

Individualized web and desktop applications with R Shiny for the analysis and visualization of study and patient data as part of projects to detect and diagnose psoriatic arthritis (PsA)

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In rheumatology, studies usually focus on indications associated with inflammation of various joints (e.g. wrists and ankles), bones or organs. In some indications, such as psoriatic arthritis (PsA), there are also dermatological manifestations (psoriasis on the skin and nails).

Automated visualizations as important tools for communication and interpretation of study- and patient-based data

In the communication of study and patient data, in addition to tabular representations of important key figures and various statistical illustrations (e.g. boxplots, histograms, etc.), more and more visually appealing visualizations are used (e.g. sketches or silhouettes of organs or extremities with infestation). Such qualitative visualizations can be found in various forms in the literature and are often associated with a high expenditure of time in their creation. They are often only created for a one-off purpose. In addition, they often lack the quantitative reference to the data. An automated and repeatable creation of such visualizations in combination with quantitative information thus represents a great help in the communication and interpretation of study- and patient-based data and information (e.g. for poster contributions, manuscripts or lectures). In order to automatically generate a visualization, interactive software is required that, based on study or patient data, expands qualitative images with quantitative information.

R Shiny as a framework for interactive web applications and more

Shiny¹ is a suitable tool for this task as a framework and extension of the free programming language R². With Shiny, interactive web applications can be created for the quick visualization and analysis of various data. Individualized Shiny applications allow the user to repeatedly carry out precisely those visualizations and analyzes that are mostly required, without requiring a great deal of training due to the depth of the program. The individualized approach also allows the combination of qualitative representation of a specific structure and the quantitative information from the data. Due to the simple repeatability of the visualizations, they are suitable not only for a simple descriptive representation but also for the general analysis of study or patient data. At Fraunhofer CIMD (Cluster of Excellence In Immune-Mediated Diseases), an individualized Shiny application (prelim. MSO Analysis Visualizer) is being developed and used as part of the 4D Clinic. This application allows visualization of so-called "Gelenkmännchen", which consist of sketches or silhouettes of people with enlarged hands and feet and the associated possibly inflamed joints (Fig. 1). There is also the option of merging several "Gelenkmännchen" figures in the form of a collage, e.g. to compare different visits or the smoking status directly with one another (Fig. 2). Dermatological manifestations, such as skin involvement or inflamed skin regions on the left and right hand, can also be displayed using automated visualization (Fig. 3). In addition, the Shiny application allows a basic statistical analysis of all relevant parameters of the study or patient data (Fig. 4).

From web to desktop

A later further development of the web application towards a desktop application is also possible. The repeatability of the automated creation of visualizations thus transforms those visualizations from a passive observation object to an actively used analysis tool.

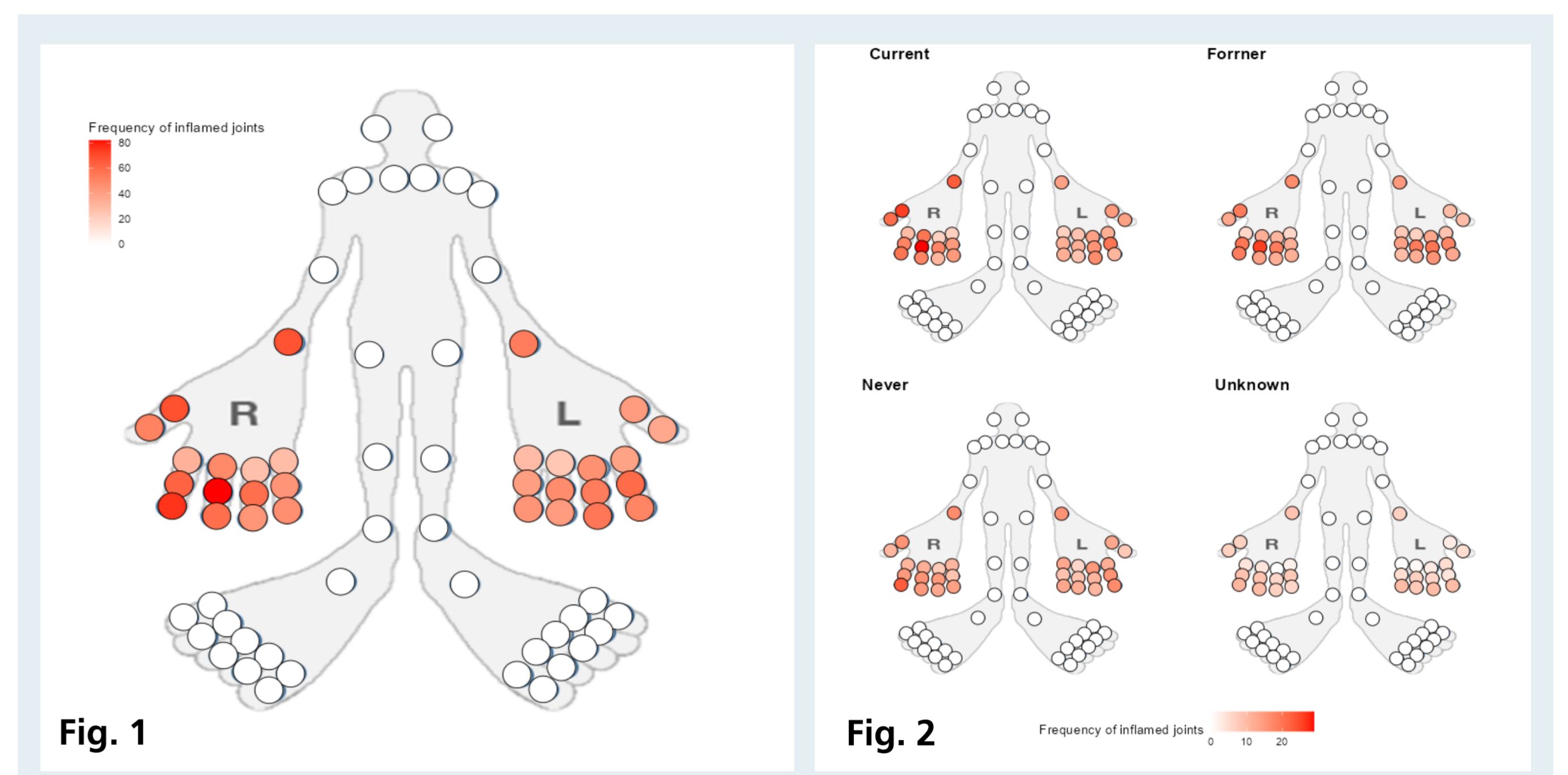


Figure 1: The "Gelenkmännchen" shows manifestations (e.g. inflammations or pain) per circle (=joint) via colour grading (black/white for absence/presence; weaker/deeper color for lower/higher amount of patients with particular manifestation). Figure 2: A collage allows the visualization of the manifestations for different groups (here smoking status is shown).

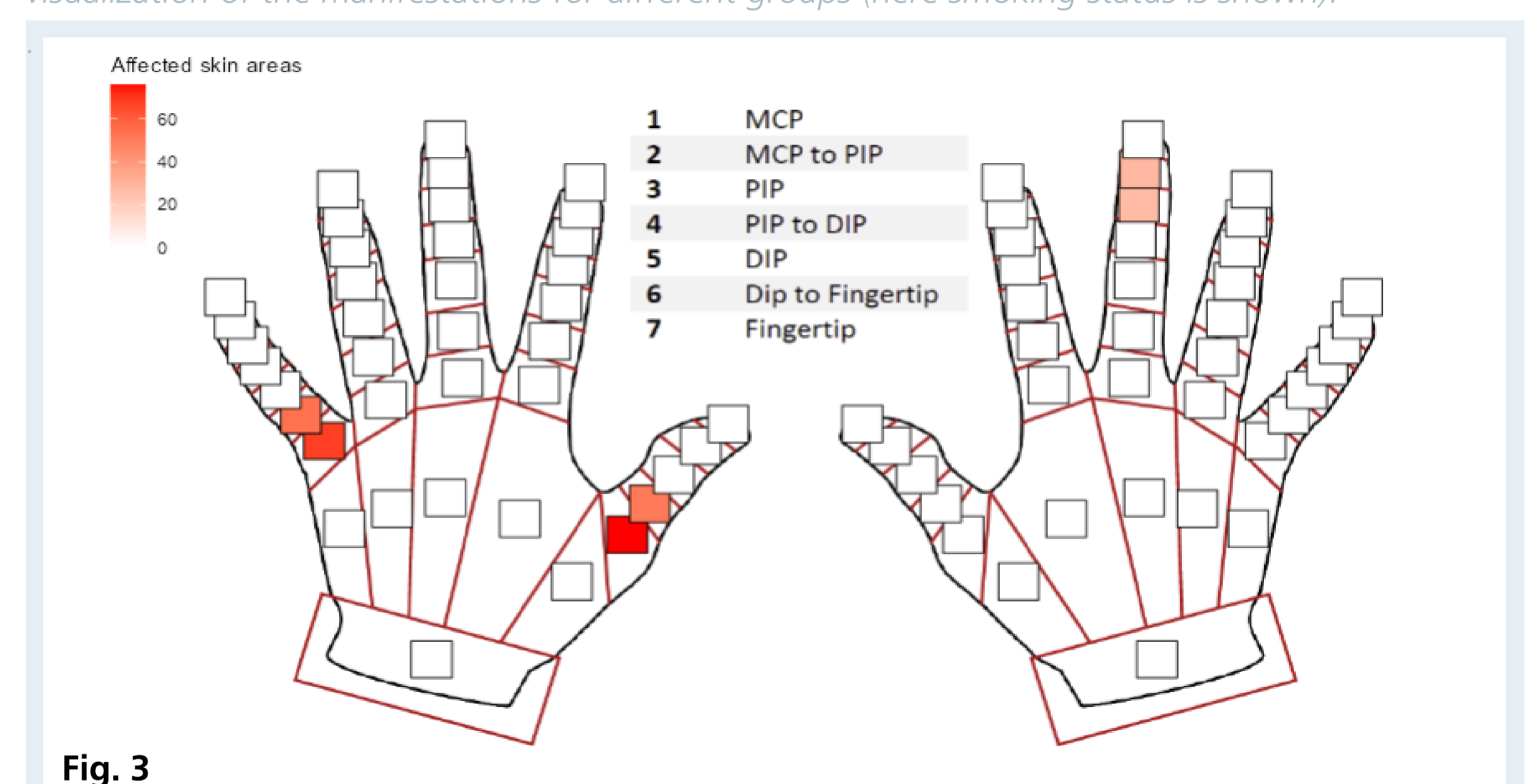


Fig. 4

Variable	Stats / Values	Freqs (% of Valid)	Graph	Valid	Missing
age [integer]	Mean (sd) : 50 (11.9) min ≤ med ≤ max: 18 ≤ 51 ≤ 83 IQR (CV) : 14 (0.2)	59 distinct values		469 (99.8%)	1 (0.2%)
sex [character]	1. (Empty string) 2. female 3. male	1 (0.2%) 284 (60.4%) 185 (39.4%)		470 (100.0%)	0 (0.0%)
bmi [numeric]	Mean (sd) : 27.5 (5.4) min ≤ med ≤ max: 17.3 ≤ 26.4 ≤ 50.1 IQR (CV) : 6.7 (0.2)	337 distinct values		449 (95.5%)	21 (4.5%)

Figure 3: Visualization of affected skin areas of both hands for dermatological studies. Boxes represent skin areas from above the wrists until above the fingertips; Figure 4: Descriptive statistics of key parameters like age, sex or bmi as starting point of analysis. The function `dfSummary` from the R package `summarytools`³ allows first insight into the study data. Besides statistical values like mean or median, minimum or maximum value, interquartile range and the coefficient of variation (CV), there is also information on valid and missing values. Furthermore, a graphical presentation of the distribution of the parameter is implemented.

¹ Chang W, Cheng J, Allaire J, Sievert C, Schloerke B, Xie Y, Allen J, McPherson J, Dipert A, Borges B (2022). `_shiny`: Web Application Framework for R. R package version 1.7.2, <<https://CRAN.R-project.org/package=shiny>>.
² R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL <https://www.R-project.org/>.
³ Comtois D (2022). `_summarytools`: Tools to Quickly and Neatly Summarize Data. R package version 1.0.1, <<https://CRAN.R-project.org/package=summarytools>>.