Low-Fat Diet on BMI, Obesity, Overweight, Blood Pressure, and Diabetes—A Two-Stage Difference-in-Difference

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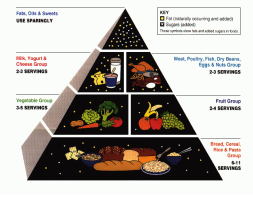
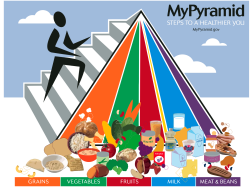
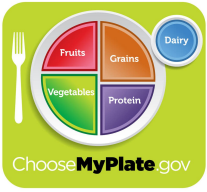
Introduction

Initial research question

In the US, what is the effect of the Food Pyramid on cardiovascular disease and obesity?







Expanded research question

What are the health effects of food-based dietary guidelines (FBDGs) around the world?

What are FBDGs

From the Food and Agriculture Organization (FAO)

"Establish a basis for public food and nutrition, health and agricultural policies and nutrition education programmes to foster healthy eating habits and lifestyles. They provide advice on foods, food groups and dietary patterns to provide the required nutrients to the general public to promote overall health and prevent chronic diseases"[1]

[1] https://www.fao.org/nutrition/education/food-dietary-guidelines/home/en/

Literature review

Ancel Keys

- Atherosclerosis: A Problem in Newer Public Health (1953)
- Coronary Heart Disease in Seven Countries (1970)

Diet-heart hypothesis

- Dietary cholesterol intake increases blood serum cholesterol, which thickens arterial walls, leading to blood flow constriction
- Eating animals fats, especially saturated fats, leads to weight gain

Lit review (cont'd)

Weight loss - studies over one year

- Toubro & Astrup (1997): low-fat diet superior to moderate-fat
- McManus et al. (2001) and Shai et al. (2008): moderate fat superior to low-fat
- Shai et al. (2008): low carb diet superior to low-fat diet

On the diet-heart hypothesis

- Kendrick (2008) - argue that high cholesterol levels don't cause heart disease
- Ravnoskov (2002; 2016; 2018) - lack of association between LDL-C and heart disease

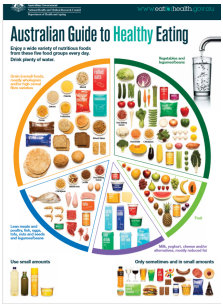
Inconsistencies with Keys' studies

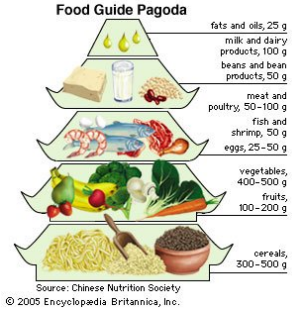
- In a 15 year follow-up to the 1970 Seven Countries Study, Keys found that while the diet in Japan westernized over the years (i.e. consuming more dietary cholesterol), coronary heart disease increased little and is still very low by American and European standard - he found it very puzzling
- In a 1997 interview, Keys said, "There's no connection whatsoever between cholesterol in food and cholesterol in blood. None."

Macronutrient recommendations

Herforth et al., 2019

- Reviewed FBDGs from 90 countries between 1986-2017
- Most countries (89%) recommend reducing fat intake
- All countries recommend starchy staples





Motivation

What are the effects of lowered fat recommendations in FBDGs on global health outcomes?

1. Mean BMI
2. Prevalence of obesity—for children, adolescents, adults
3. Prevalence of overweight—for children, adolescents, adults
4. Prevalence of type 2 diabetes
5. Rate of high blood pressure

Choosing FBDG countries

- The FAO encourages countries to submit FBDGs to their website
- Herforth et al. (2019) reviewed 90 countries with FBDGs from 1986-2017
- *Food-Based Dietary Guidelines in the WHO European Region* (2003)

Details for my paper

- Period of study: 1976-2016 and 1990-2016
- Countries: 141 total, 78 with FBDGs

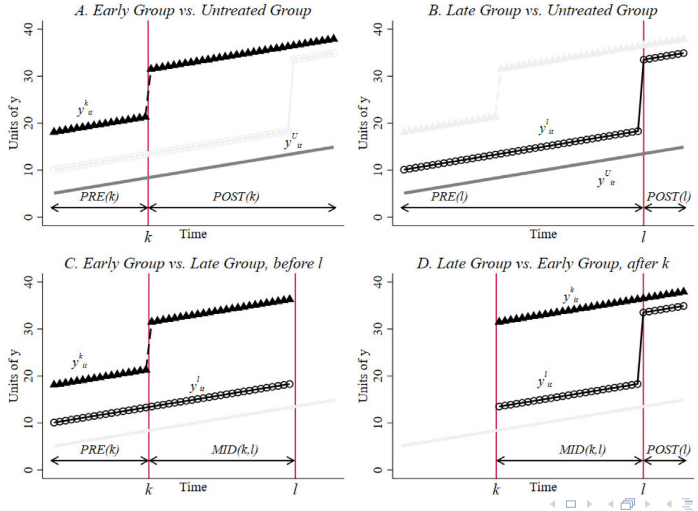
Data

Outcomes	**Source**	**Period**
Mean BMI	WHO	1976-2016
Prevalence of obesity	WHO	1976-2016
Prevalence of overweight	WHO	1976-2016
Type 2 diabetes	GHDx	1990-2016
High blood pressure	GHDx	1990-2016
Covariates		
Female (% in population)	World Bank	1976-2016
Income	Penn World Table	1976-2016

Method

- Why not standard difference-in-difference?
- Problem: with staggered treatment periods and heterogeneous treatment effects, regular DiD will result in biased estimands (Baker et al., 2021; Callaway & Sant'Anna, 2021; Goodman-Bacon, 2021)
- Solution: Two-stage DiD developed by Gardner (2021)
  - Standard errors recovered with bootstrapping (n = 500)

Problem with difference-in-difference (Goodman-Bacon, 2021)



Two-stage difference-in-difference (Gardner, 2021)

First stage

Estimate the model

$$Y_{gpit} = \lambda_g + \gamma_p + \epsilon_{gpit}$$

on the sample of observations for which $D_{gp} = 0$, retaining estimated group and time effects $\hat{\lambda}_g$ and $\hat{\gamma}_p$

Second stage

Regress adjusted outcomes $Y_{gpit} - \hat{\lambda}_g - \hat{\gamma}_p$ on $D_{gp} = 0$. Since parallel trends imply that

$$E(Y_{gpit}|g, p, D_{gp}) - \lambda_g - \gamma_p = \beta_{gp} D_{gp} = E(\beta_{gp}|D_{gp} = 1)D_{gp} + [\beta_{gp} - E(\beta_{gp}|D_{gp} = 1)]D_{gp},$$

where $E\{[\beta_{gp} - E(\beta_{gp}|D_{gp} = 1)]D_{gp}|D_{gp}\} = 0$. This procedure identifies $E(\beta_{gp}|D_{gp} = 1)$, even when the adoption and average effects of the treatment are heterogeneous for groups and periods

Results

Outcomes	Years	Observations	2SDID Estimates
Mean BMI			
Children	1976-2016	5,781	0.0301* (0.0117)
Adolescents	1976-2016	5,781	0.0289* (0.0119)
Adults	1976-2016	5,781	-0.0850*** (0.0183)
Adults (age-adjusted)	1976-2016	5,781	-0.2199*** (0.0193)
Obesity			
Children	1976-2016	5,781	1.441*** (0.0862)
Adolescents	1976-2016	5,781	1.047*** (0.0632)
Adults	1976-2016	5,781	1.217*** (0.0910)

Note: *p<0.1; **p<0.05; ***p<0.01

Results (cont'd)

Outcomes	Years	Observations	2SDID Estimates
Overweight			
Children	1976-2016	5,781	1.664*** (0.1477)
Adolescents	1976-2016	5,781	1.333*** (0.1219)
Adults	1976-2016	5,781	0.6792*** (0.0905)
Type 2 diabetes	1990-2016	3,456	447.5*** (33.36)
High blood pressure	1990-2016	3,456	-0.3864* (0.1913)

Note: *p<0.1; **p<0.05; ***p<0.01

Issues with assumptions in the method

- Spillover
  - e.g. US-World, Belgium-Luxembourg, Nordic Nutritional Recommendations (1980), *Preparation and use of food-based dietary guidelines* (1998) joint WHO/FAO consultation
- Anticipation
- Treatment related to outcomes
  - Countries experiencing worse weight and health outcomes would feel pressured to set FBDG
- Parallel trends (untestable)
- Differences in implementation

Potential solutions

- Conduct an event study on the pretreatment effect to see if anticipation is a problem
- See if adoption of FBDG was spurred on by increasing cases of bad outcomes compared to countries that did not adopt FBDG
- Use another method (e.g., synthetic control or matching) to see if the results are consistent

Things to work on

- Creating a strict (total fat $\leq$30% of calories) subgroup for FBDGs
- Framing the paper to a broader regarding government involvement in healthcare
- Looking into more covariates