An *R Shiny* Foundation for Standardized Clinical Review Tools

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OBJECTIVES

Develop standardized, interactive tools for FDA reviewers by implementing medical product review processes in the R Shiny framework:

1. Identify analyses and visualizations in medical product reviews that could be mechanized
2. Develop user-interfaces to streamline such processes in R and Shiny
3. Create an R Shiny wiki (with MediaWiki) to host information and instructions for the tools
4. Provide documentation of R code for future modifications
5. Initiate a users group for collaboration across offices at the FDA's Center for Drug Evaluation Research (CDER)

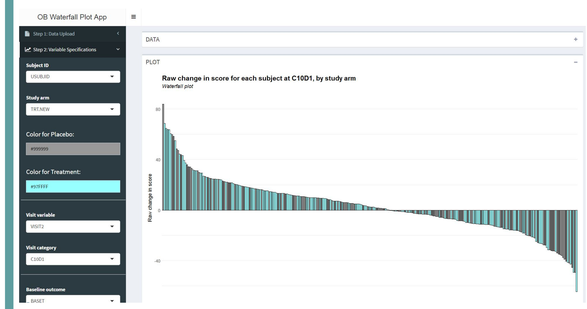
INTRODUCTION

Several offices at the U.S. Food and Drug Administration are starting to develop and use R Shiny apps as standardized clinical review tools. The Shiny library in R has emerged as an innovative technology, and its flexibility and interactivity appeal to statistical programmers. We are continuously identifying routine analyses and visualizations in medical product reviews to generate new app ideas.

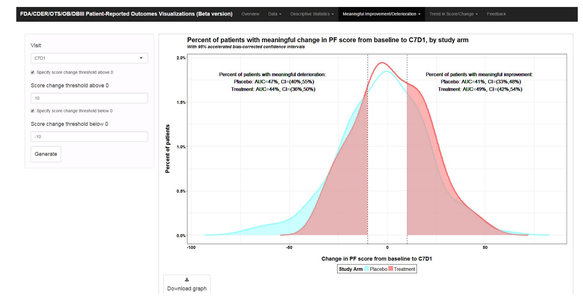
We initiated an R Shiny users group within CDER that is open to the entire FDA. The goal is to promote communication across various disciplines. We have determined a network of core R Shiny developers. We plan in the near future to create an analogous group involving external organizations, including Pharmaceutical Users Software Exchange (PhUSE), ASA, etc.

We created an R Shiny wiki to serve as a "central hub" for CDER R Shiny apps. Staff across different offices can share their R Shiny-related projects to inform each other. The wiki also hosts the R Shiny users group information and conference presentations related to R Shiny.

EXAMPLE SHINY APPS



(a) **Waterfall Plots**: This app produces waterfall plots to compare study arms at each study visit. Users have the flexibility to either focus on patient score at a visit or the score change (raw or percentage) from baseline. We have implemented settings for users to further adjust, such as the color for each study arm, the y-axis range, the title, etc. Currently, this app is standalone to only focus on waterfall plots but could be incorporated into the PRO app.



(b) **Patient-Reported Outcomes (PRO) Visualization**: This app streamlines visualizations from a PRO research along with novel ones. Example visualizations include sample sizes by study arm over a study period, distribution of score change by study arm with area for percentage of patients meeting a specified change, trend in score/score change (either continuous or categorical) over a study period, etc. We have implemented settings for users to adjust.

APPROACH

1. Identify analyses and visualizations in medical product reviews that could be mechanized

- Reviewers describe analyses and visualizations that could be employed into GUI tools to increase efficiency and reduce redundancy
- The programmer conducts research to determine the feasibility of implementing the requests in R and Shiny
- The programmer and reviewers continuously communicate to ensure a clear understanding of the inputs and outputs of each app

2. Develop user-interfaces to streamline such processes in R and Shiny

- The programmer starts off Shiny scripts from scratch, with some scripts including base code from previous research
- Shiny apps focus on a range of topics including patient-reported outcomes visualizations, waterfall plots, forest plots, etc.
- We utilize a variety of R libraries, for example: *ggplot2*, *plotly*, and *gridExtra* for visualizations, *data.table*, *dplyr*, and *reshape2* for data manipulation, *boot* for bootstrap calculations, etc.
- Additional R libraries support the functions of a Shiny app: *shinyBS*, *shinyjs*, *colorspace*, *DT*, *shinythemes*, etc.

3. Create an R Shiny wiki (with MediaWiki) to host information and instructions for the tools

- We used an existing CDER wiki, which shares knowledge and information within CDER, as a resource
- An R Shiny wiki showcases the available tools with brief descriptions and instructions

4. Provide documentation of R code for future modifications

- We generate documentation using R Markdown and then convert it to MediaWiki format
- FDA staff can obtain and modify chunks of code from the documentation

5. Initiate a users group for collaboration across offices at the FDA's Center for Drug Evaluation Research (CDER)

- The goal is to increase collaboration and promotion in utilizing Shiny to develop standardized clinical review tools across offices in CDER
- We plan for each session to focus on a main theme (e.g., demos, challenges, innovative strategies, etc.)

CONCLUSION

Several offices at the FDA are developing standardized clinical review tools to address the needs of reviewers with the Shiny library in R. These tools are inherently interactive by receiving inputs from users and outputting the results, with adjustments available to suit user preferences. This approach aligns with FDA's goals of increasing efficiency and reducing redundancy. Utilizing the CDER wiki, we created an R Shiny wiki to serve as a "central hub" for all Shiny-related projects. In addition, we have begun an R Shiny users group with the goal to promote collaboration among staff in different disciplines from multiple offices.

REFERENCES

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