Quantifying Diabetes

Lessons learned from 100,000+ blood glucose readings

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Type 1 Diabetes

- an auto-immune disease
  = the body's immune system attacks and kills the insulin-producing β-cells in the pancreas
- very little to no endogenous insulin production
  = dependent on synthetic insulin
- insulin dosing **is not easy!**
  - basal insulin
  - bolus insulin
    = matched to carbohydrates consumed, roughly

My Type 1 Diabetes

- diagnosed 12/2003 at age 19
- as of 11/2006, positive C-peptide
  = still producing *some* insulin
- using an insulin pump since 12/2006:

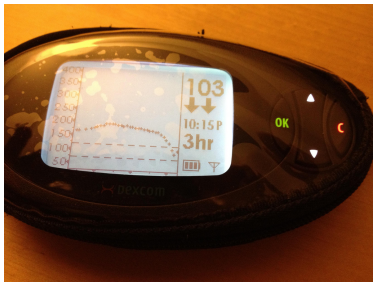
My Type 1 Diabetes, Cont'd

started using a Dexcom Continuous Glucose Monitor last year:



About the Dexcom

- the Dexcom provides:
  - an (approximate) blood glucose reading every five minutes
  - an arrow indicating
    - trend (= up, down, or steady)
    - rate-of-change
  - audible and/or vibrating alerts when blood glucose is
    - too high
    - too low
    - or changing *very* rapidly
  - ability to download data!



Blood Glucose Management

- non-diabetics blood glucose: between 70-130 mg/dL
- my goals:
  - as many readings in the "target" non-diabetic range as possible
  - keep the % of readings *below* 65 mg/dL to a minimum
  - reduce standard deviation (as measured on a day's worth of readings)
  - reduce mean

My Experiment

- first experience with Dexcom = *shock*
- next = **frustration**

My Experiment, Cont'd

Hypothesis

Carbohydrate restriction is an effective way to improve blood glucose outcomes.

Inspiration

Good Calories, Bad Calories by Gary Taubes

> *When I hear a physician saying to a type 1 diabetes patient, "Go ahead and eat whatever you want, just make sure you cover your glucose with insulin," it's like telling a firefighter, "Just go ahead and pour as much gasoline as you like on that fire youre trying to put out, as long as you cover it with enough water."*
>
> — Dr. Peter Attia

Tools

- Dexcom data export formats:
  - XML files, useful for manipulating in Python with BeautifulSoup
  - tab-delimited .csv files, useful for direct importing into R
- in R:
  - built-in non-parametric statistical functions
  - built-in plotting functions: boxplot(), etc.
  - ggplot2

Statistical Significance

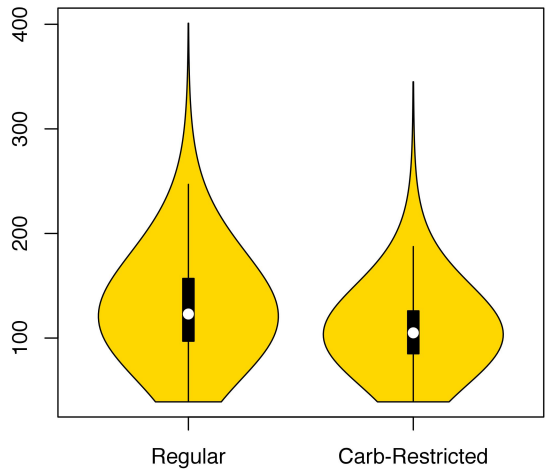
Question

Did adopting a carbohydrate-restricted diet starting January 1st, 2012 result in a statistically significant difference in blood glucose?

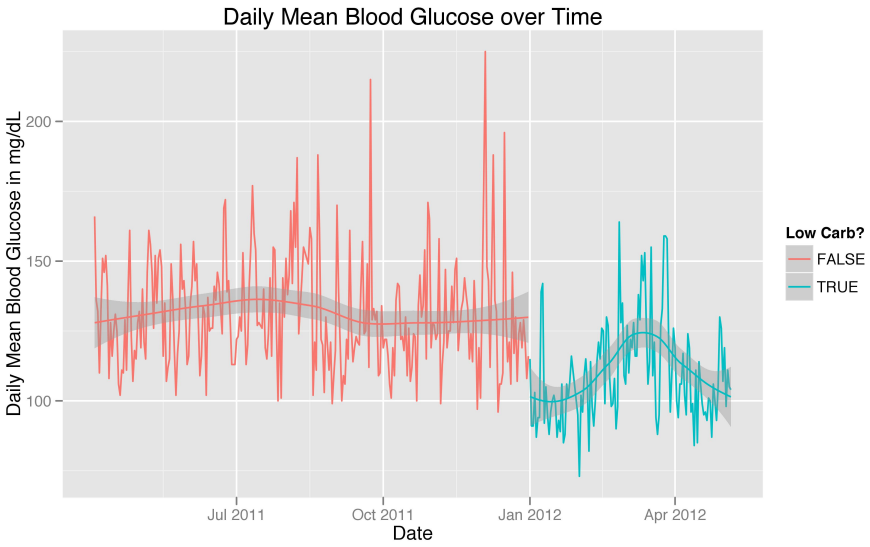
Wilcoxon rank-sum test:

- similar to the Student's t-test, but for non-parametric (= non-normally-distributed) data
- `p-value < 2.2e-16`
- **Conclusion:** change in diet resulted in significant (negative) change in blood glucose values
- estimate of the median of the difference between a sample from regular diet blood glucose data and a sample from low-carb diet data is **about −19 mg/dL**

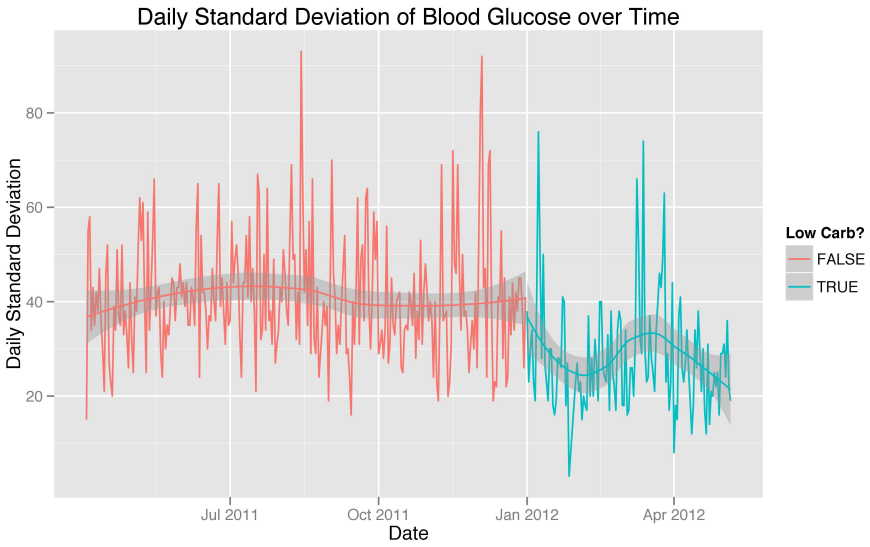
Visualizing Change: Violin Plot



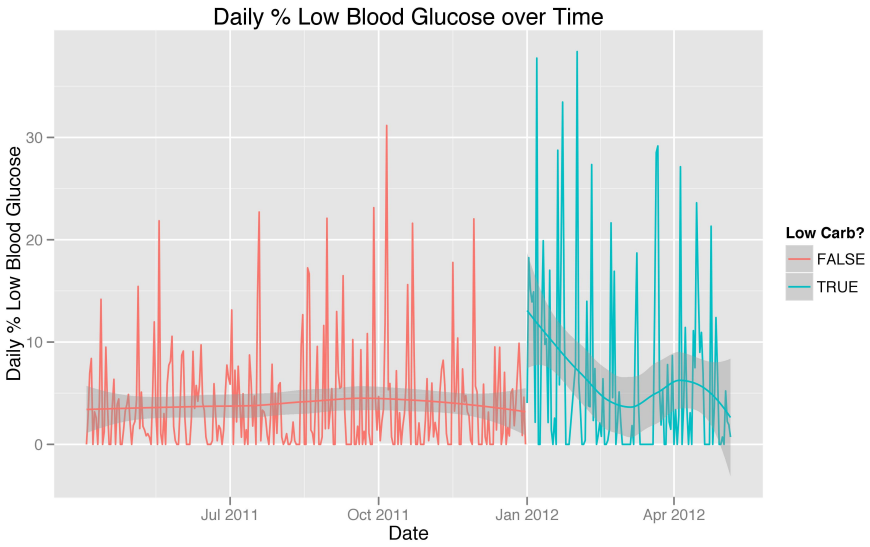
Visualizing Change: Daily Mean over Time



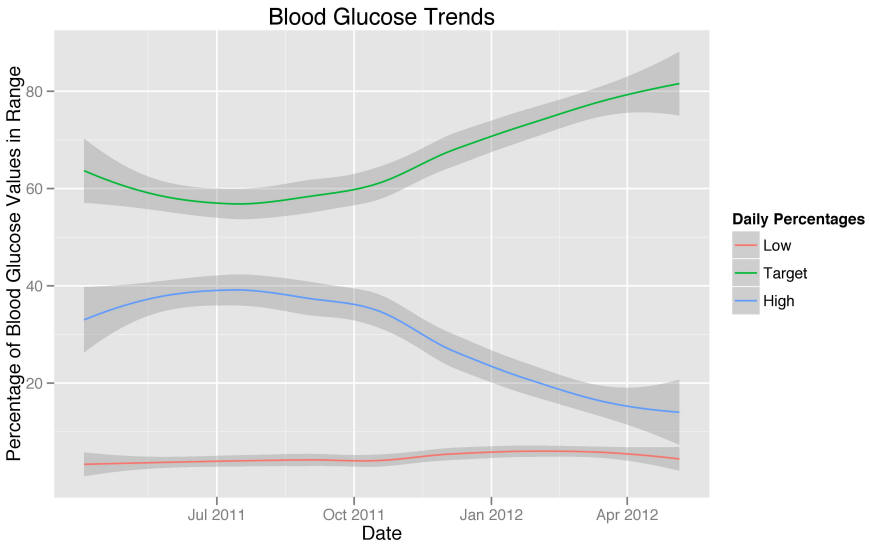
Visualizing Change: Daily Std. Deviation over Time



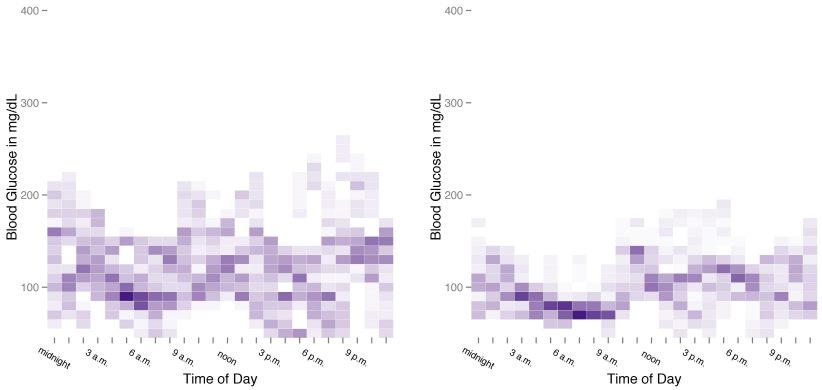
Visualizing Change: Daily % Low over Time



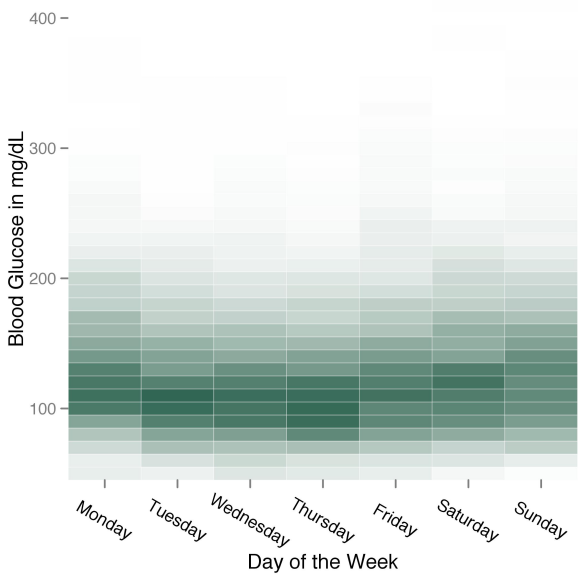
Visualizing Change: Daily Percentages over Time



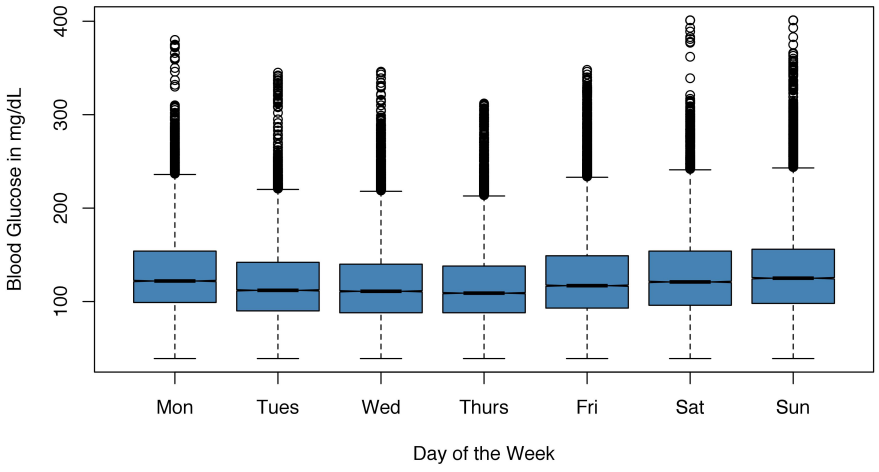
Visualizing Change: Heatmaps



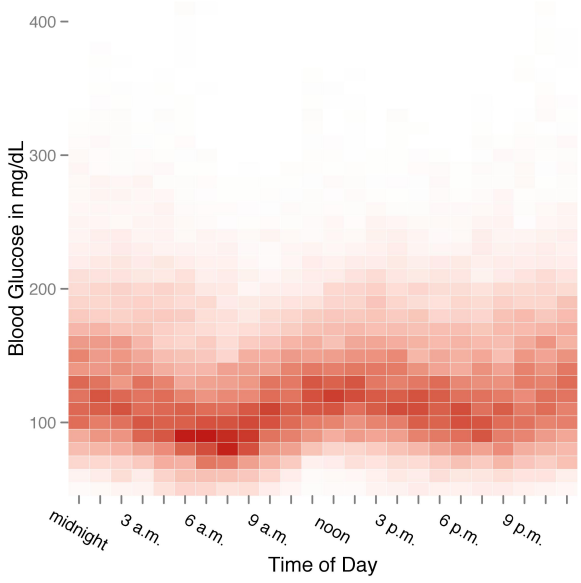
Patterns: Day of the Week



Patterns: Day of the Week Cont'd



Patterns: Time of Day



Thanks!

Contact: jana.eliz.beck@gmail.com

Upcoming Project: https://github.com/jebeck/iPancreas

(Description here: http://jebeck.github.com/iPancreas/)