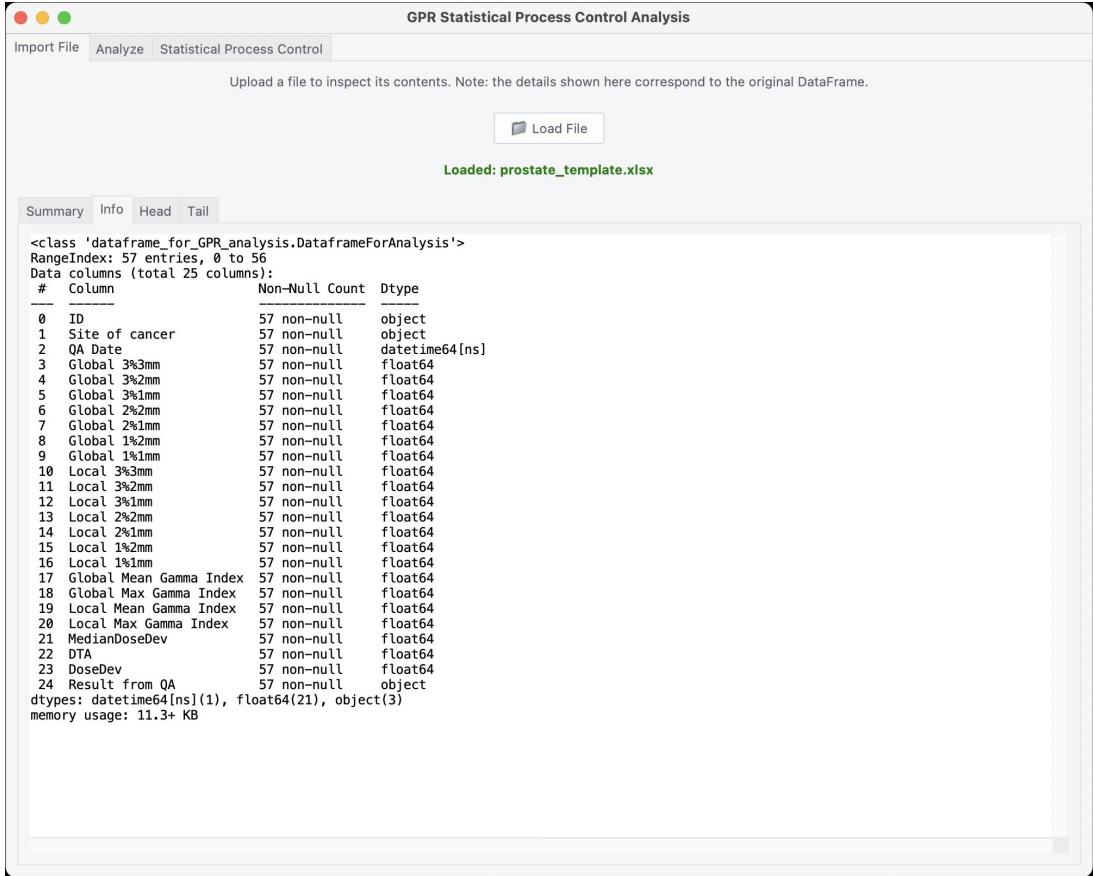
Under 'Columns:', a list of 25 items is shown, starting with ID and ending with Result from QA. Under 'Data for the SPC Analysis:', a list of 3 items is shown: ID, QA Date, and Global 3%3mm.

Figure 2: Summary subtab displaying the key dataset information.

3.2 Info

The **Info** subtab contains the data type of each column and the number of non-null entries in your Excel file. This overview helps you verify that the file structure and

column types are correct before proceeding with the analysis.



The screenshot shows the GPR Statistical Process Control Analysis software interface. At the top, there are three colored circles (red, yellow, green) and a title bar "GPR Statistical Process Control Analysis". Below the title bar are tabs: "Import File", "Analyze", and "Statistical Process Control". A sub-header says "Upload a file to inspect its contents. Note: the details shown here correspond to the original DataFrame." There is a "Load File" button with a folder icon. Below this, it says "Loaded: prostate_template.xlsx". The main area has tabs: "Summary", "Info", "Head", and "Tail". The "Info" tab is selected, displaying the following text:

```
<class 'dataframe_for_GPR_analysis.DataFrameForAnalysis'>
RangeIndex: 57 entries, 0 to 56
Data columns (total 25 columns):
 #   Column            Non-Null Count  Dtype  
--- 
 0   ID                57 non-null      object  
 1   Site of cancer    57 non-null      object  
 2   QA Date           57 non-null      datetime64[ns]
 3   Global 3%3mm     57 non-null      float64 
 4   Global 3%2mm     57 non-null      float64 
 5   Global 3%1mm     57 non-null      float64 
 6   Global 2%2mm     57 non-null      float64 
 7   Global 2%1mm     57 non-null      float64 
 8   Global 1%2mm     57 non-null      float64 
 9   Global 1%1mm     57 non-null      float64 
 10  Local 3%3mm      57 non-null      float64 
 11  Local 3%2mm      57 non-null      float64 
 12  Local 3%1mm      57 non-null      float64 
 13  Local 2%2mm      57 non-null      float64 
 14  Local 2%1mm      57 non-null      float64 
 15  Local 1%2mm      57 non-null      float64 
 16  Local 1%1mm      57 non-null      float64 
 17  Global Mean Gamma Index 57 non-null      float64 
 18  Global Max Gamma Index 57 non-null      float64 
 19  Local Mean Gamma Index 57 non-null      float64 
 20  Local Max Gamma Index 57 non-null      float64 
 21  MedianDoseDev    57 non-null      float64 
 22  DTA               57 non-null      float64 
 23  DoseDev          57 non-null      float64 
 24  Result from QA   57 non-null      object  
dtypes: datetime64[ns](1), float64(21), object(3)
memory usage: 11.3+ KB
```

Figure 3: Info subtab showing column data types and non-null counts.

3.3 Head–Tail

The **Head** and **Tail** subtabs display the first and last five rows of the dataset columns that will be used for the SPC analysis. You can use the **navigation arrows** to browse additional rows if needed.

GPR Statistical Process Control Analysis

Import File Analyze Statistical Process Control

Upload a file to inspect its contents. Note: the details shown here correspond to the original DataFrame.

Loaded: prostate_template.xlsx

Summary Info Head Tail

ID	Site of cancer	QA Date	Global 3%3mm	Global 3%2mm	Global 3%1mm	Global 2%2mm	Global 2%1mm	Global 1%2mm	Global 1%
0 10	Prostate	2019-04-01 08:48:38	100.0	100.0	100.0	99.3	99.0	89.9	
1 26	Prostate	2019-04-03 16:22:46	99.9	99.7	99.4	95.6	92.4	78.7	
2 11	Prostate	2019-04-08 08:40:14	100.0	100.0	99.8	99.7	99.5	89.9	
3 4	Prostate	2019-06-07 15:27:54	100.0	100.0	99.6	95.9	93.7	78.8	
4 37	Prostate	2019-07-24 17:27:38	100.0	99.8	99.8	98.5	98.1	89.8	

Rows to show: 5

Figure 4: Head subtab displaying the first five rows of the dataset.

GPR Statistical Process Control Analysis

Import File Analyze Statistical Process Control

Upload a file to inspect its contents. Note: the details shown here correspond to the original DataFrame.

Loaded: prostate_template.xlsx

Summary Info Head Tail

ID	Site of cancer	QA Date	Global 3%3mm	Global 3%2mm	Global 3%1mm	Global 2%2mm	Global 2%1mm	Global 1%2mm	Global 1%
52 49	Prostate	2023-07-25 08:10:12	100.0	100.0	100.0	99.8	99.0	90.6	
53 22	Prostate	2023-08-11 08:04:49	100.0	100.0	99.7	100.0	98.1	93.3	
54 52	Prostate	2023-09-14 08:17:56	99.1	98.7	98.7	98.2	96.9	92.1	
55 27	Prostate	2023-09-14 08:23:14	99.5	99.3	98.9	96.8	94.7	88.0	
56 46	Prostate	2023-10-12 08:45:10	100.0	100.0	99.6	98.8	96.1	89.9	

Rows to show: 5

Figure 5: Tail subtab displaying the last five rows of the dataset.

4 Statistical Analysis

In this tab you can perform the statistical analysis of the numerical parameters that will be used in the SPC process.

4.1 Statistics

The **Statistics** subtab presents descriptive statistics for all GPR values. These include:

- count,
- mean,
- standard deviation,
- 25%, 50%, and 75% percentiles,
- minimum and maximum values.

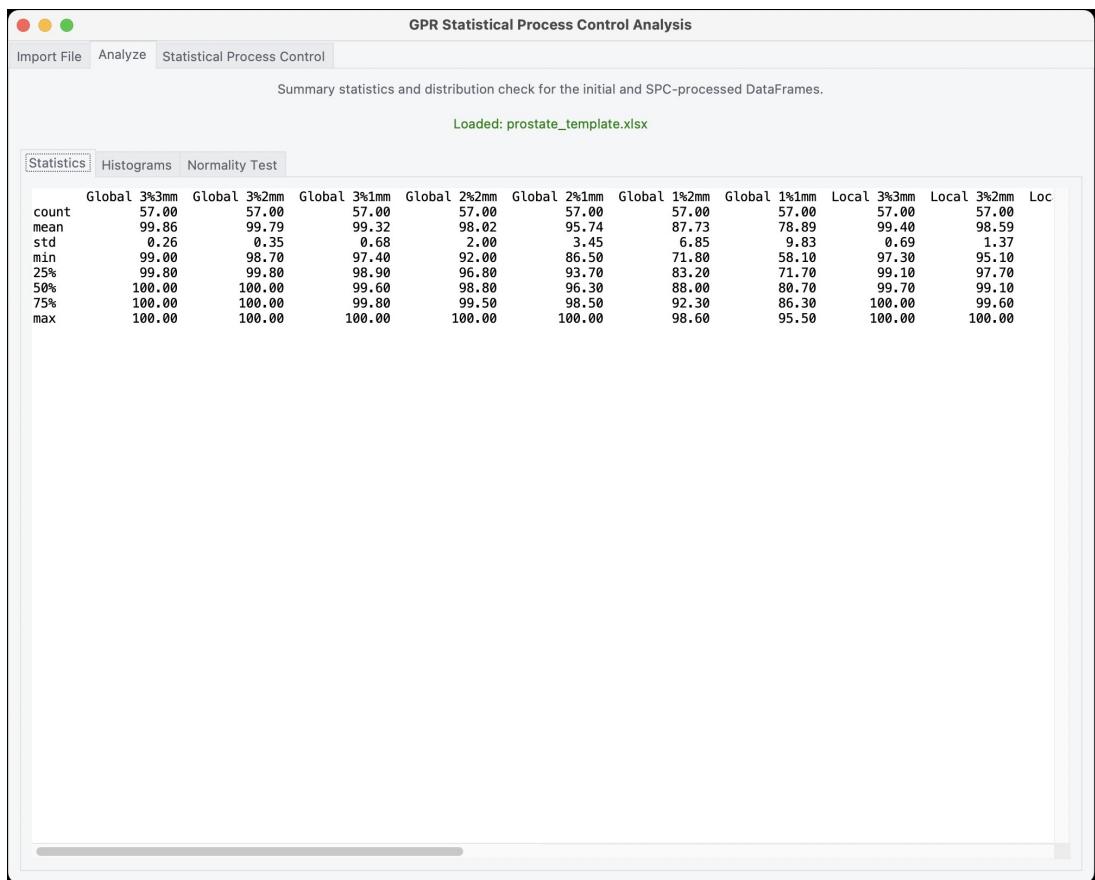


Figure 6: Statistics subtab presenting descriptive statistics for the GPR dataset.

4.2 Histograms

The **Histograms** subtab allows you to generate histogram plots for each GPR parameter in the dataset. Alongside each histogram, a kernel density estimate (KDE) curve is included to highlight the overall shape of the distribution. The corresponding skewness and kurtosis values are displayed for each parameter. You may select any combination of GPRs by clicking their corresponding checkboxes. The **Select All** button activates all available options, while **Select None** clears the selection.

After choosing the GPR values you wish to visualize, click **Plot Selected Histograms** to generate the plots.



Figure 7: Histograms subtab displaying histogram plots for the selected GPR parameters.

When you scroll down to the final plot, a **Save All to PDF** button appears. Clicking this button saves all currently generated histograms into a single PDF file at a location of your choice.

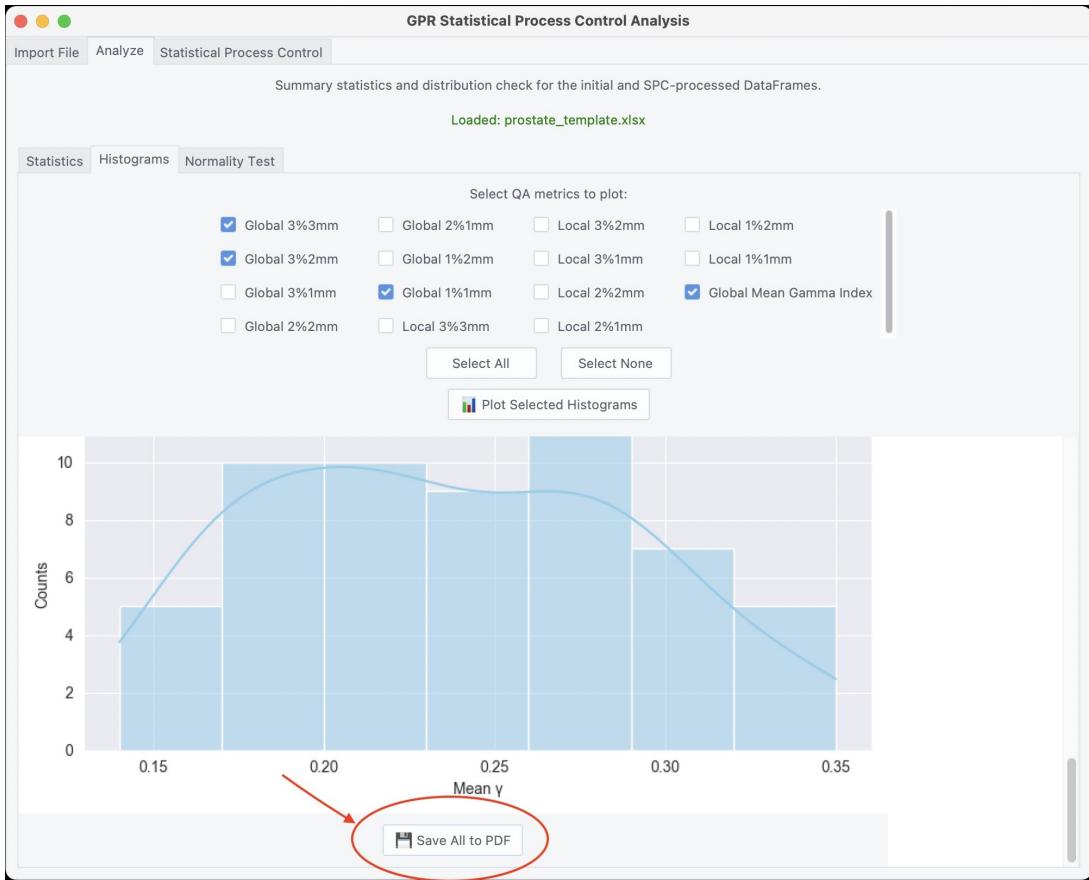


Figure 8: Save All to PDF button shown at the bottom of the scrollable area.

4.3 Normality Test

In this subtab you can perform an Anderson–Darling test on the GPR parameters you wish to test. After selecting the desired parameters, click the **Run Anderson–Darling Test** button to generate the results, which will appear in the window. A **Save as CSV** button is also provided so you can export the results to a directory you choose.

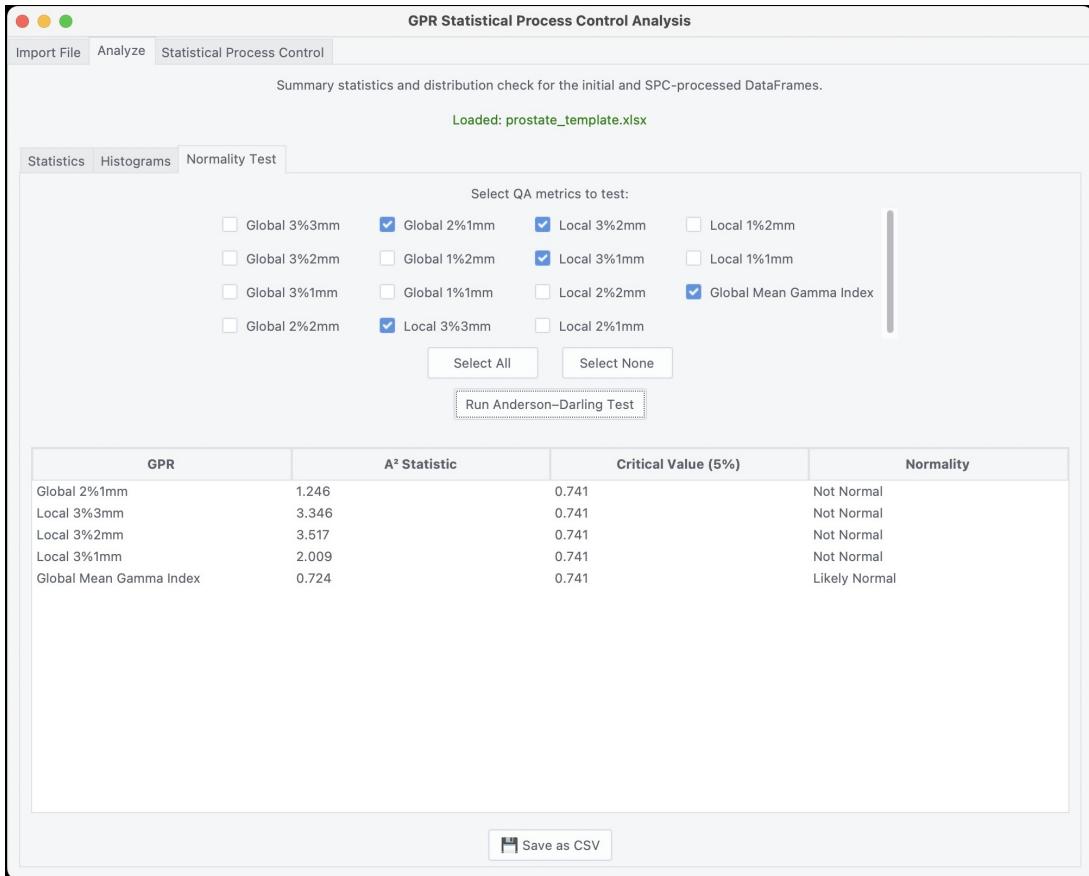


Figure 9: Normality Test subtab showing Anderson–Darling test results.

5 Statistical Process Control

The Statistical Process Control tab allows you to perform SPC analysis on the GPR metrics you select. The tool supports both normally distributed and non-normal data by offering two types of control-chart methods:

- **Shewhart I-charts** – recommended for approximately normal data,
- **Heuristic Methods** – suitable for non-normal data:
 - Weighted Standard Deviation (WSD),
 - Skewness Correction (SC),
 - Scaled Weighted Variance (SWV).

For each selected method, the tool calculates the **Upper and Lower Control Limits (UCL, LCL)** as well as the **Upper and Lower Specification Limits (USL, LSL)** for the selected GPR parameters. The tab also implements the **Identify – Eliminate – Recalculate** workflow. Using this process, you can identify outliers in the chart, eliminate them, and automatically recalculate the chart limits. As long as you remain in the

same SPC session, you may switch freely between methods. This feature is useful when initially non-normal data may become approximately normal after one or more eliminations.

At any point during this process, you may refer back to the **Analyze** (Section 4) tab to examine how the descriptive statistics of your dataset change throughout the Identify – Eliminate – Recalculate cycle.

Note: The example below describes how to apply SPC using the Shewhart method. The same procedure applies to the other methods.

5.1 I-charts

To generate the I-charts, select the GPR parameters you wish to analyse and click the **Run SHEWHART SPC** button. You can scroll through the plot area to view all generated charts. At the end of the list, a **Save All Plots to PDF** button appears, allowing you to export all current charts into a single PDF file.



Figure 10: Shewhart I-chart results.

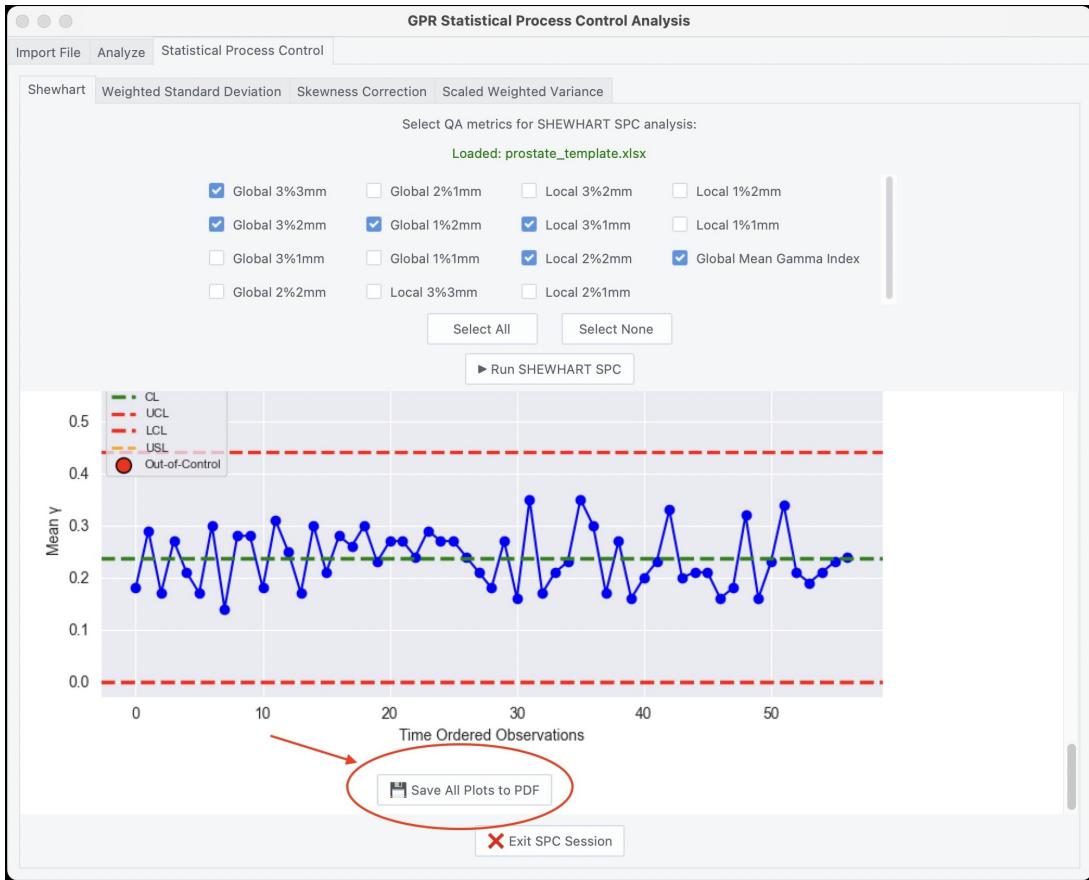


Figure 11: Saving all generated Shewhart I-charts to PDF.

5.2 Summary of Results

When you click the **Run SHEWHART SPC** button, a window titled **SHEWHART SPC Summary #1** appears. This summary presents the GPR parameters you selected, along with the mean, count, UCL/LCL, and, when available, USL/LSL. It also indicates whether each value is classified as an outlier. The summary window is scrollable even if no scrollbar is visible. If some information is not immediately shown, you can scroll to view the full content.

The number in the title (e.g., “#1”) corresponds to how many times you have executed the Shewhart SPC method during the current SPC session. You can save this information by clicking the **Save as CSV** button.

SHEWHART SPC Summary #1							
GPR	Mean	Count	LCL	UCL	LSL	USL	Outliers
Global 3%3mm	99.9	57	99.1	100.0	99.0	-	Yes
Global 3%2mm	99.8	57	98.7	100.0	98.6	-	No
Global 1%2mm	87.7	57	63.5	100.0	43.6	-	No
Local 3%1mm	94.8	57	83.7	100.0	75.7	-	No
Local 2%2mm	95.8	57	83.1	100.0	77.8	-	No
Global Mean Gamma Index	0.2	57	0.0	0.44	-	0.58	No

[Save as CSV](#)

Figure 12: The Shewhart SPC summary.

5.3 Outliers

When you run the SPC analysis, the tool informs you if any outliers are present. If outliers exist, a **Select Outliers** window appears, listing the GPR parameters that contain outlier values. You can select one or more outliers by their ID and click the **Eliminate Selected IDs** button to remove them.

Outlier elimination is performed per GPR parameter. However, when you eliminate an ID from **Global 3%/2mm**, that ID automatically is removed from all other GPR metrics as well.

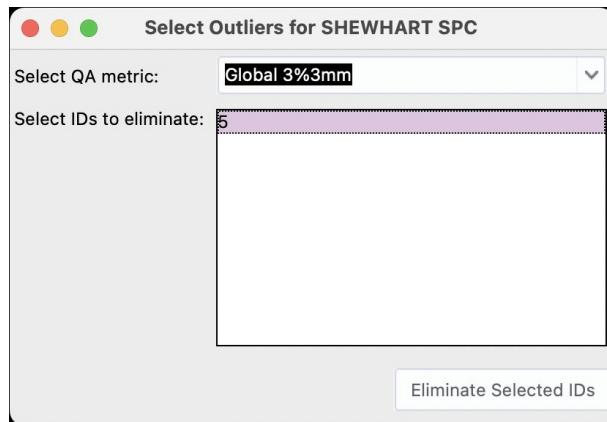


Figure 13: Outlier selection and elimination window.

When the removal is completed, the data are recalculated and updated results are generated. A new plot, an updated summary window, and (if applicable) a new outliers window will appear. At this stage, you may switch to the **Analyze** tab to check whether the statistical metrics of your dataset have changed after the elimination. Alternatively, you may select a different SPC method to continue the analysis. The **Import File** tab is not affected by eliminations; it always shows the original data exactly as they were loaded.

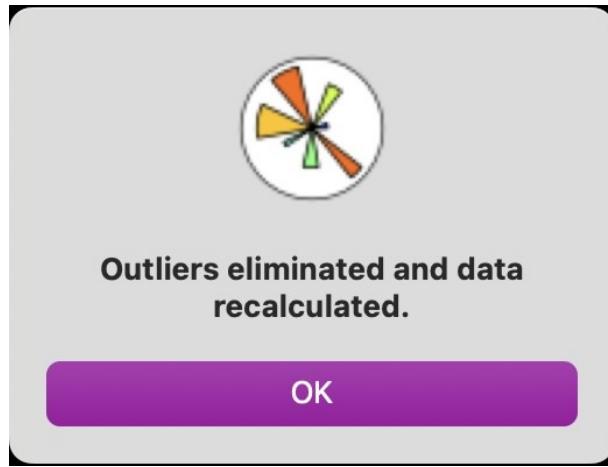


Figure 14: After removing the selected outliers.

5.4 Interactive Plots

All SPC plots in the application are interactive. By clicking on any data point in the chart, a small window appears displaying the corresponding patient ID and its exact GPR value. This feature allows you to quickly identify which observations are outliers or to inspect any point of interest on the chart.

Interactive clicking is available for all methods (Shewhart, WSD, SC, and SWV) throughout the entire SPC workflow.

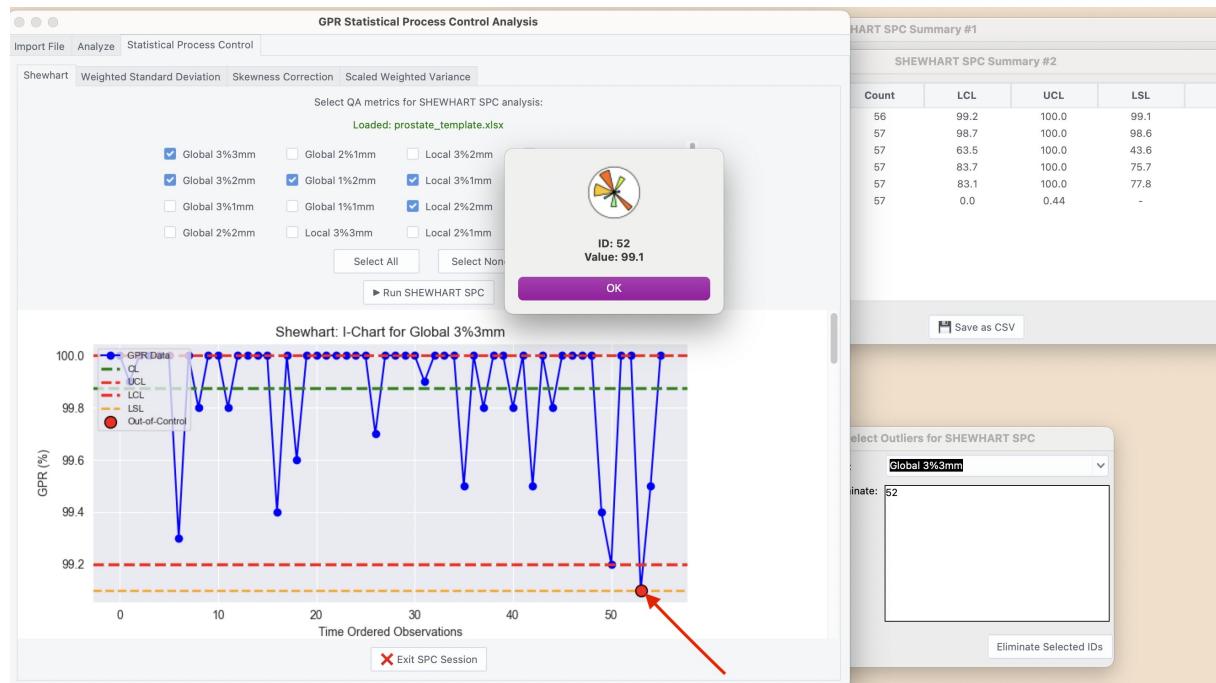


Figure 15: Clicking on a point in the chart reveals the ID and corresponding value.

5.5 Exiting the SPC Session

When you click the **Exit SPC Session** button, the application first asks whether you want to reset and reload the original dataset.

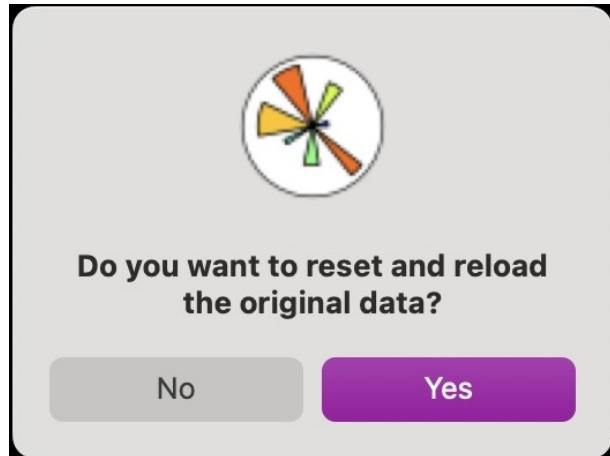


Figure 16: Prompt to reload the original dataset when exiting the SPC session.

If you select **Yes**, all temporary eliminations are going to be cleared and the dataset returns to its initial state.

After this, the application prompts you to save the **elimination log**. This log contains information about which IDs were eliminated, during which round, and using which SPC method.

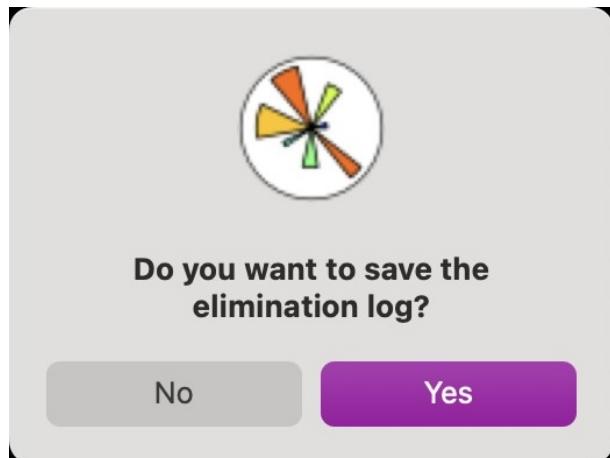


Figure 17: Prompt to save the elimination log after exiting the SPC session.

Selecting **Yes** saves the log as a CSV file in the directory of your choice. Choosing **No** closes the session without saving the log.

Finally, a confirmation message appears.

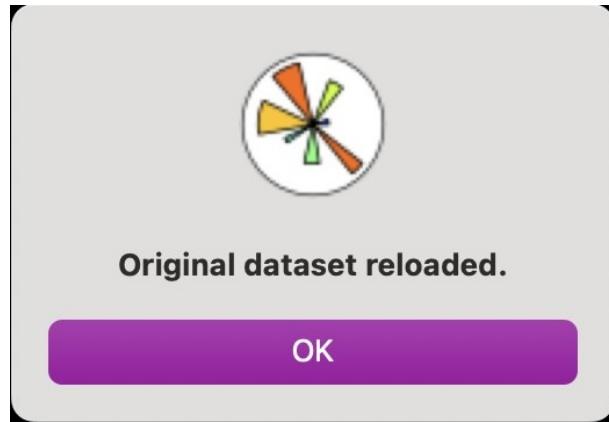


Figure 18: Notification confirming that the original dataset has been reloaded.

6 Errors and Warnings

6.1 Incorrect File Loading

If the selected Excel file does not follow the required structure, the application cannot load it. Two common issues can cause this:

1. Missing worksheet data

If the file does not contain a worksheet named `data`, the following error message appears:

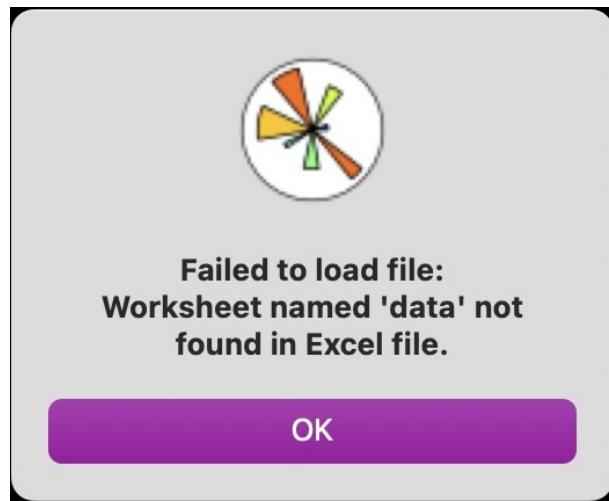


Figure 19: Error message shown when the required worksheet data is missing.

2. Missing required columns

If essential columns such as `QA Date` are missing, the tool displays an error specifying which column(s) are required:

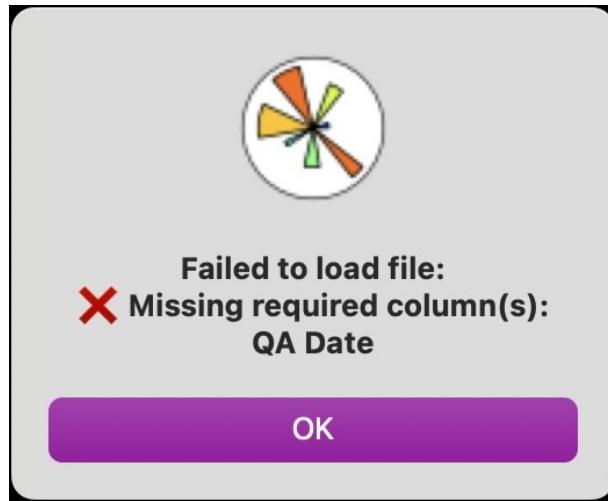


Figure 20: Error indicating that required column(s) are missing from the file.

Result

In both cases, the file cannot be loaded, the **Import File** tab displays a notification, and all other tabs remain disabled until a valid file is provided.

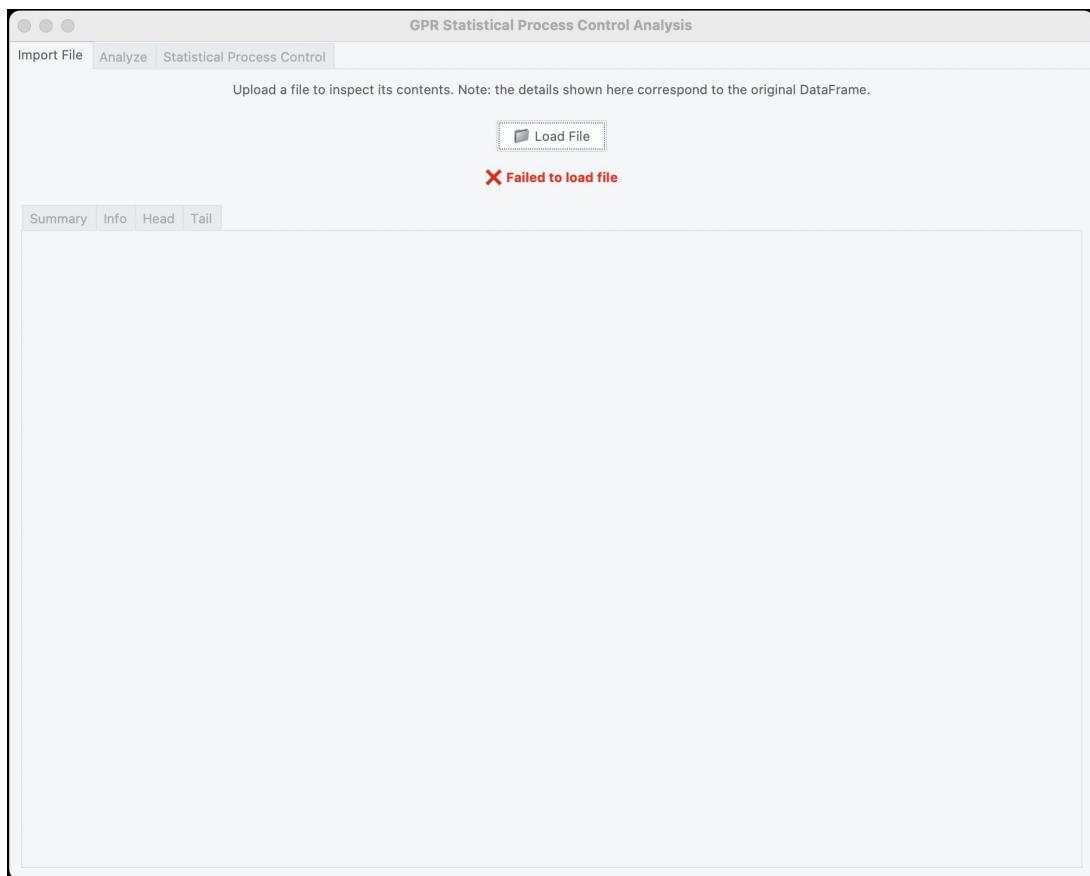


Figure 21: Import File tab indicating that the file failed to load.

To resolve the issue:

- Ensure the Excel file includes a worksheet named **data**.
- Verify that all required columns (e.g., **QA Date**, **ID**, **Site of cancer**) are present and correctly spelled.
- Use the recommended template to avoid formatting or naming inconsistencies.

6.2 Missing Columns

If the Excel file is structurally valid and the required worksheet data is present, the file loads successfully even if some non-critical columns are missing. In these cases, the application displays a warning message informing you which GPR metrics or supporting parameters are unavailable.

Missing GPR Criteria

If one or more GPR columns are missing from the dataset, a warning window appears listing the unavailable criteria:

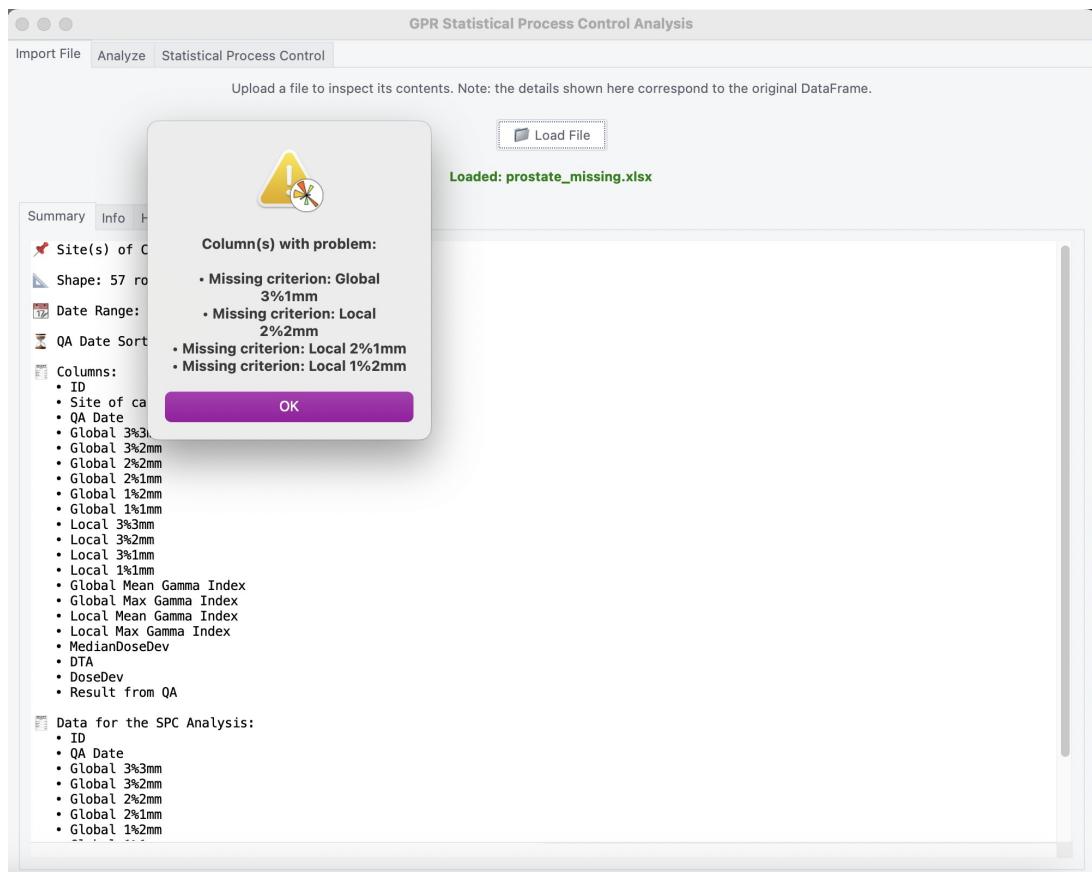


Figure 22: Warning message indicating that certain GPR criteria are missing.

These missing parameters will simply be excluded from the SPC analysis. The rest of the dataset remains fully usable.

Missing Supporting Parameters

If the column MedianDoseDev is missing from the dataset, the application displays a warning indicating that the Global Mean γ Index will be skipped during the SPC process:

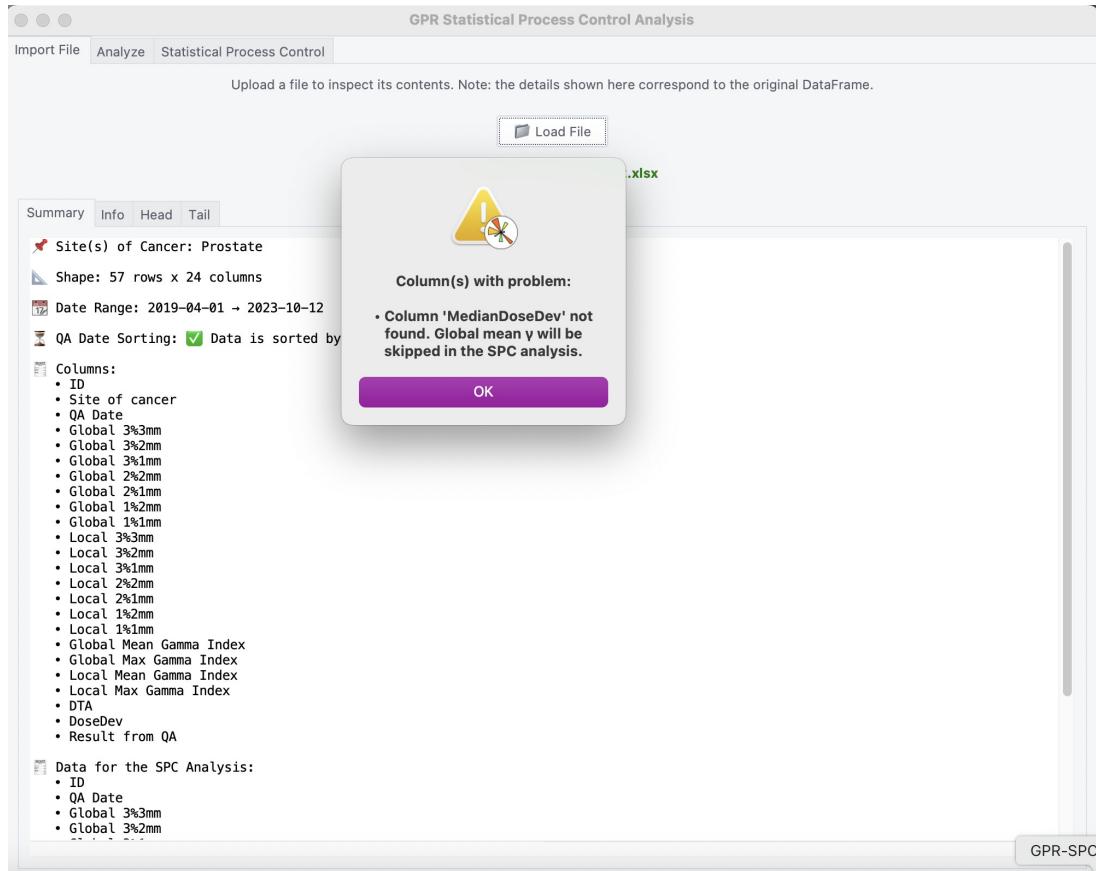


Figure 23: Warning message indicating that MedianDoseDev is missing.

7 Conclusion

This manual has presented all major features of the GPR-SPC Analyzer, including data import, statistical exploration, SPC methods, and outlier handling. If you encounter issues not covered here or wish to report a bug, please contact: aspaeug@med.uoa.gr