Costs Savings

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Cost-Effectiveness Analysis
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Outline

- Economic evaluations and cost studies
- Estimating effects: difference-in-difference
- The Colorado Family Planning Initiative
- Denver Health's smoking cessation program

Big picture (Department of Forests)

- In the last two weeks we learned the basics of costs, essentially the numerator of the incremental cost effectiveness ratio (ICER)
  $ICER = \frac{C_2 - C1}{E_2 - E_2}$
- In the next two weeks we will cover the denominator: How do we choose a relevant outcome? How do we calculate quality-adjusted life years (QALYs)? And, most relevant, how do we interpret the ICER?
- The ICER –the comparison of **incremental costs** and **incremental outcomes**– is our measure of **value**
- Today, we will talk about a type of study that focuses on the numerator: **just a comparison of costs**

Big picture (Department of Forests)

- With health care being so expensive there is more pressure to come up with with interventions that **save money**
- The unstated assumption is that the new intervention is not worse in terms of effects/outcomes although it could be equally effective
- **But remember**: Cost studies are partial evaluations. These types of studies do not provide a measure of value
- It's great if we can do something for less money, but **in general new technologies/innovations are costly**

Today

- We will talk in more detail about two examples of cost savings studies: an evaluation of the Colorado Family Planning Initiative and Denver Health's smoking cessation programs
- One goal is to apply what we have learned about costs and perspectives
- Another goal is to review the type of issues that come up when designing economic evaluations
- **There are many assumptions**. Always part of any research project

Brief detour: causal inference and difference-in-difference designs

- Guideline 3 of the assessment lecture was about establishing the measure of effectiveness
- That guideline was about the ICER denominator but the same issues arise in any type of study: in the absence of randomization, causal inference is much more difficult
- You have heard this many times: correlation does not imply causation. **But under which circumstances does correlation imply causation?**

Difference-in-difference (DiD)

- A common type of design to establish causal effects using observational data. Essentially a pre-post comparison over time including a control group
- One of the first and most famous DiD studies: John Snow's 1850 cholera epidemic. Is cholera transmitted by water or air?
- Snow collected before and after mortality data for an area that made a change in water supplier with a subsequent increase in cholera cases (the treatment)
- But a simple before and after comparison doesn't answer the question. Snow also collected before and after mortality data for households **sharing the same air but different water supplier** (the control)
- Call the before and after treatment morality rate T^{pre} and T^{post}, respectively. Call the before and after mortality rate in the control group C^{pre} and C^{post}, respectively
- The estimate of treatment effect is $(T^{post} - T^{pre}) - (C^{post} - C^{pre})$

Long Acting Reversible Contraceptives

- LARCs are reversible contraceptive methods that include intrauterine devices (IUD) and implants
- Shown to be **extremely effective** methods, with **failure rates of less than 1%, which do not depend on proper use** (this is important!)
- In contrast, the pill failure rate is about 9% **assuming proper use**
- Think for a moment about the implication: for every 100 times, 9 end in **unintended pregnancy**. Not a trivial failure rate
- Higher failure rates for teenagers and lower-income populations
- The use of LARC had been hindered by lack of knowledge, suspicion about the method and high costs: it requires insertions and they are expensive (at least in upfront costs)

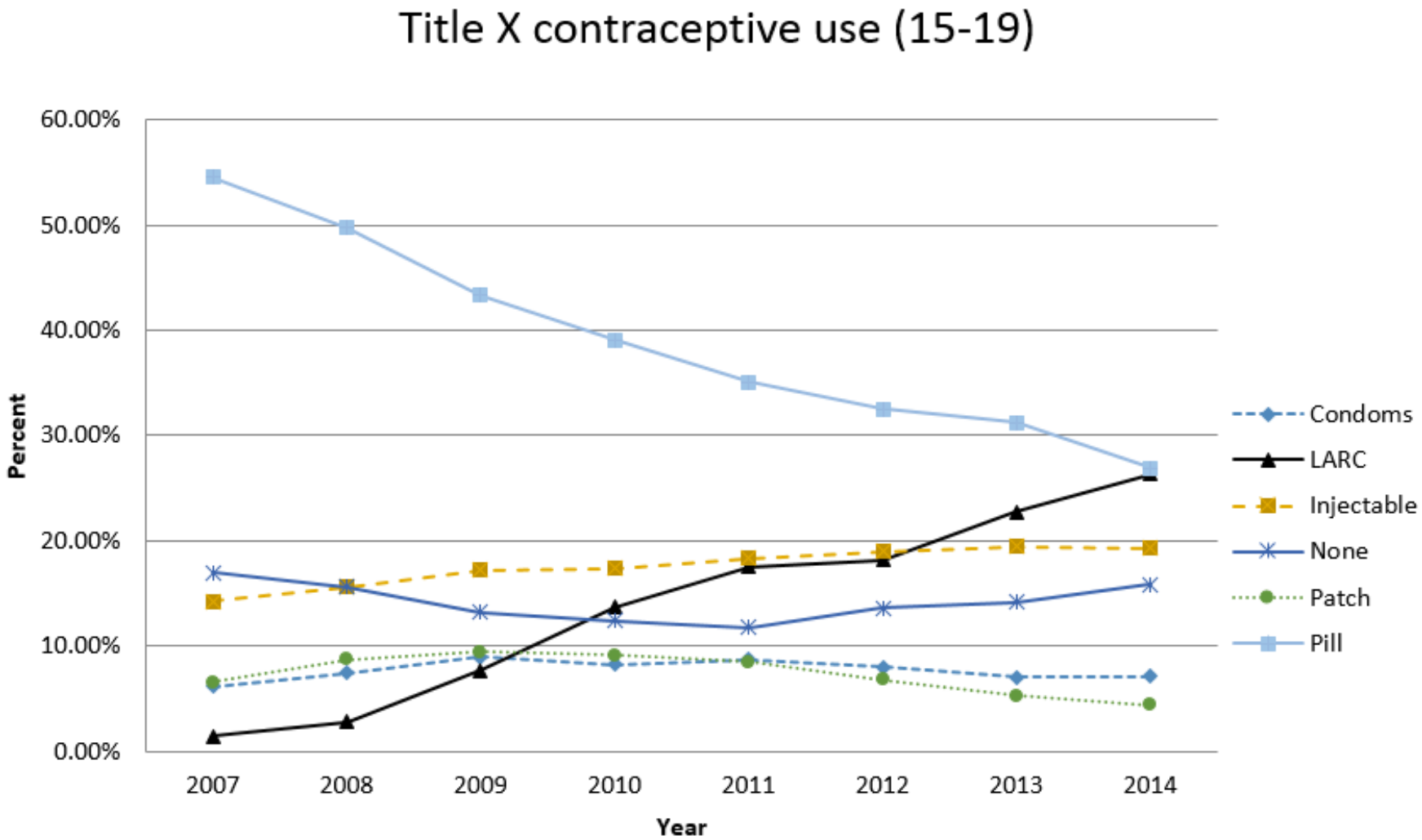
Colorado Family Planning Initiative (CFPI)

- In 2007 an anonymous donor (later revealed to be the Susan Thompson Buffet Foundation) interested in reducing unintended pregnancies chose Colorado to expand family planning services
- The program provided free LARCs to Title X clinic clients and funds for building capacity and training providers, technical assistance (including billing), and outreach efforts ($23 mill)
- Title X clinics cover young low-income women (and men) at very low costs (see the report for more details)
- Importantly, at the same time, the Buffet foundation distributed funds to other groups in Colorado for education and outreach. **It's not publicly known the amount of money distributed**
- **External validity**: The donor did not randomly choose Colorado. They thought that the conditions were better here. This has implication when considering whether a similar program would be effective in other states (recommendation 10 in your textbook)

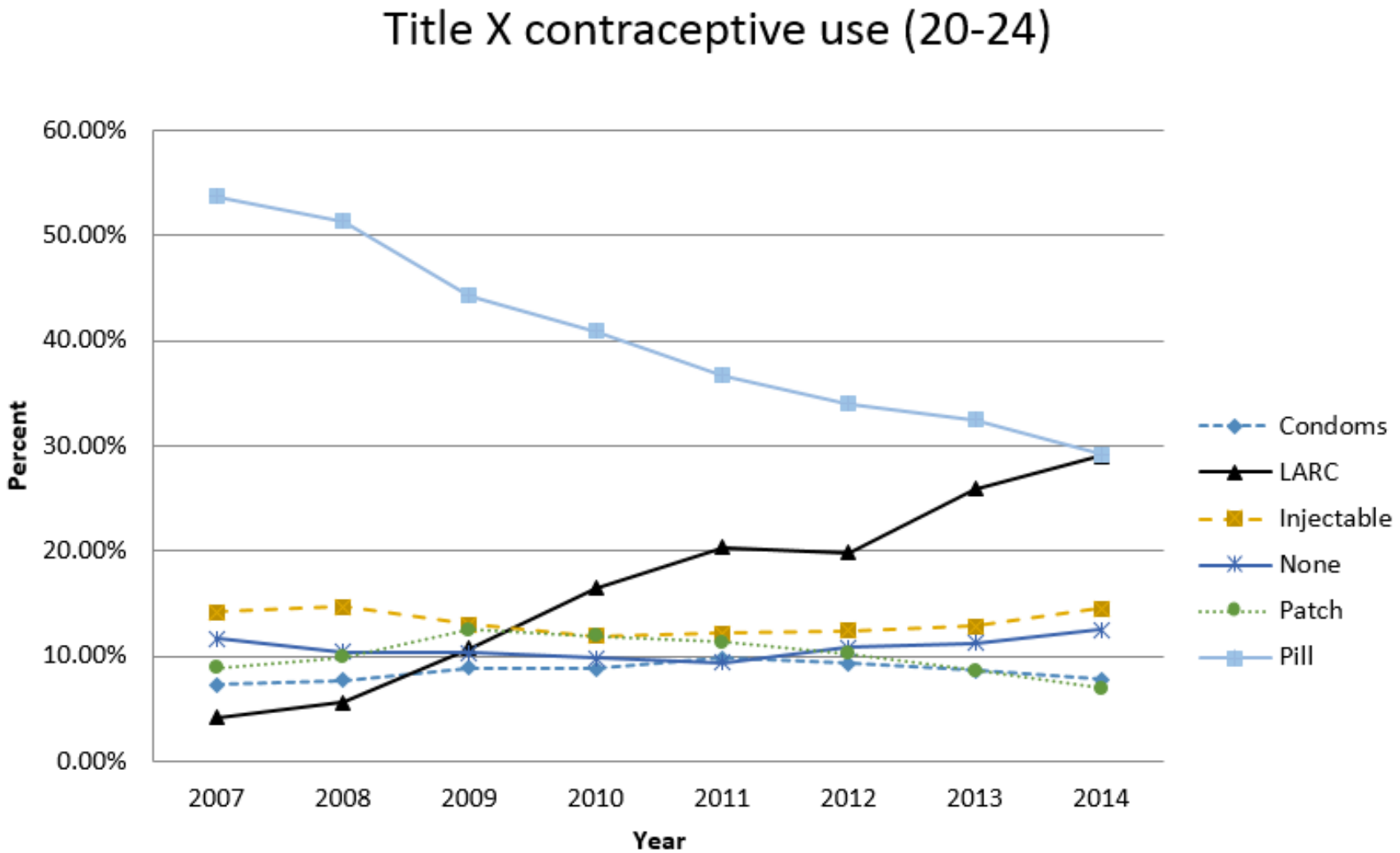
CFPI impact (sort of)

- Large increase in the number of clients using family planning services in Title X clinics (30% from 2007 to 2010)
- Large increase in the use of LARCs (mostly substitution from the pill but also additional use)
- Large reductions in population fertility rates after the program was implement, **about 40%** [!!]
- Initial results received **a lot** of press coverage

Contraception use ages 15-19



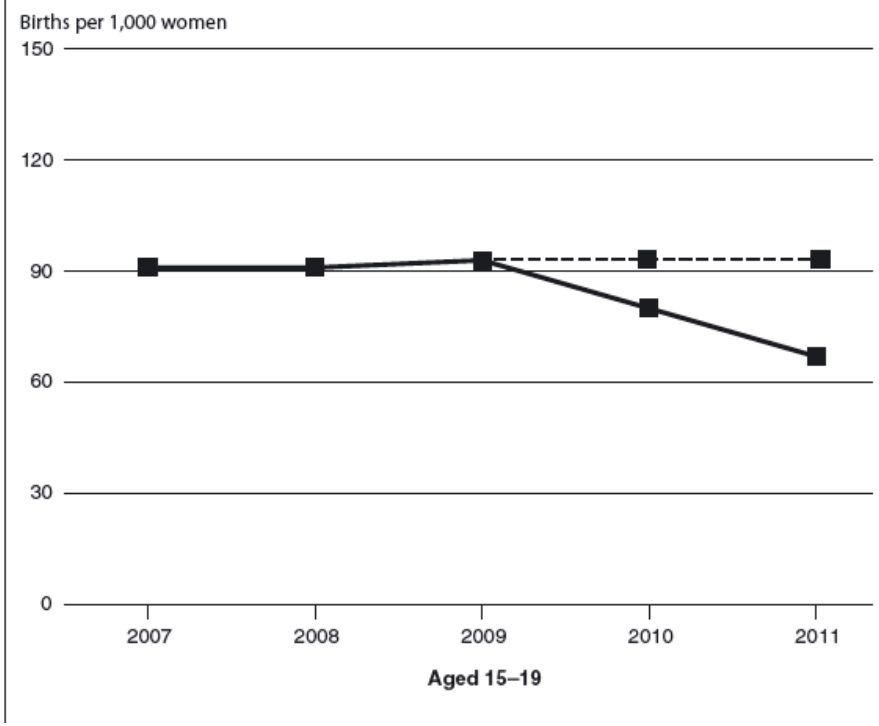
Contraception use ages 20-24



Initial results

- Ricketts et al. (2014) published initial results using Medicaid data. The numbers looked impressive (about 40% decline) but the internal validity is not good

FIGURE 1. Observed and expected age-specific fertility rates among low-income women in counties with clinics receiving Colorado Family Planning Initiative funding, 2007–2011



Funds running out

- Money from the donor was running out. CDPHE asked CO legislators for funding given the success of the program
- They said no. Why? Well, you know that contraception is controversial in politics
- CDPHE managed to get the support of over dozen foundations to keep the program going
- They also wanted to do a study on cost savings resulting from the initiative
- They thought that cost savings could be a stronger argument in favor of the program

Study objectives

- What is the causal impact of the CFPI (and related programs) on birth rates taking into account concurrent changes?
  - A major economic recession
  - Increase in LARC use across the country
  - Declining fertility rates
  - Lindo and Packman (2017) found a 6.4 decline for **teens**. Bulk of Title X clinics in CO are between 15-24
- What is the impact of the initiative on Medicaid averted spending? What is the impact of the initiative on other social programs?
  - Prenatal, delivery, and post-delivery spending
  - Infant care
  - Time horizon: 5 years. Perspective: Medicaid (C0+Federal)

Big picture before you get lost

- Before we get into more details it's helpful to stop and consider the pieces we need to estimate savings

  1) We need to estimate the **number of births averted** due to the program. This is by far the most important part. We do know a priori that the program worked, but how many births were averted?

  2) Once we have the number of births averted **we need to estimate how many mothers/infants would have been eligible for each of the programs**. Not so trivial:

  - We have the number of births averted. But how many pregnancies would have ended in abortions? Miscarriages? Are all the women/infants eligible? What's the rate?

  3) **We need costs**. We know the number of mothers who would have been eligible for prenatal care. How much does Medicaid pay for prenatal care? How much does Medicaid pay for infant care? In the first year? The second?

Framing the study in terms of our class

- We are comparing CFPI with "usual care" in Colorado. But as we saw in the chapter about assessment, usual care can be very tricky
- In the Ricketts et al. (2014) study, the underlying assumption is that **nothing would have happened** without the CFPI. Fertility rates would have been the same
- But what is the right comparison? Usual care is the comparison but you have to take into account that fertility rates would have changed anyway because of the recession, the increases in LARC use in the country, and other demographic changes
- **The right comparison is the counterfactual**: What would have happened in Colorado had the CFPI never happened? (Think about George Bailey in "It's a Wonderful Life")
- The other features are the perspective and time horizon. For the time horizon, we were constrained by data

Data

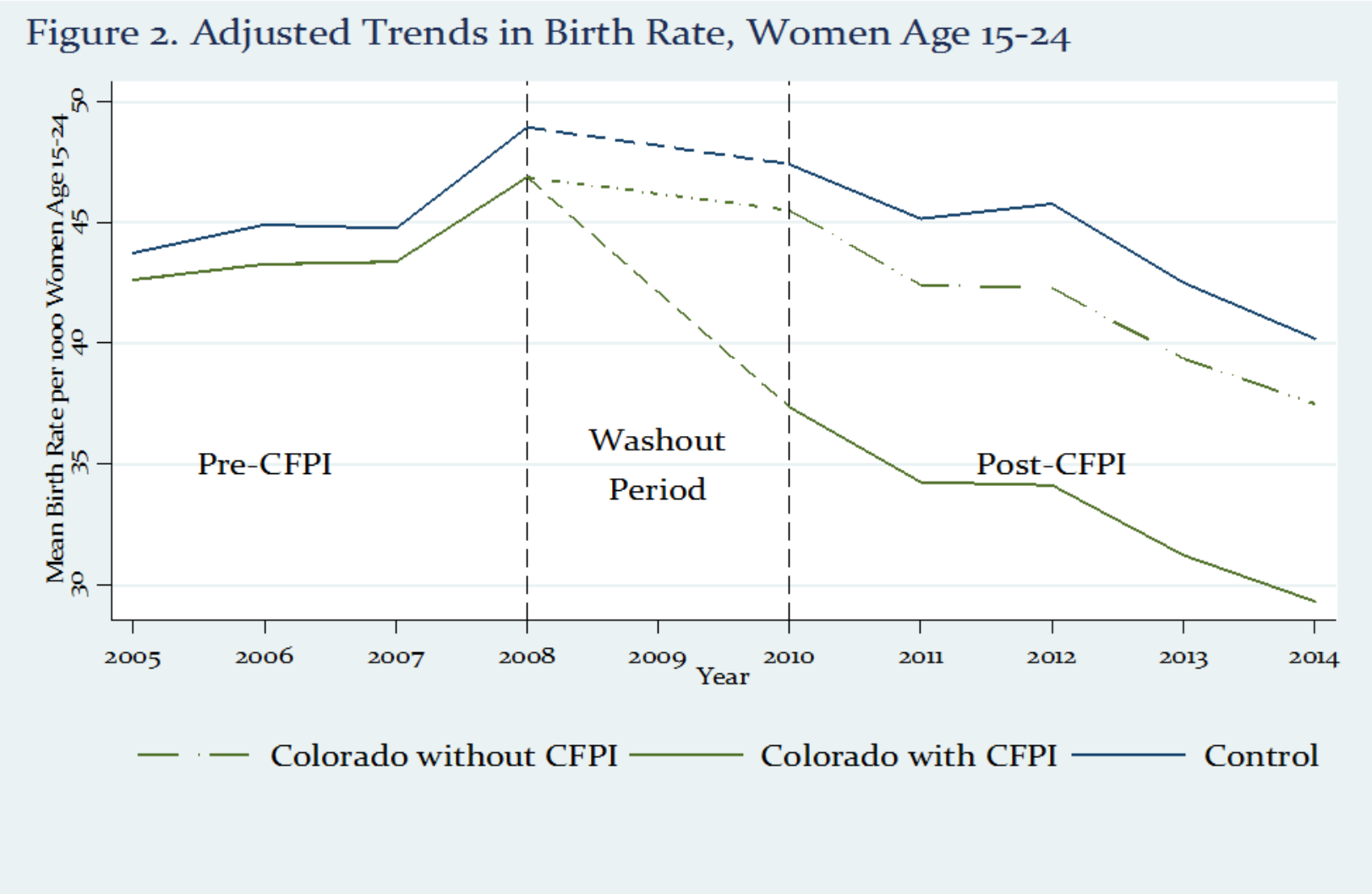
- Birth certificates data from the National Vital Statistics System at the Center for Disease Control and Prevention (2005 to 2014)
  - Number of births per year
  - Age at birth
  - County identifier
- Area Health Resource File (AHRF) at county level
  - Demographic characteristics
  - Educational attainment
  - Income
  - Unemployment
- iCare dataset (information on Title X clinic clients)
  - Number of women directly affected by the initiative
- Data from every social program evaluated (more on this later). For example, Medicaid claims for **payments**

Methods to estimate program effects

- Propensity score weighted difference-in-difference models comparing Colorado counties to other counties in the US that did not experience similar interventions (Iowa and Missouri)
- It may sound sophisticated/complicated/esoteric but it's actually a very simple idea. Compare fertility rates before and after CFPI in Colorado to fertility rates before and after in **comparable counties**. The propensity score part helps you with the "comparable counties" part
- Two important conditions for validity: pre-intervention parallel trends (can verify with data) and common shocks (need to argue since can't be verified with data but can control for some factors)
- Pre-period (2005-2008), "wash-out" period 2009, post-period (2010-2014). Had to restrict potential control counties using thresholds (total population, race, unemployment rate, % civilian population in labor force)

Results in pics

- Before and after trends



Results and Medicaid savings

- The difference-in-difference model showed a reduction of 8.15 births per 1000 population (or about 3,000 births) – this is about **half** the effect of the before/after comparison
- That's a population number. We needed an estimate of the number of women affected by the initiative. We used the number of women uninsured or eligible for public insurance using Title X clinics data
- Spending based on Medicaid claims data: a) prenatal care (240 days), b) childbirth, c) postpartum care (90 days), d) infant care
- Identified index hospitalization for delivery using Diagnostic Related Groups (DRGs)
- Used average spending to account for eligibility (for example, a mother who delivers but has no prenatal expenditure is included in the denominator)

Medicaid savings

Table 4. Average pregnancy-related Medicaid spending, mothers age 15-19 and 20-24, 2010-2014

Mother's Age	2010	2011	2012	2013	2014
15-19	$5,876	$6,311	$6,341	$6,658	$7,054
20-24	$6,167	$6,675	$6,780	$6,735	$7,066

Table 5. Average spending on all infants covered at delivery by Medicaid born to mothers ages 15-24, 2010-2014

Calendar\Birth Year:	2010	2011	2012	2013	2014
2010	$3,339				
2011	$1,644	$3,302			
2012	$1,367	$1,631	$3,547		
2013	$1,323	$1,409	$1,711	$3,855	
2014	$1,413	$1,499	$1,488	$1,790	$2,167
2015	$1,057	$1,132	$1,152	$1,291	$1,671

- Savings: **$40,842,945** (state and federal)

What about the other social programs?

- We were asked to calculate savings for these programs:
    1. Colorado Child Care Assistance Program (CCCAP)
    2. Colorado Housing Choice Voucher Program (Section 8) (CHCVP)
    3. Colorado Nurse Home Visitor Program (CNHVP)
    4. Colorado Preschool Program (CPP)
    5. Colorado Special Supplemental Nutrition Program for Women, Infants, and Children (WIC)
    6. Colorado Supplemental Nutrition Assistance Program (SNAP)
    7. Temporary Assistance to Needy Families (TANF/Colorado WORKS)
- The people in charge of these programs sometimes do not know the average cost per person
- But, these programs **cannot serve all the people in need** (some have wait lists). Only a very large reduction in births would affect these programs
- In the report these costs savings are called "potential savings" (not uncontroversial)

Example: Colorado House Choice Voucher Program (Section 8)

- The Housing Choice Voucher Program (formerly known as Section 8) provides access to safe, sanitary and affordable housing for low-income families, elderly and disabled individuals

"To estimate the potential impact of the CFPI... it is necessary to determine the **proportion** of mothers that would have been **eligible to apply** and the **probability that eligible mothers would actually receive** a voucher. Eligibility depends on a number of factors. Applicants must be 18 years of age or older, a US citizen or eligible immigrant, and must have legal capacity to enter into a lease under state and local law. In addition, applicants are subjected to income limits. In 2016, a family of 2 was required to have an annual income at or below $32,000, or about 200% of the Federal Poverty Level

Example: Colorado House Choice Voucher Program (Section 8)

... due perhaps to the low chances of obtaining benefits, **few eligible individuals apply** to the program. To estimate the probability that an individual obtains benefits in Colorado, we **assumed that low-income is the most important factor in determining eligibility**. Using 2015 Current Population Survey data, 1,585,900 individuals were at or below 200% FPL in Colorado, which translates into approximately 636,908 households, assuming an average of 2.49 individuals per household. Of these, 997 obtained a housing voucher through HCV in 2015 . Therefore, the probability that an income-eligible household obtains HCV benefits in Colorado is approximately 0.16%...

... In 2015, the **average total rental subsidy was $6,489**, with a **Federal contribution of 91.5%**.

A different method: simulations

- We also used a different method to estimate births averted: **Markov models**, or more technically correct, a **recursive decision tree** model
- The results were surprisingly similar
- You could repeat the analysis with the tools you'll learn in this class (after Spring break)
- The idea is simple: using the **actual number of women who visited Title X clinics**, simulate outcomes (pregnancies, abortions, miscarriages) under two scenarios using the **mix of contraceptives** used and their **failure rates**

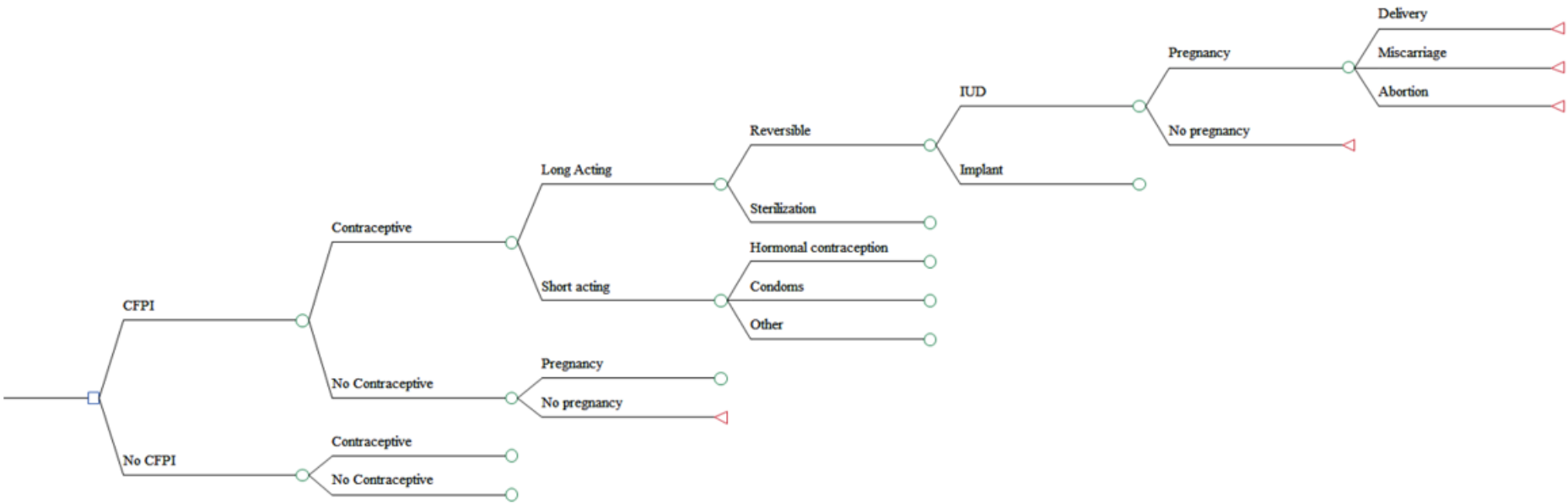
  1) The **observed scenario**: the CFPI took place and we observed the mix of contraceptives used in Title X clinics

  2) The **counterfactual scenario**: the CFPI did not take place. We assumed that the mix of contraceptives would have remained as before the 2009

- For a paper version we assumed that LARC use would have increased at the same rate as the average LARC usage in the country. Turns out it makes no difference

Decision tree inputs

Figure 1. Partial decision tree for Colorado Family Planning Initiative (CFPI) and no CFPI scenarios



All branches lead to the same outcomes: no-pregnancy and pregnancy, which may result in miscarriage, abortion, or delivery. The decision tree compares two scenarios: CFPI and no CFPI. Contraception decisions are repeated at the beginning of each year/cycle for a total of five cycles.

Decision tree

Table 1. Typical-use failure rates by type of contraceptive, age group, and data source

Method	Age 15-19	Age 20-24	Source
Condoms	17.8%	15.0%	Foster et al 2011
Diaphragm	18.9%	16.0%	Foster et al 2011
LARC			
IUD	0.8%	0.8%	Foster et al 2011
Implant	0.1%	0.1%	Foster et al 2011
Injectable	3.5%	3.0%	Foster et al 2011
Patch	9.4%	8.0%	Foster et al 2011
Pill	9.4%	8.0%	Foster et al 2011
Spermicide	34.3%	29.0%	Foster et al 2011
Sponge	12.0%	12.0%	Guttmacher Institute, 2015
Sterilization	0.5%	0.50%	Foster et al 2011
None	90.0%	85.0%	Foster et al 2011

End of the story with a happy ending

- The CO legislature gave CDPHE money to continue the program
- The cost of LARCS has decreased. The Susan Buffet foundation also funded the development of Liletta, a low cost IUD (for public clinics)

  "Liletta, which arrived in the clinic's inventory this summer, is a small device that manufacturers hope will make a big difference. Public clinics pay a wholesale price of $336 to $400 for each of the IUDs... Add in doctor's visits for placement and the total cost can exceed $1,000. Liletta's manufacturer hopes to see a wholesale price for public clinics as low as $50."

  `https://www.wired.com/story/liletta-the-iud-that-gives-women-options/`
- Liletta is about $800 in pharmacies

Now for something completely different...

"Cost Savings from Denver Health's Smoking Cessation Initiative due to Reductions in Hospitalizations from Acute Myocardial Infarction and Stroke"

- Denver Health (Denver Health and Hospital Authority's, really) is a "safety net" hospital. The majority of DHHA patients have government insurance or are uninsured. DHHA also houses Denver Public Health (DPH), Denver County's local public health department
- They have a large STD clinic and and an immunization clinic that you have probably visited if you needed vaccines to travel to exotic places
- DH implemented system-wide smoking cessation initiative starting in 2012 following the award of Amendment 35 funding

Lots of changes

- The list of changes is very large, from creating a smoke-free campus and enforcement to changing their referral systems so patients could be more efficiently referred to smoking cessation programs
- It was also a cultural change for the organization to make smoking cessation a priority
- Trained community partners in different aspects of "Ask, Advise, Refer"
- CDPHE wanted to evaluated the program. We proposed a quantitative analysis of program effects (outcomes) and a qualitative study to better understand **what** worked
- The quantitative portion could tell us if there was an effect but not which of the many things they did worked ("mixed methods")
- **If there was actually an effect, they asked us to estimate cost savings**

Research questions

- **Did the changes at Denver Health cause a reduction in the prevalence of smoking among their clients?**
  - No randomized experiment the word "cause" is problematic
- **If there was a reduction in smoking prevalence, what were the cost savings?**
  - **Perspective**: A "health system" that bears the costs of events
  - **Time horizon**: short-term (five years)
  - Focus on most salient effects: Acute myocardial infarction and stroke

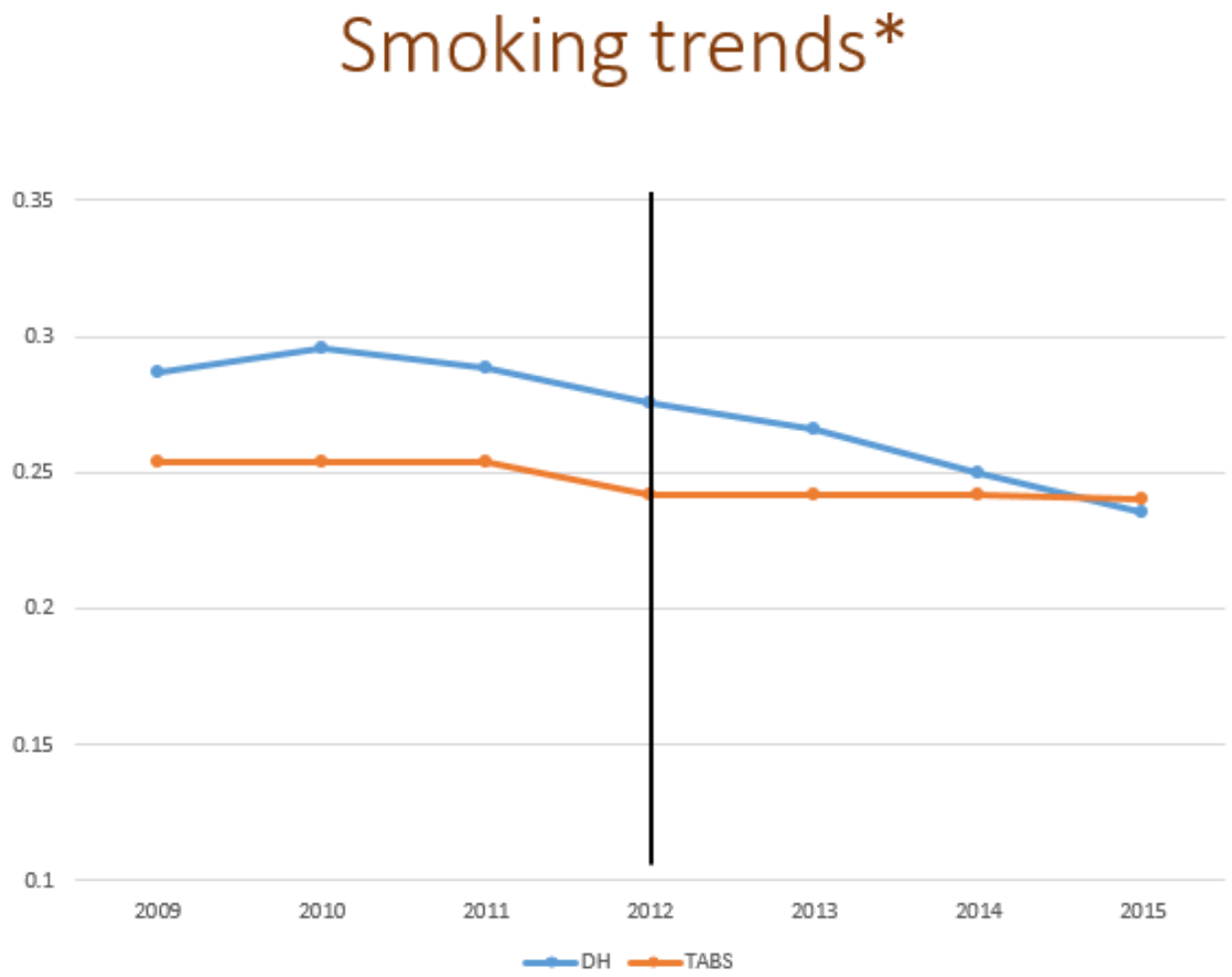
Methods

- A simple comparison of smoking prevalence before and after could provide some evidence, but what if other changes in CO were driving changes in smoking prevalence? [Sounds familiar?]
- Same method as CFPI: difference-in-difference research design
- We compare trends in smoking prevalence before and after 2012 (pre-period; 2009-2011) in DH to trends in CO before and after 2012 (post-period; 2012-2015)
- Ideally, the "control" population is similar to DH patients
- It was very difficult to come up with the comparison and difficult to get the right data (with lots of false starts)

Data

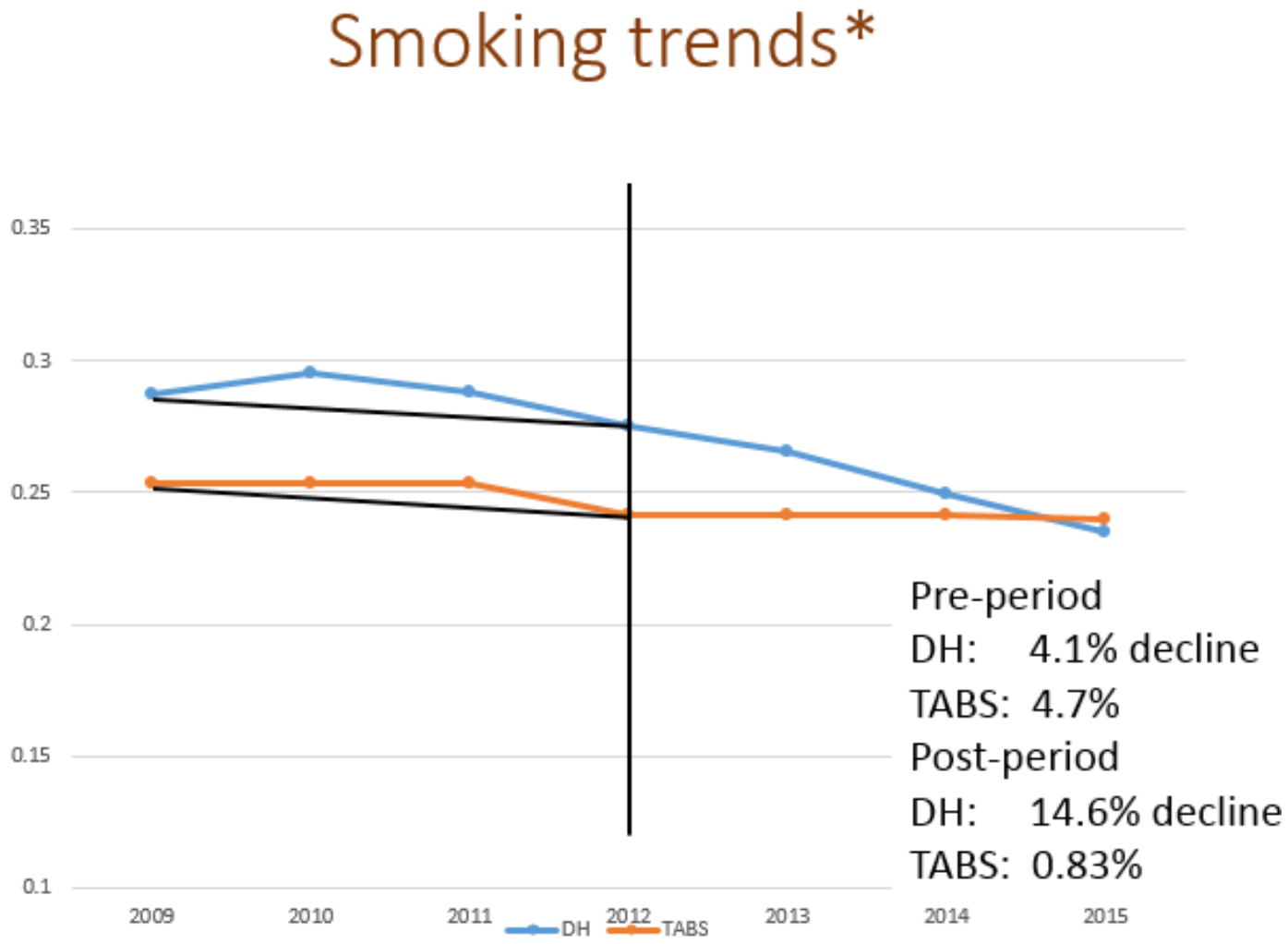
- All DH ambulatory visits extracted from EHR (2009-2015) for adults 18 or older (Lifetime Clinical Record) – 987,252 visits for 132,964 patients
- Control group: Survey data from the Attitudes and Behaviors Surveys on Health (TABS) for years 2008, 2012, 2015
  - Sample restricted to Colorado adults 18 or older
  - Self-reported income at or below 200
  - Excluded individuals with private insurance, covered by DH plan
  - To avoid spillover effects, excluded Denver county residents
- Ascertained smoking status in both datasets (smoking or not)

Results



* Unadjusted

Results



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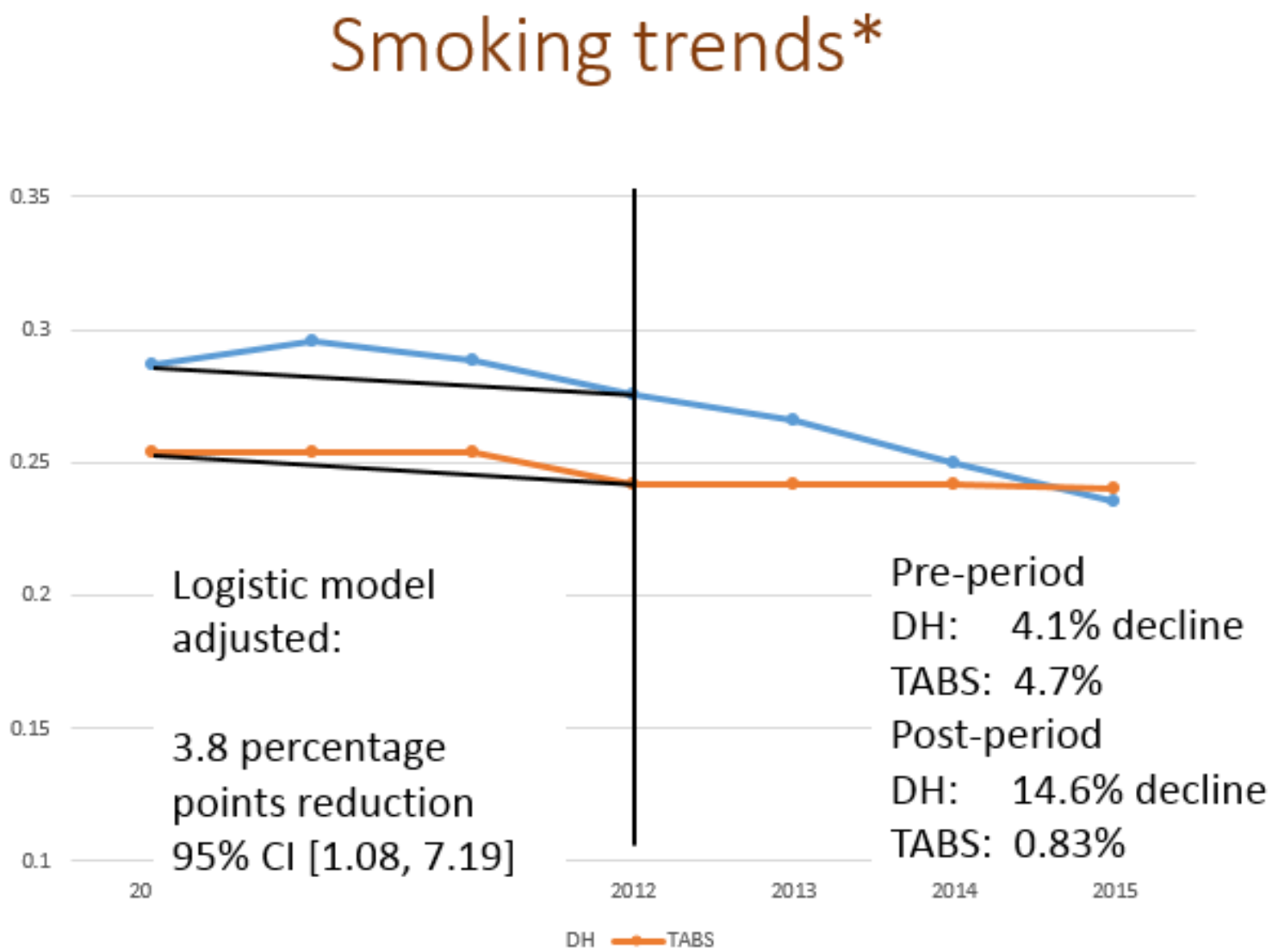
Results


Smoking trends*
0.35
0.3
0.25
0.2
0.15
0.1
20
2012
2013
2014
2015
DH
TABS
Logistic model adjusted:
3.8 percentage points reduction
95% CI [1.08, 7.19]
Pre-period
DH: 4.1% decline
TABS: 4.7%
Post-period
DH: 14.6% decline
TABS: 0.83%

From prevalence to events

- Key issue: how do we translate reductions in the prevalence of smoking into clinical events?
- Systematic literature review of papers on short-term cardiovascular health outcomes following a reduction in smoking using PubMed for the period 1990 to 2017 (US and international)
- Most articles focus on AMI and stroke. We followed Lightwood et al. (1999), Asay et al. (2017) and Hurley (2005)
- These papers reviewed literature on reductions in the relative risk of AMI and stroke after quitting smoking
- Bottom line: We combined **relative risks**, **hospitalization rates**, and the **number of patients affected** to translate reductions in the prevalence of smoking into cardiovascular events that can be valued

Some details without much goriness

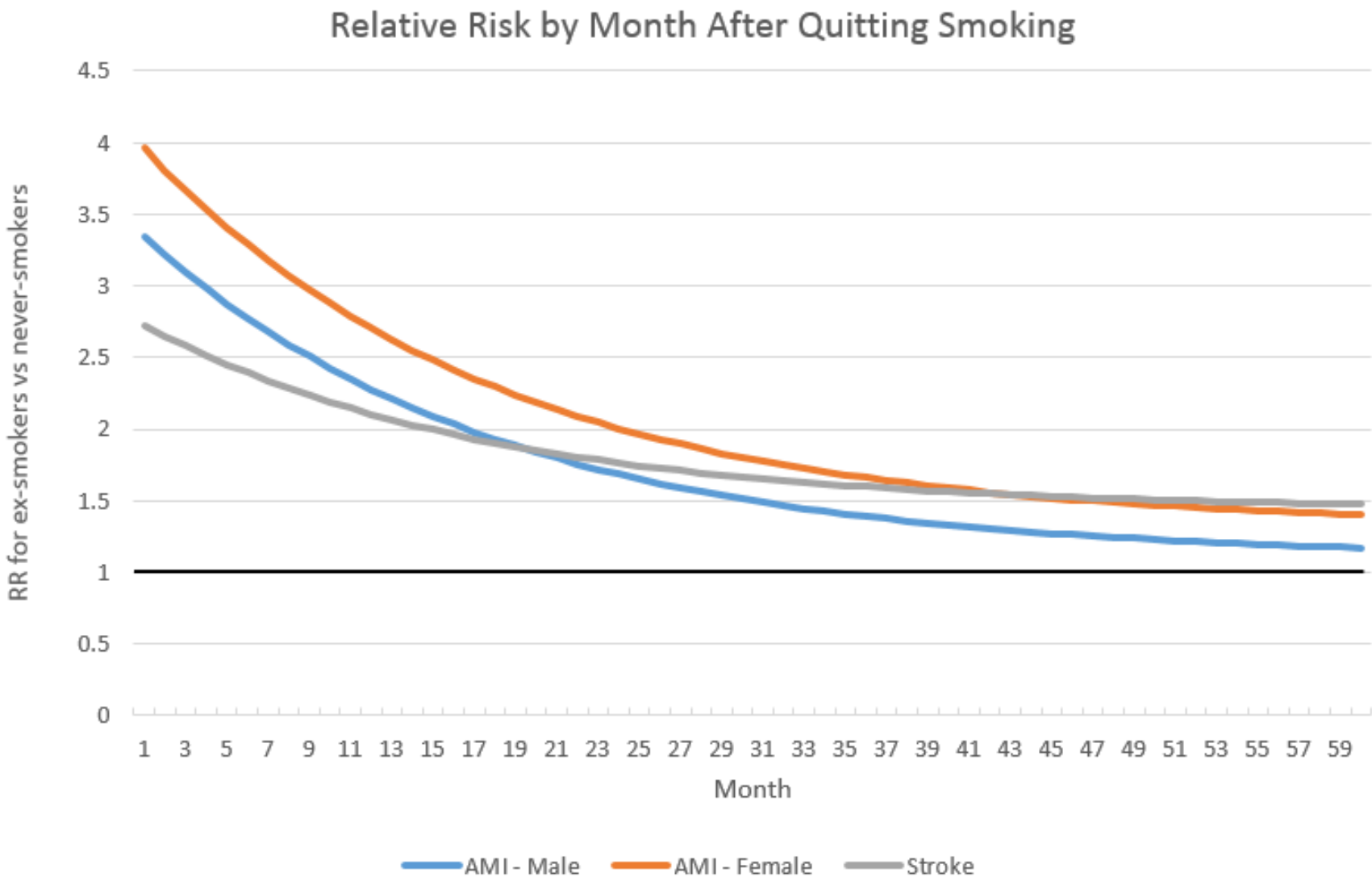
- Most of this research assume an exponential decay function :

For stroke, the relative risk for ex-smokers versus never-smokers a time t, RR(t), is given by:

$$RR(t) = (RRo - RRoo)*e^{(-t/T)} + RRoo \quad \text{Equation (1)},$$

where RRo is the relative risk of current smokers versus never-smokers, RRoo is the relative risk of long-term ex-smokers compared to never-smokers, t is time in months, and T is a parameter that determines how quickly the relative risk decreases since time from quitting. The speed of the decline is given by the

Some details without much goriness



Some details without much goriness

Table 1. Number of clinic visits and unique patients by year

Year	Visits	Unique patients
2012	416,543	128,731
2013	406,117	128,876
2014	459,764	139,826
2015	488,076	147,769

Note: Data provided by Denver Health.

Table 2. Parameters to estimate relative risk for ex-smokers vs never-smokers by month

Description	**Variable**	**AMI**	**Stroke**
Relative risk current smoker vs never smoker	RRo	3.48	2.804
Relative risk long-term smoker versus never smoker	RRoo	1.101	1.438
Female addition for RRo	RRoF	0.637	
Female addition for RRoo	RRooF	0.218	
T		17.078	16.705

Note: Parameters based on literature review, Hurley [22] and Lightwood, Phibbs [6]. Equations 1 and 2 are used in conjunction with these parameters.

Table 3. Parameters to estimate hospitalization rates and hospitalizations avoided

Description	**Variable**	**Stroke**	**AMI Male**	**AMI Female**
Proportion of smokers[1]	Ps	0.2754	0.2754	0.2754
Proportion ex smokers[1]	Pf	0.3219	0.3219	0.3219
Relative risk current[2]	RRo	2.804	3.48	4.117
Relative risk ex-smoker[2]	RRoo	1.438	1.101	1.319
Incidence in population[3]	Ro	0.001054	0.002938	0.001272
Proportion of quitters[4]	q	0.038	0.038	0.038
Number current smokers[5]	Ncs	36,838	18,419	18,419

Notes: 1. Obtained from Denver Health's EHR data; 2. Obtained from Hurley [22] and Lightwood, Phibbs [6]; 3. Obtained from https://www.colorado.gov/pacific/coepht/heart-attack-data for state-wide hospitalization rates for the year 2015. Stroke hospitalization rates are extrapolated as a proportion of AMI rates for males based on Hurley [22]; 4. Obtained from difference-in-difference model (Figure 1; 5. Based on Table 1 estimates of the Denver Health population.

Costs

- Over 5 years, a total of 178 AMI and 97 stroke hospitalizations were prevented
- The last step is to translate hospitalization averted into costs averted
- We used data from the Health Care Cost and Utilization Project (HCUP) as reported by HCUPnet [sounds familiar??]
- HCUPnet is based on data from national community hospitals, defined as short-term, non-federal, general and other hospitals, excluding hospital units of other institutions (e.g. prisons)
- Obtained costs using ICD-9 codes: AMI $20,246. Stroke: $15,068 (in 2014 dollars)
- We used costs, which are based on CMS cost-to-charge ratios

Results

- Over 5 years, DH initiatives resulted in about $5,070,912 in savings
- 95% CI [$1,441,207 – $9,594,700]
- Relatively wide confidence interval reflects uncertainly in the control data (smaller samples)
- So why not use Denver Health costs? What if we did a study from the perspective of Denver Health?

Results

- We do not consider the economic value of health improvements (not a cost effectiveness study). We do consider resources saved because of system-wide changes
- We focus on AMI and strokes but there are other health benefits that are important, like COPD and lung cancer
- Short-term study
- Study with a lot of uncertainty. For sure the estimate of treatment effects is not extremely solid

Summary

- Cost savings studies are important because costs in health care are high
- Finding interventions that save money while keeping health outcomes the same or better can certainly help budgets
- But cost savings are a partial evaluations and we, as a society, **should not assume/expect that programs that save money are the only programs worth funding**
- Economic evaluations always require thinking about every possible detail
- Lots of assumptions but that's part of any research project