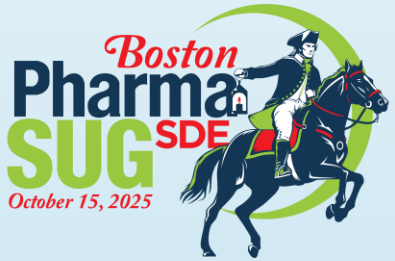
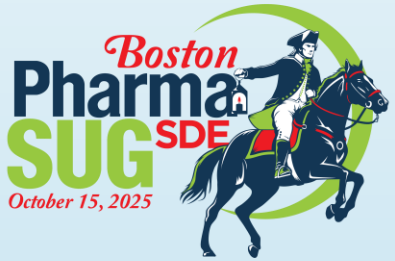


Interactive and automated generation of clinical study reports (CSRs) using {quarto} and {shiny}

Peng Zhang

- Associate Director of Innovative Data Sciences, CIMS Global
- Ph.D. in Biostatistics, Rutgers School of Public Health
- Leads the internal development of R packages, R Shiny apps, and supports software development with open-source solutions



Agenda

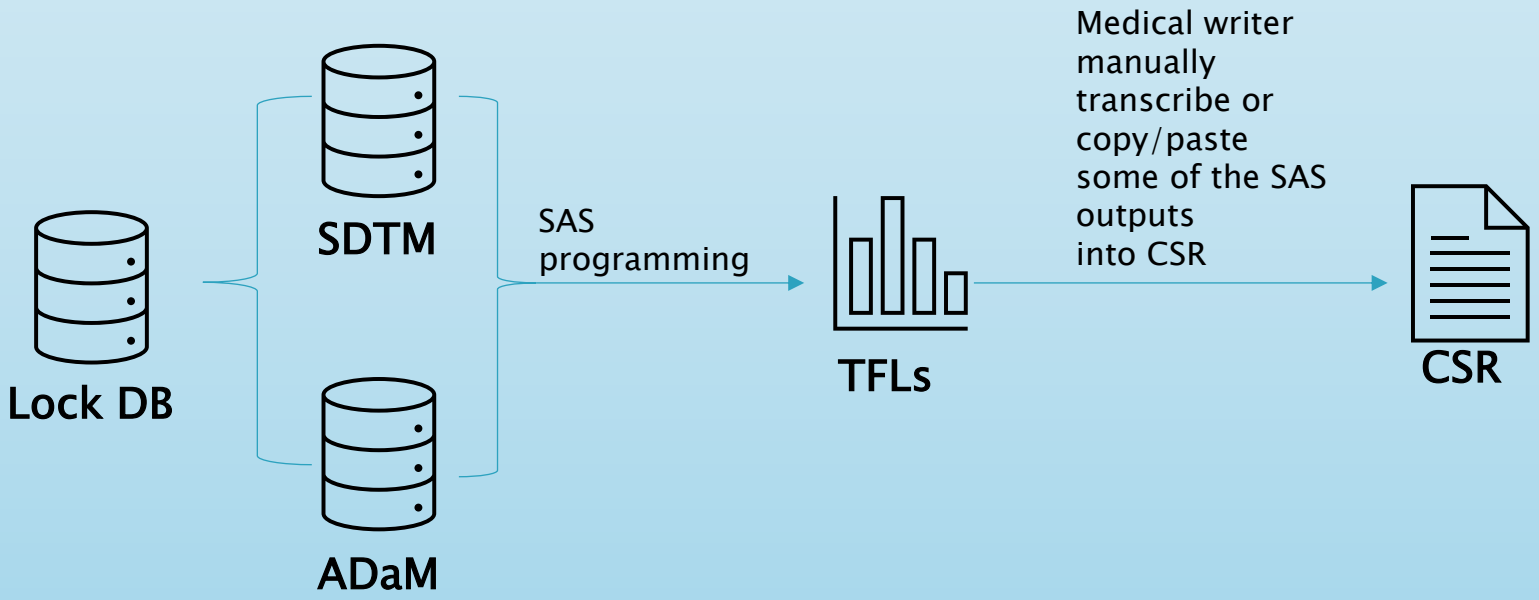
- Introduction
- Stat2csr Overview
- Stat2csr Application
- Development & Validation
- Discussion

Introduction

Current practice in CSR

- Daily Task: TFLs Generation for Statistical/Clinical Review
- Additional need for CSR Section 9 to 11: Medical writers generate narratives with inline tables and figures
- Challenges:
  - Manually copy, paste, type, and regenerate
  - Potential human error, time-consuming
  - Changes in raw data requires duplicate effort
- There has to be a more efficient way

Traditional Workflow

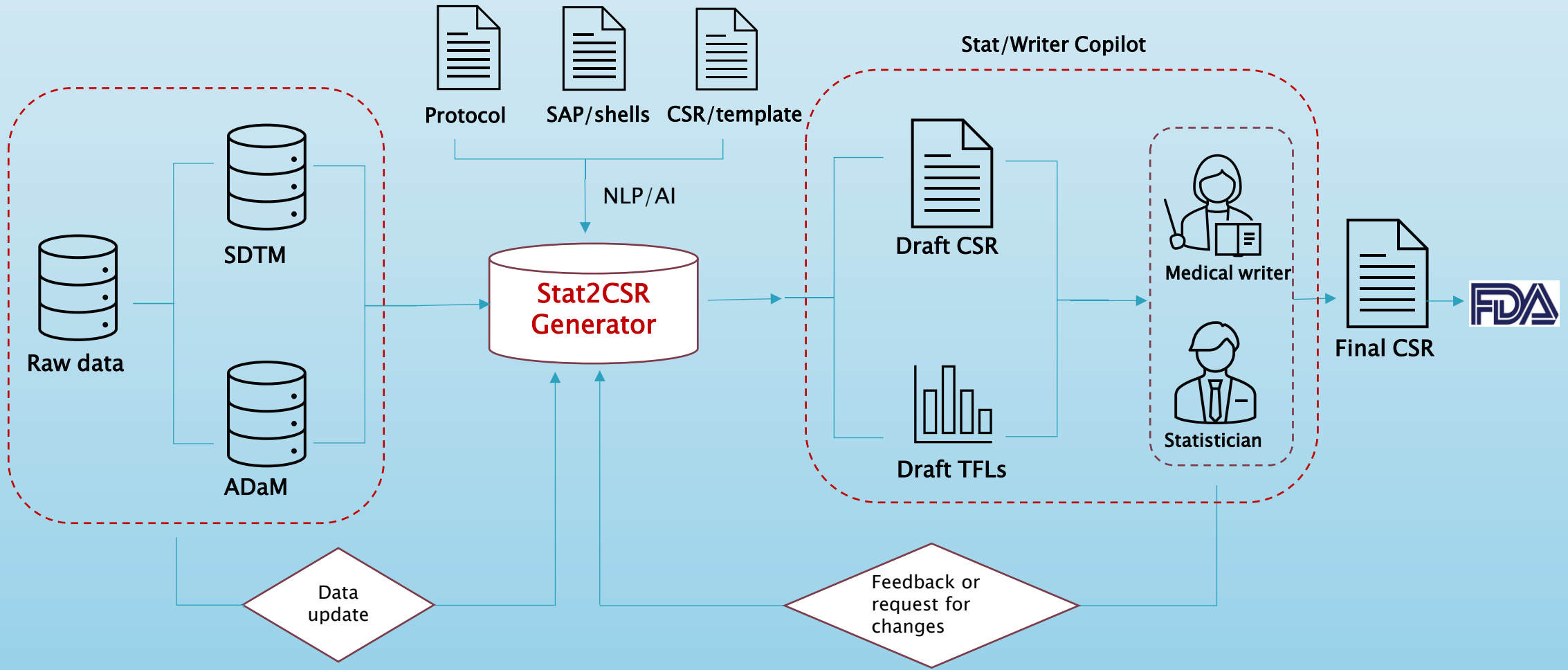


Open-source solutions

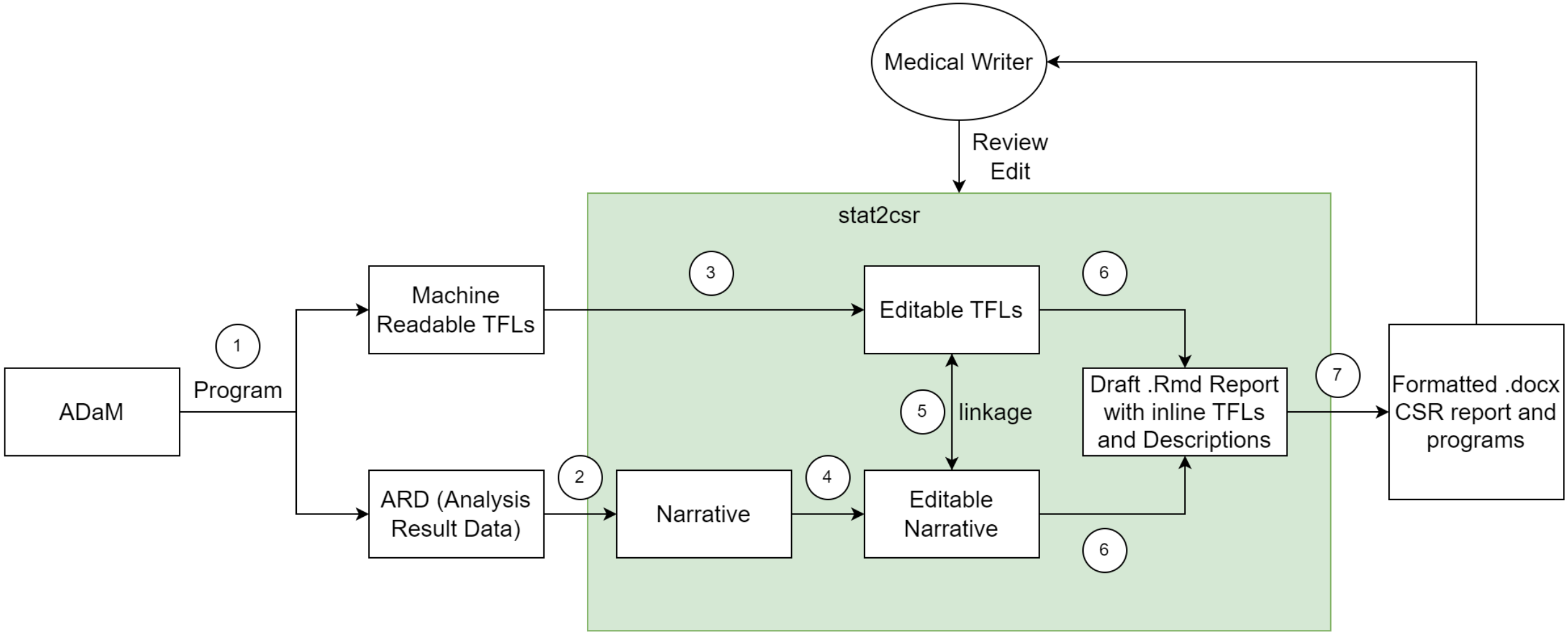
- Proprietary statistical software is effective for generating TFLs
- But it falls short when it comes to narrative or inline tables and figures.
- Leverage open-source tools ({quarto} and {shiny}) to enable:
  - A collaborative workspace for medical writers to review and edit results
  - Reusable template-driven narratives for consistency and efficiency
  - User-configured reports with inline tables, figures and narratives

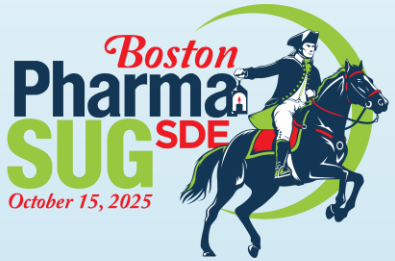
Stat2csr Overview

Stat2csr Workflow



Technical Workflow





Stat2csr Workflow

- ADaM Data Available
- Machine readable TFLs and ARD (Analysis Result Data) generated through TFL functions
- Mapping between ARD and narratives
- Combined into.Rmd/.Qmd code
- Render documents with customized contents

1. Generate TFLs & ARDs

- {rtables} + {tern} used as foundation
  - Genentech has maintained for five years
  - Exclusively created and used for Pharma industry
  - `TableTree` object as be formatted as `flextable` and `html`
  - `flextable` can be exported as .docx using {officer}
  - `html` can be used in Shiny on the webpage
- `as_result_df()` can be used to generate ARD Structure
  - ARD: CDISC Suggested format for reproducibility,
  - An intermediate layer bridging ADaM and TFLs
  - Multiple columns to describe value properties, with one column dedicated to the actual value.

TableTree and ARD

```
> t_b_dm_01$rs
                                                A: Drug X      B: Placebo        Total
Category                                        (N=134)        (N=134)        (N=268)
————————————————————————————————————————————————————————————————————————————————————
Age
  N                                                134            134            268
  Mean (SD)                                   33.8 (6.6)     35.4 (7.9)     34.6 (7.3)
  Median                                         33.0           35.0           34.0
  Q1 - Q3                                   28.0 - 39.0    30.0 - 40.0    29.0 - 39.0
  (Min, Max)                              (21.0, 50.0)   (21.0, 62.0)   (21.0, 62.0)
Sex
  N                                                134            134            268
  F                                           79 (59.0%)     82 (61.2%)    161 (60.1%)
  M                                           55 (41.0%)     52 (38.8%)    107 (39.9%)
Race
  N                                                134            134            268
  ASIAN                                       68 (50.7%)     67 (50.0%)    135 (50.4%)
  BLACK OR AFRICAN AMERICAN                   31 (23.1%)     28 (20.9%)     59 (22.0%)
  WHITE                                       27 (20.1%)     26 (19.4%)     53 (19.8%)
  AMERICAN INDIAN OR ALASKA NATIVE             8 (6.0%)      11 (8.2%)      19 (7.1%)
  MULTIPLE                                     0 (0.0%)       1 (0.7%)       1 (0.4%)
  NATIVE HAWAIIAN OR OTHER PACIFIC ISLANDER    0 (0.0%)       1 (0.7%)       1 (0.4%)
  OTHER                                        0 (0.0%)       0 (0.0%)       0 (0.0%)
  UNKNOWN                                      0 (0.0%)       0 (0.0%)       0 (0.0%)
Ethnicity
  N                                                134            134            268
  HISPANIC OR LATINO                          15 (11.2%)     18 (13.4%)     33 (12.3%)
  NOT HISPANIC OR LATINO                     104 (77.6%)    103 (76.9%)    207 (77.2%)
  NOT REPORTED                                 6 (4.5%)      10 (7.5%)      16 (6.0%)
  UNKNOWN                                      9 (6.7%)       3 (2.2%)      12 (4.5%)
>
```

	group1	group1_level	trt_var	trt	stat_name	result	fmt_result
1	Age	<NA>	TRT01P	A: Drug X	n	134.0000000	134
2	Age	<NA>	TRT01P	A: Drug X	mean	33.7686567	33.8
3	Age	<NA>	TRT01P	A: Drug X	sd	6.5533257	6.6
4	Age	<NA>	TRT01P	A: Drug X	quantile_0.25	28.0000000	28.0
5	Age	<NA>	TRT01P	A: Drug X	quantile_0.75	39.0000000	39.0
6	Age	<NA>	TRT01P	A: Drug X	median	33.0000000	33.0
7	Age	<NA>	TRT01P	A: Drug X	min	21.0000000	21.0
8	Age	<NA>	TRT01P	A: Drug X	max	50.0000000	50.0
9	Age	<NA>	TRT01P	B: Placebo	n	134.0000000	134
10	Age	<NA>	TRT01P	B: Placebo	mean	35.4328358	35.4
11	Age	<NA>	TRT01P	B: Placebo	sd	7.8954139	7.9
12	Age	<NA>	TRT01P	B: Placebo	quantile_0.25	30.0000000	30.0
13	Age	<NA>	TRT01P	B: Placebo	quantile_0.75	40.0000000	40.0
14	Age	<NA>	TRT01P	B: Placebo	median	35.0000000	35.0
15	Age	<NA>	TRT01P	B: Placebo	min	21.0000000	21.0
16	Age	<NA>	TRT01P	B: Placebo	max	62.0000000	62.0
17	Age	<NA>	TRT01P	Total	n	268.0000000	268
18	Age	<NA>	TRT01P	Total	mean	34.6007463	34.6
19	Age	<NA>	TRT01P	Total	sd	7.2896931	7.3
20	Age	<NA>	TRT01P	Total	quantile_0.25	29.0000000	29.0
21	Age	<NA>	TRT01P	Total	quantile_0.75	39.0000000	39.0
22	Age	<NA>	TRT01P	Total	median	34.0000000	34.0
23	Age	<NA>	TRT01P	Total	min	21.0000000	21.0
24	Age	<NA>	TRT01P	Total	max	62.0000000	62.0
25	Sex	F	TRT01P	A: Drug X	n	79.0000000	79
26	Sex	F	TRT01P	A: Drug X	pct	0.5895522	59.0%
27	Sex	F	TRT01P	B: Placebo	n	82.0000000	82
28	Sex	F	TRT01P	B: Placebo	pct	0.6119403	61.2%
29	Sex	F	TRT01P	Total	n	161.0000000	161
30	Sex	F	TRT01P	Total	pct	0.6007463	60.1%
31	Sex	M	TRT01P	A: Drug X	n	55.0000000	55
32	Sex	M	TRT01P	A: Drug X	pct	0.4104478	41.0%
33	Sex	M	TRT01P	B: Placebo	n	52.0000000	52
34	Sex	M	TRT01P	B: Placebo	pct	0.3880597	38.8%
35	Sex	M	TRT01P	Total	n	107.0000000	107
36	Sex	M	TRT01P	Total	pct	0.3992537	39.9%
37	Sex	<NA>	TRT01P	A: Drug X	n	134.0000000	134
38	Sex	<NA>	TRT01P	B: Placebo	n	134.0000000	134
39	Sex	<NA>	TRT01P	Total	n	268.0000000	268

2. Template-based narrative streamline report generation

- Narratives display values from tables
- A pre-defined template includes placeholders for analysis values.
- The ARD structure provides a strong framework for linking placeholders to analysis values

```
$var_df
          name       value
1  n_screened         268
2      n_rand         268
3   n_treated         268
4      n_comp         134
5    n_discon          82
6      n_ongo          52
7    name_gp1  A: Drug X
8      n_gp_1         134
9    name_gp2 B: Placebo
10     n_gp_2         134

$header
[1] "Disposition of Participants"

$md
[1] "A total of {n_screened} participants were initially screened for inclusion in the study. Of
these, {n_rand} participants were randomized into the study, and {n_treated} participants receive
d medication. The participants were divided into two groups: the {name_gp1} group ({n_gp_1}) and
the {name_gp2} group ({n_gp_2}). {n_comp} subjects had completed the study, while {n_discon} subj
ects discontinued prematurely, and {n_ongo} subjects were ongoing."
```

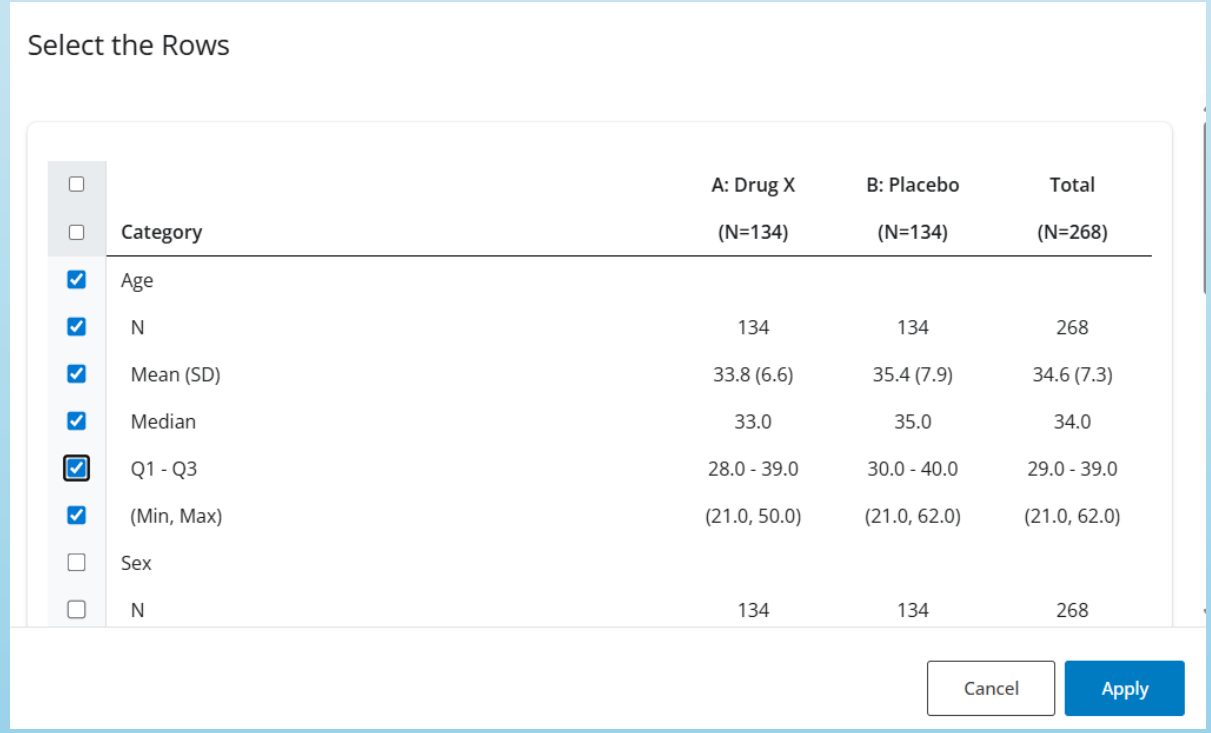
```
Disposition of Participants

A total of 268 participants were initially screened for inclusion in the study. Of these, 268
participants were randomized into the study, and 268 participants received medication. The
participants were divided into two groups: the A: Drug X group (134) and the B: Placebo group
(134). 134 subjects had completed the study, while 82 subjects discontinued prematurely, and
52 subjects were ongoing.
```

3. Interactive tables enable user-driven customization

- Customize inline Tables
- `rtables::as_html()` for 'TableTree' to be used in Shiny

Category	A: Drug X (N=134)	B: Placebo (N=134)	Total (N=268)
Age			
N	134	134	268
Mean (SD)	33.8 (6.6)	35.4 (7.9)	34.6 (7.3)
Median	33.0	35.0	34.0
Q1 - Q3	28.0 - 39.0	30.0 - 40.0	29.0 - 39.0
(Min, Max)	(21.0, 50.0)	(21.0, 62.0)	(21.0, 62.0)
Sex			
N	134	134	268
F	79 (59.0%)	82 (61.2%)	161 (60.1%)
M	55 (41.0%)	52 (38.8%)	107 (39.9%)
Race			
N	134	134	268
ASIAN	68 (50.7%)	67 (50.0%)	135 (50.4%)



4. Editable Narratives – Bridge data and narratives seamlessly

- An interactive editor for medical writer to refine narratives
- Live data integration pulls numbers directly from tables

A total of 268 participants were initially screened for inclusion in the study. Of these, 268 participants were randomized into the study, and 268 participants received medication. The participants were divided into two groups: the A: Drug X group (134) and the B: Placebo group (134). Of the total participants, 134 (50.0%) subjects had completed the study, while 82 (30.6%) subjects discontinued prematurely, and 52 (19.4%) subjects were ongoing. In the A: Drug X group, 68 (50.7%) subjects had completed the study, while 42 (31.3%) subjects discontinued prematurely, and 24 (17.9%) subjects were ongoing. In the B: Placebo group, 66 (49.3%) subjects had completed the study, while 40 (29.9%) subjects discontinued prematurely, and 28 (20.9%) subjects were ongoing.

To add more texts from medical writers.....

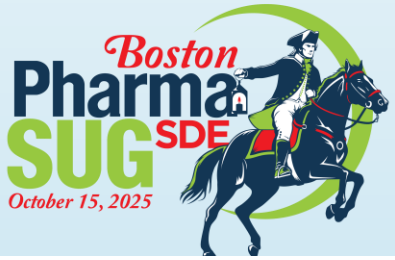
5. Linkage between tables and narratives

- Highlights shown between values in tables and narratives
- Customized template by single-click or double-click on the tables

Category	A: Drug X (N=134)	B: Placebo (N=134)	Total (N=268)
Number of Patients Screened			268
Number of Randomized Subjects	134 (100%)	134 (100%)	268 (100%)
Number of Treated Subjects	134 (100%)	134 (100%)	268 (100%)
Study Completion Status			
Completed	68 (50.7%)	66 (49.3%)	134 (50.0%)

A total of 268 participants were initially screened for inclusion in the study. Of these, 268 participants were randomized into the study, and 268 participants received medication. The participants were divided into two groups: the A: Drug X group (134) and the B: Placebo group (134). Of the total participants, 134 (50.0%) subjects had completed the study, while 82 (30.6%) subjects discontinued prematurely, and 52 (19.4%) subjects were ongoing. In the A: Drug X group, 68 (50.7%) subjects had completed the study, while 42 (31.3%) subjects discontinued prematurely, and 24 (17.9%) subjects were ongoing. In the B: Placebo group, 66 (49.3%) subjects had completed the study, while 40 (29.9%) subjects discontinued prematurely, and 28 (20.9%) subjects were ongoing.

To add more texts from medical writers.....



6. Combine Sections and Review

Stat2csr | Import Data | Working Station | Report Preview | Download Report

All Report Preview

Adverse Event	3 (2.2%)	6 (4.5%)	9 (3.4%)
Death	25 (18.7%)	23 (17.2%)	48 (17.9%)
Lack of Efficacy	2 (1.5%)	2 (1.5%)	4 (1.5%)
Physician Decision	2 (1.5%)	3 (2.2%)	5 (1.9%)
Protocol Violation	5 (3.7%)	3 (2.2%)	8 (3%)
Withdrawal By Parent/Guardian	4 (3%)	2 (1.5%)	6 (2.2%)
Withdrawal By Subject	1 (0.7%)	1 (0.7%)	2 (0.7%)
Treatment Completion Status			
Completed	68 (50.7%)	66 (49.3%)	134 (50.0%)
Ongoing	24 (17.9%)	28 (20.9%)	52 (19.4%)
Discontinued	42 (31.3%)	40 (29.9%)	82 (30.6%)

A total of 268 participants were initially screened for inclusion in the study. Of these, 268 participants were randomized into the study, and 268 participants received medication. The participants were divided into two groups: the A: Drug X group (134) and the B: Placebo group (134). Of the total participants, 134 (50.0%) subjects had completed the study, while 82 (30.6%) subjects discontinued prematurely, and 52 (19.4%) subjects were ongoing. In the A: Drug X group, 68 (50.7%) subjects had completed the study, while 42 (31.3%) subjects discontinued prematurely, and 24 (17.9%) subjects were ongoing. In the B: Placebo group, 66 (49.3%) subjects had completed the study, while 40 (29.9%) subjects discontinued prematurely, and 28 (20.9%) subjects were ongoing.

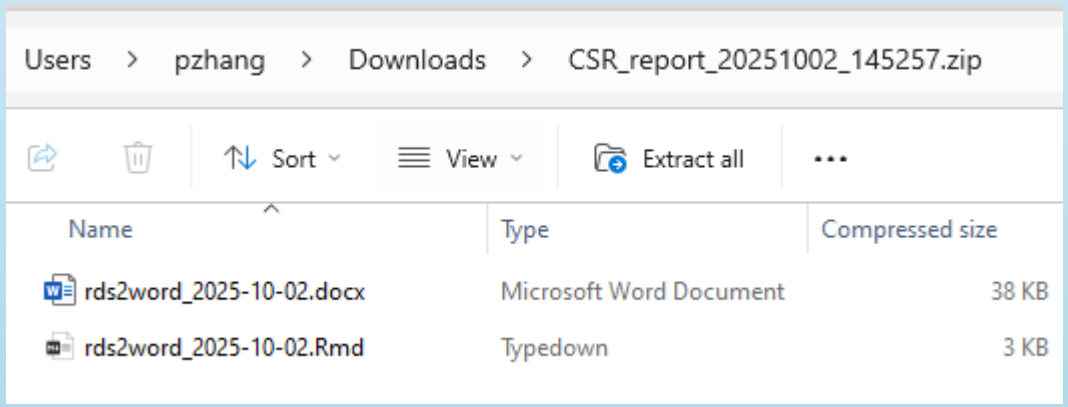
To add more texts from medical writers.....

Output Folder

Browse | No output folder selected

Generate Report (ZIP)

7. Export Outputs and Codes



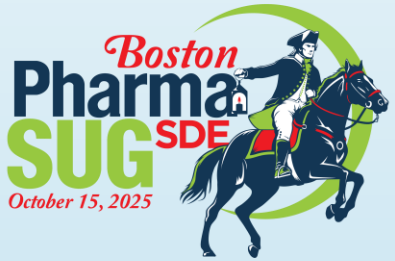
1.1 Disposition of Participants

Table 1

Category	A: Drug X (N=134)	B: Placebo (N=134)	Total (N=268)
Number of Patients Screened			268
Number of Randomized Subjects	134 (100%)	134 (100%)	268 (100%)
Number of Treated Subjects	134 (100%)	134 (100%)	268 (100%)
Study Completion Status			
Completed	68 (50.7%)	66 (49.3%)	134 (50.0%)
Ongoing	24 (17.9%)	28 (20.9%)	52 (19.4%)
Discontinued	42 (31.3%)	40 (29.9%)	82 (30.6%)
Adverse Event	3 (2.2%)	6 (4.5%)	9 (3.4%)
Death	25 (18.7%)	23 (17.2%)	48 (17.9%)
Lack of Efficacy	2 (1.5%)	2 (1.5%)	4 (1.5%)
Physician Decision	2 (1.5%)	3 (2.2%)	5 (1.9%)
Protocol Violation	5 (3.7%)	3 (2.2%)	8 (3%)
Withdrawal By Parent/Guardian	4 (3%)	2 (1.5%)	6 (2.2%)
Withdrawal By Subject	1 (0.7%)	1 (0.7%)	2 (0.7%)
Treatment Completion Status			
Completed	68 (50.7%)	66 (49.3%)	134 (50.0%)
Ongoing	24 (17.9%)	28 (20.9%)	52 (19.4%)
Discontinued	42 (31.3%)	40 (29.9%)	82 (30.6%)

A total of 268 participants were initially screened for inclusion in the study. Of these, 268 participants were randomized into the study, and 268 participants received medication. The participants were divided into two groups: the A: Drug X group (134) and the B: Placebo group (134). Of the total participants, 134 (50.0%) subjects had completed the study, while 82 (30.6%) subjects discontinued prematurely, and 52 (19.4%) subjects were ongoing. In the A: Drug X group, 68 (50.7%) subjects had completed the study, while 42 (31.3%) subjects discontinued prematurely, and 24 (17.9%) subjects were ongoing. In the B: Placebo group, 66 (49.3%) subjects had completed the study, while 40 (29.9%) subjects discontinued prematurely, and 28 (20.9%) subjects were ongoing.

To add more texts from medical writers.....



{stat2csr} Application

1. Import Results

Stat2csr | Import Data | Working Station | Report Preview | Download Report

TFL Result Path

Browse... | No file selected

Use Sample Data

Import

Section	TFL	Status
Section 10.1	Disposition of Patients	Pending
Section 11.2	Demographic and Other Baseline Characteristics	Pending
Section 12.2.2	Display of Adverse Events	Pending
Section 12.4.2	Laboratory Values Over Time	Pending
Section 12.5	Vital Signs Over Time	Pending

2. Review and Edit – Tables

Stat2csr | Import Data | Working Station | Report Preview | Download Report

Section 10.1 — Disposition of Patients

Edit the Table

Save the Section

Category	A: Drug X (N=134)	B: Placebo (N=134)	Total (N=268)
Number of Patients Screened			268
Number of Randomized Subjects	134 (100%)	134 (100%)	268 (100%)
Number of Treated Subjects	134 (100%)	134 (100%)	268 (100%)
Study Completion Status			
Completed	68 (50.7%)	66 (49.3%)	134 (50.0%)
Ongoing	24 (17.9%)	28 (20.9%)	52 (19.4%)
Discontinued	42 (31.3%)	40 (29.9%)	82 (30.6%)
Adverse Event	3 (2.2%)	6 (4.5%)	9 (3.4%)
Death	25 (18.7%)	23 (17.2%)	48 (17.9%)
Lack of Efficacy	2 (1.5%)	2 (1.5%)	4 (1.5%)
Physician Decision	2 (1.5%)	3 (2.2%)	5 (1.9%)
Protocol Violation	5 (3.7%)	3 (2.2%)	8 (3%)

A total of 268 participants were initially screened for inclusion in the study. Of these, 268 participants were randomized into the study, and 268 participants received medication. The participants were divided into two groups: the A: Drug X group (134) and the B: Placebo group (134). Of the total participants, 134 (50.0%) subjects had completed the study, while 82 (30.6%) subjects discontinued prematurely, and 52 (19.4%) subjects were ongoing. In the A: Drug X group, 68 (50.7%) subjects had completed the study, while 42 (31.3%) subjects discontinued prematurely, and 24 (17.9%) subjects were ongoing. In the B: Placebo group, 66 (49.3%) subjects had completed the study, while 40 (29.9%) subjects discontinued prematurely, and 28 (20.9%) subjects were ongoing.

2. Review and Edit – Figure

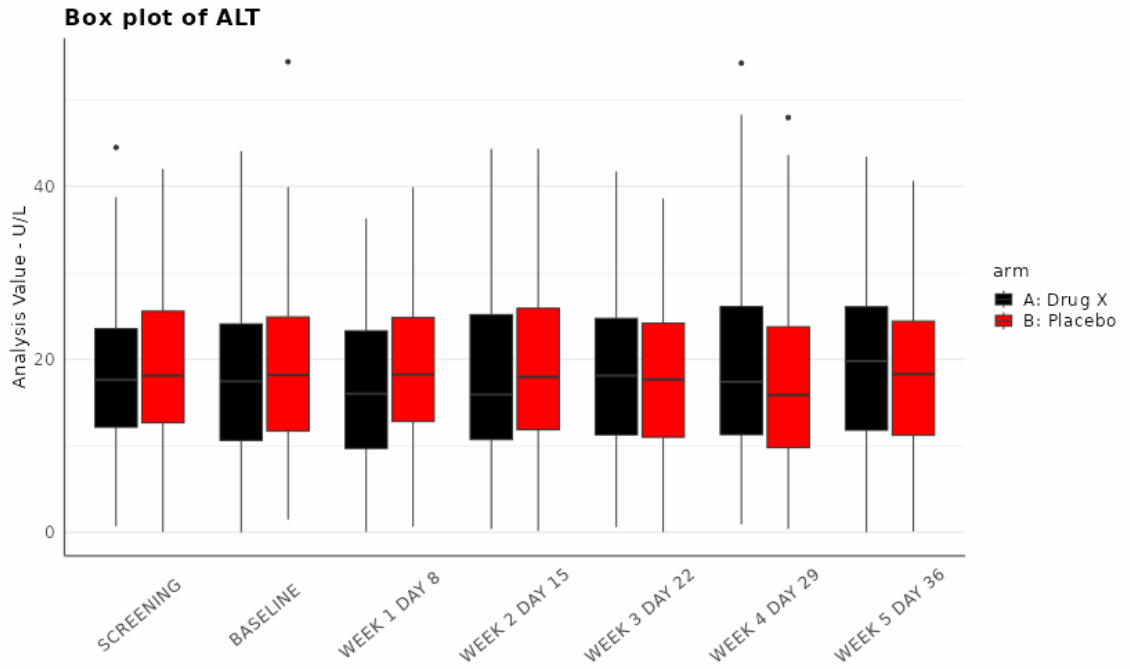
Stat2csr | Import Data | Working Station | Report Preview | Download Report

Section 12.4.2.1 — Laboratory Values Over Time (Figur ▾

Select the Figures

Save the Section

Figure 1 | Figure 2 | Figure 3



ALTIn the A: Drug X group, the median of ALT ranged from 15.9 (WEEK 2 DAY 15) to 19.8 (WEEK 5 DAY 36). In the B: Placebo group, the median of ALT ranged from 15.9 (WEEK 4 DAY 29) to 18.3 (WEEK 5 DAY 36). CRPIn the A: Drug X group, the median of CRP ranged from 8.7 (WEEK 4 DAY 29) to 9.1 (WEEK 3 DAY 22). In the B: Placebo group, the median of CRP ranged from 8.9 (BASELINE) to 9.1 (WEEK 5 DAY 36). IGAIn the A: Drug X group, the median of IGA ranged from 2.9 (BASELINE) to 2.9 (WEEK 4 DAY 29). In the B: Placebo group, the median of IGA ranged from 2.9 (BASELINE) to 2.9 (WEEK 5 DAY 36).

3. Save Section and Preview

Stat2csr | Import Data | **Working Station** | Report Preview | Download Report

Section 10.1 — Disposition of Patients | Edit the Table | Save the Section

	A: Drug X (N=134)	B: Placebo (N=134)	Total (N=268)
Number of Patients Screened			268
Number of Randomized Subjects	134 (100%)	134 (100%)	268 (100%)
Number of Treated Subjects	134 (100%)	134 (100%)	268 (100%)
Study Completion Status			
Completed	68 (50.7%)	66 (49.3%)	134 (50.0%)
Ongoing	24 (17.9%)	28 (20.9%)	52 (19.4%)

A total of 268 participants were initially screened for inclusion in the study. Of these, 268 participants were randomized into the study, and 268 participants received medication. The participants were divided into two groups: the A: Drug X group (134) and the B: Placebo group (134).

Of the total participants, 134 (50.0%) subjects had completed the study, while 82 (30.6%) subjects discontinued prematurely, and 52 (19.4%) subjects were ongoing. In the A: Drug X group, 68 (50.7%) subjects had completed the study, while 42 (31.3%) subjects discontinued prematurely, and 24 (17.9%) subjects were ongoing. In the B: Placebo group, 66 (49.3%) subjects had completed the study, while 40 (29.9%) subjects discontinued prematurely, and 28 (20.9%) subjects were ongoing.

4. Generate Report

Stat2csr | Import Data | Working Station | Report Preview | **Download Report**

All Report Preview

HISPANIC OR LATINO	15 (11.2%)	18 (13.4%)	33 (12.5%)
NOT HISPANIC OR LATINO	104 (77.6%)	103 (76.9%)	207 (77.2%)
NOT REPORTED	6 (4.5%)	10 (7.5%)	16 (6.0%)
UNKNOWN	9 (6.7%)	3 (2.2%)	12 (4.5%)

The participants were divided into two groups: the A: Drug X group (134) and the B: Placebo group (134). The mean (SD) of Age was 34.6 (7.3) with a median of 34.0 (range 21.0 to 62.0). In the A: Drug X group, the mean (SD) age was 33.8 (6.6) with a median of 33.0 (range 21.0 to 50.0). In the B: Placebo group, the mean (SD) age was 35.4 (7.9) with a median of 35.0 (range 21.0 to 62.0). Of 268 participants enrolled, 161 (60.1%) participants were F, 107 (39.9%) participants were M. In the A: Drug X group, 79 (59.0%) participants were F, 55 (41.0%) participants were M. In the B: Placebo group, 82 (61.2%) participants were F, 52 (38.8%) participants were M. Of 268 participants enrolled, 19 (7.1%) participants were American Indian or Alaska Native, 135 (50.4%) participants were Asian, 59 (22.0%) participants were Black or African American, 1 (0.4%) participants were Multiple, 1 (0.4%) participants were Native Hawaiian or Other Pacific Islander, 0 (0.0%) participants were Other, 0 (0.0%) participants were Unknown, 53 (19.8%) participants were White. In the A: Drug X group, 8 (6.0%) participants were American Indian or Alaska Native, 68 (50.7%) participants were Asian, 31 (23.1%) participants were Black or African American, 0 (0.0%) participants were Multiple, 0 (0.0%) participants were Native Hawaiian or Other Pacific Islander, 0 (0.0%) participants were Other, 0 (0.0%) participants were Unknown, 27 (20.1%) participants were White. In the B: Placebo group, 11 (8.2%) participants were American Indian or Alaska Native, 67 (50.0%) participants were Asian, 28 (20.9%) participants were Black or African American, 1 (0.7%) participants were Multiple, 1 (0.7%) participants were Native Hawaiian or Other Pacific Islander, 0 (0.0%) participants were Other, 0 (0.0%) participants were Unknown, 26 (19.4%) participants were White. Of 268 participants enrolled, 33 (12.3%) participants were Hispanic or Latino, 207 (77.2%) participants were Not Hispanic or Latino, 16 (6.0%) participants were Not Reported, 12 (4.5%) participants were Unknown. In the A: Drug X group, 15 (11.2%) participants were Hispanic or Latino, 104 (77.6%) participants were Not Hispanic or Latino, 6 (4.5%) participants were Not Reported, 9 (6.7%) participants were Unknown. In the B: Placebo group, 18 (13.4%) participants were Hispanic or Latino, 103 (76.9%) participants were Not Hispanic or Latino, 10 (7.5%) participants were Not Reported, 3 (2.2%) participants were Unknown.

Output Folder

Browse | No output folder selected

Generate Report (ZIP)

Development & Validation

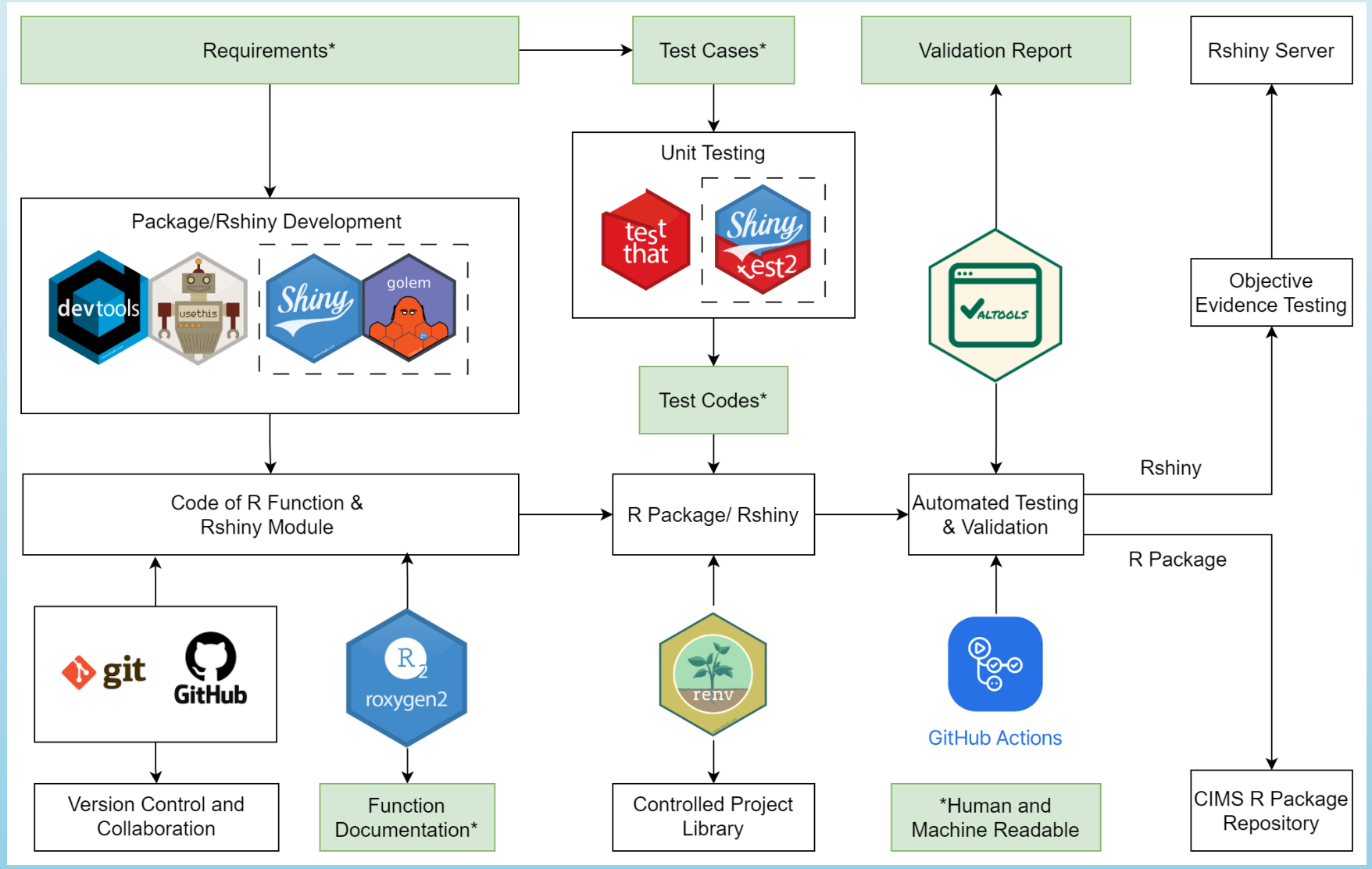
Preparation

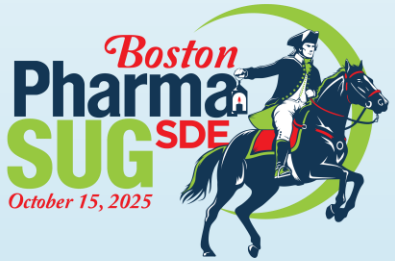
- The stat2csr is used after results are confirmed and QC'ed
  - QC Process: double validation (primary/ir programmer)
- Some Packages/Functionalities needed:
  1. Transform results into ARD (Analysis Result Data) structure
  2. Annotate ARD structure with ID so that
     - Narratives can be generated by inserting statistical results
     - Linkage between HTML output and narratives on Shiny
  3. Combine inline tables and narratives
  4. Shiny Module to implement interaction
  5. Shiny application for medical writers to use

Good Development Practice for R Package

- Good practice: high quality, easy to maintain/update in the future
- Working group {openstatsware}: white paper {openstatsguide}
- Key R Packages
  - {roxygen2}: To write function headers and generate comprehensive documentation.
  - {renv}: For managing the package environment and ensuring reproducibility.
  - {devtools} and {usethis}: For streamlined package building and efficient development workflows.
  - {testthat}/{shinytest2}: For implementing unit tests to validate the functionality of the package.
  - {valtools}: Generate Validation Report with requirement, test cases, test codes and results

CIMS Package/R Shiny Workflow



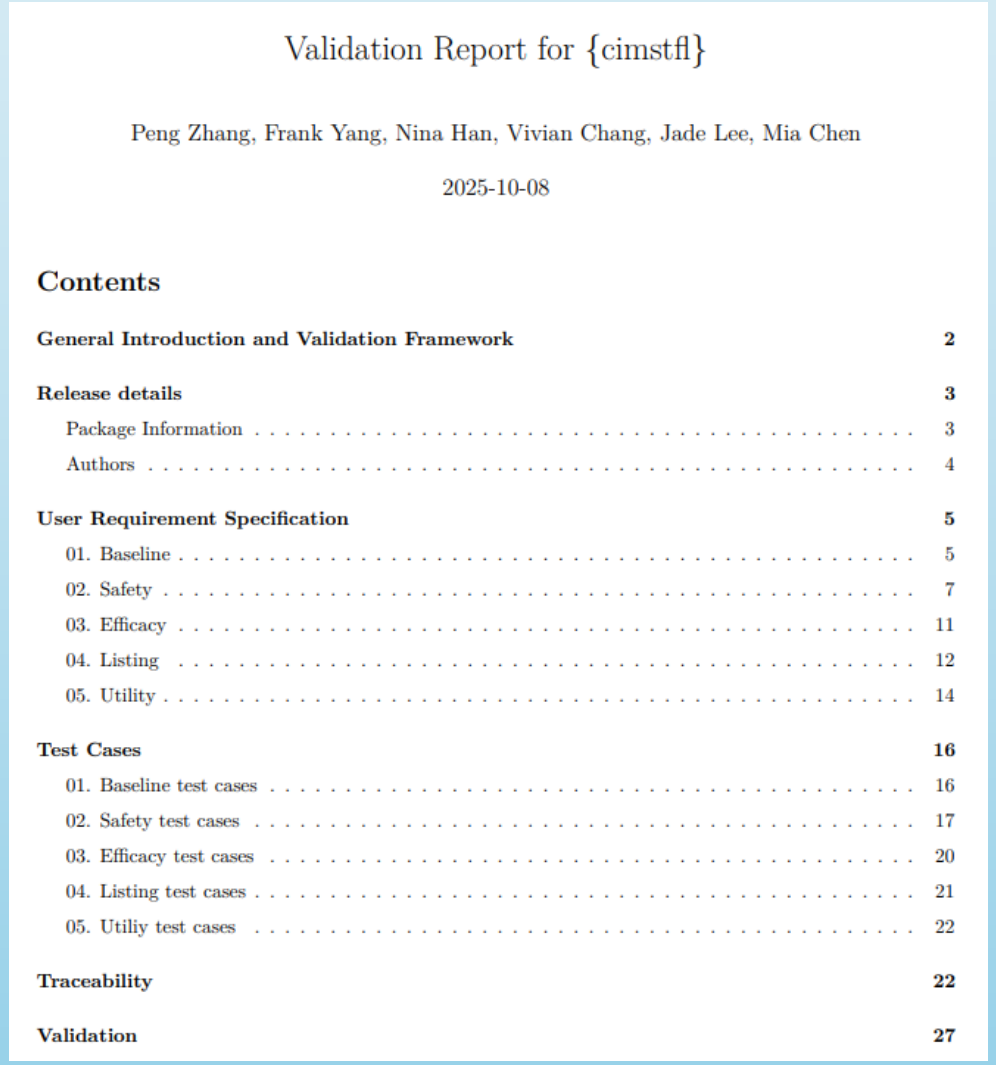


Validation approach

- No matter the approach, validation is always a concern
  - "Is your application validated?", or "What is your validation process?"
- Two concepts of Validation:
  - QC (double programming)
  - Validation (validated per requirement)
- Suggest the validation into two parts
  - Package Validation (R Package Level)
  - Operational Qualification (OQ, Shiny level)
- A validation report can serve as the preferred evidence format

Validation Report

- PHUSE White paper: R Package Validation Framework
- {valtools} solution
  - A well-written example of R package {drugdevelopeR}
- Good structure for evidence
  - Description
  - Requirement
  - Test Case
  - Test Result
  - Traceability
- Validated packages deliver consistent, high quality



Validation Report for {cimstfl}

Peng Zhang, Frank Yang, Nina Han, Vivian Chang, Jade Lee, Mia Chen

2025-10-08

Contents

Requirements– Describe expected outcomes

01.01: Disposition Table

- Specific:
  1. Generate the total screen rows with given label with only numbers in total column
  2. Generate different rows with different conditions for population set (FAS, SAF, ITT, etc.) with given label by input of population variable
  3. Generate the treatment discontinuation summary (optional)
  4. Include treatment discontinuation reason (optional)
  5. Generate the study discontinuation summary (optional)
  6. Include study discontinuation reason (optional)
- General:
  1. Generate the table with total column only (arm=NULL)
  2. Generate the table with maximum of 5 column of treatments (4 ARM + 1 Total) of the results The table tree is able to be formatted as html file
  3. Generate .docx file properly by specifying number of rows, with desired header and footnotes
  4. Generate tabletree object and ards
  5. The primary and ir function can be exported as executable code with logs or not

Test Cases

Test Cases

01. Baseline test cases

Test case 1.01.01.01: Test for disposition table. Using 'TRT01P' as the arm variable, with population 1 variable 'ITTFL' and population 2 variable 'SAFFL'. Study status is given by 'EOSSTT', treatment status by 'EOTSTT', study discontinuation by 'DCSREAS', and treatment discontinuation by 'NULL'.The screening standard applied is 'NULL'

Test case 1.01.01.02: Test for disposition table. Using 'NULL' as the arm variable, with population 1 variable 'ITTFL' and population 2 variable 'SAFFL'. Study status is given by 'NULL', treatment status by 'NULL', study discontinuation by 'NULL', and treatment discontinuation by 'NULL'.The screening standard applied is 'AGE>34'

Test case 1.01.03.01: Test for disposition table. Using 'TRT01P' as the arm variable, with population 1 variable 'ITTFL' and population 2 variable 'SAFFL'. Study status is given by 'EOSSTT', treatment status by 'EOTSTT', study discontinuation by 'DCSREAS', and treatment discontinuation by 'NULL'.The screening standard applied is 'DTHFL=='N''

Traceability Matrix

- Trace back on the relationship between requirement and test cases.
- This is helpful to ensure how each requirement is met.

Requirement ID	Test Cases
01.01 General 1	1.01.01.02
01.01 General 2	1.01.03.01
01.01 General 3	1.01.01.01
01.01 General 4	1.01.01.01
01.01 General 5	1.01.01.01
01.01 General 6	5.01.01.01
01.01 Specific 1	1.01.01.01
01.01 Specific 2	1.01.01.01
01.01 Specific 3	1.01.01.01, 1.01.01.02
01.01 Specific 4	1.01.01.01, 1.01.01.02
01.01 Specific 5	1.01.01.01, 1.01.01.02
01.01 Specific 6	1.01.01.01, 1.01.01.02
01.02 General 1	1.02.01.02
01.02 General 2	1.02.03.01
01.02 General 3	1.02.01.01

Test Results

- A table to demonstrate all the tests are passed
- Evidence to show the requirement is met
- The whole validation process assures the package are in high quality and meets what we need from the package

Setting	failed	passed	Duration
Baseline	0	81	60.297 sec
Safety	0	153	238.427 sec
Efficacy	0	27	18.071 sec
Listing	0	14	2.452 sec
Utility	0	24	43.725 sec
Total	0	299	362.972 sec

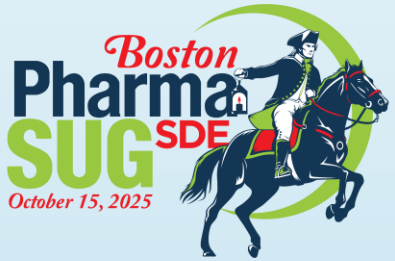
Application Validation

- Validation Report through {valtools}
- Additional evidence to show the application works per requirement
- Manual screenshot or {shinytest2} should be used for Operational Qualification (OQ)
- Similarly, a validation plan/report should be generated.
- The procedure can borrow software development SOP but a simplified version
  - Validation Procedure Reference: Emily Yate, Formation Bio https://www.youtube.com/watch?v=eOXbpiIcYU0&t

Shiny Deployment

- Workspace (Posit Workbench, RStudio, RStudio Sever)
- Deployment from RStudio to Posit Connect/Shiny Server
  - {rsconnect}
- Ensure the access control for shiny application
  - Not expected to be shared with any people outside the organization
  - Not expected to be shared with any people not in the projects
- Communicate with IT to construct internal infrastructure

Discussion



Quick Summary of stat2csr

- Propose a way of using R packages and shiny applications:
  - Provide a workspace for medical writers to review and edit the results and narratives for section 9 to 11
  - Automated reports by rendering process.
  - Validated Evidence
  - Reliable development process
  - Traceability and Reproducibility
- Only subset of the CSR results are used for report (no new calculations to ensure the consistency)

Other Potential Use Cases

- Meeting Slides for safety review
- Executive Summary Report for DMC Meeting
- Simplified version of one-click solution
- Once data is ready, the meeting materials are ready

Role of LLM/AI

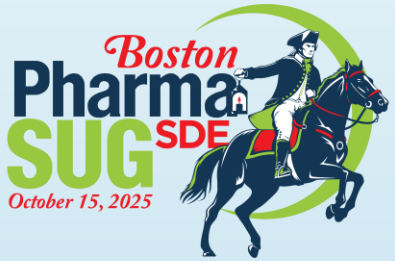
- We observe some efficient applications using LLM to automate descriptions from statistical results
  - Embedded Word adds-on
  - RAG to retrieve and summarize findings
- Concern:
  - Not 100% algorithm-based values, leading to a chance to include non-consistent value
  - Using external API: data privacy
  - Localized model: High computation resources

Alternative Solutions of LLM

- Polish narratives template with LLM
  - We do not use it for reading results
- Localized Small Language Model (low computation resources needed)
  - https://research.nvidia.com/labs/lpr/slm-agents/

Acknowledgement

- Collaborative effort from CIMS Internal Team
- Zhen Wu, Frank Yang, Vivian Chang, Jade Lee, Nina Han, Mia Chen
- Continued previous effort from PHUSE Connect US 2025 OS06
  - https://phuse.s3.eu-central-1.amazonaws.com/Archive/2025/Connect/US/Orlando/PAP_OS06.pdf
  - https://phuse.s3.eu-central-1.amazonaws.com/Archive/2025/Connect/US/Orlando/PRE_OS06.pdf



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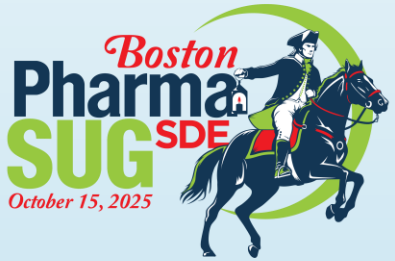

Q & A Session