Designing, building, and deploying an interactive survey monitoring dashboard using R Shiny

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Acknowledgements

- Examples for this presentation come from the National Longitudinal Study of Adolescent to Adult Health (Add Health)

- Add Health is funded by the Eunice Kennedy Shriver National Institute of Child Health and Human Development and conducted by the University of North Carolina Population Center in partnership with RTI International.

- Data presented here do not reflect actual Add Health estimates. The data were perturbed in many examples to protect the confidentiality of the study participants.

Summary

Presentation outline

- Motivation
- Static visualizations
- Interactive visualizations
- R and Shiny
- Structure (code, data, taxonomy)
- Deployment and hosting
- Benefits
- ATD Dashboard demo
- Next steps

Motivation

Challenges in complex survey management

- How best to define “success” metrics
- How best to track progress toward project-defined goals
  - response rate
  - budget
  - schedule
- How to simultaneously monitor multiple (case / interviewer / data) management systems
- How to interpret reams of tabular data which may obfuscate trends or patterns

Motivation

Adaptive Total Design (ATD)

- Process to identify and monitor **key features** of a survey design that are **critical to data quality**
- Similar to responsive design and adaptive design
- **Regular monitoring** of data
- Goal of ATD is to minimize **total survey error** and **costs**
- Allocates resources to maximally control errors and costs

Motivation

Continuous Quality Monitoring

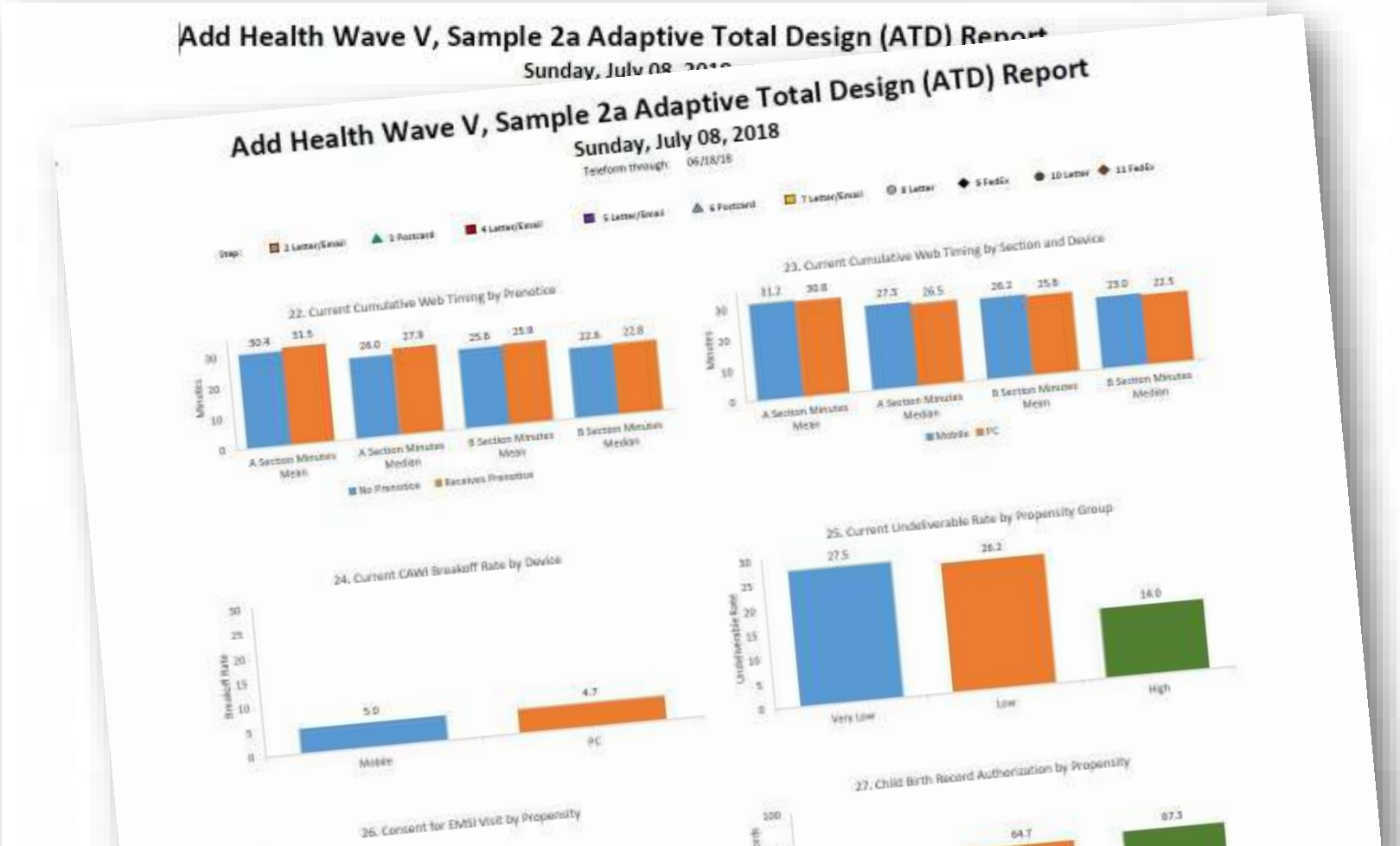
- Start with “what metrics are key to the success of our survey?”
- Determine what other factors might affect that success
- Generate a plan for regular (real-time / hourly / daily) monitoring of data

- All this is important if:
  - Your goal is to minimize total survey error and costs
  - You need to determine if / when interventions will be applied
  - You need to assess and project the outcomes of experiments during data collection

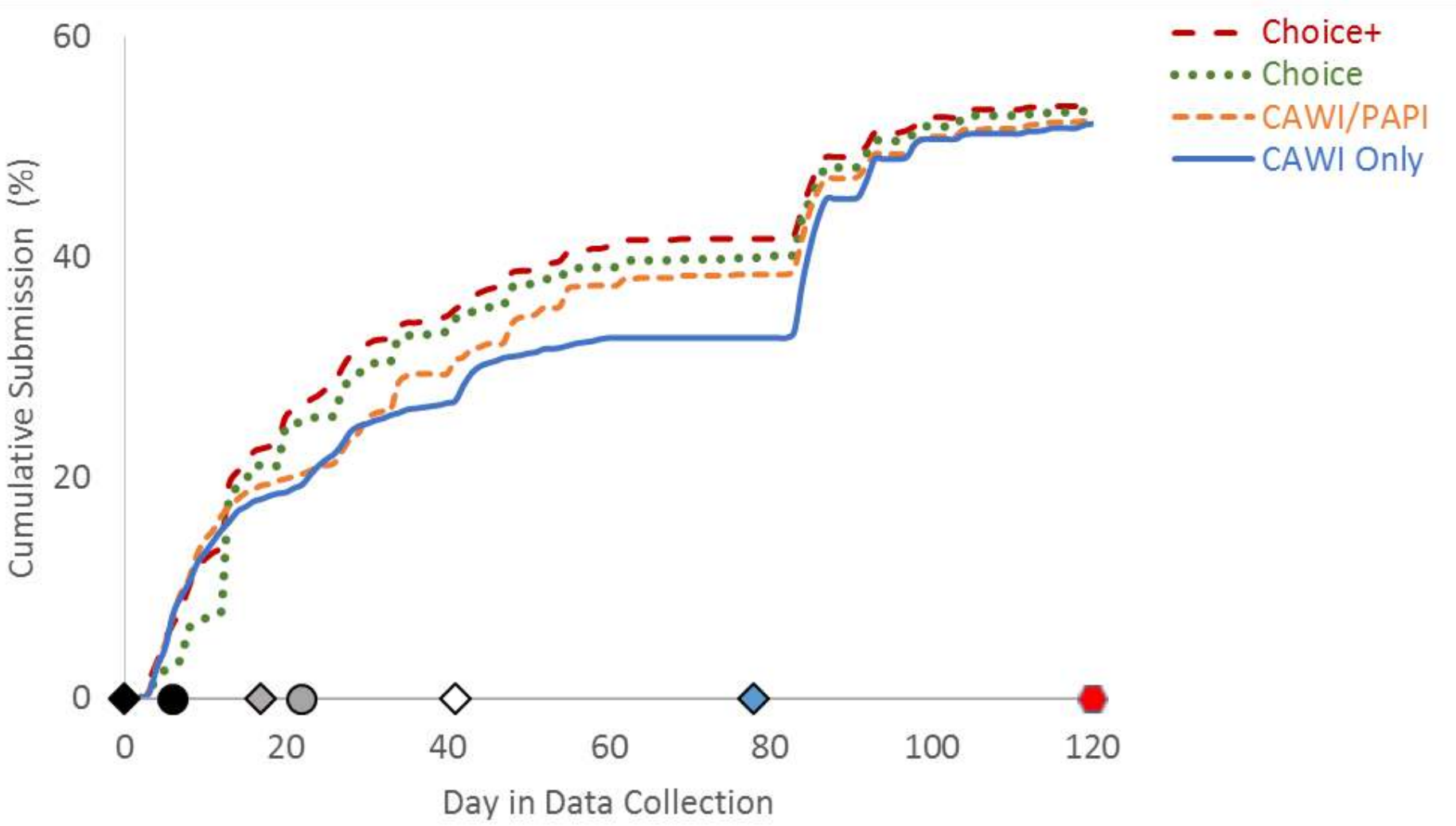
Motivation

Data visualization: critical tool

- Visualizations enable certain data to be compressed, rapidly interpreted, and easily distributed



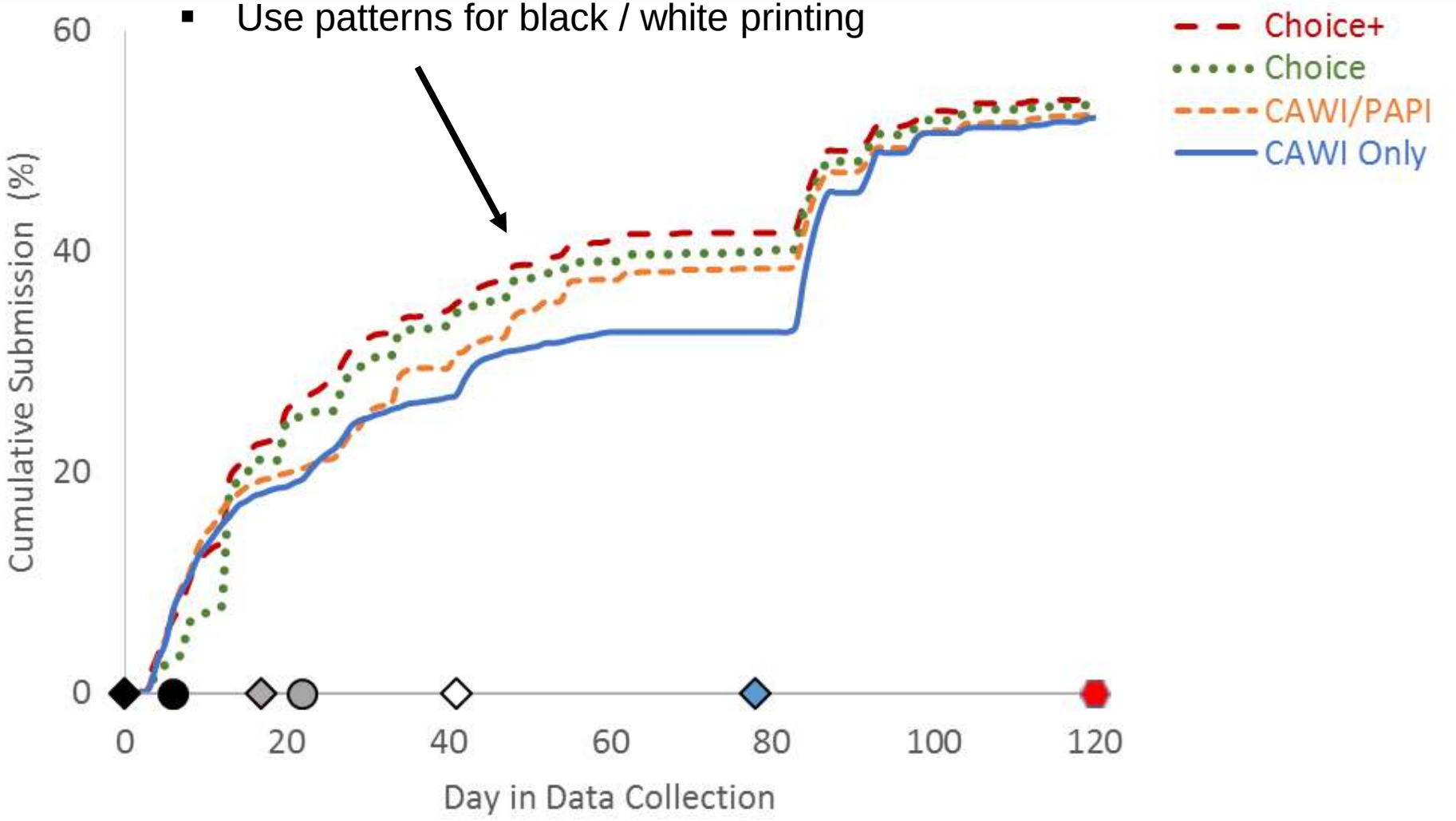
Static visualizations: response rates by mode protocol



SOURCE: Murphy, Biemer, and Berry, 2016

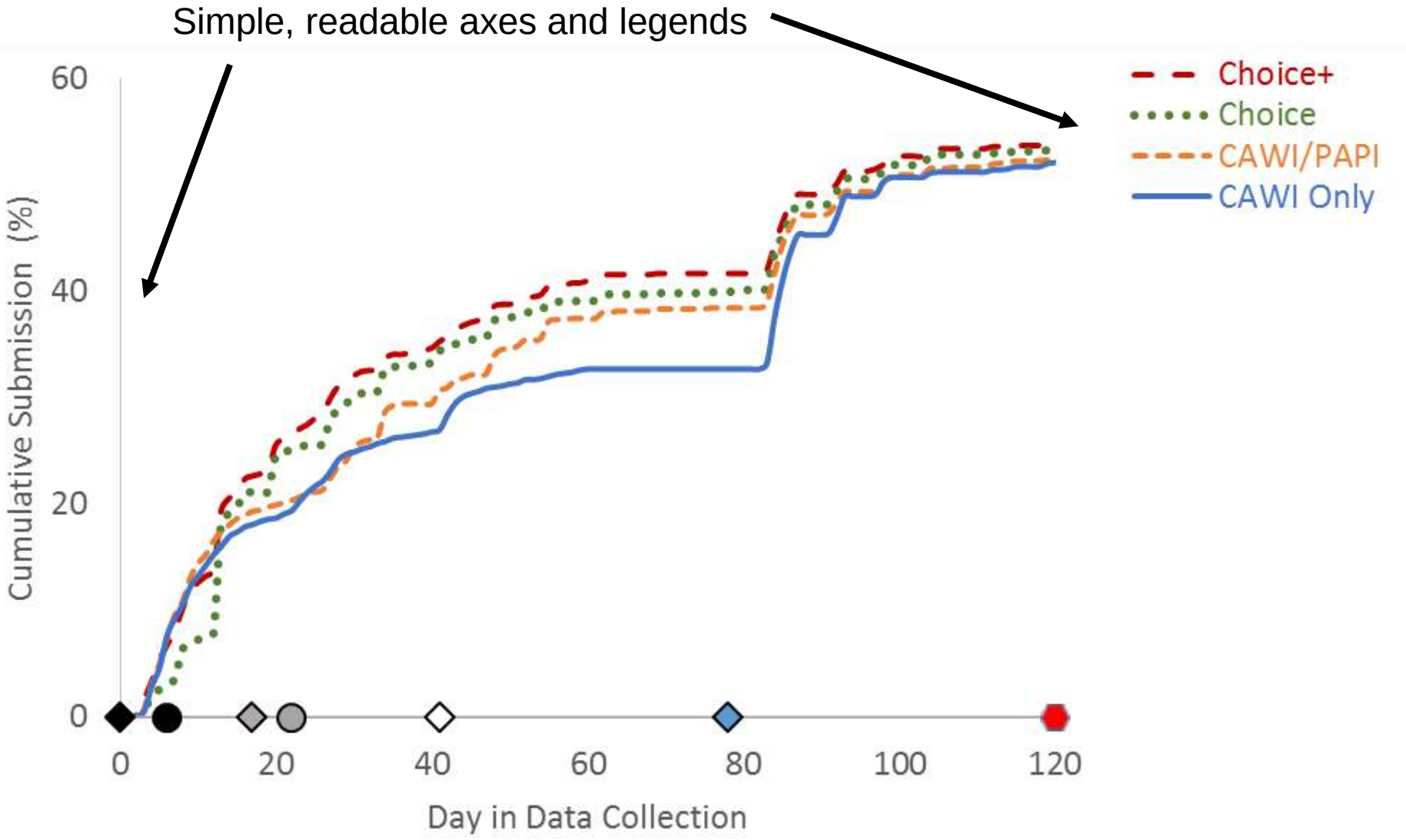
Static visualizations: response rates by mode protocol

- Limit number of lines
- Use patterns for black / white printing



SOURCE: Murphy, Biemer, and Berry, 2016

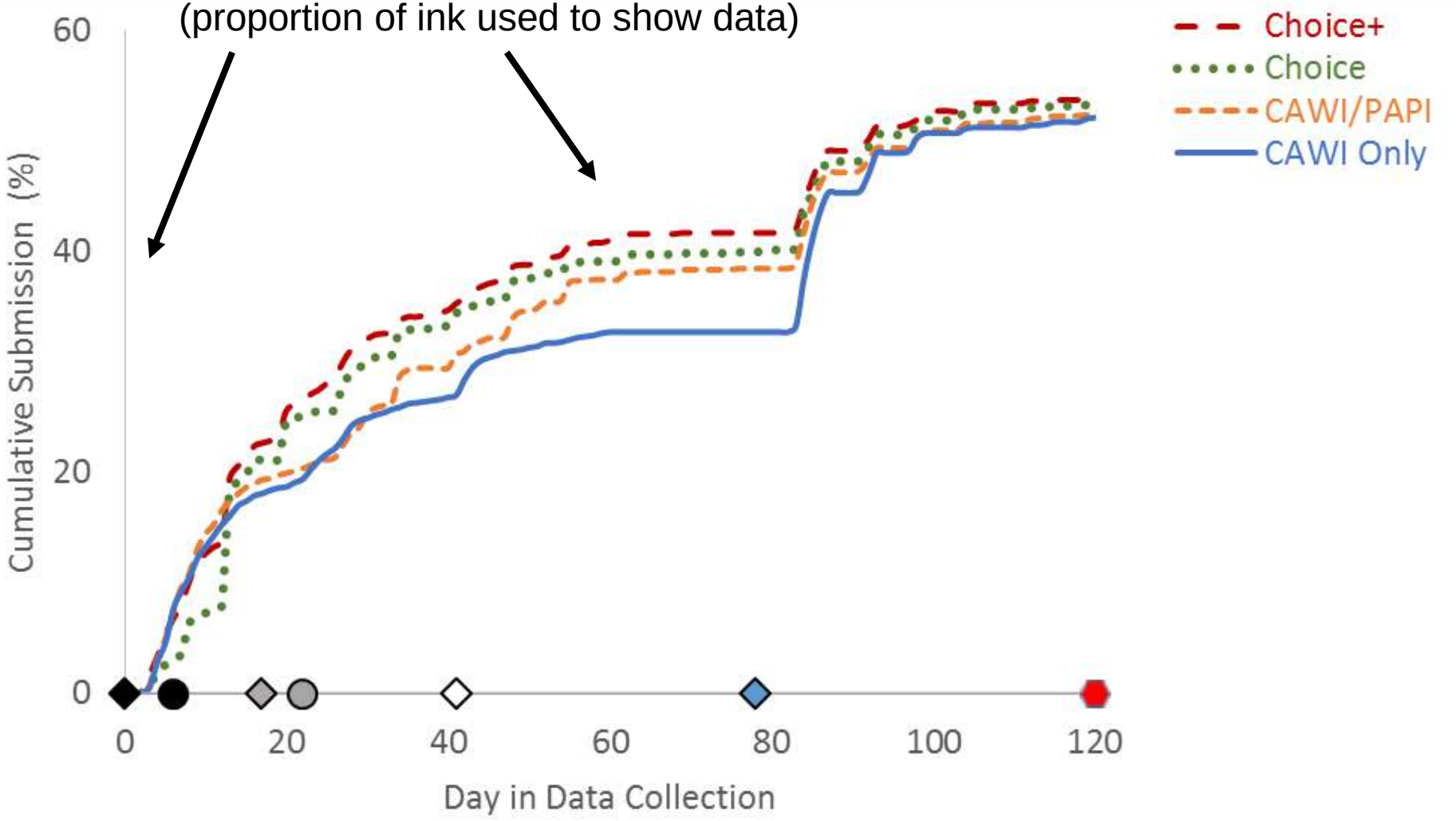
Static visualizations: response rates by mode protocol



SOURCE: Murphy, Biemer, and Berry, 2016

Static visualizations: response rates by mode protocol

Maximize the data-ink ratio
(proportion of ink used to show data)



SOURCE: Murphy, Biemer, and Berry, 2016

Interactive visualizations

Goals

- Allow users to create custom views
- Enable ability to subset data, modify display (pan, zoom, hover), and export views
- Flexibly incorporate disparate input data (e.g., survey level, respondent level, interviewer level)
- Provide web hosting for project and client teams
- Provide quick and easy setup for projects
- **Minimize user burden at every step**

Interactive visualizations

Solution

- Custom-built visualization platform programmed in **R** and **Shiny**: ATD Dashboard
- Shiny is an R package that provides a **high-level language for web application development;** avoids explicit HTML / CSS / JavaScript programming
- Can leverage robust set of packages from the R community; easily incorporate modeling
- Allows for hosting behind secure firewall with Shiny Server
- Open source and free platform (cf. Tableau)

Shiny application code architecture

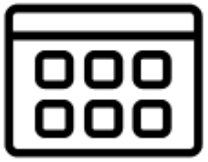
- Implemented in R; however, users do not need to interface with the underlying code
- Reactive components (observe and report)

Server

- Details **logic** and **analyses** (functions)
- Generates **warnings** (passed to UI)
- Produces **plots**

User Interface (UI)

- Interacts with server file
- Details, displays, and **dynamically updates UI**, depending on a user's selections
- Displays **warnings**



Data structure

- Input data in **flat-file format** (csv file)
- Long (stacked) data
- Metadata information included in "**blocked**" sections at file head
  - Block for **critical dates** (axis markers)
  - Block for **data taxonomy**

- Format consist of **five** columns
  - Study name: **`study`**
  - ID: **`id`**
  - Variable name: **`var`**
  - Value: **`val`**
  - Date/time-stamp: **`dt`**

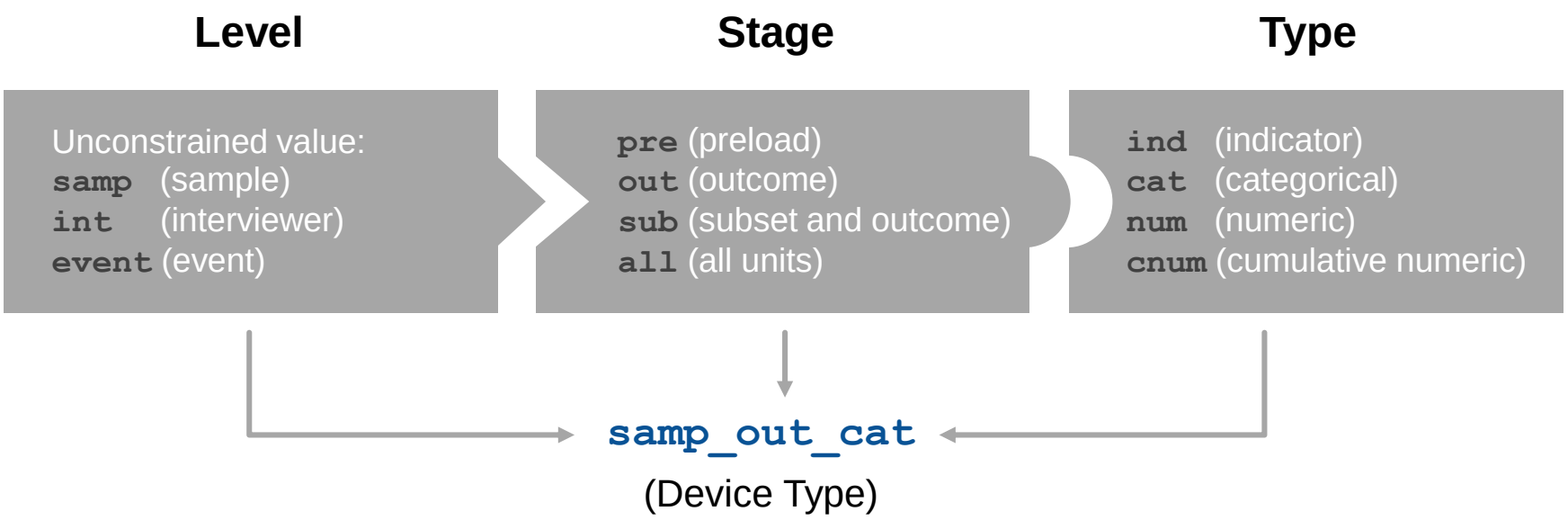
Example data

study	id	var	val	dt
...	...	...	...	...
Add Health Wave V Sample 2a	5237119	Device Type	PC	20-Mar-17
Add Health Wave V Sample 2a	5237674	Device Type	PC	17-Mar-17
Add Health Wave V Sample 2a	5237765	Device Type	Mobile	17-Mar-17
Add Health Wave V Sample 2a	5237981	Device Type	Mobile	27-Mar-17
Add Health Wave V Sample 2a	5238472	Device Type	Mobile	15-Mar-17
...	...	...	...	...

Data taxonomy

- Provides **compact attribute vocabulary**, easy to input into flat file
- Provides mechanism to limit UI selection options to **only logical combinations**
  and invoke **variable mathematical operations**
- **Mapped** to data in csv file

Type-class system



ATD Dashboard

Data

study	id	var	val	dt
...	...	...	...	...
Add Health Wave V Sample 2a	5237119	Device Type	PC	20-Mar-17
Add Health Wave V Sample 2a	5237674	Device Type	PC	17-Mar-17
Add Health Wave V Sample 2a	5237765	Device Type	Mobile	17-Mar-17
Add Health Wave V Sample 2a	5237981	Device Type	Mobile	27-Mar-17
Add Health Wave V Sample 2a	5238472	Device Type	Mobile	15-Mar-17
...	...	...	...	...

Map

study	id	var	val	dt
Add Health Wave V Sample 2a		C:Undeliverables	samp_out_ind	
Add Health Wave V Sample 2a		C:Completion Mode	samp_out_cat	
Add Health Wave V Sample 2a		C:Device Type	samp_out_cat	
Add Health Wave V Sample 2a		C:Self R. Health: Excellent	samp_out_cat	
Add Health Wave V Sample 2a		C:Self R. Health: Fair	samp_out_cat	
Add Health Wave V Sample 2a		C:Undeliverables	samp_out_ind	
...	...	...	...	...

ATD Dashboard

Data taxonomy

UI drop-down options reactively updated to allow logical combinations, conditioned on prior selections

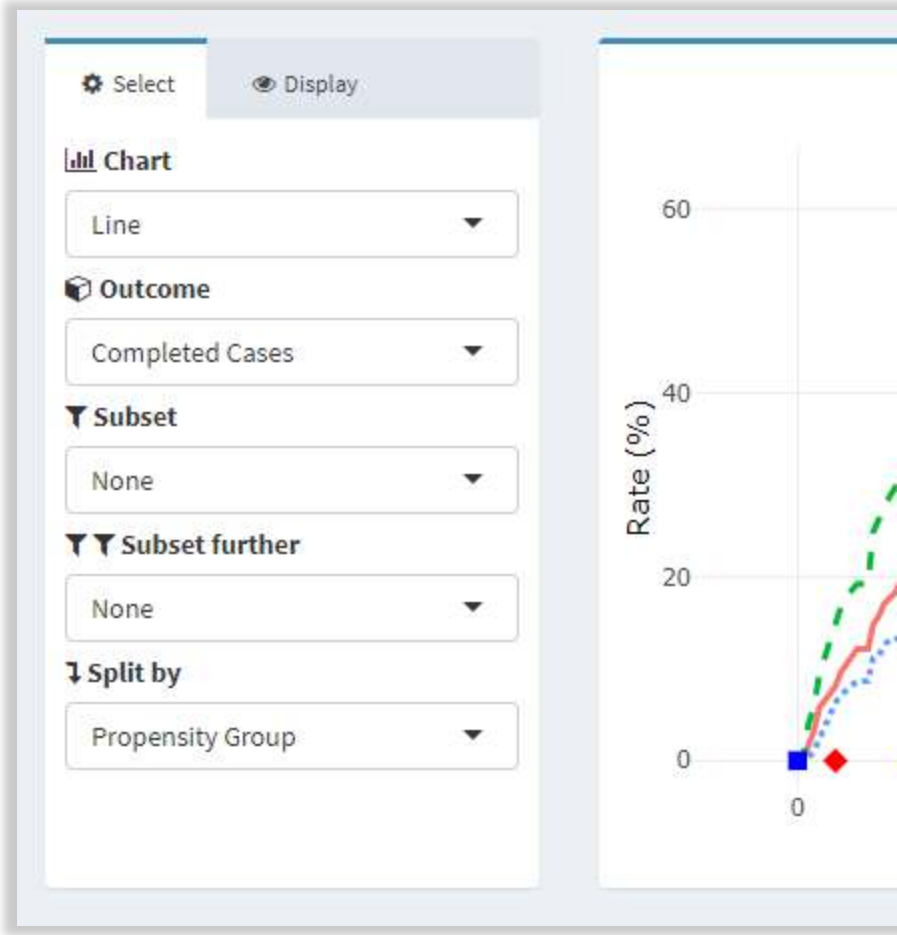
Choose **plot type**

Select primary **outcome of interest** `samp_out_cat`

Filter to **subset** (e.g., `samp_sub_ind`)

Filter to (second) **subset**

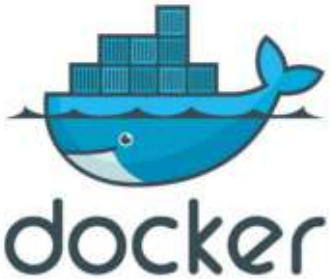
Separate outcome into categories `samp_out_cat`



Deployment and hosting

Shiny Server

- Apps deployed with RStudio Shiny Server, hosted on local or remote computers
- Can be deployed to the web or shared within a closed network behind a firewall with authentication for site access
- For reproducibility and to aid in future deployment to other servers, both R Shiny Server and an NGINX web server (used as a reverse proxy to redirect requests) were configured and deployed in Docker containers



ATD Dashboard Examples


ATD Dashboard : Add Health Wave V Sample 2a
Select
Display
Chart
Line
Outcome
Completed Cases
Subset
None
Subset further
None
Split by
Propensity Group
Daily Cumulative Rate of Completed Cases, by Propensity Group
C-High
Day: 70
Value: 45.7
Projected Completion Rate
Day: 70
Value: 32.5
B-Low
Day: 70
Value: 29.8
A-Very Low
Day: 70
Value: 20.8
(Projected Completion Rate)
A-Very Low
B-Low
C-High
Rate (%)
Day
Select
Display
Chart
Bar
Outcome
Completion Mode
Subset
Completed Cases
Subset further
None
Current Rate of Completion Mode among Completed Cases
Web
CATI
Mail
Rate (%)
Completion Mode
Current Rate of Completed Cases, by State
Rate
Select
Display
Chart
Map
Outcome
Completed Cases
Subset
None
Subset further
None

Select | Display

Chart

Line

Outcome

Completed Cases

Subset

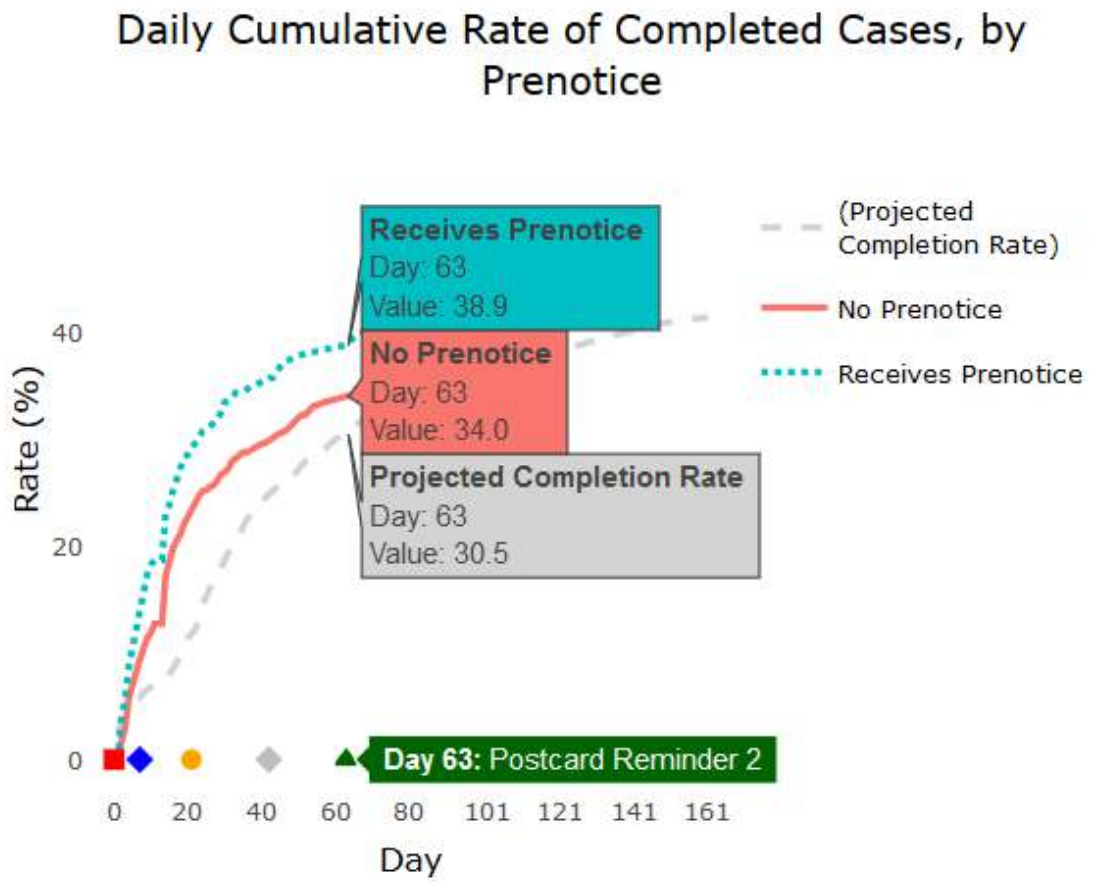
None

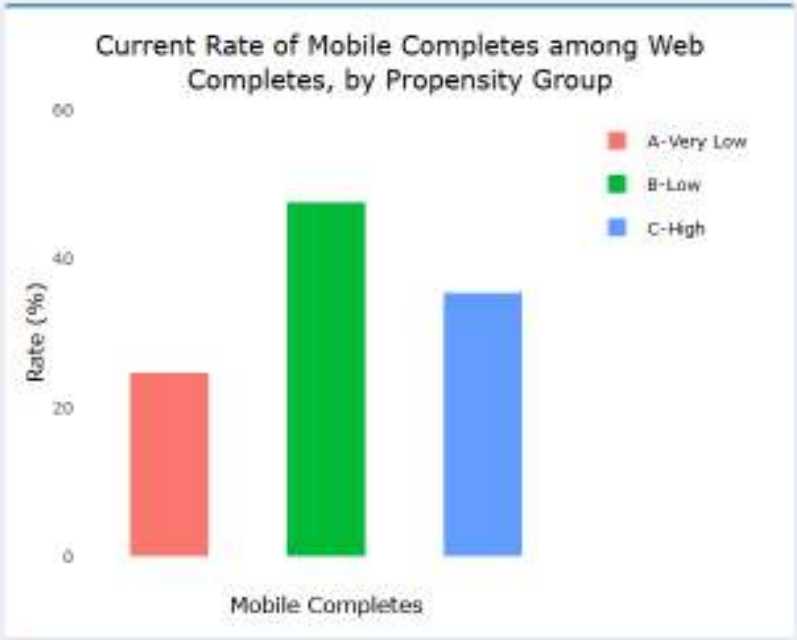
Subset further

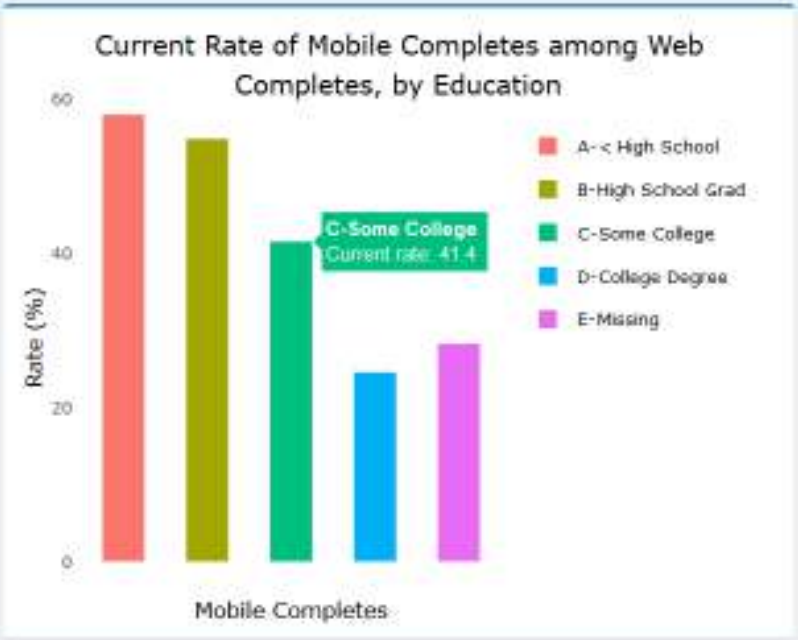
None

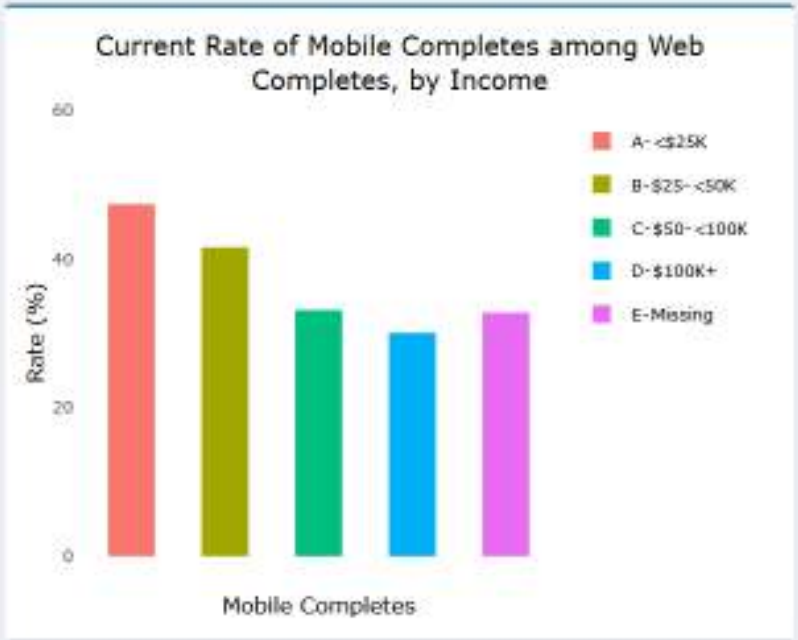
Split by

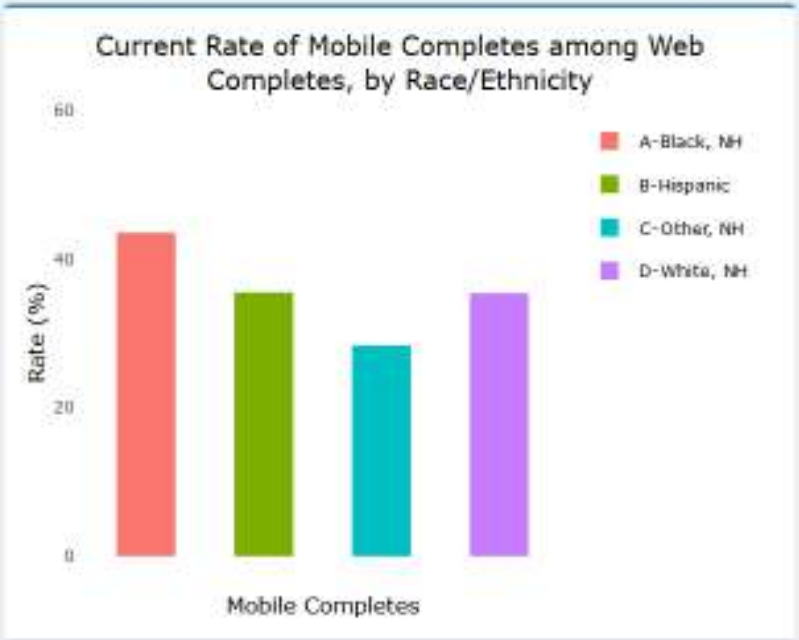
Prenotice

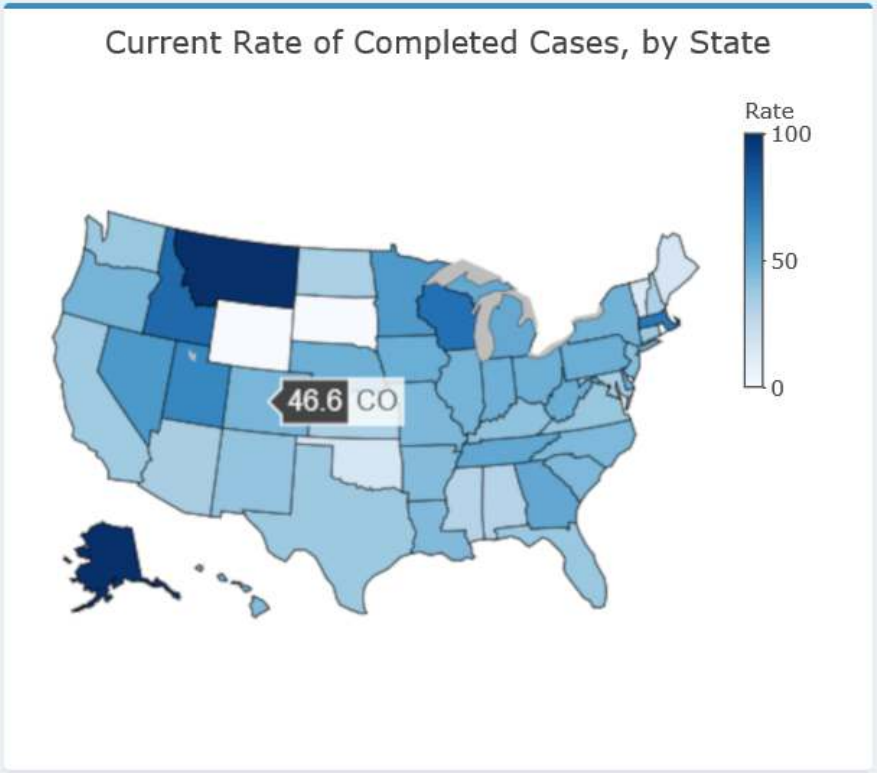


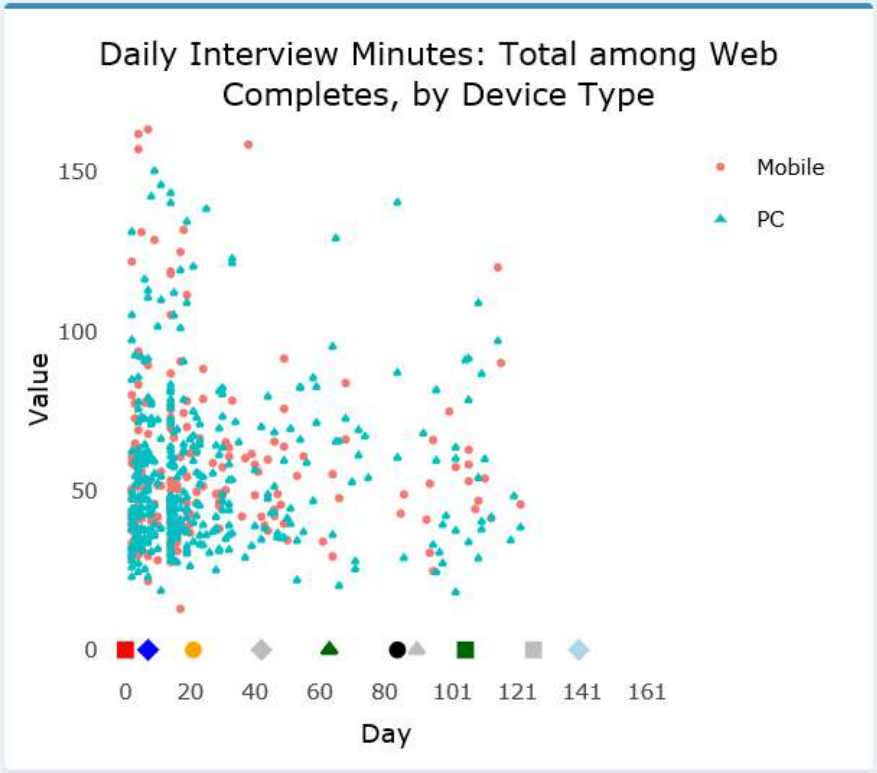

Current Rate of Mobile Completes among Web Completes, by Propensity Group
60
40
20
0
Rate (%)
A-Very Low
B-Low
C-High
Mobile Completes


Current Rate of Mobile Completes among Web Completes, by Education
60
40
20
0
Rate (%)
A-< High School
B-High School Grad
C-Some College
D-College Degree
E-Missing
C-Some College
Current rate: 41.4
Mobile Completes


Current Rate of Mobile Completes among Web Completes, by Income
60
40
20
0
Rate (%)
A-<$25K
B-$25-<50K
C-$50-<100K
D-$100K+
E-Missing
Mobile Completes


Current Rate of Mobile Completes among Web Completes, by Race/Ethnicity
60
40
20
0
Rate (%)
A-Black, NH
B-Hispanic
C-Other, NH
D-White, NH
Mobile Completes


Current Rate of Completed Cases, by State
Rate
100
50
0
46.6 CO


Daily Interview Minutes: Total among Web Completes, by Device Type
Mobile
PC
Value
150
100
50
0
0
20
40
60
80
101
121
141
161
Day

Conclusion

Reception

- **Internal** users: continual monitoring of data collection helpful for discussions related to production goals and strategies within the current sample (i.e. use of and timing of additional mailings)

- **External** users: format of “everything on a page” found to be useful to get up to speed with the current results at a glance and be prepared to discuss implications for the design of future samples with the internal team

Conclusion

Impact

- At the beginning of a study, it can be a challenge to define the key metrics for data collection
- More flexibility in monitoring and planning for future sample releases
- Many potential metrics and narrowing it down can be difficult
- Having the dashboard and needing to decide what to monitor spurred conversations about goals that might not otherwise have taken place

Conclusion

Summary of benefits

- Ability to monitor survey in near real time for decision making
- Only most important information (not reams of tables) displayed
- Leverages best practices in graphic design
- Non-programmer team members can gain insights from data; clients can interact with data directly
- No licenses required for individuals
- Codebase is reusable, easily transportable
- Codebase is easily extensible, thanks to R
- Dashboards can be shared across organization, avoiding costly licensing fees

Next steps

- Incorporate weighted data and statistical tests
- Pull-up data tables
- Allowing multiple layers of graphs

Thank you!

Contact

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