TG3: Setting the stage with beginning data analyses

Marianne Huebner, Saskia Le Cessie, Werner Vach, Maria Blettner, Danielle Bodicoat

“The initial examination of data is a valuable state of most statistical investigations, not only for scrutinizing and summarizing data, but also for model formulations.”

--Chatfield. JRSSA 1985

“In practice one has only to look at the literature to see that the methods are still generally undervalued, often neglected, and sometimes actively regarded with disfavor.”

--Chatfield. JRSSA 1985

It's a topic of interest:

Workflow for statistical analysis and report writing

viewed **17020** times

How to efficiently manage a statistical analysis project?

viewed **7159** times

How do you combine "Revision Control" with "Workflow" for R?

viewed **3074** times

StackExchange, StackOverflow, CrossValidated, Blogs

It takes time

80% of data analysis is spent on the process of cleaning and preparing the data.

Dasu and Johnson 2003

It's time well spent

Even with best intentions during data collection: data integrity checks find error rates 2-5% in the "best" datasets

Feedback from practicing statisticians

from various institutions

Spreadsheets can be problematic

ID	Sex	Date of Surgery	Height (cm)	Weight (kg)	Diagnosis
1	male	1/1/2011	163	68	1
2	M	15/1/99	167	80	2,1
3	F	2/1/09	166	unknown	2
4	M	2/15/11	172cm	82	2
4		8/19/12		85	2
5	MALE	March 1, 2013	180	67	2
6	m	3/15/2008	164	62	2 (dx 5/2/11)
7	m	4-1-2013	165 ???	66	1
8	female	April, 2005	166	n.a.	1
9	F	2007-01-25	62	65kg	diabetes
			Average=166		

Spreadsheet – corrected

id	sex	datesurgery	height	weight	diagnosis1	diagnosis2
1	male	2011-01-01	163	68	1	
2	male	1999-01-15	167	80	2	1
3	female	2009-01-02	166	NA	2	
4	male	2011-02-15	172	82	2	
4	male	2012-08-19	172	85	2	
5	male	2013-03-01	180	67	2	
6	male	2008-03-15	164	62	2	
7	male	2013-04-01	165	66	1	
8	female	2005-04-15	166	NA	1	
9	female	2007-01-25	162	65	3	

Structuring datasets

1. Each variable forms a column.
2. Each observation forms a row.

Things go wrong when:

- column headers are values, not variable names
- multiple variables are stored in one column
- variables are stored in both rows and columns
- a subject is stored in multiple tables

H. Wickham, Tidy Data 2014

*"**Despite the amount of time it takes, there has been surprisingly little research on how to clean data well**. Part of the challenge is the breadth of activities it encompasses: from outlier checking, to date parsing, to missing value imputation."*

H. Wickham, Tidy Data 2014

Data quality

- Do the date sequences make sense (birth before surgery)?
- Are data consistent between variables? (date of surgery and date of discharge vs length of stay)
- What is the proportion of missing values for each variable (e.g. Echocardiogram, 30% missing at one month follow-up, 70% missing at one year follow-up)
- What is meant by time frames of follow-up, e.g “one month”, “one year”?

RedCap data checks

- Field validation (incorrect data type)
- Field validation (out of range)
- Outliers for numerical fields

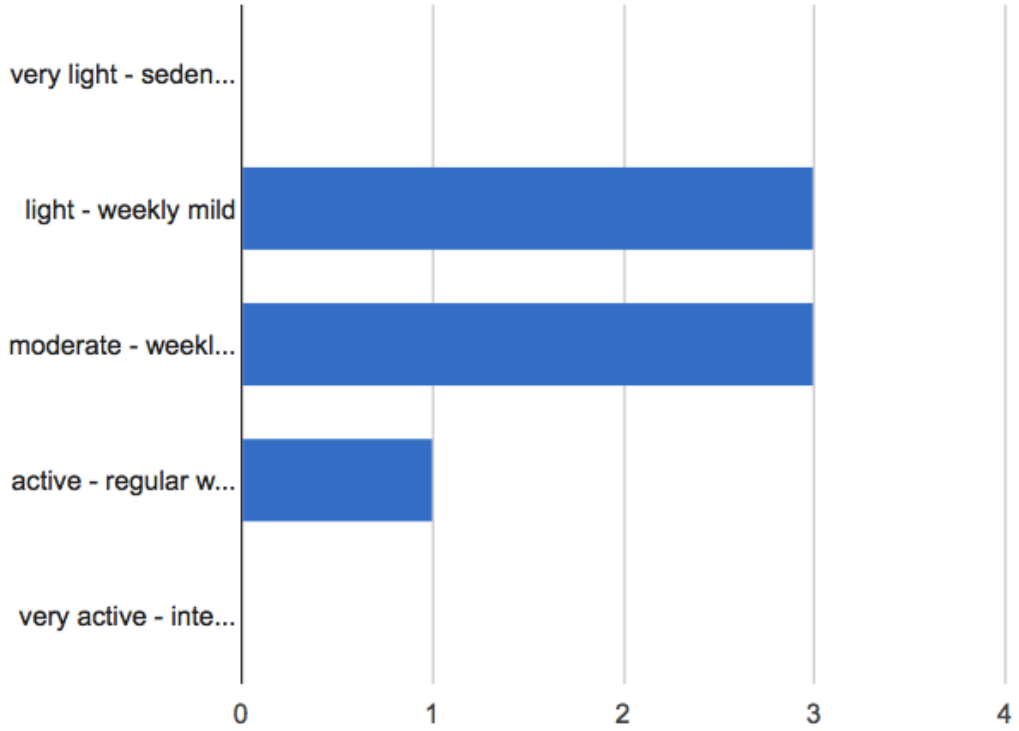
The REDCap Consortium is composed of 1,106 active institutional partners from CTSA, GCRC, RCMI and other institutions in 83 countries.

REDCap data summaries

What is your activity level?: Refresh Plot | View as Bar Chart

Total (N)	Missing	Unique
7	0 (0%)	3

Counts/frequency: very light - sedentary (0, 0%), light - weekly mild (3, 42.9%), moderate - weekly intense (3, 42.9%), active - regular workouts (1, 14.3%), very active - intense sports (0, 0%)



Reproducible research

Reinhart, Rogoff: Growth in a time of debt. 2010

Herndon, Ash, Pollin: A critique of Reinhart and Rogoff. 2013

- Selected exclusion of years/countries
- Unconventional weighting
- Coding error (averaging of wrong cells)
- Averaging a variable with missing data.

Image: http://thecolbertreport.cc.com/videos/dcyvro/austerity-s-spreadsheet-error

R markdown: data, code, report

Inference for means (t-interval or t-test)

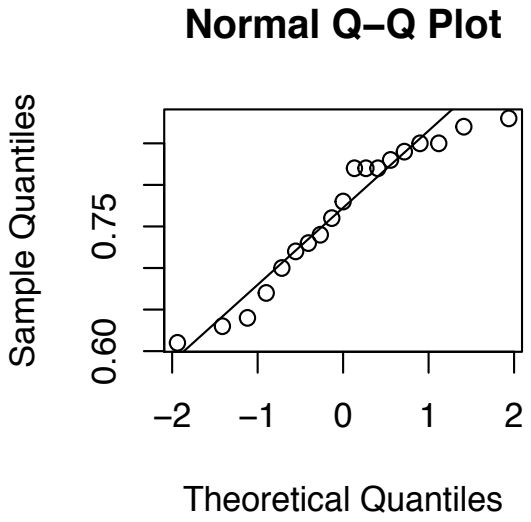
The airflow rate, FEV1, is the ratio of a person's forced expiratory volume to the vital capacity, VC (max. volume of air a person can exhale after taking a deep breath). If the enzyme has an effect, it will be to reduce the FEV1/VC ratio. The norm is 0.80 in persons with no lung dysfunction.

```
ratio <- c(0.61, 0.7, 0.63, 0.76, 0.67, 0.72, 0.64, 0.82, 0.88, 0.82, 0.78,
    0.84, 0.83, 0.82, 0.74, 0.85, 0.73, 0.85, 0.87)
```

Summary statistics

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.610   0.710   0.780   0.766   0.835   0.880
```

Are the data symmetric or approximately normal?



Report content

- Statistical report is more extensive than what will be in the manuscript
- Read in raw data
- Steps of processing data
- Numerical data summaries
- Graphical explorations, e.g density plots, boxplots, plots over time, plots of association of variables, overlaid density plots from different categories

-> Feedback from you?

Reproducible research

- **Data:** raw, processed
- **Figures**: exploratory, final
- **Code**: raw script, final script
- **Text**: readme files, documents, markdown/ knitr/sweave file

- Making data and code available: **Markdown, Knitr, Sweave, Github**

Baseline characteristics

- Data summaries for each variable and/or group
  - Location measures
  - Small or large variation
  - Conceptually or statistically motivated groupings
  - Zero inflated
  - Missingness
- Explore missing data
  - Table with number of missing for each variable
  - Comparing missing and non-missing cases
  - Always assume missingness hides a meaningful value for analysis (R. Little, T Raghunathan)

Exploring distribution of variables

- What do we expect the distribution to look like?
- Do these expectations hold?
- Check variation and outliers
- Do a few observations have a large influence?
- What is to be considered in later analyses?

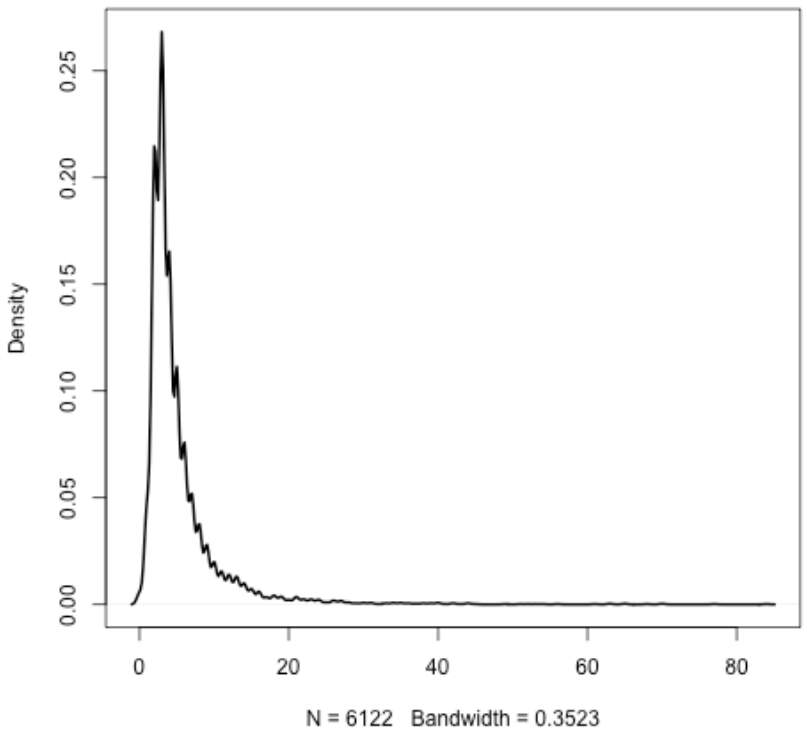
Length of Hospital Stay [days]

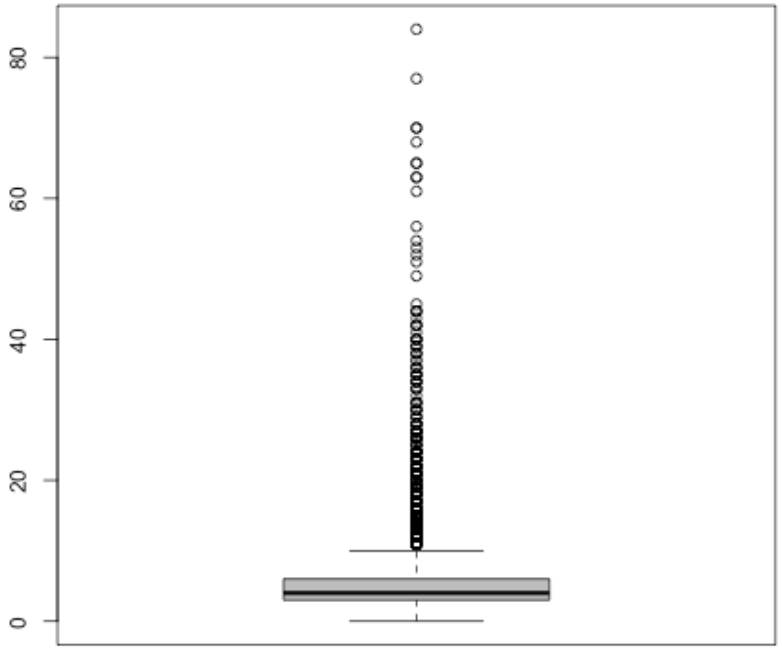
- N=6123 from electronic health records
- Years 2010-2013
- Median (1^{st}, 3^{rd} quartile): 4 (3,6)
- Range: 0-531 days
- Largest five LOS: 68, 70, 70, 77, 84, 531

-> Error 531 days

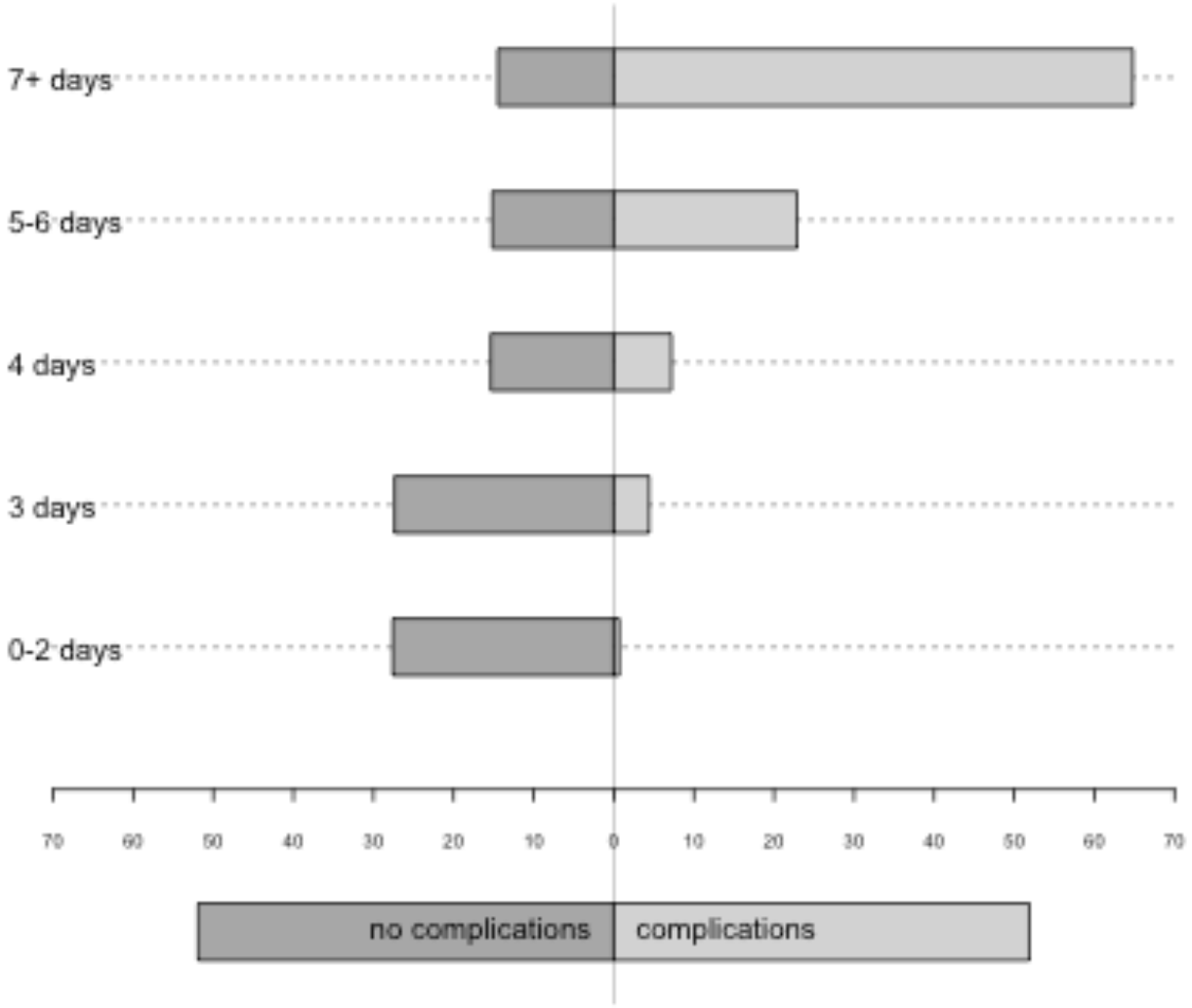
- Mean (sd): 5.4 (5.7) (without the 531 LOS)

Length of Stay [days]

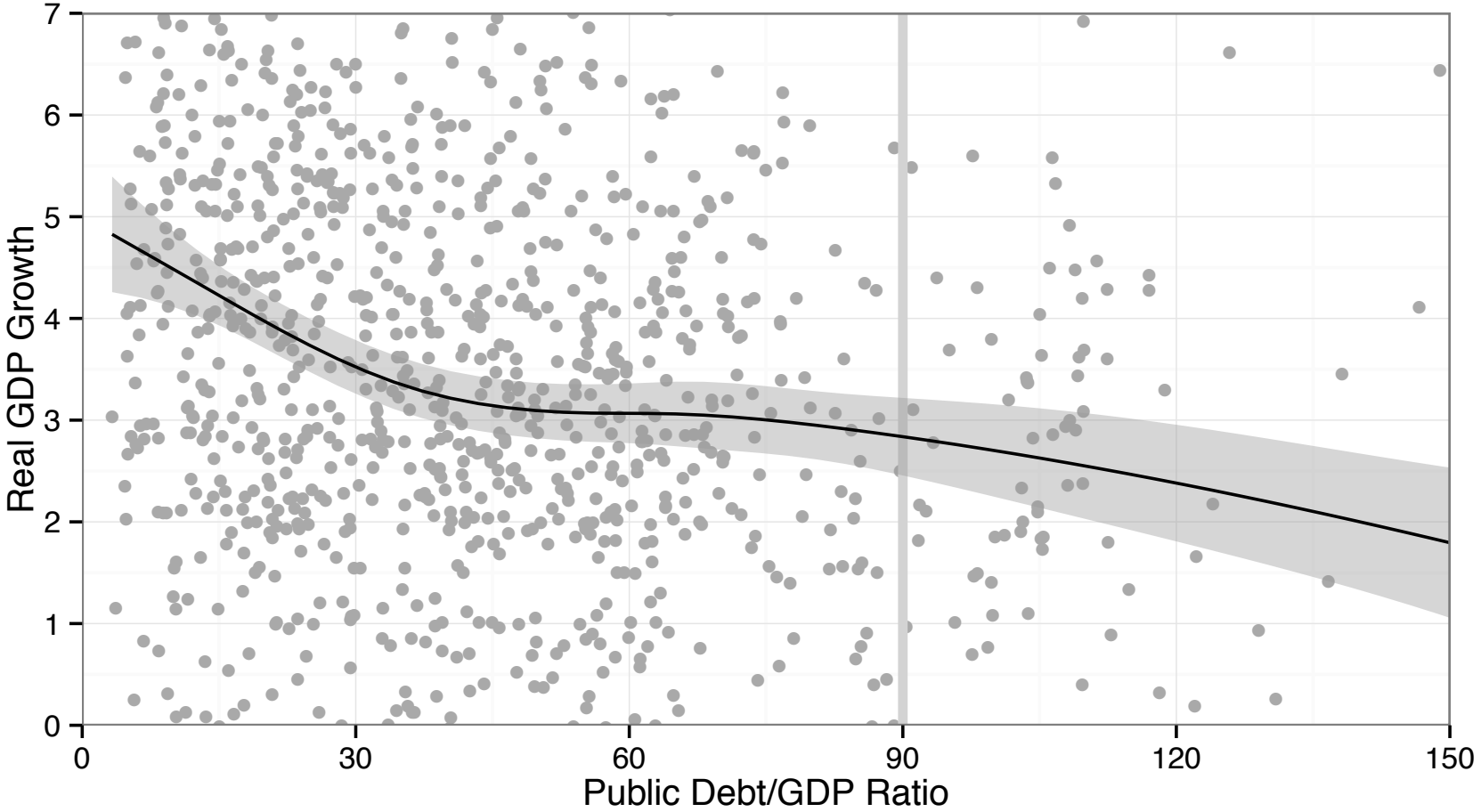




Length of Stay [% cases]



Cutoff points?

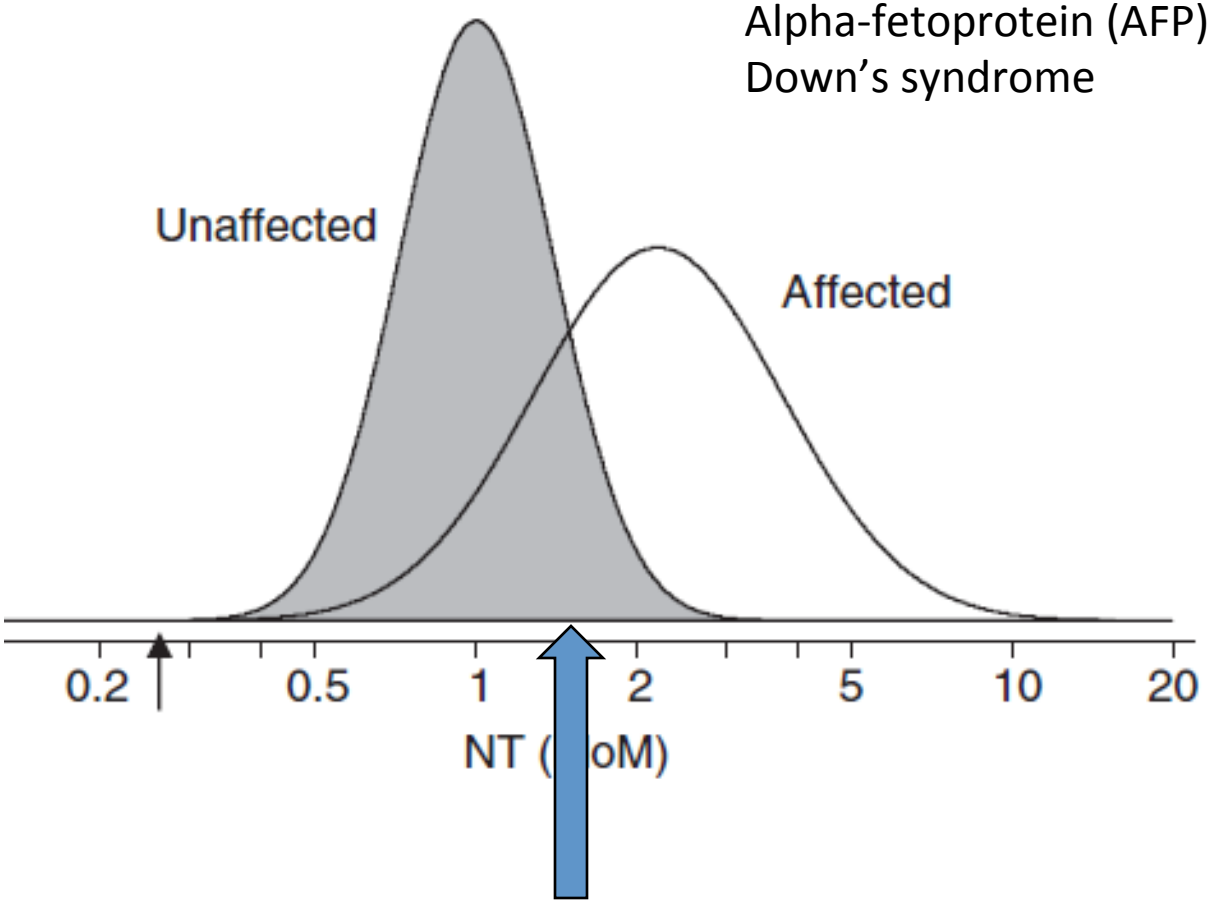


Original groupings were 0-30, 30-60, 60-90, 90+

Herndon, Ash, Pollin. A Critique of Reinhart and Rogoff. 2013.

Categorization of continuous variables

Alpha-fetoprotein (AFP) to detect Down's syndrome



Down's syndrome or not?

J Med Screen 2005;**12**:155–160

Time-to-event analyses

- How consistent/reliable is the follow-up?
  - All subject were contacted or only incidental recording of an event?
  - Detailed records for a time period but sporadic after?
  - All subjects or convenient subjects (e.g readmissions)
- Start time
  - Time since diagnosis
  - Time since surgery
  - Time since entry into study

Correlated events

1. Several measurements per subject
2. Time dependent covariates (one endpoint per subject, but a covariate changes over time)
   - Crossover treatments
   - Lab tests
3. Multiple events per subjects
   - Repeated infections
   - Rehospitalizations
   - Recurrence of tumors

Data set-up for sequential events

Choices in creating the dataset. Which model is being fit?

id	tstart	tstop	status	event	strata	duration
1	0	221	1	0	1	221
2	0	193	0	1	0	193
2	193	1100	0	1	1	907
2	1100	1130	1	0	1	30

Therneau and Grambsch: Modeling Survival Data
Therneau and Crowson: Time dependent variables. Vignette (online)
Putter, Fiocco, Geskus: Competing risks and multistate models

Data set-up for unordered events

Choices in creating the dataset. Which model is being fit?

id	tstart	tstop	event type	duration
1	0	221	1	221
2	0	193	2	193
2	193	366	2	173
2	366	1200	1	834

Modern Challenges

- New technologies: complex data, high dimensional data, big data
- Combining data from various sources: electronic health records, laboratory, pharmacy, operation notes
- Feeding data summaries to mobile apps

MAYO CLINIC

LOS Trends | ERP Compliance | Diagnosis | Registry

ERP Compliance (Elective Surgery)

Filter — LOS Trends: All — Diagnosis: All — Time Period: Last 3 Months

Surgeon	ERP Orderset (%)	LOS (Days)	Pre-Op		Intra-Op		Post-Op	
	Last 3 Months / YTD	Last 3 Months / YTD / CRS Average	G	C	I	F	D	N
[redacted]	96% / 93%	0 — 5	88%	79%	63%	83%	83%	82%
[redacted]	85% / 90%	0 — 5	76%	74%	66%	79%	82%	80%
[redacted]	98% / 97%	0 — 5	94%	95%	86%	91%	83%	91%
[redacted]	84% / 86%	0 — 5	75%	78%	68%	72%	76%	84%
[redacted]	92% / 95%	0 — 5	82%	79%	76%	84%	87%	92%
[redacted]	84% / 90%	0 — 5	72%	69%	60%	73%	69%	67%
[redacted]	100% / 96%	0 — 5	86%	92%	59%	76%	88%	100%
[redacted]	94% / 95%	0 — 5	83%	75%	81%	85%	76%	88%
CRS	92% / 93%	4.67 / 4.4	82%	79%	71%	81%	80%	84%

Modern Challenges

- Reading data from various sources: Images, web, API (Application Programming Interface, e.g twitter, facebook), GIS
- Merging data from various sources (SAS, SPSS, R, Minitab, Excel)

MOOC: *Getting and Cleaning Data*. Coursera, Jeff Leek, John Hopkins University