



Web-based Data Visualization in Biomedical Research

04Jun2015

Rho Center for Applied Data Visualization

Team of statisticians and programmers building tools specifically tailored to clinical trials research

Examples:

<http://graphics.rhoworld.com>

Source Code and Technical Documentation:

<https://github.com/RhoInc/>

Approach

Focus on interactive web-based charts with intuitive user interfaces

- Graphics are built using open-source technology.
- Gives us freedom to customize our charts
 - Simple charts for monitoring a single metric
 - Fully customized applications for data exploration.

Example 1 – Adverse Event Table

Static Table

	Negative Stratum (N=542)		Positive Stratum (N=98)		Overall (N=640)		P-value [1] SPT-Neg	P-value [2] SPT-Pos	P-value [3] Overall
	Avoidance Group (N=270)	Consumption Group (N=272)	Avoidance Group (N=51)	Consumption Group (N=47)	Avoidance Group (N=321)	Consumption Group (N=319)			
Number of Events	3552	3763	735	764	4287	4527			
Number of Participants with at Least One Event	268(99.3)	271(99.6)	51(100)	47(100)	319(99.4)	318(99.7)	0.556		0.566
Infections and infestations	267(98.9)	270(99.3)	51(100)	47(100)	318(99.1)	317(99.4)	0.647		0.659
Upper respiratory tract infection	161(59.6)	191(70.2)	26(51.0)	31(66.0)	187(58.3)	222(69.6)	0.016	0.133	0.003
Gastroenteritis	140(51.9)	175(64.3)	30(58.8)	28(59.6)	170(53.0)	203(63.6)	0.003	0.940	0.006
Rhinitis	146(54.1)	144(52.9)	38(74.5)	33(70.2)	184(57.3)	177(55.5)	0.791	0.634	0.640
Varicella	120(44.4)	145(53.3)	23(45.1)	17(36.2)	143(44.5)	162(50.8)	0.035	0.369	0.114
Lower respiratory tract infection	98(36.3)	83(30.5)	19(37.3)	20(42.6)	117(36.4)	103(32.3)	0.154	0.592	0.268
Ear infection	84(31.1)	89(32.7)	10(19.6)	11(23.4)	94(29.3)	100(31.3)	0.688	0.647	0.570
Nasopharyngitis	74(27.4)	86(31.6)	15(29.4)	15(31.9)	89(27.7)	101(31.7)	0.283	0.788	0.276
Viral infection	46(17.0)	56(20.6)	6(11.8)	10(21.3)	52(16.2)	66(20.7)	0.296	0.203	0.143
Tonsillitis	47(17.4)	54(19.9)	8(15.7)	8(17.0)	55(17.1)	62(19.4)	0.465	0.858	0.451
Eczema infected	41(15.2)	21(7.7)	5(9.8)	8(17.0)	46(14.3)	29(9.1)	0.006	0.293	0.039
Otitis media	34(12.6)	24(8.8)	5(9.8)	7(14.9)	39(12.1)	31(9.7)	0.156	0.443	0.324
Viral skin infection	21(7.8)	41(15.1)	2(3.9)	6(12.8)	23(7.2)	47(14.7)	0.006	0.110	0.002
Viral upper respiratory tract infection	30(11.1)	33(12.1)	4(7.8)	3(6.4)	34(10.6)	36(11.3)	0.711	0.779	0.779
Croup infectious	33(12.2)	20(7.4)	2(3.9)	5(10.6)	35(10.9)	25(7.8)	0.056	0.197	0.183
Respiratory tract infection	20(7.4)	22(8.1)	4(7.8)	7(14.9)	24(7.5)	29(9.1)	0.767	0.269	0.459
Molluscum contagiosum	22(8.1)	19(7.0)	2(3.9)	6(12.8)	24(7.5)	25(7.8)	0.605	0.110	0.864
Pharyngitis	22(8.1)	17(6.3)	3(5.9)	0(0)	25(7.8)	17(5.3)	0.393	0.091	0.209

Example 1 – Adverse Event Table

Interactive Graphic

Filter by Prevalence: %

Options ▾

Serious ▾

Category	Groups		AE Rate by group					Difference Between Groups										
	Control (n=211)	Intervention (n=208)	0	10	20	30	40	-8	-6	-4	-2	0	2	4	6	8	10	
▼ Infections and infestations	26.5%	31.7%				●	●											
Upper respiratory tract infection	9.5%	9.1%		●														
Respiratory tract infection	8.5%	6.7%		●														
▼ Respiratory, thoracic and mediastinal disorders	14.7%	11.1%		●		●												
Asthma	9.5%	6.3%		●		●												
Skin and subcutaneous tissue disorders	7.1%	10.1%		●		●												
General disorders and administration site conditions	7.1%	8.7%		●		●												
Injury, poisoning and procedural complications	7.6%	5.8%		●		●												
Investigations	7.1%	3.8%		●		●												
Gastrointestinal disorders	2.4%	5.8%		●		●												
▼ Nervous system disorders	5.7%	2.9%		●		●												
Headache	5.2%	1.4%		●		●												
All	55.0%	56.3%																

All identifying participant data has been removed and participant IDs have been randomized.

Live Demo:

<http://graphics.rhoworld.com/tools/aeexplorer/>

Technical Details

- Visualizations work in any modern web browser
 - Built using html, css and javascript - d3.js
 - No downloads needed
- Easy to Set-up
 - No special servers or configurations
 - Modular design - Easy to initiate multiple instances
- Compatible with many data types
- Can incorporate statistics using SAS and R

Instance Code for Adverse Event Listing

```
//Location to render the table (must be valid css)
var dataElement = ".graphic-wrapper";

//File path for the adverse event data set with 1 record per AE with
//placeholder rows for participants with no exacerbations
var dataPath = "../../studies/leap/aes/explorer/adae1_leap.csv"

//Specify column names in the raw data
var variables = {
  "id":"A_ID",
  "major":"AESOC",
  "minor":"AEPT",
  "group":"TRTC", "filters":["AEOUTC","AETRTC","AESEVC","AERELC","AESERC"],
  "details":[]
};

//Specify settings for groups, filters and display preferences
var settings = {
  "groups": [
    {"key":"Peanut Avoidance","n":321,"selected":true},
    {"key":"Peanut Consumption","n":319,"selected":true}
  ],
  "defaults":{
    "maxPrevalence":"0.0",
    "prefTerms":"Hide",
    "diffCol":"Show||
  },
  "filterSettings":[
    {"key":"AEOUTC","label":"Outcome"},
    {"key":"AETRTC","label":"Treatment Required"},
    {"key":"AESEVC","label":"Severity"},
    {"key":"AERELC","label":"Related?"},
    {"key":"AESERC","label":"Serious?"}
  ]
};

//Initialize the AE table
table.init(dataElement, dataPath, variables, settings);
```

Analysis Work Flow

Exploratory Analysis Pipeline

Raw Data

JS

Interactive Graphic

R

Analysis Results

Triggered by user input

Pre-specified Analysis Pipeline

Raw Data

SAS*

Analysis Results

JS

Interactive Graphic

Live updates with user input

* Could be SAS or R or any Statistical Programming language.

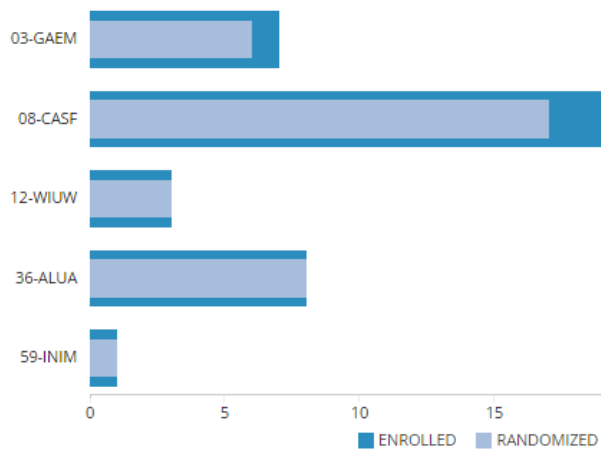
Additional Examples

Visualizations used throughout the lifecycle of a study

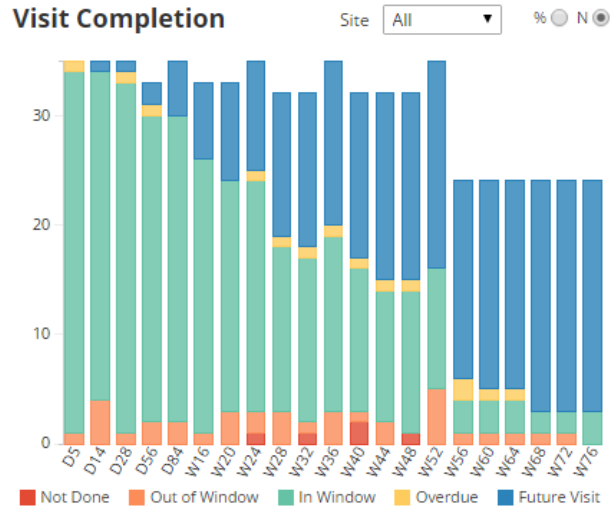
- Study Dashboards
- Monitoring tools
- Results presentations

Example 2 - Study Operations Dashboard

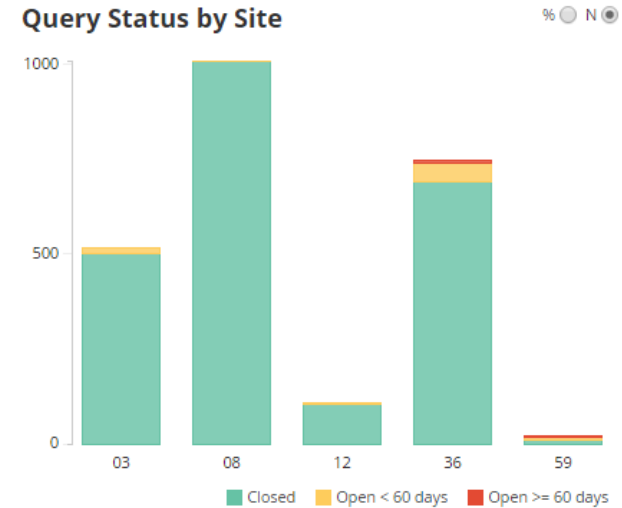
Overall Enrollment



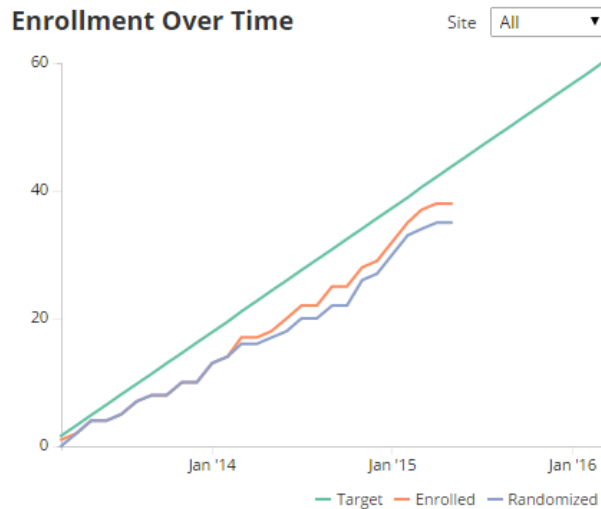
Visit Completion



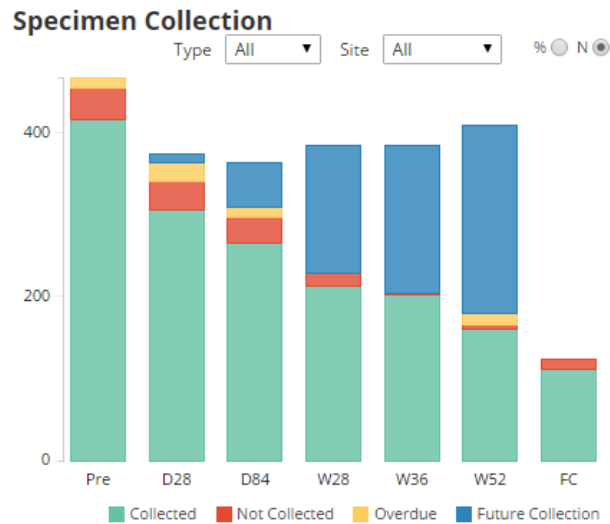
Query Status by Site



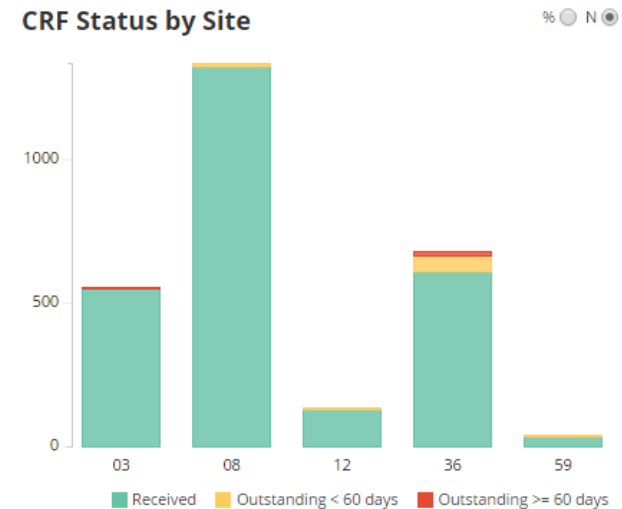
Enrollment Over Time



Specimen Collection

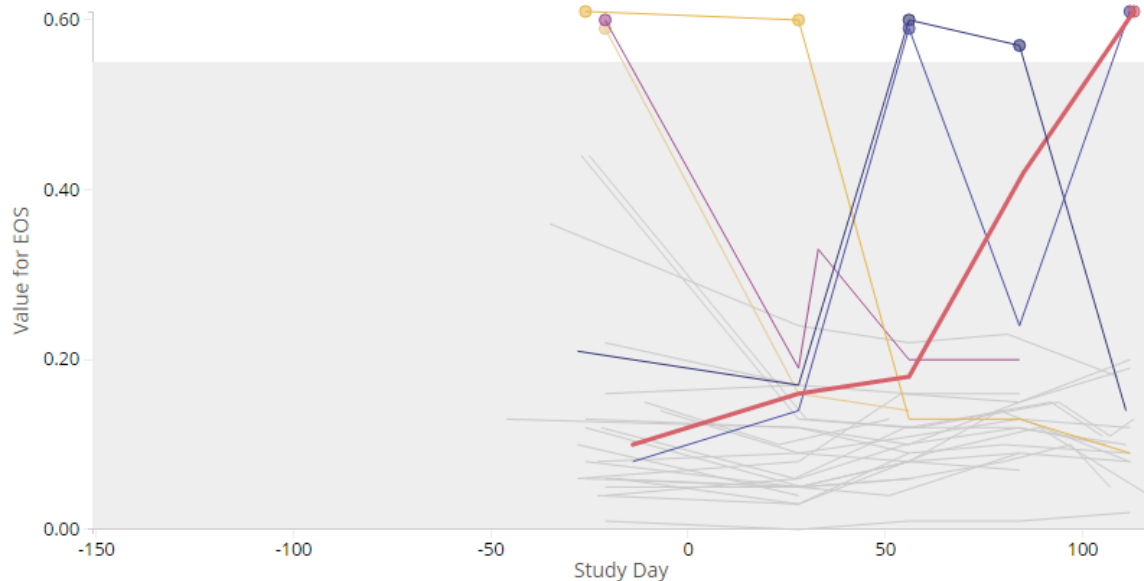


CRF Status by Site



Example 3 – Lab Data Monitoring

Measure: EOS Site: All From: 0 To: 0.55

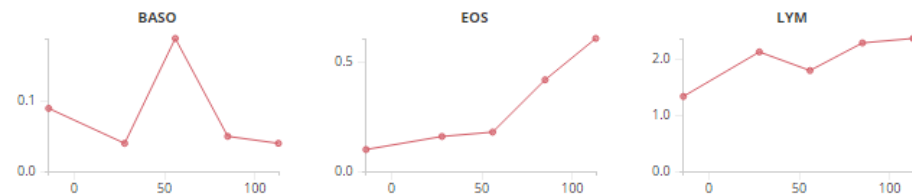


Subject ID	Screening 2	Week 4	Week 8	Week 12	Week 16
60012	0.21	0.17	0.60	0.57	0.14
60023	0.08	0.14	0.59	0.24	0.61
80247	0.61	0.60	0.13	0.13	0.09
80294	0.59	0.16	0.14		
120024	0.10	0.16	0.18	0.42	0.61
120101	0.60	0.19	0.20	0.20	

9 measures for 6 participants found outside the specified normal range.

Click a line to see participant details.

All Measures for 120024



Live Demo:

<http://graphics.rhoworld.com/tools/labnormals/>

Example 4 - Results Presentations

Manuscript Display

The NEW ENGLAND JOURNAL of MEDICINE

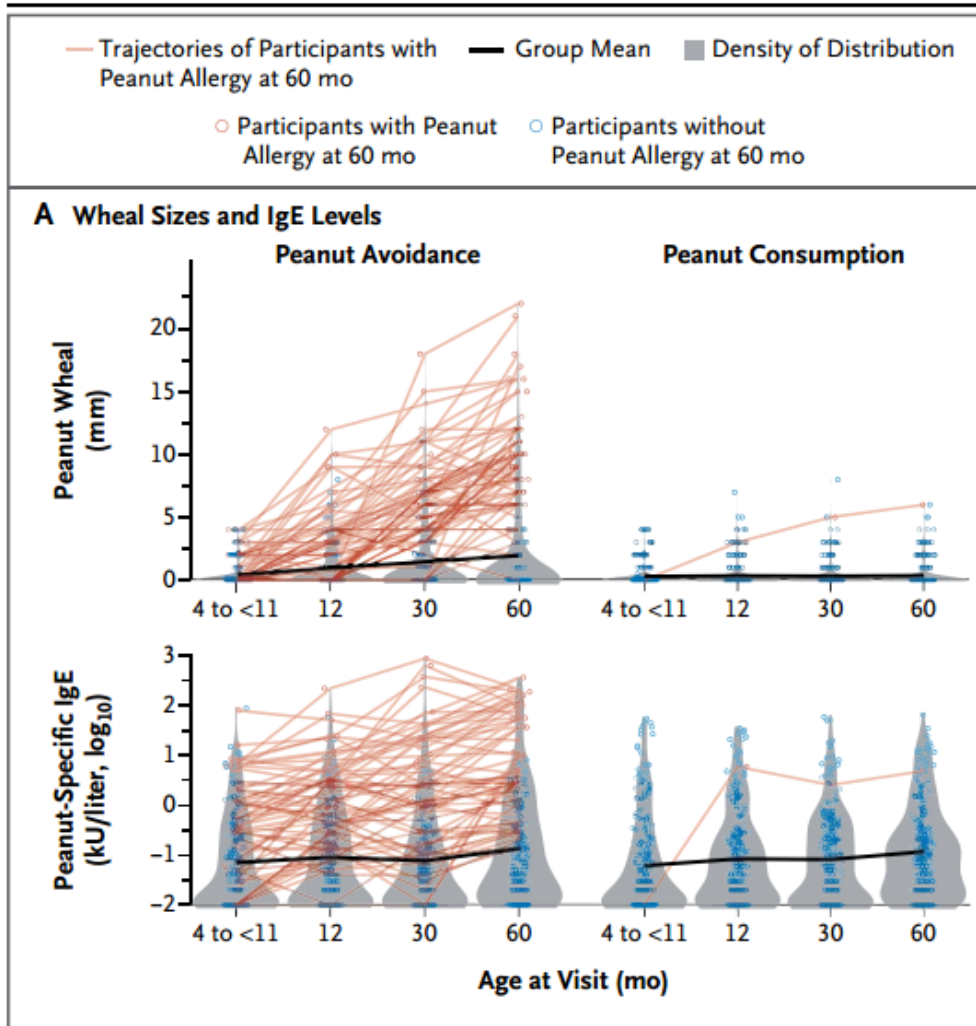


Figure 3. Immunologic Outcomes for the Peanut-Avoidance and Peanut-Consumption Groups at Baseline (4 to <11 Months of Age) and at 12, 30, and 60 Months of Age.

Panel A shows wheal sizes after the peanut-specific skin-prick test and the levels of peanut-specific IgE in participants in the avoidance and consumption groups who met the per-protocol criteria. The solid black lines show the group mean over the course of the study period; the mean wheal size after the peanut-specific skin-prick test differed significantly between the randomized groups at all time points after baseline ($P=0.002$ at 12 months and $P<0.001$ at 30 months and 60 months). The thin red lines represent the trajectory of the development of allergic responses among participants who were allergic at 60 months of age. Panel B shows the levels of peanut-specific IgG and IgG4 and the peanut-specific IgG4:IgE ratio over the course of the study period. The means of each of these measures differed significantly between the two study groups at all postbaseline time points ($P<0.001$). The \log_{10} of the ratio of peanut-specific IgG4:IgE was calculated after peanut-specific IgG4 levels were converted from milligrams per liter to nanograms per milliliter and the peanut-specific IgE levels were converted from kilo unit per liter to nanograms per milliliter with the use of the formula $(\text{IgG4} \times 1000) \div (\text{IgE} \times 2.4)$.

Manuscript:

<http://www.nejm.org/doi/full/10.1056/NEJMoa1414850>

Example 4 - Results Presentations

Online Supplement

Settings

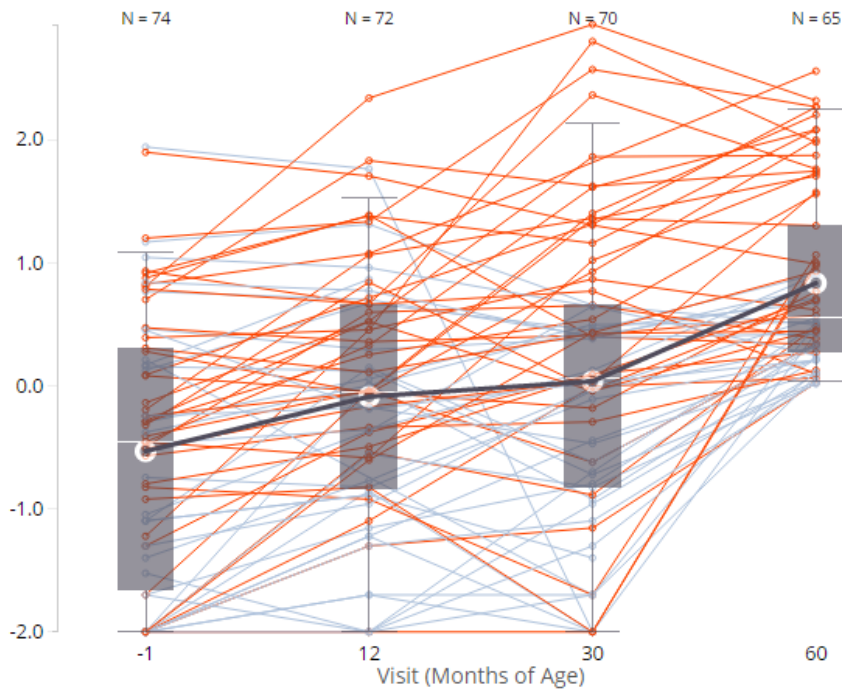
Y Values: Peanut Specific IgE (log10) | Sex: All | Ethnicity: All | SPT Stratum: All | Study Population: Per Protocol | Peanut Specific IgE at 60 Months: ≥ 1 kU/liter

Overlays

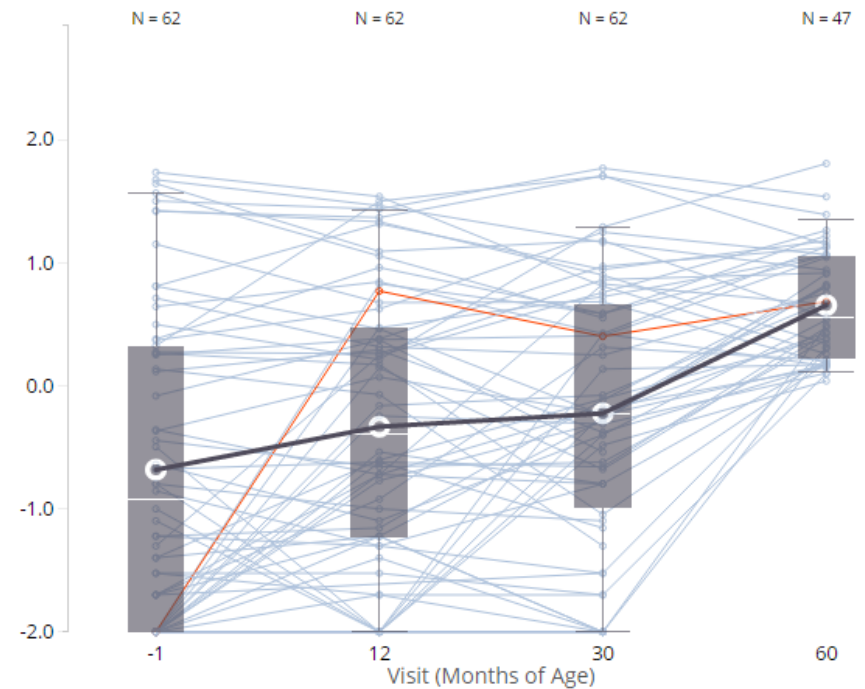
Trajectories for Participants without Peanut Allergy at 60 mo | Trajectories for Participants with Peanut Allergy at 60 mo | Summary Lines | Points | Violin Plots | Box Plots

— Participants without Peanut Allergy at 60 mo | — Participants with Peanut Allergy at 60 mo

Peanut Avoidance



Peanut Consumption

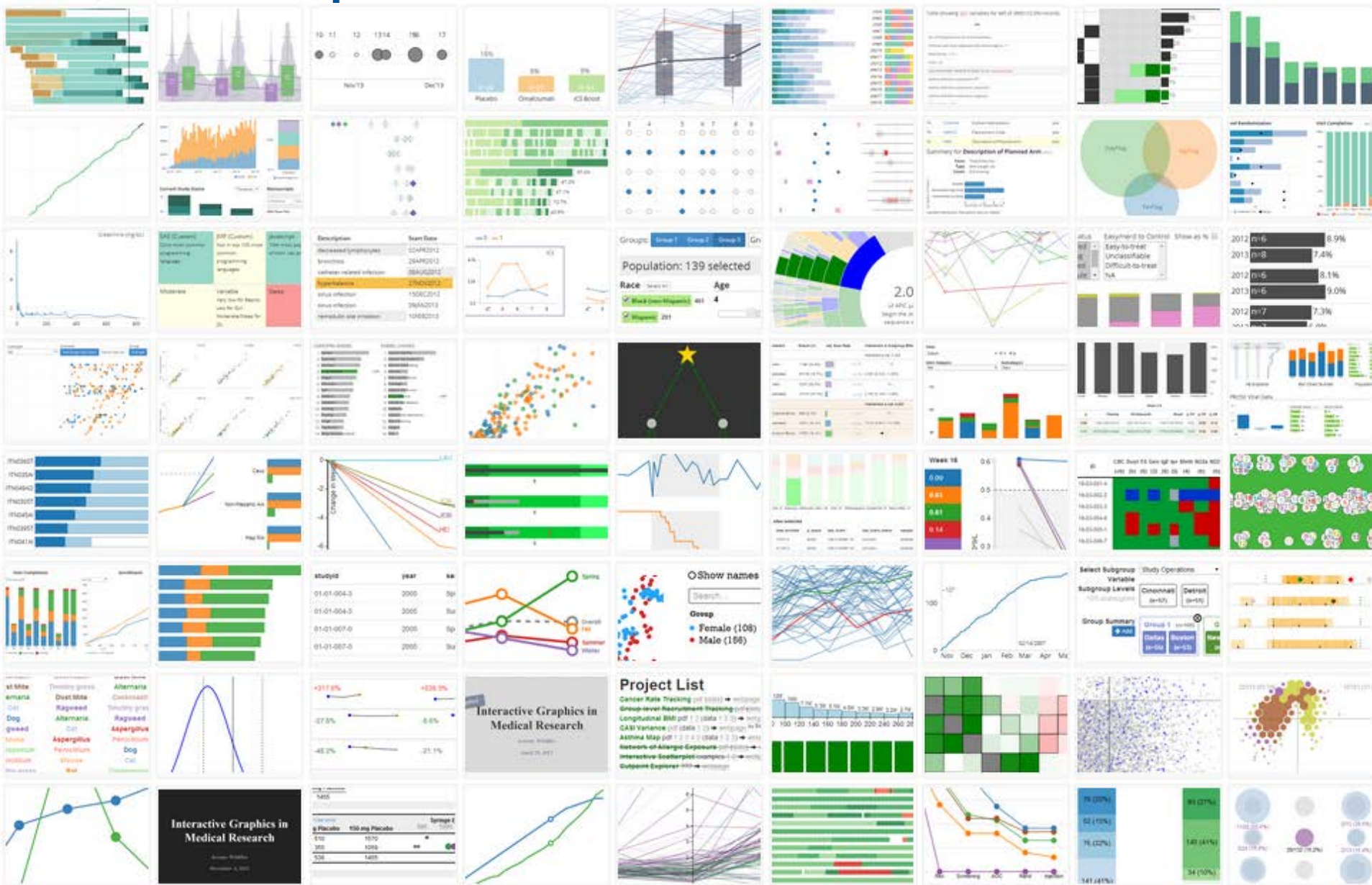


Adapted from Figure 3 in Randomized Trial of Peanut Consumption in Infants at Risk for Peanut Allergy

Live Demo:

<http://graphics.rhoworld.com/studies/leap/figure3/>

Other Examples



Thousands more at:
<http://www.d3js.org>

Limitations

- File Size
- Data/Code Sharing
- Validation

Rho Center for Applied Data Visualization

Team Members

- Ryan Bailey – Business Analyst/Project Coordinator
- Nathan Bryant – Software Engineer
- Shane Rosanbalm – Biostatistician/SAS Expert
- Agustin Calatroni – Biostatistician/R Expert
- Rich Budrevich/Martin Norland – Systems Engineer

Questions?

Contact:

graphics@rhoworld.com

Slide set and other examples:

<http://graphics.rhoworld.com>

Source Code and Technical Documentation:

<https://github.com/RhoInc/>



Reserve Slides

Example 5 – Data Exploration

Real-time R Integration

Use the controls to the left to compare participant characteristics by asthma/atopic status at a given timepoint in URECA. Click "Create Table" to update.

Create Table

Set Options

Row Variable Domain(s)
Asthma Definition ▼

Column Variable
asthma_age7 ▼

Filters

Study Visit
0 ▲
12
24
36
48
60
72
81 ▼

Atopic Status
Atopic ▲
Non-atopic ▼

Site
Baltimore ▲
Boston
New York
St. Louis ▼

Diagnosis
0 ▲
1 ▼

Table showing **Asthma Definition** variables by **asthma_b** for 485 of 3880 (12.5%) records.

Var	0 N=409	1 N=76	p.overall
Use of controller meds for 6 of last 12 mo.	0.00 (0.00)	0.17 (0.38)	<0.001
Asthma definition component: PFT	0.08 (0.27)	0.55 (0.50)	<0.001
Asthma definition component: symptoms	0.00 (0.00)	1.00 (0.00)	.
Asthma definition component: diagnosis	0.12 (0.32)	0.92 (0.27)	<0.001
Asthma at age 7	0.15 (0.36)	1.00 (0.00)	<0.001
Asthma definition: 3 group			<0.001
Asthmatic	14.9%	100%	
Asymptomatic asthmatic	47.4%	0.00%	
Non-asthmatic	37.7%	0.00%	