

# Does Cancer Screening Save Lives from Cancer?

-Effect and Mechanism of Cancer Screening-

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# Why Do We Care about Cancer Screening?

- Motivation
- Cancer is a main cause of death worldwide (13%, 7.6 million)
  - ▶ Ranks the second in developed countries and the third in developing countries
  - ▶ Cancer mortality: Lung > Stomach > Liver > Colorectal > Breast
- Definition
  - ▶ cancer screening: a procedure to detect a cancer **without symptom**
  - ▶ Clinical procedure: procedure **with a relevant symptom**
- Conventional wisdom behind cancer screening
  - ▶ Screening → Early detection → ↓ Cancer mortality → ↓ All-cause mortality
  - ▶ Cancer screening is regarded to play a central role for fighting against cancer (Cutler, 2009)

# Why Do We Care about Cancer Screening?

- Cancer screening is very popular
  - ▶ Annually \$4 billion for breast cancer screening in the US
  - ▶ Public cancer screening expenditure in Korea \$400 million (in 2010)
- However, net benefit of cancer screening is called into question
  - ▶ Clear evidence is scarce

**The New York Times**

**Health**

Benefits and Risks of Cancer Screening Are Not Always Clear, Experts Say

By TARA PARKER-POPE  
Published: October 21, 2009

- ▶ Prostate and breast cancer screening debate in 2009

**The New York Times**

**Opinion**

**The New York Times**

**Opinion**

OP-ED CONTRIBUTOR

The Great Prostate Mistake

By RICHARD J. ABLIN  
Published: March 9, 2010

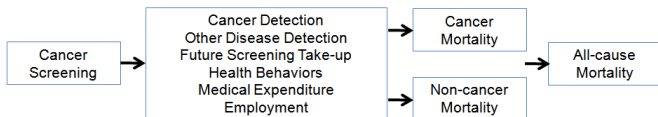
EDITORIAL

The Controversy Over Mammograms

Published November 19, 2009

# Limitation of Previous Studies

- Evidence on causal impact is rare
- No study on mechanism
  - ▶ Consequences of cancer screening are multi-dimensional



- Focus only on cancer-specific mortality
  - ▶ Inconsistencies in cancer mortality and all-cause mortality

Cancer	Screening	Cancer Mortality Gain	All-cause Mortality Gain	Papers	etc
Gastric Cancer	EGD / UGI	-	-		
Breast Cancer	Mammography	No impact ~ 30%	No impact	Nystrom et al. 2002, Shapiro et al. 1998, Alexander et al. 1999, Miller et al. 2000, Tabbar et al. 2000	RCT
Colorectal Cancer	FOBT	15~33%	No impact	Mandel et al. 1993, Hardcastle et al 1996, Kronborg et al 1996	RCT
	Signoidoscopy	43%	2.67%*	Atkin et al. 2010	RCT
	Colonoscopy	53%	-	Zauber et al. 2012	
Lung Cancer	Chest X-ray	No impact	No impact	Oken et al, 2011	RCT
	Low-dose CT	20%	6.29%*	The National Lung Screening Trial Team, 2011	RCT
Prostate Cancer	PSA	No impact ~ 20%	No impact	Andriole et al. 2009, Schroder et al. 2009	RCT

\* All-cause mortality is calculated by the author

# This Study

- The Korea's public cancer screening program
  - ▶ General health screening and cervical cancer screening since 1999
    - ★ Free for all
  - ▶ Stomach and Breast since 2002
    - ★ Below insurance contribution cut-off (poorer): free of charge
    - ★ Above insurance contribution cut-off (richer): 50% co-payment
- Regression discontinuity design
- Large administrative data for 8 years with comprehensive outcomes

# Contribution

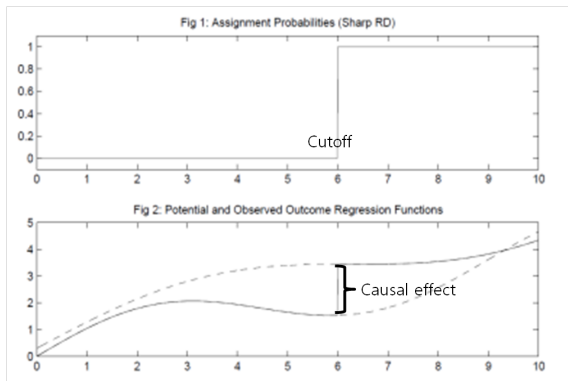
- Reliable estimates of causal effect
  - ▶ using plausibly exogenous variation
  - ▶ large number of observation
  - ▶ regression discontinuity design
- Provide evidence on 'full' impact of cancer screening
  - ▶ First study on mechanism of cancer screening
    - ★ behavioral response of cancer screening
    - ★ Explain on inconsistency between cancer and all-cause mortality
- Other contributions
  - ▶ First evidence for stomach cancer screening
  - ▶ First evidence for breast cancer screening in non-western country
  - ▶ Covers entire age group of 40 and over (even aged 70+)

# Summary of Result

Screening Offered	Male			Female		
	Gastric cancer			Gastric/Breast cancer		
	All	40-59	60+	All	40-59	60+
<b>Screening Take-up</b>						
Gastric cancer screening	↑8.4%p (146%)	↑	↑	↑8.2%p (102%)	↑	↑
Breast cancer screening		-	-	↑8.4%p (97%)	↑	↑
Information on disease status	↑	↑	↑	↑	↑	↑
<b>Mortality</b>						
Gastric cancer mortality	↓	↓	↓	↓	↓	↓
Breast cancer mortality				↓	↓	↓
Non cancer mortality	↓	↓	↑	↑	↑	↑
All-cause mortality	↓	↓	↑	↑	↑	↑
<b>Mecanism</b>						
Cancer Detection	↑	↑	↔	↑	↑	↔
Early detection	↔	↔	↔	↔	↔	↔
Future cancer screening take-up	↓	↔	↓	↓	↓	↓
Future health screening take-up	↓	↓	↓	↓	↓	↓
Individual Employment	↓	↓	↓	↔	↔	↔
Family employment	↓	↓	↓	↓	↓	↓
Meidcal Expenditure	↑	↑	↑	↑	↑	↑
Health Outcomes (Biomarker)	↔	↔	↓	↔	↔	↓

## Regression Discontinuity Design: example

- Treatment is assigned by running variable with cutoff 0.6.
- Potential outcome is dashed lines, but we observe only solid line.
- Comparing people just above to just below the cutoff who are similar but have different probability of eligibility





# Contents

- Introduction
- Institutional details
- Data: NHI (National Health Insurance) data
- Empirical estimation strategy
- Results
- Mechanism
- Conclusion and policy recommendation

# National Health Insurance(NHI)

- Universal coverage
  - ▶ NHI covers 95% of population
  - ▶ Medical Care Assistance (MCA) covers the rest (the poor)
- Single insurer
  - ▶ National Health Insurance Corporation (NHIC)
- Two categories of health insurance
  - ▶ Employee type insurance (31.4 million)
    - ★ Employees and their dependents
    - ★ Contribution rate : fixed percentage of wage
    - ★ 3.62% (in 2002) - 5.33%(in 2010)
  - ▶ Self-employed insurance (17.2 million)
    - ★ All people who are excluded from employee insurance

# National Screening Program

- Offered to people aged over 40 in every two years
  - ▶ People born in even/odds-numbered years are offered in even/odds-numbered years
  - ▶ Offer is valid for two years
- General health screening & cervical cancer screening (since 1999)
  - ▶ free of charge
- Stomach and breast cancer screening since 2002 liver(2003) and colorectal(2004)
  - ▶ Below cut-off: free of charge
  - ▶ Above cut-off: 50% copayment (\$17(stomach), \$7(breast))
- Gastric cancer screening: either UGI(X-ray) or EGD(endoscopy)
- Breast cancer screening: mammography(X-ray)

# National Screening Program

- History of NHIC cancer screening

Year	Male	Female	Cut-off (KRW)
2002	Stomach	Stomach, Breast	26180
2003	Stomach	Stomach, Breast	24630
	Liver	Liver	16750
2004	Stomach, Liver	Stomach, Liver	25260
	Colon	Breast, Colon	23150
2005	Stomach, Colon, Liver	Stomach, Breast, Colon, Liver	35000
2006	Stomach, Colon, Liver	Stomach, Breast, Colon, Liver	50000
2007	Stomach, Colon, Liver	Stomach, Breast, Colon, Liver	52500

# Data

- National Health Insurance Corporation (NHIC) Data

- ▶ Eligibility

- ★ age, gender, employment status, insurance contribution, mortality
- ★ information on wage, pension, interest income, car and real estate is available

- ▶ Medical records

- ★ diagnosis (ICD-10), medical expenditure, number of hospital and out-patient clinic days

- ▶ Screening data

- Sample; NHIC 2001-2008 data

- ▶ Aged 40 and over

- ▶ Gastric and breast cancer screening

- ★ 2002 and 2003 cohort are stacked up
- ★ by standardizing insurance contribution
- ★ previous stomach and breast cancer patients are excluded

Cohort	Year									Cohort	T						
	2001	2002	2003	2004	2005	2006	2007	2008			-2	-1	0	1	2	3	4
2002	T=0								→	2002	T=0						
2003	T=0									2003	T=0						

# Major Dependent Variables

- Cancer detection
  - ▶ New cancer cases (ICD-10)
  - ▶ Restriction : due to concern on over-diagnosis
    - ★ Medical expenditure on cancer  $\geq$ \$300 in the first year of detection
- Cancer-related mortality
  - ▶ Cancer cases + Mortality with non-zero cancer expenditure in last year of death
  - ▶ More comprehensive than cancer-specific mortality
- All-cause mortality

# Summary Statistics

- 2002-2003 cohorts

Cancer Screening Offered	2002/2003 cohort (Stacked)					
	Male			Female		
	Stomach			Stomach and Breast		
	N	Mean	Std.Dev	N	Mean	Std.Dev
<b>Panel A. General Information</b>						
Age	4,041,275	53.9	11.2	4,460,789	56.2	12.3
Cancer Screening Eligibility	4,041,275	0.347	0.476	4,460,789	0.374	0.484
Insurance contribution	4,041,275	41384	33742	4,460,789	39960	32558
Employment status	4,041,275	0.625	0.484	4,460,789	0.157	0.364
<b>Panel B. Cancer screening</b>						
<b>Gastric cancer screening takeup</b>	4,041,275	0.097	0.295	4,460,789	0.110	0.312
EGD take-up	4,041,275	0.042	0.200	4,460,789	0.043	0.202
UGI take-up	4,041,275	0.058	0.233	4,460,789	0.068	0.251
<b>Breast cancer screening takeup</b>				4,460,789	0.114	0.317
<b>Colorectal cancer screening takeup</b>	4,041,275	0.028	0.165	4,460,789	0.034	0.180
<b>Cervical cancer screening takeup</b>				4,460,789	0.100	0.301
<b>Panel C. General Screening</b>						
<b>General health screening takeup</b>	4,041,275	0.467	0.499	4,460,789	0.287	0.452
<b>Panel D. Medical expenditure(Unit:\$)</b>						
Total medical expenditure	3,641,741	709.9	1709.2	4,217,969	796.9	1524.9
Non cancer expenditure	3,641,741	643.7	1479.7	4,217,969	760.0	1395.1
All cancer	3,641,741	66.3	812.4	4,217,969	37.0	595.3
<b>Panel E. Cumulative mortality</b>						
All-cause mortality	4,041,275	0.073	0.261	4,460,789	0.057	0.231
Non-cancer mortality	4,041,275	0.047	0.211	4,460,789	0.043	0.202
Cancer related mortality	4,041,275	0.027	0.161	4,460,789	0.014	0.117

# Gastric Cancer Screening Result

- Number of gastric cancer patients by screening result

Panel A. Gastric cancer		Male, 2002-2003 cohort					
		EGD			UGI		
		Total	Cancer	Proportion	Total	Cancer	Proportion
Total		3,946,996	17,447	0.44%	3,946,996	17,447	0.44%
Not taken		3,843,901	16,467	0.43%	3,788,413	16,749	0.44%
Taken		103,095	980	0.95%	158,583	698	0.44%
Screening result	Normal	14,066	39	0.28%	101,646	215	0.21%
	Cancer suspicion	550	469	85.27%	800	138	17.25%
	Other stomach disease	88,479	472	0.53%	56,137	345	0.61%

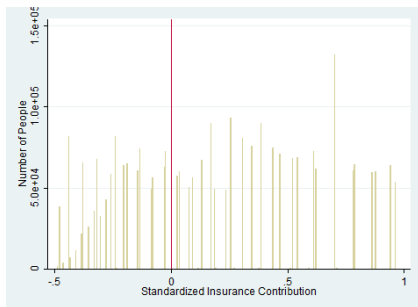
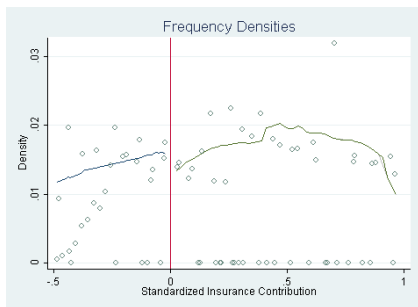
- Interpretation

- ▶ False negative is low.
- ▶ False positive is reasonable
- ▶ Detection is not many:  $607 = 469(\text{EGD}) + 138(\text{UGI})$
- ▶ Gastric cancer screening also detects other type of diseases



# Density Distribution, 2002/2003 cohort, Male

- Density distribution of insurance contribution



- ▶ Insurance contribution is smooth but discrete
  - ★ Errors are clustered by insurance contribution (Lee and Card, 2007)
- ▶ Manipulation is not likely: McCrary Test (McCrary, 2008)

# Estimation Strategy: Regression Discontinuity Design

- The regression model is

$$\text{Outcome}_{it} = \beta \mathbb{1}\{I_i \geq \tau\} + f(I_i) + \gamma X_i + \psi_c + \epsilon_i,$$

where Outcome is outcomes for individual  $i$ ,  $t$  years after screening offer

$I$  is the standardized insurance contribution

$\tau$  is the cutoff

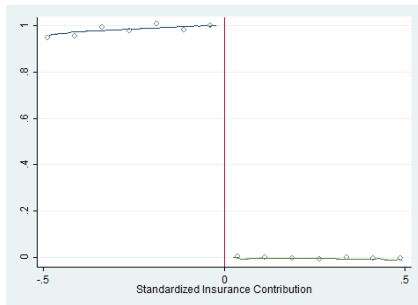
$f(I)$  is a function of the insurance contribution

$\psi$  is cohort fixed effect

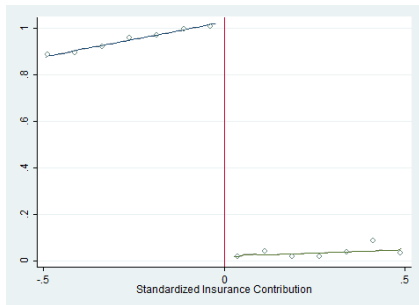
$X$  is a set of control variables - age, employment status and general screening take-up indicator

- Bandwidth : 0.2-0.5 and IK optimal bandwidth - 0.3 is preferred
- Modeling  $f(I)$ : linear, quadratic and cubic

## Male



## Female



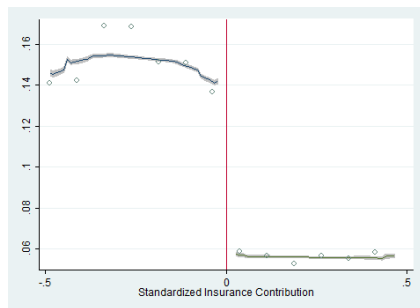
Bandwidth		0.2	0.3	0.4	0.5
Total		871,698	1,260,729	1,756,867	2,046,708
Age group	40-49	328,733	470,422	658,474	771,615
	50-59	257,104	372,108	507,651	584,909
	60-69	216,621	318,678	448,808	521,712
	70-	69,240	99,521	141,934	168,472

Bandwidth		0.2	0.3	0.4	0.5
Total		956,933	1,396,081	1,879,129	2,300,247
Age group	40-49	310,491	463,432	636,334	779,186
	50-59	310,623	449,627	597,140	713,904
	60-69	212,795	306,133	412,201	515,058
	70-	123,024	176,889	233,454	292,099

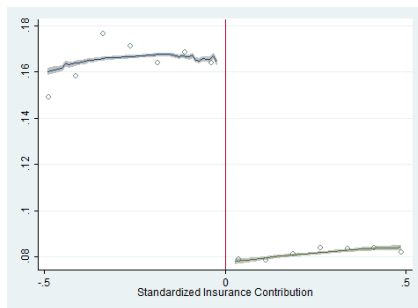
Note: Open circle plots residual + mean of dependant variable, Locally weighted linear regression with rectangular kernel, Bandwidth 0.3

# Gastric Cancer Screening Take-up, 2002/2003 cohort

↑ by 8.4%p (146%) in male

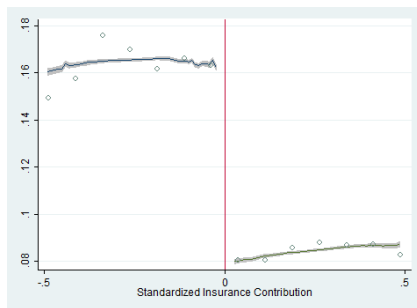


↑ by 8.2%p (102%) in female



# Breast Cancer Screening Take-up, 2002/2003 cohort, female

↑ by 8.4%p (97%)



# Cancer Screening Take-up, Male, 2002/2003 cohort

- Gastric cancer:  $\uparrow$  by 8.4%p (EGD 2.9%p, UGI 5.6%p)

Bandwidth	Male							
	Gastric cancer screening		EGD		UGI		Colon cancer screening	
	0.3	IK	0.3	IK	0.3	IK	0.3	IK
Panel A. Total								
Linear	0.0840** (0.010)	0.0783** (0.013)	0.0293** (0.004)	0.0270** (0.006)	0.0558** (0.005)	0.0506** (0.005)	0.0073 (0.005)	0.0052 (0.005)
Quadratic	0.0758** (0.013)	-0.3854** (0.056)	0.0252** (0.006)	-0.1919** (0.029)	0.0518** (0.007)	0.0520** (0.013)	0.0042 (0.007)	0.0042 (0.011)
Cubic	0.0843** (0.023)	0.4808* (0.202)	0.0303** (0.011)	0.3355** (0.024)	0.0557** (0.013)	-0.2406** (0.071)	0.0088 (0.012)	0.0811* (0.035)
N	1,260,729	465,335	1,260,729	465,334	1,260,729	606,937	1,260,729	667,548
Panel B. Age group								
40-49	0.0562** (0.011)	0.0491* (0.016)	0.0224** (0.005)	0.0205* (0.007)	0.0347** (0.006)	0.0268** (0.007)	0.0053** (0.002)	0.0051** (0.002)
50-59	0.0879** (0.010)	0.0818** (0.012)	0.0335** (0.005)	0.0302** (0.005)	0.0558** (0.006)	0.0504** (0.005)	0.0114+ (0.006)	0.0069 (0.006)
60-69	0.1047** (0.008)	0.0979** (0.009)	0.0308** (0.004)	0.0279** (0.005)	0.0751** (0.005)	0.0710** (0.005)	0.0006 (0.007)	-0.0015 (0.007)
70-	0.0907** (0.007)	0.0826** (0.010)	0.0248** (0.003)	0.0199** (0.004)	0.0662** (0.004)	0.0603** (0.005)	0.0030 (0.003)	0.0008 (0.005)

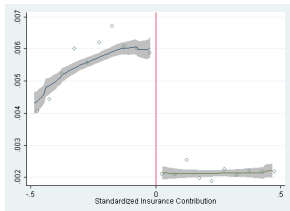
# Cancer Screening Take-up, Female, 2002/2003 cohort

- Gastric cancer screening  $\uparrow$  by 8.6%p (EGD 2.4%p, UGI 6.2%p)
- Breast cancer screening  $\uparrow$  by 8.4%p

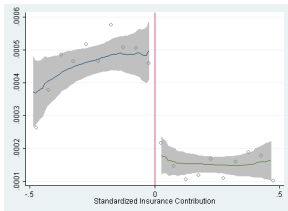
	Female							
	Gastric cancer screening		EGD		UGI		Breast cancer screening	
Bandwidth	0.3	IK	0.3	IK	0.3	IK	0.3	IK
Panel A. Total								
Linear	0.0861** (0.007)	0.0790** (0.007)	0.0242** (0.004)	0.0200** (0.003)	0.0622** (0.004)	0.0622** (0.004)	0.0838** (0.009)	0.0828** (0.013)
Quadratic	0.0826** (0.010)	0.0848** (0.014)	0.0219** (0.006)	0.0251* (0.009)	0.0612** (0.005)	0.0575** (0.006)	0.0818** (0.014)	-0.3106** (0.058)
Cubic	0.0848** (0.017)	-0.2310** (0.069)	0.0246* (0.009)	-0.1295* (0.047)	0.0609** (0.008)	0.0819** (0.019)	0.0859** (0.023)	0.3454** (0.092)
N	1,396,081	662,263	1,396,081	662,263	1,396,081	823,434	1,396,081	506,262
Panel B. Age group								
40-49	0.0759** (0.010)	0.0671** (0.006)	0.0246** (0.005)	0.0194** (0.002)	0.0512** (0.006)	0.0521** (0.005)	0.0738** (0.012)	0.0714** (0.011)
50-59	0.0966** (0.009)	0.0879** (0.010)	0.0288** (0.005)	0.0234** (0.006)	0.0682** (0.004)	0.0682** (0.004)	0.0936** (0.010)	0.0911** (0.015)
60-69	0.1076** (0.007)	0.1025** (0.009)	0.0270** (0.003)	0.0254** (0.004)	0.0816** (0.004)	0.0798** (0.005)	0.1065** (0.010)	0.1071** (0.018)
70-	0.0462** (0.003)	0.0396** (0.004)	0.0082** (0.001)	0.0058** (0.001)	0.0382** (0.003)	0.0369** (0.003)	0.0464** (0.004)	0.0474** (0.007)

# Information from EGD and UGI, Male

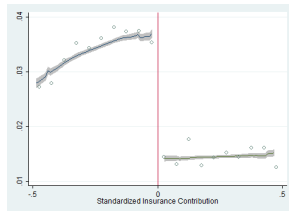
↑ 0.40%p



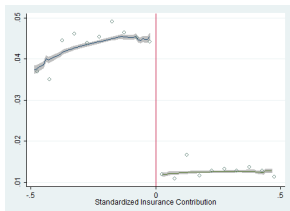
↑ 0.03%p



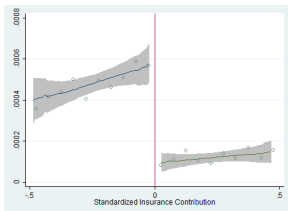
↑ 2.34%p



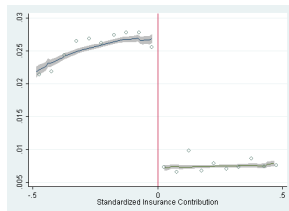
↑ 3.45%p



↑ 0.05%p



↑ 1.98%p



Normal

Cancer suspicion

Other stomach diseases



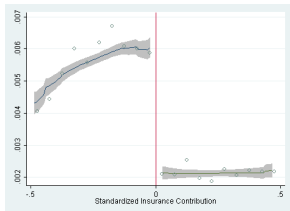
# Information from EGD and UGI, Male

- Probability of being "normal" and "other type of gastric diseases" ↑
- Probability of being "cancer suspicion" ↑ (not in all age groups)

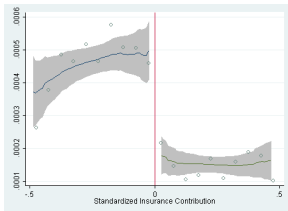
	EGD						UGI					
	Normal		Cancer Suspicion		Other Type of Gastric Diseases		Normal		Cancer Suspicion		Other Type of Gastric Diseases	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Bandwidth	0.3	IK	0.3	IK	0.3	IK	0.3	IK	0.3	IK	0.3	IK
Panel A.1. Total												
	0.0040** (0.000)	0.0038** (0.000)	0.0003** (0.000)	0.0003** (0.000)	0.0234** (0.002)	0.0230** (0.003)	0.0345** (0.002)	0.0343** (0.002)	0.0005** (0.000)	0.0005** (0.000)	0.0198** (0.001)	0.0195** (0.001)
N	1,260,729	871,698	1,260,729	935,784	1,260,729	871,698	1,260,729	935,781	1,260,729	935,781	1,260,729	935,781
Panel A.2 Age group												
40-49	0.0028** (0.001)	0.0021** (0.001)	0.0001 (0.000)	0.0001+ (0.000)	0.0150** (0.003)	0.0154** (0.003)	0.0198** (0.003)	0.0188** (0.003)	0.0002** (0.000)	0.0002** (0.000)	0.0111** (0.001)	0.0095** (0.001)
50-59	0.0049** (0.001)	0.0054** (0.001)	0.0003* (0.000)	0.0004** (0.000)	0.0255** (0.003)	0.0252** (0.003)	0.0343** (0.002)	0.0339** (0.002)	0.0005** (0.000)	0.0005** (0.000)	0.0192** (0.001)	0.0200** (0.001)
60-69	0.0041** (0.000)	0.0039** (0.000)	0.0003 (0.000)	0.0001 (0.000)	0.0289** (0.002)	0.0269** (0.002)	0.0490** (0.002)	0.0497** (0.002)	0.0010** (0.000)	0.0010** (0.000)	0.0281** (0.001)	0.0280** (0.002)
70-	0.0038** (0.000)	0.0034** (0.000)	0.0007** (0.000)	0.0006* (0.000)	0.0207** (0.002)	0.0186** (0.003)	0.0413** (0.003)	0.0412** (0.004)	0.0003 (0.000)	0.0004 (0.000)	0.0257** (0.001)	0.0253** (0.001)

# Information from EGD and UGI, Female

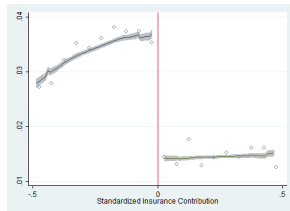
↑ 0.54%p



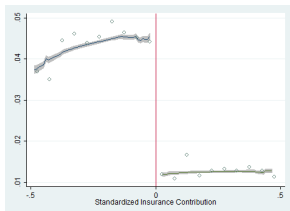
↑ 0.01%p



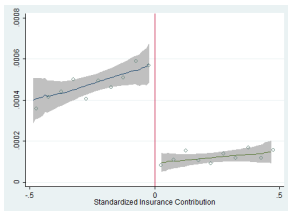
↑ 2.11%p



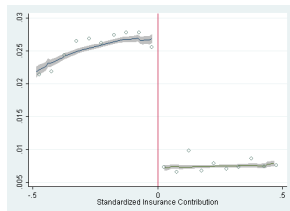
↑ 4.80%p



↑ 0.02%p



↑ 1.89%p



Normal

Cancer suspicion

Other stomach diseases

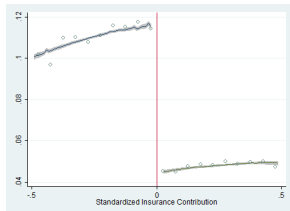
# Information from EGD and UGI, Female

- Probability of being "normal" and "other type of gastric diseases" ↑
- Probability of being "cancer suspicion" ↑ (not in all age groups)
- less "cancer suspicion" than in male

	EGD						UGI					
	Normal		Cancer Suspicion		Other Type of Gastric Disease		Normal		Cancer Suspicion		Other Type of Gastric Disease	
	0.3	IK	0.3	IK	0.3	IK	0.3	IK	0.3	IK	0.3	IK
Panel A.1 Total												
	0.0054** (0.001)	0.0056** (0.001)	0.0001* (0.000)	0.0001* (0.000)	0.0211** (0.002)	0.0186** (0.003)	0.0460** (0.003)	0.0442** (0.003)	0.0002** (0.000)	0.0002** (0.000)	0.0188** (0.001)	0.0187** (0.001)
N	1,396,081	1,026,626	1,396,081	956,933	1,396,081	728,327	1,396,081	728,327	1,396,081	1,026,628	1,396,081	1,178,589
Panel A.2. Age group												
40-49	0.0066** (0.001)	0.0067** (0.001)	0.0002** (0.000)	0.0002** (0.000)	0.0207** (0.003)	0.0184** (0.002)	0.0402** (0.003)	0.0402** (0.003)	0.0001* (0.000)	0.0001* (0.000)	0.0130** (0.001)	0.0124** (0.001)
50-59	0.0065** (0.001)	0.0066** (0.001)	0.0000 (0.000)	0.0000 (0.000)	0.0248** (0.003)	0.0212** (0.005)	0.0524** (0.004)	0.0497** (0.004)	0.0001 (0.000)	0.0001 (0.000)	0.0193** (0.001)	0.0196** (0.001)
60-69	0.0050** (0.001)	0.0054** (0.001)	0.0000 (0.000)	0.0001 (0.000)	0.0235** (0.002)	0.0220** (0.002)	0.0557** (0.003)	0.0513** (0.003)	0.0003* (0.000)	0.0004** (0.000)	0.0278** (0.002)	0.0280** (0.002)
70-	0.0009+ (0.001)	0.0010 (0.001)	0.0000 (0.000)	0.0000 (0.000)	0.0076** (0.001)	0.0060** (0.001)	0.0246** (0.002)	0.0237** (0.003)	0.0002 (0.000)	0.0002 (0.000)	0.0140** (0.001)	0.0129** (0.001)

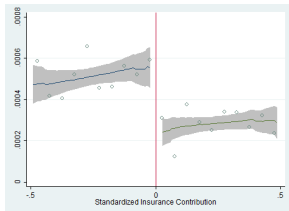
# Information from mammography, Female

↑ 7.12%p



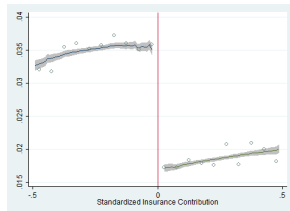
Normal

↑ 0.03%p



Cancer suspicion

↑ 1.84%p



Other breast diseases

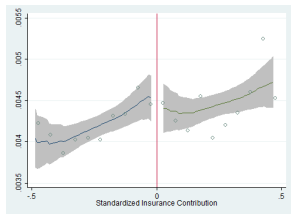
## Information from mammography, Female

- Probability of being "normal" and "other type of breast diseases" ↑
- Probability of being "cancer suspicion" ↑ (not in age 40-49 group)

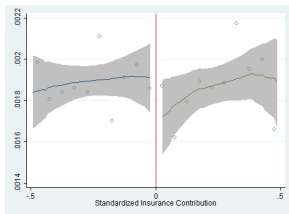
Panel C. Mammography	Normal		Cancer Suspicion		Other Type of Breast Disease	
	0.3	IK	0.3	IK	0.3	IK
Panel C.1 Total						
	0.0712** (0.006)	0.0684** (0.010)	0.0003** (0.000)	0.0003** (0.000)	0.0184** (0.002)	0.0179** (0.003)
N	1,396,081	506,258	1,396,081	1,343,026	1,396,081	728,327
Panel C.2. Age group						
40-49	0.0551** (0.006)	0.0509** (0.007)	0.0001 (0.000)	0.0001 (0.000)	0.0259** (0.003)	0.0258** (0.004)
50-59	0.0795** (0.007)	0.0755** (0.012)	0.0004** (0.000)	0.0004** (0.000)	0.0203** (0.002)	0.0203** (0.003)
60-69	0.0954** (0.010)	0.0942** (0.017)	0.0005** (0.000)	0.0005** (0.000)	0.0147** (0.001)	0.0139** (0.002)
70-	0.0412** (0.004)	0.0430** (0.007)	0.0002* (0.000)	0.0002* (0.000)	0.0055** (0.001)	0.0043** (0.000)

# Cancer Detection, incidence when $t \leq 2$

- No 'on average' change in cancer detection



Gastric ca, Male

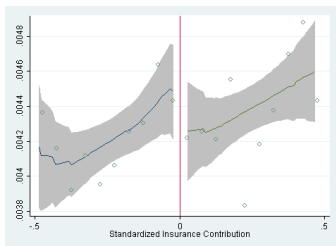


Gastric ca, Female

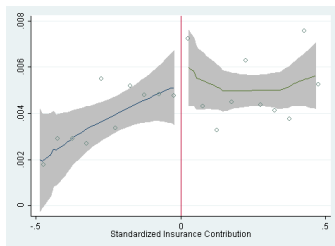


Breast ca, Female

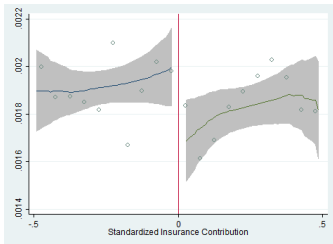
# Cancer Detection by age group, incidence when $t \leq 2$



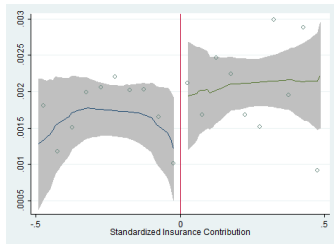
Gastric ca, Male, 40-69



Gastric ca, Male, 70-



Gastric ca, Female, 40-69



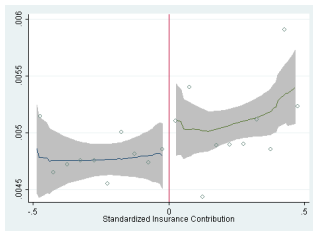
Gastric ca, Female, 70-

# Cancer Detection, incidence when $t \leq 2$

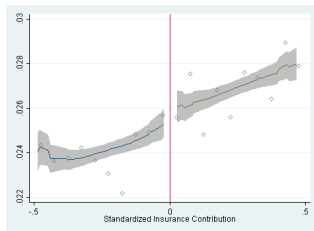
Gastric cancer	Male		Female		Female	
	Gastric cancer cumulative incidence		Gastric cancer cumulative incidence		Breast cancer cumulative incidence	
Bandwidth	0.3	IK	0.3	IK	0.3	IK
Panel A. Total						
Linear	0.0002 (0.000)	0.0002 (0.000)	0.0001 (0.000)	0.0001 (0.000)	0.0001 (0.000)	0.0001 (0.000)
Quadratic	0.0001 (0.000)	0.0001 (0.000)	0.0000 (0.000)	0.0000 (0.000)	0.0000 (0.000)	0.0000 (0.000)
Cubic	-0.0008+ (0.000)	-0.0008+ (0.000)	-0.0003 (0.000)	-0.0003 (0.000)	-0.0003 (0.000)	-0.0003 (0.000)
N	1,234,492	1,234,492	1,380,172	1,380,172	1,380,172	1,380,172
Panel B. Age group 40-69						
Liner	0.0004 (0.000)	0.0004+ (0.000)	0.0003** (0.000)	0.0003** (0.000)	0.0001 (0.000)	0.0001 (0.000)
Quadratic	0.0008* (0.000)	0.0006+ (0.000)	0.0001 (0.000)	0.0001 (0.000)	0.0001 (0.000)	0.0000 (0.000)
Cubic	0.0005 (0.001)	0.0011* (0.000)	-0.0001 (0.000)	-0.0001 (0.000)	0.0001 (0.000)	0.0001 (0.000)
N	1,033,688	1,211,825	1,208,767	1,208,767	1,208,767	1,248,269
Panel C. Age group						
40-49	0.0002* (0.000)	0.0002* (0.000)	0.0003+ (0.000)	0.0003+ (0.000)	0.0003+ (0.000)	0.0003+ (0.000)
50-59	0.0003 (0.001)	0.0003 (0.001)	-0.0001 (0.000)	-0.0001 (0.000)	-0.0001 (0.000)	-0.0001 (0.000)
60-69	0.0006 (0.000)	0.0006 (0.000)	0.0008** (0.000)	0.0008** (0.000)	0.0008** (0.000)	0.0008** (0.000)
70-	-0.0011 (0.001)	-0.0011 (0.001)	-0.0011** (0.000)	-0.0011** (0.000)	-0.0011** (0.000)	-0.0011** (0.000)



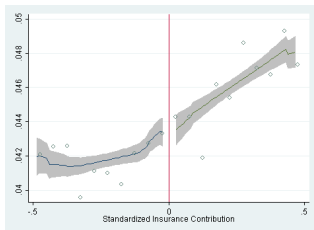
# 5-Year Mortality, Gastric Cancer Screening, Male



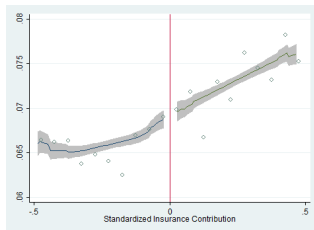
Gastric cancer mortality



All cancer mortality



Non-cancer mortality



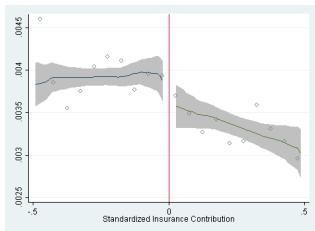
All-cause mortality

## 5-Year Cumulative mortality, Gastric Cancer Screening, Male

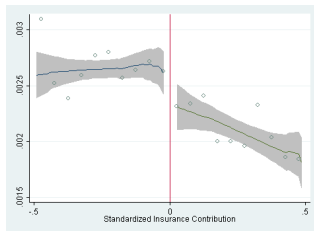
Panel A. Male								
	Gastric cancer mortality		Cancer mortality		Non cancer mortality		Total mortality	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bandwidth	0.3	IK	0.3	IK	0.3	IK	0.3	IK
Panel A1. Total								
Linear	-0.0004 (0.000)	-0.0003 (0.000)	-0.0004 (0.001)	0.0011+ (0.001)	-0.0001 (0.001)	0.0006 (0.001)	-0.0005 (0.001)	-0.0008 (0.001)
Quadratic	-0.0005 (0.000)	-0.0006 (0.000)	0.0003 (0.001)	-0.0012 (0.006)	-0.0023 (0.002)	-0.0026 (0.002)	-0.0020 (0.002)	-0.0016 (0.002)
Cubic	-0.0001 (0.001)	-0.0002 (0.001)	0.0009 (0.001)	-0.0475 (0.029)	-0.0029 (0.003)	-0.0019 (0.002)	-0.0020 (0.004)	-0.0030 (0.004)
N	1,260,729	1,441,721	1,260,729	465,335	1,260,729	1,373,890	1,260,729	1,218,000
Panel A2. Age group								
40-49	-0.0001 (0.000)	-0.0002 (0.000)	-0.0011** (0.000)	-0.0016** (0.000)	0.0001 (0.001)	0.0007 (0.001)	-0.0009 (0.001)	-0.0011 (0.001)
50-59	-0.0005 (0.000)	-0.0006 (0.000)	0.0001 (0.001)	-0.0009 (0.001)	-0.0029** (0.001)	-0.0024* (0.001)	-0.0029+ (0.002)	-0.0028+ (0.002)
60-69	0.0001 (0.001)	0.0004 (0.001)	0.0017 (0.001)	0.0042* (0.001)	0.0027 (0.002)	0.0016 (0.002)	0.0044+ (0.002)	0.0052* (0.002)
70-	-0.0019 (0.001)	-0.0013 (0.001)	-0.0003 (0.004)	0.0151** (0.003)	0.0031 (0.004)	0.0029 (0.004)	0.0028 (0.005)	0.0027 (0.005)
Panel A3. Employment status								
No	-0.0004 (0.000)	-0.0002 (0.000)	0.0011 (0.001)	0.0039** (0.000)	0.0022 (0.002)	0.0032+ (0.002)	0.0034+ (0.002)	0.0032+ (0.002)
Yes	-0.0003 (0.000)	-0.0003 (0.000)	-0.0010+ (0.001)	-0.0002 (0.001)	-0.0005 (0.001)	-0.0006 (0.001)	-0.0015 (0.001)	-0.0012 (0.001)

- mortality gain in age group 40-59 due to non-cancer mortality ↓
- mortality loss in age group 60+ due to non-cancer mortality ↑
- mortality loss in unemployed
- size of coefficient: non-cancer mortality ≫ cancer-specific mortality

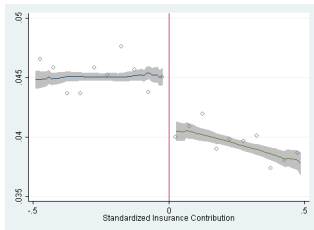
# 5-Year Cumulative mortality, Gastric/Breast Cancer Screening, Female



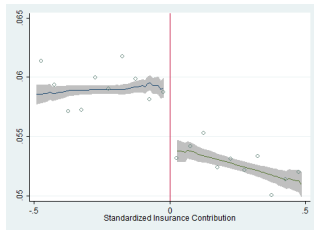
Gastric cancer mortality



Breast cancer mortality



Non-cancer mortality



All-cause mortality

## 5-Year Cumulative mortality, Gastric/Breast Cancer Screening, Female

Bandwidth	Female									
	Gastric cancer mortality		Breast cancer mortality		Cancer mortality		Non cancer mortality		Total mortality	
	0.3	IK	0.3	IK	0.3	IK	0.3	IK	0.3	IK
Panel A1. Total										
Linear	-0.0001 (0.000)	-0.0002 (0.000)	-0.0001 (0.000)	-0.0001 (0.000)	0.0003 (0.000)	0.0004 (0.000)	0.0015* (0.001)	0.0010 (0.001)	0.0017+ (0.001)	0.0023* (0.001)
Quadratic	-0.0002 (0.000)	-0.0004 (0.000)	-0.0000 (0.000)	-0.0000 (0.000)	0.0003 (0.000)	0.0001 (0.000)	0.0011 (0.001)	0.0026** (0.001)	0.0015 (0.001)	0.0006 (0.001)
Cubic	-0.0005 (0.000)	-0.0000 (0.000)	-0.0000 (0.000)	-0.0001 (0.000)	-0.0011 (0.001)	-0.0000 (0.001)	0.0036** (0.001)	0.0070** (0.001)	0.0022 (0.002)	0.0045* (0.002)
N	1,396,081	1,026,628	1,396,081	1,343,027	1,396,081	1,524,119	1,396,081	1,026,628	1,396,081	1,178,589
Panel A2. Age group										
40-49	0.0001 (0.000)	0.0001 (0.000)	0.0001+ (0.000)	0.0001+ (0.000)	0.0003 (0.000)	0.0003 (0.000)	0.0004 (0.000)	0.0001 (0.001)	0.0007 (0.000)	0.0006 (0.001)
50-59	-0.0001 (0.000)	-0.0001 (0.000)	-0.0002 (0.000)	-0.0002 (0.000)	0.0011* (0.000)	0.0011** (0.000)	0.0001 (0.001)	0.0002 (0.001)	0.0012 (0.001)	0.0012+ (0.001)
60-69	-0.0004 (0.000)	-0.0003 (0.000)	-0.0001+ (0.000)	-0.0002+ (0.000)	-0.0007 (0.001)	-0.0005 (0.001)	0.0026* (0.001)	0.0023+ (0.001)	0.0021 (0.002)	0.0029+ (0.002)
70-	0.0005 (0.001)	0.0005 (0.001)	0.0010 (0.001)	0.0012 (0.001)	0.0005 (0.001)	0.0005 (0.001)	0.0082* (0.003)	0.0084* (0.003)	0.0078* (0.003)	0.0101** (0.003)
Panel A3. Employment status										
No	-0.0002 (0.000)	-0.0001 (0.000)	-0.0001 (0.000)	-0.0001 (0.000)	0.0003 (0.000)	0.0004 (0.000)	0.0017** (0.001)	0.0013+ (0.001)	0.0019* (0.001)	0.0025** (0.001)
Yes	0.0001 (0.000)	-0.0001 (0.000)	-0.0001 (0.000)	-0.0001 (0.000)	0.0000 (0.001)	0.0001 (0.001)	0.0005 (0.001)	0.0004 (0.001)	0.0005 (0.001)	0.0005 (0.001)

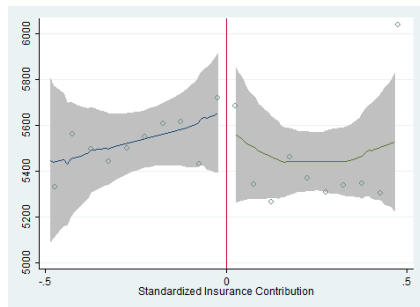
- mortality loss in age group 60+ due to non-cancer mortality ↑
- mortality loss in unemployed due to non-cancer mortality ↑
- size of coefficient: non-cancer mortality ≫ cancer-specific mortality

## Summary of major outcomes

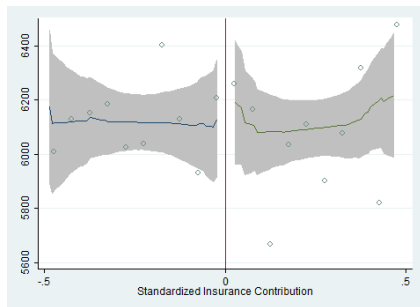
- Gastric cancer detection ↑ in age group 40-69
- No gastric/breast cancer mortality gain in all age group
- Non-cancer mortality increase in age group 60+
- Mortality gain in male aged 40-59, loss in female aged 60+
- Mortality loss in unemployed
- Mainly due to non-cancer mortality change
  
- Mechanism: Why?
  - ▶ early detection
  - ▶ future cancer screening take-up
  - ▶ health behavior (health screening take-up)
  - ▶ medical expenditure
  - ▶ employment status
  - ▶ intermediate health outcome (bio-markers)

## Early Detection, Gastric cancer, Male

Intensity of treatment at the first year of cancer detection: No change



$t \leq 2$



$3 \leq t \leq 6$

# Early Detection, Gastric cancer, Male

No impact on early detection

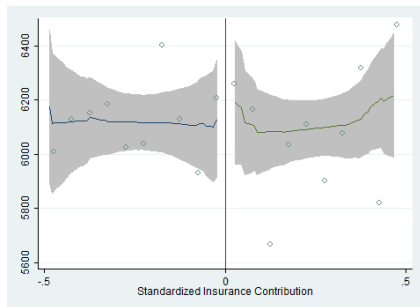
	Medical expenditure at the first year of gastric cancer detection							
	Total medical expenditure		Medical expenditure on cancer		Medical expenditure on gastric cancer		Total medical expenditure	
	(1)	(2)	(3)	(4)	(5)	(6)	Cancer at year 1 and 2 (7)	Cancer at year 3 to 6 (8)
Bandwidth	0.3	IK	0.3	IK	0.3	IK	0.3	0.3
Panel A. Total								
	-7.3962 (9.361)	-15.4479 (10.008)	-9.7963 (7.607)	-8.8128 (7.983)	0.1983 (2.720)	-2.4613 (2.794)	84.2522 (181.294)	-78.4764 (165.672)
N	1,254,653	2,248,343	1,254,653	1,766,516	1,254,653	2,452,143	5,237	10,595
Panel B. Age group								
40-49	-0.7168 (11.158)	-1.0595 (8.977)	1.2864 (10.068)	9.3969 (9.853)	5.4846* (2.361)	0.2473 (3.007)	-76.7124 (622.637)	-285.4879 (764.193)
50-59	-1.9363 (18.521)	-17.0531 (14.033)	1.1234 (15.012)	-12.4211 (12.151)	0.0965 (4.991)	0.5980 (3.486)	142.7898 (288.486)	-409.1748+ (199.790)
60-69	-0.4999 (15.488)	-13.9725 (13.183)	-16.1516 (13.275)	-6.2073 (11.546)	-3.7742 (7.075)	-3.8693 (5.192)	130.6946 (283.649)	83.7671 (208.028)
70-	-12.9943 (24.556)	1.5500 (29.628)	-26.6781 (24.526)	-21.7213 (21.581)	-5.3233 (10.680)	-9.0987 (7.556)	-234.4581 (354.035)	61.0237 (299.308)

## Early Detection, Gastric cancer, Female

Intensity of treatment at the first year of cancer detection: No change



$t \leq 2$

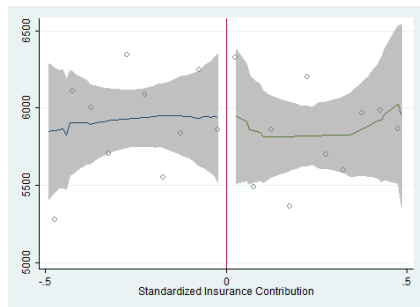


$3 \leq t \leq 6$

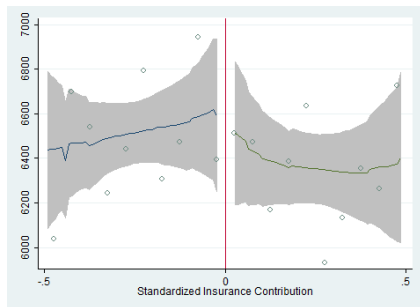


## Early Detection, Breast cancer, Female

Intensity of treatment at the first year of cancer detection: No change



$t \leq 2$

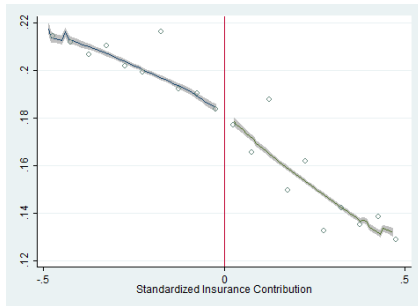


$3 \leq t \leq 6$

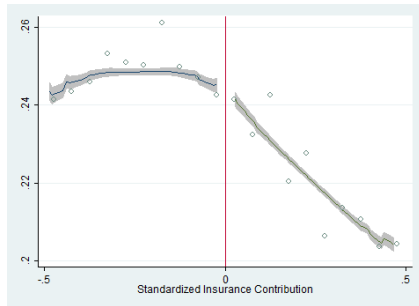
## No impact on early detection

	Medical expenditure at the first year of gastric cancer detection						Medical expenditure at the first year of gastric cancer detection		Medical expenditure at the first year of breast cancer detection	
	Total		Cancer		Gastric cancer		Cancer at year 1 and 2	Cancer at year 3 to 6	Cancer at year 1 and 2	Cancer at year 3 to 6
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Bandwidth	0.3	IK	0.3	IK	0.3	IK	0.3	0.3	0.3	0.3
Panel A. Total										
	4.6013 (4.861)	8.0214 (4.854)	5.6312 (4.825)	6.8357+ (4.061)	1.9313 (1.381)	2.7461* (1.248)	50.5512 (440.339)	337.1053 (321.680)	-174.3070 (304.631)	-13.7649 (363.435)
N	1,390,186	1,758,707	1,390,186	2,290,677	1,390,186	1,980,953	2,373	4,785	2,163	4,562
Panel B. Age group										
40-49	1.0383 (9.284)	-6.1328 (10.105)	1.6233 (8.534)	-6.5195 (7.612)	4.4124+ (2.445)	3.3357 (2.154)	392.5506 (615.894)	651.0105 (889.750)	-114.0355 (520.948)	96.7100 (522.998)
50-59	13.8870 (11.014)	21.8460* (9.145)	14.8769 (9.739)	18.3932* (7.353)	2.3726 (2.357)	4.0071* (1.811)	179.5794 (354.960)	915.1197* (389.643)	-295.7908 (433.811)	195.0428 (358.834)
60-69	-4.2083 (14.811)	12.9128 (11.130)	-2.7087 (10.259)	9.9977 (8.076)	0.2991 (2.661)	2.1011 (2.953)	74.2598 (910.802)	81.6748 (606.627)	67.8566 (1,136.521)	-410.3573 (760.124)
70-	4.3152 (18.777)	-0.4103 (17.124)	6.9390 (12.959)	2.2765 (9.881)	-1.6013 (3.868)	1.9221 (3.299)	-582.1691* (277.937)	-98.3422 (268.296)	-761.2676 (1,203.626)	-1,268.0716 (812.464)

# Future NHIC Gastric Cancer Screening Take-up, Male



Round 2



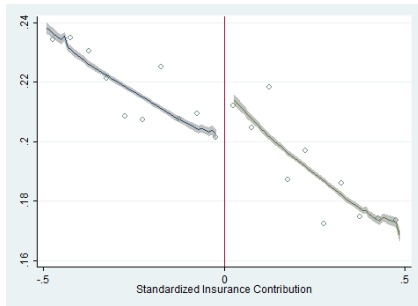
Round 3

# Future NHIC Gastric Cancer Screening Take-up, Male

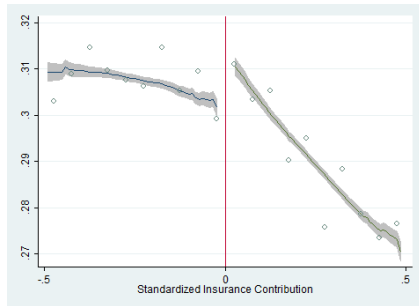
	Gastric cancer screening			
	Round2		Round3	
	(1)	(2)	(7)	(8)
Bandwidth	0.3	IK	0.3	IK
Panel A. Total				
	0.0046 (0.007)	0.0027 (0.003)	0.0006 (0.002)	0.0002 (0.002)
N	1,260,729	465,344	1,260,729	1,218,000
Panel B. Age group				
40-49	0.0041 (0.006)	-0.0003 (0.004)	-0.0012 (0.002)	-0.0012 (0.002)
50-59	0.0025 (0.009)	-0.0005 (0.006)	0.0022 (0.003)	0.0022 (0.004)
60-69	-0.0008 (0.009)	0.0029* (0.001)	-0.0069+ (0.004)	-0.0073+ (0.004)
70-	-0.0024 (0.006)	-0.0087 (0.005)	-0.0088* (0.004)	-0.0096* (0.003)
Panel C. Employment status				
No	-0.0048 (0.009)	-0.0073 (0.004)	-0.0108** (0.003)	-0.0115** (0.003)
Yes	0.0041 (0.007)	0.0005 (0.002)	0.0004 (0.003)	0.0000 (0.003)

- Screening take-up ↓ in age group 60+ and those unemployed

# Future NHIC Gastric Cancer Screening Take-up, Female

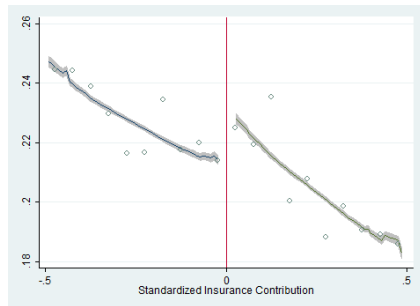


Round 2

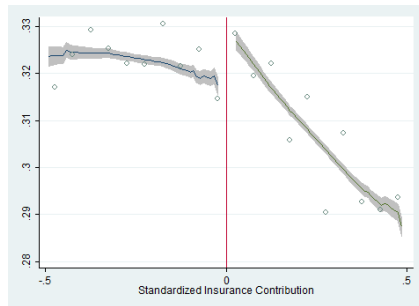


Round 3

# Future NHIC Breast Cancer Screening Take-up, Female



Round 2



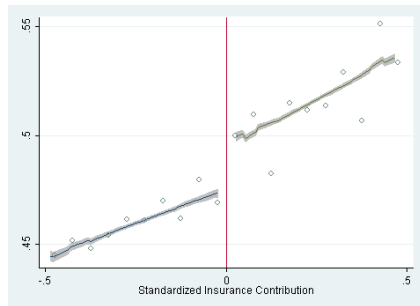
Round 3

# Future NHIC Cancer Screening Take-up

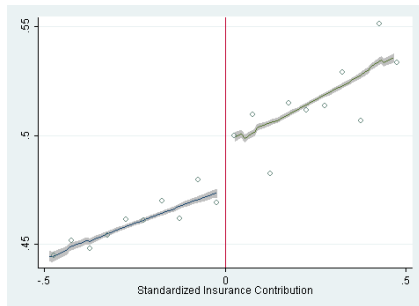
	Gastric cancer screening				Breast cancer screening			
	Round 2		Round 3		Round 2		Round 3	
	(1)	(2)	(7)	(8)	(13)	(14)	(15)	(16)
Bandwidth	0.3	IK	0.3	IK	0.3	IK	0.3	IK
Panel A. Total								
	-0.0113 (0.009)	-0.0158* (0.006)	-0.0111** (0.003)	-0.0148** (0.004)	-0.0124 (0.008)	-0.1221+ (0.059)	-0.0121** (0.003)	-0.0168** (0.003)
N	1,396,081	445,477	1,396,081	728,327	1,396,081	271,655	1,396,081	662,263
Panel B. Age group								
40-49	-0.0101 (0.007)	-0.0204** (0.006)	-0.0101* (0.004)	-0.0155** (0.003)	-0.0112 (0.007)	-0.4091** (0.012)	-0.0119** (0.004)	-0.0209** (0.003)
50-59	-0.0178+ (0.009)	-0.0228** (0.006)	-0.0148** (0.005)	-0.0182* (0.006)	-0.0199* (0.009)	0.4372 (0.354)	-0.0152** (0.005)	-0.0167** (0.005)
60-69	-0.0085 (0.010)	-0.0015 (0.008)	-0.0106** (0.004)	-0.0067 (0.004)	-0.0080 (0.011)	0.1586** (0.031)	-0.0101* (0.004)	-0.0088+ (0.004)
70-	-0.0043 (0.006)	-0.0108* (0.004)	-0.0071* (0.003)	-0.0102** (0.002)	-0.0045 (0.005)	-0.0637 (0.035)	-0.0086** (0.002)	-0.0108** (0.003)
Panel C. Employment status								
No	-0.0127 (0.009)	-0.0172* (0.007)	-0.0134** (0.004)	-0.0177** (0.005)	-0.0135 (0.009)	-0.1282+ (0.060)	-0.0142** (0.004)	-0.0192** (0.004)
Yes	-0.0043 (0.008)	-0.0158* (0.005)	-0.0018 (0.004)	-0.0099** (0.003)	-0.0057 (0.009)	-0.1424** (0.020)	-0.0013 (0.004)	-0.0120** (0.002)

- Screening take-up ↓ in those unemployed

# Future NHIC Health Screening Take-up, Male



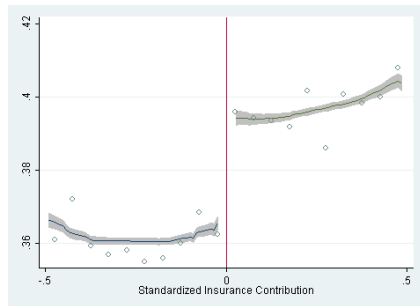
Round 2



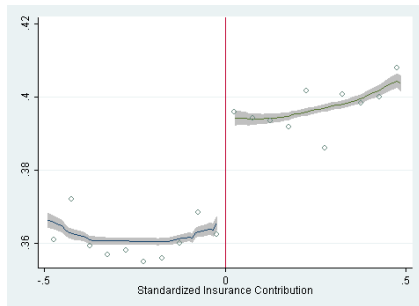
Round 3



# Future NHIC Health Screening Take-up, Female



Round 2



Round 3

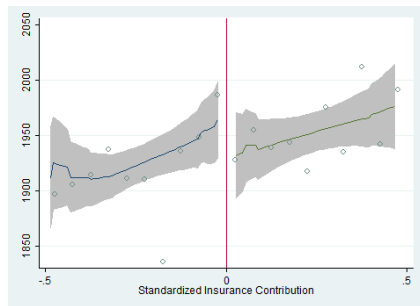
# Future NHIC Health Screening Take-up

	Male				Female			
	General Health Screening: Round2		General Health Screening: Round3		General Health Screening: Round2		General Health Screening: Round3	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bandwidth	0.3	IK	0.3	IK	0.3	IK	0.3	IK
Panel A. Total								
Linear	-0.0238** (0.007)	-0.0314** (0.009)	-0.0204** (0.007)	-0.0253** (0.006)	-0.0272** (0.005)	-0.0341** (0.003)	-0.0213** (0.004)	-0.0324** (0.002)
N	1,260,729	667,548	1,260,729	465,344	1,396,081	506,252	1,396,081	445,477
Panel B. Age								
40-49	-0.0236* (0.011)	-0.0378* (0.015)	-0.0249+ (0.012)	-0.0315* (0.011)	-0.0245** (0.008)	-0.0421** (0.005)	-0.0173* (0.007)	-0.0345** (0.005)
50-59	-0.0233** (0.005)	-0.0294** (0.007)	-0.0143** (0.004)	-0.0157** (0.003)	-0.0350** (0.004)	-0.0375** (0.002)	-0.0263** (0.003)	-0.0305** (0.005)
60-69	-0.0237** (0.003)	-0.0200** (0.002)	-0.0230** (0.003)	-0.0165** (0.004)	-0.0266** (0.003)	-0.0252** (0.003)	-0.0250** (0.002)	-0.0266** (0.000)
70-	-0.0201** (0.005)	-0.0184* (0.007)	-0.0177** (0.004)	-0.0276** (0.004)	-0.0117** (0.004)	-0.0153** (0.003)	-0.0094** (0.003)	-0.0222** (0.003)
Panel C. Employment status								
No	-0.0268** (0.002)	-0.0237** (0.002)	-0.0216** (0.003)	-0.0178** (0.002)	-0.0270** (0.004)	-0.0301** (0.004)	-0.0225** (0.003)	-0.0316** (0.002)
Yes	-0.0219+ (0.011)	-0.0342* (0.016)	-0.0204+ (0.011)	-0.0289* (0.010)	-0.0064 (0.013)	-0.0443+ (0.020)	0.0043 (0.014)	-0.0284+ (0.013)

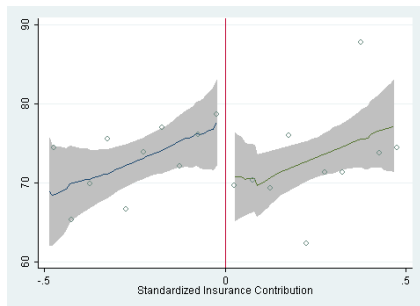
- Health screening take-up ↓ in all subgroup

# Change of Medical Expenditure, Male

## Medical expenditure increases



Total (5 years)



Gastric cancer (5 years)

# Change of Medical Expenditure, Male

	Total			Cancer			Non Cancer			Gastric Cancer		
	Year 1-2	Year 3-5	Year 1-5	Year 1-2	Year 3-5	Year 1-5	Year 1-2	Year 3-5	Year 1-5	Year 1-2	Year 3-5	Year 1-5
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Bandwidth	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Panel A. Total												
Linear	6.9992 (10.299)	32.3208 (20.080)	48.5721+ (25.211)	3.0016 (7.022)	15.0468 (12.158)	23.0248+ (12.286)	3.9976 (8.507)	17.2741 (22.960)	25.5473 (29.070)	2.8395 (2.224)	5.2489+ (2.780)	9.1622* (4.314)
Quadratic	9.3783 (17.165)	58.4732+ (32.826)	92.0222* (40.767)	7.1540 (12.076)	7.0328 (14.652)	19.5920 (14.160)	2.2242 (13.983)	51.4404 (39.583)	72.4302 (48.970)	4.2417 (3.846)	7.1741+ (3.640)	11.7642+ (6.351)
Cubic	-4.1849 (27.367)	82.9804+ (46.980)	116.0794+ (58.055)	-2.5384 (18.686)	14.2974 (25.381)	17.9990 (25.758)	-1.6465 (21.138)	68.6830 (56.754)	98.0804 (68.971)	1.0652 (5.703)	10.7440 (6.694)	8.5593 (10.529)
N	970,661	905,003	841,751	970,661	905,003	841,751	970,661	905,003	841,751	970,661	905,003	841,751
Panel C. Baseline medical expenditure												
Lowest	7.5634 (10.549)	46.8948+ (24.137)	72.4897+ (35.750)	3.7711 (7.751)	8.7262 (14.756)	31.0895+ (16.830)	3.7923 (11.127)	38.1685 (22.373)	41.4002 (39.448)	1.0490 (2.960)	-0.8371 (9.831)	2.3273 (7.938)
Low	1.5902 (11.700)	56.1635+ (28.597)	78.8521** (26.551)	-6.0711 (6.966)	6.6048 (18.673)	7.6669 (19.489)	7.6613 (8.651)	49.5587+ (26.399)	71.1852* (29.660)	0.1021 (2.442)	13.4045+ (7.168)	15.8170+ (8.226)
High	20.0725 (13.342)	10.3114 (31.003)	34.9772 (33.961)	11.3137+ (6.282)	21.3653 (20.302)	25.1124 (23.470)	8.7588 (9.861)	-11.0539 (16.164)	9.8647 (22.187)	9.8627+ (5.221)	6.4272 (5.553)	14.4086+ (8.351)
Highest	12.1697 (34.145)	38.6018 (67.429)	51.9674 (88.468)	3.6088 (17.095)	22.8725 (21.983)	29.9582 (24.549)	8.5609 (31.431)	15.7293 (74.198)	22.0092 (96.890)	-0.0123 (2.966)	1.6808 (10.588)	2.8985 (12.405)
Panel E. Employment status												
No	15.6282 (19.016)	-13.8946 (29.301)	-1.6479 (31.604)	11.5193 (10.284)	-8.8093 (17.257)	-4.1783 (19.390)	4.1089 (13.333)	-5.0852 (26.428)	2.5304 (30.660)	2.3975 (2.785)	4.5086 (5.614)	8.5392 (7.721)
Yes	-3.1163 (10.942)	58.9330* (22.219)	75.7082* (29.593)	-4.5211 (6.403)	31.4784* (11.362)	41.9872** (11.817)	1.4048 (11.520)	27.4546 (26.647)	33.7210 (35.012)	3.2242 (2.351)	5.9543 (4.301)	9.5571+ (5.521)

- Medical expenditure increases

- ▶ in those with employed and low baseline medical expenditure
- ▶ perhaps information effect of cancer screening: access to medical services ↑

# Change of Medical Expenditure, Female

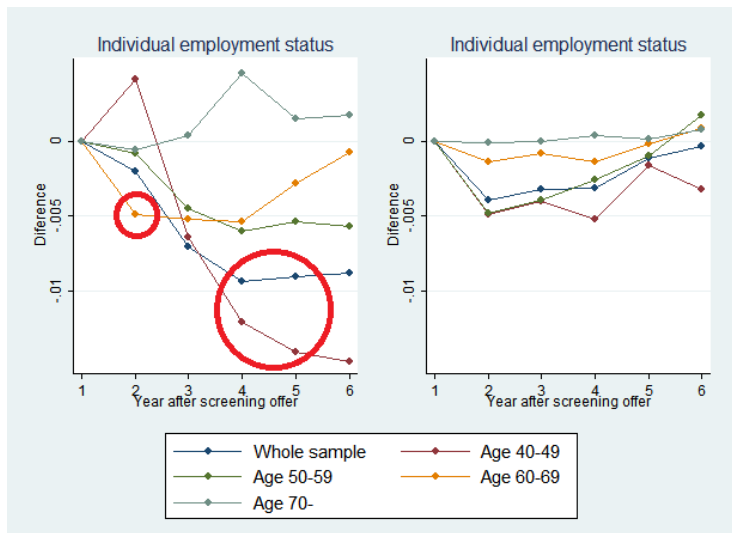
	Total			Cancer			Non Cancer			Gastric Cancer		
	Year 1-2	Year 3-5	Year 1-5	Year 1-2	Year 3-5	Year 1-5	Year 1-2	Year 3-5	Year 1-5	Year 1-2	Year 3-5	Year 1-5
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Bandwidth	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Panel A. Total												
Linear	23.6446** (8.024)	26.6055 (22.605)	23.9376 (21.114)	7.6695+ (3.754)	-9.7475 (6.432)	-3.7622 (7.555)	15.9751* (7.208)	25.3986 (24.287)	27.6998 (17.127)	0.5163 (0.788)	2.8262 (2.461)	2.5841 (2.709)
Quadratic	27.9915* (11.291)	71.8558 (53.869)	55.5022+ (30.055)	6.3631 (3.816)	-2.0351 (10.064)	0.4942 (11.746)	21.6284* (9.274)	214.8853** (57.264)	55.0081* (20.566)	0.2905 (1.064)	-3.3181 (4.144)	2.3422 (3.880)
Cubic	9.1179 (22.802)	13.0601 (27.770)	16.5921 (58.006)	-1.3195 (6.688)	-1.9560 (7.968)	-23.7451 (17.542)	10.4374 (18.592)	17.6106 (22.282)	40.3372 (46.371)	-0.1366 (1.716)	2.4674 (2.312)	5.1893 (5.571)
N	1,219,294	1,120,102	1,123,043	1,219,294	2,154,042	1,123,043	1,219,294	856,576	1,123,043	1,219,294	1,812,103	1,123,043

- Medical expenditure increases
  - ▶ only within two years from cancer screening
  - ▶ information effect is small in female

# Changes in Employment Status

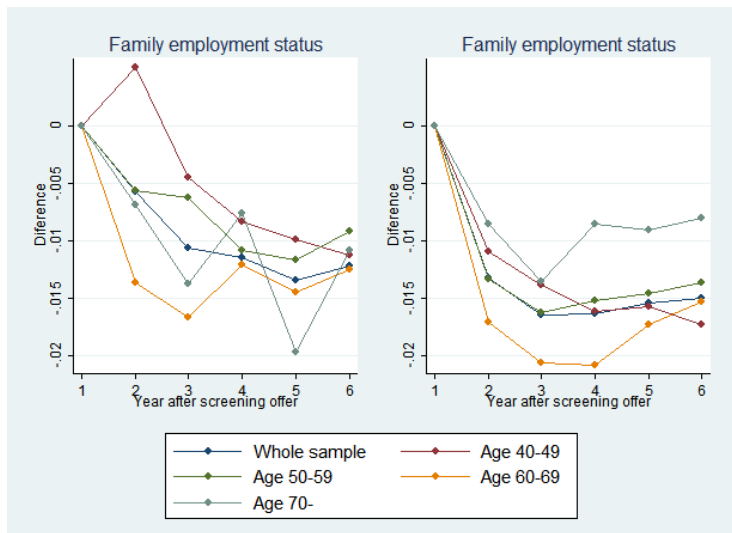
1.0%p ↓ in Male

No change in Female



# Household Employment Status

1.0%p ↓ in both Male and Female, bigger in age group 60+



# Bio-markers: Intermediate Health outcomes

- Bio-markers are reliable indicator of health behavior and disease status
- Types of bio-makers
  - ▶ BMI (Body Mass Index) - obesity
  - ▶ Blood sugar level - Diabetes Mellitus(DM)
  - ▶ Blood pressure - hypertension
  - ▶ Cholesterol - hyperlipidemia
  - ▶ Hemoglobin - anemia
  - ▶ Gamma GTP - alcohol consumption
  - ▶ SGOP/SGPT - liver diseases



# Bio-markers: Intermediate Health outcomes, Male

- Becomes worse especially in age group 60+ and unemployed
  - corresponding non-cancer mortality ↑ in age group 60+

	Bandwidth	BMI				Blood Sugar				Systolic Blood Pressure			Diastolic Blood Pressure				
		Round 2		Round 3		Round 2		Round 3		Round 2		Round 3	Round 2		Round 3		
		0.3	IK (0.34)	0.3	IK (0.25)	0.3	IK (0.48)	0.3	IK (0.27)	0.3	IK (0.14)	0.3	IK (0.35)	0.3	IK (0.14)	0.3	IK (0.36)
Total	Linear	0.0103 (0.010)	0.0073 (0.009)	0.0133 (0.009)	0.0118 (0.010)	0.1296 (0.237)	0.2749 (0.187)	0.5619 (0.379)	0.5937 (0.378)	0.2930* (0.125)	0.1484 (0.145)	0.0852 (0.102)	0.1636 (0.106)	0.1746** (0.054)	0.2090** (0.056)	0.0297 (0.095)	-0.0052 (0.083)
	Quadratic	0.0170 (0.017)	0.0177 (0.015)	0.0220 (0.013)	0.0307* (0.013)	-0.1641 (0.441)	0.0705 (0.275)	0.5434 (0.653)	0.5189 (0.666)	0.1662 (0.202)	0.1433 (0.212)	-0.0732 (0.116)	-0.1064 (0.101)	0.2350** (0.073)	0.0575 (0.066)	-0.0376 (0.102)	0.0454 (0.106)
	Cubic	-0.0112 (0.025)	0.0062 (0.020)	0.0372 (0.024)	0.0235 (0.025)	0.4191 (0.624)	-0.2257 (0.433)	0.9295 (0.961)	1.0609 (0.940)	0.0990 (0.275)	4.7479** (0.317)	-0.4224* (0.169)	-0.1328 (0.151)	0.0908 (0.113)	-0.1402 (0.326)	-0.5274** (0.125)	-0.2211* (0.108)
	N	384,997	450,414	340,497	286,307	385,222	630,814	340,704	331,232	385,090	184,123	340,602	394,516	385,068	184,114	340,584	425,584
Age	40-49	-0.0270+ (0.015)	-0.0278* (0.013)	-0.0049 (0.016)	-0.0114 (0.018)	-0.0829 (0.226)	-0.1193 (0.218)	0.2195 (0.454)	0.2978 (0.436)	0.0700 (0.139)	-0.2568 (0.177)	0.2064+ (0.100)	0.3200* (0.143)	0.0246 (0.087)	-0.0155 (0.100)	0.0731 (0.080)	0.0470 (0.080)
	50-59	0.0371* (0.016)	0.0333* (0.015)	0.0065 (0.011)	0.0036 (0.012)	-0.2508 (0.401)	-0.1579 (0.283)	0.2179 (0.422)	0.1893 (0.436)	0.5772** (0.182)	0.4071 (0.257)	0.1003 (0.180)	0.1585 (0.173)	0.3355** (0.089)	0.4601** (0.072)	0.0516 (0.161)	0.0088 (0.140)
	60-69	0.0333+ (0.018)	0.0323+ (0.018)	0.0554** (0.019)	0.0728** (0.020)	0.8785+ (0.459)	1.7941** (0.491)	2.1642** (0.502)	2.0776** (0.515)	0.5467* (0.238)	0.4922* (0.211)	-0.1374 (0.267)	-0.1289 (0.249)	0.3248* (0.129)	0.2729** (0.075)	-0.0157 (0.231)	-0.1549 (0.194)
	70-	0.1333** (0.045)	0.1034* (0.043)	0.0686 (0.043)	0.0637 (0.047)	2.8744+ (1.596)	1.6600 (1.339)	0.3260 (1.522)	0.7080 (1.427)	-0.3386 (0.834)	1.0494 (1.003)	-0.0599 (0.609)	-0.2939 (0.570)	0.1117 (0.456)	0.3138 (0.366)	-0.4342 (0.521)	0.0665 (0.476)
Employment Status	No	0.0642* (0.023)	0.0777** (0.021)	0.0634** (0.018)	0.0551** (0.019)	2.0493** (0.615)	1.7891** (0.430)	2.0396** (0.296)	2.1142** (0.287)	0.5727+ (0.279)	0.7866** (0.180)	0.0494 (0.192)	-0.0789 (0.184)	0.4168* (0.169)	0.3945** (0.116)	-0.0189 (0.164)	0.0295 (0.157)
	Yes	-0.0039 (0.013)	-0.0106 (0.012)	-0.0026 (0.011)	-0.0021 (0.012)	-0.3530 (0.218)	-0.1062 (0.195)	0.0763 (0.437)	0.0894 (0.445)	0.2262 (0.144)	-0.0205 (0.178)	0.0976 (0.101)	0.2324+ (0.124)	0.1125* (0.051)	0.1628* (0.054)	0.0463 (0.089)	-0.0166 (0.084)

# Bio-markers: Intermediate Health outcomes, Female

- Becomes worse especially in age group 60+
  - corresponding non-cancer mortality ↑ in age group 60+ and unemployed

	Bandwidth	BMI				Blood Sugar				Hemoglobin				Cholesterol			
		Round 2		Round 3		Round 2		Round 3		Round 2		Round 3		Round 2		Round 3	
		0.3	IK (0.43)	0.3	IK (0.23)	0.3	IK (0.31)	0.3	IK (0.13)	0.3	IK (0.19)	0.3	IK (0.09)	0.3	IK (0.09)	0.3	IK (0.17)
Total	Linear	0.0317** (0.009)	0.0289** (0.009)	0.0351** (0.007)	0.0325** (0.006)	0.7414** (0.233)	0.7414** (0.233)	0.1305 (0.194)	0.2313 (0.363)	-0.0160 (0.010)	-0.0152 (0.012)	-0.0200+ (0.012)	-0.0247* (0.010)	-0.7940* (0.282)	-1.0732** (0.164)	-0.1358 (0.370)	-0.6282 (0.368)
	Quadratic	0.0343** (0.012)	0.0412** (0.010)	0.0263** (0.008)	0.0278** (0.009)	0.6439* (0.298)	0.6439* (0.298)	0.0029 (0.323)	-4.3077** (0.801)	-0.0151 (0.015)	0.0268 (0.019)	-0.0490** (0.013)	0.0600 (0.134)	-1.5167** (0.429)	24.2060** (0.460)	-1.1306+ (0.658)	0.9866+ (0.545)
	Cubic	0.0363+ (0.021)	0.0207 (0.013)	0.0369* (0.014)	0.0312 (0.022)	0.7123 (0.618)	0.7123 (0.618)	-0.2556 (0.564)	4.9855* (2.154)	0.0159 (0.018)	0.1458** (0.040)	-0.0008 (0.027)	2.8744** (0.034)	-0.8047 (0.489)	24.2060** (0.460)	1.0307 (0.704)	6.7302** (1.041)
	N	273,675	409,982	267,961	191,555	273,933	273,933	268,214	91,469	273,933	148,040	268,214	82,974	273,417	84,169	267,015	134,675
Age	40-49	0.0059 (0.015)	0.0180 (0.013)	0.0162+ (0.009)	0.0168+ (0.009)	0.4737* (0.211)	0.4737* (0.211)	-0.4027 (0.278)	-0.3294+ (0.153)	-0.0317+ (0.016)	-0.0235 (0.020)	-0.0340* (0.014)	-0.0391* (0.015)	-0.4541 (0.469)	-0.8953+ (0.390)	-0.5379 (0.421)	-1.0640* (0.392)
	50-59	0.0374* (0.017)	0.0222 (0.014)	0.0526** (0.011)	0.0464* (0.017)	0.1692 (0.246)	0.1692 (0.246)	-0.0042 (0.289)	-0.1900 (0.447)	-0.0204 (0.018)	-0.0432 (0.024)	-0.0244* (0.011)	-0.0207+ (0.010)	-1.4702** (0.373)	-1.6695** (0.406)	0.0506 (0.519)	-0.6450 (0.587)
	60-69	0.0417** (0.012)	0.0391** (0.013)	0.0427+ (0.024)	0.0276 (0.022)	1.4634* (0.539)	1.4634* (0.539)	1.2075+ (0.603)	1.9919 (1.063)	0.0027 (0.018)	0.0346+ (0.017)	-0.0185 (0.016)	-0.0414** (0.008)	-0.9914 (0.697)	-0.6661 (0.844)	-0.0678 (0.528)	-0.8946 (0.572)
	70-	0.1492* (0.062)	0.1586** (0.050)	-0.0157 (0.056)	0.0230 (0.053)	5.0456* (2.324)	5.0456* (2.324)	1.6977 (1.349)	0.7234 (1.695)	0.0166 (0.052)	0.0452 (0.080)	0.0482 (0.032)	0.1137+ (0.048)	0.7960 (1.346)	1.0425 (1.057)	-1.1091 (2.259)	3.7241 (2.088)
Employment Status	No	0.0476** (0.010)	0.0468** (0.010)	0.0395** (0.008)	0.0280** (0.005)	0.8989* (0.329)	0.8989* (0.329)	0.2576 (0.298)	0.4704 (0.555)	-0.0019 (0.009)	-0.0051 (0.012)	-0.0195 (0.012)	-0.0221 (0.015)	-1.0568** (0.269)	-1.5029** (0.182)	-0.3006 (0.346)	-0.4741 (0.372)
	Yes	-0.0034 (0.016)	-0.0030 (0.015)	0.0228+ (0.012)	0.0414** (0.012)	0.3062 (0.249)	0.3062 (0.249)	-0.2652 (0.274)	-0.4051 (0.344)	-0.0295 (0.020)	-0.0348+ (0.018)	-0.0247 (0.017)	-0.0366* (0.012)	-0.5087 (0.598)	-0.2302 (0.579)	0.2373 (0.502)	-0.9809* (0.409)

# Conclusion and Policy Recommendation

- Conclusion

- ▶ Mortality gain only on male aged 40-59
- ▶ Mortality loss in age group 60+ and unemployed
- ▶ Cancer screening has a small impact (not statistically significant) on target cancer mortality
- ▶ Cancer screening has a bigger impact on non-cancer mortality
  - ★ health behavior change
  - ★ medical expenditure
  - ★ employment status
- ▶ (Not shown) Behavioral Change: gastric cancer screening > colorectal cancer screening

# Conclusion and Policy Recommendation

- Is Conventional wisdom of cancer screening correct?
  - ▶ Screening → Early detection → ↓ Cancer mortality → ↓ All-cause mortality
- Policy recommendation
  - ▶ All-cause mortality must be an end point outcome
  - ▶ Behavioral change and non-cancer mortality must be considered
    - ★ implication for sigmoidoscopy and colonoscopy
  - ▶ "Tailored" mass cancer screening is necessary (risk group)
  - ▶ Awareness campaign ("symptom") can be more efficient than mass screening

# Suggestion for students want to be an empirical economist

- Focus very on causal impact (endogeneity)
  - ▶ Matching
  - ▶ IV
  - ▶ Fixed effect model
  - ▶ Regression discontinuity design
  - ▶ RCT (Randomized Controlled Trial)
- Labor/Health/Education Economics
  - ▶ Data accessibility
  - ▶ Institutional details!
  - ▶ Econometrics
  - ▶ US vs. Korean data
- Development Economics
  - ▶ Funding - KOICA
  - ▶ Connections
  - ▶ Econometrics
  - ▶ Brave heart