Affecting Mealtime Choices through Smartphone Reminders

Personalizing the Fight Against Climate Change
A Randomized Control Study

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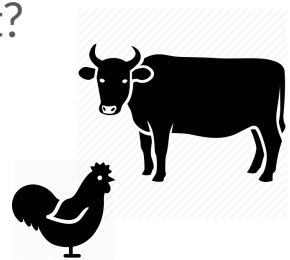
Research Question

- Can we alter people's meat eating behaviour by reminding them about the climate and environmental consequences of eating meat?
- Livestock impacts:
  - Greenhouse Gases - 14.5 % of Anthropogenic GHGs (FAO[1])
  - Deforestation - 75% of deforested areas in Amazonia are cattle ranches (WorldBank[2])
  - Reduced Biodiversity
  - Reduced Water Quality
- Habits are hard to break, 'doing the right thing' doesn't usually work



Images: Cow: https://icon-library.net/12-512_9870.html, Chicken: https://icon-library.net/bird-06-512.html

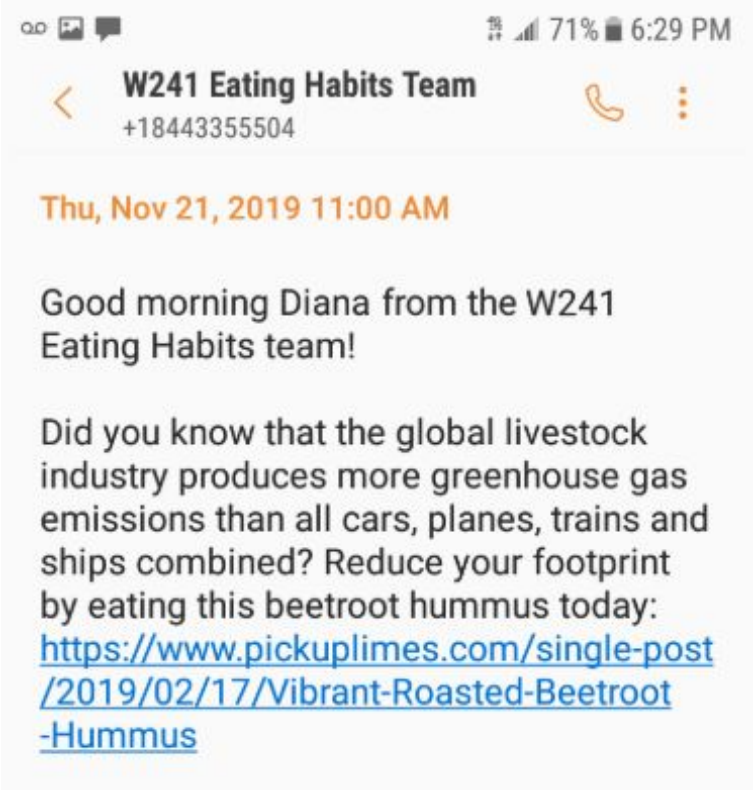
Hypothesis

- When subjects are sent an SMS reminder which includes facts about the effects of eating land-based meat on the environment, along with a recipe for a meatless meal, they will eat less meat.
- We expect that people will eat meat less frequently after receiving treatment.

What is Treatment?

Daily SMS Reminder

- Fact about impact of eating land-based meat on the environment.
- Include recipe for meatless meal



What are our Outcomes?

- Number of times a person eats in a day - ‘Total Eating Occasions’
- Number of times they eat meat in a day - ‘Meat Eating Occasions’

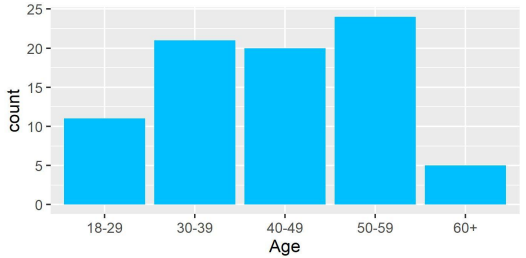
$$\text{Compute Ratio} = \frac{\text{Meat Eating Occasions}}{\text{Total Eating Occasions}}$$

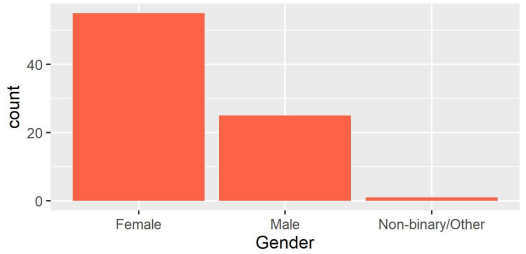
Study Phases

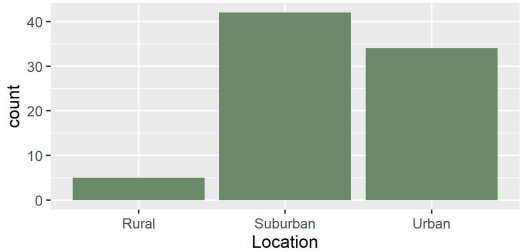
- **Phase 1: Enrollment** - Survey, Social Media + Outreach, Opt-in
- **Phase 2: Baseline** - 3 Days - Initial Eating Habits
- **Phase 3: Randomization** - Assignment to Treatment/Control
- **Phase 4: Experiment** - 7 days - Apply Treatment, Collect Outcome Measures
- **Phase 5: Evaluation** - Post-Experiment Survey & Results Analysis

Measurement Units

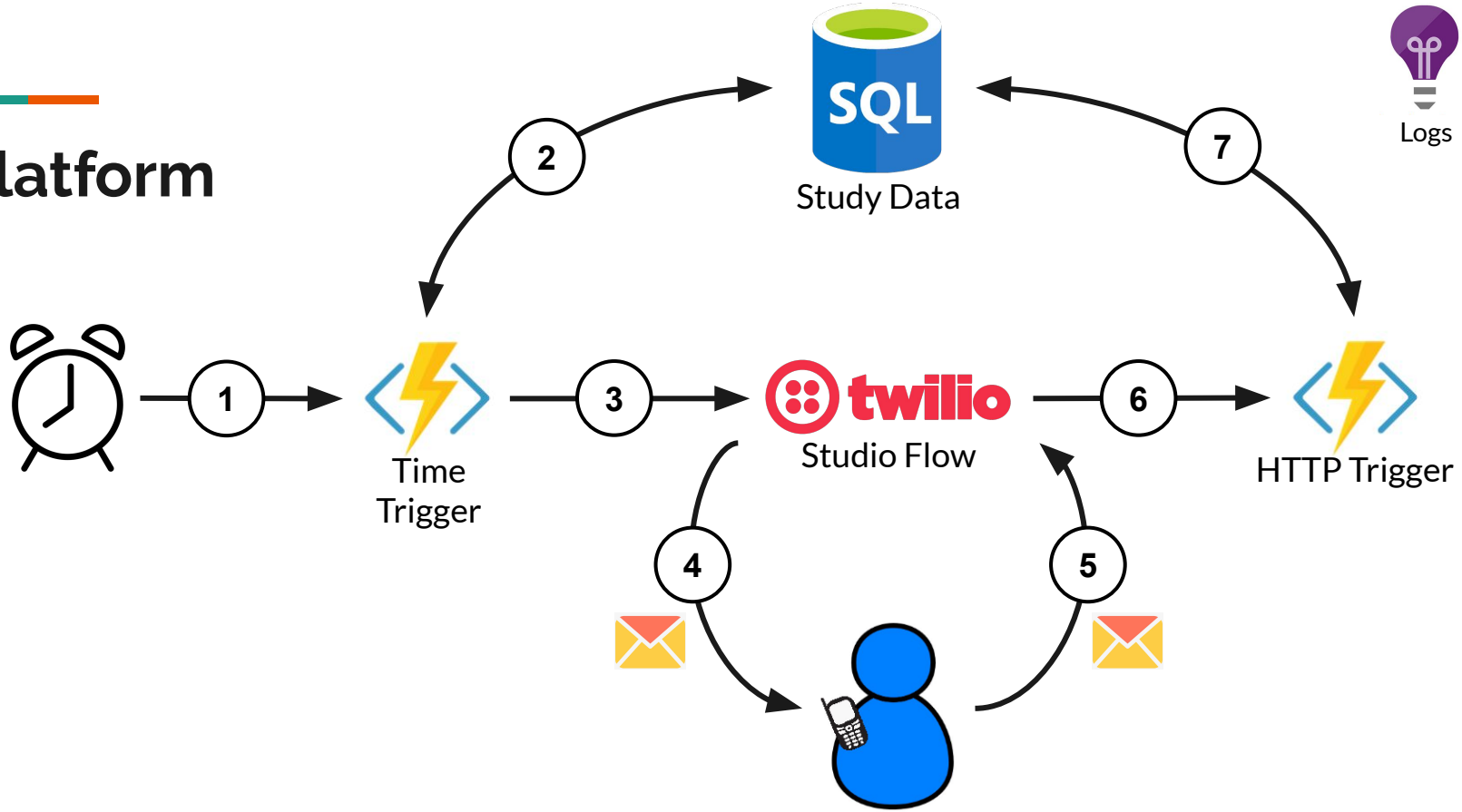
- Single participant unit
  - 18+
  - Canada or USA
  - Eats Food
  - Cell Phone
- Recruitment
  - Posted enrollment survey link on social media (Facebook, Instagram, etc.)
  - Sent survey link by direct email
  - Self selected
- Acceptance
  - Confirmation of enrollment SMS required to be considered a ‘complier’ and active in the study





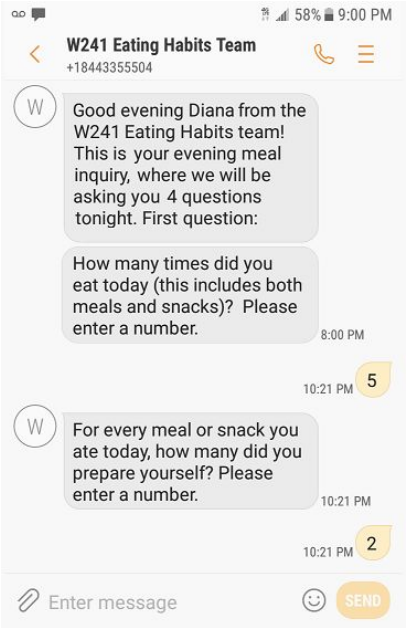


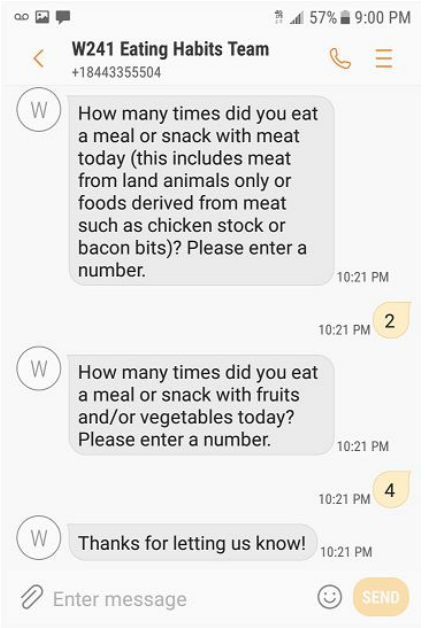
Platform


SQL
Study Data
Logs
2
7
1
3
6
Time
Trigger
twilio
Studio Flow
HTTP Trigger
4
5

Collecting Baseline Outcomes

- Personalized greeting
- Setting expectations
- Two types of questions
  - Measures of interest (1 & 3)
  - Measures to “throw off” (2 & 4)
- Closing with a “thank you”

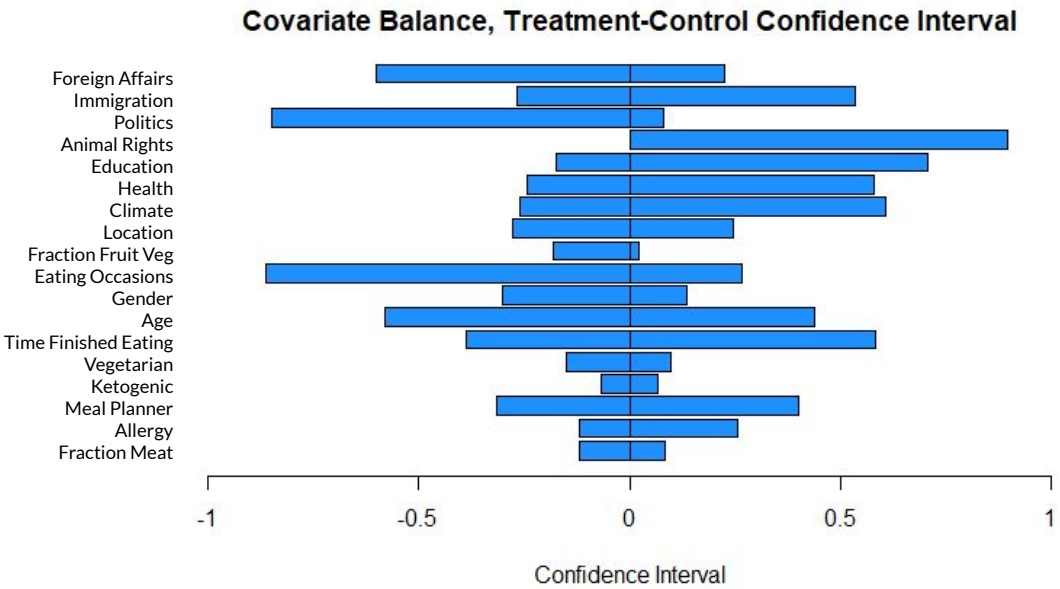




Randomization

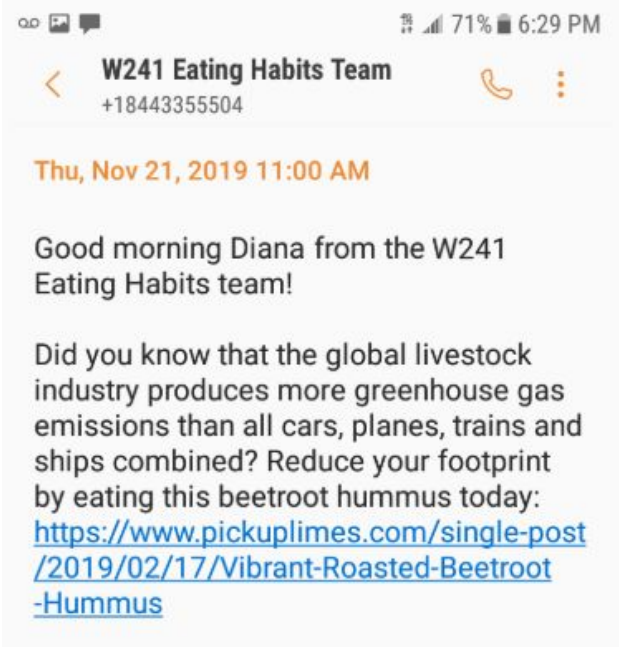
- Blocked Randomization / Matched Pair Design
- `blockTools` package
- Blocked on (things we felt might make a difference to eating habits):
  - Meat eaten in Baseline (fraction)
  - Food Allergy Status
  - If person was meal planner
  - Ketogenic Diet status
  - Vegetarian Diet Status
  - Time of day person is finished eating
- Did the randomization work?

Randomization - Successful!

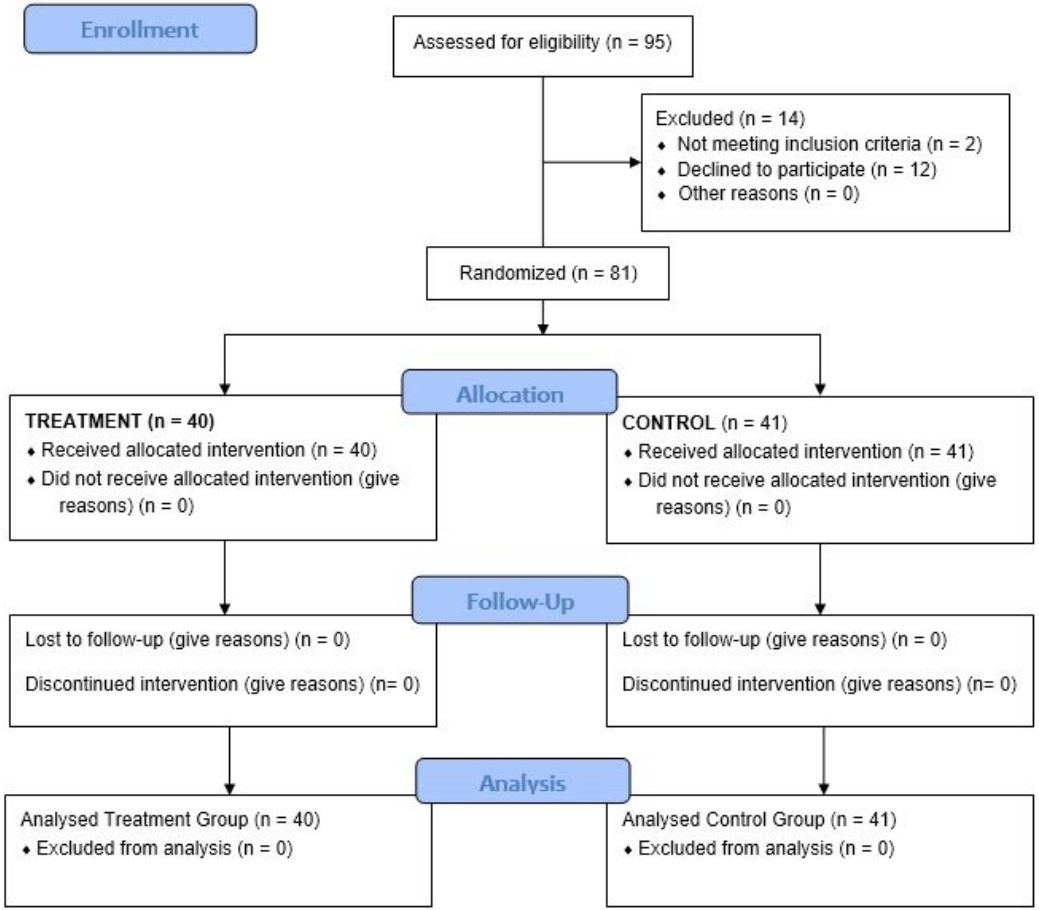


Administering Treatment

- SMS reminder approximately 11 am daily to Treatment Group for 7 days
- Contained:
  - Message regarding meat and environment
  - Link to meatless recipe
  - Request for Confirmation



Participant Flow Diagram



Causality

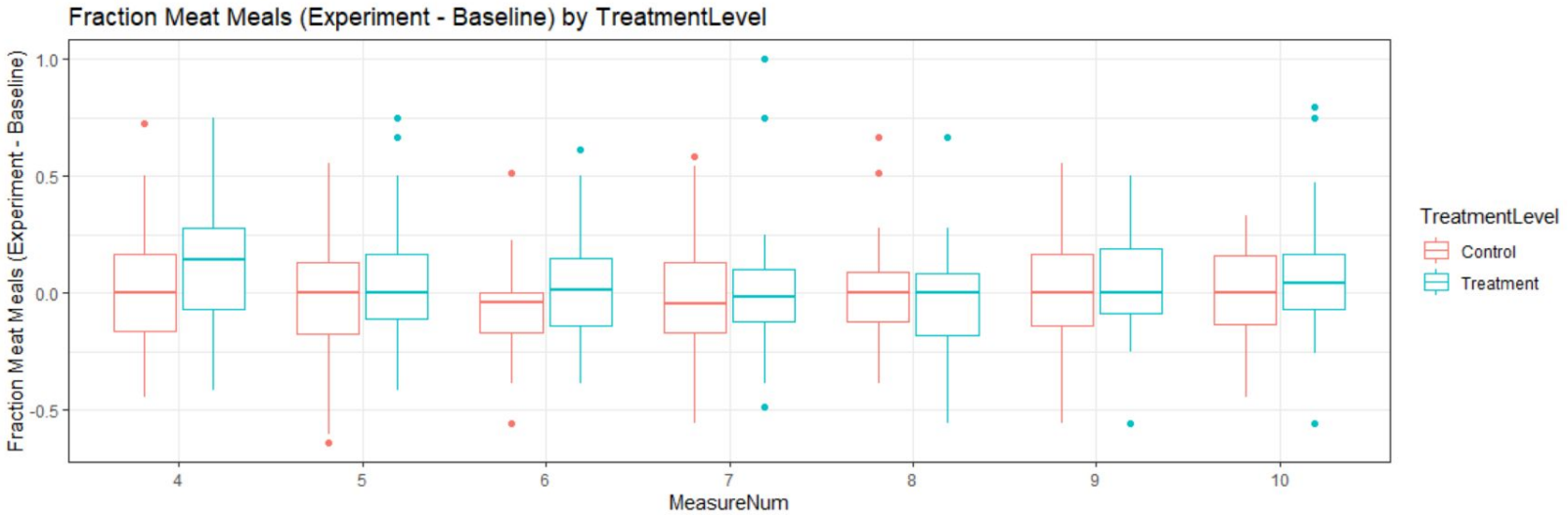
- Pretest-Posttest Control Group Design (Time Series) / Difference in Differences

	Randomization	Baseline Meas. (3d)	Treatment (7d)	Experiment Meas. (7d)
Treatment	R	O	X	O
Control	R	O	--	O

- Differences per individual: (Experimental Measurement) - (Baseline Measurement)
- Causal:
  - (Treatment Group) - (Control Group)
  - Random
  - Blocked

Outcome Measures - First Look

- Computed Ratio: Fraction of Meat Meals
- If FracMeatMeals is different Treatment to Control, once the Baseline is factored out, that = effect.



Analysis & Results

Excludability Assumption Checking

- Number of eating occasions
- Decreased slightly with Treatment
- Clustered on individual over 7 days of treatment
- Were expecting # of Eating Occasions to be insensitive to treatment

Treatment effect on number of Eating Occasions in experiment

	Dependent variable:
	TotalNumEO
Constant	0.908 (0.385, 1.432)
MeanEO_Baseline	0.794 (0.640, 0.947)
Treat	-0.325 (-0.556, -0.094)
Observations	498
R^2	0.481
Adjusted R^2	0.479
Residual Std. Error	1.083 (df = 495)
F Statistic	229.174^{***} (df = 2; 495)
Note:	*p<0.05; **p<0.01; ***p<0.001

Analysis & Results - Mixed Effects Model

- Fixed Effects - constants across individual participants
- Random Effects - vary across individual participants

```
model = lmer(
    FracMeat ~ Treat +
               factor(MeasureNum, ordered=TRUE) +
               factor(BlockNum) +
               (1|MeanFracMeat_Baseline) +
               (1|ID)
)
```

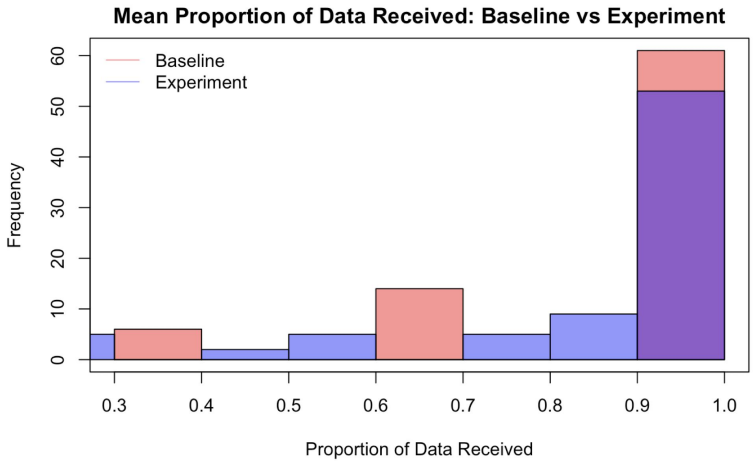
Analysis & Results - Mixed Effects Model

Mixed Effects modeling, No Covariates

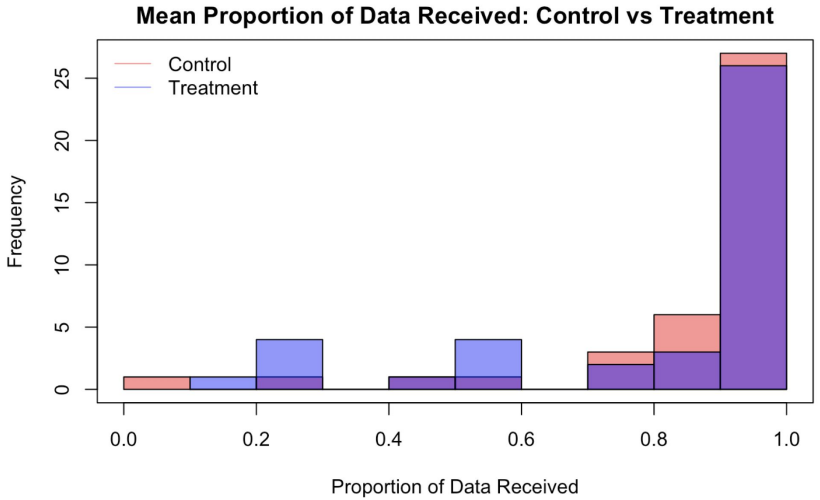
	Dependent variable:
	FracMeat
Constant	0.087 (0.113)
Treat	0.046 (0.032)
factor(MeasureNum, ordered = TRUE).L	0.013 (0.026)
factor(MeasureNum, ordered = TRUE).Q	0.084** (0.026)
factor(MeasureNum, ordered = TRUE).C	-0.013 (0.027)
factor(MeasureNum, ordered = TRUE)4	0.002 (0.026)
factor(MeasureNum, ordered = TRUE)5	0.008 (0.027)
factor(MeasureNum, ordered = TRUE)6	-0.009 (0.026)
Observations	488
Log Likelihood	-36.477
Akaike Inf. Crit.	174.954
Bayesian Inf. Crit.	388.660
Note:	*p<0.05; **p<0.01; ***p<0.001

as.factor(BlockNum)2	0.345* (0.154)	as.factor(BlockNum)22	0.532*** (0.140)
as.factor(BlockNum)3	0.208 (0.156)	as.factor(BlockNum)23	0.413** (0.140)
as.factor(BlockNum)4	0.060 (0.142)	as.factor(BlockNum)24	0.356* (0.143)
as.factor(BlockNum)5	0.711*** (0.165)	as.factor(BlockNum)25	0.083 (0.148)
as.factor(BlockNum)6	0.404** (0.147)	as.factor(BlockNum)26	0.426** (0.160)
as.factor(BlockNum)7	0.483** (0.151)	as.factor(BlockNum)27	0.475*** (0.142)
as.factor(BlockNum)8	0.278 (0.150)	as.factor(BlockNum)28	0.136 (0.148)
as.factor(BlockNum)9	0.059 (0.100)	as.factor(BlockNum)29	0.343* (0.144)
as.factor(BlockNum)10	0.297 (0.156)	as.factor(BlockNum)30	-0.029 (0.092)
as.factor(BlockNum)11	0.352* (0.148)	as.factor(BlockNum)31	0.258 (0.156)
as.factor(BlockNum)12	0.380** (0.142)	as.factor(BlockNum)32	0.397** (0.145)
as.factor(BlockNum)13	0.423** (0.142)	as.factor(BlockNum)33	0.529*** (0.142)
as.factor(BlockNum)14	0.373* (0.151)	as.factor(BlockNum)34	0.665*** (0.190)
as.factor(BlockNum)15	0.360* (0.150)	as.factor(BlockNum)35	0.307* (0.149)
as.factor(BlockNum)16	0.429** (0.138)	as.factor(BlockNum)36	0.459*** (0.138)
as.factor(BlockNum)17	0.340* (0.147)	as.factor(BlockNum)37	0.035 (0.084)
as.factor(BlockNum)18	0.467*** (0.137)	as.factor(BlockNum)38	0.303 (0.157)
as.factor(BlockNum)19	0.296** (0.111)	as.factor(BlockNum)39	0.306* (0.138)
as.factor(BlockNum)20	0.216 (0.162)	as.factor(BlockNum)40	0.466*** (0.136)
as.factor(BlockNum)21	0.121 (0.169)	as.factor(BlockNum)41	0.139 (0.190)

Missing Data



T-test p-value: 0.3373



T-test p-value: 0.2737

Outstanding Questions and Concerns

- Eating Occasions a function of treatment
  - How to address?
  - Instrumental Variable approach?
- Attrition/Missingness
  - Number of responses per person is variable - how to take into account?
  - Especially for Panel Data case
- Power
  - Number of participants low
  - Length of study
  - More accurate measures (how?)
- Short code Phone numbers ($$)
- Priming and irking people with remarks
  - Do a panel to determine best treatment messages?

References

1) Gerber, P. J., Steinfeld, H., Henderson, B., Mottet, A., Opio, C., Dijkman, J., … Tempio, G. (2013). *Tackling climate change through livestock—A global assessment of emissions and mitigation opportunities.* Retrieved from Food and Agriculture Organization of the United Nations (FAO) website: http://www.fao.org/docrep/018/i3437e/i3437e.pdf

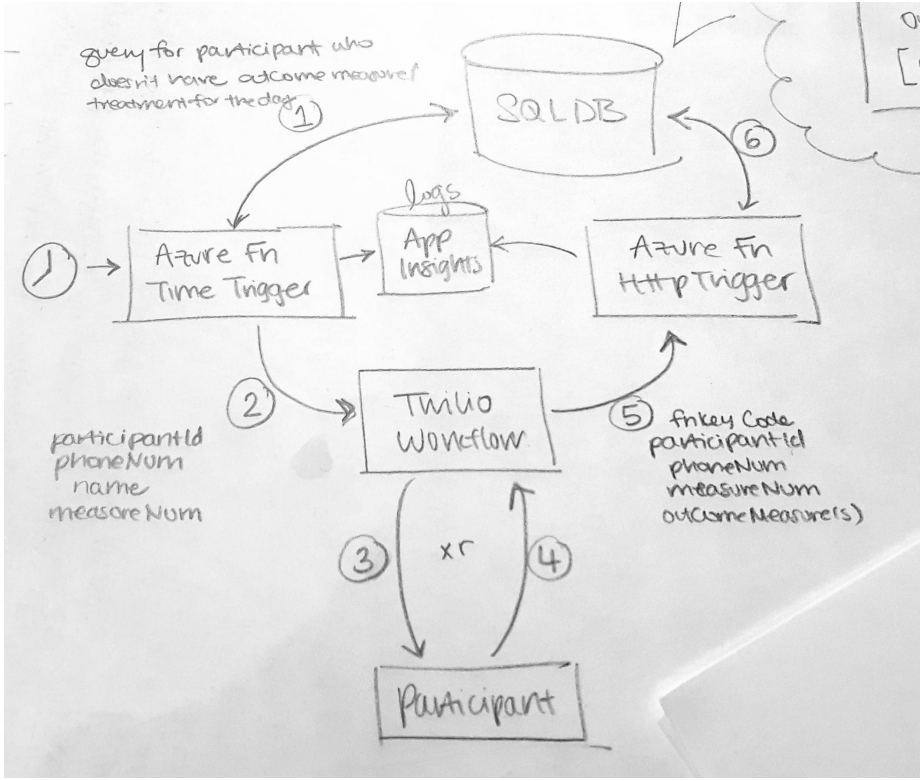
2) Margulis, S. (2003). *Causes of Deforestation of the Brazilian Amazon*. https://doi.org/10.1596/0-8213-5691-7

3) https://stats.stackexchange.com/questions/4700/what-is-the-difference-between-fixed-effect-random-effect-and-mixed-effect-mode

4) W271 - Week 13 on Linear Mixed Effects Modeling

5) Gerber and Green (2012). Field Experiments: Design, Analysis, and Interpretation.

EXTRA SLIDES



Key Assumptions

- Non-interference (SUTVA)
  - Only 2 of 73 respondents to final survey noted discussing with other survey participants
- Excludability Assumption
  - Treatment is the only thing that differs systematically between our two groups that affects meat consumption
- Data missing completely at random
  - If missing data are systematically related to our observations, then calculated values are biased
- Weak Generalizability
  - Convenience sample
  - No overweighting of underrepresented groups of interest
  - No sampling in accordance with population subgroup proportions
- Measurement Asymmetries Balanced through Parallelism
  - Treatment and Control are interacted with in the same way, with only treatment differing

Analysis & Results- Means over Time

```
model = lm(
    MeanFracMeat_Experiment ~
        MeanFracMeat_Baseline +
        Treat
)
```

Basic Model, All Treatment Days Aggregated, No Covariates

	Dependent variable:
	MeanFracMeat_Experiment
Constant	0.138 (0.070, 0.205)
Treat	0.056 (-0.012, 0.125)
MeanFracMeat_Baseline	0.611 (0.475, 0.748)
Observations	81
R^2	0.467
Adjusted R^2	0.453
Residual Std. Error	0.155 (df = 78)
F Statistic	34.172^{***} (df = 2; 78)
Note:	*p<0.1; **p<0.05; ***p<0.01