Moral Hazard and Less Invasive Medical Treatment for Coronary Artery Disease: An Analysis of Smoking and Drinking in the Health and Retirement Survey*

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Abstract

To test whether less invasive medical technologies induce moral hazard at the individual level we study how changes in patient smoking and alcohol drinking behavior are related to three common treatments for Coronary Artery Disease (CAD): medical management, Percutaneous Coronary Intervention (PCI), and Coronary Artery Bypass Graft (CABG). We employ the Health and Retirement Survey linked to respondents' Medicare claim files. We find that that those who have more invasive treatment are more likely to quit smoking and quit drinking. These findings have implications for comparative effectiveness research in that long term outcomes, such as mortality, that are affected by patient behavior, may differ systematically with treatment invasiveness.

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I. Introduction

Coronary Artery Disease (CAD) is a common and deadly disease. In 2010, over 350,000 people died of CAD in the United States, making the disease responsible for roughly one in seven deaths (Murphy, Xu, and Kochanek, 2012). CAD is caused by a buildup of plaque on the arterial walls leading to the heart, resulting in reduced blood flow. If the buildup is not checked, CAD can result in a myocardial infarction (MI) (aka "heart attack") due to insufficient oxygen reaching the heart.

A number of medical treatments are available to patients with CAD. First, and least invasive, is "medical management." Medical management involves non-surgical treatment including prescription medication, lifestyle modification, and frequent monitoring. The second treatment is a surgical procedure known as Percutaneous Coronary Intervention (PCI). A surgeon performing PCI makes a small incision and arthroscopically inserts and inflates a balloon at the site of the lesion to expand the vessel. PCI in the modern era usually involves the placement of a wire mesh stent at the blockage site, which assists in keeping the arterial walls expanded to maintain blood flow. The PCI procedure takes approximately 60 minutes and the patient usually spends one night in the hospital.[1] The third and generally most invasive treatment is Coronary Artery Bypass Graft (CABG) surgery[2], a major procedure that involves harvesting a section of vessel from a different area of the body (either vessels in the groin or chest wall) and opening the chest cavity via a sternectomy and connecting one healthy part of the diseased artery to another, surgically bypassing the lesion. CABG surgery takes approximately four hours and patients generally spend at least a week recovering in the hospital.[3]

Of the two surgical procedures, PCI is the more recent, having been initially used in the late 1970s, more than a decade after CABG was first performed, and its use expanding rapidly upon FDA approval of the coronary stent in 1994 (Cutler and Huckman, 2003). Since the development of PCI, there have been numerous studies comparing the effectiveness of the two procedures in various populations (see Rodriguez et al. 2001 and Serruys et al. 2009 for two recent articles with a summary of prior research). While the results vary, our general interpretation is that PCI involves lower perioperative mortality– due partly to fewer surgical

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[1] http://www.medicinenet.com/coronary_artery_bypass_graft/article.htm (accessed 5/31/12)
[2] Less invasive CABG procedures have been in development and increasing use in recent years, though these were very infrequent during the period we examine.
[3] http://www.medicinenet.com/coronary_angioplasty/article.htm (accessed 5/31/12)

complications from a less invasive procedure – but that the two procedures have similar long term outcomes. In other words, among those patients who survive the perioperative period, CABG patients have better long term outcomes than PCI patients. In addition CABG seems to bring more relief from the symptoms of CAD, particularly angina. However, to date the medical literature has attributed this almost exclusively to CABG being mechanically superior in terms of blood flow restoration. While previous randomized trial based studies have controlled for smoking status at treatment, we are unaware of any study that has considered whether differential post- operative behavior change in patients may be driving these long term outcome differences.

In this paper, we test one hypothesis that may explain why CABG patients have relatively good long-term outcomes, despite a higher surgical complication rate. Specifically, we expect that the more invasive nature of CABG surgery – a patient is in the hospital for a week, has a longer post-operative recovery period, and is left with a major scar and residual pain from the sternectomy long after the procedure – sends a stronger signal to the patient that he as a serious health problem. As a result, we hypothesize that a patient who undergoes CABG rather than PCI is more likely to change his behavior in a way that promotes good health and a longer life: he is more likely to quit smoking, begin exercising, improve his diet, and avoid excessive alcohol intake.

This hypothesis is consistent with a prior economic research on moral hazard, showing that individuals change their behavior when their perceived risks change. Peltzman's (1975) study of the effects of automobile safety regulation is a classic and seminal example. He develops a model in which the introduction of the legally mandated installation of various safety devices on automobiles lowers the price of driving intensity (faster and more reckless driving) because it lowers the probability that the driver will die in an accident. Hence the demand for this activity rises. Empirically, he finds that the increase in this offsetting behavior (reckless driving) is so large that the regulations at issue had very little impact on highway deaths and actually increased pedestrian deaths. More recently, Dave and Kaestner (2009) investigate the impact of health insurance access on the health behaviors of the elderly, showing that access to Medicare at age 65 leads to a reduction in preventative behaviors and an increase in risky health behavior amongst the elderly. Peltzman (2011) demonstrates how medical technology breakthroughs can lead to offsetting behavior by showing that the age cohorts that benefited the most from the introduction of antibiotics experienced worse mortality rates from risky health behaviors.

In this study, we test two potential behavioral responses to undergoing procedures – smoking and drinking participation – and find behavior consistent with patient offsetting behavior. Patients who undergo a more invasive treatment for CAD, i.e. CABG, are more likely to quit smoking and drinking.

II. Data

In this study, we look at the Health and Retirement Survey (HRS) linked to respondents' Medicare data for 1990-2010. The HRS provides information on smoking and drinking behavior in each wave, as well as individual characteristics. The Medicare records identify those patients who have been diagnosed with CAD and show which of them have undergone PCI or CABG, along with the exact date of each diagnoses and procedure.

The HRS is a longitudinal survey of older adults who were age 50-69 when the survey began in 1992 and their spouses were surveyed and again biennially from that point forward (we have data through 2010). A second cohort of those 70 and older (the AHEAD cohort) and their spouses were surveyed in 1993, 1995 and then brought in line chronologically with the HRS in 1998. Two subsequent cohorts that were younger than the original HRS were also added in 1998. In the HRS all participants are asked questions about their general state of health, previously diagnosed conditions, physical and cognitive function, health behaviors, and work, income and assets.

At each wave individual respondents are asked their current smoking status and whether they consume alcohol. Retrospective smoking questions were asked in the baseline HRS and then inconsistently in subsequent waves, so we rely on the current smoking status questions which are consistently asked to identify those who quit wave to wave.[4] Subsequent to baseline the HRS and AHEAD respondents were also consistently asked questions about the frequency and quantity of alcohol consumed, and we use this data in additional models. If the individual

[4] This approach using wave to wave smoking status over-simplifies the complexity of smoking and quitting behavior, but still allows us to investigate our key question: what is the *difference* in quitting behavior between CAD patients undergoing medical management, PCI, or CABG. However, using the retrospective questions which weren't asked until much later introduces survivor bias, which may be more problematic.

dies during the same inter-wave period they are treated, their last known smoking and drinking status is imputed forward.

The Medicare data are provided by the Center for Medicare & Medicaid Services (CMS). To identify CAD patients and the type of treatment they underwent, we use the Medicare Standard Analytical Files, including the Inpatient, Outpatient, Skilled Nursing Facility, Carrier, Durable Medical Equipment, Home Health Agency, and Hospice claims files. These files contain one or more records for each individual.[5] Each record contains the ICD-9-CM codes for all diagnoses made and procedures performed during that stay or claim. We identify CAD patients as those who have at least one diagnosis code beginning with 410, 411, 412, 413, or 414. We identify PCI patients as those CAD patients with at least one procedure code beginning with 0066, 3601, 3602, 3605, and 3606. We identify CABG patients as those CAD patients with procedure codes beginning with 361.[6] Finally, we identify medically managed patients as those patients who have been diagnosed with CAD, but do not have a concurrent or subsequent PCI or CABG procedure. To avoid misclassification because individuals may have been treated before they entered Medicare or before entering the HRS, we exclude individuals who in their baseline wave report having been previously told they had heart disease.

We also use all available claims up to and including the claim in which the individual's treatment date is established for our analysis to identify differences in initial diagnosis date versus treatment date (for those who undergo a procedure), whether the patient had an acute myocardial infarction at any point up to and including treatment date, and any relevant comorbid conditions the patient may have had for the purposes of clinical risk adjustment for severity of illness (Elixhauser et al, 1998).

III. Initial Analysis

In total, 10,250 HRS respondents were linked to Medicare data and diagnosed with CAD at any point in time. Of these individuals, 6,543 were diagnosed with CAD after entering Medicare and having an initial HRS survey with 5,026 receiving medical management (MM),

[5] A single record in the Inpatient file corresponds to a stay in a hospital. A single record in the Skilled Nursing Facility file corresponds to a stay in a Skilled Nursing Facility. A single record in the Outpatient file corresponds to a claim by an institutional outpatient provider (Hospital outpatient clinic, rural health clinics, etc.). A single record in the Carrier claim file corresponds to a claim by a non-institutional outpatient provider (physicians, physician assistants, etc.)

[6] For both PCI and CABG, we exclude the small number of patients that do not have a concurrent or prior CAD diagnosis.

964 receiving PCI, and 553 receiving CABG (Table 1). If individuals had both PCI and CABG they were included in the CABG category, because that is the more invasive treatment. Our results are robust to including them in the PCI category or excluding them altogether.

Basic demographic and clinical characteristics of these patients are shown in Table 1. Overall, when compared to medical management, patients who undergo a procedure (PCI or CABG) are more likely to be younger, male, married and white. They also have more clinical conditions, including congestive heart failure, peripheral vascular disease and diabetes, though these are not different between PCI and CABG recipients.

Table 1. Patient characteristics in the wave preceding treatment

Treatment	Medical Mgmnt	PCI	CABG	Overall
N=	5026	964	553	6543
Female	57.7%	44.1%	30.2%	53.4%
Age	75.2	74.4	74.4	75.0
Self rated health prior to treatment				
Excellent	8.2%	5.6%	7.7%	7.8%
Very good	23.1%	21.8%	19.3%	22.6%
Good	33.1%	32.4%	36.2%	33.2%
Fair	24.2%	27.3%	26.9%	24.9%
Poor	11.4%	13.0%	9.9%	11.5%
Educational attainment				
No degree	34.4%	30.7%	33.5%	33.8%
GED	4.0%	4.7%	5.8%	4.2%
HS	30.8%	34.6%	27.9%	31.2%
HS/GED	14.5%	13.9%	11.6%	14.2%
AA/ lt BA	2.5%	2.5%	2.7%	2.5%
BA	8.4%	8.1%	9.4%	8.5%
MA/MBA	3.9%	3.4%	6.0%	4.0%
Law/MD/PhD	1.4%	2.0%	3.1%	1.6%
Other	0.0%	0.1%	0.0%	0.0%
Race				
White	82.7%	88.2%	91.1%	84.2%
Black	14.7%	8.7%	6.5%	13.1%
Other	2.5%	3.1%	2.4%	2.6%
Marital Status				
Married	56.3%	65.0%	72.3%	58.9%
Married spouse absent	0.9%	0.3%	0.6%	0.8%
Partnered	1.6%	1.0%	1.7%	1.6%

Separated	1.2%	0.4%	0.4%	1.0%
Divorced	5.7%	5.6%	4.1%	5.5%
Separated/Divorced	1.6%	0.7%	0.2%	1.3%
Widowed	30.2%	25.0%	19.3%	28.5%
Never married	2.5%	2.0%	1.4%	2.4%
Financial well being				
Total Household Assets (000s of $)	310.2	311.5	366.3	302.6
Out of pocket medical spending in most recent year ($)	3093.2	2926.9	2481.9	3017.5
Oop medical spending in most recent year post treat (4)	4752.4	5456.5	5291.5	4905.7
Clinical comorbidities				
Congestive heart failure	7.8%	25.4%	25.3%	11.9%
Vavular disease	3.9%	20.3%	25.7%	8.2%
Pulmonary circulation disorders	0.8%	3.3%	3.3%	1.4%
Peripheral vascular disorder	3.8%	21.5%	28.4%	8.5%
Hypertension	31.6%	76.5%	75.2%	41.9%
uncomplicated	27.5%	73.9%	71.8%	38.1%
Paralysis	0.4%	1.6%	0.9%	0.6%
Other neuro disorders	1.3%	3.6%	1.6%	1.6%
Chronic pulmonary disease	8.2%	25.2%	26.2%	12.2%
Diabetes (uncomplicated)	10.0%	33.1%	32.2%	15.3%
Diabetes (complicated	1.0%	7.8%	9.2%	2.7%
Hypothyroidism	3.7%	12.9%	9.4%	5.5%
Renal failure	1.5%	5.6%	7.2%	2.6%
Liver disease	0.2%	0.4%	0.9%	0.3%
Peptic ulcer disease	0.1%	0.1%	0.2%	0.1%
Lymphoma	0.2%	0.4%	0.2%	0.2%
Metastatic cancer	0.4%	0.6%	0.7%	0.5%
Solid tumor	1.6%	5.1%	6.7%	2.6%
Rheumatoid arthritis	0.8%	3.3%	2.4%	1.3%
Coagulopathy	0.5%	3.8%	8.0%	1.6%
Obesity	0.9%	8.6%	7.8%	2.6%
Weight loss	0.6%	1.1%	1.1%	0.7%
Fluid and electrolyte disorders	2.9%	14.9%	17.9%	6.0%
Blood loss anemia	0.4%	2.2%	2.5%	0.8%
Deficiency anemia	3.4%	13.7%	13.9%	5.8%
Alcohol abuse	0.4%	0.8%	1.3%	0.5%
Drug abuse	0.1%	0.0%	0.4%	0.1%
Psychoses	0.4%	1.7%	2.0%	0.7%
Depression	1.3%	5.7%	3.3%	2.1%

Table 2. Summary statistics of outcomes by treatment group

Treatment group	Med Mgmnt	PCI	CABG	Total
N=	5026	964	553	6543
Smoked in wave preceding treatment	13.45%	12.14%	11.75%	13.11%
Drank alcohol in wave preceding treatment	42.35%	40.15%	46.38%	42.36%
# drinks on days drinking wave preceding treatment	0.39	0.33	0.41	0.38
Days drinking per week wave preceding treatment	0.78	0.78	0.92	0.79

Our health behaviors of interest in the wave immediately preceding treatment are in table 2 above. Smoking in the wave prior to treatment was 13.5%, 12.1% and 11.8% for the MM, PCI and CABG group respectively. Drinking participation in the wave prior to treatment was 42.4%, 40.2% and 46.4% for the MM, PCI and CABG group respectively. Trends in smoking and drinking participation can be seen in figures 1 and 2 below.

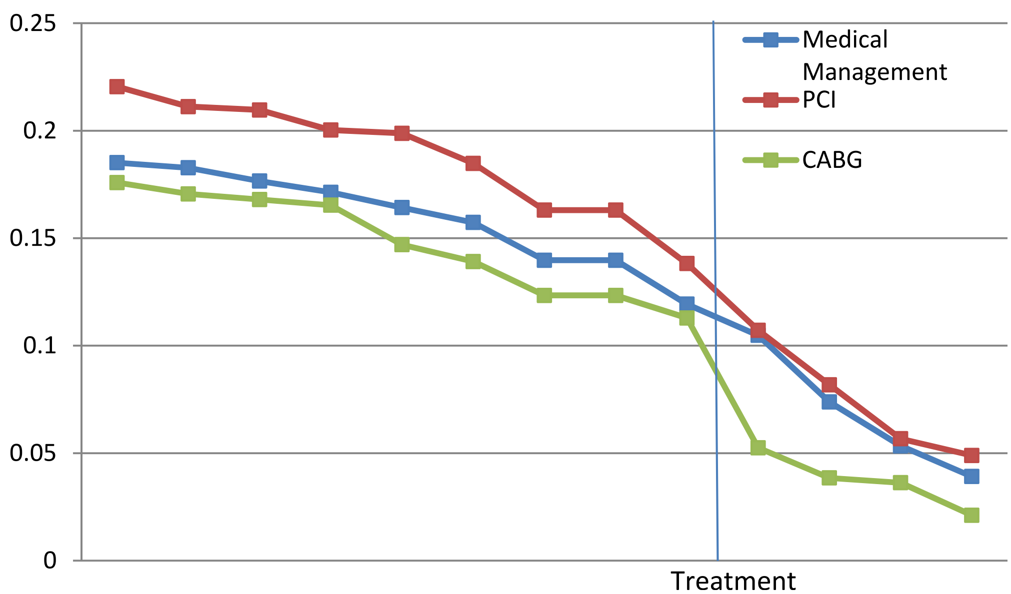

Figure 1. Trends in smoking participation among HRS respondents by wave relative to treatment date. (Behavior is imputed back from first known smoking status)

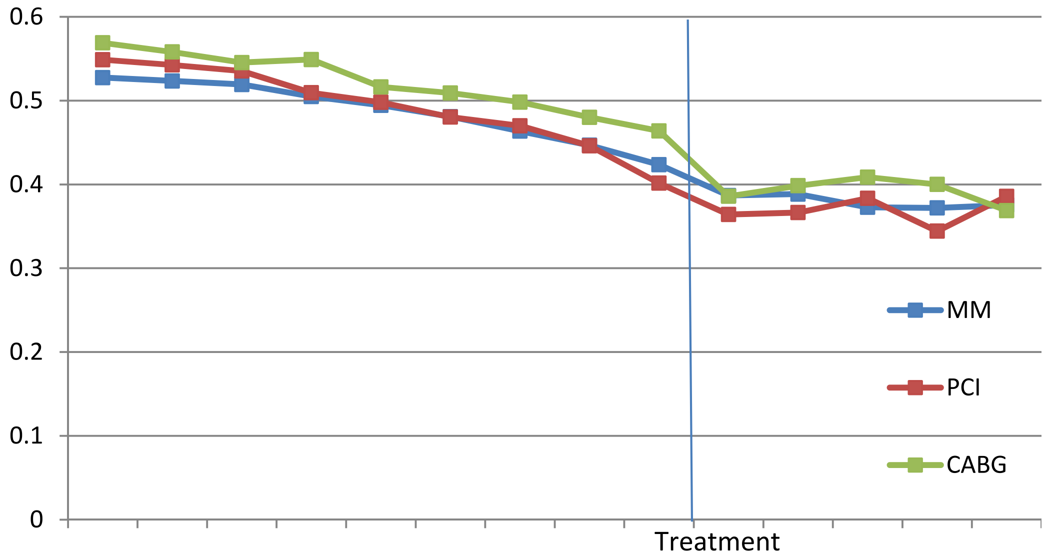

Figure 2. Trends in drinking participation by wave among HRS respondents relative to treatment date. (Behavior is imputed back from first known smoking status)

These trend data are relative to the treatment date, which is represented by the vertical line. These are consistent with the broad hypothesis in our study – patients who undergo a more invasive treatment for CAD are more likely quit smoking. However, they could also be consistent with a story in which people who undergo CABG surgery are also more likely to quit smoking for reasons unrelated to surgery. Thus we construct multiple regression models to test our hypothesis adjusting for other factors.

IV. Regression models

Quit and quantity and frequency change models

As an initial test of whether individuals receiving PCI or CABG are more likely to quit smoking or drinking, we estimate the following quit model among those who smoke or drank in the wave immediately preceding treatment:

$$q = \rho_0 + \rho_1 p + \rho_2 c + \rho X \qquad (1)$$

where q is an indicator for those who did not smoke (or drink) in the survey wave subsequent to receiving either PCI (p) or CABG (c). X is vector of individual control variables including race, gender, age at treatment and its square, clinical comorbidities up to and including those diagnosed at the treatment date, whether the individual had an AMI, and a series of other survey measures as reported at the wave preceding treatment including educational attainment, marital status, self-rated health, the most recent year's out of pocket medical spending, and total household assets at the wave preceding treatment.

The HRS also began to collect consistent and detailed alcohol consumption data in the second wave. So for individuals who are treated after wave 2, we use this data to assess changes in the number drinks consumed on days of drinking and number of days per week drinking between the wave preceding treatment and following treatment. Specifically q in these models is defined as number of drinks or number of days drinking in the period immediately prior to treatment minus the number reported in the period immediately following treatment. In each of the above models we are concerned about potential intracluster correlation within treatment groups across time. As such we present both standard errors without adjustment and standard errors that are clustered within treatment type (i.e. MM, PCI, CABG) within year. Thus, in the quit models there are 51 potential clusters and in the quantity and frequency models for drinking there are 48 potential clusters.

Longitudinal participation models

Subsequent to these models we further test whether the patterns in participation observed in figures 1 and 2 at the time of treatment are driven by treatment type, and if there is a diagnosis effect using a longitudinal model of smoking and drinking behavior. We define π as a participation dummy variable equal to one if a person smokes (or drinks) at a given wave and zero otherwise; we define d as a diagnosis dummy variable that equals zero in the waves before diagnosis and one in the waves subsequent to diagnosis; we define s as an intervention dummy equal to zero in the waves prior to those individuals receiving either PCI or CABG having it performed and one in all waves after that.

For the medical management individuals, the model is

$$\pi = \alpha_0 + \alpha_1 d \qquad (2)$$

For the pci group, the model is

$$\pi = \beta_0 + \beta_1 d + \beta_2 s \qquad (3)$$

For the cabg group, the model is

$$\pi = \gamma_0 + \gamma_1 d + \gamma_2 s \qquad (4)$$

Note that the variable s is not relevant for those in the MM group. We pool the three equations by multiplying the second one by p (a dummy that equals 1 for pci patients), the third by c (a dummy that equals 1 for cabage patients), and the first by 1 – p – c (a dummy that equals 1 for medical management patients). The pooled model becomes

$$\pi = \alpha_0 + (\beta_0 - \alpha_0)p + (\gamma_0 - \alpha_0)c + \alpha_1 d + (\beta_1 - \alpha_1)pd + (\gamma_1 - \alpha_1)cd + \beta_2 ps + \gamma_2 cs. \quad (5)$$

We estimate these using a first difference approach, analogous to the 2 period quit model.

As in the quit models we are again concerned about potential intra-cluster correlation within observations this time stemming from either within person or within treatment type and treatment year. Therefore we present standard errors clustered by individual, and standard errors clustered within treatment type within treatment year.

V. Results

The results of the quit models and quantity and frequency of drinking models are in table 3. While having PCI does not have a statistically significant impact on quitting smoking or drinking, CABG does. Neither procedure appears to have a statistically significant impact

Table 3. Model of impact of CAD treatment type on smoking cessation and alcohol consumption behavior.

	(1) Quit smoking	(2) Quit drinking alcohol	(3) Quantity per occasion	(4) Frequency
PCI	0.050	0.022	-0.049	-0.053
	(0.063)	(0.028)	(0.039)	(0.060)
	[0.063]	[0.036]	[0.031]	[0.063]
CABG	0.295	0.074	-0.046	-0.120
	(0.072)*	(0.033)*	(0.049)	(0.075)
	[0.061]*	[0.037]+	[0.037]	[0.079]
Observations	803	2629	5118	5118
Number of clusters	50	51	48	48
Sample	Smokers in wave preceding treatment	Drinkers in wave preceding treatment	All individuals treated after wave 2	All individuals treated after wave 2

Standard errors in parentheses are not clustered. Standard errors in brackets are clustered at the treatment type (MM, PCI, CABG) by treatment year level. + $p < 0.10$, * $p < 0.05$

Model includes gender, age at treatment, age at treatment squared, Elixhauser clinical comorbidity indicators, acute myocardial infarction indicator, educational attainment, race, marital status at wave preceding treatment, self-rated health at wave preceding treatment, out of pocket medical spending in year leading up to wave preceding treatment, and value of household assets at wave preceding treatment.

on changes in the quantity or frequency of alcohol consumption. To be precise, those smokers who receive CABG are 29.5 percentage points more likely to quit smoking by the wave following treatment. Those who drink alcohol are 7.4 percentage points more likely to quit drinking by the wave following treatment. While the effects for PCI patients are not statistically significant, the point estimate of the impacts of having PCI on quitting smoking is similar to what we have found in other work using NHIS data with a larger sample size.

The results of the longitudinal smoking participation model are in table 4. The first column contains the estimates without wave fixed effects and the second column includes wave fixed effects.[7]

Table 4. Pooled model of impact of CAD treatment type on individual

CABG X post surgery	-0.025 (0.014)$^{+}$ [0.013]$^{+}$	-0.040 (0.015)* [0.013]*
PCI X post surgery	-0.002 (0.009) [0.007]	-0.017 (0.010)$^{+}$ [0.008]*
Diagnoses with CAD	-0.021 (0.004)* [0.006]*	-0.036 (0.005)* [0.008]*
PCI X post diagnosis	-0.015 (0.012) [0.013]	0.002 (0.013) [0.014]
CABG X post diagnosis	-0.030 (0.016)$^{+}$ [0.021]	-0.013 (0.017) [0.022]
Wave fixed effects	No	Yes
Observations	39362	39362

Standard errors in parentheses are clustered at the individual level. Standard errors in brackets are clustered within treatment type (MM, PCI, CABG) within treatment year. $^{+}$ $p < 0.10$, * $p < 0.05$
Model includes AMI occurrence, marital status, out of pocket medical spending, and value of household assets at each wave (or first differences as appropriate).

[7] Because this is an unbalanced panel, these fixed effects are relative to the wave immediately preceding treatment since every individual is in the analysis for at least that wave and the wave immediately following treatment. We have also modeled this using the RAND wave definitions as a way to control for changing technology, and the results are similar.

Depending on model specification, the estimated impact of being diagnosed on smoking participation is a 2.1 to 3.6 percentage point reduction in smoking. Undergoing CABG results in a 2.5 - 4.0 percentage point additional reduction in smoking participation, while undergoing PCI has no additional impact on quit behavior when wave fixed effects are excluded and a 1.7 percentage point additional reduction when these wave fixed effect are included .

The results of the longitudinal alcohol participation model are in table 5. The columns are analogous to those in table 4.

Table 5. Pooled model of impact of CAD treatment type on individual alcohol participation behavior.

CABG X post surgery	-0.033	-0.057
	(0.025)	(0.026)*
	[0.028]	[0.029]+
PCI X post surgery	-0.021	-0.044
	(0.017)	(0.019)*
	[0.019]	[0.021]*
Diagnoses with CAD	-0.017	-0.040
	(0.007)*	(0.010)*
	[0.009]+	[0.013]*
PCI X post diagnosis	0.022	0.048
	(0.020)	(0.022)*
	[0.019]	[0.023]*
CABG X post diagnosis	-0.032	-0.006
	(0.028)	(0.030)
	[0.034]	[0.036]
Wave fixed effects	No	Yes
Observations	39362	39362

Standard errors in parentheses are clustered at the individual level. Standard errors in brackets are clustered within treatment type (MM, PCI, CABG) within treatment year. $^{+}$ $p < 0.10$, * $p < 0.05$
Model includes AMI occurrence, marital status, out of pocket medical spending, and value of household assets at each wave (or first differences as appropriate).

As in the case of smoking participation, being diagnosed with CAD reduces drinking participation, with the estimated reduction between 1.7 and 4.0 percentage points. The estimates of the impact of CABG on alcohol participation are mixed as well, with the estimated additional reduction being 3.3 (imprecisely estimated) to 5.7 percentage points. In contrast to the case of smoking there appears to be some additional negative impact of having PCI on alcohol consumption, with an estimated reduction of between 2.1 (imprecisely estimated) to 4.4 percentage points.

Diagnosis and treatment for those who receive PCI and CABG often do not occur on the same admission, but do occur within a narrow time window which means they occur within the same inter-wave period. Because of the estimated effects of diagnosis and treatment in the above models may not cleanly capture the isolate effect of treatment differences. So as a first sensitivity analysis, we examined the longitudinal participation models for both drinking and smoking including all MM patients since diagnosis and treatment assignment co-occur, and only including those whose PCI or CABG treatment is the same as their diagnosis date. This is model (5) without the diagnosis variable or the interactions with it included. The estimates effects are in table 6.

Table 6. Pooled model of impact of CAD treatment type on individual smoking participation and alcohol consumption behavior for those who had PCI or CABG on the date of their first CAD claim (procedure same as diagnosis date)

	Smokes		Drinks alcohol	
CABG X post surgery	-0.046 (0.030) [0.026]$^{+}$	-0.040 (0.030) [0.026]	-0.089 (0.048)$^{+}$ [0.054]	-0.085 (0.048)$^{+}$ [0.054]
PCI X post surgery	-0.024 (0.016) [0.023]	-0.018 (0.016) [0.023]	0.014 (0.025) [0.022]	0.018 (0.025) [0.023]
Wave fixed effects	No	Yes	No	Yes
Observations	31816	31816	31816	31816

Standard errors in parentheses are clustered at the individual level. Standard errors in brackets are clustered at the treatment type (MM, PCI, CABG) by treatment year level.$^{+}$ $p < 0.10$, * $p < 0.05$
Model includes AMI occurrence, marital status, out of pocket medical spending, and value of household assets at each wave (or first differences as appropriate).

While the estimates are not as precise as in the previous two tables, the direction and magnitude of the impact of undergoing CABG are similar for the smoking participation model and the PCI effect is similar in magnitude, but not precisely estimated. In the case of alcohol consumption the estimated impacts of CABG are much larger though not very precisely estimated, and PCI effects are not different from zero.

In table 7 are results of a longitudinal model of quantity and frequency of alcohol consumption. Being diagnosed with CAD has a negative impact on both quantity and frequency of consumption.

Table 7. Pooled model of impact of CAD treatment type on individual alcohol quantity and frequency of consumption behavior.

	Number of drinks on occasions of drinking		Days per week drinking	
CABG X post surgery	-0.045 (0.053) [0.050]	-0.079 (0.058) [0.052]	-0.268 (0.106)* [0.116]*	-0.262 (0.109)* [0.117]*
PCI X post surgery	-0.035 (0.028) [0.020]+	-0.069 (0.036)+ [0.025]*	-0.105 (0.059)+ [0.042]*	-0.099 (0.065) [0.047]*
Diagnoses with CAD	-0.061 (0.021)* [0.022]*	-0.094 (0.034)* [0.033]*	-0.111 (0.029)* [0.025]*	-0.110 (0.042)* [0.036]*
PCI X post diagnosis	0.013 (0.046) [0.050]	0.053 (0.055) [0.059]	0.050 (0.078) [0.061]	0.037 (0.085) [0.065]
CABG X post diagnosis	-0.059 (0.083) [0.069]	-0.020 (0.090) [0.075]	0.064 (0.120) [0.093]	0.055 (0.126) [0.096]
Wave fixed effects	No	Yes	No	Yes
Observations	30856	30856	30856	30856

Standard errors in parentheses are clustered at the individual level. Standard errors in brackets are clustered at the treatment type (MM, PCI, CABG) by treatment year level. $^{+}$ $p < 0.10$, * $p < 0.05$
Model includes AMI occurrence, marital status, out of pocket medical spending, and value of household assets at each wave (or first differences as appropriate).

The impact of CABG on quantity consumed is not precisely estimated, but the effects on frequency are consistent with our theory and large and precise in all but the individual & wave fixed effect model. The impact of having PCI is precisely estimated for both quantity and frequency, again except for the individual & wave fixed effect models. The PCI effect relative to CABG is not distinguishable in the quantity models, but it is in models of drinking frequency.

VI. Conclusion

In this paper, we sought to explore whether there was evidence of individual moral hazard in new medical technologies that treat diseases less invasively. Specifically we examined whether treatment for CAD that is more invasive had a differential impact on smoking and alcohol consumption. While these findings are preliminary, we do find evidence that suggests those who receive more invasive procedures may be more likely to quit smoking or drinking, and to consume alcohol less frequently after undergoing the procedure. These results are generally robust, though more model refinement is in order.

VII. References

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