# Health screening and selection: Evidence from biennial subsidies in South Korea

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# Motivation

- The goal of health screening is to find diseases early among asymptomatic people
- Early detection and treatment reduce premature deaths and suffering from diseases

Table: 5 year survival rates for cancers by summary stage in Korea

| | Localized | Regional | Distant |
|---|---|---|---|
| Total | 91.8% | 74.5% | 26.0% |
| Stomach | 97.4% | 61.4% | 6.6% |
| Colorectal | 93.8% | 82.2% | 20.3% |
| Breast | 98.9% | 92.7% | 45.2% |
| Cervical | 96.9% | 81.0% | 35.2% |
| Liver | 62.4% | 25.0% | 3.1% |

# Motivation

- Why do we need to test asymptomatic people?
  - Symptoms only become noticeable when a disease has significantly advanced
  - Symptomatic people are motivated to seek screening without intervention
    (Same for high risk group due to a genetic predisposition)

- Mismatch of ideal and actual participants among asymptomatic people
  - Ideal participants
    - Less healthy people more likely to have a disease
  - Actual participants
    - Participants are from higher socioeconomic background (Bender et al., 2014)
    - Participants are more likely to show positive health behaviors (Waller et al., 1990)
    - Participants show lower mortality (Strandberg et al., 1995)

- What policy can better target unhealthy people?
  - Providing subsidies for health screenings
  - Lower-income people may be more sensitive to subsidies
  - Lower-income people are often less healthy

# Research question

1. How do subsidies affect screening participation?
   - National Health Screening Program in Korea
   - Subsidies for various screenings (general and cancer screenings)
   - Variation in age cutoff and subsidy schedules (biennial, annual)
2. Who responds to screening subsidies?
   - Characterize compliers with subsidies
   - Compare compliers with always-takers and never-takers
   - Health conditions / socioeconomic status / health behaviors
3. What is the effect of screening on diagnoses and health care utilizations?
   - Use exogenous variation in subsidies

# Preview of results

1. Subsidies increase yearly screening participation from 10% to 30%
2. There are spillover effects in take-up within an individual across different types of screenings and within each screening between spouses
3. Screening subsidies increase participation among those with lower socioeconomic backgrounds and worse health conditions
4. Screening leads to 9% increase in hospital visits for a new illness one was not initially aware of

# Contributions

1. Selection in health screening
   - Those most likely to benefit from preventive services are not using them (Bender et al., 2014, 2015; Strandberg et al., 1995; Jones et al., 2019; Thomas et al., 2021; Hungerford et al., 2016; Gafar et al., 2020)
   - Current US health screening guidelines are not well targeted (Einav et al., 2020; Kowalski, 2023)
   - First to show subsidies target people with lower-income and worse health conditions (Kim and Lee, 2017; Bitler and Carpenter, 2016)
2. Bundling and peer effect in preventive services
   - Spillover in take-up of different health screenings (Bitler and Carpenter, 2016; Kowalski, 2023)
   - Peer effect in screening take-up (Pruckner et al., 2020; Kling et al., 2007; Christakis and Fowler, 2007; Cohen-Cole and Fletcher, 2008; Argys and Rees, 2008; Lundborg, 2006; Carrell et al., 2011)

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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

Implementation

# 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
- Subsidy starting age
  - $Age \geq 40$: biennial subsidy
  - $Age < 40$: no subsidy

# Variation in subsidy schedule across screenings

| | Biennial subsidy | | | | Annual subsidy | | 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 | 5 | 110 | 20 |
| Target | | | Female | Female | High risk group | | | Male |
| Subsidized medical tests | | Gastroscopy, biopsy | Mammogram | Pap smear | Ultrasound, MSAFP | Fecal occult blood test****, colonoscopy, biopsy | | |

* Liver screening is subsidized up to twice a year.
** Colorectal screening was biennially subsidized until 2012 after which it became annually subsidized.
*** The subsidy starting age for cervical screening was lowered to 20 in 2016.
**** Colonoscopy is subsidized only for those with positive result from FOBT.

Liver high risk group

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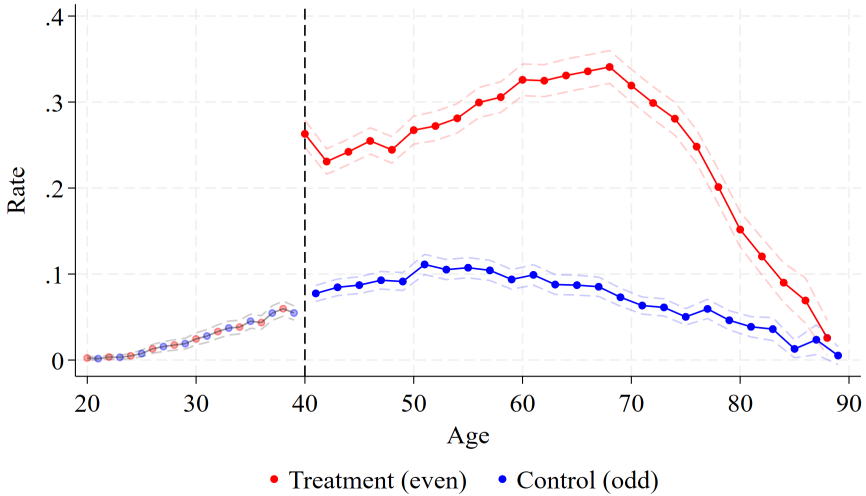
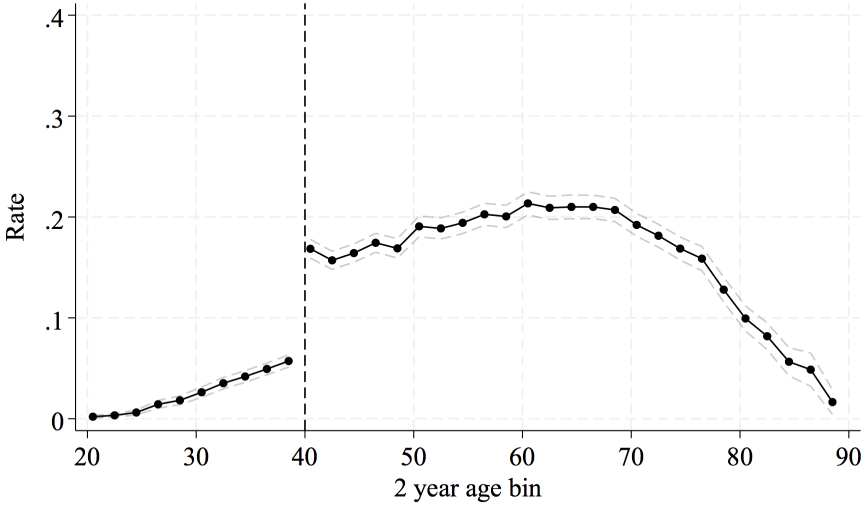
# Stomach cancer screening take-up by age



# Measuring the effect of subsidies on take-up

- 3 effects from biennial subsidy design
  - Recommendation effect: even $\uparrow$, odd $\uparrow$
  - Subsidy effect: even $\uparrow$
  - Substitution effect: even $\uparrow$, odd $\downarrow$
- Regression discontinuity design at age 40 using 2 year average take-up
  - Binning ages by 2 years: [38, 39], [40, 41]
  - 2-year average take-up $\Rightarrow$ substitution effect cancels out
  - Measuring recommendation effect + subsidy effect
- Comparing even vs odd age group from age 40
  - Age $\geq 40$ $\Rightarrow$ recommendation effect cancels out
  - Measuring subsidy effect + substitution effect

# Stomach screening - 2 year age bins



# Regression discontinuity at age 40 using 2 year bins

- Binning
  - Bin ages by 2 years and use bins as a unit of age
    $\Rightarrow$ [34, 35], [36, 37], [38, 39], [40, 41], [42, 43], [44, 45]
  - Denote each bin with the midpoint
    $\Rightarrow$ $agebin_{it} = 34.5, 36.5, 38.5, 40.5, 42.5, 44.5$

- Econometric specification

$$screen_{it} = \alpha_0 + \alpha_1 \cdot a_{it} + \alpha_2 \cdot \mathbb{1}\{a_{it} > 0\} + \alpha_3 \cdot a_{it} \times \mathbb{1}\{a_{it} > 0\} + \varepsilon_{it} \quad (1)$$

  - $a_{it} = (agebin_{it} - 39.5)$
  - Individual $i$ in year $t$
  - Analytical sample: age $\in$ [34, 45]
  - Standard error clustered at the individual level

# Comparing even vs odd age groups from age 40

- Comparison between even age vs odd age from age 40
  - Variation comes from year of birth being even or odd
- Balance between even (treatment) and odd (control) group
  - Even age (treatment) group is younger than the odd age (control) group by design
  - Subsidy eligibility is random conditional on $f(age)$
- Econometric specification

$$y_{it} = \beta_0 + \beta_1 \cdot age\_even_{it} + f(age_{it}) + \epsilon_{it} \tag{2}$$

  - Individual $i$ in year $t$
  - Analytical sample: age $\in$ [40,89]
  - $f(age)$: linear splines with 5 years interval
  - Standard error clustered at the individual level

# Balance table: balanced conditional on f(age)

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

# 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 collection

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# Regression discontinuity for 2 year average take-up

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Any | General | Stomach | Breast | Cervical |
| $Age \geq 40$ | 0.097*** | 0.086*** | 0.105*** | 0.112*** | 0.074*** |
| | (0.008) | (0.007) | (0.006) | (0.009) | (0.010) |
| Constant | 0.121*** | 0.095*** | 0.061*** | 0.064*** | 0.093*** |
| | (0.005) | (0.005) | (0.004) | (0.005) | (0.006) |
| N | 34713 | 34713 | 34713 | 17725 | 17725 |
| Adj $R^2$ | 0.017 | 0.020 | 0.032 | 0.037 | 0.013 |
| Sample age range | [34, 45] | [34, 45] | [34, 45] | [34, 45] | [34, 45] |
| Subsidy starting age | 40 | 40 | 40 | 40 | 30 |

# Comparing even vs odd ages

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Any | General | Stomach | Breast | Cervical |
| Age even | 0.204*** | 0.187*** | 0.190*** | 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 | 5012 | 4804 | 4830 | 2904 | 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 | 0.122 | 0.102 | 0.083 | 0.067 | 0.056 |

# Intertemporal substitution

- Increase in participation or change in screening timing?
  - Intertemporal substitution widen the gap without any net increase in take-up
  - Hard to disentangle the subsidy effect from substitution effect
  - Counterfactual: recommendation for biennial screening from age 40 but without subsidies
- Evidence for (or against) intertemporal substitution
  1. Ages before and after 40 for those already participating before 40 Around age 40
  2. Monthly distribution of screening take-up Screening months

  $\Rightarrow$ No strong sign of substitution

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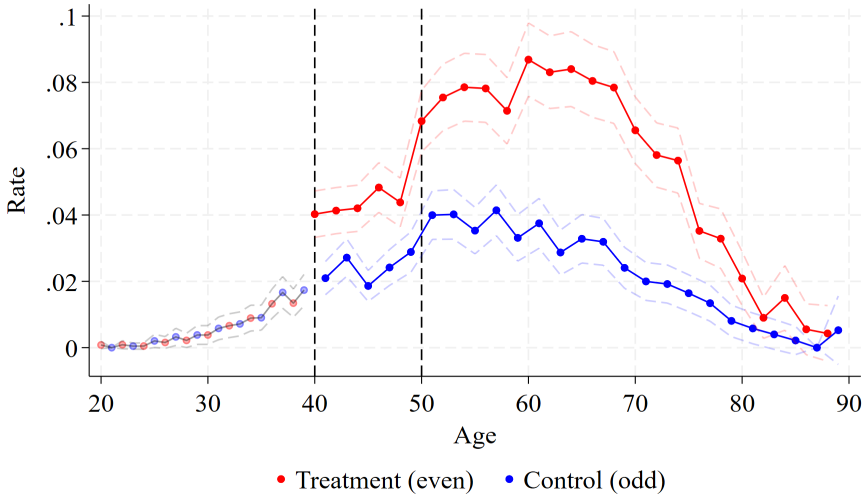
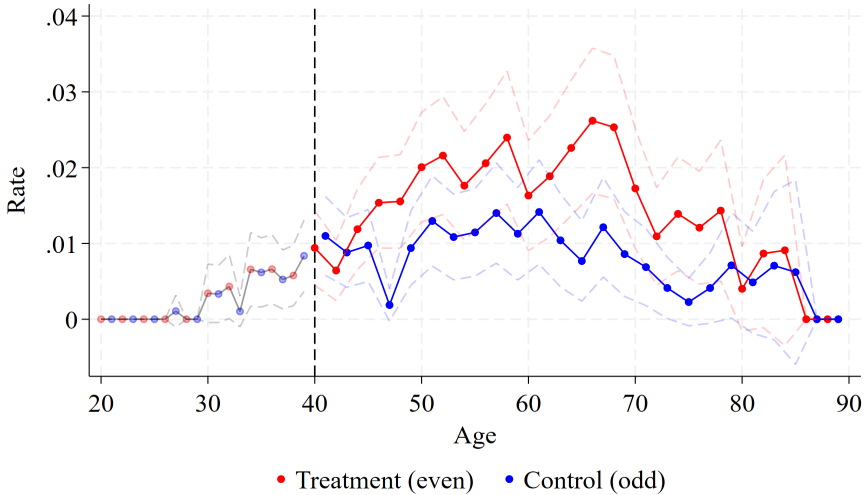
# Colorectal screening - annual subsidy



# Prostate screening - no subsidy



# Cross spillover across different types of screenings

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Annual subsidy | | No subsidy | | Biennial subsidy |
| | Liver | Colorectal | Prostate | Lung | Cervical |
| Age even | 0.027*** | 0.017*** | 0.007*** | 0.006*** | 0.037*** |
| | (0.001) | (0.002) | (0.001) | (0.001) | (0.004) |
| Age even $\times age \geq 50$ | | 0.023*** | | | |
| | | (0.002) | | | |
| Age even $\times age \geq 40$ | | | | | 0.128*** |
| | | | | | (0.005) |
| N | 107183 | 107183 | 50260 | 107183 | 69236 |
| Sample age range | [40, 89] | [40, 89] | [40, 89] | [40, 89] | [30, 49] |
| Subsidy starting age | 40 | 50 | 40 | 40 | 30 |
| Age controls | Y | Y | Y | Y | Y |
| Control group mean | 0.028 | 0.027 | 0.009 | 0.009 | 0.056 |

Cervical screening

# Interpretation: positive or negative spillover?

- Common take-up pattern: biennial take-up from age 40
  - Most common subsidy rule
  - Major screening (general and stomach) subsidy rule
- Positive spillover: less frequent subsidies than biennial schedule from 40
  - Prostate / lung screening
  - Liver screening of non-high risk group
  - Colorectal screening at age [40, 49]
  - Colorectal screening using colonoscopy
- Negative spillover: more frequent subsidies than biennial schedule from 40
  - Cervical screening at age [30, 39]
  - Liver screening of high-risk group
  - Colorectal screening at age [50, 59]
  - Colorectal screening using fecal occult blood test

# Mechanisms

- People receive multiple screenings on the same day
  - Fixed costs in visiting hospital
  - Many clinics and hospital provide screenings as a bundle
  - Among hospitals that offer general screening, 70% conduct stomach and colorectal screening and 37% conduct all major cancer screenings
- If received on different dates, people receive them after general screening
  - Doctor's recommendation to receive other screenings at the general screening

Share (same day) Reg (same day)

- Breast and cervical screenings are not the ones generating spillover
  - General and stomach screening have the highest take-up

Heterogeneity (gender)

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# Spillover in take-up between spouses

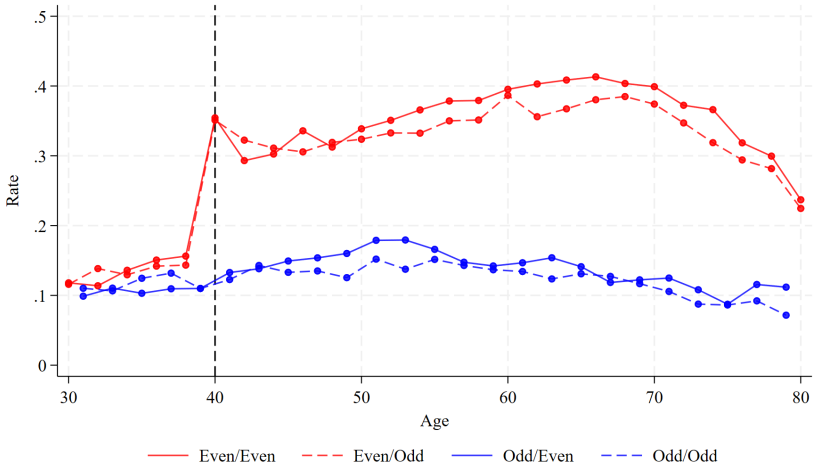
- Analytical sample
  - Dataset contains all the household members
  - Currently married couples
  - Own age $\geq$ 40 & spouse age $\geq$ 40

- Econometric specification

$$y_{it} = \gamma_0 + \gamma_1 \cdot age\_even_{it} + \gamma_2 \cdot spouse\_age\_even_{it} + \gamma_3 \cdot age\_even_{it} \times spouse\_age\_even_{it} + \phi_{it} \quad (3)$$

  - $y_{it}$: 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 | 0.214*** | 0.213*** | 0.213*** | 0.213*** |
| | (0.006) | (0.006) | (0.004) | (0.004) |
| Spouse age even | 0.016*** | 0.015*** | | |
| | (0.005) | (0.004) | | |
| Age even | 0.001 | 0.003 | | |
| × Spouse age even | (0.009) | (0.009) | | |
| Spouse screening | | | 0.078*** | 0.079*** |
| | | | (0.017) | (0.017) |
| N | 79962 | 79782 | 79962 | 79782 |
| Odd/Odd group mean | 0.128 | 0.128 | 0.128 | 0.128 |
| Demographic controls | | Y | | Y |
| Estimator | OLS | OLS | 2SLS | 2SLS |

# Mechanisms

- Husbands are more likely to participate if wives are eligible for subsidies, but not vice versa
  Direction
- Spouses can get screening together on the same day.
  Share (same day) Reg (same day)
- No spousal spillover for screenings that are for women or men only
  In each screening

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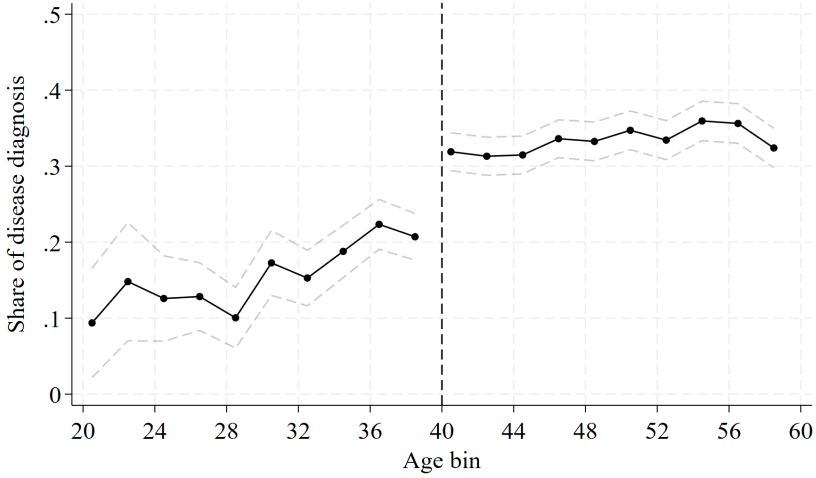
# Selection into screening

- We care not only the increase in screening participation rate, but the characteristics of the new participants (compliers)
- Compliance groups following Angrist et al. (1996)

| | Even age (treatment) | Odd age (control) |
|---|---|---|
| Always-takers | Yes | Yes |
| Compliers | Yes | No |
| Defiers | No | Yes |
| Never-takers | No | No |

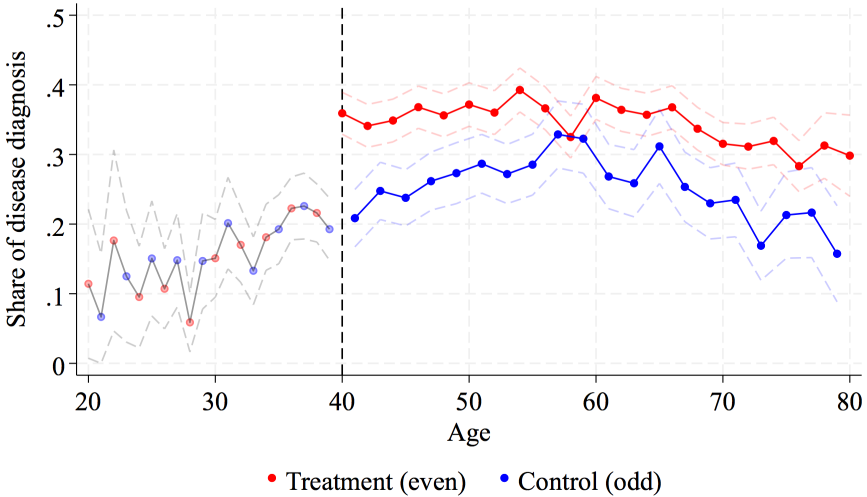
- We want the policy to target compliers who are more likely to have a disease
- 2 reference groups in comparing compliers
  - Compliers vs Always-takers $\Rightarrow$ composition of screening participants
  - Compliers vs Never-takers $\Rightarrow$ who shows positive health behaviors?

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




Screening results | Einav et al. (2020)

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



# How can we more rigorously characterize compliers?

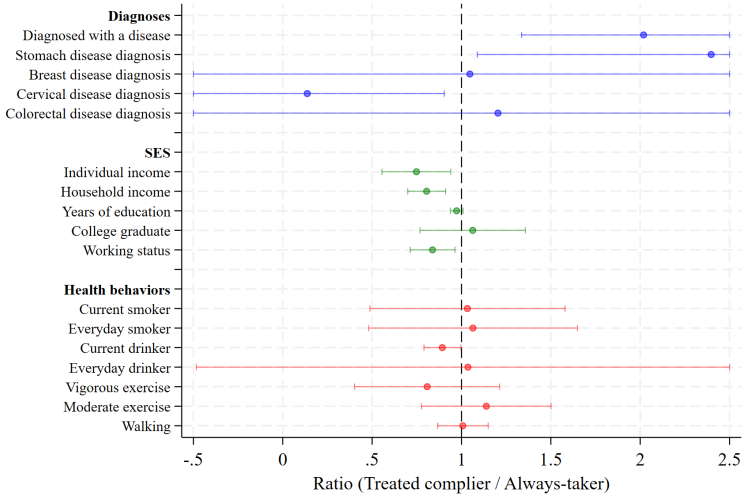
- We need to adjust for group shares when estimating characteristics
- 3 steps
  1. Estimate always- and never-takers characteristics
  2. Back out complier characteristics
  3. Compare compliers to always- and never-takers

| | Even age (treatment) | Odd age (control) |
|---|---|---|
| Always-takers | Yes | Yes |
| Compliers | Yes | No |
| Never-takers | No | No |

- Ratios
  - Treated compliers / Always-takers
  - Untreated compliers / Never-takers

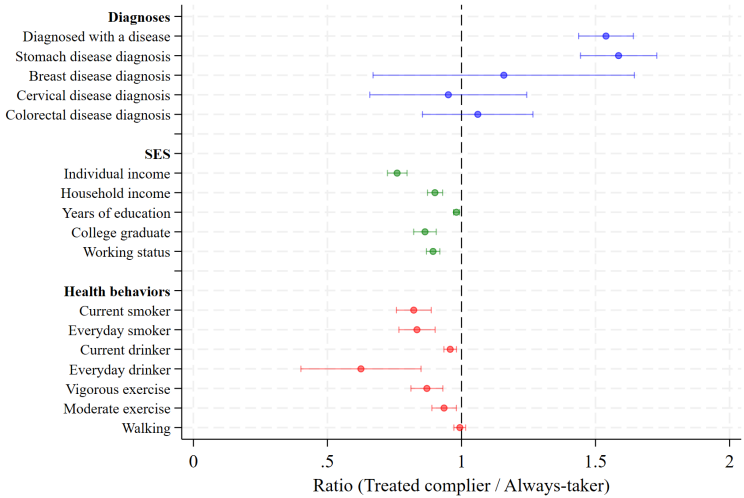
Detail

# Compliers vs Always-takers using age 40 discontinuity

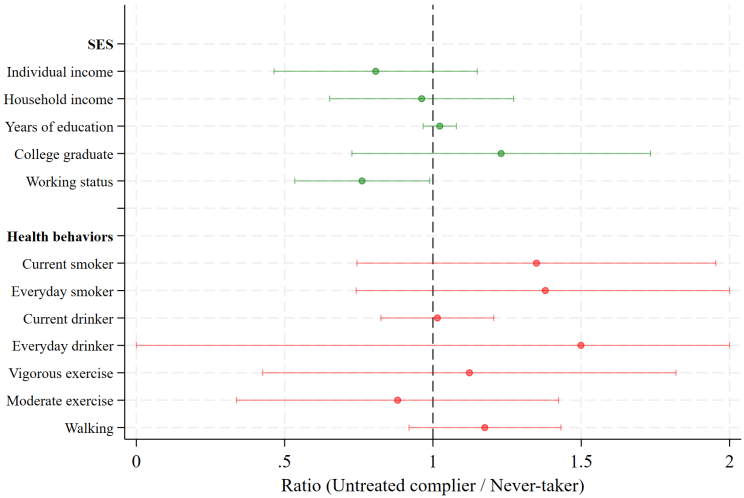



Cervical

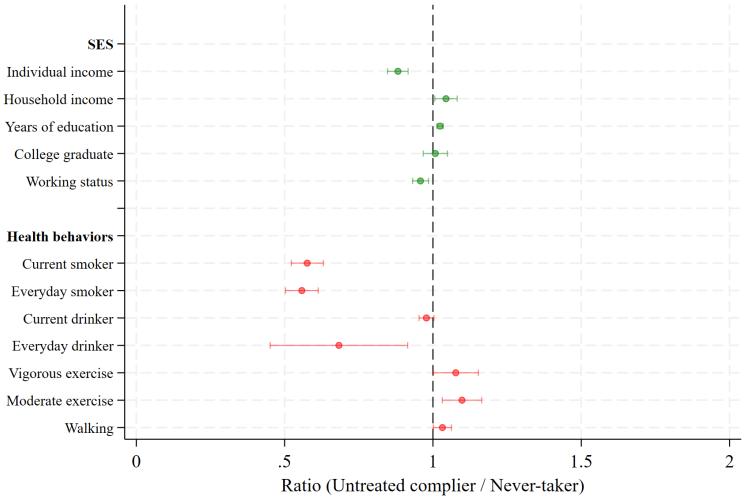
# Compliers vs Always-takers by comparing even and odd ages



# Compliers vs Never-takers using age 40 discontinuity



# Compliers vs Never-takers by comparing even and odd ages



# Who are compliers in cross spillover effects?

- Annual and no-subsidy screening participants are a subset of biennial screening participants Subset
- Compliers are the ones who participate in annual and no-subsidy screenings among biennial screening participants (one-sided noncompliance)
- Econometric specification

$$y_{it} = \delta_0 + \delta_1 \cdot screen_{it} + \varepsilon_{it} \tag{4}$$

  - Sample: biennial screening participants
  - Outcome: diagnosis, socioecnomic status and health behaviors
  - Explanatory variable: take-up of annual or no-subsidy screenings
  - Standard errors are clustered at the individual level

# Spillover compliers are healthier and have higher socioeconomic status

| | (1) | (2) | (3) |
|---|---|---|---|
| | Annual | No-subsidy | Sample mean |
| **Panel A. Diagnoses** | | | |
| Stomach disease diagnosis | –0.026*** | –0.086*** | 0.228 |
| | (0.006) | (0.010) | |
| Breast disease diagnosis | –0.006* | –0.019*** | 0.022 |
| | (0.003) | (0.004) | |
| Cervical disease diagnosis | –0.018*** | –0.022 | 0.062 |
| | (0.006) | (0.016) | |
| **Panel B. SES** | | | |
| Individual income | 874*** | 1499*** | 1592 |
| | (49) | (110) | |
| Household income | 1012*** | 1393*** | 4564 |
| | (66) | (145) | |
| Years of education | 0.975*** | 1.342*** | 10.769 |
| | (0.073) | (0.129) | |
| College graduate | 0.074*** | 0.131*** | 0.196 |
| | (0.007) | (0.014) | |
| Working status | 0.063*** | 0.141*** | 0.635 |
| | (0.008) | (0.012) | |

# Spillover compliers show health behaviors consistent with higher income

| | (1) | (2) | (3) |
|---|---|---|---|
| | Annual | No-subsidy | Sample mean |
| **Panel C. Health behaviors** | | | |
| Current smoker | 0.044*** | 0.116*** | 0.146 |
| | (0.006) | (0.013) | |
| Everyday smoker | 0.041*** | 0.100*** | 0.138 |
| | (0.006) | (0.013) | |
| Current drinker | 0.066*** | 0.149*** | 0.655 |
| | (0.008) | (0.012) | |
| Everyday drinker | 0.018*** | 0.035*** | 0.060 |
| | (0.004) | (0.009) | |
| Vigorous exercise | 0.050*** | 0.104*** | 0.235 |
| | (0.007) | (0.014) | |
| Moderate exercise | 0.050*** | 0.107*** | 0.409 |
| | (0.008) | (0.014) | |
| Walking | 0.012** | 0.031*** | 0.812 |
| | (0.006) | (0.010) | |

# Summary of selection analysis

- Compliers with subsidies
  - Compared to always-takers, compliers have lower socioeconomic status and worse health conditions (Kim and Lee, 2017)
  - Compared to never-takers, compliers show better health behaviors (Oster, 2020; Einav et al., 2020; Kowalski, 2023)

Panel

- Compliers in cross spillover
  - Compliers have higher socioeconomic status and better health conditions
- Opposite selection pattern compared to Einav et al. (2020)
  - Einav et al. (2020): Mammogram starting age recommendation based on medical studies
  - This study: Subsidies (90-100%) for various screening

  $\Rightarrow$ Subsidies better target those who are more likely to benefit from screenings

Einav et al. (2020)

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# Effect of screening on diagnoses and health care utilizations

- Outcome variables
  - Health care utilizations
    - Number of hospital visits (aggregate + diagnosis category)
    - Outpatient, inpatient and emergency care
  - Proxy for new diagnosis
    - **NOT** disease diagnosis from health screening
    - **First** outpatient hospital visit
- Two-stage least square estimation

$$y_{it} = \eta_0 + \eta_1 \cdot screen_{it} + \mathbf{f}(\mathbf{age_{it}}) + \varepsilon_{it} \tag{5}$$

  - $screen_{it}$ 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 health screening on outpatient visits

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Control group mean | ITT | LATE | Adjusted p-values | N |
| **Panel A. Outpatient visits** | | | | | |
| Outpatient visit | 20.8088 | 0.0977 | 0.4784 | 0.866 | 107183 |
| | | (0.0757) | (0.3709) | | |
| High blood pressure | 2.7100 | 0.0001 | 0.0007 | 0.993 | 107183 |
| | | (0.0115) | (0.0618) | | |
| Hyperlipidemia | 0.9847 | 0.0073 | 0.0390 | 0.888 | 107183 |
| | | (0.0073) | (0.0391) | | |
| Diabetes | 1.1378 | 0.0115 | 0.0616 | 0.866 | 107183 |
| | | (0.0097) | (0.0521) | | |
| Stomach | 0.9716 | 0.0685*** | 0.3613*** | 0.000 | 107183 |
| | | (0.0117) | (0.0616) | | |
| Breast | 0.1141 | 0.0013 | 0.0066 | 0.993 | 56923 |
| | | (0.0116) | (0.0608) | | |
| Female genital | 0.3440 | 0.0053 | 0.0321 | 0.932 | 56923 |
| | | (0.0094) | (0.0571) | | |
| Liver | 0.1114 | 0.0030 | 0.1118 | 0.932 | 107183 |
| | | (0.0043) | (0.1604) | | |
| Colorectal | 0.3069 | 0.0086 | 0.2603 | 0.866 | 107183 |
| | | (0.0064) | (0.1955) | | |
| Male genital | 1.2352 | −0.0343 | −4.6905 | 0.866 | 50260 |
| | | (0.0259) | (3.6077) | | |
| Lung | 0.1435 | 0.0066 | 1.0699 | 0.888 | 107183 |
| | | (0.0064) | (1.0402) | | |

# Health screening increases first hospital visits for a new illness

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Control group mean | ITT | LATE | Adjusted p-values | N |
| **Panel B. First outpatient visits** | | | | | |
| First outpatient visit | 3.9335 | 0.0742*** | 0.3632*** | 0.000 | 107183 |
| | | (0.0153) | (0.0749) | | |
| High blood pressure | 0.0509 | 0.0015 | 0.0082 | 0.767 | 107183 |
| | | (0.0015) | (0.0080) | | |
| Hyperlipidemia | 0.0239 | 0.0034*** | 0.0184*** | 0.005 | 107183 |
| | | (0.0010) | (0.0054) | | |
| Diabetes | 0.0255 | 0.0009 | 0.0048 | 0.771 | 107183 |
| | | (0.0011) | (0.0057) | | |
| Stomach | 0.1863 | 0.0246*** | 0.1300*** | 0.000 | 107183 |
| | | (0.0031) | (0.0161) | | |
| Breast | 0.0085 | 0.0023** | 0.0121** | 0.164 | 56923 |
| | | (0.0011) | (0.0055) | | |
| Female genital | 0.0891 | 0.0062** | 0.0380** | 0.150 | 56923 |
| | | (0.0027) | (0.0166) | | |
| Liver | 0.0097 | 0.0009 | 0.0320 | 0.737 | 107183 |
| | | (0.0007) | (0.0272) | | |
| Colorectal | 0.0786 | 0.0035* | 0.1054* | 0.351 | 107183 |
| | | (0.0019) | (0.0590) | | |
| Male genital | 0.0681 | −0.0024 | −0.3222 | 0.771 | 50260 |
| | | (0.0027) | (0.3749) | | |
| Lung | 0.0197 | 0.0003 | 0.0551 | 0.771 | 107183 |
| | | (0.0010) | (0.1689) | | |

# Effect of health screening on inpatient visits

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Control group mean | ITT | LATE | Adjusted p-values | N |
| **Panel A. Inpatient visits** | | | | | |
| Inpatient visit | 0.23291 | 0.00555 | 0.02719 | 0.804 | 107183 |
| | | (0.00391) | (0.01915) | | |
| High blood pressure | 0.00571 | 0.00021 | 0.00115 | 0.997 | 107183 |
| | | (0.00056) | (0.00299) | | |
| Hyperlipidemia | 0.00043 | 0.00018 | 0.00095 | 0.939 | 107183 |
| | | (0.00018) | (0.00097) | | |
| Diabetes | 0.00692 | −0.00025 | −0.00133 | 0.997 | 107183 |
| | | (0.00067) | (0.00357) | | |
| Stomach | 0.01181 | 0.00133 | 0.00703 | 0.843 | 107183 |
| | | (0.00101) | (0.00534) | | |
| Breast | 0.00721 | 0.00041 | 0.00216 | 0.997 | 56923 |
| | | (0.00146) | (0.00762) | | |
| Female genital | 0.00412 | −0.00016 | −0.00094 | 0.997 | 56923 |
| | | (0.00083) | (0.00507) | | |
| Liver | 0.00524 | 0.00082 | 0.03084 | 0.882 | 107183 |
| | | (0.00069) | (0.02593) | | |
| Colorectal | 0.01633 | −0.00026 | −0.00799 | 0.997 | 107183 |
| | | (0.00135) | (0.04094) | | |
| Male genital | 0.01249 | 0.00059 | 0.08096 | 0.997 | 50260 |
| | | (0.00127) | (0.17323) | | |
| Lung | 0.01183 | 0.00207* | 0.33331* | 0.588 | 107183 |
| | | (0.00116) | (0.19063) | | |

# Effect of health screening on emergency visits

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| | Control group mean | ITT | LATE | Adjusted p-values | N |
| **Panel B. Emergency visits** | | | | | |
| ER visit | 0.12520 | −0.00238 | −0.01165 | 0.956 | 107183 |
| | | (0.00259) | (0.01268) | | |
| High blood pressure | 0.00113 | −0.00004 | −0.00021 | 0.993 | 107183 |
| | | (0.00025) | (0.00136) | | |
| Hyperlipidemia | 0.00008 | −0.00001 | −0.00004 | - | 107183 |
| | | (0.00007) | (0.00035) | | |
| Diabetes | 0.00261 | −0.00032 | −0.00174 | 0.956 | 107183 |
| | | (0.00045) | (0.00239) | | |
| Stomach | 0.00758 | −0.00015 | −0.00077 | 0.993 | 107183 |
| | | (0.00061) | (0.00324) | | |
| Breast | 0.00043 | −0.00020 | −0.00106 | 0.956 | 56923 |
| | | (0.00024) | (0.00126) | | |
| Female genital | 0.00060 | −0.00031 | −0.00190 | 0.858 | 56923 |
| | | (0.00023) | (0.00139) | | |
| Liver | 0.00157 | 0.00054 | 0.02024 | 0.928 | 107183 |
| | | (0.00046) | (0.01742) | | |
| Colorectal | 0.00720 | 0.00072 | 0.02189 | 0.928 | 107183 |
| | | (0.00062) | (0.01886) | | |
| Male genital | 0.00586 | −0.00055 | −0.07544 | 0.956 | 50260 |
| | | (0.00072) | (0.09920) | | |
| Lung | 0.00414 | 0.00009 | 0.01407 | 0.993 | 107183 |
| | | (0.00049) | (0.07856) | | |

# Table of Contents

# Conclusion

1. Screening subsidies are effective in increasing participation and targeting less healthy group
2. Receiving screenings together (multiple screenings AND with a spouse) increases participation
3. Screening leads to new diagnoses and subsequently induce individuals to seek medical care.

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# Implementation of the health screening program

- Nationwide program
  - Target: all the citizens covered by National Health Insurance Service (NHIS)
  - History: (1980) Beginning of the program $\rightarrow$ (2004) Current system
- How can I receive subsidized screenings
  - Providers: public health clinics / private clinics and hospitals designated by the NHIS
    $\Rightarrow$ (Dec 2023) 6,600 screening centers for general screening $\rightarrow$ 4600 people per center
  - Appointment: normally required but varies by hospitals and type of screenings
- Do people know about the screening program and the subsidies?
  - Even-odd subsidy rule has been used throughout the study period
  - Reminder mails (and mobile notifications)
    - Sent to those eligible for subsidies
    - Mail contains the type of screenings to receive and screening providers in the neighborhood

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# High risk group for liver screening

1. Individuals with the following diseases
   - Cirrhosis
   - Chronic liver disease
2. Individuals who were diagnosed with positive results in the previous year general health screening
   - Hepatitis B surface antigen test
   - Hepatitis C virus HCV antibody test

   $\Rightarrow$ can be found through blood test
3. Individuals who used medical services for the following diseases in the past two years are excluded
   - Liver cell carcinoma, hepatocellular carcinoma and liver cancer (C22.0)
   - Intrahepatic bile duct carcinoma and Cholangiocarcinoma (C22.1)

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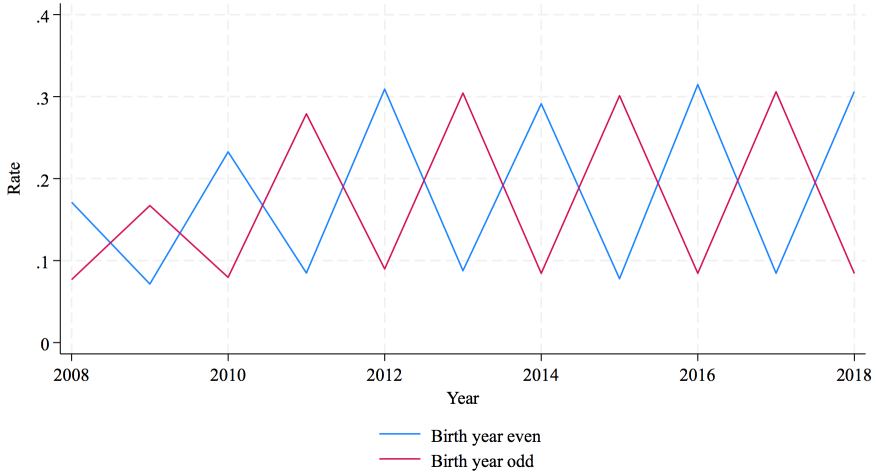
# First stage by birth year

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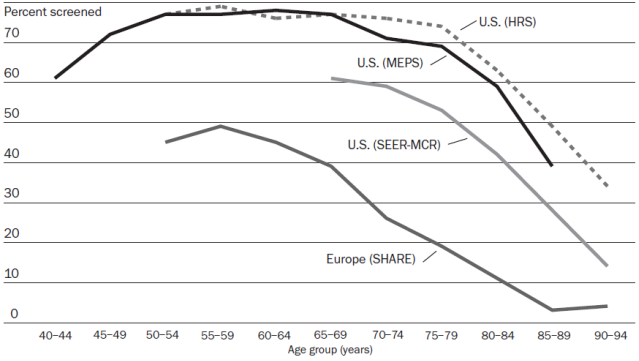
# Breast screening in the US and Europe (Howard et al., 2009)

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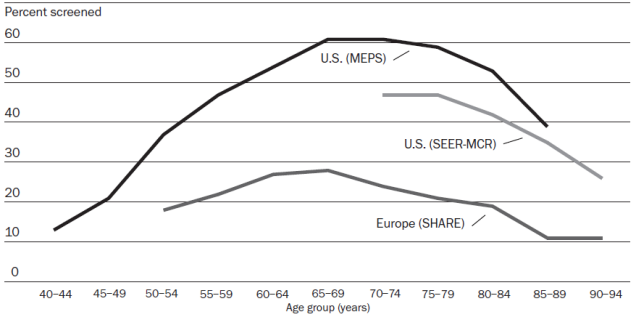
# Colorectal screening in the US and Europe (Howard et al., 2009)

**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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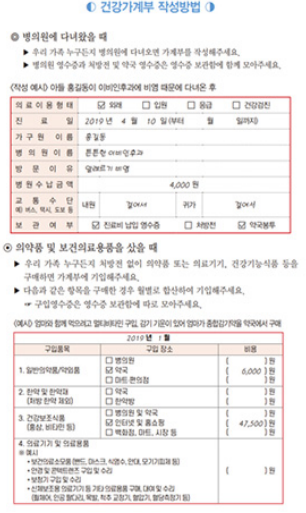
# Health care usage data collection

- 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 | 2019년 4월 10일(부터 | 월 | 일까지) | | |
| 가구원 이름 | 홍길동 | | | | |
| 병의원 이름 | 푸른항 이비인후과 | | | | |
| 방문이유 | 알레르기 비염 | | | | |
| 병원수납금액 | 4,000 원 | | | | |
| 교통수단 (버스, 택시, 도보 등) | 내린 | 걸어서 | 귀가 | 걸어서 | |
| 보관여부 | ☑ 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 약국에고 멀티비타민 구입, 감기 기운이 있어 엄마가 종합감기약을 약국에서 구매

2019년 1월

| 구입품목 | 구입 장소 | 비용 |
|---|---|---|
| 1. 일반의약품/약입품 | ☐ 병의원<br>☑ 약국<br>☐ 마트 편의점 | ( ) 원<br>( 6,000 ) 원<br>( ) 원 |
| 2. 천약 및 한약재 (처방 한약 제외) | ☐ 약국<br>☐ 한약방 | ( ) 원<br>( ) 원 |
| 3. 건강보조식품 (홍삼, 비타민 등) | ☐ 병의원 및 약국<br>☑ 인터넷 및 홈쇼핑<br>☐ 백화점, 마트, 시장 등 | ( ) 원<br>( 47,500 ) 원<br>( ) 원 |
| 4. 의료기기 및 의료용품<br>※ 예시<br>• 보건의료소모품 (밴드, 마스크, 식염수, 진대, 모기기피제 등)<br>• 안경 및 콘택트렌즈 구입 및 수리<br>• 보청기 구입 및 수리<br>• 신체보조용 의료기기 등 기타 의료용품 구매, 대여 및 수리<br>(휠체어, 인슐린 펌프외, 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<br>□ Pharmacy<br>□ CVS | { } KRW<br>{ } KRW<br>{ } KRW |
| Oriental medicine | □ Pharmacy<br>□ Acupuncture clinic | { } KRW<br>{ } KRW |
| Dietary supplement (ginseng, vitamin, etc) | □ Hospital or pharmacy<br>□ Internet shopping<br>□ Department store | { } KRW<br>{ } KRW<br>{ } KRW |
| Any other medical products (e.g.)<br>- Bandage, mask, insect repellent<br>- Glasses, contact lenses<br>- Hearing aid | | { } KRW |

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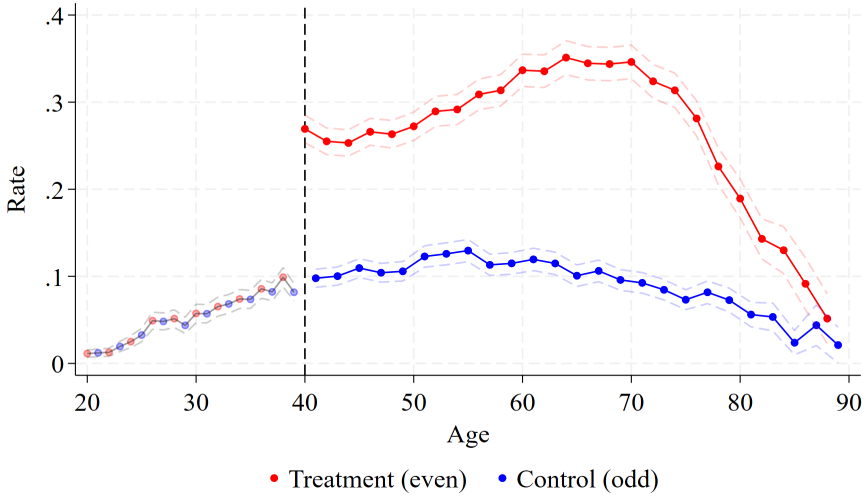
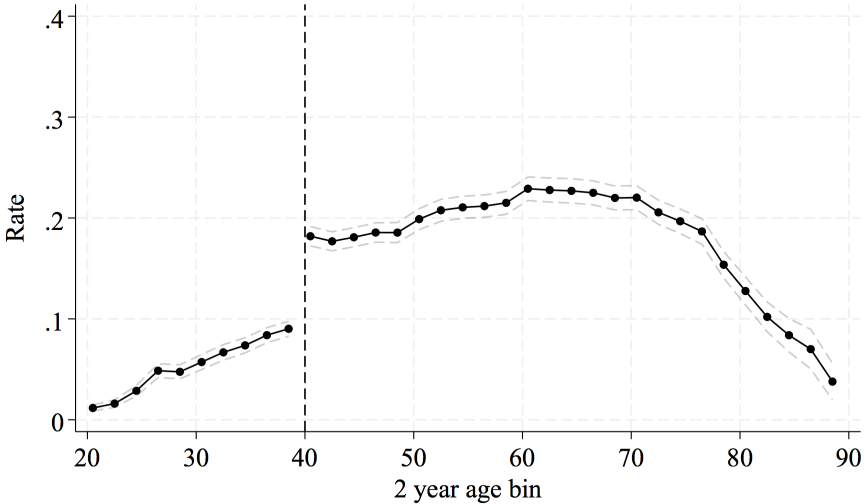
# General screening - even vs odd age



# General screening - 2 year age bins

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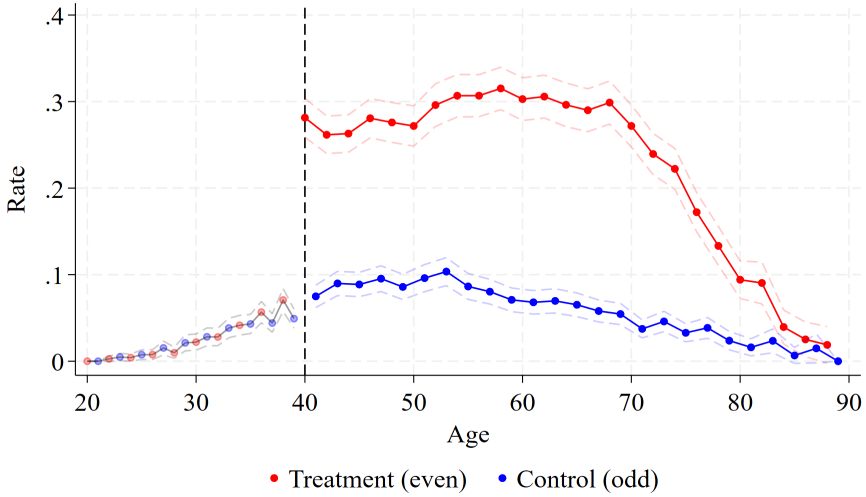
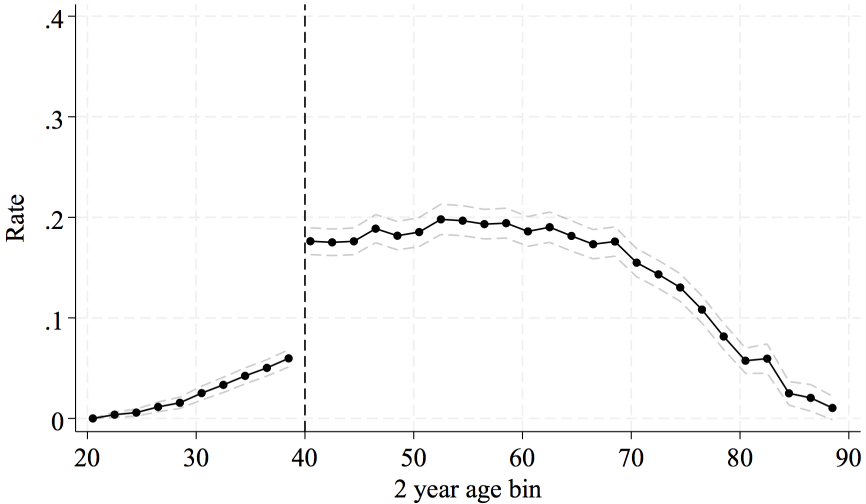
# Breast screening - even vs odd age



# Breast screening - 2 year age bins

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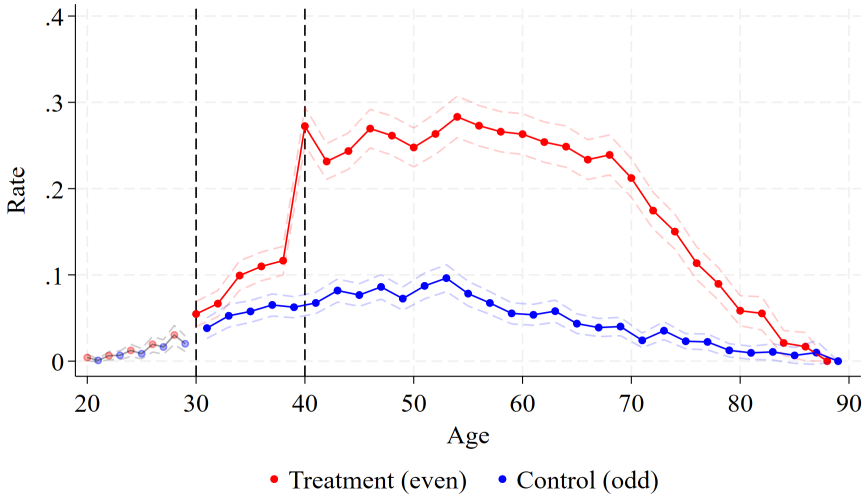
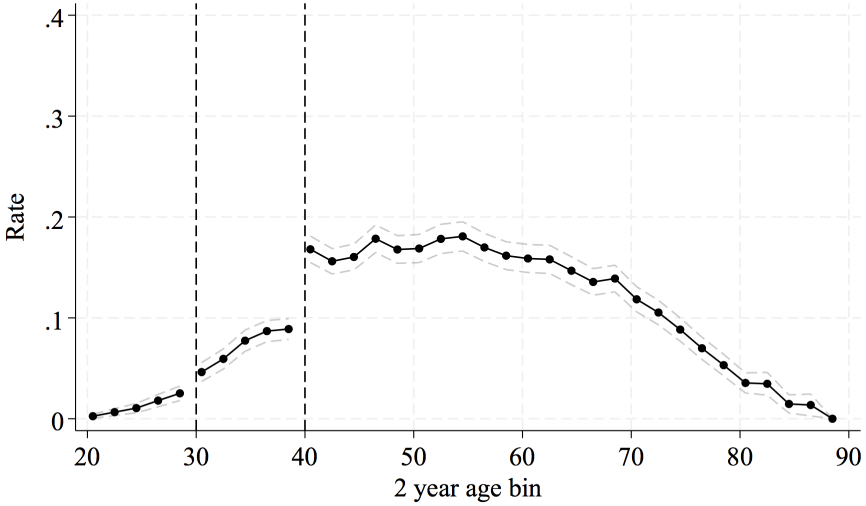
# Cervical screening - even vs odd age



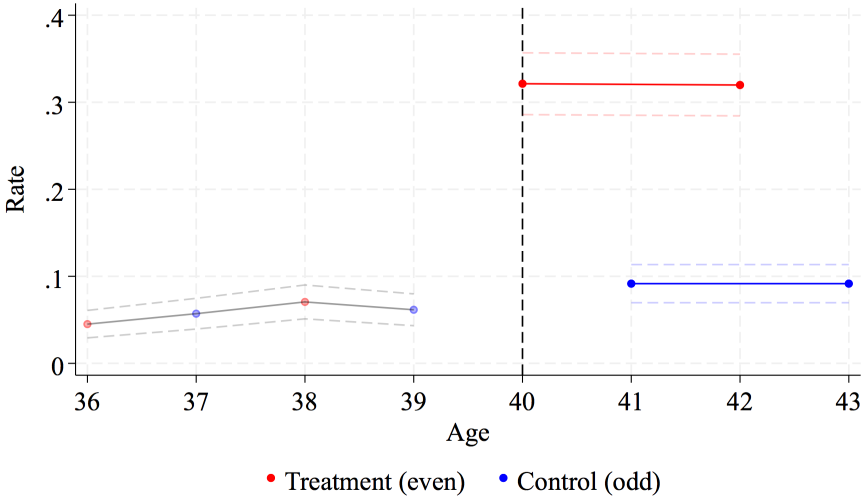
# Cervical screening - 2 year age bins



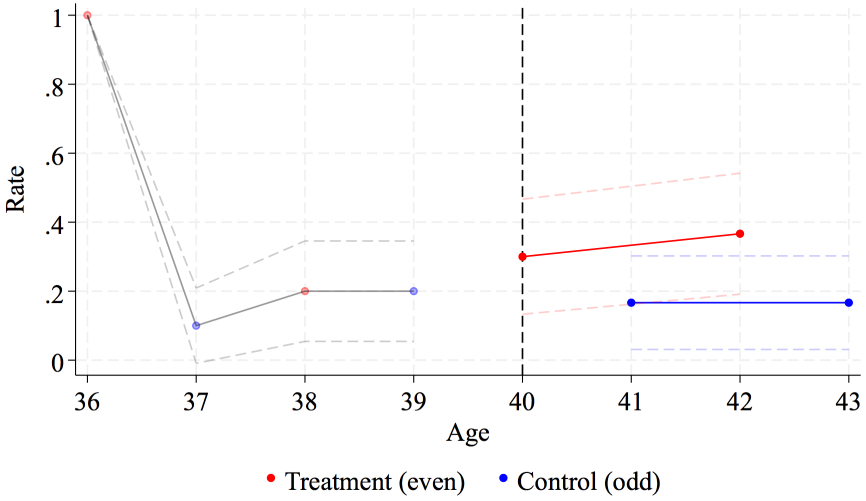
# Tracking cohorts around age 40

- Drop in screening rate in odd age group after 40 is a clear sign of intertemporal substitution
- Opposing recommendation effect can increase participation in odd age group canceling out substitution effect
- Keep recommendation effect constant by examining 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, 37, 38 and 39

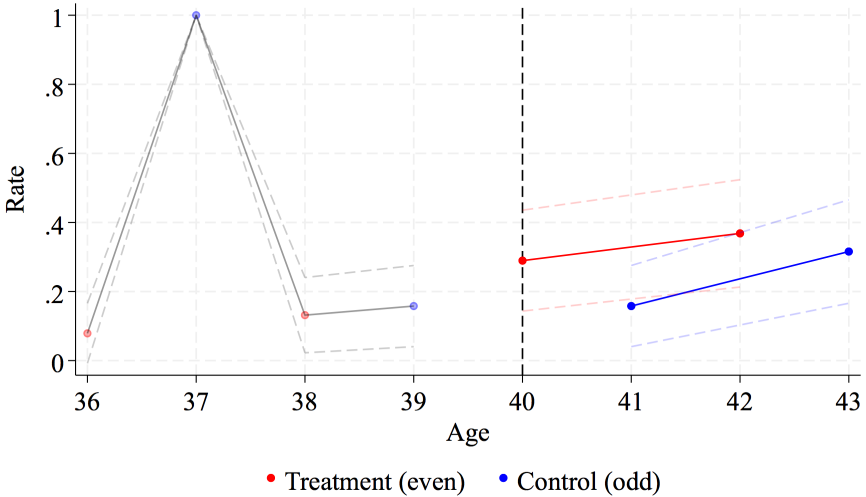
# Stomach screening take-up for the 4 cohorts



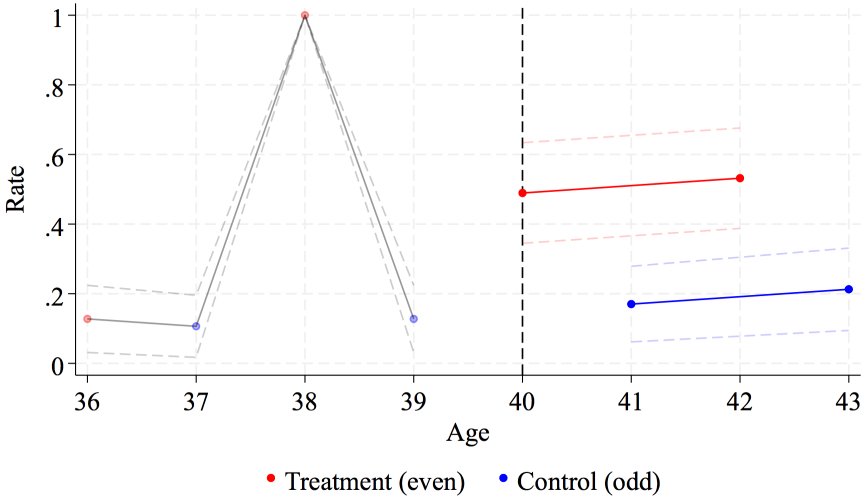
# Stomach screening take-up for participants at age 36



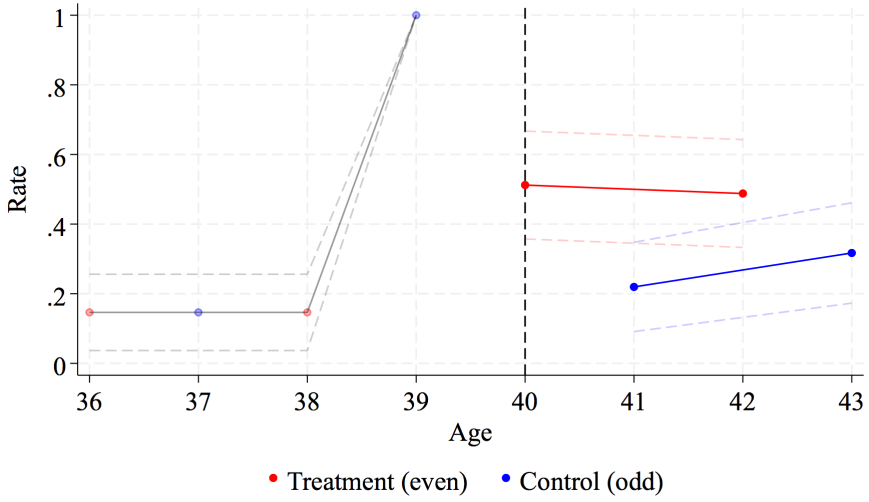
# Stomach screening take-up for participants at age 37



# Stomach screening take-up for participants at age 38



# Stomach screening take-up for participants at age 39

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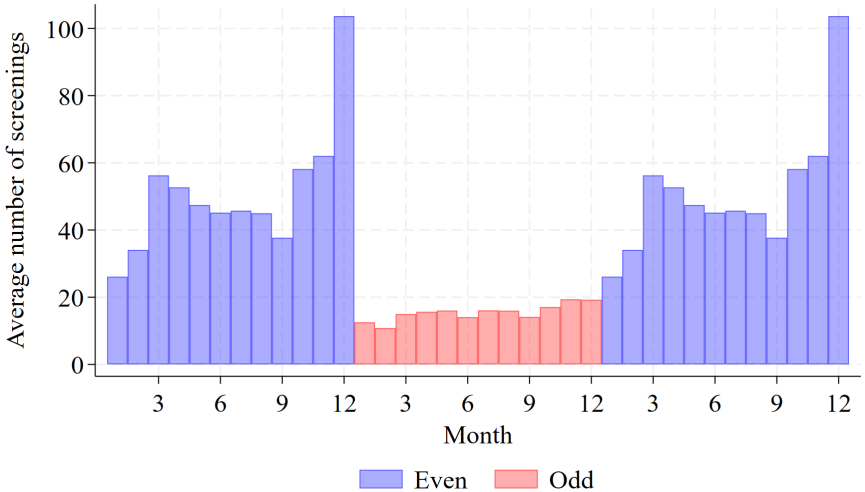
# Months of stomach screening for age [40, 89]

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# Comparing screening months before and after 40

- Stacked regression

$$screen_{imt} = \gamma_0 + \gamma_1 \cdot after40_{imt} + \gamma_2 \cdot age\_even_{imt} + \sum_{m=2}^{12} month_m \tag{6}$$

$$+ \gamma_3 \cdot after40_{imt} \cdot age\_even_{imt} + \sum_{m=2}^{12} month_m \cdot after40_{imt} + \sum_{m=2}^{12} month_m \cdot age\_even_{imt} \tag{7}$$

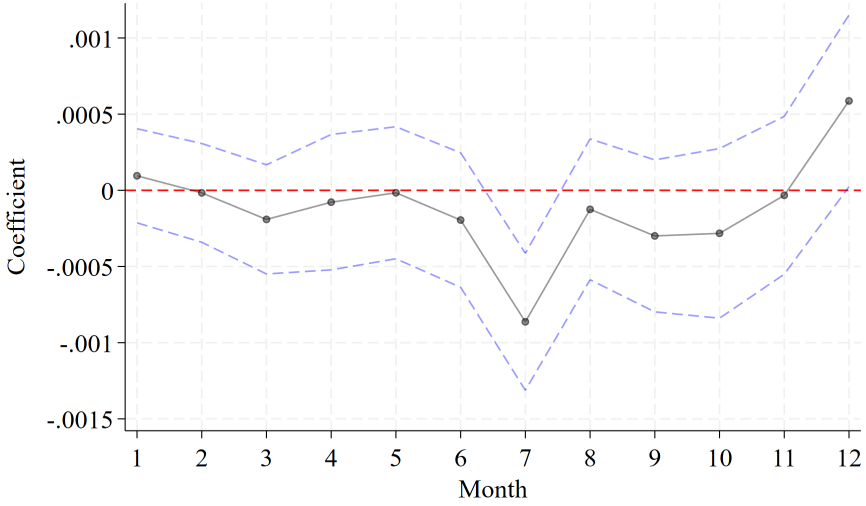
$$+ \sum_{m=2}^{12} month_m \cdot after40_{imt} \cdot age\_even_{imt} \tag{8}$$

  - Stacked by months $\Rightarrow$ Unit of observations: individual-month-year
  - Sample: age $\in$ [20, 89]
  - Saturated model of 3 variables: $after40_{imt}$, $age\_even_{imt}$ and $\sum_{m=2}^{12} month_m$
  - Standard error clustered at the individual level

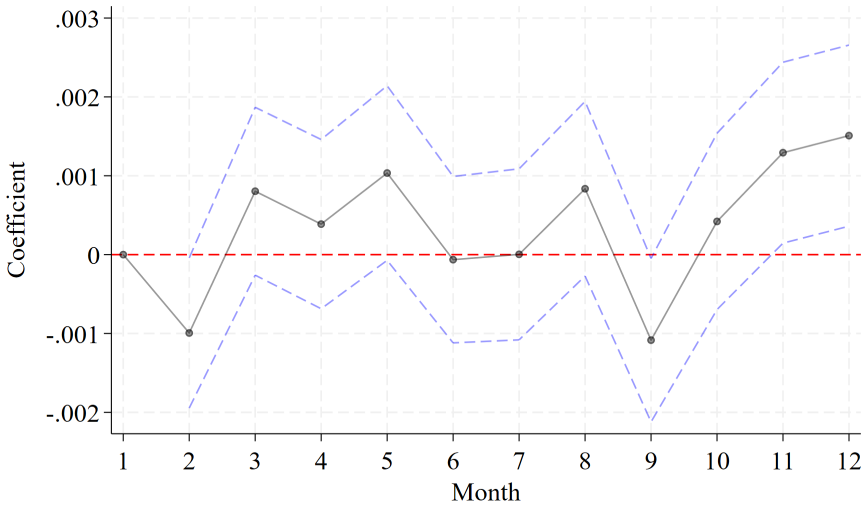
# Interpretation of coefficients

- $age\_even_{imt} + \sum_{m=2}^{12} month_m \cdot age\_even_{imt}$
  - $\Rightarrow$ comparison between even and odd before 40
  - $\Rightarrow$ There should be no difference
- $\sum_{m=2}^{12} month_m \cdot above40_{imt}$
  - $\Rightarrow$ comparison between odd ages before and after 40
  - $\Rightarrow$ Jan/Feb/Nov/Dec should show smallest increase (inverted U-shape)

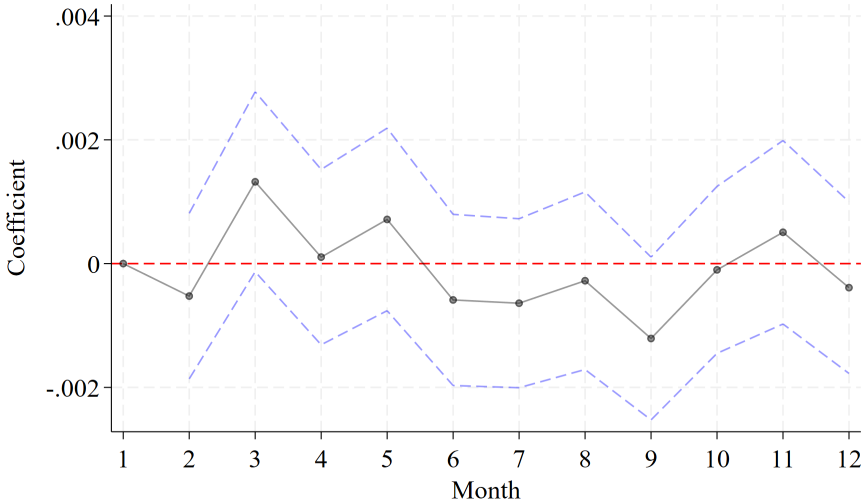
# No difference in monthly take-up between even and odd before 40



# No inverted U-shape for increase in take-up for odd before and after 40



# No inverted U-shape for low income households either

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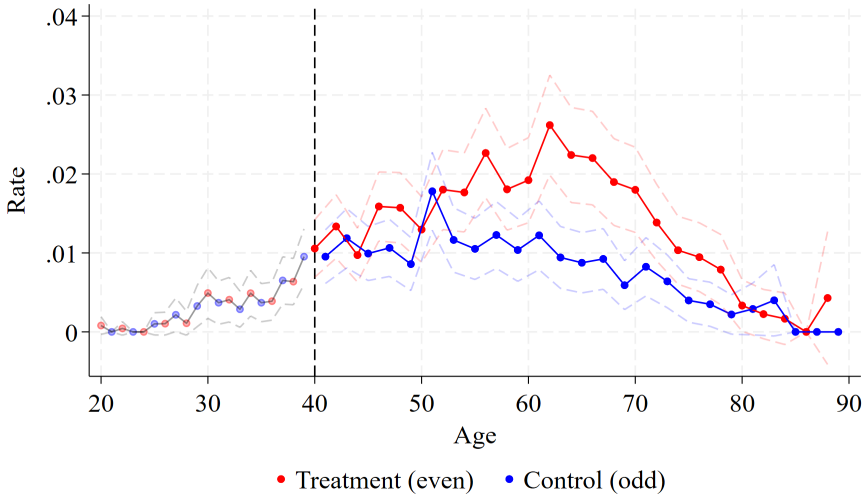
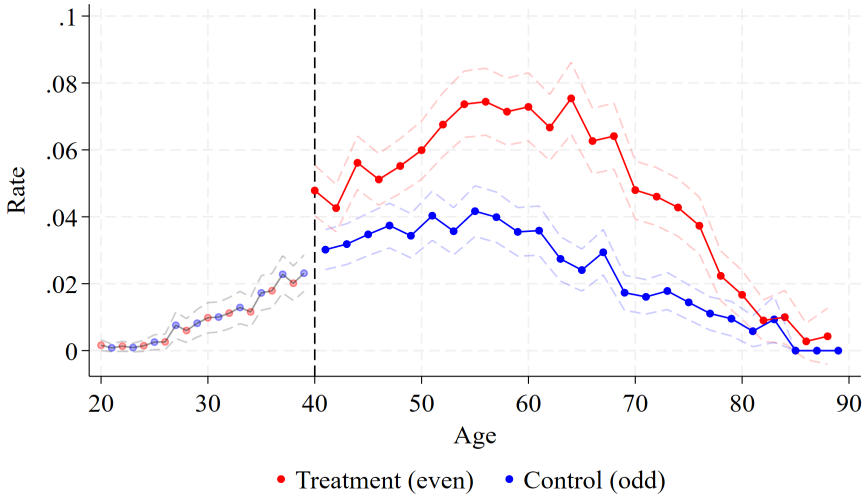
# Lung screening - no subsidy



# Liver screening - annual subsidy

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# Cross spillover: people receive multiple screenings on the same day

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Liver | Colorectal | Prostate | Lung |
| $\Pr(\text{general} = 1 \mid \text{screen} = 1)$ | 0.844 | 0.799 | 0.786 | 0.699 |
| $\Pr(\text{same day} \mid \text{screen} = 1, \text{general} = 1)$ | 0.948 | 0.856 | 0.960 | 0.937 |
| $\Pr(\text{general first} \mid \text{screen} = 1, \text{general} = 1)$ | 0.036 | 0.120 | 0.024 | 0.047 |
| $\Pr(\text{general later} \mid \text{screen} = 1, \text{general} = 1)$ | 0.008 | 0.178 | 0.004 | 0.002 |

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# Cross spillover: people receive multiple screenings on the same day

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Annual subsidy | | No subsidy | |
| | Liver | Colorectal | Prostate | Lung |
| **Panel A. Outcome: conducted on the same day with general screening** | | | | |
| Age even | 0.023*** | 0.024*** | 0.005*** | 0.004*** |
| | (0.001) | (0.001) | (0.001) | (0.001) |
| N | 107183 | 107183 | 50260 | 107183 |
| Control group mean | 0.022 | 0.017 | 0.007 | 0.006 |
| **Panel B. Outcome: conducted after general screening** | | | | |
| Age even | 0.0012*** | 0.0040*** | 0.0001 | 0.0005*** |
| | (0.0002) | (0.0004) | (0.0001) | (0.0001) |
| N | 107183 | 107183 | 50260 | 107183 |
| Control group mean | 0.0007 | 0.0022 | 0.0002 | 0.0002 |
| **Panel C. Outcome: conducted before general screening** | | | | |
| Age even | 0.0003*** | 0.0064*** | 0.0001 | 0.0000 |
| | (0.0001) | (0.0005) | (0.0001) | (0.0000) |
| N | 107183 | 107183 | 50260 | 107183 |
| Control group mean | 0.0001 | 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 |

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# Cross spillover: women do not show stronger spillover

| | (1) | (2) | (3) |
|---|---|---|---|
| | Liver | Colorectal | Lung |
| Age even | 0.025*** | 0.036*** | 0.007*** |
| | (0.002) | (0.002) | (0.001) |
| Age even × Female | 0.003 | –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 | 0.027 | 0.009 |

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# Spousal spillover direction

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| | Among wives (husband ⇒ wife) | | Among husbands (wife ⇒ husband) | |
| Age even | 0.220*** | 0.219*** | 0.142*** | 0.141*** |
| | (0.004) | (0.004) | (0.004) | (0.004) |
| Spouse age even | 0.006 | | 0.017*** | |
| | (0.004) | | (0.004) | |
| Spouse screening | | 0.046 | | 0.079*** |
| | | (0.030) | | (0.017) |
| N | 50863 | 50863 | 50863 | 50863 |
| Estimator | OLS | 2SLS | OLS | 2SLS |

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# 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 |

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# 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 |

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# Spousal spillover in each screening

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
|---|---|---|---|---|---|---|---|---|
| | General | Stomach | Liver | Colorectal | Lung | Breast | Cervical | Prostate |
| Age even | 0.163*** | 0.165*** | 0.023*** | 0.030*** | 0.005*** | 0.168*** | 0.156*** | 0.007*** |
| | (0.003) | (0.003) | (0.001) | (0.001) | (0.001) | (0.004) | (0.003) | (0.001) |
| Spouse age even | 0.010*** | 0.012*** | 0.002 | 0.004*** | 0.001 | 0.001 | 0.000 | −0.001 |
| | (0.003) | (0.003) | (0.001) | (0.001) | (0.001) | (0.004) | (0.003) | (0.001) |
| N | 101726 | 101726 | 101726 | 101726 | 101726 | 50863 | 50863 | 50863 |

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# Screening results

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

| Screening | Take-up | Disease diagnosis |
|---|---|---|
| Aggregate | | 32.6% |
| Stomach | 17.8% | 22.8% |
| Breast | 16.3% | 2.2% |
| Cervical | 13.9% | 6.2% |
| Colorectal | 4.3% | 19.8% |

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# 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

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# 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

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# Disease classifications for female genital

- (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

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# 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

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# 1. Estimate Always- and Never-takers characteristics

- Individually identifiable always- and never-takers

| | Even age (treatment) | Odd age (control) |
|---|---|---|
| Always-takers | Yes | Yes |
| Compliers | Yes | No |
| Never-takers | No | No |

- Estimating equation

$$y_{it} = \beta_0 + \beta_1 treat_{it} + \beta_2 screen_{it} + \beta_3 treat_{it} \times screen_{it} + \nu_{it} \tag{9}$$

- Average characteristics
  - Always-takers: $g_{AT}(y) = \hat{\beta}_0 + \hat{\beta}_2$
  - Never-takers: $g_{NT}(y) = \hat{\beta}_0 + \hat{\beta}_1$

# 2. Back out complier characteristics

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

| | Even age (treatment) | Odd age (control) |
|---|---|---|
| Always-takers | Yes | Yes |
| Compliers | Yes | No |
| Never-takers | No | No |

- Estimating equation

$$y_{it} = \beta_0 + \beta_1 treat_{it} + \beta_2 screen_{it} + \beta_3 treat_{it} \times screen_{it} + \nu_{it} \tag{10}$$

- Those getting screened in the treatment group

$$\begin{aligned} g_T(y) &= \frac{\pi_{AT}}{\pi_{AT} + \pi_C} g_{AT}(y) + \frac{\pi_C}{\pi_{AT} + \pi_C} g_C^1(y) \\ &= \hat{\beta}_0 + \hat{\beta}_1 + \hat{\beta}_2 + \hat{\beta}_3 \end{aligned}$$

- Those not getting screened in the control group

$$\begin{aligned} g_U(y) &= \frac{\pi_{NT}}{\pi_{NT} + \pi_C} g_{NT}(y) + \frac{\pi_C}{\pi_{NT} + \pi_C} g_C^0(y) \\ &= \hat{\beta}_0 \end{aligned}$$

# 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 with clustering at individual level (500 replications)

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# Annual and no-subsidy screening participants receive biennial screenings

Annual- and no-subsidy screening participants are a subset of biennial subsidy screening participants

- $\Pr(\text{Any biennial screening} = 1 \mid \text{liver screening} = 1) = 0.98$
- $\Pr(\text{Any biennial screening} = 1 \mid \text{colorectal screening} = 1) = 0.96$
- $\Pr(\text{Any biennial screening} = 1 \mid \text{lung screening} = 1) = 0.98$
- $\Pr(\text{Any biennial screening} = 1 \mid \text{prostate screening} = 1) = 0.99$

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# Selection analysis using panel variation in even vs odd age take-up

- Using 11 years of panel information to define compliance groups

| | Even age (treatment) | Odd age (control) |
|---|---|---|
| Always-takers | Yes | Yes |
| Compliers | Yes | No |
| Defiers | No | Yes |
| Never-takers | No | No |

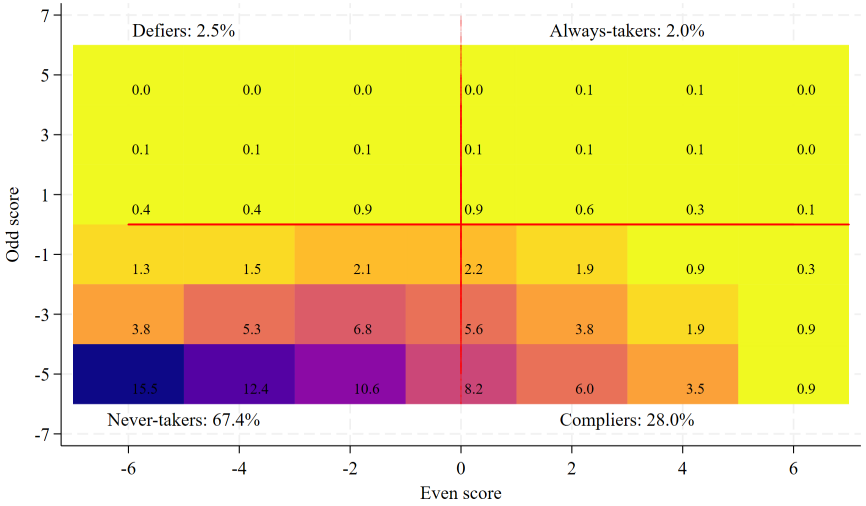
- Analytical sample
  - Balanced sample without attrition during 11 years
  - First year age $\geq 40$
  - 5,514 unique individuals

- Even and odd scores for classification

$$even\_score_i = \sum_t [\mathbb{1}\{screen_{ia} = 1\} - \mathbb{1}\{screen_{ia} = 0\}], \qquad a\ even$$

$$odd\_score_i = \sum_t [\mathbb{1}\{screen_{ia} = 1\} - \mathbb{1}\{screen_{ia} = 0\}], \qquad a\ odd$$

# Bivariate distribution of even and odd scores for first year even age



# Compliers have worse health conditions and lower socioeconomics status

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | Always | Complier | Defier | Never | Complier / Always | Complier / Defiers | Complier / Never |
| **Panel A. Diagnoses** | | | | | | | |
| Diagnosed with a disease | 0.277 | 0.350 | 0.306 | 0.321 | 1.264*** | 1.146*** | 1.093*** |
| | (0.018) | (0.006) | (0.019) | (0.007) | (0.084) | (0.076) | (0.031) |
| Stomach disease diagnosis | 0.141 | 0.203 | 0.154 | 0.182 | 1.435*** | 1.314*** | 1.114*** |
| | (0.014) | (0.006) | (0.016) | (0.006) | (0.145) | (0.139) | (0.047) |
| Breast disease diagnosis | 0.011 | 0.011 | 0.012 | 0.009 | 1.005** | 0.933** | 1.241*** |
| | (0.004) | (0.002) | (0.006) | (0.002) | (0.422) | (0.471) | (0.297) |
| Cervical disease diagnosis | 0.030 | 0.031 | 0.026 | 0.031 | 1.032*** | 1.168*** | 0.999*** |
| | (0.007) | (0.003) | (0.010) | (0.004) | (0.264) | (0.445) | (0.146) |
| Colorectal disease diagnosis | 0.042 | 0.042 | 0.048 | 0.042 | 1.001*** | 0.886*** | 0.993*** |
| | (0.008) | (0.003) | (0.009) | (0.003) | (0.207) | (0.180) | (0.095) |
| **Panel B. SES** | | | | | | | |
| Individual income | 2456 | 990 | 2391 | 1225 | 0.403*** | 0.414*** | 0.808*** |
| | (244) | (37) | (209) | (27) | (0.043) | (0.039) | (0.035) |
| Household income | 5817 | 3862 | 5443 | 3634 | 0.664*** | 0.710*** | 1.063*** |
| | (313) | (67) | (271) | (44) | (0.038) | (0.037) | (0.023) |
| Years of education | 11.949 | 9.789 | 11.476 | 9.445 | 0.819*** | 0.853*** | 1.036*** |
| | (0.359) | (0.099) | (0.343) | (0.075) | (0.026) | (0.027) | (0.013) |
| College graduate | 0.279 | 0.115 | 0.271 | 0.137 | 0.411*** | 0.424*** | 0.840*** |
| | (0.040) | (0.008) | (0.037) | (0.006) | (0.066) | (0.065) | (0.068) |
| Working status | 0.742 | 0.555 | 0.729 | 0.598 | 0.748*** | 0.761*** | 0.928*** |
| | (0.031) | (0.010) | (0.031) | (0.007) | (0.034) | (0.036) | (0.020) |

# Compliers are less likely to smoke, drink and exercise

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|---|
| | Always | Complier | Defier | Never | Complier / Always | Complier / Defiers | Complier / Never |
| **Panel C. Health behaviors** | | | | | | | |
| Current smoker | 0.128 | 0.099 | 0.222 | 0.207 | 0.779*** | 0.447*** | 0.479*** |
| | (0.024) | (0.007) | (0.031) | (0.006) | (0.158) | (0.068) | (0.035) |
| Everyday smoker | 0.118 | 0.096 | 0.208 | 0.200 | 0.811*** | 0.460*** | 0.478*** |
| | (0.023) | (0.007) | (0.030) | (0.006) | (0.171) | (0.073) | (0.036) |
| Current drinker | 0.701 | 0.601 | 0.705 | 0.593 | 0.858*** | 0.853*** | 1.013*** |
| | (0.034) | (0.010) | (0.032) | (0.007) | (0.044) | (0.041) | (0.020) |
| Everyday drinker | 0.038 | 0.057 | 0.096 | 0.080 | 1.479*** | 0.589*** | 0.702*** |
| | (0.011) | (0.004) | (0.018) | (0.003) | (0.443) | (0.120) | (0.062) |
| Vigorous exercise | 0.298 | 0.200 | 0.272 | 0.191 | 0.671*** | 0.735*** | 1.050*** |
| | (0.022) | (0.005) | (0.019) | (0.004) | (0.053) | (0.056) | (0.035) |
| Moderate exercise | 0.498 | 0.385 | 0.462 | 0.338 | 0.773*** | 0.833*** | 1.141*** |
| | (0.020) | (0.006) | (0.023) | (0.004) | (0.034) | (0.043) | (0.023) |
| Walking | 0.843 | 0.816 | 0.817 | 0.771 | 0.969*** | 0.999*** | 1.059*** |
| | (0.016) | (0.005) | (0.013) | (0.003) | (0.019) | (0.017) | (0.008) |
| **Panel D. Married subsample** | | | | | | | |
| Pr(even/odd or odd/even) | 0.505 | 0.477 | 0.616 | 0.500 | | | |
| Share | 0.022 | 0.283 | 0.026 | 0.669 | | | |

# Summary of selection analysis using panel variation

- Compliers compared to always-takers
  - More likely to find a disease through screening
  - Have less income and education
  - Less likely to smoke, drink and exercise
- Compliers compared to never-takers
  - Less likely to smoke and drink and more likely to exercise
- Who are defiers?
  - More likely to have a spouse with different even or odd age

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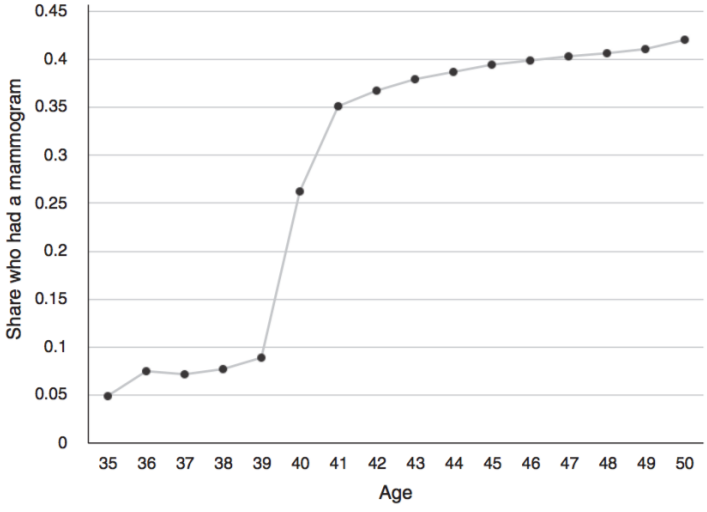
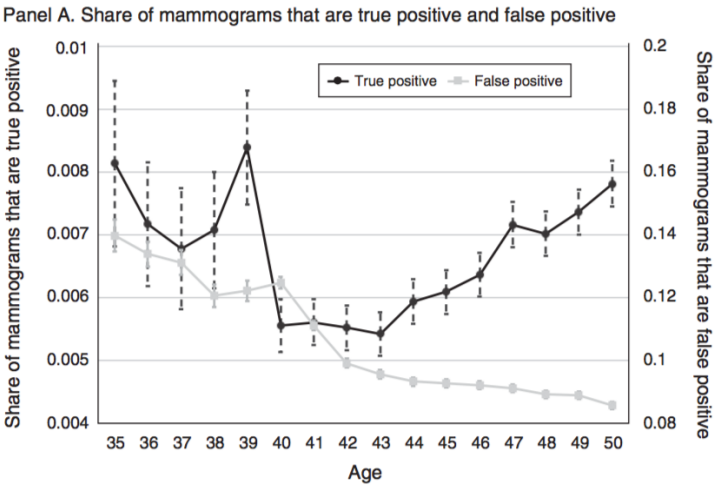
# Einav et al. (2020) AER



# Einav et al. (2020) AER




Complier vs Always-taker Selection summary

# Effect of spouse's subsidy eligibility on first hospital visits

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | First outpatient visit | High blood pressure | Hyperlipidemia | Diabetes | Stomach | Breast | Female genital | Liver | Colorectal | Male genital | Lung |
| **Panel A. Reduced form regressions** | | | | | | | | | | | |
| Age even | 0.0689*** | 0.0014 | 0.0032*** | –0.0005 | 0.0245*** | 0.0014 | 0.0075** | 0.0001 | 0.0047** | –0.0020 | 0.0008 |
| | (0.0179) | (0.0017) | (0.0012) | (0.0012) | (0.0035) | (0.0014) | (0.0035) | (0.0008) | (0.0022) | (0.0031) | (0.0012) |
| Spouse | 0.0198 | 0.0017 | 0.0010 | 0.0015 | 0.0046 | 0.0008 | 0.0003 | 0.0001 | 0.0000 | 0.0009 | 0.0008 |
| age even | (0.0179) | (0.0017) | (0.0012) | (0.0012) | (0.0035) | (0.0014) | (0.0035) | (0.0008) | (0.0022) | (0.0031) | (0.0012) |
| Estimator | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS | OLS |
| **Panel B. Second stage regressions** | | | | | | | | | | | |
| Screening | 0.3165*** | 0.0062 | 0.0146*** | –0.0029 | 0.1135*** | 0.0049 | 0.0290** | 0.0005 | 0.0220** | –0.0122 | 0.0037 |
| | (0.0827) | (0.0079) | (0.0054) | (0.0055) | (0.0164) | (0.0054) | (0.0138) | (0.0040) | (0.0103) | (0.0186) | (0.0057) |
| Spouse | 0.0676 | 0.0076 | 0.0037 | 0.0073 | 0.0126 | 0.0043 | 0.0004 | 0.0002 | –0.0017 | 0.0045 | 0.0035 |
| screening | (0.0828) | (0.0079) | (0.0054) | (0.0055) | (0.0164) | (0.0081) | (0.0209) | (0.0040) | (0.0103) | (0.0120) | (0.0057) |
| Estimator | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS | 2SLS |
| N | 79782 | 79782 | 79782 | 79782 | 79782 | 39890 | 39890 | 79782 | 79782 | 39892 | 79782 |
| Odd/Odd | 4.0076 | 0.0466 | 0.0244 | 0.0252 | 0.1947 | 0.0104 | 0.1063 | 0.0089 | 0.0819 | 0.0738 | 0.0193 |
| Controls | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |

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