What happens when health screenings are subsidized? Evidence from biennial subsidies in South Korea

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Motivation

- What is a health screening?
  - Medical tests for **asymptomatic** people to check for diseases
  - Some diseases require early treatment before symptoms appear
  - Early diagnosis (before symptoms) $\Rightarrow$ early treatment $\Rightarrow$ mortality $\downarrow$ health care costs $\downarrow$
- Do health screenings work?
  - Cutler (2008): biggest and cost-effective contribution to the war on cancer in US
  - Clinical RCTs: diagnoses $\uparrow$, but limited impact on mortality (Krogsbøll et al., 2012; Kowalski, 2023)
- Mismatch between intended and actual participants
  - The goal is to find sick people among seemingly healthy (asymptomatic) people
  - Ideal target is those who might have a disease & do not yet know
  - Actual participants are healthier than nonparticipants (Bender et al., 2015; Jones et al., 2019)

Motivation

- Previous literature focus on screening guidelines
  - USPSTF provides screening guidelines with specific target
    - Mammogram starting age: 40↑ $\rightarrow$ [50, 74] $\rightarrow$ [40, 74]
  - Those who start to participate from 40 (compliers) are healthier than those who participate before 40 (always-takers) (Einav et al., 2020)

- Are there any other policies that better target unhealthy people?
  - Different treatment $\Rightarrow$ different selection
  - Screening subsidies from Korean National Health Screening Program
  - Relevance in the US context
    - NBCCEDP provides free screening for people with low income
    - ACA requires private health insurances to cover screenings with no cost-sharing
    - Einav et al. (2020) use data before the ACA

Research question

1. How do subsidies affect screening participation?
   - National Health Screening Program in Korea
   - Rich variation in subsidy schedules across screening types
2. Who responds to screening subsidies?
   - Health conditions
   - Socioeconomic status
   - Health behaviors
3. What is the effect of screening on health care utilizations and diagnoses?

Preview of results

1. Subsidies increase screening participation and generate spillover across individuals and types of screenings.

2. Compared to always-takers, compliers with screening subsidies are negatively selected on income and hence show worse health conditions.

3. Health screening increases first hospital visits for a new illness, a proxy for new diagnosis.

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Korean health screening program

- 3 types of screening covered by the National Health Insurance in Korea
  - General health screening
  - Cancer screenings (5 types)
  - Infant/children health screening
- General health screening
  - Most basic tests for health conditions
  - Measurement of height, weight, blood pressure, chest X-ray, dental test, blood test, uroscopy and health risk evaluation
- Cancer screening
  - Stomach cancer screening
  - Breast cancer screening
  - Cervical cancer screening
  - Liver cancer screening
  - Colorectal cancer screening

Screening subsidy criteria

- Biennial subsidy rule
  - Those born in even years can get subsidized screening in even years
  - Those born in odd years can get subsidized screening in odd years
- Eligible for subsidies during a calendar year when the age is even
  - Age = current year - birth year
  - No subsidy when age is odd
  - Subsidy eligibility switch on and off every year
  - Eligible once every two years
- Age cutoff
  - $Age \geq 40$: biennial subsidy
  - $Age < 40$: no subsidy

Variation in subsidy eligibility across screenings

	Biennial				Annual		No-subsidy	
	General	Stomach	Breast	Cervical	Liver	Colorectal	Lung	Prostate
Frequency	2 years	2 years	2 years	2 years	0.5 year	1 year		
Subsidy starting age	40	40	40	30	40	50		
Subsidy amount	100%	90%	90%	100%	90%	90%	0%	0%
Copay (**$**)	0	7	3.5	0	10	16	110	20

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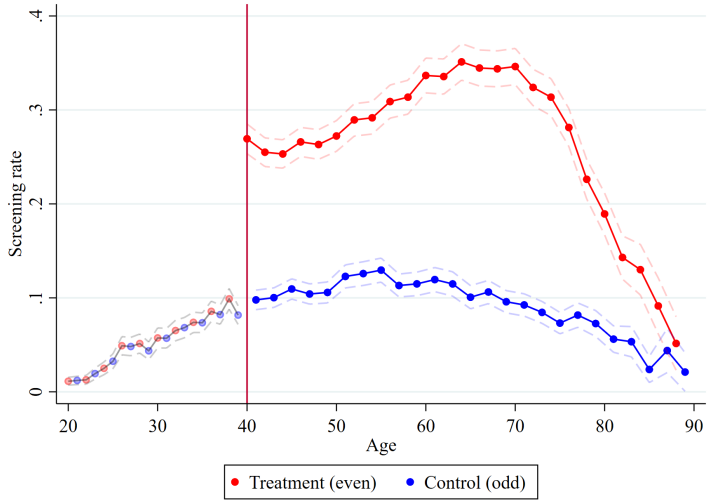
General health screening take-up by age



Imbalance between treatment and control group

- Comparison between even age vs odd age from age 40
  - Variation comes from year of birth
- Not balanced on age
  - Treatment group is younger than control group
  - Mechanical effect due to starting age 40
  - Imbalance on other covariates correlated with age
- Age is the only driver of imbalance between the two groups
  - Subsidy eligibility is random conditional on $f(age)$

Age distribution

Balance table: balanced conditional on f(age)

	(1)	(2)	(3)	(4)
	Treatment group	Control group	Unconditional difference	Conditional difference
Age	58.697	59.240	–0.543***	-
	(12.532)	(12.353)	(0.026)	-
Female	0.530	0.532	–0.002**	–0.002*
	(0.499)	(0.499)	(0.001)	(0.001)
Currently married	0.799	0.798	0.001	–0.001
	(0.401)	(0.402)	(0.001)	(0.001)
Years of education	10.320	10.227	0.093***	–0.003
	(4.510)	(4.538)	(0.009)	(0.008)
Working status	0.610	0.608	0.001	–0.003*
	(0.488)	(0.488)	(0.002)	(0.001)
Individual income	1446.3	1425.7	20.6***	2.8
	(2081.6)	(2068.1)	(5.5)	(5.2)
Household income	4104.4	4086.7	17.7	3.2
	(3708.6)	(3737.9)	(14.6)	(14.3)
Own a house	0.734	0.737	–0.002*	–0.000
	(0.442)	(0.441)	(0.001)	(0.001)
Number of household members	3.067	3.051	0.016***	–0.004
	(1.317)	(1.317)	(0.003)	(0.003)
N	54274	52909		
Share	(0.51)	(0.49)		
F(8, 15939)				1.65
				(0.10)

Identification strategy

- Econometric specification

$$y_{it} = \alpha + \gamma \cdot age\_even_{it} + f(age_{it}) + \varepsilon_{it} \quad (1)$$

  - Individual i in year t
  - Analytical sample: age $\in$ [40,89]
  - $f(age)$: linear splines with 5 years interval

- Using panel data
  - Research design only requires cross sectional data
  - New experiment every year with the same people
  - Panel used as pooled cross section
  - Standard error clustered at individual level

Data

- Korean health panel study dataset
  - Annual panel data from 2008 to 2018
  - Household level sampling (7000) / Individual level data (21,300)
  - Survey data collected through face-to-face interview (self-reported)
  - Information on
    - Demographic and SES
    - Health care usage
    - Health behaviors

- Health care usage (outpatient, inpatient, emergency)
  - Unit of observations: **every visit to a hospital**
  - Information
    - Date
    - Hospital bills, drug expenditures
    - Type of hospitals visited
    - Diagnosis (ICD-10)
    - First visit vs Recurring visit
    - Health screening records: screening type, tests performed, screening results, disease found

Data comparison Data collection

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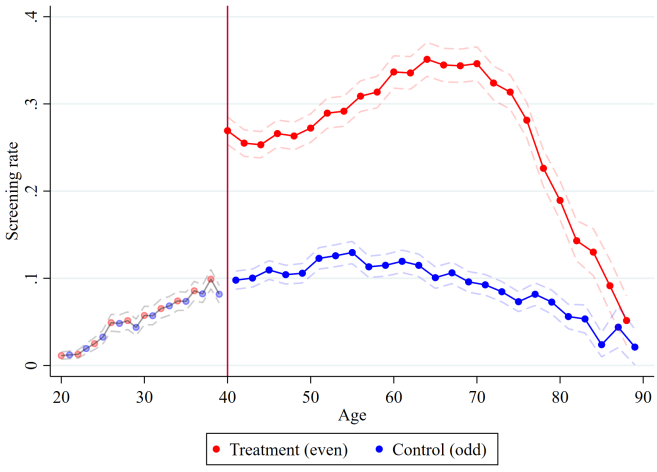
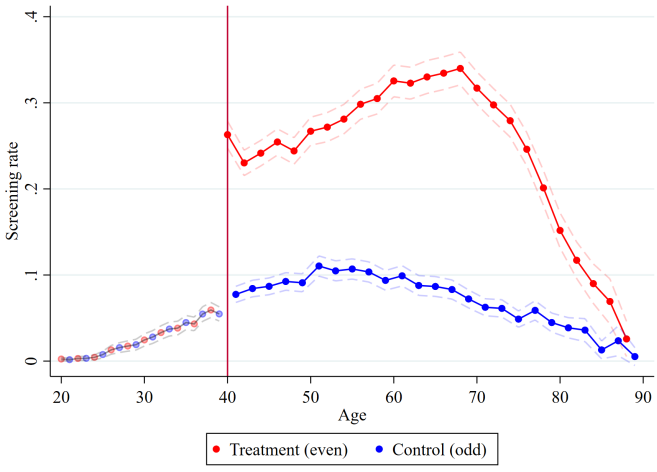
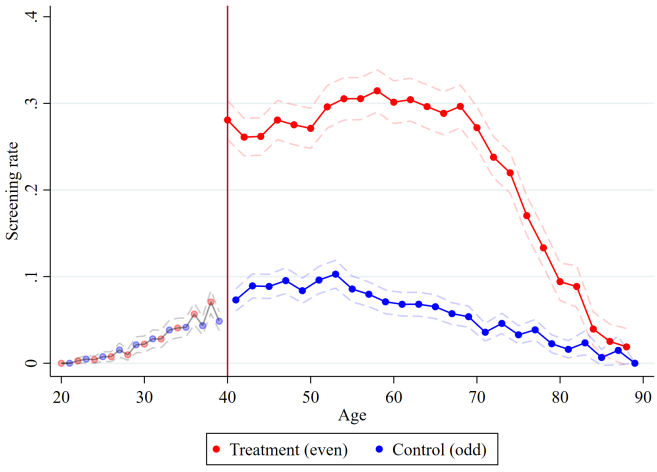
General screening - biennial subsidy



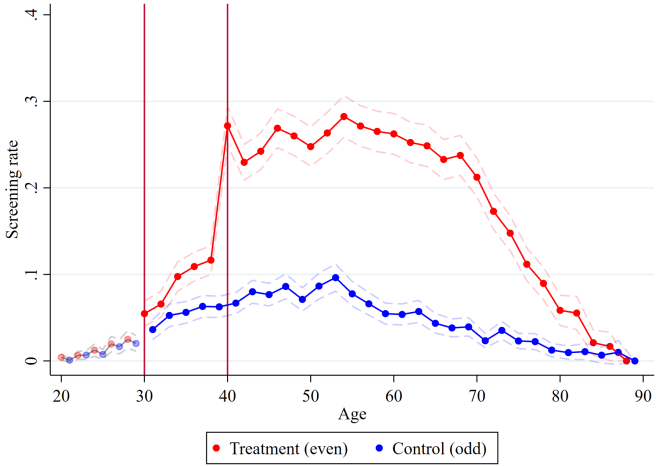
Stomach screening - biennial subsidy



Breast screening - biennial subsidy



Cervical screening - biennial subsidy



Negative spillover

First stage regression - biennial screenings

	(1)	(2)	(3)	(4)	(5)
	Any	General	Stomach	Breast	Cervical
Age even	0.204***	0.187***	0.189***	0.191***	0.164***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)
N	107183	107183	107183	56923	56923
Adj R^2	0.068	0.061	0.069	0.080	0.074
F-statistic	5022	4804	4835	2908	2520
Sample age range	[40, 89]	[40, 89]	[40, 89]	[40, 89]	[40, 89]
Subsidy starting age	40	40	40	40	30
Age controls	Y	Y	Y	Y	Y
Control group mean	0.121	0.102	0.082	0.067	0.055

Robustness Bounding

Intertemporal substitution

- Are subsidies increasing participation or reallocating screenings?
  - One can delay or get screening early to be eligible for subsidies
- Hard to disentangle the monetary incentive effect from substitution effect
  - Counterfactual: recommendation for biennial screening from age 40 but without subsidies
  - Using information around the age cutoff suggests limited substitution

  US mammogram | Already participating | Screening months
- Is it a problem?
  1. Estimating marginal increase in take-up per dollar spent $\Rightarrow$ Yes
  2. Characterizing who responds to subsidies $\Rightarrow$ No

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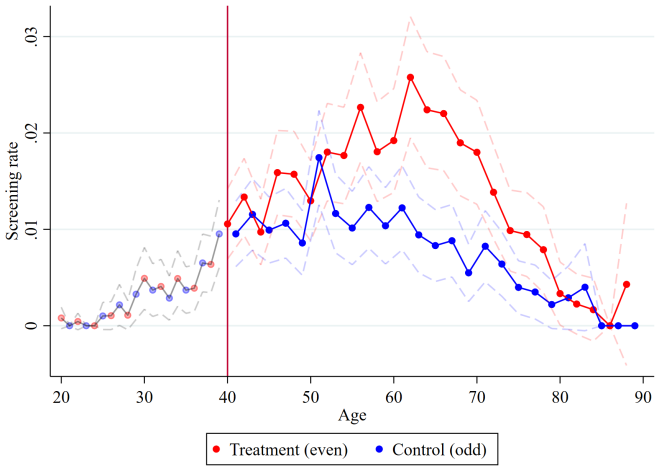
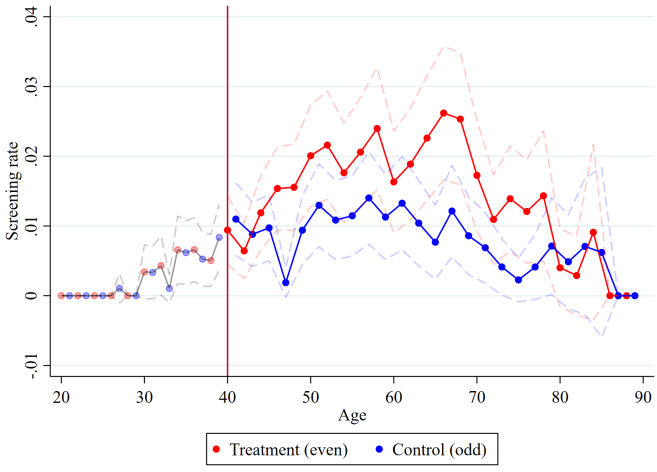
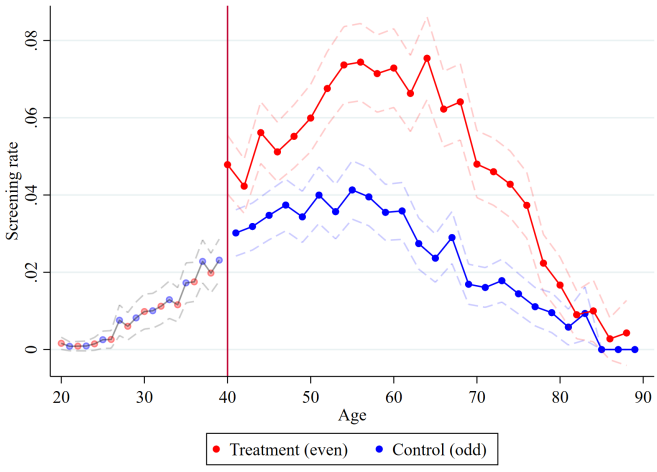
Lung screening - no-subsidy



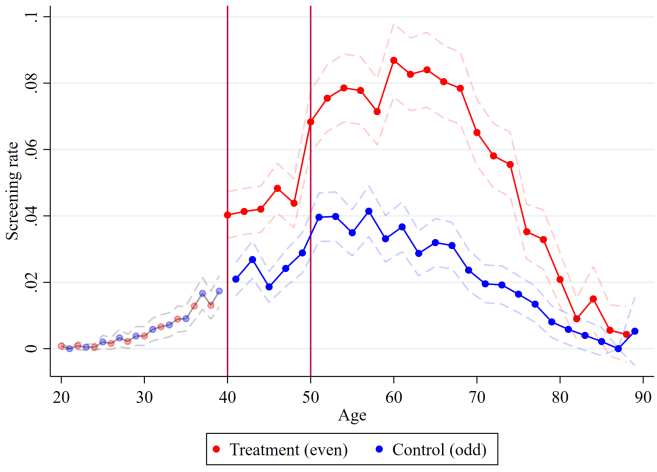
Prostate screening - no-subsidy



Liver screening - annual subsidy



Colorectal screening - annual subsidy



Positive inter-screening spillover

	(1)	(2)	(3)
	No subsidy		Annual subsidy
	Lung	Prostate	Colorectal
Panel A. ITT			
Age even	0.006***	0.007***	0.020***
	(0.001)	(0.001)	(0.002)
Panel B. LATE			
Biennial screening	0.031***	0.046***	0.115***
	(0.003)	(0.006)	(0.011)
N	107183	50260	31089
Sample age range	[40, 89]	[40, 89]	[40, 49]
Subsidy starting age			50
Age controls	Y	Y	Y
Control group mean	0.009	0.009	0.024

Robustness

Negative inter-screening spillover

	(1)	(2)	(3)
	Annual subsidy		Biennial subsidy
	Liver	Colorectal	Cervical
Age odd	–0.027***	–0.038***	
	(0.001)	(0.002)	
Age even			0.177***
			(0.006)
Age even × age < 40			–0.135***
			(0.008)
N	107183	76094	27714
Sample age range	[40, 89]	[50, 89]	[30, 49]
Subsidy starting age	40	50	30
Age controls	Y	Y	Y
Even group mean	0.055	0.066	

Robustness Cervical screening

Mechanisms

- People receive multiple screenings at each hospital visit
  - Fixed cost in hospital visit (e.g. travel cost, psychological toll, taking a day off)
  - Doctor's recommendation at general health screening

Share (multiple) Reg (multiple) Heterogeneity (gender)

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Spillover in take-up between spouses

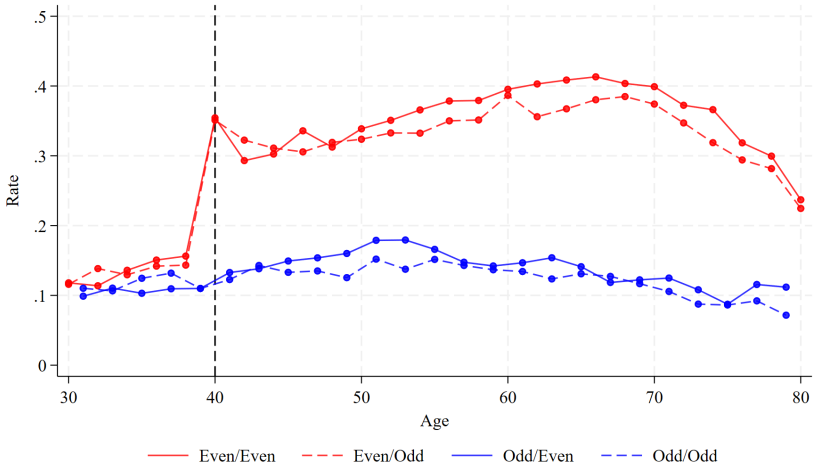
- Analytical sample
  - Dataset contains all the household members
  - Currently married people (50,863 couple pairs)
  - No age restrictions

- Econometric specification

$$y_{it} = \theta \cdot age\_even_{it} + \sigma \cdot spouse\_age\_even_{it} + \tau \cdot age\_even_{it} \times spouse\_age\_even_{it} + \phi_{it} \quad (2)$$

  - y_{it}: own screening take-up of individual i in year t
  - Standard error clustered at couple level
  - Variation comes from 4 types of couples with different subsidy compositions

Comparing between 4 types of couples



Spousal spillover in take-up

	(1)	(2)	(3)	(4)
	Outcome var: Own screening take-up			
Age even	0.181***	0.179***	0.179***	0.179***
	(0.005)	(0.005)	(0.003)	(0.003)
Spouse age even	0.012***	0.010***		
	(0.004)	(0.004)		
Age even	0.000	0.003		
× Spouse age even	(0.008)	(0.008)		
Spouse screening			0.068***	0.066***
			(0.018)	(0.018)
N	101726	101493	101726	101493
Odd/Odd group mean	0.123	0.123	0.123	0.123
Demographic controls		Y		Y
Estimator	OLS	OLS	2SLS	2SLS

In each screening

Mechanisms

- Direction of spillover: wife $\Rightarrow$ husband

  Direction

- Spouses are getting screening on the same day

  Share (same day) Reg (same day)

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Selection into screening

- Do subsidies induce participation of sicker people?
  - Need to compare those who participate without subsidies (always-takers) with those who participate in response to subsidies (compliers)
- Compliance groups (Angrist et al., 1996)

	Treatment (even age)	Control (odd age)
Always-takers	Yes	Yes
Compliers	Yes	No
Never-takers	No	No

  - Individual identification is generally not possible
  - Group characteristics can still be calculated
- 2 steps of characterization
  - Descriptive evidence by sample adjustment
  - Estimate characteristics with regression

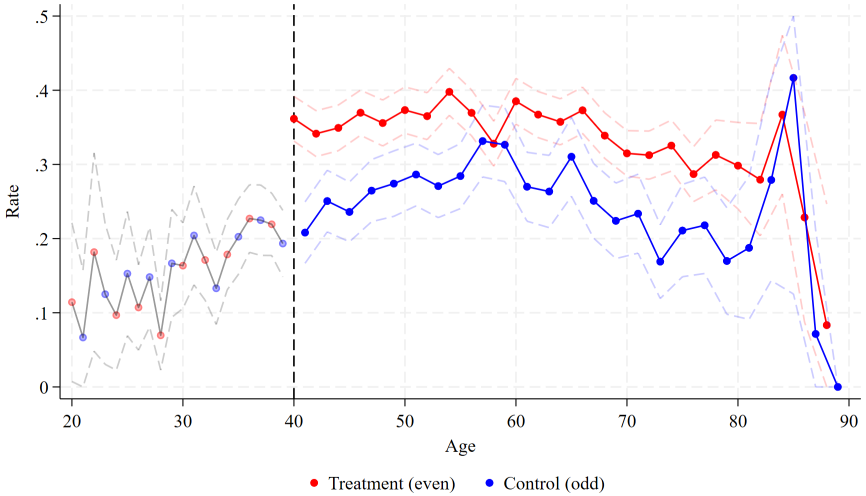
Compliers vs Always-takers

- Restrict the sample to screening participants

	Treatment (even age)	Control (odd age)
Always-takers	Yes	Yes
Compliers	Yes	No
Never-takers	No	No

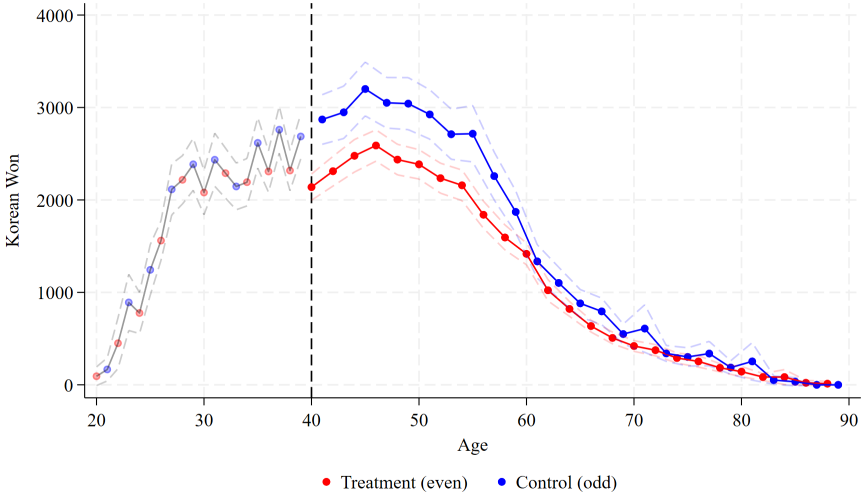
- Compare **average** characteristics between treatment and control
  - Always-takers have same mean in both groups conditional on age
  - Difference comes from compliers in the **treatment group**
  - Causal effects of screening cancel out

Compliers are more likely to be diagnosed with a disease than always-takers

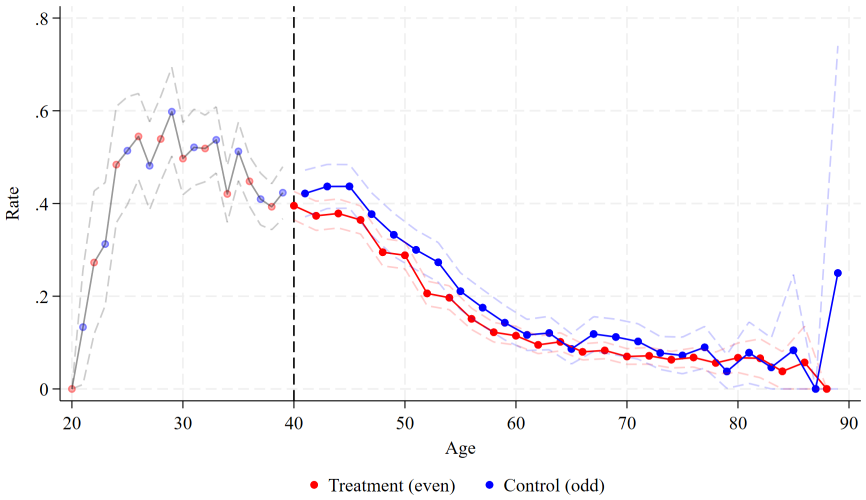


Einav et al. (2020)

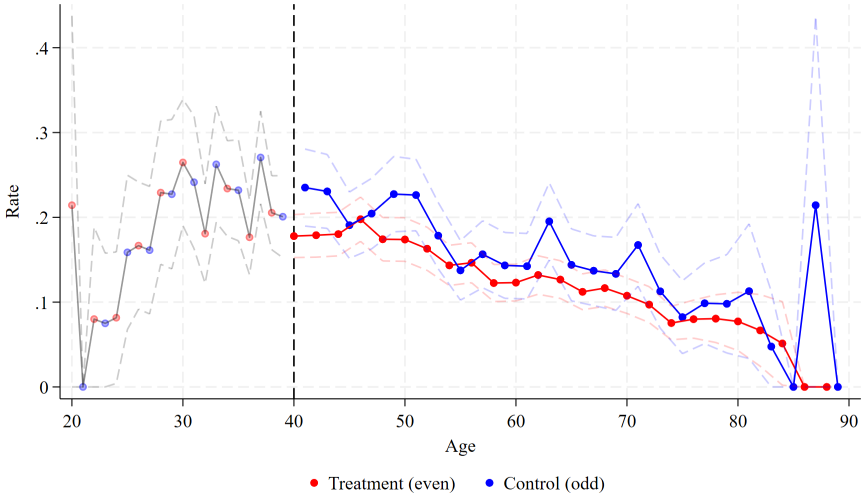
Compliers have lower individual income than always-takers



Compliers are less likely to be college graduate than always-takers



Compliers are less likely to be smokers than always-takers



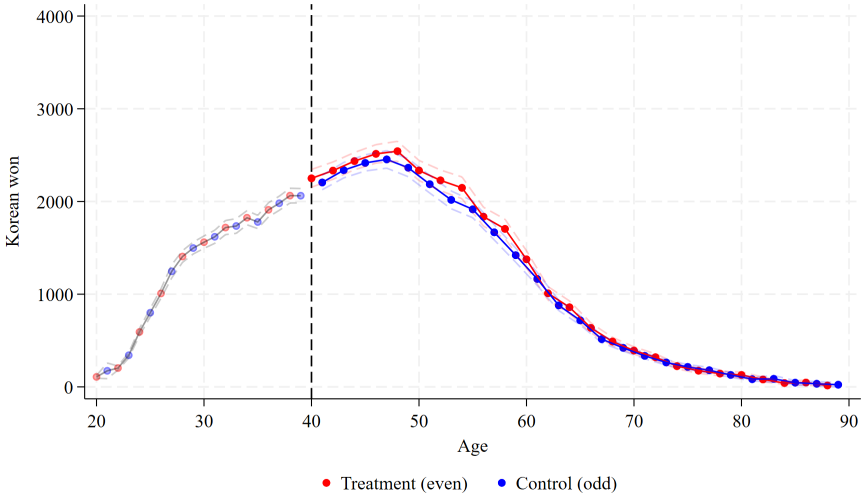
Compliers vs Never-takers

- Restrict the sample to screening non-participants

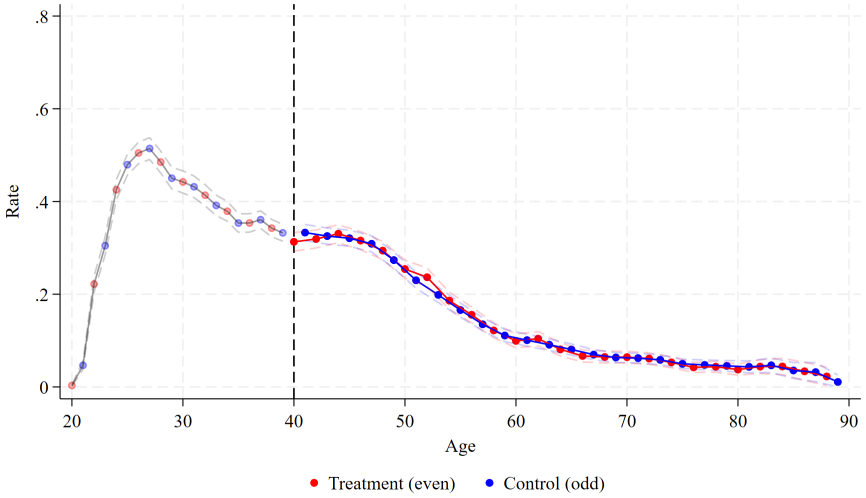
	Treatment (even age)	Control (odd age)
Always-takers	Yes	Yes
Compliers	Yes	No
Never-takers	No	No

- Compare **average** characteristics between treatment and control
  - Never-takers have the same mean in both groups conditional on age
  - Difference comes from compliers in the **control group**
  - No causal effects of screening

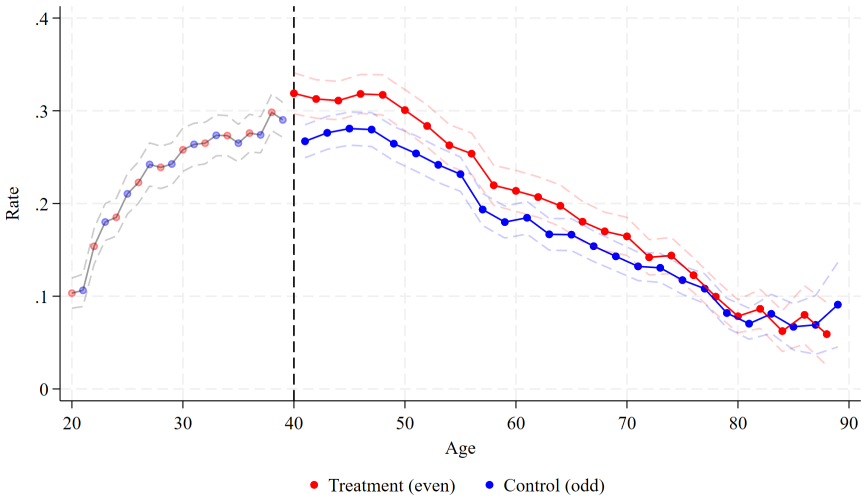
Compliers and never-takers have similar level of individual income



Compliers and never-takers are equally likely to be a college graduate



Compliers are less likely to be a smoker than never-takers



How can we more rigorously characterize compliers?

- We need to adjust for group shares when estimating characteristics
- 3 steps
  1. Estimate always- and never-takers characteristics (CIA assumption)
  2. Back out complier characteristics
  3. Compare compliers to always- and never-takers

	Treatment (even age)	Control (odd age)
Always-takers	Yes	Yes
Compliers	Yes	No
Never-takers	No	No

1. Estimate Always- and Never-takers characteristics

- Individually identifiable always- and never-takers

	Treatment group (even age)	Control group (odd age)
Always-takers	Yes	Yes
Compliers	Yes	No
Never-takers	No	No

- Estimating equation

$$y_{it} = \beta_1 age\_even_{it} + \beta_2 screen_{it} + \beta_3 age\_even_{it} \times screen_{it} + \beta_4 \times f(age_{it}) + \nu_{it} \quad (3)$$

- Average characteristics
  - Always-takers: $g_{AT}(y) = \hat{\beta}_2 + \hat{\beta}_4 \times f(age_{it})$
  - Never-takers: $g_{NT}(y) = \hat{\beta}_1 + \hat{\beta}_4 \times f(age_{it})$

2. Back out complier characteristics

- Treated compliers in the treatment group, untreated compliers in the control group

	Treatment group (even age)	Control group (odd age)
Always-takers	Yes	Yes
Compliers	Yes	No
Never-takers	No	No

- Estimating equation

$$y_{it} = \beta_1 age\_even_{it} + \beta_2 screen_{it} + \beta_3 age\_even_{it} \times screen_{it} + \beta_4 \times f(age_{it}) + \nu_{it} \quad (4)$$

- Those getting screened in the treatment group

$$\begin{aligned} g_T(y) &= \frac{\pi_{AT}}{\pi_{AT} + \pi_C} g_{AT}(y) + \frac{\pi_C}{\pi_{AT} + \pi_C} g_C^1(y) \\ &= \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3 + \hat{\beta}_4 \times f(age_{it}) \end{aligned}$$

- Those not getting screened in the control group

$$\begin{aligned} g_U(y) &= \frac{\pi_{NT}}{\pi_{NT} + \pi_C} g_{NT}(y) + \frac{\pi_C}{\pi_{NT} + \pi_C} g_C^0(y) \\ &= \hat{\beta}_4 \times f(age_{it}) \end{aligned}$$

3. Compare compliers to always- and never-takers

- Taking ratios
  - Treated compliers to always-takers: $g_C^1(y)/g_{AT}(y)$
  - Untreated compliers to never-takers: $g_C^0(y)/g_{NT}(y)$

- Why differentiate between treated and untreated compliers?
  - Characteristics in the same year
  - Unclear pre-determined characteristics
  - Difference between treated and untreated complier characteristics = LATE

- Minor details in estimation
  - Age = 40
  - Standard error calculated with bootstrap clustered at individual level (500 replications)

Complier characteristics compared to always-takers

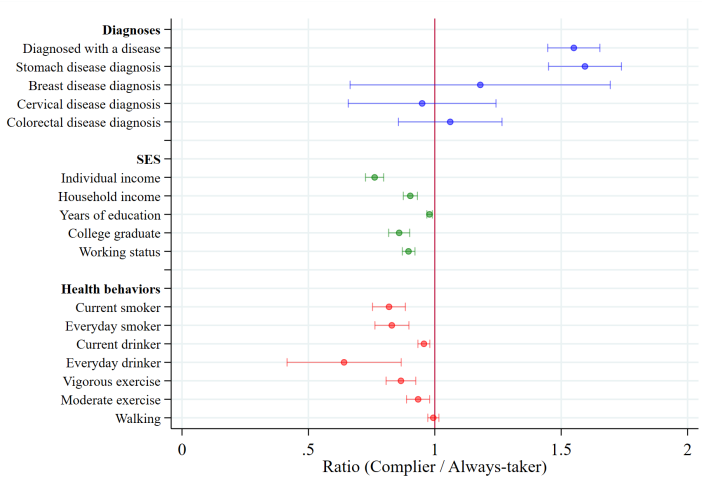


Table Screening results Medical tests Health care

Complier characteristics compared to never-takers

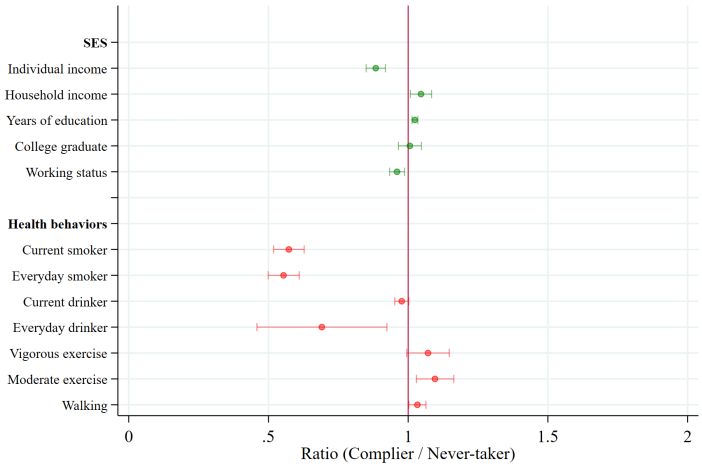


Table | Medical tests | Health care

Summary of complier characteristics

- Compliers vs Always-takers
  - Compliers are negatively selected on income
    $\Rightarrow$ Lower SES (income, edu)
    $\Rightarrow$ Worse health conditions
    $\Rightarrow$ Less likely to smoke, drink and exercise
- Compliers vs Never-takers
  - Compliers are positively selected on health behaviors
- Different treatment from Einav et al. (2020)
  - Einav et al. (2020): Mammogram starting age recommendation based on medical studies
  - This study: Subsidizing 90-100% of screening costs

    $\Rightarrow$ Evidence that subsidizing screening induces compliers who need screening more

Literature Einav et al. (2020)

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Effect of screening on diagnoses

- Does health screening lead to new diagnoses?
  - How to measure diagnoses
    - Health screening results
    - **Outpatient care data**
  - Number of first hospital visits for a new illness
    - ⇒ First visit vs recurring visit
    - ⇒ Diagnosis code (ICD-10)
- Two-stage least square estimation

$$y_{it} = \eta + \lambda \cdot screen_{it} + f(age_{it}) + \mu_{it} \tag{5}$$

  - $screen_{it}$ is instrumented by age_even_{it}
  - Standard error clustered at individual level
  - Westfall-Young adjusted p-values for multiple hypotheses testing (Jones et al., 2019)
  - Only capture short-run effect

Effect of screening on diagnoses

	(1)	(2)	(3)	(4)	(5)
	Control mean	ITT	LATE	Adjusted p-values	N
Panel A. Health care utilizations					
Outpatient visit	20.7796	0.0713	0.3494	0.886	107183
		(0.0757)	(0.3713)		
Inpatient visit	0.2329	0.0056	0.0272	0.702	107183
		(0.0039)	(0.0192)		
Emergency visit	0.1252	−0.0024	−0.0117	0.886	107183
		(0.0026)	(0.0127)		
Panel B. First outpatient visits					
First outpatient visit	3.9160	0.0607***	0.2976***	0.003	107183
		(0.0152)	(0.0747)		
First outpatient visit for a cancer	0.0160	0.0029***	0.0143***	0.123	107183
		(0.0011)	(0.0055)		
Stomach cancer	0.0023	0.0007	0.0037	0.675	107183
		(0.0004)	(0.0024)		
Breast cancer	0.0033	0.0016**	0.0086**	0.352	56923
		(0.0008)	(0.0042)		
Cervical cancer	0.0003	−0.0001	−0.0007	0.886	56923
		(0.0002)	(0.0009)		
Liver cancer	0.0009	0.0002	0.0071	0.886	107183
		(0.0003)	(0.0104)		
Colorectal cancer	0.0019	0.0005	0.0150	0.807	107183
		(0.0004)	(0.0126)		
Lung cancer	0.0020	0.00001	0.0011	0.988	107183
		(0.00042)	(0.0666)		
Prostate cancer	0.0032	−0.0011	−0.1525	0.675	50260
		(0.0007)	(0.0994)		

Effect of screening on short-term mortality

- National Vital Statistics death certificate data
  - All individual level deaths (1997-2017)
  - Death age
  - Cause of deaths
- Registered population data
  - Population for each age and year
- Reduced form regression

$$mort_{ay} = \nu + \omega \cdot age\_even_a + f(age_a) + \xi_{ay} \tag{6}$$

  - Mortality: number of deaths per 1,000 people
  - Weighted by population
  - Robust standard errors used
  - Short-term effect within at most 1 year

Effect of screening on short-term mortality

	(1)	(2)	(3)	(4)
	Total	Cancer	Cardiovascular	Other
Age even	0.035	0.007	0.008	0.020
	(0.169)	(0.036)	(0.064)	(0.081)
N	945	945	945	945
Age controls	Y	Y	Y	Y
Control group mean	20.053	6.684	6.684	6.684

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Conclusion

1. Biennial screening policy **raises screening rate** by 20%P from 12%.
2. There is **spillover in take-up** across different types of screening and between spouses.
3. Subsidizing screening induces **compliers negatively selected on income and health conditions** compared to always-takers.
4. Subsidizing screening **increases first hospital visits for new diseases.**

References

Angrist, J. D., Imbens, G. W., and Rubin, D. B. (1996). Identification of causal effects using instrumental variables. *Journal of the American statistical Association*, 91(434):444–455.

Bender, A. M., Jørgensen, T., and Pisinger, C. (2015). Is self-selection the main driver of positive interpretations of general health checks? the inter99 randomized trial. *Preventive medicine*, 81:42–48.

Cutler, D. M. (2008). Are we finally winning the war on cancer? *Journal of Economic Perspectives*, 22(4):3–26.

Einav, L., Finkelstein, A., Oostrom, T., Ostriker, A., and Williams, H. (2020). Screening and selection: The case of mammograms. *American Economic Review*, 110(12):3836–70.

Howard, D. H., Richardson, L. C., and Thorpe, K. E. (2009). Cancer screening and age in the united states and europe. *Health Affairs*, 28(6):1838–1847.

Jones, D., Molitor, D., and Reif, J. (2019). What do workplace wellness programs do? evidence from the illinois workplace wellness study. *The Quarterly Journal of Economics*, 134(4):1747–1791.

Kim, H. B., Lee, S. A., and Lim, W. (2019). Knowing is not half the battle: Impacts of information from the national health screening program in korea. *Journal of health economics*, 65:1–14.

Kim, H. B. and Lee, S.-m. (2017). When public health intervention is not successful: Cost sharing, crowd-out, and selection in korea's national cancer screening program. *Journal of health economics*, 53:100–116.

Kowalski, A. E. (2023). Behaviour within a clinical trial and implications for mammography guidelines. *The Review of Economic Studies*, 90(1):432–462.

Krogsbøll, L. T., Jørgensen, K. J., Larsen, C. G., and Gøtzsche, P. C. (2012). General health checks in adults for reducing morbidity and mortality from disease: Cochrane systematic review and meta-analysis. *Bmj*, 345.

Previous studies

- $>^{Kim}$: Kim and Lee (2017) $>^{Einav}$: Einav et al. (2020) $>^{Kw}$: Kowalski (2023)

	Always-takers	Compliers	Never-takers
Health conditions (Cancer incidence, all-cause mortality)		Kim > $Einav$ < $Park$	Kim > $Einav$ > Kw
Socioeconomic status (Income, education)		$Einav$ ≈ $Park$	$Einav$ > $Park$ ≈
Health Behaviors (Smoking, drinking)		Kw > $Einav$ ≈ $Park$	Kw > $Einav$ > $Park$

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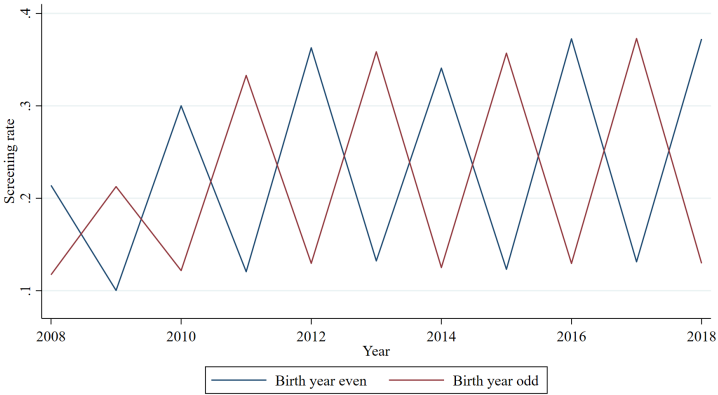
First stage by birth year



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Comparison with administrative dataset

	Health panel survey	Administrative panel
N / year	18,000	1,000,000
Used by		Kim and Lee (2017) Kim et al. (2019)
Unit of sampling	Household	Individual
Health behavior	Every year	Conditional on screening
First visit for an illness	Yes	No
Demographic & SES	Detailed	Limited

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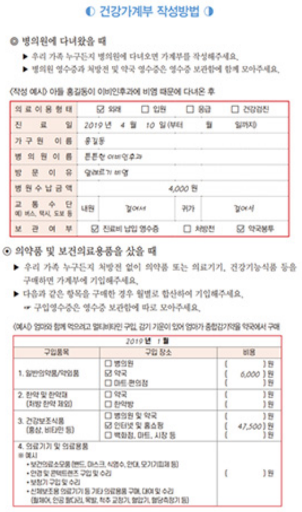
Health care usage data collection

- Recording health care usage
  - Survey participants are asked to keep health diary and store receipts from every visit to hospitals and pharmacies
- No gap
  - During annual interviews, enumerator goes through health diary from the last time of interview

Health diary



◐ 건강가계부 작성방법 ◑

◎ 병의원에 다녀왔을 때

- ▶ 우리 가족 누구든지 병의원에 다녀오면 가계부를 작성해주세요.
- ▶ 병의원 영수증과 처방전 및 약국 영수증은 영수증 보관함에 함께 모아주세요.

(작성 예시) 아들 홍길동이 이비인후과에 비염 때문에 다녀온 후

의료이용형태	☑ 외래 ☐ 입원 ☐ 응급 ☐ 건강검진			
진료일	2019 년 4 월 10 일(부터 월 일까지)			
가구원 이름	홍길동			
병의원 이름	튼튼한 이비인후과			
방문 이유	알레르기 비염			
병원수납금액	4,000 원			
교통수단 예) 버스, 택시, 도보 등	내원	걸어서	귀가	걸어서
보관 여부	☑ 진료비 납입 영수증 ☐ 처방전 ☑ 약국봉투			

◉ 의약품 및 보건의료용품을 샀을 때

- ▶ 우리 가족 누구든지 처방전 없이 의약품 또는 의료기기, 건강기능식품 등을 구매하면 가계부에 기입해주세요.
- ▶ 다음과 같은 항목을 구매한 경우 월별로 합산하여 기입해주세요.
  ☞ 구입영수증은 영수증 보관함에 따로 모아주세요.

(예시) 엄마와 함께 먹으려고 멀티비타민 구입, 감기 기운이 있어 엄마가 종합감기약을 약국에서 구매

2019년 1월		
구입품목	구입 장소	비용
1. 일반의약품/약외품	☐ 병의원 ☑ 약국 ☐ 마트·편의점	( )원 (6,000)원 ( )원
2. 한약 및 한약재 (처방 한약 제외)	☐ 약국 ☐ 한약방	( )원 ( )원
3. 건강보조식품 (홍삼, 비타민 등)	☐ 병의원 및 약국 ☑ 인터넷 및 홈쇼핑 ☐ 백화점, 마트, 시장 등	( )원 (47,500)원 ( )원
4. 의료기기 및 의료용품 ※ 예시 •보건의료소모품(밴드, 마스크, 식염수, 안대, 모기기피제 등) •안경 및 콘택트렌즈 구입 및 수리 •보청기 구입 및 수리 •신체보조용 의료기기 등 기타 의료용품 구매, 대여 및 수리 (휠체어, 인공 팔다리, 목발, 척추 교정기, 혈압기, 혈당측정기 등)		( )원

<How to write health diary>

- Visit to hospital
  - Record it for all the household members
  - Store hospital receipts, prescriptions and pharmacy receipts in a box

<Example> After a visit to ENT for allergy

Type	□Outpatient □Inpatient □ Emergency □ Screening			
Date	From: April 10, 2019 To:			
Name	John Doe			
Name of the hospital	Dr. Jane M. Doe, MD			
Purpose	Allergy			
Hospital bills	$40			
Transportation	To	Walking	From	Walking
Receipts	□ Hospital □ Prescription □ Pharmacy			

- Purchase of OTC drugs, oriental medicine, dietary supplements
  - Record it for all the household members
  - Store hospital receipts, prescriptions and pharmacy receipts in a box

<Example> Purchase of multivitamin and Tylenol

January 2019		
Item	Place	Cost
OTC drugs	□ Hospital □ Pharmacy □ CVS	{ } KRW { } KRW { } KRW
Oriental medicine	□ Pharmacy □ Acupuncture clinic	{ } KRW { } KRW
Dietary supplement (ginseng, vitamin, etc)	□ Hospital or pharmacy □ Internet shopping □ Department store	{ } KRW { } KRW { } KRW
Any other medical products (e.g.) - Bandage, mask, insect repellent - Glasses, contact lenses - Hearing aid		{ } KRW

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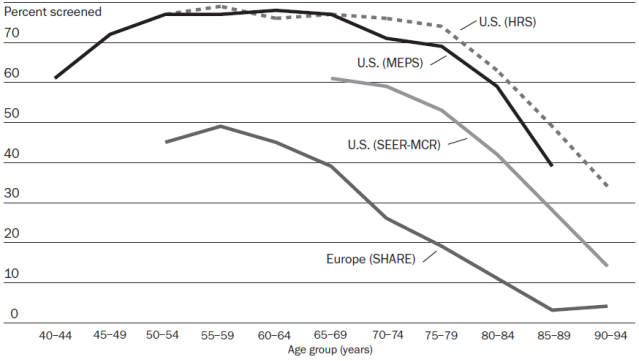
Breast screening in the US and Europe (Howard et al., 2009)

EXHIBIT 3
Receipt Of Mammography In The Past Two Years Among Women Ages 44–94 In Europe And The United States, By Age Group, 2004



SOURCES: U.S. screening rates are from the Medical Expenditure Panel Survey (MEPS), the Health and Retirement Study (HRS), and Surveillance, Epidemiology, and End Results (SEER)–Medicare data (SEER-MCR). European rates are from the Survey of Health, Ageing, and Retirement in Europe (SHARE).

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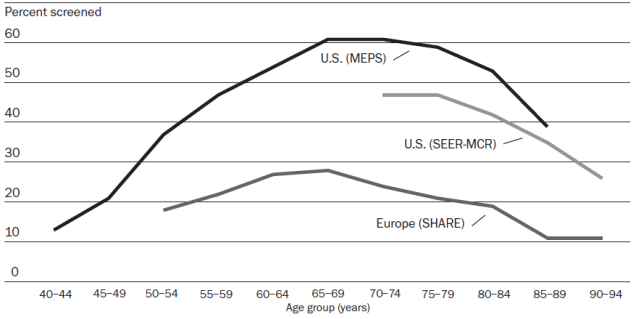
Colorectal screening in the US and Europe (Howard et al., 2009)

EXHIBIT 4
Receipt Of Colonoscopy, Sigmoidoscopy, And Fecal Occult Blood Tests Among Women And Men Ages 44–94 In The Past Ten Years In Europe And In The Past Five Years In The United States, By Age Group, 2004



SOURCES: U.S. screening rates are from the Medical Expenditure Panel Survey (MEPS); and Surveillance, Epidemiology, and End Results (SEER)–Medicare data (SEER-MCR). European rates are from the Survey of Health, Ageing, and Retirement in Europe (SHARE).

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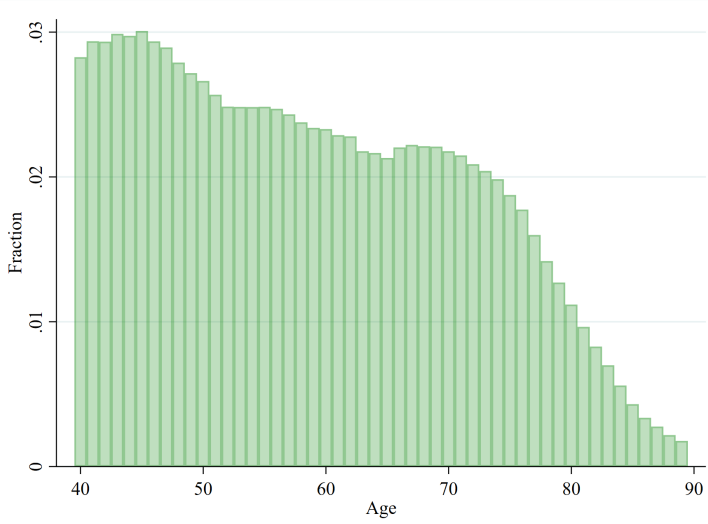
Age distribution for $age \in [40, 89]$



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Robustness: balance table

	(1)	(2)	(3)
	3 years	5 years	7 years
Female	–0.002*	–0.002*	–0.002*
	(0.001)	(0.001)	(0.001)
Currently married	–0.001*	–0.001	–0.001
	(0.001)	(0.001)	(0.001)
Years of education	–0.003	–0.003	–0.003
	(0.008)	(0.008)	(0.008)
Working status	–0.003**	–0.003*	–0.003*
	(0.002)	(0.001)	(0.001)
Individual income	1.1	2.8	1.2
	(5.3)	(5.2)	(5.2)
Household income	0.6	3.2	–4.5
	(15.4)	(14.3)	(14.1)
Own a house	–0.000	–0.000	0.000
	(0.001)	(0.001)	(0.001)
Number of household members	–0.004	–0.004	–0.004*
	(0.003)	(0.003)	(0.003)

back

Bounding: balance table

	(1)	(2)	(3)
	Age $\in$ [39, 89]	Age $\in$ [40, 89]	Age $\in$ [41, 89]
Age	0.521***	–0.543***	0.562***
	(0.026)	(0.026)	(0.025)
Female	–0.001	–0.002**	–0.001
	(0.001)	(0.001)	(0.001)
Currently married	–0.001	0.001	–0.002**
	(0.001)	(0.001)	(0.001)
Years of education	–0.094***	0.093***	–0.107***
	(0.009)	(0.009)	(0.010)
Working status	–0.006***	0.001	–0.007***
	(0.001)	(0.002)	(0.002)
Individual income	–16.235***	20.607***	–24.789***
	(5.470)	(5.508)	(5.618)
Household income	–23.153	17.735	–31.182**
	(14.766)	(14.555)	(14.995)
Own a house	0.003***	–0.002*	0.003**
	(0.001)	(0.001)	(0.001)
Number of household members	–0.027***	0.016***	–0.034***
	(0.003)	(0.003)	(0.003)
N	110121	107183	104153

back

Robustness: first stage

	(1)	(2)	(3)	(4)	(5)
	Any	General	Stomach	Breast	Cervical
Panel A. Linear splines of age					
Interval 3	0.204***	0.187***	0.189***	0.190***	0.163***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)
Interval 5	0.204***	0.187***	0.189***	0.191***	0.164***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)
Interval 7	0.204***	0.187***	0.189***	0.190***	0.164***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)
Panel B. Linear splines with 5 years interval plus additional covariates					
Full controls	0.204***	0.187***	0.190***	0.191***	0.164***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)
Individual FE	0.206***	0.189***	0.191***	0.192***	0.165***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)

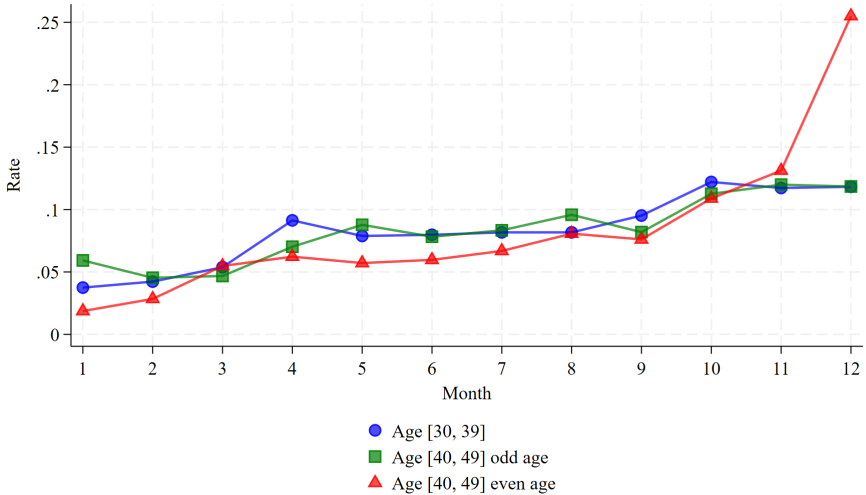
back

Bounding: first stage

	(1)	(2)	(3)
	Age $\in [39, 89]$	Age $\in [40, 89]$	Age $\in [41, 89]$
Any	0.205***	0.204***	0.204***
	(0.003)	(0.003)	(0.003)
General	0.187***	0.186***	0.188***
	(0.003)	(0.003)	(0.003)
Stomach	0.191***	0.189***	0.190***
	(0.003)	(0.003)	(0.003)
Breast	0.192***	0.191***	0.190***
	(0.003)	(0.004)	(0.004)
Cervical	0.165***	0.165***	0.162***
	(0.003)	(0.003)	(0.003)
N	110121	107183	104153

back

[Intertemporal substitution] Months of stomach screening for age [30, 49]



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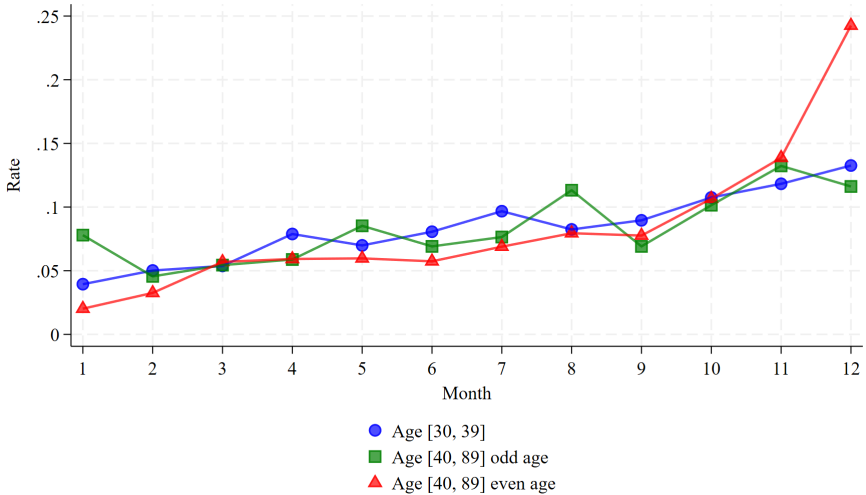
[Intertemporal substitution] Months of breast screening for age [30, 49]



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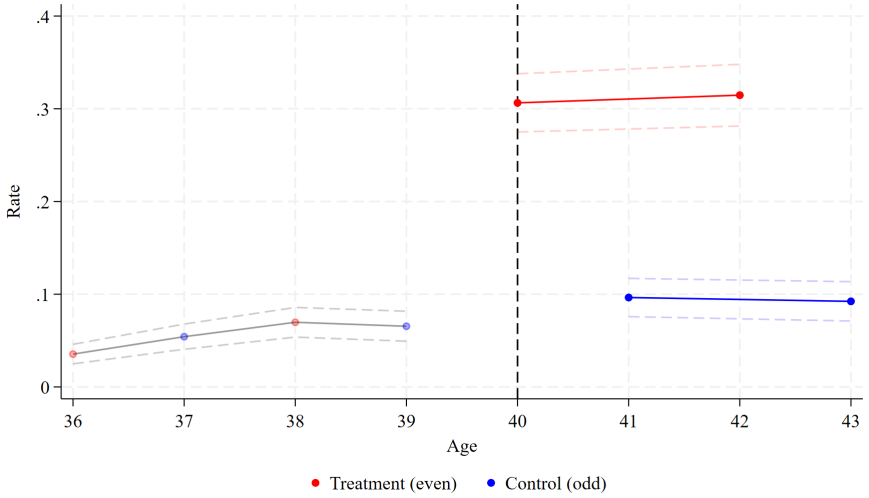
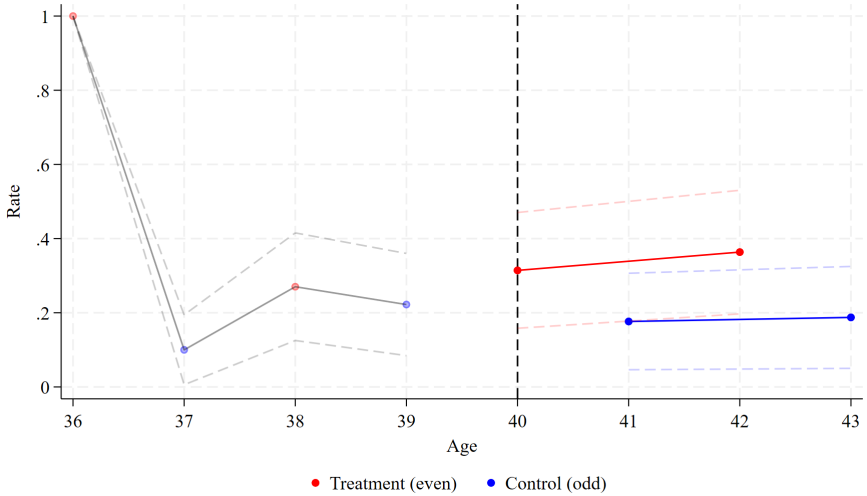
[Intertemporal substitution] Tracking cohorts around age 40

- Sufficient sign of intertemporal substitution Substitution model
- Hard to detect drop in screening rate (**b**) due to new people participating from age 40 (recommendation effect)
- Examine people who were already participating in screening before 40
  - Track 4 age cohorts around age 40
  - Common age range 36 - 43
  - Examine those who took up screening at age 36

Stomach screening take-up for the 4 cohorts



Stomach screening take-up for participants at age 36



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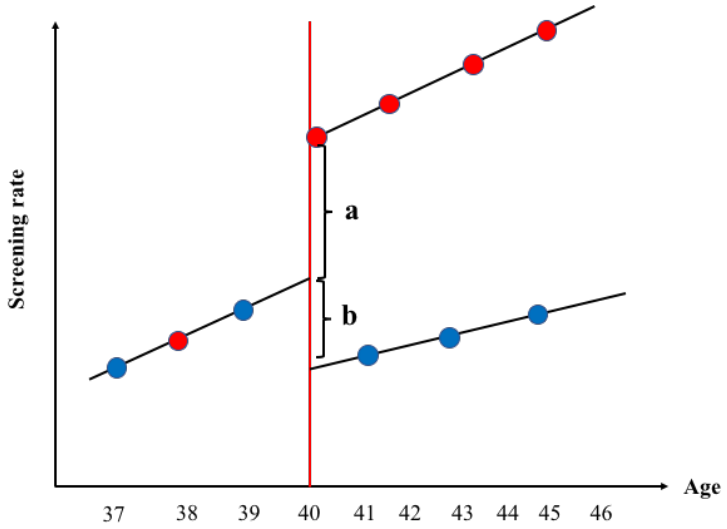
Sufficient sign of intertemporal substitution



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Robustness: positive inter-screening spillover

	(1)	(2)	(3)
	No subsidy		Annual subsidy
	Lung	Prostate	Colorectal
Panel A. Linear splines of age			
Interval 3	0.006***	0.007***	0.020***
	(0.001)	(0.001)	(0.002)
Interval 5	0.006***	0.007***	0.020***
	(0.001)	(0.001)	(0.002)
Interval 7	0.006***	0.007***	0.020***
	(0.001)	(0.001)	(0.002)
Panel B. Linear splines with 5 years interval plus additional covariates			
Full controls	0.006***	0.007***	0.020***
	(0.001)	(0.001)	(0.002)
Individual FE	0.006***	0.007***	0.021***
	(0.001)	(0.001)	(0.002)

back

Robustness: negative inter-screening spillover

	(1)	(2)	(3)	(4)
	Liver	Colorectal	Cervical	
	Age odd	Age odd	Age even	Age even × age < 40
Panel A. Linear splines of age				
Interval 3	−0.027***	−0.038***	0.176***	−0.133***
	(0.001)	(0.002)	(0.006)	(0.008)
Interval 5	−0.027***	−0.038***	0.177***	−0.135***
	(0.001)	(0.002)	(0.006)	(0.008)
Interval 7	−0.027***	−0.038***	0.177***	−0.134***
	(0.001)	(0.002)	(0.006)	(0.008)
Panel B. Linear splines with 5 years interval plus additional covariates				
Full controls	−0.027***	−0.038***	0.179***	−0.136***
	(0.001)	(0.002)	(0.006)	(0.008)
Individual FE	−0.028***	−0.038***	0.181***	−0.141***
	(0.001)	(0.002)	(0.006)	(0.008)

back

Bounding: Inter-screening spillover

	(1)	(2)	(3)
	Age $\in$ [39, 89]	Age $\in$ [40, 89]	Age $\in$ [41, 89]
Liver	0.027***	0.027***	0.027***
	(0.001)	(0.001)	(0.001)
Colorectal	0.033***	0.033***	0.034***
	(0.001)	(0.001)	(0.001)
Lung	0.006***	0.006***	0.007***
	(0.001)	(0.001)	(0.001)
Prostate	0.007***	0.007***	0.008***
	(0.001)	(0.001)	(0.001)
N	110121	107183	104153

back

Inter-screening spillover: take-up on the same day with general screening

	(1)	(2)	(3)	(4)
	Liver	Colorectal	Lung	Prostate
$\Pr(\text{general} = 1 \mid \text{screen} = 1)$	0.845	0.801	0.703	0.790
$\Pr(\text{same day} \mid \text{screen} = 1, \text{general} = 1)$	0.948	0.856	0.937	0.960
$\Pr(\text{general first} \mid \text{screen} = 1, \text{general} = 1)$	0.035	0.122	0.044	0.024
$\Pr(\text{general later} \mid \text{screen} = 1, \text{general} = 1)$	0.008	0.177	0.004	0.004

back

Inter-screening spillover: take-up on the same day with general screening

	(1)	(2)	(3)	(4)
	Annual subsidy		No subsidy	
	Liver	Colorectal	Lung	Prostate
Panel A. Outcome: conducted on the same day				
Age even	0.023***	0.024***	0.004***	0.005***
	(0.001)	(0.001)	(0.001)	(0.001)
N	107183	107183	107183	50260
Control group mean	0.022	0.017	0.006	0.007
Panel B. Outcome: conducted after general screening				
Age even	0.0013***	0.0041***	0.0005***	0.0001
	(0.0002)	(0.0004)	(0.0001)	(0.0001)
N	107183	107183	107183	50260
Control group mean	0.0006	0.0022	0.0002	0.0002
Panel C. Outcome: conducted before general screening				
Age even	0.0003***	0.0063***	0.0001**	0.0001
	(0.0001)	(0.0005)	(0.0000)	(0.0001)
N	107183	107183	107183	50260
Control group mean	0.0002	0.0029	0.0000	0.0000
Sample age range	[40, 89]	[40, 89]	[40, 89]	[40, 89]
Subsidy starting age	40	50		
Age controls	Y	Y	Y	Y

back

Inter-screening spillover: heterogeneity by gender

	(1)	(2)	(3)
	Liver	Colorectal	Lung
Age even	0.025***	0.036***	0.007***
	(0.002)	(0.002)	(0.001)
Age even × Female	0.002	−0.005*	−0.002
	(0.003)	(0.003)	(0.001)
Female	−0.017***	−0.012***	−0.008***
	(0.002)	(0.002)	(0.001)
N	107183	107183	107183
Control group mean	0.028	0.026	0.009

back

Tests for colorectal screening (CDC)

Method	Recommended frequency	Description
Fecal occult blood test (FOBT)	Annual	Use the chemical guaiac to detect blood in the stool
Fecal immunochemical test (FIT)	Annual	Use antibodies to detect blood in the stool
FIT-DNA test	Every 3 years	Combine FIT with a test to detect altered DNA in the stool
Flexible sigmoidoscopy	Every 5 years, or every 10 years with a FIT every year	check for polyps or cancer inside the rectum and lower third of the colon with a short, thin, flexible lighted tube
Colonoscopy	Every 10 years	check for polyps or cancer inside the rectum and the entire colon with longer tube
CT Colonography (Virtual Colonoscopy)	Every 5 years	use X-rays and computers to produce images of the entire colon

back

Spousal spillover in each screening

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	General	Stomach	Liver	Colorectal	Lung	Breast	Cervical	Prostate
Age even	0.162***	0.163***	0.023***	0.029***	0.005***	0.167***	0.155***	0.007***
	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.004)	(0.004)	(0.001)
Spouse screening	0.059***	0.065***	0.010	0.022***	0.004	0.010	0.003	−0.003
	(0.017)	(0.017)	(0.008)	(0.008)	(0.004)	(0.026)	(0.025)	(0.005)
N	101726	101726	101726	101726	101726	50863	50863	50863

back

Spousal spillover direction

	(1)	(2)	(3)	(4)
	Among wives (husband ⇒ wife)		Among husbands (wife ⇒ husband)	
Even age	0.220***	0.218***	0.142***	0.141***
	(0.004)	(0.004)	(0.004)	(0.004)
Spouse even age	0.007		0.017***	
	(0.004)		(0.004)	
Spouse checkup		0.048		0.079***
		(0.031)		(0.018)
N	50863	50863	50863	50863
Estimator	OLS	2SLS	OLS	2SLS

back

Spousal spillover: take-up on the same day

	(1)	(2)	(3)	(4)	(5)
	Total	Even/Even	Even/Odd	Odd/Even	Odd/Odd
Pr(same day | both participate)	0.423	0.494	0.303	0.362	0.462
Pr(Spouse first | both participate)	0.114	0.132	0.095	0.105	0.096
Pr(Spouse later | both participate)	0.114	0.134	0.088	0.113	0.091

back

Spousal spillover by screening day

	(1)	(2)	(3)	(4)	(5)	(6)
	Outcome var: On the same day		Outcome var: In 30 days before spouse		Outcome var: In 30 days after spouse	
Age even	0.002	0.002	0.004***	0.004***	0.004***	0.004***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Spouse age even	0.002	0.002	0.004***	0.004***	0.003***	0.003***
	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Age even	0.069***	0.070***	0.014***	0.015***	0.014***	0.015***
× Spouse age even	(0.005)	(0.005)	(0.002)	(0.002)	(0.002)	(0.002)
N	101726	101493	101726	101493	101726	101493
Odd/Odd group mean	0.029	0.029	0.006	0.006	0.006	0.006
Demographic controls		Y		Y		Y
Estimator	OLS	OLS	OLS	OLS	OLS	OLS

back

Complier characterization - Diagnoses

	(1)	(2)	(3)	(4)	(5)	(6)
	Average value				Ratio	
	Always-takers	Treated compliers	Untreated compliers	Never-takers	CP_1/AT	CP_0/NT
Panel A. Diagnoses						
Diagnosed with a disease	0.258	0.399	-	-	1.550***	-
	(0.006)	(0.007)	-	-	(0.053)	-
Stomach disease diagnosis	0.171	0.273	-	-	1.594***	-
	(0.006)	(0.006)	-	-	(0.074)	-
Breast disease diagnosis	0.022	0.026	-	-	1.180	-
	(0.004)	(0.003)	-	-	(0.263)	-
Cervical disease diagnosis	0.069	0.065	-	-	0.950	-
	(0.007)	(0.006)	-	-	(0.149)	-
Colorectal disease diagnosis	0.190	0.202	-	-	1.061	-
	(0.011)	(0.011)	-	-	(0.104)	-

always never

Complier characterization - SES

	(1)	(2)	(3)	(4)	(5)	(6)
	Average value				Ratio	
	Always-takers	Treated compliers	Untreated compliers	Never-takers	CP_1/AT	CP_0/NT
Panel B. SES						
Individual income	2614	1991	1949	2205	0.762***	0.884***
	(55)	(50)	(53)	(40)	(0.018)	(0.018)
Household income	5568	5030	4997	4778	0.903***	1.046**
	(74)	(69)	(95)	(54)	(0.014)	(0.019)
Years of education	14.174	13.880	13.888	13.560	0.979***	1.024***
	(0.066)	(0.068)	(0.081)	(0.046)	(0.006)	(0.005)
College graduate	0.388	0.333	0.335	0.333	0.859***	1.006
	(0.011)	(0.010)	(0.011)	(0.009)	(0.021)	(0.021)
Working status	0.796	0.713	0.724	0.754	0.896***	0.960***
	(0.010)	(0.010)	(0.012)	(0.008)	(0.013)	(0.014)

always never

Complier characterization - Health behaviors

	(1)	(2)	(3)	(4)	(5)	(6)
	Average value				Ratio	
	Always-takers	Treated compliers	Untreated compliers	Never-takers	CP_1/AT	CP_0/NT
Panel C. Health behaviors						
Current smoker	0.233	0.191	0.171	0.298	0.819***	0.573***
	(0.010)	(0.010)	(0.011)	(0.009)	(0.033)	(0.028)
Everyday smoker	0.218	0.181	0.157	0.284	0.830***	0.554***
	(0.010)	(0.009)	(0.011)	(0.009)	(0.034)	(0.028)
Current drinker	0.849	0.812	0.797	0.816	0.957***	0.977*
	(0.009)	(0.009)	(0.012)	(0.007)	(0.012)	(0.013)
Everyday drinker	0.043	0.028	0.035	0.051	0.641***	0.691***
	(0.005)	(0.005)	(0.006)	(0.004)	(0.115)	(0.119)
Vigorous exercise	0.310	0.268	0.283	0.264	0.866***	1.071*
	(0.009)	(0.009)	(0.012)	(0.007)	(0.030)	(0.039)
Moderate exercise	0.456	0.426	0.426	0.389	0.934***	1.096***
	(0.010)	(0.010)	(0.015)	(0.008)	(0.023)	(0.034)
Walking	0.791	0.786	0.778	0.753	0.994	1.033**
	(0.008)	(0.008)	(0.012)	(0.007)	(0.011)	(0.016)

always never

Complier characterization - Medical tests

	(1)	(2)	(3)
	Average value		Ratio
	Always-takers	Treated Compliers	CP_1/AT
Panel A. Tests covered by NHIS			
Blood/urine/stool/X-ray	0.801	0.886	1.106***
	(0.005)	(0.006)	(0.012)
Endoscopy	0.574	0.776	1.352***
	(0.007)	(0.008)	(0.024)
Biopsy	0.026	0.031	1.190
	(0.002)	(0.002)	(0.153)
Panel B. Tests not covered by NHIS			
Sonogram	0.319	0.275	0.863***
	(0.007)	(0.007)	(0.031)
CT	0.042	0.016	0.374***
	(0.003)	(0.002)	(0.071)
MRI	0.010	0.006	0.593**
	(0.001)	(0.001)	(0.180)
PET	0.002	–0.000	–0.229***
	(0.001)	(0.000)	(0.266)
EEG	0.002	0.002	0.743
	(0.001)	(0.001)	(0.618)
EKG	0.159	0.127	0.794***
	(0.005)	(0.005)	(0.048)
Bone density	0.033	0.029	0.857
	(0.003)	(0.003)	(0.126)

always never

Complier characterization - Health care usage & expenditures

	(1)	(2)	(3)	(4)	(5)	(6)
	Average value				Ratio	
	Always-takers	Treated compliers	Untreated compliers	Never-takers	CP_1/AT	CP_0/NT
Panel A. Health care utilizations						
Outpatient visit	9.098	10.263	10.007	6.532	1.128**	1.532***
	(0.360)	(0.350)	(0.482)	(0.213)	(0.058)	(0.087)
Inpatient visit	0.089	0.085	0.057	0.117	0.954	0.481***
	(0.012)	(0.011)	(0.020)	(0.009)	(0.167)	(0.176)
Emergency visit	1.221	1.211	1.356	1.332	0.992	1.018
	(0.055)	(0.064)	(0.096)	(0.050)	(0.043)	(0.068)
Panel B. Health care expenditures						
Outpatient expenditure	294931	280914	301873	161079	0.952	1.874***
	(13122)	(13001)	(19773)	(7445)	(0.064)	(0.147)
Inpatient expenditure	67598	75791	97104	79261	1.121	1.225
	(15311)	(13440)	(28395)	(9612)	(0.347)	(0.400)
Emergency expenditure	3467	4475	4642	3811	1.291	1.218
	(713)	(821)	(1742)	(584)	(0.365)	(0.539)

always never

Screening results

- Screening results
  - Find any disease? $\Rightarrow$ Which disease? (ICD-10)
  - Multiple answers allowed
  - Not available for never-takers

Screening	Take-up	Find a disease	ICD-10 codes
Find disease		32.6%	
Stomach	17.8%	22.8%	ICD-10
Breast	16.3%	2.2%	ICD-10
Cervical	13.9%	6.2%	ICD-10
Colorectal	4.3%	19.8%	ICD-10

back

Disease classifications for stomach

- (K29) Gastritis and duodenitis
- (K52) Other noninfective gastroenteritis and colitis
- (K21) Gastro-oesophageal reflux disease
- (K25) Gastric ulcer
- (B98) Helicobacter pylori
- (K31) Other diseases of stomach and duodenum
- (K20) Esophagitis
- (C16) Malignant neoplasm of stomach
- (K26) Duodenal ulcer

back

Disease classifications for breast

- (N63) Unspecified lump in breast
- (N64) Other disorders of breast
- (D24) Benign neoplasm of breast
- (N60) Benign mammary dysplasia
- (C50) Malignant neoplasm of breast

back

Disease classifications for female reproductive system

- (N76) Other inflammation of vagina and vulva
- (N71) Inflammatory disease of uterus, except cervix
- (N85) Other noninflammatory disorders of uterus, except cervix
- (N83) Noninflammatory disorders of ovary, fallopian tube and broad ligament

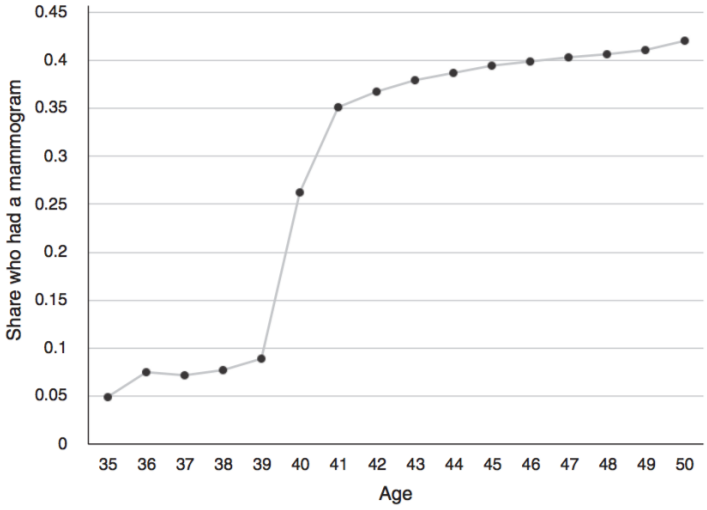
back

Disease classifications for colon and rectum

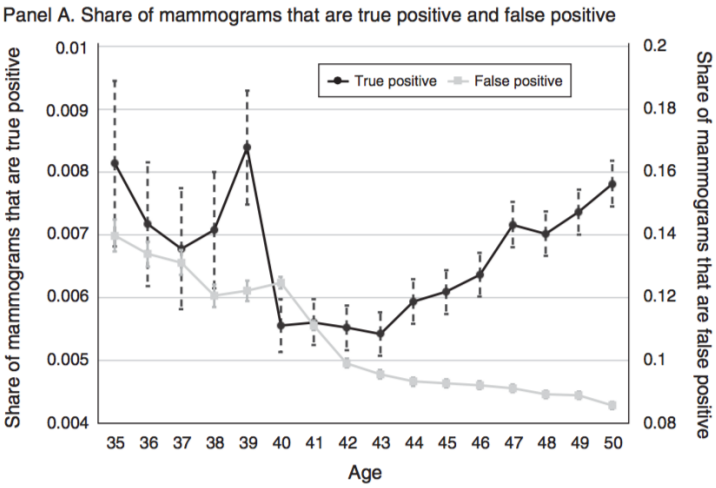
- (K63) Other diseases of intestine
- (D12) Benign neoplasm of colon, rectum, anus and anal canal
- (D13) Benign neoplasm of other and ill-defined parts of digestive system
- (R19) Other symptoms and signs involving the digestive system and abdomen
- (C18) Malignant neoplasm of colon

back

Einav et al. (2020) AER



Einav et al. (2020) AER



Selection summary | Complier vs Always-taker