Paper RE10

Optimizing Workflow in Pharma: Innovative Dashboard Creation

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ABSTRACT

Dashboards have become essential in the data-driven world, particularly within the pharmaceutical industry. In an era of increasing automation, dashboards serve as powerful tools to streamline the workflow from data exploration to report generation. In Novo Nordisk, the use of programming languages such as Python and R has enhanced and optimized the dashboard creation process. This presentation emphasizes the development of dashboards for data exploration and visualization from the stakeholder perspective. By utilizing the latest R packages, these dashboards function as effective reporting tools, enabling outputs to be generated with just a few clicks, thereby eliminating the need for extensive programming. Additionally, it highlights the necessary precautions that should be taken while creating dashboards.

INTRODUCTION

In modern pharmaceutical research, dashboards have become indispensable tools for providing centralized, real-time views of complex clinical data. They play a pivotal role in accelerating insights from "bench to bedside" by enabling faster, data-driven decisions for trial management, patient safety monitoring, and overall research efficiency. By transforming dense datasets into interactive visual formats, dashboards improve communication among clinicians, researchers, and sponsors while significantly reducing manual data-gathering efforts.

The utility of these platforms spans the entire lifecycle of a clinical trial:

Enrollment & Recruitment Monitoring: Visualizing accrual rates and study phase status to identify bottlenecks quickly.

Performance Monitoring (KPIs): Tracking key performance indicators like site performance and completion timelines for sponsors and managers.

Patient Safety & Outcomes: Integrating patient-reported outcomes (PROMs) and real-world data (RWE) to spot adverse events early and improve patient care.

Data Analysis & Decision Support: Providing actionable insights for critical go/no-go decisions in drug development and supporting model-based development (MBDD).

While platforms such as Microsoft Power BI or Python-based Dash are popular, the R ecosystem—specifically Shiny, flexdashboard—offers a highly tailored environment for clinical trial lifecycle.

RATIONALE: THE NEED FOR SPEED

In the pharmaceutical industry, time is the ultimate resource. Every day saved in the trial conduct phase translates to getting life-saving treatments to patients faster. While trial durations are fixed for patient safety, the reporting phase offers a clear opportunity for optimization.

However, traditional clinical programming is often an iterative, time-consuming process where programmers spend significant time writing and re-running code for every stakeholder request. By replacing manual coding with an automated, click-based alternative, we can drastically reduce the time from data database lock to final submission without compromising accuracy.

THE UNIVERSAL REACTIVE ARCHITECTURE

The dashboard is designed as a Universal Reactive Engine that transforms user inputs into clinical report artifacts. Unlike traditional tools with hardcoded outputs, this architecture uses a flexible "grammar" mapping UI states to dynamic R functions.

1) **DATA LAYER & REACTIVE BINDING**
   The application utilizes reactive binding to scan the raw environment data. This allows the app to adapt its UI to the data structure dynamically, ensuring that the tool remains useful across different clinical studies without manual reconfiguration.

2) **APPLICATION LOGIC: THE PARAMETER MAPPER**
   Acting as the "Brain" of the system, the Parameter Mapper translates human-friendly UI selections into internal R symbols. For example, a user selecting a "Treatment Arm" in a dropdown is internally converted to the corresponding variable name, such as sym("ARM"), which is then fed into the compute engines.

3) **COMPUTE ENGINES**
   The system employs generalized constructors for its compute engines. Whether the user is requesting a statistical table or a figure, the engine applies those specific choices to a generic pipeline, ensuring a consistent and robust output generation process.

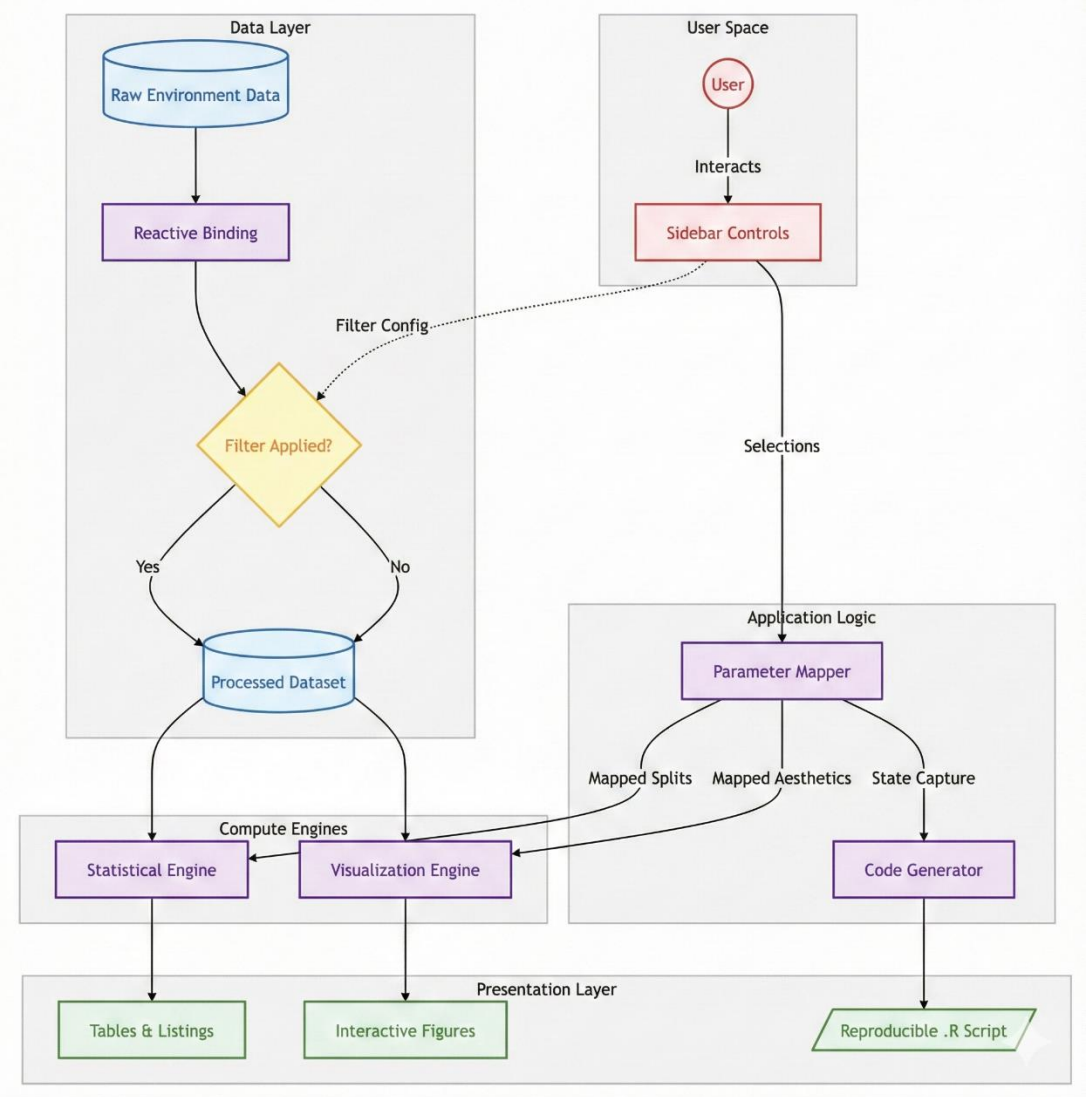


FIG: 1

(FLOWCHART OF **UNIVERSAL REACTIVE ENGINE**)

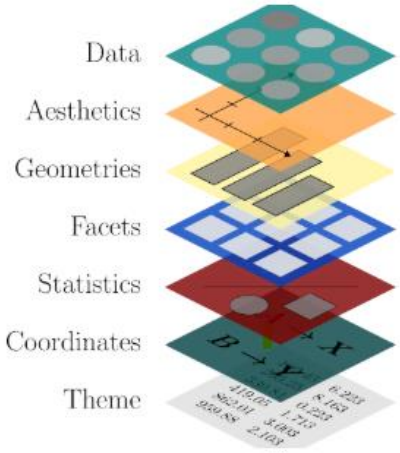
CORE REPORTING ENGINES

The dashboard's power stems from the integration of three industry-standard R packages:

- **rtables:** Designed to create and display complex clinical tables. It utilizes a functional pipeline including basic_table(), split_rows_by(), split_cols_by(), analyze(), build_table() etc. to build multi-dimensional outputs.

- **rlistings:** Used for producing and displaying clinical listings. It focuses on key functions like as_listing(), key_cols(), disp_cols() etc. to maintain data integrity and readability.

- **ggplot2:** A declarative system for creating graphics based on the "Grammar of Graphics". This allows the dashboard to build publication-ready figures by layering data, aesthetics, and geometries.



KEY FEATURES & CAPABILITIES

- A core capability is Real-Time Data Selection, allowing users to dynamically access and map live environment datasets, such as ADSL or ADAE, for immediate report generation.
- This is complemented by Precision Data Filtration, which enables the interactive subsetting of patient data to focus on specific subgroups without the need for manual coding.
- The platform's Click-Based Output Creation allows for the rapid generation of clinical-grade Tables, Listings, and Figures (TLFs) using pre-validated reporting engines like rtables, rlistings and ggplot2.
- To ensure reproducibility and eliminate "black box" operations, the system features automated Code Generation, which captures every UI interaction and synthesizes it into a standalone, reproducible R script for full auditability.
- Finally, Simplified Output Download capabilities allow stakeholders to export these high-quality results and their associated metadata in various formats for immediate review or submission.

DEMO: TABLES, LISTINGS & FIGURES

Following figures (FIG:2, FIG:3, FIG: 4, FIG:5, FIG: 6, FIG:7) represent the dashboard interface to create tables, listings and figures respectively.

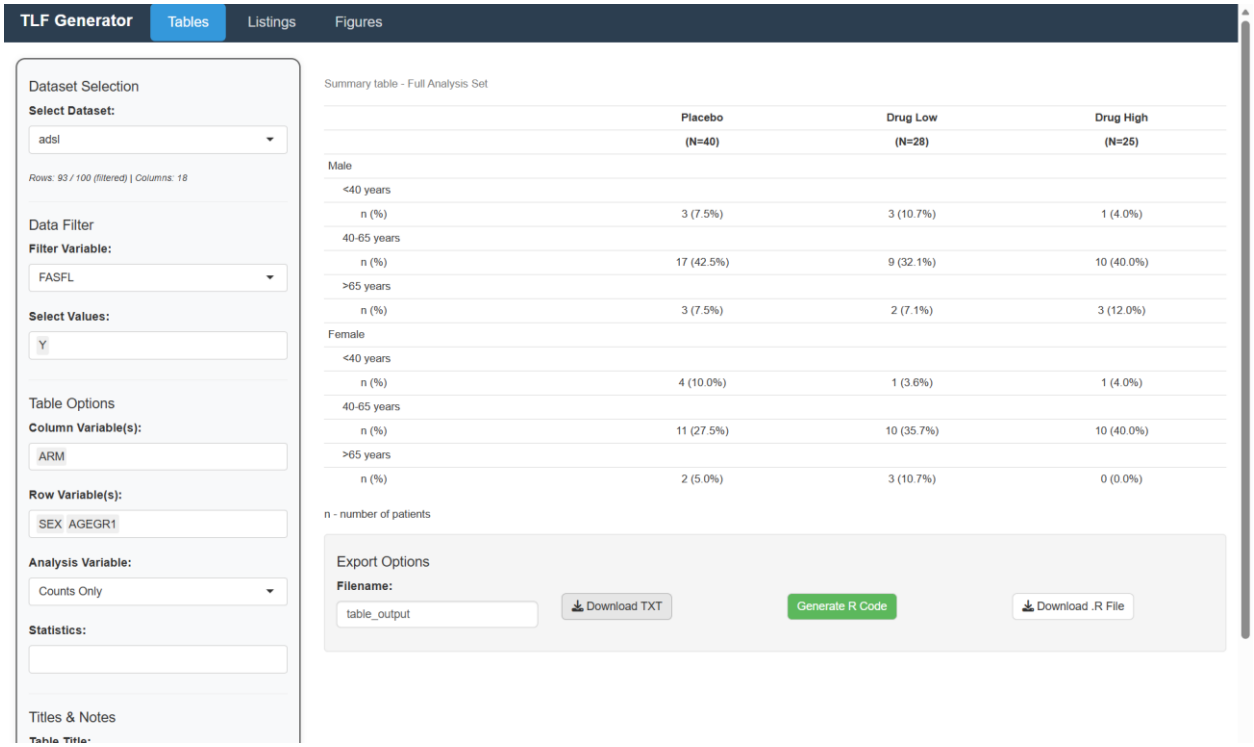

TLF Generator
Tables
Listings
Figures
Dataset Selection
Select Dataset:
adsl
Rows: 93 / 100 (filtered) | Columns: 18
Data Filter
Filter Variable:
FASFL
Select Values:
Y
Table Options
Column Variable(s):
ARM
Row Variable(s):
SEX AGEGR1
Analysis Variable:
Counts Only
Statistics:
Titles & Notes
Summary table - Full Analysis Set
Placebo (N=40)
Drug Low (N=28)
Drug High (N=25)
Male
<40 years
n (%) 3 (7.5%) 3 (10.7%) 1 (4.0%)
40-65 years
n (%) 17 (42.5%) 9 (32.1%) 10 (40.0%)
>65 years
n (%) 3 (7.5%) 2 (7.1%) 3 (12.0%)
Female
<40 years
n (%) 4 (10.0%) 1 (3.6%) 1 (4.0%)
40-65 years
n (%) 11 (27.5%) 10 (35.7%) 10 (40.0%)
>65 years
n (%) 2 (5.0%) 3 (10.7%) 0 (0.0%)
n - number of patients
Export Options
Filename:
table_output
Download TXT
Generate R Code
Download .R File

FIG: 2

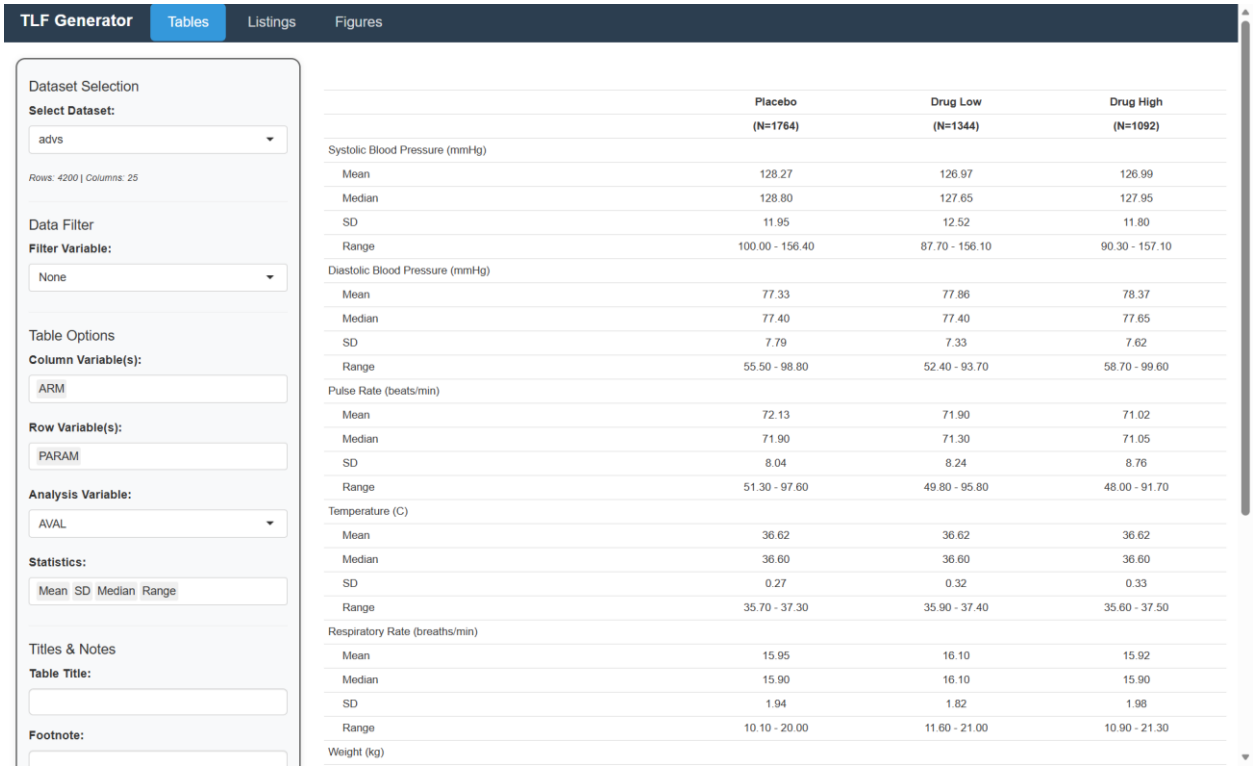
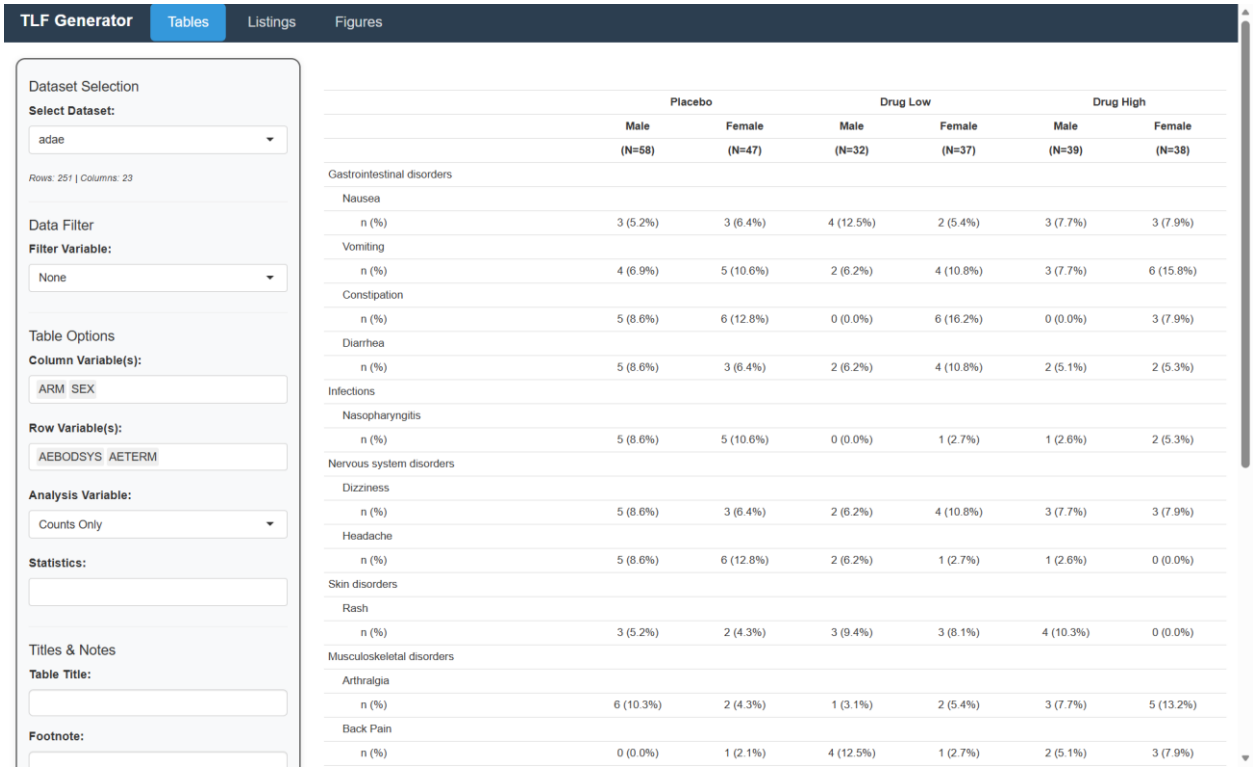
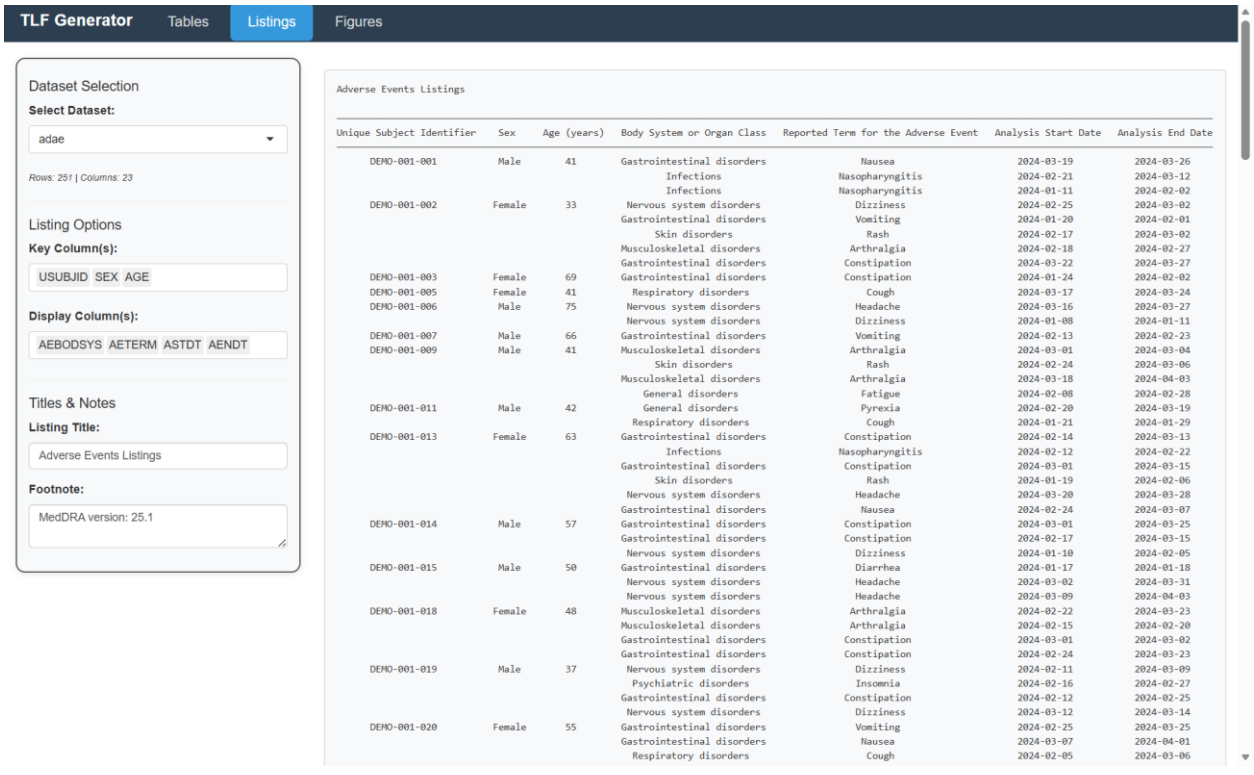

TLF Generator
Tables
Listings
Figures
Dataset Selection
Select Dataset:
advs
Rows: 4200 | Columns: 25
Data Filter
Filter Variable:
None
Table Options
Column Variable(s):
ARM
Row Variable(s):
PARAM
Analysis Variable:
AVAL
Statistics:
Mean SD Median Range
Titles & Notes
Table Title:
Footnote:
Placebo (N=1764)
Drug Low (N=1344)
Drug High (N=1092)
Systolic Blood Pressure (mmHg)
Mean 128.27 126.97 126.99
Median 128.80 127.65 127.95
SD 11.95 12.52 11.80
Range 100.00 - 156.40 87.70 - 156.10 90.30 - 157.10
Diastolic Blood Pressure (mmHg)
Mean 77.33 77.86 78.37
Median 77.40 77.40 77.65
SD 7.79 7.33 7.62
Range 55.50 - 98.80 52.40 - 93.70 58.70 - 99.60
Pulse Rate (beats/min)
Mean 72.13 71.90 71.02
Median 71.90 71.30 71.05
SD 8.04 8.24 8.76
Range 51.30 - 97.60 49.80 - 95.80 48.00 - 91.70
Temperature (C)
Mean 36.62 36.62 36.62
Median 36.60 36.60 36.60
SD 0.27 0.32 0.33
Range 35.70 - 37.30 35.90 - 37.40 35.60 - 37.50
Respiratory Rate (breaths/min)
Mean 15.95 16.10 15.92
Median 15.90 16.10 15.90
SD 1.94 1.82 1.98
Range 10.10 - 20.00 11.60 - 21.00 10.90 - 21.30
Weight (kg)

FIG: 3



	Placebo		Drug Low		Drug High	
	Male	Female	Male	Female	Male	Female
	(N=58)	(N=47)	(N=32)	(N=37)	(N=39)	(N=38)
Gastrointestinal disorders						
Nausea						
n (%)	3 (5.2%)	3 (6.4%)	4 (12.5%)	2 (5.4%)	3 (7.7%)	3 (7.9%)
Vomiting						
n (%)	4 (6.9%)	5 (10.6%)	2 (6.2%)	4 (10.8%)	3 (7.7%)	6 (15.8%)
Constipation						
n (%)	5 (8.6%)	6 (12.8%)	0 (0.0%)	6 (16.2%)	0 (0.0%)	3 (7.9%)
Diarrhea						
n (%)	5 (8.6%)	3 (6.4%)	2 (6.2%)	4 (10.8%)	2 (5.1%)	2 (5.3%)
Infections						
Nasopharyngitis						
n (%)	5 (8.6%)	5 (10.6%)	0 (0.0%)	1 (2.7%)	1 (2.6%)	2 (5.3%)
Nervous system disorders						
Dizziness						
n (%)	5 (8.6%)	3 (6.4%)	2 (6.2%)	4 (10.8%)	3 (7.7%)	3 (7.9%)
Headache						
n (%)	5 (8.6%)	6 (12.8%)	2 (6.2%)	1 (2.7%)	1 (2.6%)	0 (0.0%)
Skin disorders						
Rash						
n (%)	3 (5.2%)	2 (4.3%)	3 (9.4%)	3 (8.1%)	4 (10.3%)	0 (0.0%)
Musculoskeletal disorders						
Arthralgia						
n (%)	6 (10.3%)	2 (4.3%)	1 (3.1%)	2 (5.4%)	3 (7.7%)	5 (13.2%)
Back Pain						
n (%)	0 (0.0%)	1 (2.1%)	4 (12.5%)	1 (2.7%)	2 (5.1%)	3 (7.9%)

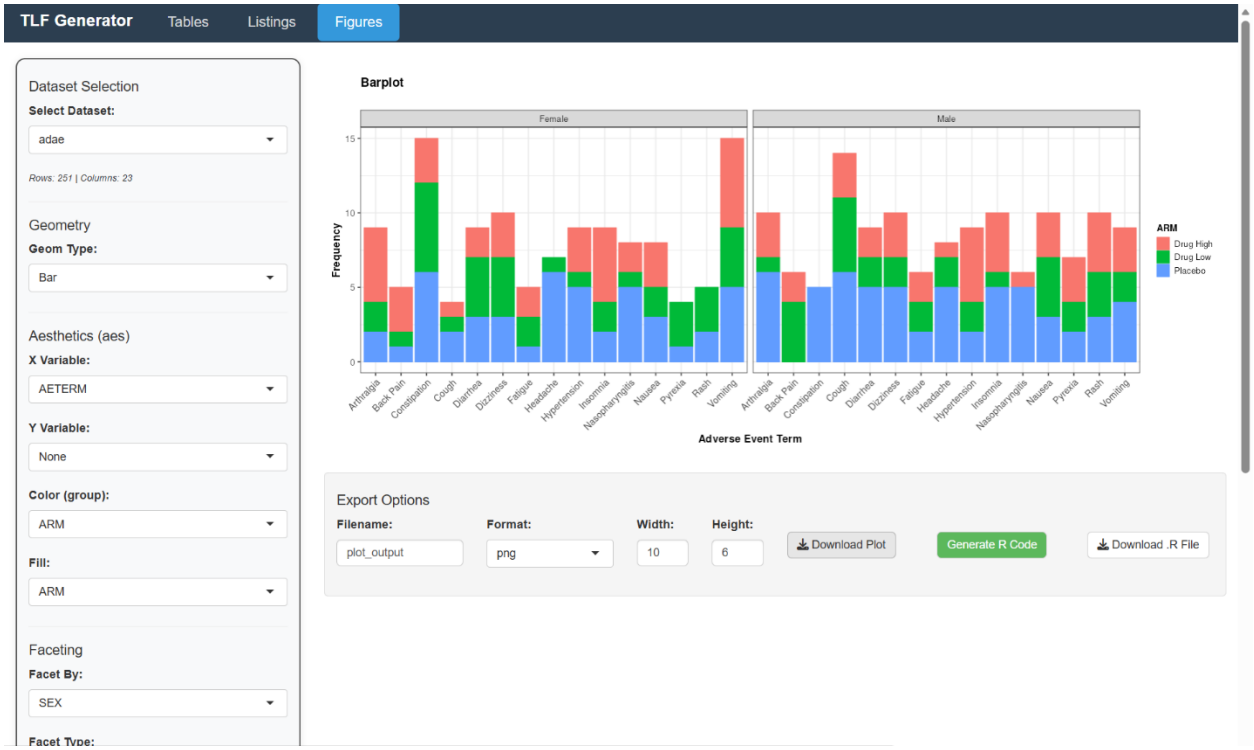
FIG: 4



Adverse Events Listings

Unique Subject Identifier	Sex	Age (years)	Body System or Organ Class	Reported Term for the Adverse Event	Analysis Start Date	Analysis End Date
DEMO-001-001	Male	41	Gastrointestinal disorders	Nausea	2024-03-19	2024-03-26
			Infections	Nasopharyngitis	2024-02-21	2024-03-12
			Infections	Nasopharyngitis	2024-01-11	2024-02-02
DEMO-001-002	Female	33	Nervous system disorders	Dizziness	2024-02-25	2024-03-02
			Gastrointestinal disorders	Vomiting	2024-01-20	2024-02-01
			Skin disorders	Rash	2024-02-17	2024-03-02
			Musculoskeletal disorders	Arthralgia	2024-02-18	2024-02-27
			Gastrointestinal disorders	Constipation	2024-03-22	2024-03-27
DEMO-001-003	Female	69	Gastrointestinal disorders	Constipation	2024-01-24	2024-02-02
DEMO-001-005	Female	41	Respiratory disorders	Cough	2024-03-17	2024-03-24
DEMO-001-006	Male	75	Nervous system disorders	Headache	2024-03-16	2024-03-27
			Nervous system disorders	Dizziness	2024-01-08	2024-01-11
DEMO-001-007	Male	66	Gastrointestinal disorders	Vomiting	2024-02-13	2024-02-23
DEMO-001-009	Male	41	Musculoskeletal disorders	Arthralgia	2024-03-01	2024-03-04
			Skin disorders	Rash	2024-02-24	2024-03-06
			Musculoskeletal disorders	Arthralgia	2024-03-18	2024-04-03
			General disorders	Fatigue	2024-02-08	2024-02-28
DEMO-001-011	Male	42	General disorders	Pyrexia	2024-02-20	2024-03-19
			Respiratory disorders	Cough	2024-01-21	2024-01-29
DEMO-001-013	Female	63	Gastrointestinal disorders	Constipation	2024-02-14	2024-03-13
			Infections	Nasopharyngitis	2024-02-12	2024-02-22
			Gastrointestinal disorders	Constipation	2024-03-01	2024-03-15
			Skin disorders	Rash	2024-01-19	2024-02-06
			Nervous system disorders	Headache	2024-03-20	2024-03-28
			Gastrointestinal disorders	Nausea	2024-02-24	2024-03-07
DEMO-001-014	Male	57	Gastrointestinal disorders	Constipation	2024-03-01	2024-03-25
			Gastrointestinal disorders	Constipation	2024-02-17	2024-03-15
			Nervous system disorders	Dizziness	2024-01-10	2024-02-05
DEMO-001-015	Male	50	Gastrointestinal disorders	Diarrhea	2024-01-17	2024-01-18
			Nervous system disorders	Headache	2024-03-02	2024-03-31
			Nervous system disorders	Headache	2024-03-09	2024-04-03
DEMO-001-018	Female	48	Musculoskeletal disorders	Arthralgia	2024-02-22	2024-03-23
			Musculoskeletal disorders	Arthralgia	2024-02-15	2024-02-20
			Gastrointestinal disorders	Constipation	2024-03-01	2024-03-02
			Gastrointestinal disorders	Constipation	2024-02-24	2024-03-23
DEMO-001-019	Male	37	Nervous system disorders	Dizziness	2024-02-11	2024-03-09
			Psychiatric disorders	Insomnia	2024-02-16	2024-02-27
			Gastrointestinal disorders	Constipation	2024-02-12	2024-02-25
			Nervous system disorders	Dizziness	2024-03-12	2024-03-14
DEMO-001-020	Female	55	Gastrointestinal disorders	Vomiting	2024-02-25	2024-03-25
			Gastrointestinal disorders	Nausea	2024-03-07	2024-04-01
			Respiratory disorders	Cough	2024-02-05	2024-03-06

FIG: 5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Listings
Figures
Dataset Selection
Select Dataset:
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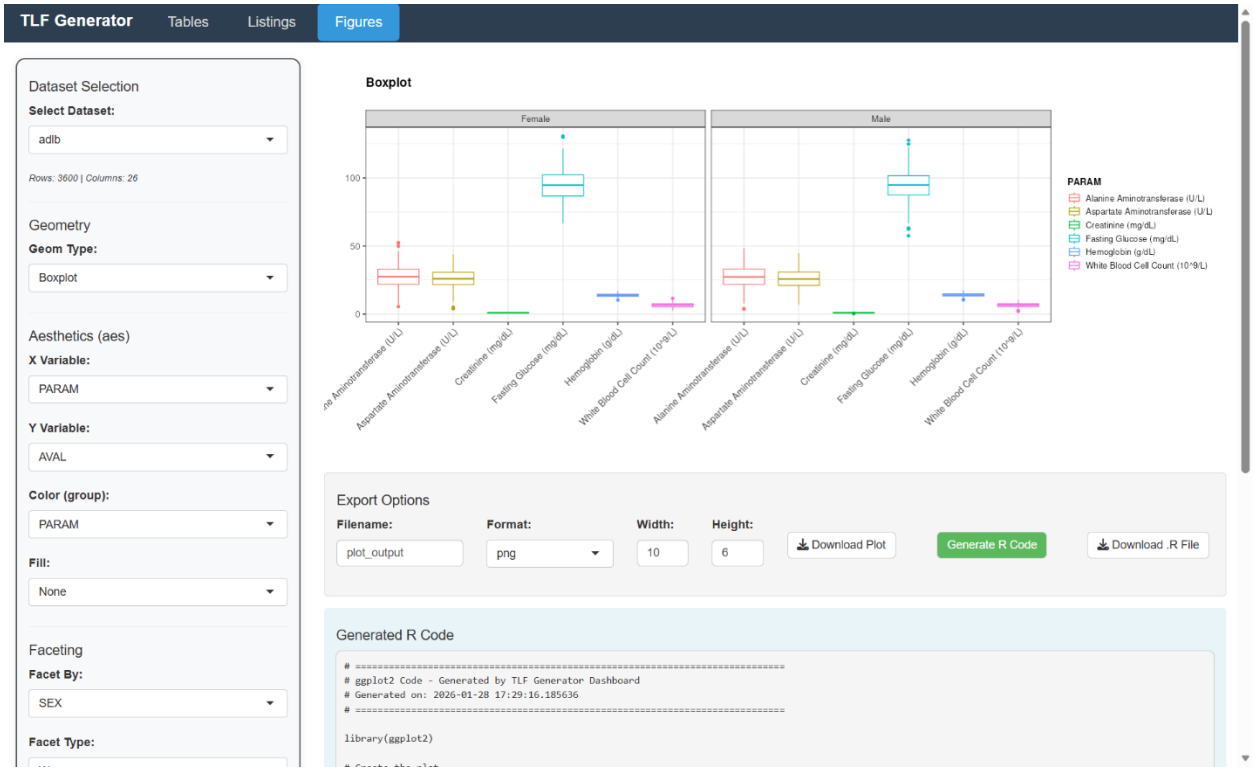
Rows: 251 | Columns: 23
Geometry
Geom Type:
Bar
Aesthetics (aes)
X Variable:
AETERM
Y Variable:
None
Color (group):
ARM
Fill:
ARM
Faceting
Facet By:
SEX
Facet Type:
Barplot
Female
Male
Frequency
Adverse Event Term
ARM
Drug High
Drug Low
Placebo
Export Options
Filename:
plot_output
Format:
png
Width:
10
Height:
6
Download Plot
Generate R Code
Download .R File

FIG: 6


TLF Generator
Tables
Listings
Figures
Dataset Selection
Select Dataset:
adlb
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Geometry
Geom Type:
Boxplot
Aesthetics (aes)
X Variable:
PARAM
Y Variable:
AVAL
Color (group):
PARAM
Fill:
None
Faceting
Facet By:
SEX
Facet Type:
Boxplot
Female
Male
PARAM
Alanine Aminotransferase (U/L)
Aspartate Aminotransferase (U/L)
Creatinine (mg/dL)
Fasting Glucose (mg/dL)
Hemoglobin (g/dL)
White Blood Cell Count (10^9/L)
Export Options
Filename:
plot_output
Format:
png
Width:
10
Height:
6
Download Plot
Generate R Code
Download .R File
Generated R Code
# ggplot2 Code - Generated by TLF Generator Dashboard
# Generated on: 2026-01-28 17:29:16.185636
library(ggplot2)

FIG: 7

Benefits & Improvements

The dashboard provides significant **Benefits** by streamlining the entire reporting lifecycle, primarily through the reduction of repetitive manual re-validation of clinical outputs. By automating the generation process, it ensures that deliverables are of high-precision and high-quality, maintaining the rigorous accuracy required for informed patient care decisions. The system's "Black Box Recorder" logic provides reliable reproducibility, as every generated output is accompanied by a standalone R script that allows for full auditability and peer review. Ultimately, these features drive substantial operational efficiency by allowing non-programmers to perform complex investigative tasks in real-time, drastically reducing the time and manual work traditionally spent on standard clinical trial reporting.

Looking toward Future **Improvements**, the roadmap for the dashboard focuses on expanding its technical depth and breadth within the pharmaceutical ecosystem. This includes the development of advanced statistical analysis capabilities to perform complex inferential tests directly within the user interface. Strategic plans also involve a significant catalog expansion toward a template-based system that offers a library of standard clinical output formats. To further empower clinical teams, we aim to integrate more granular data-mining features for enhanced real-time data exploration. Finally, the roadmap includes the creation of custom requirement modules tailored to the high-frequency tasks most used by study groups, ensuring the tool remains a specialized and indispensable asset in the clinical reporting phase.

CONCLUSION

The implementation of this innovative dashboard represents a fundamental shift in clinical trial reporting, moving from a slow, iterative manual coding process to an automated, click-based environment that provides stakeholders with instant access to critical insights. Ultimately, by streamlining the reporting phase, we accelerate the delivery of life-saving treatments, ensuring that our technical innovations translate directly into improved outcomes for patients worldwide.

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