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Realization of Low Probability Clinical Risks and Physician Behavior: Evidence from Primary Care Physicians

By

Ity Shurtz, Yoav Goldstein and Gabriel Chodick

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בנין פרץ נפתלי, קמפוס האוניברסיטה העברית, הר הצופים, ירושלים 9190501
The Hebrew University Campus, MT. Scopus, 9190501 Jerusalem, Israel
www.falk.huji.ac.il

Realization of low probability clinical risks and physician behavior: evidence from primary care physicians*

Ity Shurtz† Yoav Goldstein‡ Gabriel Chodick§

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Abstract

We examine whether primary care physicians alter their clinical decision making following realizations of low probability risks among their patients – events of colon cancer diagnoses. Relying on comprehensive administrative visit level data from a large Israeli HMO, we find that physicians increase their use of colonoscopy tests substantially during the first three months following colon cancer diagnosis and that in the subsequent twelve months, the effect dissipates. Considering that in our setting, it is unlikely that colon cancer diagnoses convey information in the traditional sense, these results indicate the existence of attention effects. Unexpected diagnoses induce a stronger physician response and the increase in the use of colonoscopy tests is more pronounced among patients who are similar to the patient diagnosed with colon cancer, in line with recent work on cognitive mechanisms and memory where surprises and associative memory play a key role in decision making. We find no evidence that the quality of colonoscopy tests decreases with the increase in their use, suggesting that in response to recent colon cancer diagnoses, physicians increase adherence to colonoscopy among their at-risk patients rather than merely lowering the cut-off risk level of prescribing colonoscopy tests.

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†Department of Economics, Ben-Gurion University of the Negev, Beer-Sheva, 8410501, Israel. Phone: 972-8-6472295. Email:shurtz@bgu.ac.il

‡Department of Economics, Hebrew University of Jerusalem, Israel. Phone: 972-. Email:yoav.goldstein1@mail.huji.ac.il

§Sackler School of Medicine, Tel-Aviv University, Israel. Maccabitech, Maccabi Healthcare Services.

1 Introduction

Improving the knowledge on physician decision making is widely recognized as key to understanding treatment choices in medical care.[1] Exposure to realizations of low-probability risks is known to affect individuals' actions (see e.g., Gallagher, 2014; Cameron and Shah, 2015). Such occurrences are an integral element of physicians' work environment. In particular, they arise whenever a physician encounters a patient with a newly diagnosed rare medical condition. However, their impact on physician decision making is not well understood. This paper aims to contribute to the understanding of this issue. It examines whether primary care physicians (PCPs) – experts regularly making high-stakes decisions – alter their clinical decision making following realizations of a low probability health risk among their patients, focusing on events of *colon cancer diagnosis*.

PCPs are a particularly important group of physicians that play a central role in the delivery of healthcare in developed countries, where they account for a substantial portion of healthcare costs - around 14% of total health spending in OECD countries.[2] In the framework of their practice, PCPs provide first-contact healthcare services, disease diagnosis, maintenance of continuity of care, management of chronic conditions, and coordination with other healthcare providers (Starfield et al., 2005). While colon cancer risk is one of many potential health risks, it is perhaps the most appropriate one for examining the issue at hand. Colon cancer is the second most deadly type of cancer worldwide (Center et al., 2009; Siegel et al., 2015). Despite the availability of various screening tests and the evidence supporting their effectiveness, colon cancer screening rates are relatively low (Richman et al., 2016) and PCP engagement is widely recognized as key to increasing them (Triantafillidis et al., 2017). Hence, a better grasp of physician behavior vis-à-vis colon cancer screening is interesting in its own right.

We rely on administrative data from Maccabi Healthcare, a large Israeli HMO (Maccabi). These data contain the records of roughly 30 million visits covering the clinical decision making of about 1,100 of Maccabi's PCPs over the four-year period 2012-2015, providing a comprehensive and highly detailed description of these physicians' behavior during that period. We measure physicians' response to colon cancer diagnoses by the degree of change in colonoscopy use among their patients. As we explain in detail below, this is a natural measure of physicians' response in this context since PCPs are typically actively involved in prescribing colonoscopy tests to their patients.

To draw causal inference, we analyze the response of physicians who experienced their first colon cancer diagnosis early on in the sample period in comparison to the behavior

[1] See Chandra et al. (2011).

[2] In several high-income countries, more than 40% of the physician workforce is composed of PCPs (Papanicolas et al., 2018).

of physicians who experienced their first diagnosis only several months later, following the approach of Fadlon and Nielsen (2019). This strategy is based on the randomness of the exact timing of a colon cancer diagnosis among physicians' patients in a short period of time.[3]

We find that in the first three months after a colon cancer diagnosis, the use of colonoscopy among the physician's patients substantially increases by roughly 20%. However, the effect appears to dissipate, and it becomes much smaller in the subsequent twelve months. We proceed by investigating two underlying channels of physicians' response to events of colon cancer diagnosis.

The first is the role of surprises in inducing physicians' response. An unforeseen diagnosis may draw more the physician's attention to colon cancer risk. In a preliminary analysis, we find that physicians' response is more pronounced in diagnoses involving young and female patients, who are less likely to be diagnosed with colon cancer. To run a more thorough analysis, we apply machine learning techniques using patient information available in our database in order to create an ex-ante risk score for each patient. We then analyze the response to colon cancer diagnoses by the risk score of the recently diagnosed patient. We find that unexpected diagnoses, those involving low-risk patients, induce a stronger physician response.

The second channel is associative recall. We assess whether the event of colon cancer diagnosis is more likely to be retrieved when a decision about a colonoscopy for a patient, who is similar to the recently diagnosed patient, is made. To this end, we examine if the increase in the use of colonoscopy tests is more pronounced among patients who share characteristics with the patient recently diagnosed. We find that the increase in colonoscopy use of young patients and women is associated with diagnoses of young patients and women, respectively.

We then leverage the availability of information on colonoscopy outcomes to examine whether the increase in the use of colonoscopy following colon cancer diagnoses is accompanied by a decrease in their quality. If the proportion of positive colonoscopy tests declined, this would suggest that the additional tests are those of lower-risk patients.[4] We find no evidence of a decrease in test quality after a colon cancer diagnosis. We corroborate these results by checking if our measure of ex-ante colon cancer risk was affected by physicians' response to recent diagnoses and find no indication that it did.

Our findings contribute to the understanding of the link between physicians' first-hand

[3] We also analyze the main results using coarsened exact matching and find very similar results (See Appendix A.2).

[4] A colonoscopy is considered positive if the doctor finds any polyps or abnormal tissue in the colon.

encounters with the realization of rare health risks and their subsequent clinical decision making. They indicate that when making decisions about prescribing colonoscopy tests, physicians' perception of colon cancer risk is affected by recent diagnoses of colon cancer among their patients. In that respect, they allude to the notion of the so-called availability heuristic—the tendency to estimate the probability of some event by the ease with which one can recall instances of that event (Thaler, 2016).[5]

Notably, we conduct our analysis through the lens of attention effects. However, the results could reflect learning from one's experience whereby a recent diagnosis contains new information and causes estimates of colon cancer risk to be updated. Nevertheless, it is important to keep in mind that the clinical setting we study—colon cancer screening—is part of the country's universal screening program. The success of all HMOs in the country, including Maccabi, in inducing sufficiently high screening rates is monitored based on their colon cancer screening rate quality index. As a result, PCPs are continuously exposed to up-to-date information concerning colon cancer risk and screening guidelines. Additionally, one would expect that learning effects would be manifested mostly among younger, inexperienced physicians. However, we find no evidence that this group exhibits a stronger response to recent colon cancer diagnoses. Therefore, our findings are more likely to reflect attention effects.

Our research is part of a growing literature that studies how realizations of medical risks affect physician decisions. Choudhry et al. (2006) showed that physicians who treated a patient with warfarin (a blood-thinner) who then experienced an adverse bleeding event were less likely to prescribe warfarin subsequently. More recently, in the context of the delivery room, Singh (2021) showed that if the prior patient had complications in one delivery mode (cesarean or vaginal), the physician would be more likely to switch to the other. In line with our results, Wang et al. (2022) find an increase in breast and colorectal cancer screening rates within one year of exposure to new breast or colorectal cancer diagnoses.[6] Our study joins this literature, documenting physicians' responses to realizations of colon cancer. The novelty of our study is twofold. It is the first, to the best of our knowledge, to explore the role cognitive processes play in physicians' response to realizations of medical risk. Our findings support recent work on cognitive mechanisms and memory where surprises (Bordalo et al., 2017; Kahneman and Miller, 1986) and associative memory (Gilboa and Schmeidler, 1995; Laibson, 2001; Mullainathan, 2002; Enke et al., 2020) play a key role in decision making. Additionally, our study evaluates the consequences of such realizations on the quality of physician decision-making, finding no indication that it decreased. These results support the view that, in response to cancer

[5]Tversky and Kahneman (1974) describe it by using an example: "one may assess the risk of heart attack among middle-aged people by recalling such occurrences among one's acquaintances."

[6]In a related paper, Chodick et al. (2022) document the immediate and temporary effect of encounters with patients recently diagnosed with cancer on physicians' decisions. They show that physicians increase their rate of testing (for the most common tests) for about an hour immediately following such encounters.

diagnoses, physicians increase their efforts to encourage adherence to colonoscopy tests among their at-risk patients and do not merely lower the cut-off risk level of prescribing them.

More broadly, our paper relates to the literature on behavioral aspects of physician decision making.[7] Existing work on this issue includes that of Rizzo and Zeckhauser (2003), which shows that physicians respond to loss aversion with respect to reference income by engaging in income-generating activities, including changing the style of their practice. Frank and Zeckhauser (2007) show that drug prescribing patterns are consistent with the use of ready-to-wear treatments. Namely, physicians have a small number of favorite drugs that they prescribe to most patients with a given condition. Coussens (2018) shows that physicians in emergency departments tend to perform more tests on patients arriving just after their round birthday (left-digit bias). Mullainathan and Obermeyer (2019) find evidence of bounded rationality in physicians' decisions to perform stress tests or catheterize emergency patients.[8]

The remainder of the paper is organized as follows. In Section 2 we provide some background; in Section 3 we describe the data; in Section 4 we lay out our empirical strategy; Section 5 provides the empirical evidence and Section 6 concludes.

2 Background - colon cancer and the Israeli healthcare system

Colon cancer is one of the most common types of cancer in terms of its incidence and the second most deadly type of cancer worldwide (Center et al., 2009; Siegel et al., 2015). It is more common among men, and the risk of developing colon cancer increases with age.[9] Early diagnosis of colon cancer is based mainly on two medical examinations. The first, the occult blood test (OBT)—a lab test used to check stool samples for hidden blood—is considered to be cheap, simple, and effective. The US Preventive Services Task Force (USPSTF) recommends that every individual aged 50-75 should perform an OBT once

[7] Healthcare consumers' inattention has been studied quite extensively. For example, Brot-Goldberg et al. (2017) find that consumers are sensitive to "spot prices" at the time of care. Abaluck et al. (2018) show that Medicare part D enrollees are more responsive to salient plan benefit changes. Fadlon and Nielsen (2019) show that health shocks (heart attacks and strokes) affect family members' consumption of preventive care mostly via increased salience.

[8] See also, Olenski et al. (2020) and Shurtz (2022) on physicians' left digit bias in the context of coronary-artery bypass graft surgery (CABG) and primary care and Chandra et al. (2011) for a review.

[9] Approximately 4.6% of men and 4.2% of women in developed countries will be diagnosed with colon cancer in the course of their lives. The median age at diagnosis is 68 for men and 72 for women (Extracted on 17-9-19 from https://www.cancer.org).

a year.[10] The second examination is colonoscopy, an exam used to detect abnormalities in the colon. During a colonoscopy, a flexible tube is inserted into the rectum and a tiny camera at its tip allows the physician to view the inside of the colon and remove tissue as needed. This is a high-performance examination but one that is also relatively complex and expensive. A colonoscopy is considered negative if there are no abnormalities in the colon and positive if any polyps (or other abnormal tissue) are found. Most polyps are not cancerous, but some can be precancerous. Polyps removed during colonoscopy are normally sent to a laboratory for analysis to determine whether they are cancerous, precancerous, or noncancerous, and may take several weeks to diagnose (Levin et al., 2008).

The Israeli healthcare system has been running a national screening program for the early diagnosis of colon cancer since 2005. The program was initiated as a joint effort of the Ministry of Health and the Israel Cancer Association. The level of PCP success in implementing the program in all four Israeli HMOs is monitored via a relevant "quality index", i.e., every year, each HMO is required to report the proportion of patients aged 50-74 that was screened for colon cancer.

Maccabi is the second largest of four HMOs that provide the bulk of primary care in the country.[11] Maccabi has 2.5 million members – about a quarter of the Israeli population. Members can choose their PCP and are free to change their PCP at the beginning of every yearly quarter. Most of Maccabi's physicians (about eighty percent) are freelancers and are typically not formally part of a group practice. In line with the national screening program, in Maccabi, individuals aged 50-74 whose risk of colon cancer is considered normal are advised to undergo, free of charge, the OBT once a year. The OBT does not normally require PCP involvement. Members receive text reminders and can pick up a test kit at the clinic or lab with no need for a doctor's referral. In contrast to the OBT, the physician makes the decision whether to refer the patient to a colonoscopy or, alternatively, to a gastroenterologist for further consulting based on factors that determine the patient's risk. Patients who are considered to be at high risk, i.e., those with a positive OBT, a family history of colon cancer, or other symptoms indicating possible colorectal cancer, are typically advised to perform (and are eligible for) a periodic (once every ten years) colonoscopy.[12] Colonoscopy tests are performed in a specialized center with the appropriate staff and equipment. The results are typically reported directly to the patient by the physician performing the colonoscopy on the same

[10] Extracted on 17-9-19 from https://www.uspreventiveservicestaskforce.org.

[11] Israeli residents may freely choose whichever HMO they prefer, but in practice, there is little patient movement across HMOs.

[12] 65% of individuals with a positive OBT – for whom the test is normally recommended – underwent a colonoscopy in 2019 (extracted on 8-17-22 from https://en.israelhealthindicators.org/). Table A.1 compares the characteristics of patients that had a colonoscopy and patients who did not have one. The table shows that patients who had a colonoscopy were much more likely to undergo an OBT (before the colonoscopy) and had a family history of colon cancer.

day. If a polyp was removed, the analysis results are returned to the patient within two weeks. This information usually also appears in the patient's electronic medical record and is visible to the PCP.

3 Data

The data contain the records of all of the visits to 1,133 of Maccabi's PCPs by about 1,400,000 patients during the years 2012-2015, which amounts to a total of about 30,400,000 visits. These data include physician and patient identifiers and indicate the identity of patients who are enrolled with a physician in a given quarter. Also available are patient characteristics such as gender, age, country of origin, and chronic conditions, along with a full summary of their laboratory tests, imaging, and drug prescriptions and whether these were filled. Additionally, the data contain information on physician characteristics such as age, gender, country of origin, name of medical school, year of graduation, specialty, years of experience, etc.

3.1 Sample

We focus on patients aged 50-74, the target population of the national screening program (and the USPSTF) for the early diagnosis of colon cancer, and those considered to be at the highest risk.[13] In order to concentrate only on physicians who regularly treat this population, we include only those who have at least 50 enrolled patients of that age group on average.

3.2 Identification of events of colon cancer diagnosis

To accurately identify the timing of a diagnosis, we rely on a combination of two indications originating from two sources of information about the diagnosis. The first is when a colon cancer diagnosis code first appears in the patient's medical record.[14] The second indication is the date of the diagnosis as it appears in the Cancer Registry file. This record accurately reflects the time of the patient's cancer diagnosis, as reported to the Ministry of Health database, typically done by the PCP.

[13] We also perform the analysis expanding the group of patients to ages 40-80. The results are very similar (see Section 5.5).

[14] We identify a diagnosis of colon cancer using ICD9 code (153-153.9).

The time of the cancer diagnosis and the time that the PCP learns about it do not coincide exactly. Patients are typically informed about a colon cancer diagnosis by a specialist, not their regular PCP. However, the PCP is involved in the diagnosis process from the initial referral to the colonoscopy test or the specialist. The PCP is also the patient's main point of contact to discuss and manage subsequent treatment and is often the one that records the diagnosis in Maccabi's medical records. Therefore, the time at which the physician learns about the diagnosis is normally very close to the time the cancer diagnosis is recorded in the medical record.

We define a recent colon cancer diagnosis as the occurrence of these two indications within one month of each other. Namely, a physician i experienced a diagnosis in month m if two conditions were met. First, a diagnosis of colon cancer was recorded for the first time in that month in the medical record of one of her patients.[15] Second, the diagnosed patient was also registered with the Cancer Registry. The time of diagnosis, as it appears in the Cancer Registry, is within one month of the time of diagnosis that was recorded in Maccabi's medical records. This definition is our preferred one because it ensures that the appearance of the colon cancer diagnosis code in the Maccabi medical records actually reflects the accurate timing of diagnosis as opposed to a diagnosis that was coded during a follow-up visit which is associated with an earlier diagnosis of colon cancer. Figure A.1 shows the number of colon cancer diagnoses in each quarter during our data period.

We want to observe at least nine months of pre-diagnosis data for each PCP in our sample. Since our data is available starting at the beginning of 2012, we exclude the colon cancer diagnoses that occurred in the first nine months of 2012. If a physician experienced such a colon cancer diagnosis and a subsequent diagnosis less than nine months later, we exclude that later diagnosis as well, as it does not contain clean nine months of pre-diagnosis data.

With this additional restriction, we observe 549 colon cancer diagnoses experienced by 324 PCPs in the period of October 2012 - December 2015. For each physician, we keep the first diagnosis in that period (i.e., 324 colon cancer diagnoses). Additionally, we keep only physicians who were active in the two years surrounding their first colon cancer diagnosis, nine months before it and 15 months after it. Namely, we exclude physicians with periods of inactivity around their first diagnosis (40 physicians). After these restrictions, we have a set of 284 PCP first diagnosis pairs in our data period.

[15] If the diagnosis was recorded towards the end of the month, after the 23^{rd} day of the month, we assign it to the following month.

3.3 Main outcome variable

As we explained above, physicians typically play an active role in every colonoscopy their patients undergo, and therefore, the use of colonoscopy tests is a natural measure of physicians' response to colon cancer diagnoses.[16] We observe about 2,500 colonoscopy tests per quarter (The quarterly number of colonoscopy tests in the sample period appears in red triangles in Figure A.2). To create a measure of colonoscopy use, we first define an *unscreened patient* as a patient who is enrolled with the physician, is in the age range 50-74, and did not have a colonoscopy in the prior ten years. We then calculate the monthly share of the PCP's patients' colonoscopy tests out of the total number of the PCP's unscreened patients. This is our main outcome variable, and we refer to it as *colonoscopy share*.

To execute our analysis, we aggregate these data at the physician-by-month level, weighting each observation by the physician's monthly work volume, i.e., the number of patients that the physician encountered in a month.

4 Empirical strategy

In this section, we lay out our empirical strategy for estimating the effect of colon cancer diagnoses on subsequent physician behavior. The ideal experiment for studying this issue would involve the random assignment of physicians to exposure to colon cancer diagnoses. One would then compare the behavior (e.g., colonoscopy share) of physicians in the treatment and comparison groups. Our data allow us to implement a quasi-experimental research design analogous to this ideal experiment.

To draw causal inference, we follow the approach of Fadlon and Nielsen (2019) and define physicians that experience their first colon cancer diagnosis early on in the sample period as the *treatment group*. To form the *comparison group*, we match treatment group physicians with colon cancer diagnoses in month t with physicians who experience their first diagnosis a fixed number of months later, which we denote Δ. Using this procedure, we assign to the comparison group physicians a *comparison event* time using the timing of the event of colon cancer diagnosis of their matched treatment group physicians, exactly Δ months before they actually experienced their first diagnosis. This procedure allows us to observe Δ months of post-diagnosis data in which members of the comparison group still did not experience their own first diagnosis. We measure the behavior of physicians in the treatment group before and after the timing of their diagnosis and compare it to

[16] This is different from the OBT whereby, as we explain above, Maccabi directly encourages every individual in the age range 50 - 74 to do the test annually without the physician's involvement.

the behavior of physicians in the comparison group around their assigned comparison event using standard difference-in-differences estimators. We set $\Delta = 15$, which allows us to observe 15 months of post diagnosis data while keeping the treatment and comparison groups balanced on their observable characteristics, as we show below in Section 5.[17]

We define the treatment group as physicians who experienced their first diagnosis during the 15-month period that started in October 2012 and ended at the end of 2013, i.e., physician i belongs to the treatment group if she experienced a colon cancer diagnosis in month $t \in [10/2012, 12/2013]$. 144 PCPs belong to the treatment group. Next, we create the comparison group by assigning a comparison event to PCPs who experienced their first colon cancer diagnosis exactly 15 months after the treatment group's colon cancer diagnoses. For example, we match the treatment group physicians that experience their diagnosis in October 2012 with comparison group physicians whose first diagnosis occurred in January 2014. We assign to all of them the event time of October 2012. This procedure implies that a physician belongs to the comparison group if she experienced a colon cancer diagnosis at months $t \in [01/2014, 03/2015]$. The final comparison group is composed of 94 PCPs.[18]

The assumption underlying this approach is that absent the colon cancer diagnosis, the outcomes of the treatment and comparison groups would share a common trend. The plausibility of this assumption is based on the notion that the particular month in which a colon cancer diagnosis occurs is as good as random. Our empirical analysis allows us to examine this assumption using the trend of the comparison and treatment group's colonoscopy share in the pre-diagnosis period. If they follow the same trend, this supports the assumption that the two groups do not differ in any relevant dimension.

We estimate a DD regression model with treatment leads and lags of the form:

$$y_{it} = \alpha + \sum_{r \neq -1, r=-3}^{4} [\gamma_r \cdot T_r + \delta_r \cdot T_r \cdot treat_i] + D_i + M_t + \varepsilon_{it}, \tag{1}$$

where y_{it} is the outcome for physician i at time t (e.g., colonoscopy share); T_r are indicators for the time relative to the diagnosis in periods of 3 months, i.e., *quarters relative to diagnosis*. The parameters of interest are δ_r, which estimate the period r treatment effect relative to T_{-1}, the three-month period before diagnosis occurs. D_i and M_t are physician and year-month fixed effects, respectively.

[17] See Fadlon and Nielsen (2019) for a discussion of the considerations in choosing Δ. We show in Section 5.5 that our results are not sensitive to the choice of Δ.

[18] While it is technically possible in this framework, we do not allow physicians to be part of both the Treatment and Control Group. Consequently, the 46 physicians with first colon cancer diagnoses in the period 04/2015 - 12/2015 are left out of the Comparison Group. Table A.2 compares the characteristics of physicians within our sample (treatment and comparison groups) against physicians excluded from the sample.

In addition, in order to quantify mean treatment effects, we estimate the standard DD equation of the form:

$$y_{it} = \beta + \gamma \cdot post_{it} + \delta \cdot post_{it} \cdot treat_i + D_i + M_t + \varepsilon_{it}, \tag{2}$$

In this regression, $post_{it}$ denotes an indicator for whether the observation belongs to post-diagnosis periods. The parameter δ captures the average effect of colon cancer diagnoses on physician outcomes.

5 The effect of colon cancer diagnoses on subsequent physician behavior

We now analyze the effect of a colon cancer diagnosis on subsequent physician behavior using the approach we described in Section 4. We first examine the characteristics of the treatment and comparison groups. Columns (1)-(4) of Table 1 show the mean and standard deviation of relevant variables, and columns (5)-(6) report the difference between them and the p-value of a t-test of the hypothesis that this difference is zero. Time-varying means of patient characteristics and physician activity are calculated for the first nine months of 2012, before any of the colon cancer diagnoses in our sample were made.

The table shows that the treatment and comparison groups are quite well-balanced for physician and patient characteristics. The only statistically significant differences between them are in work volume. The monthly number of enrolled patients and the number of patients that paid a visit to the physician are, on average, 29% and 18% larger in the treatment group, respectively. It comes as no surprise that physicians in the treatment group, who, by design, were more likely to experience their first cancer diagnosis early on in the sample period, have a higher patient volume on average.[19] Nonetheless, there are two reasons to think that this imbalance should not be a cause of concern about the validity of our design. First, in the alternative empirical approach we take, which is described in detail in appendix A.2, the work volume of the two groups is well-balanced, and we find the same results. Second, as we show below, the two groups exhibit similar levels and trends in colonoscopy share in the pre-diagnosis period, further alleviating the concern that these differences are driving the results.

[19] A related issue is that physicians' history of cancer diagnoses prior to 2012 is unobserved. A higher patient volume may be associated with a history of more exposure to colon cancer diagnosis events.

5.1 The effect of colon cancer diagnoses on colonoscopy share

Figure 1 displays the raw means of colonoscopy share in quarters relative to the colon cancer diagnosis, separately for the comparison and treatment groups. The solid red line shows the treatment group's means, and the blue dashed line shows the comparison group's means. Reassuringly the two groups appear to roughly coincide with each other on a similar level and on the same trend in quarters -3, -2, and -1. In quarter 0, the quarter immediately after the diagnosis, a gap opens between the colonoscopy share of the treatment and comparison groups. In quarter 1, this gap decreases, and the smaller divergence between the two groups persists in the subsequent four quarters. Figure 2 displays the results of the estimation of Equation 1. Consistent with the impression of Figure 1, the estimation results are very small and statistically insignificant in the periods before the diagnosis. In quarter 0, the first quarter after the diagnosis, we find a statistically significant 0.22 percentage points increase in colonoscopy share. With a baseline level of 1.18%, This result reflects a 19% increase in the treatment group's colonoscopy share. In the subsequent quarters, the coefficients remain positive, yet they are much smaller.

To quantify the average effect of the diagnosis, Table 2 presents the estimates of Equation 2. As we have seen above, physicians' response to the diagnosis appears to occur immediately after a colon cancer diagnosis and to weaken in later periods. Therefore, in addition to the *full sample*, which includes all nine months before a colon cancer diagnosis and fifteen months after it, we perform the average effect analysis on two alternative samples. The first is a *balanced sample* that keeps nine months of data before and after the diagnosis. The second is a *hole sample*, which is similar to the full sample but excludes the three months immediately after a colon cancer diagnosis. The latter sample aims to quantify the longer-run effect of a colon cancer diagnosis.

Columns (1), (2), and (3) of Table 2 show that the average effects of a recent colon cancer diagnosis, the coefficient of $Treat * Post$ (δ), in the baseline regression for the full, balanced, and hole samples are 0.096, 0.102, and 0.070, respectively. To interpret the magnitude of the estimates, note that with a baseline of colonoscopy share of 1.18, 1.14, and 1.21 in these samples, the mean effect reflects an increase of 8%, 9%, and 6% in colonoscopy share, respectively.[20] The coefficients in the full and balanced samples are statistically significant at the 99% level. The hole sample coefficient is only marginally statistically significant at the 90% level.

[20]We calculate the baseline as the constant of the regression, plus the coefficients of post and treat (in a specification with no fixed-effects).

In summary, consistent with the visual impression of the raw data, we find a large and statistically significant increase in colonoscopy share in the first three months following a colon cancer diagnosis. In the subsequent twelve months, the effect is much smaller. Overall, these results suggest a large physician response to colon cancer diagnoses – about 9% on average – that dissipates over time.[21] This result is robust to a variety of robustness tests, as we report in subsection 5.5.

5.2 Channels of physician response

The previous results showed that a diagnosis of colon cancer generates an increase in the use of colon cancer screening. Here, we explore two underlying channels of response. First, we assess the role of surprise in generating a physician's response. A more unforeseen diagnosis may draw more physicians' attention to colon cancer risk. The hypothesis is, therefore, that a colon cancer diagnosis of a low-risk patient would induce a stronger physician response than that of a high-risk patient. Second, we examine whether physicians' response to colon cancer diagnoses involves associative recall. Namely, if the diagnosis is more likely to be retrieved when a decision about a colonoscopy for a patient, who is similar to the recently diagnosed patient, is made. If associative memory is at play, then we would expect a more pronounced response among patients who share the characteristics of the diagnosed patient. For example, if the patient diagnosed with cancer were a woman, our hypothesis is that the diagnosis generated a larger increase in the colonoscopy share among the physician's female patients.

i) The degree of surprise

To begin looking into this issue, we note that, as we mentioned earlier, men are more likely to be diagnosed with colon cancer than women and that the risk of colon cancer is rapidly increasing with age (see, Society (2020)). Hence, a preliminary assessment of the role of surprise would be to examine physicians' response to colon cancer diagnoses that involve younger relative to older patients and female relative to male patients.

Let *Char* be one such characteristic of the diagnosis. For example, *Char* can be an indicator variable that takes the value 1 if the diagnosed patient was "young" (or "female") and 0 if she was "older" (or "male"). Note that *Char* equals 0 for the comparison group's

[21] To get a sense of the magnitude of the results, the number of colonoscopy tests in the period (in both treatment and comparison groups) is about 15,000. The 144 treatments of colon cancer diagnoses alone generate an overall increase of about 550 colonoscopy tests, about 3.7% of the total number of tests in the sample period. The total magnitude of this phenomenon is probably much larger, given that the total number of colon cancer diagnoses in the sample period is more than twice as large.

physicians since they are not exposed to any diagnosis of colon cancer during the analysis period. We estimate the following triple difference model on the balanced sample:[22]

$$
\begin{aligned}
(3) \qquad y_{it} = \alpha &+ \beta_0 \cdot Char_i + \beta_1 \cdot Char_i \cdot treat_i \\
&+ \gamma_0 \cdot post_{it} + \gamma_1 \cdot post_{it} \cdot Char_i + \gamma_2 \cdot post_{it} \cdot treat_i \\
&+ \delta_0 \cdot post_{it} \cdot treat_i \cdot Char_i + D_i + M_t + \varepsilon_{it}
\end{aligned}
$$

The coefficient of interest, δ_0, measures how the average response to colon cancer diagnoses varies by $Char$.

Table 3 shows the results of estimating Equation 3 using the balanced sample. When $Char_i$ is a dummy for colon cancer diagnoses that involve a young patient (age < 62, the median patient age in our sample), there is a positive difference of 0.10 percentage points between the effects of colon cancer diagnoses involving young – relative to older – patients (Column 1). Column (2) shows the results of a similar analysis, but where $Char_i$ is a dummy for colon cancer diagnoses of a female patient. We find a positive difference of 0.11 percentage points in the response to cancer diagnoses that were associated with female patients.

These suggestive results motivate a more thorough examination of the role of surprise. Ideally, to assess how surprising the cancer diagnosis was, we would like to know the probability of colon cancer diagnosis of the patient, as it was perceived ex-ante by the physician. To obtain a valid estimate of this probability, we create a predicted measure of a patient's colon cancer risk as of January 2012 using the relevant data available to the physician. Specifically, we use the information on age, gender, chronic conditions such as diabetes and high blood pressure, and colonoscopy tests the patients underwent in the prior ten years. We apply machine learning techniques to create a predicted colon cancer risk for all the patients in our database (Appendix Section A.1 provides a full description of this process). We assign to each diagnosis in our sample the January 2012 colon cancer *risk score* of the diagnosed patient.

With the diagnosis risk score defined, we begin with a graphical analysis of the role of surprise presented in Figure 3. To create the figure, we calculated, for each of the colon cancer diagnoses, Δ colonoscopy share—the difference in the physician's mean colonoscopy share between the nine months after to the nine months before the diagnosis.[23] This procedure generated 144 data points, one for each diagnosis in the treatment group, with a defined Δ colonoscopy share and diagnosis risk score. The (red) hollow

[22]Note that when $Char$ is constant at the physician level, we exclude it and its interaction with $treat$ from the estimation, in order to avoid multi-colinearity.

[23]More accurately, we calculated Δ colonoscopy share using the residuals of a regression of colonoscopy share on physician and time fixed-effects and the time-varying control variables we have used throughout this study.

circles plot the mean Δ colonoscopy share against the risk score in bins with a width of 0.2. To form a visual reference, we fitted a linear regression line to the data. The general impression from the figure is that a higher risk score is associated with a smaller Δ colonoscopy share. In colon cancer diagnoses that are associated with low-risk patients - those with a predicted risk of close to zero - mean Δ colonoscopy share is around 0.15, and at the other extreme, when risk score is close to one, Δ colonoscopy share is around zero. As a placebo exercise, we repeated this procedure for the comparison group and plotted the results in blue hollow squares.[24] As expected, Δ colonoscopy share is very close to zero across all the range of diagnosis risk scores in that group.

To formally examine the impression of the figure, we ran the regression DDD model in Equation 3 where δ_0 is the parameter of interest, capturing the variation in the response to the diagnosis by $Char_i$, the diagnosis risk score. Column (3) of Table 3 displays the results. We find a negative difference of 0.17 percentage points between the effects of colon cancer diagnoses with the highest risk score to those with the lowest risk score. Taken together, these results show that colon cancer diagnoses involving low-risk patients generate a stronger physician response, indicating that the surprise created by the diagnosis plays a role in drawing physicians' attention and inducing their response.

ii) Associative recall

In this section, we examine if colon cancer diagnoses induce a stronger response among patients who share the characteristics of the diagnosed patient. We start with patient age. Recall that Table 3 showed that physicians' response to colon cancer diagnoses is more pronounced when the involved patient was young (age < 62). We now examine if there is any variation in the response by patient age. To do this, we split the patient population in two at age 62 – the median patient age in our sample – and create two additional physician-level monthly outcome variables: 1) colonoscopy share under age 62; 2) colonoscopy share at age 62 and above. We then estimate Equation 3 again with these two outcome variables using the balanced sample. Panel A of Table 4 shows the results. Column (1) shows that in patients under age 62, the increase in colonoscopy tests is driven by the response to colon cancer diagnoses of young patients. In contrast, Column (2) shows that for patients aged 62 and above, the results are slightly (and insignificantly) more pronounced after the diagnosis of older patients. Therefore, colon cancer diagnoses involving young patients generate a larger increase in the colonoscopy share of young patients, but a similar association is not present in the colonoscopy share of older patients.

[24]There is no natural way to assign diagnosis risk to the comparison group. To facilitate this placebo exercise, we assign each comparison group's diagnosis the risk score of the patient diagnosed with cancer Δ months later.

Table 3 showed that the response to colon cancer diagnoses of women generated a stronger response than those of men. We examine next if this response varies by patient gender by creating another two physician-level monthly outcome variables for women and men. Panel B of Table 4 reports the results. As column (1) shows, for the colonoscopy share of women, the estimates are positive and statistically significant. Namely, the increase in colonoscopy share of women arises in response to diagnoses of female patients. By contrast, the results for the colonoscopy share of men are small and statistically insignificant. These results show that there exists an association between the characteristics of the patient that was diagnosed with colon cancer and physicians' response, supporting the view that associative memory plays a role in physicians' response.

5.3 The effect of colon cancer diagnoses on positive colonoscopy results

Here, we examine the effect of a colon cancer diagnosis on the outcomes of colonoscopy tests. Two possible channels of physician response, each with different consequences for the outcomes of colonoscopy tests, may underlay the results reported in Section 5.1. First, if, following a colon cancer diagnosis, physicians tend to prescribe more colonoscopy tests to patients that otherwise would not receive them, then, on average, the quality of colonoscopy tests would decrease. Namely, physicians would lower the cut-off risk level and prescribe colonoscopy tests to lower-risk patients. Second, following a colon cancer diagnosis, physicians may become more diligent in overseeing colon cancer screening and inducing take-up among at-risk patients. This is particularly relevant for a colonoscopy, which is considered a relatively unpleasant test due to the invasiveness of the procedure. In this channel, physicians increase their effort to induce adherence of at-risk patients, and additional colonoscopy tests would maintain their quality. A priori, it is unclear which of these two response channels dominates, and evidence on this issue can provide some insight into physicians' response to colon cancer diagnoses.

To study this issue, we analyze the colonoscopy tests in the balanced sample at the individual test level instead of the physician-month level (n=14,727), leveraging the availability of information about the results of the colonoscopy tests in our data. We create a measure of colonoscopy "quality" – a *positive test* indicator that equals one if a colonoscopy is positive, namely, if any polyps were found.[25] A negative effect of colon cancer diagnosis on colonoscopy quality would suggest that the likelihood of detecting a polyp became lower, i.e., the patients tested are at lower risk for colon cancer, and the quality of colonoscopy tests decreased. Panel A of Table 5 shows the estimation results

[25]To be precise, the indicator takes the value 1 if a diagnosis of a benign polyp in the colon (ICD9 211.3), or a malignant neoplasm of the colon (ICD9 153-153.9), or a neoplasm with unspecified behavior (ICD9 235.2), is found in the three weeks after the colonoscopy test.

of a linear probability model akin to Equation 2 run on the colonoscopy-level sample. The estimate for positive colonoscopy tests (column 1) is positive and insignificant, with a point estimate of 0.22 percentage points.[26]

The results show no evidence that the quality of colonoscopy tests decreased along with the increase in their quantity following a colon cancer diagnosis. Taken at face value, these results support the view that in response to colon cancer diagnoses, physicians increase their effort to induce adherence to colonoscopy tests among their at-risk patients. It is important to keep in mind, however, that the analysis lacks the statistical power to be conclusive. To corroborate this result, we use a second outcome, the risk score of patients undergoing a colonoscopy. A decrease in the average predicted colon cancer risk among patients that undergo colonoscopy would again suggest that following a colon cancer diagnosis, lower-risk patients are sent to have a colonoscopy. The risk-score analysis also gives a positive and insignificant point estimate of 0.49, supporting the interpretation that physicians induce adherence among at-risk patients.

5.4 Alternative explanations

We now discuss two alternative explanations for the results. One explanation concerns information that a colon cancer diagnosis may convey to the physician about the patient's relatives. Another is a demand side explanation, according to which, following a cancer diagnosis, relatives and friends of the diagnosed patient request the colonoscopy test.

Information on relatives. Relatives and, in particular, first-degree relatives—parent, child, or sibling—of diagnosed colon cancer patients are at increased risk of developing colon cancer relative to the general population (Henrikson et al., 2015). Indeed, in our sample of Maccabi patients, about 18% of the patients undergoing a colonoscopy have an indication of a family history of colon cancer in their electronic medical record.[27] A colon cancer diagnosis may inform the PCP that relatives of the diagnosed patient, who are also enrolled with him, are at high risk of colon cancer. Consequently, this information may increase the use of colonoscopy tests by the physician following the diagnosis.

To assess the role of this channel, we repeat the analysis, excluding colonoscopy tests that were associated with a recent family history of a cancer diagnosis. If our main results are driven primarily by this informational channel, they should not be present or should

[26] We ran an analogous analysis at the aggregate level, which generates very similar results (see appendix Table A.3).

[27] This figure refers to icd9 code v16.0 for family history of colon cancer that was recorded in the patient's electronic medical record up to 3 months before the colonoscopy.

be much weaker, when we exclude these tests. The results of this exercise (Figures A.3 and A.4 and Table A.4) are identical to the main results reported in Section 5.1 indicating that they do not arise via new information on family history of colon cancer generated by the diagnosis.

Demand side spillovers. Demand side spillovers are known to affect health behaviors (Fadlon and Nielsen, 2019). Other patients that learn about the colon cancer diagnosis (natural candidates are the spouse or colleagues) and are also enrolled with the same PCP might request a colonoscopy. We examine if the response of spouses of patients diagnosed with colon cancer drives the result. Out of 144 patients with a colon cancer diagnosis in our treatment group, we identified 62 spouses.[28] We estimated the effects of cancer diagnoses on colonoscopy share again, excluding the spouses from the analysis and the results remain identical (Table A.5).

We were not able to examine the demand side response of colleagues as we lack information on patients' workplaces. However, we argue that it is unlikely that this channel is the main driver of our results. To warrant a referral, the patients, who are colleagues of the diagnosed patient and are enrolled with the same PCP, should be "marginal". I.e., they must be high-risk patients that did not intend to be tested had they not heard about their colleague's cancer diagnosis. Additionally, as most of the effect we found arises in the first quarter after the diagnosis, the process of obtaining a referral and undergoing the colonoscopy should have been very fast.[29]

5.5 Robustness tests

In this section, we present robustness tests for different elements of the study. Overall, our main results are robust to these checks. Specifically, the results are not sensitive to the choice of the patient age range in the sample, the exact definition of colon cancer diagnosis, the outcome variable formulation, and the choice of Δ. The results are also robust to time-varying patient controls. Reproducing the analysis using an alternative study design also gives very similar results. Finally, the results concerning physician surprise are robust to the machine learning tool used to generate the risk measure.

[28] We use information on the identity of the payer of Maccabi's membership and consider patients with the same payer id as spouses.

[29] Note that the effects documented in Fadlon and Nielsen (2019) persist years after the exposure to the medical risk.

Age range. Throughout the analysis, we use data on patients aged 50-74, which is the target group for screening of the Israeli Ministry of Health and the USPSTF. Repeating the analysis using a larger age range, 40-80, we find similar results. The estimate of δ, the increase in colonoscopy share following colon cancer diagnosis, is 0.052 percentage points (0.023 SE), with a baseline of 0.74%.

Outcome variables. We checked several alternative measures of colonoscopy tests use. First, we used the number of the physician's enrolled patients instead of the number of unscreened patients as the denominator of colonoscopy share. Second, we included only the patients who paid a visit to the physician in the specific month as the denominator of colonoscopy share. A third specification is using a simple count of colonoscopy tests. The results of these three alternative specifications are very similar to those of our main specification (see Appendix Table A.6).

Definition for colon cancer diagnosis. We define a colon cancer diagnosis based on two indications (Maccabi's diagnoses and the Ministry of Health registry), that occur within 30 days. We checked several other definitions, changing the time gap between the two indications of diagnosis, and find that the results are not sensitive to the gap we use. Panel B. of Appendix Table A.7 shows the main result with varying gaps (60/45/30 days between diagnosis and registry).

Choice of Δ. Our empirical strategy involves a choice of Δ, the number of months of post diagnosis data in which members of the comparison group still did not experience their own first diagnosis. We chose $\Delta = 15$, but we verify that our analysis is robust to this choice and find that alternative specifications of Δ give very similar results. In Panel A of Appendix Table A.7 we report the main result with alternative choices of Delta ($\Delta = 9, 12, 15$).

Controlling for patient characteristics. In our main specification, we do not use any control variables, since these are not required for the identification of the causal effects in our setting. However, we show that controlling for a rich set of patient characteristics does not affect our results. Specifically, we estimate Equation 2, including X_{it}, which is a vector of time-varying control variables (monthly patient characteristics and chronic conditions): the number of patients that the physician encountered in a month, the share of male patients, mean patient age, and the share of patients that are diagnosed with diabetes, cancer, obesity, cardiovascular disease (CVD), and transient ischemic attack (TIA). Tables A.8 and A.9 show that our main results do not change when we include X_{it} in the estimated equation.

Alternative design. We validate the empirical strategy by taking an alternative approach in which we assign comparison event timing to the comparison group using a coarsened exact matching (CEM) method. We describe this approach and report the results in Appendix Section A.2. The main difference between the two approaches is that the CEM approach relies on the variation in the occurrence of a colon cancer diagnosis, allowing for PCPs who did not experience any colon cancer diagnoses in the sample period to be included in the comparison group while our main approach relies only on the variation in the exact timing of the diagnosis (see Deshpande and Li (2019) for further discussion about this issue). These two approaches complement each other in the sense that, ultimately, we analyze the effect of colon cancer diagnoses on the treatment group, which is almost the same in the two specifications, relative to two independently matched comparison groups. Reassuringly, the results we find using the two approaches are very similar.[30]

Colon cancer risk measure. We use risk score, which is based on a random forest estimation, to study the role of surprises in the response to events of colon cancer diagnoses. As a further validation check, we ran a logistic regression to predict the risk score for each patient using the same explanatory variables (Figure A.5 shows the share of patients diagnosed with cancer according to their normalized logit risk score), and the results remain similar (see Table A.10).

6 Conclusion

This paper examines whether PCPs alter their clinical decision making following a colon cancer diagnosis. We find a large and statistically significant increase in the use of colonoscopy tests in the first three months following a diagnosis and a much smaller and insignificant effect in the subsequent twelve months, suggesting a substantial yet dissipating physician response to colon cancer diagnoses. We do not find evidence that the quality of colonoscopy tests decreases with the increase in their use.

Our findings contribute to the existing evidence on the role of attention effects in physicians' decision making and, more generally, among professionals and experts. The effect is unlikely to arise due to the information that the diagnosis conveys to physicians. Instead, our findings suggest that when making decisions about colonoscopy tests for

[30] A growing literature shows that Two-way fixed-effects regression might be biased in such contexts (see Roth et al., 2022, for a review). However, since we match each treated physician with a not-yet-treated physician, our approach provides unbiased estimates under the parallel trends assumption, even if there are heterogeneous treatment effects.

patients, physicians' perception of colon cancer risk is affected by recent colon cancer diagnoses. In that respect, they allude to the notion of the so-called availability heuristic.

Furthermore, our findings shed light on the cognitive processes underlying this phenomenon. Physicians respond more strongly to colon cancer diagnoses involving low-risk patients, suggesting that colon cancer diagnoses that generate a surprise create a stronger attention effect. Additionally, we show that physicians' response is more pronounced among patients who share the characteristics of the diagnosed patient, indicating associative recall of the diagnosis, i.e., the diagnosis is more likely to be retrieved when a decision about a colonoscopy for a patient, who is similar to the patient involved in the diagnosis, is made.

To consider the implications of our results, one should keep in mind that while some recommend the colonoscopy test for the normal risk population (Telford et al., 2010), in the Israeli health care system, a colonoscopy is prescribed only to high risk patients. Colonoscopy completion among those patients, e.g., those with a positive OBT, is known to be lacking (Paltiel et al., 2021), i.e., the marginal test is arguably cost-effective. If colon cancer diagnoses operate as naturally occurring reminders about the risk of colon cancer, drawing attention to preventive activity with otherwise no immediate consequences, then our results show that in response to such reminders, PCPs increase their patients' use of cancer screening tests without compromising quality.

A fast-growing literature studies the role of "soft" means to induce adherence with cancer screening from the patient side (e.g., Goldzahl et al. (2018) and Milkman et al. (2013)). However, it is not clear that simple reminders affect physicians' screening decisions (Sequist et al., 2009). Our results suggest that reminders, which are similar to real-world situations in the clinic, may be an effective way to draw physicians' attention by setting off the cognitive channels we document in this paper. The effects of such interventions, however, warrant further research.

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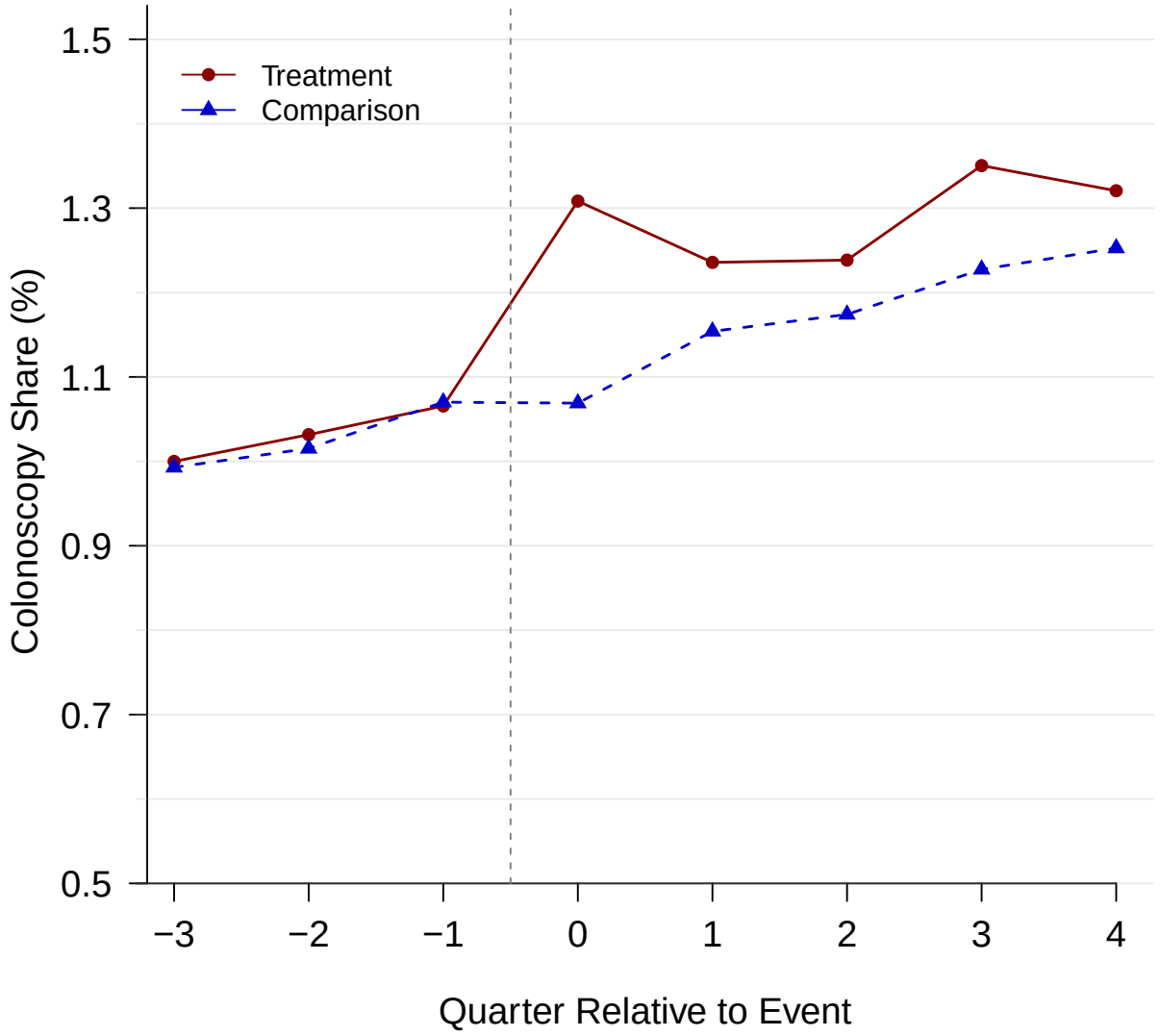
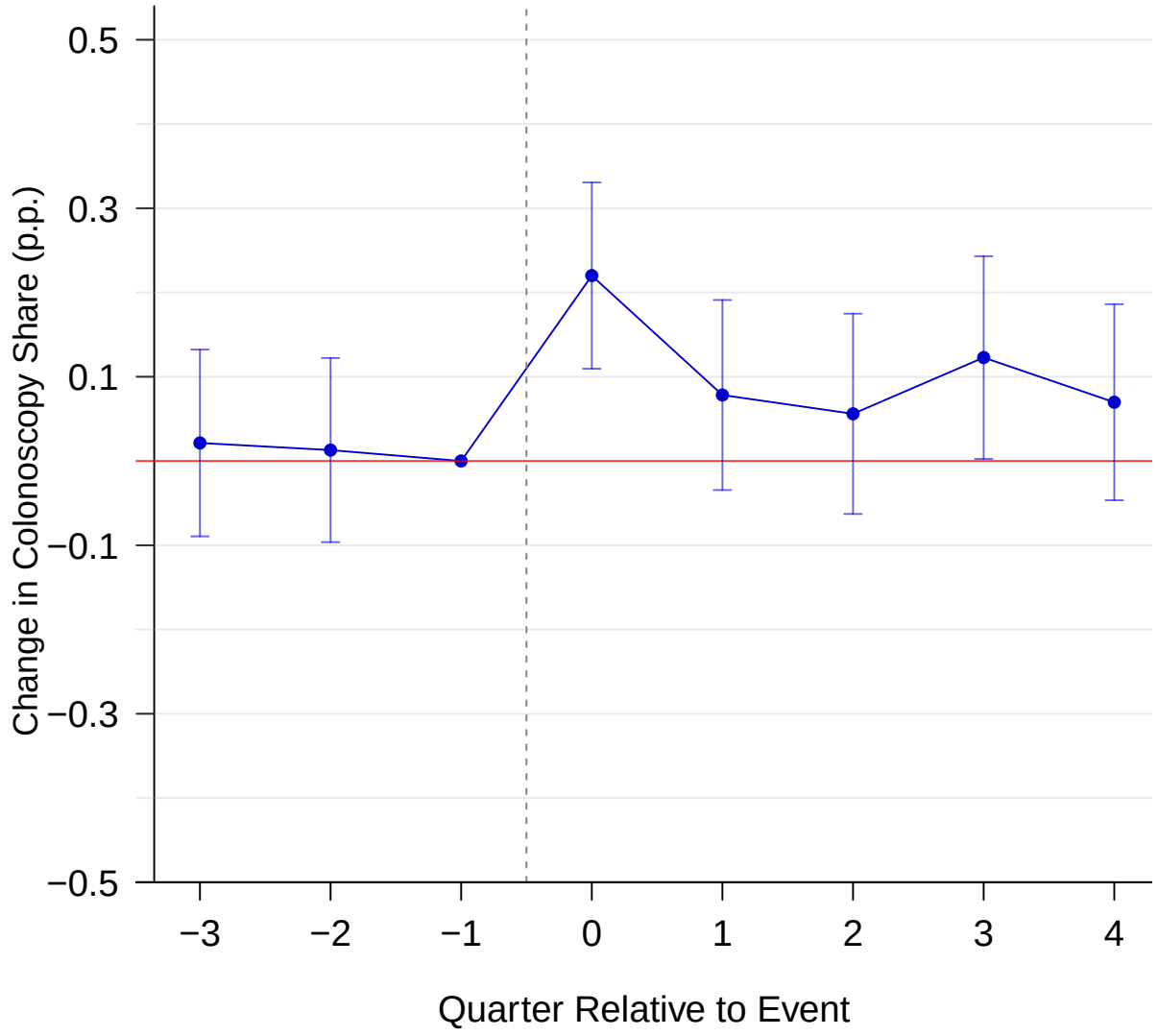
Figure 1: The effect of colon cancer diagnoses on physicians' colonoscopy share



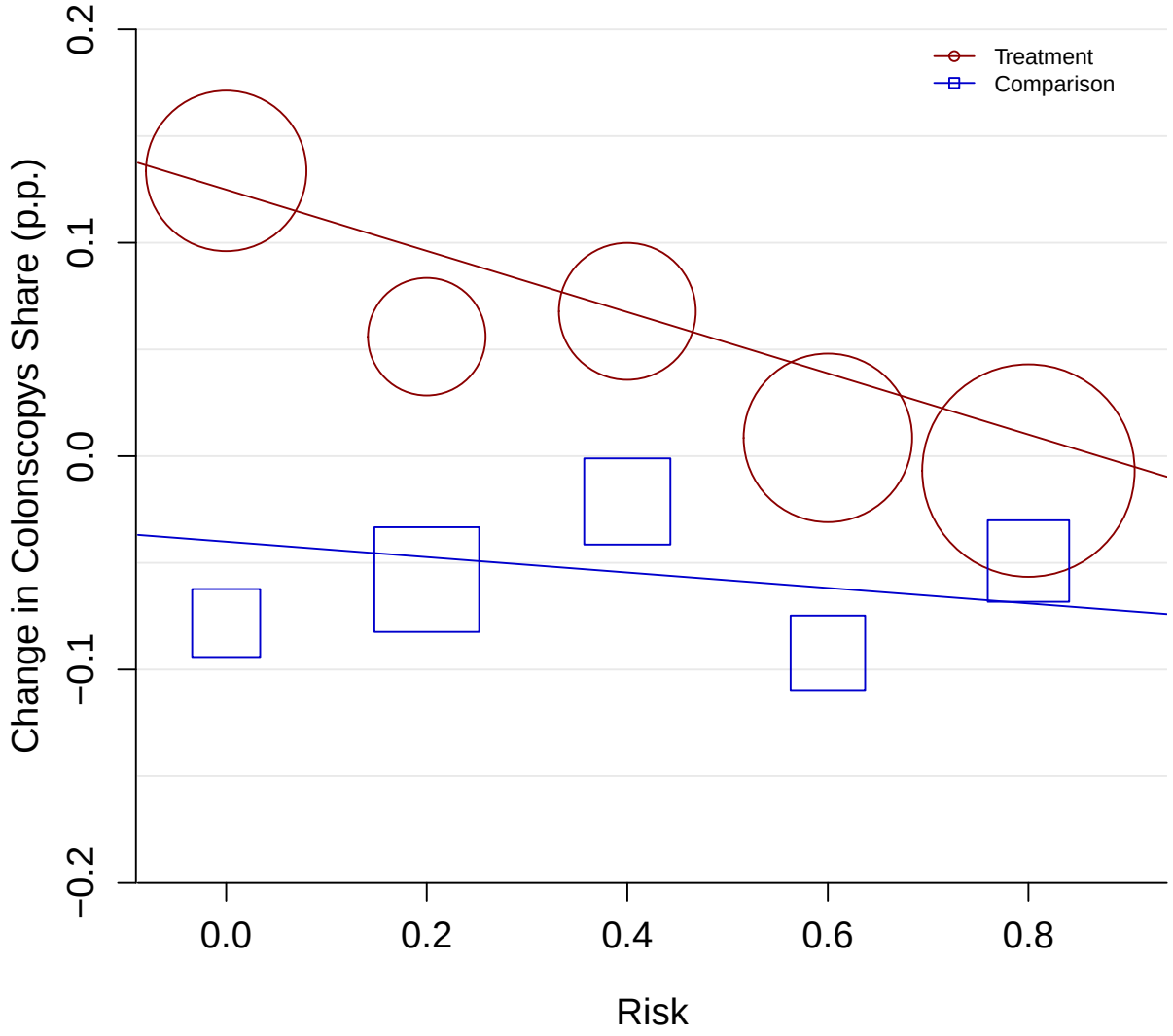
NOTE: The figure plots colonoscopy share rates for the treatment group physicians (red solid line) and comparison group physicians (blue dashed line). Means are weighted by monthly physician work volume (i.e., the number of patients that the physician encountered in a month). The sample is the full sample of 9 months before and 15 months after the colon cancer diagnosis, which includes 5,712 observations at the physician-month level. colonoscopy share is measured by percentages, i.e., a value of 1 on the y-axis indicates that, on average, each month, 1% of the patients had a colonoscopy.

Figure 2: The effect of colon cancer diagnosis on physicians' colonoscopy share, DD with treatment leads and lags



NOTE: The figure plots DD regression coefficients (Equation 1), i.e., δ_r for $r \neq -1, -3 \leq r \leq 4$ and their 90% confidence intervals (vertical lines). The sample is the full sample of 9 months before and 15 months after the colon cancer diagnosis, which includes 5,712 observations at the physician-month level. The dependent variable is colonoscopy share. Point estimates are in percentage points. E.g., with a baseline of 1, an estimate of 0.1 means a 0.1pp effect, which is a ten percent increase. Standard errors are clustered at the physician level.

Figure 3: The association between risk score and the response to colon cancer diagnosis



NOTE: The figure plots the mean Δ colonoscopy share against event risk score in bins of the width of 0.2 for physicians in the treatment group (red circles) and comparison group (blue squares). The size of the circle/square represents the total work volume of physicians in the specific bin (i.e., the average number of patients that the physicians in that bin encountered in a month). The sample is the balanced panel of 9 months before and 9 months after the colon cancer diagnosis, which includes 4,284 observations at the physician-month level. Y-axis values are in percentage points, i.e., a value of 1 on the y-axis represents a 1pp change in the outcome.

Table 1: Balancing table for the final sample, January–September 2012

	Comparison Group		*Treatment Group*		*Difference*	
	Mean (1)	SD (2)	Mean (3)	SD (4)	Mean (5)	P-value (6)
Physician characteristics						
Age	57.35	8.54	57.15	8.51	-0.20	0.86
Share male	55.32	49.98	56.94	49.69	1.63	0.81
Years in Maccabi	19.06	7.47	19.12	7.51	0.06	0.95
Patient characteristics						
Age	59.69	1.44	59.93	1.51	0.25	0.20
Socio-economic	6.42	1.25	6.41	1.32	-0.01	0.96
Share male	48.06	6.58	48.27	6.21	0.21	0.81
Share obesity	27.03	6.26	27.01	6.51	-0.02	0.98
Share diabetes	21.96	6.09	22.43	6.24	0.47	0.57
Share cancer	17.18	4.04	18.53	7.92	1.36	0.32
Share CVD	4.59	2.32	4.65	1.92	0.05	0.85
Share TIA	1.79	1.10	1.78	0.87	-0.01	0.97
Physician Activity						
Enrolled patients	441.13	230.16	522.92	277.74	81.79	0.01
Visited patients	126.53	81.01	163.88	110.76	37.35	0.00
Colonoscopy share	0.94	0.42	0.96	0.40	0.02	0.78
Number of physicians	94		144		238	
Observations	2,256		3,456		5,712	

NOTE: The table shows means and standard deviations for the treatment and comparison groups in the final sample, which included only patients in the age range 50-74; means were calculated for the first 9 months of data (January–September 2012) using the physician-month level data weighted by physician work volume (i.e., the number of patients that the physician encountered in a month).

Table 2: The effect of colon cancer diagnosis on colonoscopy share, DD

Panel:	Full	Balanced	Hole
	(1)	(2)	(3)
Treat * Post	0.096***	0.102***	0.070*
	(0.036)	(0.040)	(0.038)
Baseline	1.18	1.14	1.21
Physician FEs	+	+	+
Time FEs	+	+	+
Observations	5,712	4,284	4,998

NOTE: The table shows the DD regression results (δ in Equation 2). The dependent variable, colonoscopy share, is measured by percentages, i.e., a baseline value of 1 indicates that, on average, each month, 1% of the physician's patients had a colonoscopy. The point estimates are in percentage point units. E.g., with a baseline of 1, an estimate of 0.1 means a 0.1pp effect, which is a ten percent increase. Standard errors are clustered at the physician level.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table 3: The association between risk score and the response to colon cancer diagnosis

Char:	Young	Female	Risk
	(1)	(2)	(3)
Treat * Post * *Char*	0.100^{*}	0.106^{**}	-0.168^{**}
	(0.056)	(0.049)	(0.084)
Treat * Post	0.052	0.073^{*}	0.194^{***}
	(0.043)	(0.042)	(0.061)
Physician FEs	+	+	+
Time FEs	+	+	+
Observations	4,284	4,284	4,284
Baseline	1.14	1.14	1.14

NOTE: The table shows the variation in the response to a colon cancer diagnosis by the diagnosed patient's age and gender (δ_0 in Equation 3), using the balanced sample. The dependent variable is colonoscopy share, which is measured in percentages, i.e., a baseline value of 1 means that, on average, 1% of the physicians' patients had a colonoscopy each month. The point estimates are in percentage point units. E.g., with a baseline of 1, an estimate of 0.1 means a 0.1pp effect, which is a ten percent increase. Standard errors are clustered at the physician level.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table 4: Physicians' response towards patients with the same characteristics as patients diagnosed with colon cancer

	(1)	(2)
Panel A.		
	Patient age < 62	Patient age ≥ 62
Treat * Post * Young	0.182^{***}	-0.085
	(0.182)	(0.107)
Treat * Post	0.022	0.157^{*}
	(0.049)	(0.082)
Baseline	1.074	1.482
Observations	4,284	4,284
Panel B.		
	Female	Male
Treat * Post * Female	0.151^{**}	0.051
	(0.065)	(0.074)
Treat * Post	0.029	0.070
	(0.057)	(0.066)
Baseline	1.120	1.227
Observations	4,284	4,284
Physician FEs	+	+
Time FEs	+	+

NOTE: The table shows the estimates of the association between age group and gender of patients diagnosed with cancer and physician's response to patients of the same age group and gender (δ_0 in Equation 3), using the balanced sample. The dependent variable is colonoscopy share among different groups of patients, which is measured in percentages – a baseline value of about 1 means that, on average, 1% of the physician's patients in that group had a colonoscopy each month. The point estimates are in percentage point units. E.g., with a baseline of 1, an estimate of 0.18 of Treat * Post * Young means a 0.18 pp effect, which is an eighteen percent increase. Standard errors are clustered at the physician level.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table 5: The effect of colon cancer diagnosis on colonoscopy quality

	Positive test	Risk-score
	(1)	(2)
Treat * Post	0.215	0.489
	(0.961)	(1.018)
Baseline	8.569	57.308
Observations	14,727	14,727
Physician FEs	+	+
Time FEs	+	+

NOTE: The table shows the DD regression analysis of the colonoscopy tests in the balanced sample at the individual test level. The dependent variables are a dummy for a positive test (Column 1) and the random forest based risk score of patients undergoing colonoscopy (Column 2). For column 1, a baseline value of 8 means that a polyp is found in 8% of colonoscopy tests. The point estimate of 0.215 represents a 0.2 pp increase, a (0.2/8=) 2.5 percent increase. The risk score (Column 2) is measured by a normalized value between 0 and 100. With a baseline of 57, the 0.49 estimate implies a roughly 1 percent increase in the risk score. Standard errors are clustered at the physician level.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

A Appendix

A.1 Generating colon cancer risk score

As discussed in Section 5, we use a machine-learning approach to recover ex-ante risk of colon cancer for the patients in our sample as of January 2012. We implement a random forest algorithm based on the information that the database contains about each patient. The explanatory variables were age, sex, whether the patient was diabetic or had high blood pressure, and three dummy variables for undergoing a colonoscopy in three time periods (2003-2011, 2007-2011, 2011).

Note that our colon cancer indicator is an outcome of the type of "rare event", i.e., it takes the value of 1 at a low frequency in the data and therefore, decision trees tend to predict just "no cancer" on each branch. To address this issue, we followed the common practice of oversampling the "cancer" group (Chen et al., 2004). Thus, in every sample, we included all "cancer" patients and a similar number of "no cancer" patients. Predicted cancer risk scores are then adjusted using the Bayes rule.

To avoid overfitting the random forest model, we use a standard regularization technique. We randomly split our original data set into a training set (80% of the original sample) and a test set (20% of the original sample). Then, we tune the parameters of the model (number of trees and number of explanatory variables) based only on the training set. Therefore, we randomly split the training set into a training-training set (80% of the training sample) and a training-test set (20% of the training sample). Then we define a grid with 5 different values for the number of trees (200, 400, 600, 800, 1000) and 4 different values for the number of variables (2, 3, 4, 5) and calculate the training-test brier score for every combination.[31] The optimal combination was 800 trees with 2 explanatory variables. Thus, we built our final forest with these parameters and calculate the test error.

For the final algorithm, we calculated the brier score for the training set (0.000505) and the test set (0.000484). The distribution of risk scores in our sample of patients in the age range 50-74 has a mean of 0.00381 and a standard deviation of 0.00401. The minimum is 0.000514, and the maximum is 0.039708. For ease of interpretation, we normalize the risk score by calculating the percentile of the distribution.[32] Figure A.6 shows the share

[31] Brier score is a standard measure for probability classification accuracy. It is defined as the sum of squared differences between the real class and the predicted probability. In our case, let y_i be an indicator variable taking the value 1 if the patient had cancer, and denote the predicted risk score by our random forest model by p_i, brier score is calculated as $\sum_{i=1}^{n}(y_i - p_i)^2$.

[32] As described in the text, we use the risk score in two different contexts. First, we analyze the relationship between the risk score of the patient involved in the event and the physicians' response. Second, we estimate the

of patients diagnosed with cancer according to their normalized risk score. The graphs indicate that the predicted ex-ante probability we assign to each patient is a useful proxy for ex-ante cancer risk.

A.2 Alternative design - CEM

In our main results section, we adopted the approach of Fadlon and Nielsen (2019) for matching treatment colon cancer diagnoses to the comparison group. Here, we take a different approach that is using a coarsened exact matching (CEM) procedure.

Treatment and comparison group. As we described in the main text, we start from a set of physicians' first colon cancer diagnoses made in the period October 2012 - December 2015. We define the *matching treatment group* as physicians that experienced their first diagnosis during the 12-month period starting in October 2012 and ending in September 2013, i.e., physician i belongs to the treatment group if she experienced a colon cancer diagnosis in month $t \in [10/2012, 9/2013]$. There are 120 PCPs in the matching treatment group. Note that this group is very similar to the treatment group in the main text. In fact, it is a subset of the treatment group we use in the main text because it does not include the colon cancer diagnoses that occurred in the last three months of 2013. Using the entire treatment group from the main text would be at the cost of having a smaller comparison group.

Next, because we want to be able to match physicians from the treatment group to any of the physicians from the comparison group and to allow for a 9-month diagnosis free pre-period, we must allow for a gap of nine months between the last diagnosis in the matching treatment group and the first diagnosis in the matching comparison group diagnosis. Hence, we define the comparison group as including the physicians that experience their first diagnosis in the period that starts in July 2014 and ends in December 2015. We also include in the comparison group physicians that did not experience any diagnosis during the sample period. While these physicians may have different characteristics than the ones that experience a colon cancer diagnosis during the sample period, we rely on the matching method to account for such potential differences. With these definitions, there are 120 PCPs in the matching treatment group and 390 PCPs in the matching comparison group.

Matching. Next, we carry out a CEM matching procedure with the goal of coupling each matching treatment group PCP with a single comparison group PCP if such a match ex-

DD equation with the mean risk score of patients who undergo colonoscopy in a specific month. Accordingly, we normalize the risk measure with respect to the distribution of patients diagnosed with cancer (first analysis), and with respect to the full sample (second analysis).

ists. Our goal is to assign the treatment diagnosis to the matched comparison group PCP, and therefore a one-to-one matching is a natural approach. To implement the matching approach, we use physician gender and age as well as the following time-varying clinic characteristics: average of the monthly number of patients that the physician encountered in a month in the age range 50-74 and mean colonoscopy share. We calculate the time-varying clinic characteristics for the first nine months of 2012 before any of the colon cancer diagnoses occurred. We then run a CEM procedure using the variables described above.[33] As a final step, within the CEM cell, we match each treatment group physician to the closest comparison group physician based on their average colonoscopy share in the first 9 months of 2012 before any of the colon cancer diagnoses occurred.

We find a match to 115 physicians from the treatment group and, therefore, have 115 couples of treatment and comparison group physicians. Each couple is assigned the treatment diagnosis time (there are 84 physicians in the comparison Group, meaning that some of the comparison group physicians are matched to more than one treatment group physician). For each comparison physician, we assign the treatment diagnosis of his matched treatment group physician. Our final sample consists of 4,140 physician-month observations of 199 physicians over a period of 30 months between January 2012 and June 2014. During this period, we observe 115 treatment colon cancer diagnoses. Table A.11 is a balancing table calculated for the period January-September 2012. The table shows that after the matching, the treatment and comparison groups are well-balanced in their characteristics. With this matched sample of treatment and comparison group, we proceed to run the same analysis shown in the main text.

Appendix Figure A.7 displays the mean colonoscopy share in the treatment (solid line) and comparison (dashed line) groups three quarters before the diagnosis and three quarters after it. In the pre-period, the two groups appear to coincide roughly. Indeed we matched physicians based on the average level of colonoscopy share in the 9-month period January - September 2012. However, for most colon cancer diagnoses, there was a lag between this period and the occurrence of the diagnosis. Furthermore, we did not force the treatment and comparison groups to share the same trend in colonoscopy share, and so the fact that the levels and trends of the two groups appear to coincide provides support to the view that our matching approach did well in coupling the comparison physicians with the treatment physicians. In quarter 0, just after the diagnosis, the two lines diverge, and this divergence is apparent in the subsequent two quarters as well but appears to grow smaller.

Figure A.8, shows the estimates of Equation 1. Consistent with the impression of Figure A.7, we observe a small and statistically insignificant result for δ_{-3}-, δ_{-1}. In the first quarter after the diagnosis, we find a statistically significant 0.25 percentage point

[33]Note that variables that are not included in the matching algorithm are nonetheless balanced.

increase in colonoscopy share. In the subsequent quarters, the coefficients are smaller with $\delta_1 = 0.148$, $\delta_2 = 0.144$.

To quantify the average effect of the diagnosis, Table A.12 presents the estimates of Equation 2. The first column shows that the coefficient of $Treat * Post$ (δ) in the baseline regression is 0.120 and the second that the estimate of the coefficient in a regression with physician and time fixed-effects is 0.10. The third and last column shows that after adding the time-varying control variables, the coefficient becomes 0.10. All coefficients are statistically significant at the 99% level. Overall, the results are remarkably similar to the results in the main text.

Using this sample, we also replicate all the other results. Table A.10 shows the association between risk score and the response to events of a colon cancer diagnosis. Table A.13 shows the association between the response in colonoscopy use among different groups of patients and the diagnosis of similar patients. Table A.14 shows the impact of events of a colon cancer diagnosis on the quality of the following colonoscopies.

A.3 Physician characteristics and the response to colon cancer diagnoses

It is interesting to examine how the response to colon cancer diagnoses varies by physician characteristics. To look into this issue, we estimate the triple difference model (equation 3) on the balanced sample. One natural question that arises is whether gender plays a role in physicians' response. Panel A of Table A.15 reports no difference between female and male physicians.

We next ask whether older physicians, who are typically more experienced, are less responsive to colon cancer diagnoses. To check this, we run equation 3 by physician age, defining $Char_i$ to be a dummy for a young physician, under 55 years old. We find no difference between younger and older physicians (Table A.15, Panel B). We think of physician age as a proxy to experience. This proxy is imperfect as physicians of the same age may have different years of experience. We thus run a complementing analysis using physician tenure at the HMO, defining $Char_i$ to be a dummy for a physician with less than 19 years at the HMO. Panel C of the table shows that there is no significant difference between both groups of physicians in this case, as well. This proxy too, is not perfect as it does not account for the experience physicians gained with other employers. However, both proxies show no significant role for experience in the response to cancer diagnoses.

We also study how the effects vary by physician's training. First, we investigate if physicians that graduated from higher-quality medical schools are less responsive to events of colon cancer, using information on the ranking of medical schools. We construct an indicator for a high-quality school that equals one for physicians that studied in a medical school which appears in the top 500 institutions according to Shanghai Ranking in 2017.[34] The results, shown in Panel D of Table A.15, indicate that the response to cancer diagnoses is (borderline significantly) *more* pronounced among graduates of high-quality medical schools.

Lastly, we study how the response varies by specialty. The majority of PCPs in our sample are primary care specialists, but about 40% of them are internal medicine specialists who work as primary care physicians. We construct an indicator variable for internal medicine specialists and compare their behavior to that of the rest of the physicians. The results are shown in Panel E of Table A.15. We find that the effect is driven by primary care specialists and not by internal medicine specialists.

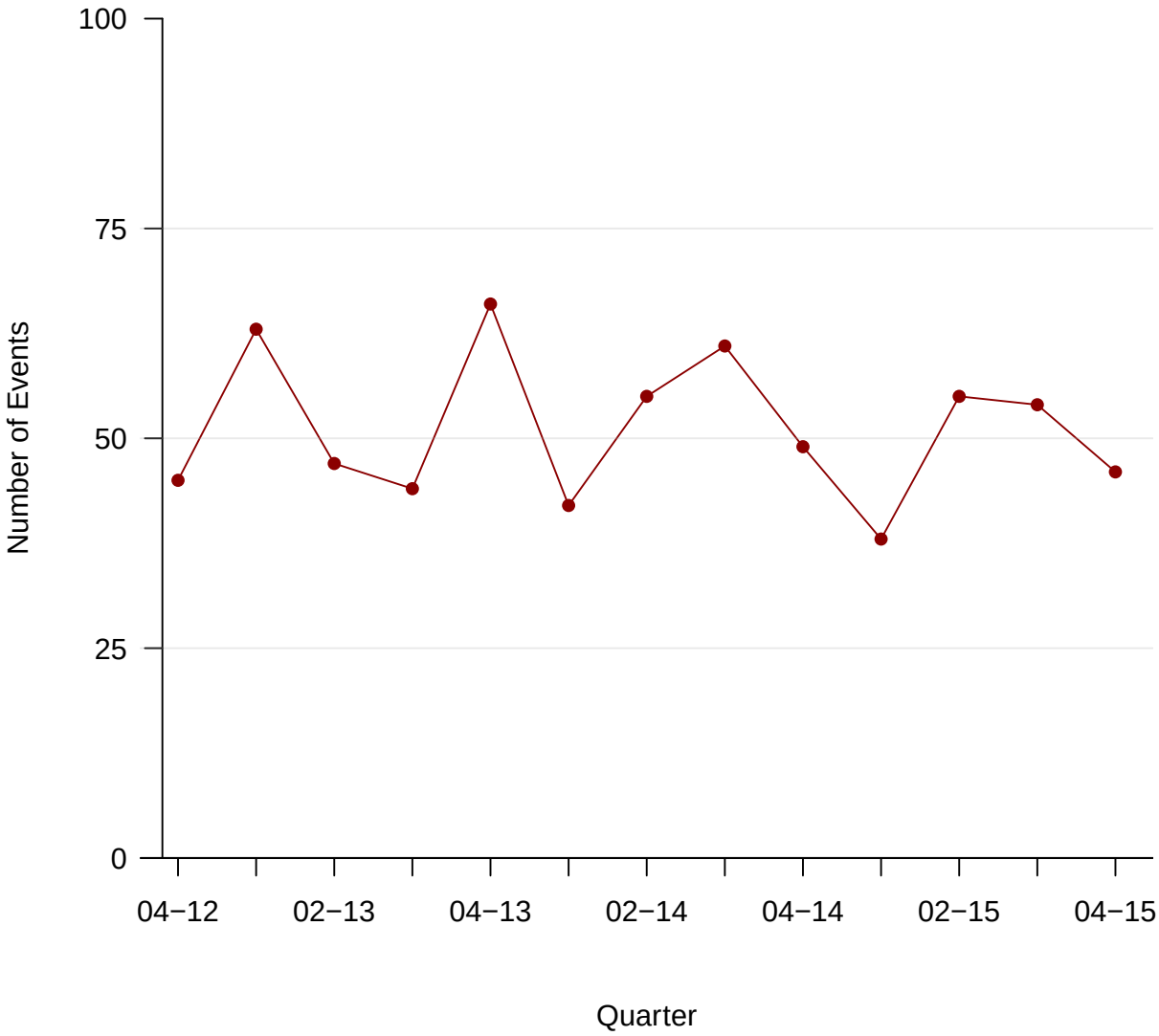
To recap, we find that while gender and experience are not a source of variation in the response to cancer diagnosis, physicians' training appears to matter. The response is more pronounced among physicians from better schools and those who have training in primary care, not internal medicine. Possibly, physicians who are more conscious of preventive care are more susceptible to events of colon cancer diagnosis.

Spillovers across physicians. An additional issue that might be interesting to examine is spillover effects across physicians. Namely, that cancer diagnosis affects the patients of other physicians. While this is a natural extension to our analysis, we leave it to future work because we have limited information on the professional relationships between physicians in our data. This is in part because, in Maccabi, it is less common for physicians to work together in teams. Importantly, if peer effects arise, given our design, they imply that we estimate a lower bound of the actual effect of a cancer diagnosis as physicians in the comparison group may be directly affected by the diagnosis.

[34]The ranking was retrieved on September 13th, 2022 from https://www.shanghairanking.com/rankings/gras/2017/RS0401 and it is the earliest available ranking. Physicians whose medical school rank we could not identify were assigned to the low-quality group.

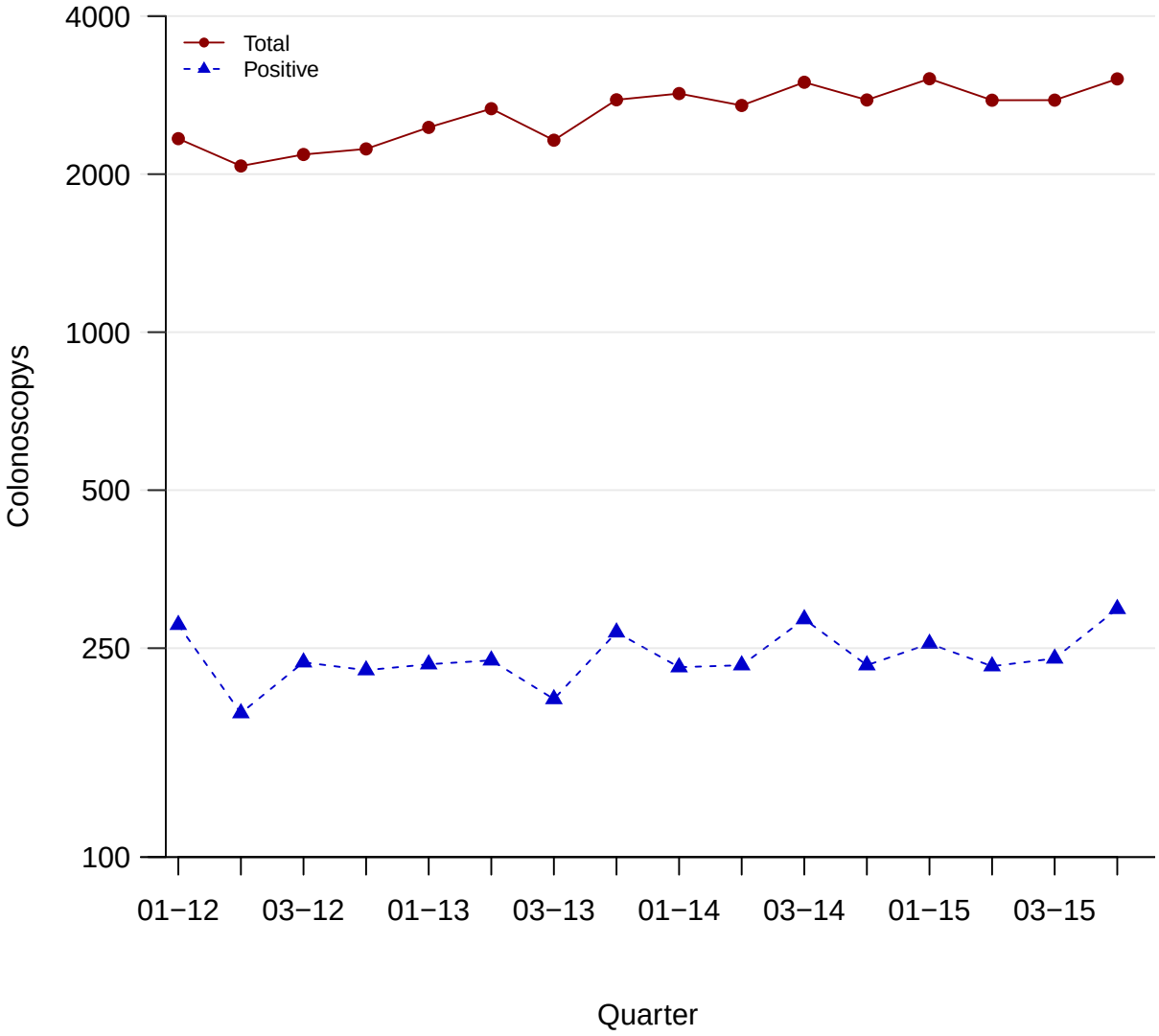
A.4 Appendix exhibits - figures

Figure A.1: Verified colon cancer diagnoses



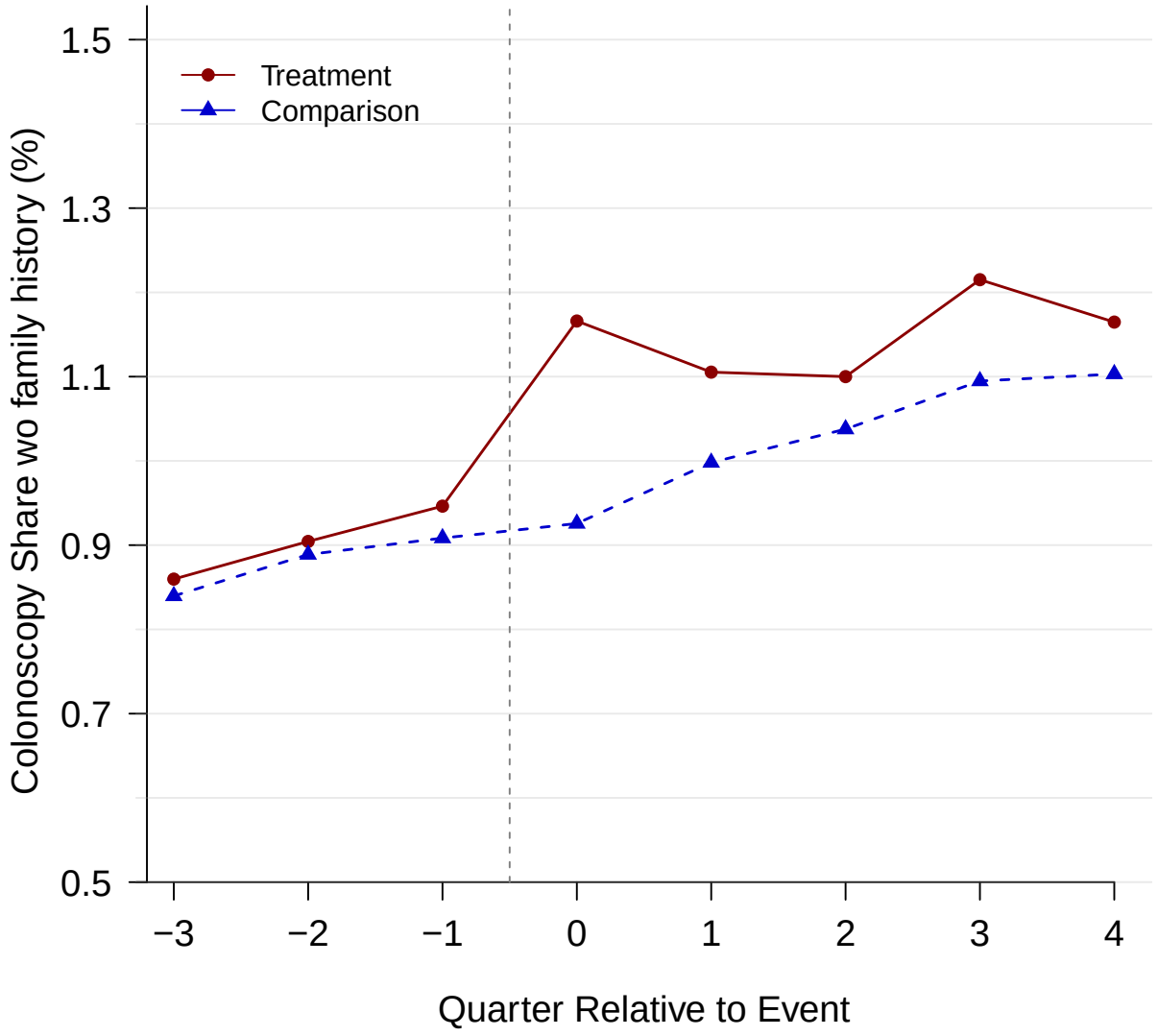
NOTE: The figure plots the quarterly number of events of colon cancer diagnoses (according to the definition discussed in the text) for the period October 2012 - December 2015.

Figure A.2: Colonoscopy tests and their outcomes



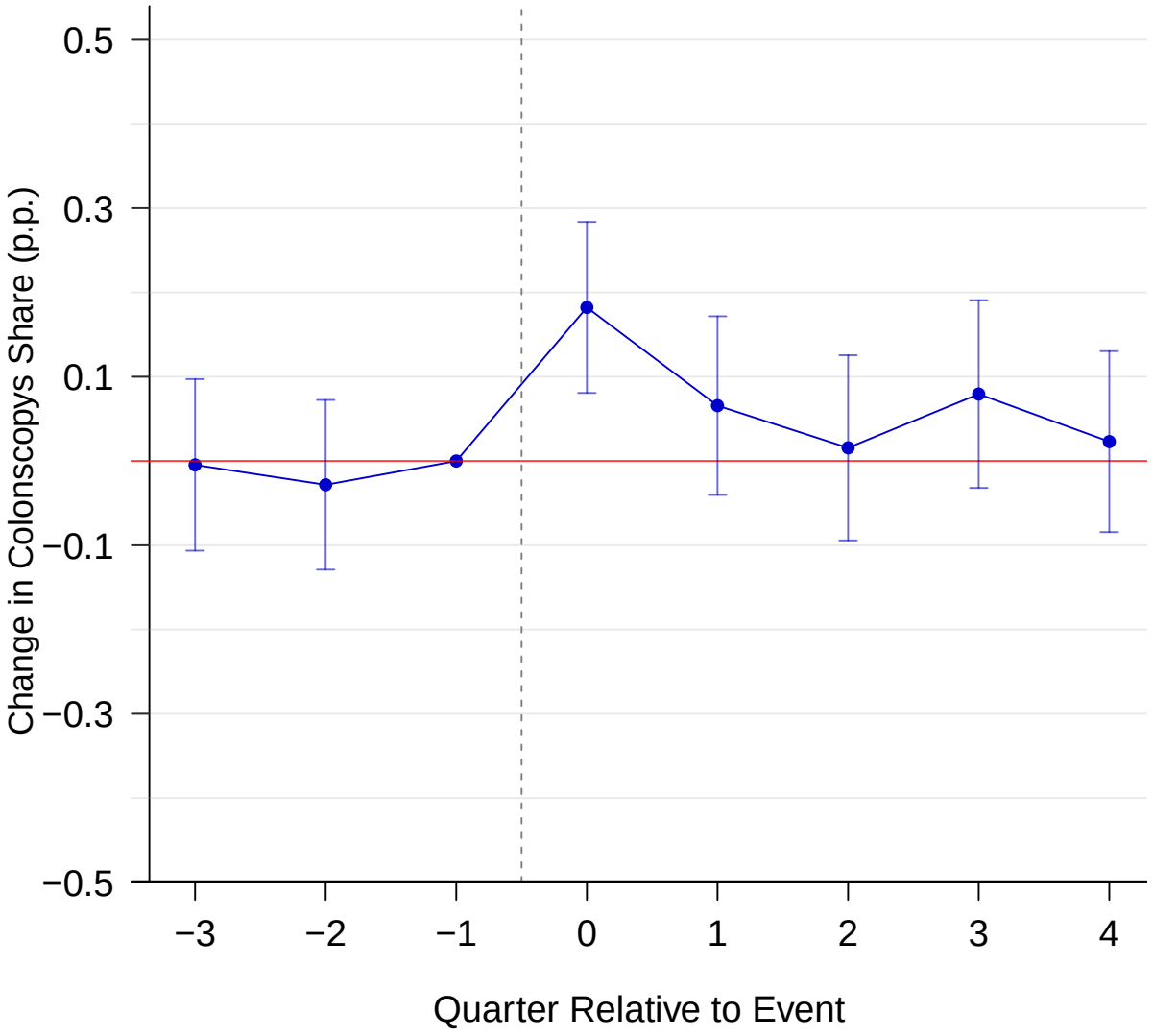
NOTE: This figure plots the quarterly numbers of colonoscopy tests (red solid line) and positive colonoscopies (blue dashed line) of patients enrolled with physicians in our sample. The scale is logarithmic (numbers on the y-axis are the levels that correspond to the log).

Figure A.3: The effect of colon cancer diagnosis on colonoscopy share without family history



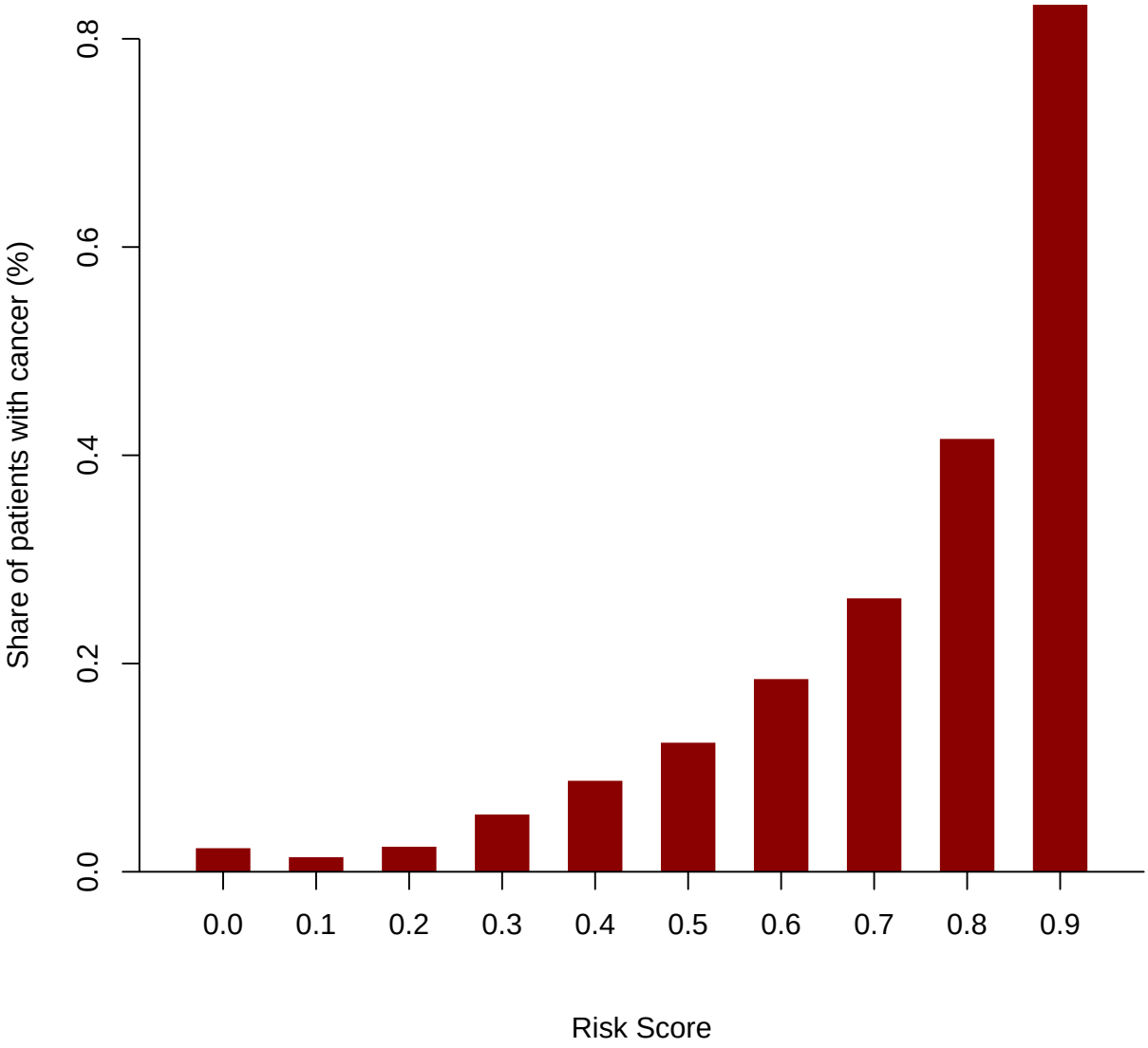
NOTE: The figure plots average rates of colonoscopy share without a family history – colonoscopy share excluding tests that were associated with a recent family history diagnosis – codes for family history of colon cancer recorded up to 3 months before the colonoscopy. Treatment group physicians' rates are plotted in a red solid line and comparison group physicians' rates are in the blue dashed line. Means are weighted by monthly physician work volume (i.e., the number of patients that the physician encountered in a month). The sample is the full sample of 9 months before and 15 months after the colon cancer diagnosis, which includes 5,712 observations at the physician-month level. The outcome is measured by percentages, i.e., a value of 1 on the y-axis means that on average, each month 1% of the patients underwent a colonoscopy.

Figure A.4: The effect of colon cancer diagnosis on Colonoscopy Share without family history, DD with treatment leads and lags



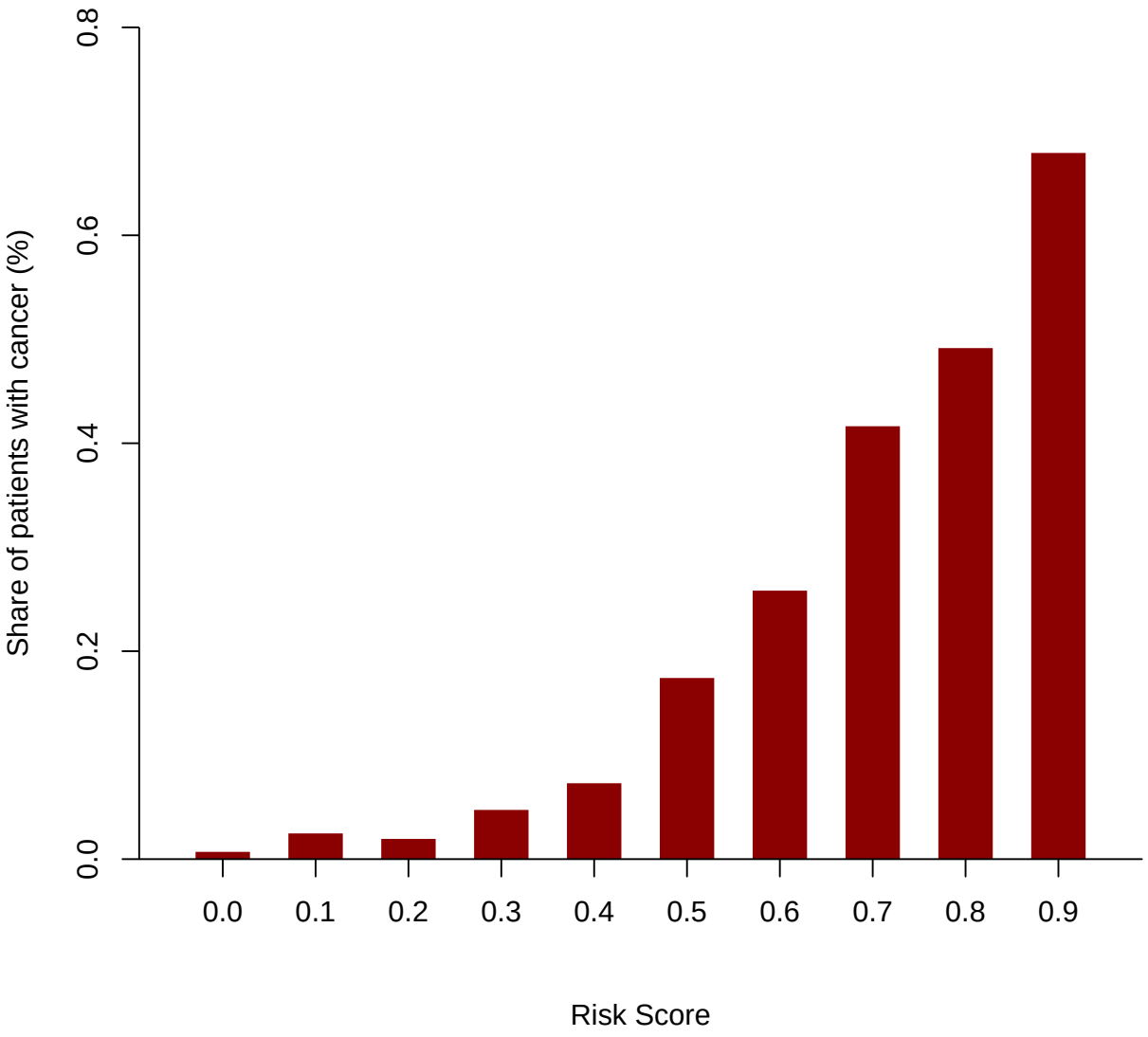
NOTE: The figure plots DD regression coefficients (Equation 1), i.e. δ_r for $r \neq -1, -3 \leq r \leq 4$ and their 90% confidence intervals (vertical lines). The sample is the full sample of 9 months before and 15 months after the colon cancer diagnosis, which includes 5,712 observations at the physician-month level. The dependent variable is colonoscopy share without a family history – colonoscopy share excluding tests that were associated with a recent family history diagnosis – codes for family history of colon cancer recorded up to 3 months before the colonoscopy. Point estimates are in percentage points, i.e., a value of 1 on the y-axis represents a 1pp change in the outcome. Standard errors are clustered at the physician level.

Figure A.5: Share of patients with cancer by risk score (logistic regression)



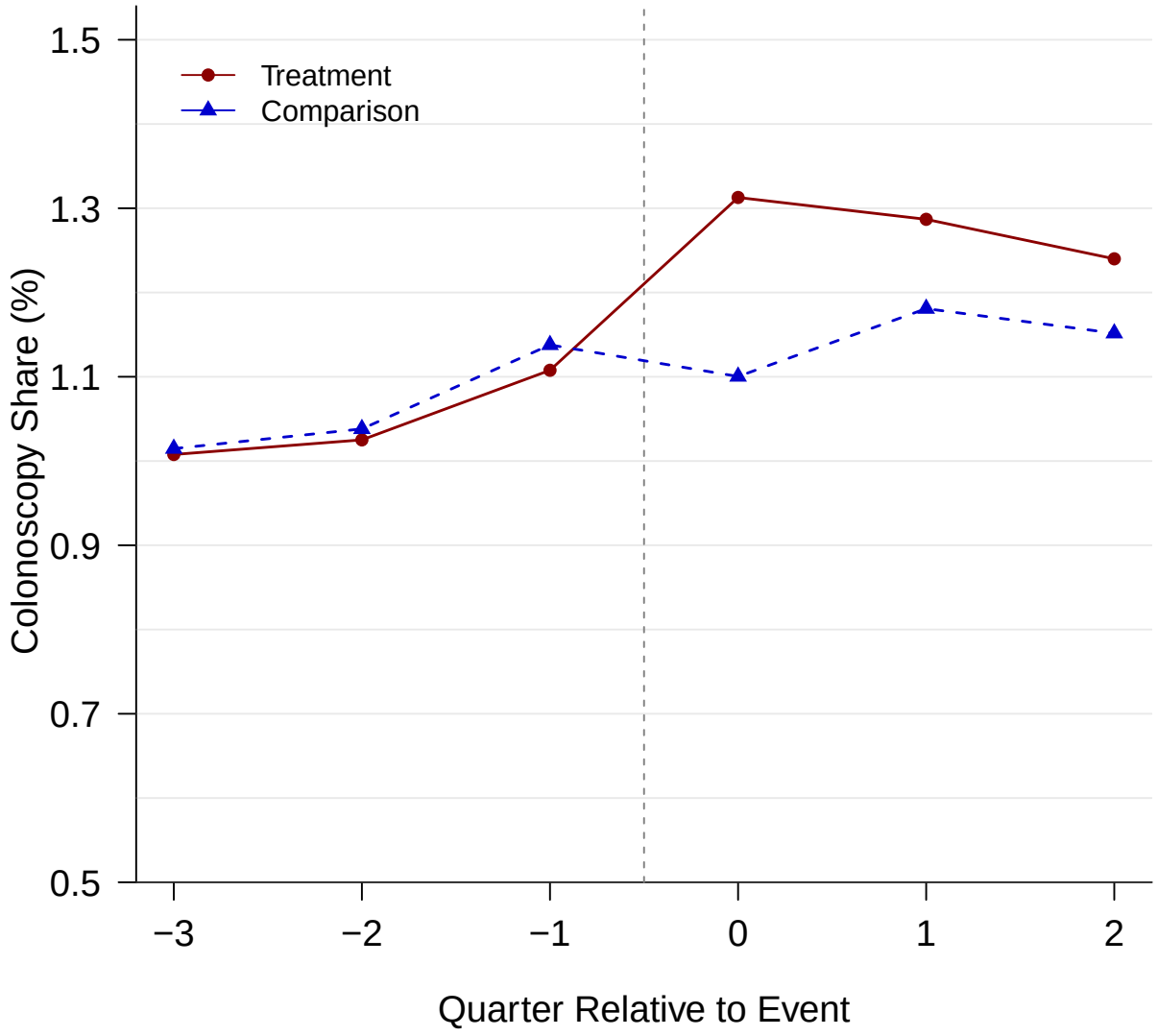
NOTE: Thie figure plots the share of patients diagnosed with cancer during the period in bins with a width of 0.2 of (logistic regression based) risk level

Figure A.6: Share of patients with cancer by risk score (random forest)



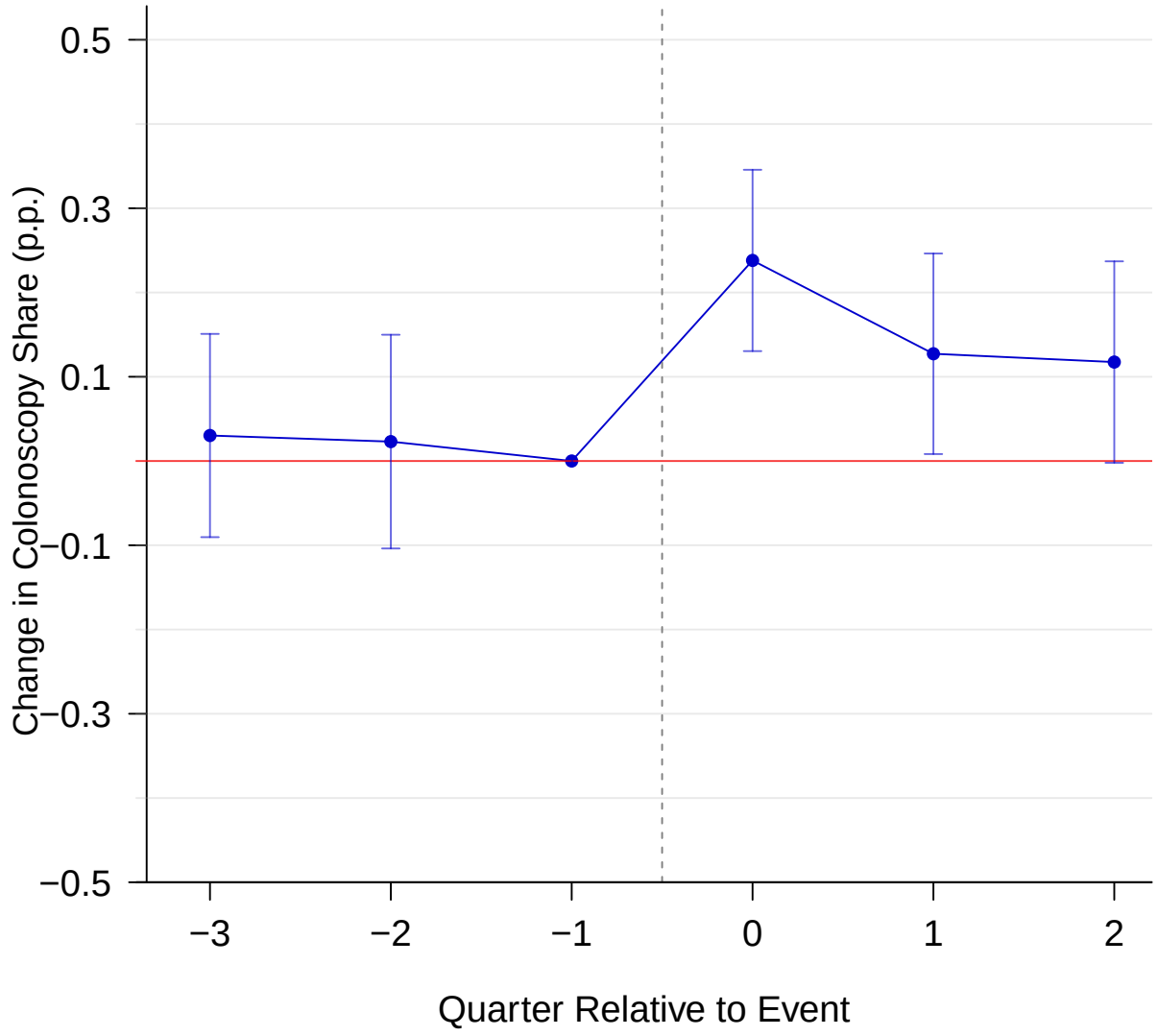
NOTE: The figure plots the share of patients diagnosed with cancer during the period in bins with width of 0.2 of (random forest based) risk level.

Figure A.7: Effect of colon cancer diagnoses on physicians' colonoscopy share (matching sample)



NOTE: This figure plots colonoscopy share rates for the treatment group physicians (red solid line) and comparison group physicians (blue dashed line). Means are weighted by monthly physician work volume (i.e., the number of patients that the physician encountered in a month). The sample includes 4,140 observations at the physician-month level. The outcome is measured by percentages, i.e., a value of 1 on the y-axis indicates that, on average, each month 1% of the patients underwent a colonoscopy.

Figure A.8: Effect of colon cancer diagnoses on physicians' colonoscopy share, DD (matching sample)



NOTE: The figure plots DD regression coefficients (Equation 1), i.e. δ_r for $r \neq -1, -3 \leq r \leq 4$ and their 90% confidence intervals (vertical lines). The dependent variable is colonoscopy share. Point estimates are in percentage points, i.e., a value of 1 on the y-axis indicates a 1pp change in the outcome. The sample includes 4,140 observations at the physician-month level. Standard errors are clustered at the physician level.

A.5 Appendix exhibits - tables

Table A.1: Patients screened and unscreened (colonoscopy test)

	Unscreened	*Screened*
Age	58.94	58.73
Share male	0.48	0.49
Socio-Economic	6.40	6.72
Mean Risk	0.50	0.51
Share Family History Diagnosis	0.02	0.12
Share Screened with OBT	0.30	0.42
Share TIA	0.02	0.02
Share cancer	0.14	0.18
Share diabetes	0.21	0.21
Share CVD	0.04	0.04
Share obesity	0.27	0.27
Number of patients	136,954	31,079

NOTE: The table compares patients who underwent a colonoscopy (during 2013-2015) with patients that did not. All means are calculated using 2012 data.

Table A.2: Physicians included and excluded from the sample

	Excluded	*Comparison*	Treatment
Physicians characteristics			
Age	52.95	57.35	57.15
Share male	0.50	0.55	0.57
Years in Maccabi	15.42	19.06	19.12
Patients characteristics			
Age	59.38	59.69	59.93
Socio-Economic	6.57	6.42	6.41
Share male	0.48	0.48	0.48
Share obesity	0.26	0.27	0.27
Share diabetes	0.20	0.22	0.22
Share cancer	0.17	0.17	0.19
Share CVD	0.04	0.05	0.05
Share TIA	0.02	0.02	0.02
Physician activity			
Enrolled patients	307.42	441.13	522.92
Visited patients	78.11	126.53	163.88
Colonoscopys	2.01	2.70	3.34
Number of physicians	415	94	144

NOTE: The table compares physicians within our sample (treatment and comparison groups) with physicians excluded from our analysis. The sample includes only physicians with at least 50 enrolled patients. All means were calculated using the first 9 months of data (January-September 2012).

Table A.3: The effect of colon cancer diagnosis on colonoscopy quality at the physician level

	Positive test	Risk score
	(1)	(2)
Treat * Post	0.015	0.014
	(0.010)	(0.011)
Baseline	0.086	0.53
Observations	4,284	3,802
Physician FEs	+	+
Time FEs	+	+

NOTE: This table shows the DD regression analysis of the colonoscopy tests in the balanced sample at the physician-month level. The dependent variables are the share of positive colonoscopy tests among the physician's population (Column 1) and the average random forest based risk-score of patients undergoing colonoscopy (Column 2). For column 1, a baseline value of 0.086 means that a polyp is found in 0.086% of the physician's enrolled patients. The point estimate of 0.015 represents a 0.015 pp increase, a (0.015/0.086=) 17 percent increase. Risk score (Column 2) is measured by a normalized value between 0 and 100. The 0.014 estimate implies a 3 percent increase in the risk score (0.014/0.53). Standard errors are clustered at the physician level. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table A.4: The effect of colon cancer diagnosis on colonoscopy share without family history

Sample:	Full	Balanced	Hole
	(1)	(2)	(3)
Treat * Post	0.082**	0.094**	0.056
	(0.033)	(0.037)	(0.035)
Baseline	1.06	1.01	1.08
Physician FEs	+	+	+
Time FEs	+	+	+
Observations	5,712	4,284	4,998

NOTE: This table shows the DD regression results (δ in Equation 2). The dependent variable is colonoscopy share without family history – colonoscopy share excluding tests that were associated with a recent family history diagnosis – codes for family history of colon cancer up to 3 months before the colonoscopy were recorded. The dependent variable is measured in percentages – the baseline value of about 1 means that, on average, 1% of the physician's patients had a colonoscopy each month. The point estimates are in percentage point units. E.g., with a baseline of 1, an estimate of 0.1 means a 0.1 pp effect, which is a ten percent increase. Standard errors are clustered at the physician level. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table A.5: The effect of colon cancer diagnosis on colonoscopy share, excluding spouses

Sample:	Full	Balanced	Hole
	(1)	(2)	(3)
Treat * Post	0.097***	0.103***	0.071*
	(0.036)	(0.040)	(0.038)
Baseline	1.18	1.14	1.21
Physician FEs	+	+	+
Time FEs	+	+	+
Observations	5,712	4,284	4,998

NOTE: The table shows the DD regression results (δ in Equation 2). The dependent variable is colonoscopy share, excluding tests that were associated with partners of patients who are involved in the event of colon cancer diagnosis. The dependent variable is measured in percentages – the baseline value of about 1 means that, on average, 1% of the physician's patients had a colonoscopy each month. The point estimates are in percentage point units. E.g., with a baseline of 1, an estimate of 0.1 means a 0.1 pp effect, which is a ten percent increase. Standard errors are clustered at the physician level. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table A.6: The Effect of colon cancer diagnosis on alternative outcomes, DD

	(1)
A. Dependent variable: Colonoscopys/Enrolled	
Treat * Post	0.063***
	(0.024)
Baseline	0.70
B. Dependent variable: Colonoscopys/Visited	
Treat * Post	0.192***
	(0.065)
Baseline	1.55
C. Dependent variable: Colonoscopys	
Treat * Post	0.473***
	(0.167)
Baseline	4.89
Physician FEs	+
Time FEs	+
Observations	4,284

NOTE: This table shows the DD regression results (δ in Equation 2) on alternative outcome variables, using the balanced sample of 9 months before and 9 months after the colon cancer diagnosis. Standard errors are clustered at the physician level. The numbers in panels A and B represent percentages (baseline) and percent points (estimates). The numbers in panel C represent the number of colonoscopies.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table A.7: The effect of colon cancer diagnosis on colonoscopy share, DD robustness

	(1)	(2)	(3)
A. Event definition	60	45	30
Treat * Post	0.101**	0.110***	0.102***
	(0.042)	(0.040)	(0.040)
Baseline	1.14	1.18	1.14
Events	138	141	144
Comparison	84	87	94
Observations	3,996	4,104	4,284
B. Delta (Δ)	9	12	15
Treat * Post	0.125***	0.071*	0.102***
	(0.037)	(0.038)	(0.040)
Baseline	1.13	1.18	1.14
Events	143	143	144
Comparison	116	111	94
Observations	4,662	4,571	4,284
Physician FEs	+	+	+
Time FEs	+	+	+

NOTE: The table shows robustness tests for our main result (Equation 2). The dependent variable is colonoscopy share, which is measured in percentages. The baseline value of about 1 means that, on average, 1% of the physician's patients had a colonoscopy each month. The point estimates are in percentage point units. E.g., with a baseline of 1, an estimate of 0.1 means a 0.1 pp effect, which is a ten percent increase. Panel A shows the main result for different event definitions varying the time gap between two indications of an event, the EMR, and the National Cancer Registry. Panel B shows the main result for different values of Delta (Δ). The estimates use the balanced sample of 9 months before and 9 months after the colon cancer diagnosis. Standard errors are clustered at the physician level.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table A.8: The effect of colon cancer diagnosis on colonoscopy share, DD with treatment leads and lags

	(1)	(2)	(3)
Quarter -3	0.012	0.021	0.020
	(0.084)	(0.067)	(0.067)
Quarter -2	0.021	0.013	0.012
	(0.081)	(0.066)	(0.066)
Quarter -1	0	0	0
	(-)	(-)	(-)
Quarter 0	0.244***	0.220***	0.220***
	(0.086)	(0.067)	(0.067)
Quarter 1	0.086	0.078	0.079
	(0.087)	(0.069)	(0.069)
Quarter 2	0.069	0.056	0.055
	(0.089)	(0.072)	(0.072)
Quarter 3	0.128	0.123*	0.121
	(0.091)	(0.073)	(0.073)
Quarter 4	0.072	0.070	0.067
	(0.087)	(0.071)	(0.071)
Physician FEs		+	+
Time FEs		+	+
Patient Characteristics			+
Observations	5,712	5,712	5,712

NOTE: The table shows regression results of the DD model with treatment leads and lags (Equation 1), i.e., δ_r for $r \neq -1, -3 \leq r \leq 4$. The dependent variable is colonoscopy share, which is measured in percentages – the baseline value of about 1 means that, on average, 1% of the physician's patients had a colonoscopy each month. The point estimates are in percentage point units. E.g., with a baseline of 1, an estimate of 0.1 means a 0.1 pp effect, which is a ten percent increase. Standard errors are clustered at the physician level.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table A.9: The effect of colon cancer diagnosis on colonoscopy share, DD

Sample:	Full			Balanced			Hole		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Treat * Post	0.109**	0.096***	0.096***	0.122***	0.102***	0.100**	0.078*	0.070*	0.067*
	(0.044)	(0.036)	(0.036)	(0.050)	(0.040)	(0.040)	(0.047)	(0.038)	(0.038)
Baseline	1.18	1.18	1.18	1.14	1.14	1.14	1.21	1.21	1.21
Physician FEs		+	+		+	+		+	+
Time FEs		+	+		+	+		+	+
Patient Characteristics			+			+			+
Observations	5,712	5,712	5,712	4,284	4,284	4,284	4,998	4,998	4,998

NOTE: The table shows the DD regression results (δ in Equation 2). The dependent variable is colonoscopy share, which is measured in percentages – the baseline value of about 1 means that, on average, 1% of the physician's patients had a colonoscopy each month. The point estimates are in percentage point units. E.g., with a baseline of 1, an estimate of 0.1 means a 0.1 pp effect, which is a ten percent increase. Standard errors are clustered at the physician level.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table A.10: The association between risk-score and the response to colon cancer diagnosis, robustness

	Logit, Main Sample	RF, Matching Sample	Logit, Matching Sample
	(1)	(2)	(3)
Treat * Post * Risk	-0.178^{**}	-0.122	-0.151^{*}
	(0.082)	(0.092)	(0.090)
Treat * Post	0.193^{***}	0.212^{***}	0.224^{***}
	(0.060)	(0.065)	(0.063)
Baseline	1.14	1.13	1.13
Physician FEs	+	+	+
Time FEs	+	+	+
Observations	4,284	4,140	4,140

NOTE: The table shows the variation in response to a colon cancer diagnosis by the patient's ex-ante risk (δ_0 in Equation 3). Column (1) uses the main balanced sample and the logistic regression based risk score. Columns (2)-(3) use the matching sample and the random forest and logistic regression based risk scores, respectively. The dependent variable is colonoscopy share, which is measured in percentages – the baseline value of about 1 means that, on average, 1% of the physician's patients had a colonoscopy each month. The point estimates are in percentage point units. E.g., with a baseline of 1, an estimate of 0.1 means a 0.1 pp effect, which is a ten percent increase. Standard errors are clustered at the physician level. $^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table A.11: Balancing table for the matching sample, January–September 2012

	Comparison group		*Treatment group*		*Difference*	
	Mean	SD	Mean	SD	Mean	P-Value
Physicians characteristics						
Age	58.23	8.01	58.74	8.18	0.51	0.68
Share male	59.13	49.15	59.13	49.15	0.00	1.00
Years in Maccabi	20.19	6.04	20.54	7.01	0.35	0.71
Patients characteristics						
Age	60.00	1.63	59.68	1.54	-0.32	0.20
Socio-Economic	6.54	1.38	6.58	1.28	0.04	0.85
Share male	48.62	7.26	48.20	6.13	-0.41	0.70
Share obesity	26.22	6.16	25.30	6.18	-0.92	0.30
Share diabetes	22.00	6.86	21.20	5.98	-0.80	0.41
Share cancer	19.04	4.67	17.50	8.52	-1.55	0.31
Share CVD	4.39	2.21	4.81	1.82	0.42	0.18
Share TIA	1.73	0.88	1.85	0.87	0.12	0.35
Physician activity						
Enrolled patients	525.32	299.69	504.29	274.99	-21.03	0.62
Visited patients	165.87	112.97	162.91	108.48	-2.96	0.85
Colonoscopy Share	1.00	0.37	0.99	0.40	-0.01	0.88
Number of physicians	84		115		199	
Observations	2,070		2,070		4,140	

NOTE: The table shows means and standard deviations for the treatment and comparison groups in the matching sample; All means were calculated using the first 9 months of data (January-September 2012) and were calculated at the physician-month level, weighted by physician work volume, including only patients in the age range 50-74.

Table A.12: The effect of colon cancer diagnosis on colonoscopy share, DD matching sample

	(1)	(2)	(3)
Treat * Post	0.152***	0.144***	0.145***
	(0.045)	(0.044)	(0.043)
Baseline	1.13	1.13	1.13
Physician FEs		+	+
Time FEs		+	+
Patient Characteristics			+
Observations	4,140	4,140	4,140

NOTE: This table shows the regression results (Equation 2) using the matching sample. The dependent variable is colonoscopy share, which is measured in percentages, i.e., a baseline value of 1 means that, on average, 1% of the physician's patients had a colonoscopy each month. The point estimates are in percentage point units. E.g., with a baseline of 1, an estimate of 0.1 means a 0.1 pp effect, which is a ten percent increase. Standard errors are clustered at the physician level.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table A.13: Physicians' response towards patients with the same characteristics as patients diagnosed with cancer, matching sample

	(1)	(2)
Panel A.		
	Patient age < 62	Patient age ≥ 62
Treat * Post * Young	0.168^{**}	-0.097
	(0.074)	(0.118)
Treat * Post	0.022	0.290^{***}
	(0.050)	(0.080)
Baseline	1.074	1.482
Observations	4,140	4,140
Panel B.		
	Female	Male
Treat * Post * Female	0.177^{**}	0.065
	(0.073)	(0.083)
Treat * Post	0.016	0.168^{***}
	(0.57)	(0.065)
Baseline	1.074	1.482
Observations	4,140	4,140
Physician FEs	+	+
Time FEs	+	+

NOTE: This table shows the estimates of the association between the age group and gender of patients diagnosed with cancer and physician's response to patients of the same age group and gender (δ_0 in Equation 3), using the matching sample. The dependent variable is colonoscopy share among different groups of patients, which is measured in percentages, i.e., a baseline value of 1 means that, on average, 1% of the physician's patients in that group had a colonoscopy each month. The point estimates are in percentage point units. E.g., with a baseline of 1, an estimate of 0.18 of Treat * Post * Young means a 0.18 pp effect, which is an eighteen percent increase. Standard errors are clustered at the physician level.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table A.14: The effect of colon cancer diagnosis on colonoscopy quality, matching sample

	Polyp share	Risk score
	(1)	(2)
Treat * Post	1.835*	0.832
	(0.939)	(0.901)
Baseline	8.501	57.058
Observations	15,158	15,158
Physician FEs	+	+
Time FEs	+	+

This table shows the DD regression analysis of the colonoscopy tests in the balanced sample at the individual test level (and the matching sample). The dependent variables are a dummy for a positive test (Column 1) and the random forest based risk-score of patients undergoing colonoscopy (Column 2). For column 1, a baseline value of 8 means that a polyp is found in 8% of colonoscopy tests. The point estimate of 1.835 represents a 1.835 pp increase, about (2/8=) 25 percent increase. Risk score (Column 2) is measured by a normalized value between 0 and 100. The 0.83 estimate implies about a 2 percent increase in the risk score (0.83/57). Standard errors are clustered at the physician level.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$

Table A.15: Response to colon cancer diagnosis by physician characteristics

Panel	Balanced
A.	
Treat * Post * Female PCP	−0.003
	(0.080)
Treat * Post	0.103**
	(0.051)
B.	
Treat * Post * Young PCP	0.005
	(0.080)
Treat * Post	0.099*
	(0.055)
C.	
Treat * Post * Inexperienced PCP (Years in Maccabi < 19)	0.055
	(0.079)
Treat * Post	0.078
	(0.054)
D.	
Treat * Post * High-quality medical school	0.148*
	(0.079)
Treat * Post	0.029
	(0.054)
E.	
Treat * Post * PC Specialization	0.206**
	(0.084)
Treat * Post	−0.041
	(0.070)
Physician FEs	+
Time FEs	+
Observations	4,284
Baseline	1.14

NOTE: The table shows the analysis by physician characteristics (δ_1 Equation 3). The dependent variable is colonoscopy share, which is measured in percents – the baseline value of about 1 means that, on average, 1% of the physician's patients had a colonoscopy in each month. The point estimates are in percentage point units. E.g., with a baseline of 1, an estimate of 0.1 means a 0.1 pp effect, which is a ten percent increase. Standard errors are clustered at the physician level. The sample is the balanced sample of 9 months before and 9 months after the colon cancer diagnosis.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$