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Do Colon Cancer Screening Programs Reduce Mortality?

Evidence from Spain

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by

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Abstract

The two main objectives of colon cancer screening programs are to prevent and early detect possible cancers in the medium-risk population. Hence, with this paper, I study the following two questions. First, is the program successful at reducing colon cancer mortality rate? Second, what are the key roles early detection and prevention have in reducing mortality rate? To answer these questions, I use individual level data on mortality and morbidity from the Spanish National Institute of Statistics (INE) and an Instrumental Variable – generalised Difference-in-Differences approach. I find that the introduction of colon cancer screening programs leads to a significant decrease in colon cancer mortality rate in treated regions. In addition, the program has a larger impact on mortality rate the longer it stays in place for a continuous time. Furthermore, I find that early detections and preventions significantly reduce colon cancer mortality rate, with a greater prevention effect in the longer run.

Keywords: Colon Cancer, Screening Program, Early Detections, Preventions, Mortality, Hospitalisations.

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1. Introduction

Colon cancer (CC) has become a leading cause of death among the Spanish population during the last decades. Since the early 2000s, CC has been ranked in the top 10 main causes of death and it has represented the second most frequent death by cancer in Spain (Instituto Nacional de Estadística, 2019). Moreover, the specific mortality rates by CC have been steadily increasing since the 1980s (Appendix figure 4) embodying a mortality rate around 50% in the first 5 years (López-Abente Ortega et al., 2005). All of this, according to future previsions, will be associated with a higher incidence (Bezerra-de-Souza et al., 2012), which will increase the health demand derived from this illness. In addition, the costs from surgery, hospitalisation, and chemotherapy to treat CC will play an important role in treatment expenditures. Based on these facts and the evidence that CC mortality can be reduced by screening (Hardcastle et al., 1996), the European Union started recommending, since the early 2000s, to all the member states the introduction of CC screening programs (Council European Union, 2003).

Following the recommendations of the European Union, in Spain, the first colon cancer screening program was implemented in Catalonia in the year 2000, being the aim of the program to early detect and prevent future CC cases and reduce CC related mortality. To do so, middle risk population was targeted, that is, women and men that range in the 50 - 69 years age group. After Catalonia, many regions followed. However, it was not until 2018 when all the regions implemented the program (Red de Programas de Cribado de Cáncer, 2018).

While a considerable amount of papers have focused on investigating the effectiveness of screening tests in mortality reduction, there is not much evidence on how successful colon cancer screening programs have been, as health policies, in reducing CC mortality rate. Thus, in this paper, I investigate whether the implementation of these programs had an actual impact on CC mortality rate. Moreover, there is little literature analysing the importance early detections and preventions might have in reducing mortality rate. Therefore, in this paper I also examine the key role early detections and preventions have in reducing mortality rate.

The differences in the timing at implementing CC screening programs creates the perfect conditions for exploring the effect of the program through a generalised Difference-in-Differences (DiD) empirical strategy. Hence, by using a generalised DiD model, I am able to

estimate the effect of the implementation of the program on CC mortality rate. However, since the data is only available until the year 2010, I can only observe the impact of the program for the regions that implemented the program before that year. Additionally, I use an IV identification strategy to address the causal relationship between CC hospitalisations and CC mortality rate. In this scenario, I use the program implementation as an exogenous shock on CC hospitalisations to find a causal relationship between CC hospitalisations and CC mortality rate, which will be used to determine the key role early detections and preventions have at reducing mortality rate. Therefore, in this paper, I do not only try to address a causality between the introduction of the program and CC mortality rate, but also a causal relationship between the increase in hospitalisations and CC mortality rate. This latter relationship is crucial at the moment of determining the key role early detections and prevention might have at explaining CC mortality behaviour.

In order to estimate this model, I collect individual level data on mortality for the period 1980-2010. Mortality data provides individual information on the cause of death, which I use to calculate province level CC mortality rates. Similarly, I also collect data on morbidity for every single person that was hospitalised in Spain in the 1980-2010 period by cause of hospitalisation. Again, I use this information to compute province level CC hospitalisation rates. Both datasets are collected from the Spanish National Institute of Statistics (INE).

Results suggest that the effect of CC screening programs on CC mortality rate is negative and time consistent. The implementation of the program reduces CC mortality on average by 7.5% in treated provinces. From the treatment dynamics results, I observe that the effect of the program gets stronger and gains significance as it stays in place for a continuous period of time. The most significant and strongest reduction in mortality appears after the program has stayed in place for more than seven years. Regarding the effect of the program on CC hospitalisations, that is, the first stage, I observe that the implementation of the program has a strong and significant impact on the number of hospitalisations. From this exogenous shock, I estimate the causal effect of hospitalisations on mortality, which appears to be negative and significant, especially after the fourth period. By observing this causal relationship, I estimate the early detection and prevention effects on mortality. Thus, a ten units increase in early detections would decrease CC mortality by 0.32 deaths per 100.000 inhabitants. Moreover, a ten units increase in preventions would decrease CC mortality between 0.03 and 0.41 deaths per 100.000 inhabitants, the coefficient being larger as the program stays in place for a continuous period of

time. To sum up, increasing early detections and preventions by ten units per 100,000 inhabitants could result in a reduction of CC mortality rate from 1.48% to 3.07%.

I perform a further analysis on the days a patient stays at the hospital in order to determine one of the mechanisms through which hospitalisations might reduce CC mortality. The main hypothesis here would be that a reduction in the severity of the cancer would result in a decrease in the number of days a patient stays at the hospital, and thus mortality. This analysis shows that, as expected, the introduction of the program negatively affected the days a patient stays at the hospital. Moreover, results also show that early detections are the only factor leading the reduction in the days of stay, meaning that patients get treated earlier.

In order to provide additional robustness checks for the results, I perform a placebo exercise for those outside the targeted population, that is, for individuals younger than 50. Results show that there is not any significant effect on those individuals, meaning that the screening program only affected the targeted population.

This study contributes to the existing literature in several ways. First, it provides evidence that the successfulness of the screening tests in reducing CC mortality is also reflected in the effect CC screening programs have in reducing overall CC mortality rate. Therefore, unlike Kim & Lee (2017), I demonstrate that in this case screening programs are successful in reducing mortality. Second, I demonstrate that early detections and preventions are crucial in reducing CC mortality, with a greater prevention effect in the longer run. The negative early detections effect on mortality is also corroborated by looking at the effect on the days a patient stays hospitalised. This proves that colon cancer screening programs are successful in targeting middle risk population, due to the fact that, otherwise, the early detection effect on mortality would be zero.

The paper is presented as follows. Section 2 provides the background on CC screening programs. Section 3 frames the paper in the existing literature. Section 4 describes the datasets for the analyses. Section 5 describes the theoretical framework used in the paper. Section 6 discusses the empirical approach and the assumptions used in the paper. Section 7 presents the results and Section 8 tests for a placebo. Finally, Sections 9 and 10 provide a potential mechanism and concluding remarks on the paper.

2. Background

2.1. Screening Programs as a Cost Reduction Solution

The increasing number of colon cancer diagnosis during the last decades has led to an upward evolution of colon cancer related mortality and to an increase in the number of colon cancer hospitalisations. Figures 2, 4, 6 and 8 in the appendix show the yearly evolution of the absolute number of colon cancer deaths and mortality rate as well as the absolute number of colon cancer hospitalisations and hospitalisation rate in Spain. From these figures and from figures 1 and 3 in the appendix, it can be observed that while there was a decrease in the overall mortality rate after the 2000s in Spain, CC mortality rate did not decrease during this period, but increased. Moreover, all of this, with the low average survival rate for CC diagnosed patients, ranging around 55.2% – 57.9% in the 5 first years based on the 2000 – 2007 estimates by Heitman, Hilsden, Au, Dowden, & Manns (2010), emphasizes the importance colon cancer has and will have in our society. Figures 6 and 8 in the appendix also indirectly highlight the increasing continuous costs the health care system is suffering from the increase in the number of colon cancer hospitalisations. These costs increase the later the cancer is diagnosed and thus, they contribute to a larger growth in health care expenditure. According to the paper by Corral et al., (2015) the average CC treatment cost increases from €6,573, if the diagnosis is *in situ,* to €36,894 in a *third stage* diagnosis. In fact, from these costs, 59.2% corresponded to surgery-hospitalisation and 19.4% to chemotherapy treatments.

Most of colon cancers appear on a pre-existing polyp in the mucosa of the colon, which with time and as a consequence of the action of different agents, evolves into a malignant tumour. One of the key characteristics of this process is that it takes on average around 10 years to complete the transformation, being crucial for preventive care, permitting the early detection of precancerous polyps and improving the results. As a measure for the early detection and prevention of CC, the main screening strategies are based on faeces samples (Faecal Occult Blood Test, FOBT) or on colonoscopies. FOBTs have been proved to be more cost-effective compared to colonoscopies, mainly due to the high frequency of polyps on over 50 years old

population, where only a 10% of them become cancer. As a result, colonoscopies are used in case of getting a positive result from the FOBT (Grau & Castells, 2014).

As mentioned, screenings can help to avoid the development of precancerous polyps into cancer (Grau & Castells, 2014) and to increase the numbesr of early detected cases. Therefore, a reduction in the number of patients requiring hospitalisation, chemotherapy etc. caused from prevention and the decrease in the severity of the treatment caused by early detections, would lead into a reduction in health care expenditure. As screenings techniques, FOBTs have been proved to be effective (Mandel et al., 1993; Hardcastle et al., 1996). Consequently, in order to prevent and early detect CC, different regional governments in Spain started to implement CC screening programs with the aim of reducing the incidence in medium risk populations. In conclusion, CC preventive care is an essential element for reducing mortality and at the same time controlling health care costs.

2.2. Colon Cancer Screening Programs in Spain

Scientific advances have expanded CC related knowledge such as the pathogenic mechanisms involved in the onset of it, and the diagnostic tools developed to detect early lesions. Moreover, new treatments improving the prognostic and increasing the survival rate in this type of patients have been developed. By considering all these conditions, many different preventive care strategies have been implemented with the aim of increasing the early detection rate and prevention of CC (Salas Trejo et al., 2012).

Following the European Commission recommendations and each region's oncologic plans, CC screening programs started to be implemented in the early 2000s in Spain. Catalonia was the first region acting and implementing a CC screening program, being first the main objective to evaluate the feasibility and successfulness of such program. By targeting men and women between the 50- and 69-years age group, they started performing FOBTs as CC screening tests, where the targeted population was identified by using a population-based information system. The first results detecting CC and precancerous polyps appeared to be successful. After that region, in 2006, Murcia and Valencia followed. Again, preliminary results

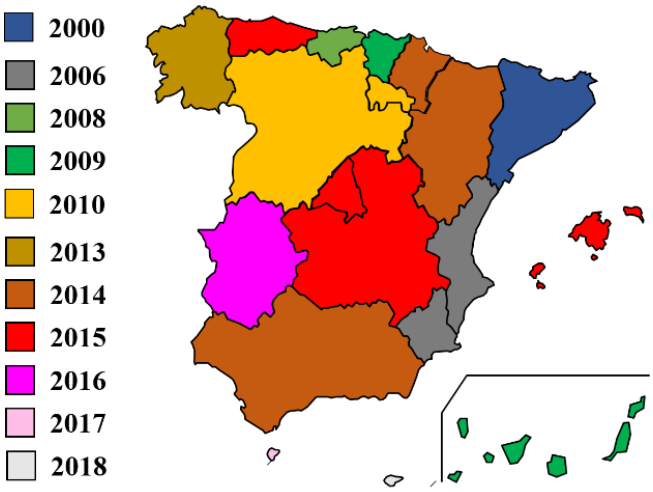


Figure 1: Introduction of the CC Screening program in Spain[1]

showed that the screening was successful at detecting precancerous polyps and CC in these regions (Castells et al., 2007). By the year 2007, the implementation of the program was part of the National Health Service strategy to deal with cancer, and of most oncology plans in the remaining regions. However, it was not until 2018 when the program was completely implemented in all the regions (Red de Programas de Cribado de Cáncer, 2018) (figure 1).

2.2.1. Screening Program Implementation

The main objectives of CC screening programs are to reduce the incidence and mortality from CC in the medium-risk population by increasing early detections and preventions. Medium risk population are considered to be men and women ranging in the 50- to 69-years age group with no previous CC antecedents in their families.

Once the CC screening program is approved to be implemented in a region, an invitation to the targeted population is sent, where the targeted group is informed about the participation in the program. If the proposal is accepted, all the materials and instructions needed for taking the samples are delivered to the person. For the screening test, 2 samples of 3 successive stools

[1] **Note**: Implementations by year: Catalonia (2000); Murcia and Valencia (2006); Cantabria (2008); Basque Country and Canary Islands (2009); Castilla y Leon and La Rioja (2010); Galicia (2013); Andalusia, Aragon and Navarra (2014); Asturias, Balearic Islands, Castilla-La Mancha and Madrid (2015); Extremadura (2016); Ceuta (2017); and Melilla (2018).

are taken without initial dietary restriction. If, as a result, FOBT shows to be positive, a colonoscopy under sedation will be offered. Depending on the result of the colonoscopy, a personalised follow-up frequency will be recommended. The follow-up frequency will be defined as 10 years if the result from the colonoscopy is adequate. On the contrary, If the result is an adenoma, patients will follow periodic controls with colonoscopies according to the monitoring protocol of the program. In the case of invasive cancer, the patient will be treatment at the reference hospital. (Salas Trejo et al., 2012) (Eguino Villegas et al., 2012).

3. Literature Review

Literature on the effectiveness of screening tests in reducing mortality is abundant. There are many medical researches analysing the effectiveness of FOBTs, colonoscopies etc. as well as their cost-effectiveness. However, there is not much evidence on how regional or country level CC screening program implementations, as health policies, that use FOBTs as screening tests, have affected the evolution of CC mortality rate. Therefore, I will first provide literature about FOBTs effectiveness in mortality reduction and, after that, some literature on the successfulness of screening programs, as health policies, in reducing mortality. In addition, I will also provide literature on the key role early detection and prevention might have at reducing mortality rate.

The negative effects of FOBTs on CC mortality are more than proved. Mandel et al. (1993) showed by randomized CC screenings that the effect of annual FOBTs decreased the 13 years cumulative CC mortality by 33% on the screened group. Hardcastle et al (1996) also analysed the effect of FOBTs on mortality by randomizing CC screenings in the UK and they found that the reduction in CC mortality in individuals who accepted the first FOBTs compared with the control group was 39% lower. Another study in Denmark, by Kronborg, Fenger, Olsen, Jørgensen, & Søndergaard (1996) randomized individuals to get a FOBT over 10 years, in intervals of 2 years between each FOBT, and they came out with the results that the mortality ratio between screened and non-screened was of 0.82. Consequently, from all these papers I can find that FOBTs can be used as a successful tool for detecting and preventing CC.

Knowing the effects FOBTs have on mortality is an important factor at the moment of implementing screening programs. However, analysing the real effect the introduction of screening programs, as policies, might have on mortality is also a crucial element. Consequently, I provide literature examining the way similar programs have been implemented, and their successfulness in mortality reduction. On the one hand, Kim & Lee (2017) analysed the effect of stomach and breast cancer screening programs in Korea. They showed that free cancer screenings substantially increased the screening take up rate, yielding more cancer detections. However, the increase in cancer detection was quickly crowded out through other channels of cancer detection such as private cancer screening. Hence, they conclude that crowd-out and

selection effects help to explain why the program has been unable to reduce cancer mortality. On the other hand, Kadiyala & Strumpf (2016) compared cancer test and detection rates on either side of US guideline-recommended initiation ages using a Regression Discontinuity design. From this, they estimated significant effects of screening on earlier breast cancer detection at age 40 and colorectal cancer detection at age 50, supporting the positive effects of the screening program. Finally, Bitler & Carpenter, (2016) also showed that state health insurance mandates requiring coverage of screening mammograms significantly increased mammography screenings by 4.5-25 percent. Moreover, they also found that mandates increased detection of early stage in-situ precancers. Hence, health insurance mandates covering mammography screenings can assumed to act as incentive to screen programs, which appeared to be successful at detecting cancer and reducing mortality. In short, effective screening techniques do not always lead to successful screening program outcomes.

Having observed the potential benefits FOBTs have in reducing CC related mortality rate through an increase in the number of early-detection and prevention, and the direct impact this has on hospitalisations, I try to address a causal relationship between hospitalisations and mortality. That way, I will be able to determine the key role early-detection and prevention have in reducing mortality. In theory, first, one would expect that while early-detections have a greater impact than preventions in the number of hospitalisations, a higher number of hospitalisations would result in a negative effect on mortality. Nevertheless, once the prevented cases started to kick-in and show a greater impact in hospitalisations than early-detections, one would expect a reduction in hospitalisations and thus a positive relationship between hospitalisations and mortality. Following this idea, I try to find previous papers identifying the key role hospitalisations may have on mortality. Unfortunately, literature on that is lacking. There is only one paper by Howard (2005) analysing the effect prostate cancer early detections have on live expectancy, showing that the benefits of early detections tend to go towards zero as the risk of death increases. Thus, from this paper one could interpret that a higher number of early detections could not always result in a reduced mortality rate if those detected had a high-risk of death. This conclusion might be one of the main reasons why the colon cancer screening program only targets middle risk population.

In conclusion, in this paper, I complement the existing literature, first by determining whether the implementation of CC screening programs have a negative impact on CC mortality rate and, second, by measuring the effect early-detections and prevention have on reducing mortality rate.

4. Theoretical Framework: Colon Cancer Screening Programs and Hospitalisations

The two main objectives of CC screening programs are to increase the early detection rate and to prevent CC, which would lead to changes in the number of hospitalisations. An increase in early detections would positively affect the number of hospitalisations since there will be a larger number of cancer detections early on, which otherwise would not have been detected until later. In this paper these will be referred to as early detected future patients. Looking at the second objective, an increase in preventions would reduce the number of hospitalisations due to the fact that patients at risk could be detected and CC prevented before development. In short, the implementation of the program would have, overall, an ambiguous effect on the number of CC hospitalisations.

As mentioned above, the number of hospitalisations is affected by early detections and preventions. From this I derive a linear relationship between hospitalisations, early detections, and preventions seen in equation 1. The first two terms of this equation show a relationship between the changes in hospitalisations and early detections. In the first term, changes in hospitalisations in period t can be seen to be positively affected by early detected future patients in period t. I assume that early detected future patients are limited to two periods into the future. In the second term, changes in hospitalisations are negatively affected by early detected patients from the previous periods. Some of the patients that would have been hospitalised in period t would with the program instead be detected in periods t – 1 and t – 2. The third term shows the negative effect past prevention has on current changes in hospitalisations. In this sense, this term reflects the effect past prevented patients, that would have developed cancer in period t if they had not been screened in periods t – 3 or earlier, have on the current changes in hospitalisations. Furthermore, I assume that there will be patients whose polyps could not be detected early enough to fully prevent development into cancer. These cases will be assumed to be the ones from periods t – 1 and t – 2. Based on these hypotheses, I define the relationship between CC hospitalisations, early detections and prevention as follows:

$$(1) \quad \Delta hosp_t = \delta_0 ED_t - \sum_{j=1}^{2} \delta_j \, ED_{t-j} \; - \sum_{j=3}^{10} \pi_j \, Prev_{t-j} + \; \varepsilon_t$$

Where $\Delta hosp_t$ refers to the change in the number of hospitalisations in year t, δ_0 measures the effect of early detected future patients on CC hospitalisations in period t, δ_j the reduction in hospitalisations due to the early detections from previous periods and π_j the effect of past prevention. Unfortunately, information on early detected cases and prevented cases is not available, which makes it impossible to directly estimate the parameters of such equation. However, ideally, I would like to present the following equations in order to observe the effect of the program on early detections and prevented cases:

$$(2) \quad \sum_{i=1}^{2} \omega_i hosp_{t+i} = \; \mathrm{ED}_t \; = \; \theta Prog_t$$

$$(3) \quad \sum_{i=3}^{10} \tau_i hosp_{t+i} = \; \mathrm{Prev}_t = \; \rho Prog_t$$

Where θ and ρ show the effect of the program on the number of early detections and preventions respectively, and ω_i and τ_i the share of patients that are early-detected and prevented from future periods in period t, respectively. Hence, by using the theoretical model explained above, I can derive the following expression from equations (1), (2) and (3):

$$(4) \; \Delta hosp_t = \sum_{i=1}^{2} \delta_0 \omega_i \, hosp_{t+i} \; - \sum_{j=1}^{2} \sum_{i=1}^{2} \delta_j \omega_i \, hosp_{t+i-j} \; - \sum_{j=3}^{10} \sum_{i=3}^{10} \pi_j \tau_i \, hosp_{t+i-j} \; + \; \varepsilon_t$$

Where $\pi_j \tau_i = 0$ and $\delta_j \omega = 0$ if $i \neq j$

$$\Delta hosp_t = \; \sum_{i=1}^{2} \delta_0 \omega_i \, hosp_{t+i} \; - \sum_{j=1}^{2} \delta_j \omega_j \, hosp_t \; - \sum_{j=3}^{10} \pi_j \tau_j \, hosp_t \; + \; \varepsilon_t$$

$$hosp_t \left(1 + \sum_{j=1}^{2} \delta_j \omega_j \; + \sum_{j=3}^{10} \pi_j \tau_j \right) \; - \; hosp_{t-1} = \omega_1 \delta_0 \, hosp_{t+1} \; + \; \omega_2 \delta_0 \, hosp_{t+2} \; + \; \varepsilon_t$$

$$hosp_{t+2} = \; -\frac{\omega_1}{\omega_2} hosp_{t+1} + \frac{(1 + \sum_{j=1}^{2} \delta_j \omega_j \; + \sum_{j=3}^{10} \pi_j \tau_j \,)}{\delta_0 \omega_2} \; hosp_t + \frac{-1}{\delta_0 \omega_2} hosp_{t-1} + \; \varepsilon_t$$

$$AR(3): \; hosp_t = \; \varphi_1 hosp_{t-1} + \; \varphi_2 hosp_{t-2} \; + \varphi_3 hosp_{t-3} \; + \; \varepsilon_t$$

Where φ_i are AR(3) coefficients capturing the early-detection and prevention parameters presented earlier. By running this regression and performing the Bayesian Information Criteria (BIC) test, I can observe that the data fits the model described, showing that the theoretical model can be trusted.

In order to estimate the effect of the program on CC hospitalisations, I substitute the right-hand side of equations (2) and (3) in (1) and estimate the following equation:

$$(5) \quad \Delta hosp_t = \sum_{j=0}^{2} \delta_j \theta Prog_{t-j} - \sum_{j=3}^{10} \pi_j \rho Prog_{t-j} + \varepsilon_t$$

Where, I assume $\lambda_j = \pi_j \rho$ to be 0 for the first 3 periods due to the fact that the prevention effect of the program will start taking action after period 3, as explained above. Consequently, I can simplify equation 5 as:

$$(6) \quad \Delta hosp_t = \sum_{j=0}^{2} \eta_j Prog_{t-j} + \varepsilon_t$$

Here, since CC hospitalisations would only depend on early detections in the first 3 periods, $\eta_j = \delta_j \theta$ would show the effect of the change in early detections on changes in hospitalisations. Thus, if $\eta_j > 0$, a positive change in early detections would show a positive impact on hospitalisations, meaning that the program had a positive effect on the number of hospitalisations.

In conclusion, in the theoretical model described, I can observe that the screening program affects the changes in hospitalisations differently depending on the stage of the program. Based on this, two outcomes could be observed. The first being a clear positive effect of the increase in early detections on hospitalisations during the first periods as a consequence of the implementation of the program. The second being first a small but gradually increasing negative impact of the increase in preventions on hospitalisations. In this sense, I would expect that while early-detections have a greater impact than preventions, the effect of the program in the change in hospitalisations should be positive. Once the prevented cases start to show a greater impact on the change in hospitalisations than early-detections, I would expect the effect of the program in the change in hospitalisations to be negative.

5. Data

5.1. National Institute of Statistics (INE) Data

In this section, I describe the data employed in the analysis. The information I use has been collected from the INE from the data sources "Death statistics according to cause of death", "Hospital morbidity survey" and "Population statistics". The first database shows information on the cause of death for every person that died in Spain. The second database shows individual-level information on morbidity, that is, information on every person that was hospitalised. Finally, the third database shows yearly data on the population for each province and region. These databases cover the 17 autonomous regions and 2 autonomous cities, and their respective 52 provinces, during the 1980-2010 period. The regions (and provinces) of Spain are the following: Andalusia (Almeria, Cadiz, Cordoba, Granada, Huelva, Jaen, Malaga, and Sevilla), Aragon (Huesca, Teruel, and Zaragoza), Asturias (Asturias), Basque Country (Araba, Bizkaia, and Gipuzkoa), Canary islands (Las Palmas and Santa Cruz de Tenerife), Cantabria (Cantabria), Castilla la Mancha (Albacete, Ciudad Real, Cuenca, Guadalajara, and Toledo), Castilla y León (Avila, Burgos, Leon, Palencia, Salamanca, Segovia, Soria, Valladolid, and Zamora), Catalonia (Barcelona, Gerona, Lerida, and Tarragona), Ceuta (Ceuta) and Extremadura (Badajoz, and Caceres), Galicia (La Coruña, Lugo, Ourense, and Pontevedra), Balearic Islands (Balearic Islands), La Rioja (La Rioja), Madrid (Madrid), Melilla (Melilla), Murcia (Murcia), Navarra (Navarra) and Valencia (Alicante, Castellon, and Valencia).

The variables observed in the first dataset provide information on the cause of death, province of residence, province of birth, province of death, year of death, gender, age, civil state, date of birth and size of the municipality of the deceased. In total, I observe 10,651,075 individuals over the whole sample. However, the only variables I use are the cause of death, the province of residence, age, year of birth and gender. From this information, I am able to compute the overall national and province mortality rates as well as CC national and province mortality rates per 100.000 inhabitants for every year. Mortality rate variables are calculated as follows:

$$(7a) \quad Mortality\ rate_t = \frac{Deaths_t}{Population_t}\ x\ 100.000$$

The morbidity dataset provides information on those that were assigned a bed at a hospital. Here, I observe individual information on the date of hospital admission, the number of days hospitalised, gender, the cause of hospitalisation, the location of the hospital, province of residence of the patient, the age of the patient and the discharge status. This dataset displays information on 74,867,683 individuals over the 1980-2010 period. I use this information to calculate the number of hospitalised per 100.000 inhabitants per province and per year.

$$(7b) \quad Hospitalisation\ rate_t = \frac{Hospitalisations_t}{Population_t}\ x\ 100.000$$

I collapse both mortality and morbidity individual-level information into province-level data and I combine them to observe the evolution of mortality and morbidity rates of each province and region over time (Figures 9 and 10 in the appendix). I then, construct a post-program period indicator, P_{rt}, which will take the value of one in the year the program is implemented and in the following years. This variable will be the main treatment variable of interest.

5.2. Study Sample

The study sample consists of those in the target population, that is, those in the 50-69-year age group. However, I do not exclude people older than 69, due to the fact that over the years people that were treated will leave the target group and such effect would be excluded. Individuals with CC antecedents in their family should also be excluded from the sample due to the fact that they are considered as high-risk population and the program is only oriented to middle-risk population. Nevertheless, there is not information available on familiar's cancer cases and, therefore, it is not possible to distinguish between high-risk and middle-risk population. However, this might not be a problem since high-risk population is independent to being part of the target population as it only depends on family antecedents and genetic predisposition.

Table 1: Summary Statistics (1980-2010 period)

	Control Group		Treatment Group	
Variables	Mean	Std. Dev.	Mean	Std. Dev.
Demographic Variables				
Mortality dataset				
Gender	0.53	0.10	0.54	0.07
Age	74.76	2.54	74.07	1.76
Morbidity dataset				
Gender	0.56	0.17	0.57	0.15
Age	70.46	3.74	69.86	3.26
Days hospitalised	20.30	7.94	19.64	8.11
Outcome Variables				
CC Mortality rate	18.04	1.54	16.39	2.69
CC Hospitalisation rate	33.04	38.49	34.63	37.66
Observations	1179	-	434	-

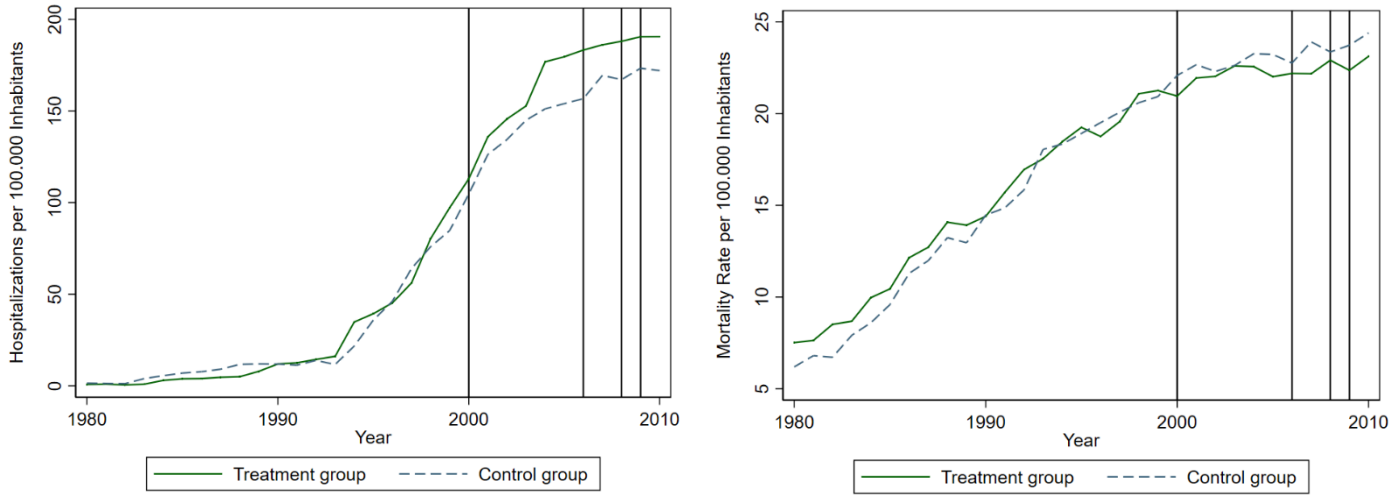
Note: The Mean and the Std. Dev. of the variables are calculated by collapsing all the observations at the province level. The **control group** is composed of the following regions (and provinces): Andalusia (Almeria, Cadiz, Cordoba, Granada, Huelva, Jaen, Malaga, and Sevilla), Aragón (Huesca, Teruel, and Zaragoza), Asturias (Asturias), Castilla la Mancha (Albacete, Ciudad Real, Cuenca, Guadalajara, and Toledo), Castilla y León (Avila, Burgos, Leon, Palencia, Salamanca, Segovia, Soria, Valladolid, and Zamora), Ceuta (Ceuta), Extremadura (Badajoz, and Caceres), Galicia (La Coruña, Lugo, Ourense, and Pontevedra), Balearic Islands (Balearic Islands), La Rioja (La Rioja), Madrid (Madrid), Melilla (Melilla), and Navarra (Navarra). The **treatment group** is composed of the following regions (and provinces): Catalonia (Barcelona, Gerona, Lerida, and Tarragona), Valencia (Alicante, Castellon, and Valencia), Murcia (Murcia), Cantabria (Cantabria), Basque Country (Araba, Bizkaia, and Gipuzkoa) and Canary islands (Las Palmas and Santa Cruz de Tenerife).

Table 1 presents descriptive statistics for treatment and control groups for the whole period sample. I define the treatment group as the provinces that implemented the program between the years 2000 and 2010 and the control group the provinces that did implement the program after 2010. Additionally, this table is divided into two sections: demographic variables and outcome variables.

Population demographic variables are divided by dataset, that is, by mortality and morbidity, and show the average age and gender distribution in both data sources. From this, I can observe that both treatment and control groups are balanced, meaning that the groups are composed by similar individuals. For example, the average age of death and hospitalisation are 74 and 70 years, respectively, in treated and non-treated provinces. In terms of gender, this table shows that the ratio of males over females is similar in the two groups. However, the proportion of males is greater than the one of females, that is, men tend to die more from CC than women.

Finally, regarding the number of days hospitalised, I can observe that the average person stays around 20 days in both treated and non-treated regions.

The main outcome variables, measured in deaths and hospitalisations per 100,000 inhabitants are constructed by using ICD-10 based on information, which captures all type of diseases regardless the detection channel. A concern with ICD-10 classification of diseases mentioned in Kim & Lee (2017) is that there might be over-diagnosis of the cases. Thus, to prevent misinterpretation from over-diagnosis, I restrict cancer hospitalisations to those that incur at least one day of hospitalisation. These variables show that on average control regions suffer from a higher CC mortality. Therefore, it may be the case that the health care system in control regions is worse at treating patients than in treated regions. However, this might not be a problem at the moment of estimating the impact of the policy if this level of bias remains constant over the years. The province bias is eliminated by employing the DiD estimation strategy if it is constant over time. This assumption seems plausible when looking at the evolution of the mortality and hospitalisation rate in figures 2 and 3, where it can be observed that both treatment and control regions follow the same pattern of behaviour before the first program is introduced. Hence, I can say that the difference in CC mortality and hospitalisations between the groups may not lead to a bias in the results. The parallel trend assumption will be statistically tested in the empirical approach section.



Figures 2 and 3: Evolution of Colon Cancer Hospitalisations (Left) and Mortality Rate (Right)

6. Empirical Approach

The scope of this section is to define the models that will help answering previously defined questions. First, is the program successful at reducing CC mortality rate? Second, which are the key roles early detection and prevention have at reducing mortality rate? To do so I use an IV-DiD identification strategy.

6.1. Reduced Form

To analyse whether the program is successful at reducing CC mortality rate I use a quasi-experimental Difference-in-Differences (DiD) specification strategy, which will estimate the effect of the introduction of CC screening programs on CC mortality rate. The DiD model I use is characterised by having multiple treatment times due to the fact that treated regions did not implement the program in the same year. From that, the reduced form relationship is defined as:

$$(8) \quad y_{prt} = \alpha_p + \beta P_{rt} + \mu_t + \varepsilon_{prt}$$

Where, y_{prt} denotes CC mortality rate at time t for province p in region r; P_{rt} is a dummy variable equal to one within ten years after the implementation of the CC screening program; β measures the average reduced form impact of the policy on CC mortality rate outcomes for the treated regions; α_p and μ_t are province and year fixed effects, respectively; and ε_{prt} is a random error. Standard errors are clustered by province.

To assess the dynamics of the treatment effect and to justify the assumption that regions introducing the program were on parallel trends with respect to the other regions in the pre-treatment period, I estimate the yearly effect of the program on CC mortality. For that, I regress the outcome variable on yearly post- and pre-treatment dummy variables. The reduced form yearly effect is defined as:

$$(9) \quad y_{prt} = \alpha_p + \sum_{j=0}^{10} \beta_{-j} P_{rt-j} + \sum_{j=1}^{10} \beta_j P_{rt+j} + \mu_t + \varepsilon_{prt}$$

Where, P_{rt-j} is a dummy variable capturing anticipatory effects and P_{rt+j} post-treatment effects. Hence, the coefficients β_{-j} test for the existence of parallel trend assumptions, as they reflect the relationship between current outcomes and future program implementations. To validate the parallel trend assumption, I would expect these coefficients to be close to zero and not statistically significant. The coefficients β_j, however, capture the dynamics of the treatment effect, as they reflect the relationship between current CC mortality rate and past program implementation. In short, the coefficients of each dummy variable measure the reduced form impact of the policy on CC mortality rate for each year before and after being the program implemented.

6.2. First-Stage

In order to be able to answer the second question, first I need to observe the effect of the program on hospitalisations. Based on the theoretical model explained in section 4, I will be able to determine which effect, e.g. early detections, or prevention, is driving the changes in hospitalisations depending on the time period. For that, I run the same regressions as in the previous section but by changing the outcome variable with the number of hospitalisations. With this, I should observe that the effect of the program on hospitalisations is only affected through early detections during the first periods and see that the effect on hospitalisations weakens after preventions start to kick-in. Again, to justify the parallel trend assumption I also observe pre-treatment periods effect, which should show no significant values.

6.3. Second-Stage

Having determined the effect of the program on CC hospitalisations is essential at the moment of analysing the causal effect of hospitalisations on mortality rate, and, therefore, the effect of early detections and preventions on mortality. This is due to the fact that the program provides an exogenous variation in hospitalisations that can be used to account for omitted variables that could bias the results. Therefore, I use an IV identification strategy approach where the program implementation is taken as an instrument for CC hospitalisations, which, based on the theoretical model explain in 4, would let me analyse the effect of early detections and preventions on CC mortality.

The IV approach relies on four assumptions that must be satisfied for the identification to work: the independence assumption, exclusion restriction, monotonicity, and the existence of a first-stage. First, the independence assumption is satisfied since the introduction of the program is independent across regions. Second, according to exclusion restriction assumption, CC mortality is affected by the implementation of the screening program only through CC hospitalisations. This channel could be broken down if patients started taking more healthy habits as a consequence of the raise in awareness caused by the program advertisement and, hence, CC mortality decreased. However, people's behaviour take time to change, and thus, it is realistic to assume that in the short and medium-run there is no significant change in their behaviour. In any case, I provide evidence that this channel is non-existent in the robustness check section. Third, the monotonicity assumption states that while the instrument may have no effect on some people, the ones who are affected must be affected in the same way. In this scenario the monotonicity assumption would stop to hold once the preventive effect started to take place. This is because the instrument would push some people into being hospitalised (early detected) while pushing others out (prevented), resulting in an ambiguous effect of hospitalisations on mortality. Thus, after the third period, when the preventive measures would start showing an effect on hospitalisations, the causal effect of CC hospitalisations on CC mortality would be broken down. Therefore, in order to address a valid causal relationship, I use the first 3 periods, where the monotonicity assumption would still hold, to determine a causal effect of hospitalisations on mortality. This effect, based on the theoretical model describe above, would be the same as the early detection effect on mortality. Consequently, after determining the effect early detections have at reducing mortality in the first periods, I could determine the size of prevention in the following periods by subtracting the average effect of early detections during the first periods from the effect of hospitalisations on mortality in periods four to ten. Finally, the last condition for an IV to work is that there must be a significant first-stage effect of the instrument on the treatment. To prove that, I present the first-stage F-statistics results in table 3, which show that after period four, the value of this test is greater than 10, suggested least value by Stock, Wright, & Yogo (2002).

In order to estimate the causal effect of hospitalisations on mortality over the years, needed to determine the magnitude of the effect of early detections and preventions on mortality, I present the following 2SLS equation:

$$(10) \quad \widehat{hosp}_{prtn} = \alpha_p + \sum_{j=0}^{10} \psi_{-j} P_{rt-j} + \sum_{j=1}^{n} \psi_j P_{rt+j} + \mu_t + \varepsilon_{prt}, \qquad where\ n = 1, \dots, 10$$

$$y_{prtn} = \alpha_p + \widehat{hosp}_{rtn} + \mu_t + \varepsilon_{prt}$$

Here, I am able to observe the causal relationship between CC hospitalisations and CC mortality rate as the program has been in place over time. In this sense, when n = 1 I would estimate the effect of CC hospitalisations on CC mortality when the program has stayed in place only during one period, If n = 2, I would estimate the same effect but when the program has been in place for two years, and so on until n = 10, which would show the causal relationship between CC hospitalisations and CC mortality after being the program implemented for ten years. At the same time, by running this regression, I would also account for the parallel trend assumption required for the identification to be correct.

In conclusion, with this specification I would be able to observe the evolution of the coefficient expressing the causal relationship between hospitalisations and mortality over the years and break it down to see the magnitude of the effect of early detections and preventions on mortality.

7. Results

7.1. First-Stage and Reduced Form Effect

In this section, I present the main results derived from the models specified above with the aim of answering previously presented questions. Table 2 is divided into two panels: panels A and B. Panel A, that is, columns one and two, show the first-stage regressions of the effect of the CC screening program implementation on CC hospitalisations. Panel B, that is, columns three and four, show the reduced form effect of the CC screening program implementation on CC mortality rate. The odd-numbered columns are estimated from equation 8, but they are adapted to include pre-program effects. Therefore, I augment this equation to include a Pre-Program indicator, which will be a dummy equal to one in all ten periods before the program implementation. In this sense, by estimating this augmented equation I will be able to determine whether both treated and control provinces were on parallel trends before the program implementation as well as the effect of the program on colon cancer hospitalisations and mortality rate. The even-numbered columns are estimated from equation 9, which includes ten periods lags and leads required to capture treatment dynamics effects and pre-treatment effects.

By looking at the estimates of the augmented equation 8 in column one, I can observe that the program implementation had a positive effect on the number of hospitalisations. The implementation of the program increased the number of colon cancer hospitalisations in treated provinces by 14.22 hospitalisations per 100,000 inhabitants. Based on this result, if treated provinces had not been treated, the mean of the CC hospitalisations variable in treated provinces, for after treatment periods, would have been 69.93 hospitalisations per 100,000 inhabitants (84.15 – 14.22)[2]. Consequently, in relative terms, the implementation of the program increased CC hospitalisations in treated regions by 20.33% (14.22 / 69.93). The estimates in column three show that the CC screening program implementation had a negative and significant effect in

[2] The parallel trend assumption allows me to calculate the counterfactual for the treatment group by subtracting the treatment effect to the mean of the treated provinces after being treated (Appendix table 1).

Table 2: First-Stage and Reduced-Form Effect: Estimated effect of the Colon Cancer Screening Program Implementation on Hospitalisations and Mortality Rate

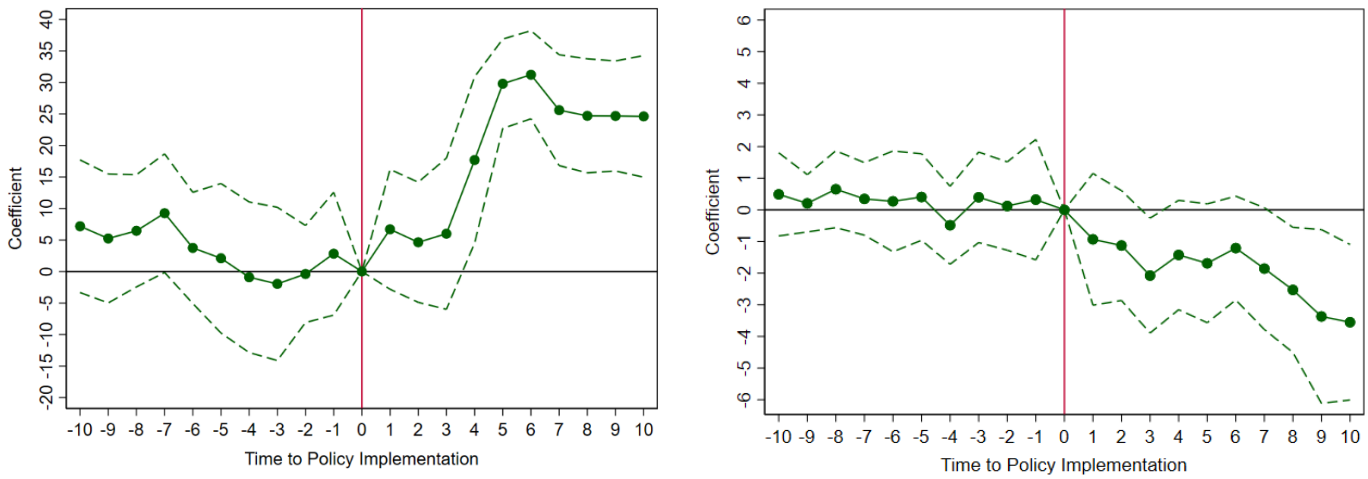
	Panel A		Panel B	
Dependent Variable	(1) Colon Cancer Hospitalisations	(2) Colon Cancer Hospitalisations	(3) Colon Cancer Mortality	(4) Colon Cancer Mortality
Pre-Program	2.373		-0.111	
	(3.432)		(0.593)	
Post-Program	14.22*		-1.939**	
	(7.267)		(0.891)	
Pre-Program(t-10)		7.180		0.493
		(5.365)		(0.667)
Pre-Program(t-9)		5.239		0.211
		(5.216)		(0.456)
Pre-Program(t-8)		6.449		0.657
		(4.540)		(0.609)
Pre-Program(t-7)		9.252*		0.354
		(4.798)		(0.577)
Pre-Program(t-6)		3.742		0.277
		(4.497)		(0.804)
Pre-Program(t-5)		2.098		0.416
		(6.047)		(0.687)
Pre-Program(t-4)		-0.918		-0.474
		(6.092)		(0.615)
Pre-Program(t-3)		-1.972		0.409
		(6.198)		(0.715)
Pre-Program(t-2)		-0.404		0.133
		(3.925)		(0.698)
Pre-Program(t-1)		2.822		0.337
		(4.966)		(0.957)
Post-Program(t+1)		6.691		-0.913
		(4.849)		(1.047)
Post-Program(t+2)		4.634		-1.106
		(4.859)		(0.862)
Post-Program(t+3)		5.993		-2.053**
		(6.116)		(0.902)
Post-Program(t+4)		17.69***		-1.397
		(6.729)		(0.858)
Post-Program(t+5)		29.79***		-1.632*
		(3.613)		(0.932)
Post-Program(t+6)		31.22***		-1.147
		(3.565)		(0.820)
Post-Program(t+7)		25.60***		-1.787*
		(4.483)		(0.954)
Post-Program(t+8)		24.70***		-2.453**
		(4.612)		(0.982)
Post-Program(t+9)		24.68***		-3.290**
		(4.454)		(1.369)
Post-Program(t+10)		24.61***		-3.468***
		(4.919)		(1.224)
Province Fixed	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES
Observations	1,613	1,613	1,613	1,613

Note: The effect at period t is set as zero, being the leads and lags coefficients estimated based on that. Robust standard errors (clustered by provinces) are reported in parentheses: *** p<0.01, ** p<0.05, * p<0.1

reducing CC mortality rate. More precisely, the implementation of the program reduced CC mortality rate by 1.939 deaths per 100,000 inhabitants. Again, based on this result, if the treated provinces had not been treated, the mean of CC mortality in treated provinces, for after treatment periods, would have been 25.779 deaths per 100,000 inhabitants (23.84 + 1.939). In relative terms, CC mortality rate decreased by 7.5% in treated provinces (1.939 / 25.779). The estimates from the augmented equation 8, columns one and three, also suggest that the parallel trend assumption is satisfied due to the fact that the Pre-Program indicator coefficient is not significantly different from zero. Thus, I can state that both treated and control regions were in parallel trends before the program implementation.

Estimates of equation 9, in even-numbered columns, confirm that the parallel trend assumption between treated and non-treated provinces is satisfied, being in line with the results from equation 8. The estimates from equation 9 also show the dynamics effect of the treatment. As a result, column two suggests that the effect of the program on hospitalisations starts to take place mainly after period four, where the coefficients appear to be strongly significant. In addition, it can also be observed that the magnitude of the coefficient starts to decrease in period seven and after, which could be a sign of preventions affecting the number CC hospitalisations, as mentioned in section 2,4. Regarding the dynamics of the reduced form effect, results suggest that the effect of the program significantly reduces mortality but only after the program has stayed in place for seven to ten periods, getting more negative the more time the program has stayed in place.

In figures 4 and 5 I plot the pre-treatment and treatment dynamics coefficients estimated in the even-numbered columns in table 2, as well as the 95% confidence intervals. By doing so, I provide a more visual representation of the evolution of the effect of the program over the years. As such, by looking at both figures, the parallel trend assumption can be observed to be satisfied as the coefficients fluctuate around the value of zero before it is implemented. The treatment dynamics effect can be observed to show an effect only after the implementation period.



Figures 4 and 5: First-Stage (Left) and Reduced Form Effect (Right)

7.2. Second-Stage

After having observed a clear first-stage and a reduced form effect, I present in table 3 the IV estimates of equation 10. This table is divided into two panels. In panel A, I present the causal relationship between hospitalisations and mortality and in panel B the effects of early detections and preventions on mortality. In the first panel, columns one to ten show the causal relationship between CC hospitalisations and current CC mortality rate as the program stays in place over time. In other words, in column one, the estimate will show the effect of hospitalisation on mortality when the program has stayed in place only during one period, whereas in column ten the estimate will show the effect of hospitalisation on mortality after the program has stayed in place for ten periods. By doing so, I can observe how past program implementations affect current hospitalisations and thus mortality over time, which will show the evolution of the causal effect of CC hospitalisations on CC mortality over the years.

All the estimates presented in Panel A of table 3 show a clear negative relationship between CC hospitalisations and CC mortality, suggesting that an increase in CC hospitalisations will reduce CC mortality rate. However, the estimates appear to be significant only for columns five to ten. The significance of the results is in line with first-stage effect findings due to the fact that, from the first-stage results, one could observe that the program showed significant effects on hospitalisation only after the fourth periods since its implementation. Hence, since causality goes from hospitalisations to mortality and not the other

way around, this would mean that the causal effect of hospitalisations on mortality should only be significant after that period. This hypothesis could also be validated by looking at the F-statistics value. For the IV to work the F-statistics required in the first-stage is usually suggested to be larger than 10 (Stock, Wright, and Yogo, 2002). As such, this is observed in columns four to ten, where the F-statistics ranges from 15 to 51. This suggests that the first-stage effect in the first three periods after the program was implemented was not strong enough, which would be a sign that the program took time to take-off, and that, hence, the causal effect should not show a significant effect in those periods.

By observing that there is not a significant strong effect of the program on hospitalisations in the first three periods since its implementation, I can say that there were not significant effects on early detections or preventions in those periods either. Thus, it is reasonable to assume that the early detection effect would start to appear after the third period, that is, only once the first-stage effect is significantly strong. Hence, by using the theoretical model described in the section 2.4. early detections would be the only channel through which the program would affect hospitalisations in periods four, five and six. That is, early detection effects would appear four to six years after the implementation of the program, and prevention effects after the seventh year. As a result, I could calculate the average effect of CC hospitalisations on mortality from periods four, five and six and define it as the early detection effect on mortality[3]. Consequently, the effect of preventions in periods seven to ten will be calculated by subtracting the previously estimated early detection effect from the overall hospitalisation effect.

These results can be observed in Panel B of table 3, where the average early detection coefficient is -0.0321 and the prevention coefficient gets larger over the years in columns seven to ten. As it can be seen, the coefficient goes from being close to zero in period seven, to -0.0414 in period ten. These coefficients show the causal relationship between a unit increase in early detections and preventions on mortality, measured in 100,000 inhabitants. As such, a unit increase in early detections would reduce mortality by 0.0321 deaths per 100,000 inhabitants. In other words, early detecting ten patients per 100.000 inhabitants would decrease

[3] The average early detection effect calculated from the coefficients of periods four, five and six after the implementation of the CC screening program, shown in columns four five and six, respectively, is robust to the inclusion of preceding periods to the analysis. Hence, using the coefficients from column three or earlier to calculate the average effect does not change the coefficient of the early detection effects significantly. Consequently, the early detection effect can be seen to be correctly specified.

Table 3: IV estimates: Estimated effect of Colon Cancer Hospitalisations, Early Detections and Preventions on Colon Cancer Mortality Rate.

Dependent Variables	(1) Colon Cancer Mortality (n=1)	(2) Colon Cancer Mortality (n=2)	(3) Colon Cancer Mortality (n=3)	(4) Colon Cancer Mortality (n=4)	(5) Colon Cancer Mortality (n=5)	(6) Colon Cancer Mortality (n=6)	(7) Colon Cancer Mortality (n=7)	(8) Colon Cancer Mortality (n=8)	(9) Colon Cancer Mortality (n=9)	(10) Colon Cancer Mortality (n=10)
IV estimates: Older than 50 years old.										
Panel A										
Colon Cancer Hospitalisations	-0.0382 (0.0525)	-0.0323 (0.0524)	-0.0214 (0.0510)	-0.0312 (0.0371)	-0.0349* (0.0191)	-0.0304** (0.0132)	-0.0351** (0.0165)	-0.0449** (0.0203)	-0.0600** (0.0270)	-0.0735** (0.0326)
Kleibergen-Paap rk Wald F statistic	4.090	4.412	6.868	15.335	35.790	38.535	48.578	54.169	51.353	51.988
Panel B										
Early Detection (Average effect: n = 4, 5 and 6)	-0.0321	-0.0321	-0.0321	-0.0321	-0.0321	-0.0321	-0.0321	-0.0321	-0.0321	-0.0321
Prevention	-	-	-	-	-	-	-0.003	-0.0128	-0.0279	-0.0414
Province Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,613	1,613	1,613	1,613	1,613	1,613	1,613	1,613	1,613	1,613
R-square	0.824	0.828	0.835	0.829	0.826	0.829	0.826	0.818	0.805	0.824

Robust standard errors (clustered by province) are reported in parentheses
*** p<0.01, ** p<0.05, * p<0.1

CC mortality rate by 0.321 deaths per 100,000 inhabitants. Thus, if the average CC deaths in treated provinces for post treatment periods is 23.84 deaths per 100,000 inhabitants, increasing early detected patients by ten would help reducing CC mortality by 1.35% (0.321 / 23.84). From preventions side, increasing preventions by one patient per 100,000 inhabitants would result in a decrease in CC mortality ranging from -0.003 to -0.0414 deaths per 100,000 inhabitants depending on how long the program has stayed in place. In other words, if ten patients per 100,000 inhabitants were prevented, CC mortality would be reduced by 0.03 to 0.41 deaths per 100,000 inhabitants. In relative terms this would result in decreasing CC mortality rate between 0.126% and 1.72% (0.03 / 23.84; 0.41 / 23.84). To sum up, increasing early detections and preventions by ten patients per 100,000 inhabitants would result in a reduction of CC mortality rate from 1.48% to 3.07%.

By looking at the changes in the number of hospitalisations over the years between the treatment and control group, I calculate the overall effects early detections and preventions have on mortality. These effects are calculated from the IV estimates in table 3. I first start with the early detection effect and then with the prevention effect. Firstly, in the first stage, it is shown that CC hospitalisations increased by around 30 hospitalisations per 100,000 inhabitants in the treatment group in periods five and six, that is, when early detections were driving the changes in the number of hospitalisations uniquely. These 30 units increase in hospitalisations, or, as defined, in early detections, would reflect a reduction in CC mortality rate by 1.02 deaths per 100,000 inhabitants (30 x 0.034). Secondly, also from the first stage, one can observe that from periods six to ten, there is a decrease in five hospitalisations per 100,000 inhabitants, which, as stated, it could be explained by the increase in the number of preventions. Thus, increasing the number of prevented patients by five would be translated into a reduction of 0.207 deaths per 100,000 inhabitants (5 x 0.0414). To sum up, after being the program implemented for ten years, early detections and preventions would jointly reduce CC mortality rate by 1.246 deaths per 100,000 inhabitants. In relative terms, reducing CC mortality by 1.246 deaths per 100,000 inhabitants translates into a 5.7% reduction in CC mortality over the mean (1.246 / 21.901).

These last results, however, do not coincide with the reduced form estimates in table 2, column four. Here, while the reduced form effect predicted a decrease in 3.468 deaths per 100,000 inhabitants after ten years, in the previous analysis results predicted a reduction of 1.266 deaths per 100,000 inhabitants. This difference can be driven from the assumption that early detections did not increase after period six, and that they remained constant in 30 hospitalisations per 100,000 inhabitants. As such, I also assumed preventions to be around five

hospitalisations per 100,000 inhabitants (Table 4, panel A). Nevertheless, these assumptions are not likely to hold due to the fact that the program continuously increases the number of people screened over the years. In order to solve this problem, I propose the early detection and prevention dynamics presented in panel B of table 4.

Table 4: Early Detections and Preventions Effect on Mortality

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Fixed Early Detected Cases						
	Colon Cancer Hospitalisations			Colon Cancer Mortality		
Periods	First-Stage Effect	Preventions	Early Detections	Estimated Effect	Reduced Form Effect	Difference
5	29.79	0	29.79	-1.01286	-1.632	-0.61914
6	31.22	0	31.22	-1.06148	-1.147	-0.08552
7	25.60	4.40	30.00	-1.20516	-1.787	-0.58184
8	24.70	5.30	30.00	-1.24242	-2.450	-1.20758
9	24.68	5.32	30.00	-1.24325	-3.290	-2.04675
10	24.61	5.39	30.00	-1.24615	-3.468	-2.22185
Panel B: Potential Dynamics						
	Effect on Colon Cancer Hospitalisations			Effect on Colon Cancer Mortality		
Periods	First-Stage Effect	Preventions	Early Detections	Estimated Effect	Reduced Form Effect	Difference
5	29.79	0	29.79	-1.01286	-1.632	-0.61914
6	31.22	0	31.22	-1.06148	-1.147	-0.08552
7	25.60	22.40	48.00	-1.70400	-1.787	-0.08300
8	24.70	35.30	60.00	-2.49784	-2.450	0.04784
9	24.68	40.32	65.00	-3.30514	-3.290	0.01514
10	24.61	35.39	60.00	-3.51115	-3.468	0.043146

As mentioned before in table 3, preventions did not show any effect in periods five and six due to the fact that early detections were the only channel through which the introduction of the program affected the number of hospitalisations. Thus, according to this hypothesis, the estimated effect of hospitalisations on mortality for those periods would have to be the same as the reduced form effect on mortality. To demonstrate that, in table 4, I calculate the overall

effect early detections have on mortality in those periods. For that, I multiply the early detections coefficient, that is, -0.0321, by the number of CC hospitalisations presented in column four. These calculations, in column five, show that the estimated effect early detections have on mortality is not significantly different from the reduced form effect for the periods five and six. Thus, there is evidence to defend the hypothesis that early detections were the only channel through which the program affected the number in hospitalisations in those periods. In panel B, I present a potential early detection and prevention dynamics, that, with the estimates in table 3, I can use to calculate the effect early detections and preventions have on mortality. As a result, I can observe that if early detections and preventions followed the dynamics presented in columns three and four, the estimated effects and reduced form effects in periods seven to ten would coincide. These dynamics would show an increasing number of preventions over the years, as expected.

8. Robustness Check: Placebo Test

Checking for parallel trends assumption is crucial for determining that there are not biases in the estimates. This assumption has been proved to hold in both the first stage and reduced form models. However, there might still be shocks in treated provinces, which could create some bias in the results, that were not accounted at the moment of testing the parallel trends assumption. For example, it could be the case that the provinces that implemented the program had a stronger budget that also helped with the expansion of other related programs, causing an upward bias in the results. One example would be that these provinces could have implemented campaigns to raise awareness about the importance of having a healthy lifestyle and reduce future colon cancer development. Therefore, in order to observe for these potential biases, I provide a placebo test. More concretely, I estimate the same 2SLS model as in equation 10 but for the population that was not targeted by the program, that is, for people under 50. Thus, I would expect to find an effect on those under 50 years old if any other related program had been implemented. If such an effect was found, then results could be overestimated.

Table 5 presents the regression estimates for those younger than 50 years old. Following table 3, columns one to ten show the causal relationship between CC hospitalisations and current CC mortality rate as the program stays in place over time. Results show that for those younger than 50, there is not any significant estimate supporting that the causal relationship between CC hospitalisations and CC mortality rate is different from zero. Hence, with this placebo test I can show that there are not underlying effects that could have driven the results in table 3.

In conclusion, these results, as well as the tests that justify the assumption that regions introducing the program were on parallel trends with respect to the other regions in the pre-treatment period, show that the estimates determining the causality between early detections and preventions on mortality are robust.

Table 5: Robustness Check: Estimated effect of Colon Cancer Hospitalisations on Colon Cancer Mortality Rate. Not Targeted Population: < 50 years old.

Dependent Variables	(1) Colon Cancer Mortality (n=1)	(2) Colon Cancer Mortality (n=2)	(3) Colon Cancer Mortality (n=3)	(4) Colon Cancer Mortality (n=4)	(5) Colon Cancer Mortality (n=5)	(6) Colon Cancer Mortality (n=6)	(7) Colon Cancer Mortality (n=7)	(8) Colon Cancer Mortality (n=8)	(9) Colon Cancer Mortality (n=9)	(10) Colon Cancer Mortality (n=10)
IV estimates: Younger than 50 years old.										
Colon Cancer Hospitalisations	0.127	0.162	0.160	0.0174	-0.0136	-0.0858	-0.136	-0.207	-0.202	-0.0998
	(0.156)	(0.181)	(0.166)	(0.0721)	(0.0631)	(0.0918)	(0.123)	(0.148)	(0.154)	(0.0767)
Province Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,613	1,613	1,613	1,613	1,613	1,613	1,613	1,613	1,613	1,613
R-square	0.065	0.063	0.063	0.070	0.071	0.072	0.072	0.070	0.070	0.072

Robust standard errors (clustered by province) are reported in parentheses
*** p<0.01, ** p<0.05, * p<0.1

9. Potential Mechanism

As it was mentioned several times in the paper, the main two objectives of the program are to increase the number of early detected and prevented colon cancer cases, which would lead to a lower colon cancer mortality. Therefore, in this section, I explore one of the mechanism through which early detections might be successful at reducing mortality: the severity of the cancer. The reason for analysing this cannel is because cancers would be detected in an earlier stage and, thus, in a less severe condition. Preventions, however, would not cause any impact on the severity of the cancer since they would just prevent people from getting cancer. To perform this analysis, I estimate the causal effect colon cancer hospitalisations have on the days hospitalised. In this case, the days a patient stays hospitalised will act as a proxy for the severity of the cancer, meaning that the less severe the cancer the shorter the stays at the hospital. From this, I would expect two results: first, early detections would reduce the number of days a patient stays hospitalised since the severity is reduced, and second, preventions would not show any effect on the number of days a patient stays hospitalised.

Results are reported in table 6 and are estimated from equation 10, but by changing the dependent variable to be the days hospitalised. Table 6 is presented in line with tables 3 and 4, meaning that columns one to ten show the causal relationship between CC hospitalisations and the days patients remain hospitalised as the program stays in place over time. Results show that there is a negative and significant relationship in columns six to ten. This negative relationship only appears after the program positively and significantly affected the number of hospitalisations in the first-stage. Thus, an increase in hospitalisations reduces the number of days a patient stays in the hospital. These results are in line with previously presented hypothesis due to the fact that early detections would be driving the changes in the number of hospitalisations in the first periods. Therefore, the negative relationship between CC hospitalisations and the number of days hospitalised in periods five to seven is driven by early detections. Moreover, from these results I can also observe that the effect early detections have on the severity of the cancer depends on how long the program has stayed in place. This is due to the fact that early detections in the first periods will not be comparable to early detections later on. In the first periods, early detected cases will be more severe and, thus, might not show

big reductions in the days hospitalised as in the periods after. Therefore, the effect on the days hospitalised could vary with time. Finally, I also observe that from columns eight to ten coefficients remain constant, which by looking at table 3, they correspond to the periods when preventions started to show an effect. Hence, this evidence demonstrates that preventions did not contribute to the reduction in the days patients remained hospitalised.

By looking at the estimates, an increase in early detections significantly reduces the number of days hospitalised between 0.041 and 0.063 days depending on how long the program has stayed in place. From those, the highest negative effect corresponds to columns eight to ten, that is, when the program has stayed in place for eight to ten years. Thus, if the average days a patient stays at a hospital in treated provinces for post treatment periods is 13.601 days, increasing early detected patients by ten would help reducing the number of days by 3% to 4.6% (0.41 / 13.601; 0.63 / 13.601).

These results, again, remain dependent on the parallel trend assumption mentioned in the previous analyses. To provide evidence that the results reported in table 5 are in line with this assumption, I present in the appendix table 2 the reduced form effect of the program on the days hospitalised. These results show that before the policy implementation the values are not significantly different from zero, meaning that both treatment and control group were in parallel trend before the program implementation. Therefore, by demonstrating that both the first stage and the new reduced form have parallel trends, the estimates presented in table 6 are valid.

Finally, in the second part of the table, I present the same estimates but for those younger than 50 years old. Therefore, in this part, I test for a placebo in order to determine whether there were effects where they should not be. From these results, one can observe that the coefficients reported are not significantly different from zero for all the columns. Consequently, this placebo test shows that the results presented in the first part of the table, that is, for those in the target population, are robust.

Table 6: Estimated effect of Colon Cancer Hospitalisations on Days Hospitalised.

Dependent Variables	(1) Days Hospitalised (n=1)	(2) Days Hospitalised (n=2)	(3) Days Hospitalised (n=3)	(4) Days Hospitalised (n=4)	(5) Days Hospitalised (n=5)	(6) Days Hospitalised (n=6)	(7) Days Hospitalised (n=7)	(8) Days Hospitalised (n=8)	(9) Days Hospitalised (n=9)	(10) Days Hospitalised (n=10)
IV estimates: Older than 50 years old.										
Colon Cancer Hospitalisations	0.0801	0.0933*	0.0961	0.0424	-0.0190	-0.0410**	-0.0538***	-0.0623***	-0.0663***	-0.0665**
	(0.0519)	(0.0563)	(0.0588)	(0.0322)	(0.0207)	(0.0179)	(0.0196)	(0.0226)	(0.0246)	(0.0268)
Kleibergen-Paap rk Wald F statistic	4.090	4.412	6.868	15.335	35.790	38.535	48.578	54.169	51.353	51.988
IV estimates: Younger than 50 years old.										
Colon Cancer Hospitalisations	0.0877	0.0786	0.0685	-0.0141	-0.0193	-0.0597	0.00694	0.0191	0.103	0.218
	(0.630)	(0.657)	(0.620)	(0.372)	(0.254)	(0.208)	(0.188)	(0.174)	(0.186)	(0.204)
Province Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,613	1,613	1,613	1,613	1,613	1,613	1,613	1,613	1,613	1,613

Robust standard errors (clustered by province) are reported in parentheses
*** p<0.01, ** p<0.05, * p<0.1

10. Discussion and Conclusion

The increasing number of colon cancer diagnosis during the last decades has led to an upward evolution of colon cancer related mortality and to an increase in the number of colon cancer hospitalisations. These effects also implicitly reflect continuous increases in the health care expenditures over the years. As a result, with this paper, I try to motivate the importance the introduction of colon cancer screening programs might have at reducing colon cancer mortality rate, which at the same time could be translated into lower health care expenditures.

In this paper, I examine whether the introduction of CC screening programs in Spain in the 2000s reduced CC mortality rate. Moreover, I further analyse the key role colon cancer early detections and preventions have on reducing mortality rate. For that, I use individual level data on mortality and morbidity provided by the INE, which I use to calculate CC mortality and hospitalisation rate for the provinces that implemented and did not implement the program before 2010. To estimate the impact of the introduction of the program on colon cancer mortality rate I use a generalised differences-in-differences method. In this model, the introduction of the CC screening program is taken as a treatment variable that measures the impact of the program on mortality. To estimate the key roles early detections and prevention have on mortality reduction I use an instrumental variable approach. Here, the introduction of the CC screening program is used as an exogenous shock in CC hospitalisations that will show the causal effect of hospitalisations on mortality rate. As a result, and from the theoretical model explained before, I break down the effect of CC hospitalisation on mortality in early detections and preventions effects.

Results suggest that there is a negative and significant effect of the introduction of the program on CC mortality rate. More concretely, there is a cumulative reduction of 1.94 deaths per 100,000 inhabitants. By observing treatment dynamics, the estimates indicate that the greatest effects are driven the longer the program has been in place. From this, I observe that the reduction in CC mortality rate is the largest once the program has stayed in place for eight to ten years. Regarding early detection and prevention effects, I estimate that early detections reduce colon cancer mortality by 0.034 deaths per 100,000 inhabitants, whereas preventions reduce colon cancer mortality up to 0.041 deaths per 100,000 inhabitants. Preventions show a

larger effect the longer the program has stayed in place. In relative terms, increasing the number of early detections and preventions by ten patients per 100,000 inhabitants could result in a reduction of CC mortality rate from 1.48% to 3.07%. Finally, I also analyse one of the main potential mechanism through which the program affects colon cancer mortality rate. This mechanism, measured in the days a patient stays hospitalised, shows the importance early detections have at reducing the severity of the cancer. Results suggest that early detections successfully helped reducing the severity of the cases. More concretely, early detecting ten patients would reduce the number of stays at the hospital by 0.6 days.

These results demonstrate that the effectiveness of FOBTs presented in the literature is reflected in the program outcomes. This was one of the main concerns at the moment of implementing state level screening programs due to the fact that results could have been in line with Kim & Lee (2017), and show that effective screening techniques would not always lead to successful screening programs. Thus, in this case, the implementation of CC screening programs, as health policies, result in effective reductions on mortality. Moreover, the negative relationship between CC hospitalisations and CC mortality shows that a greater number of hospitalisations results in a lower mortality rate. Therefore, this would determine that the CC screening program is still in the first phase. Being in the second phase would mean that a decrease in the number of hospitalisations would result in a reduction in mortality, which would happen once the effect of preventions was larger than the effects of early detections. Finally, the negative effect of the program on the severity of the cancers shows that CC screening programs would also reduce health care expenditures, since, as mentioned by Corral et al., (2015) the early detection of a cancer results in reductions of treatment costs.

When analysing these results, one must bear in mind that they may lack from external validity and that the effects may not be extrapolated to other cancer screening programs. Each cancer is different and so they are the screening techniques. Hence, I would not expect the same effects for, in example, breast cancer or cervical cancer screening programs. This paper, however, proves that the introduction of CC screening programs is successful in reducing CC mortality, giving arguments to the population to participate in the program. As a final point, and in line with the previous argument, I would like to stress the importance of screening. Thus, future policies should be focused on incentivising people to participate in the program. It is relatively easy to take preventive measures for detecting pre-cancerous polyps, which can be easily removed if detected. Therefore, increasing the awareness about the huge benefits taking

part in the program has and minimising the taboos or embarrassments the process can create is essential for increasing the participation and, consequently, reducing CC mortality rate.

References

Bezerra-de-Souza, D. L., Bernal, M. M., Gómez, F. J. & Jorge Gómez, G. (2012). Predictions and Estimations of Colorectal Cancer Mortality, Prevalence and Incidence in Aragon, Spain, for the Period 1998-2022, *Revista Española de Enfermedades Digestivas*, vol. 104, no. 10, pp.518–523.

Bitler, M. P. & Carpenter, C. S. (2016). Health Insurance Mandates, Mammography, and Breast Cancer Diagnoses, *American Economic Journal: Economic Policy*, vol. 8, no. 3, pp.39–68.

Castells, X., Sala, M., Ascunce, N., Salas, D., Zubizarreta, R. & Casamitjana, M. (2007). Descripción Del Cribado Del Cáncer En España, *Proyecto DESCRIC. Madrid: Plan de Calidad Para El Sistema Nacional de Salud. Ministerio de Sanidad y Consumo. Agència d'Avaluació de Tecnologia i Recerca Mèdiques de Cataluña*, Available Online: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Descripción+del+cribado+del+cáncer+en+España#0.

Corral, J., Borràs, J. M., Chiarello, P., García-Alzorriz, E., Macià, F., Reig, A., Mateu de Antonio, J., Castells, X. & Cots, F. (2015). Estimación Del Coste Hospitalario Del Cáncer Colorrectal En Cataluña, *Gaceta Sanitaria*, vol. 29, no. 6, pp.437–444.

Council European Union. (2003). Council Recommendation of December 2003, Available Online: https://ec.europa.eu/jrc/sites/jrcsh/files/2_December_2003 cancer screening.pdf.

Eguino Villegas, A., Fernández Crespo, A. I., Fernández Sanchez, B., García Álvarez, G. & Pascual Fernández, C. (2012). Cáncer Colorrectal. Una Guía Práctica, Available Online: www.aecc.es.

Grau, J. & Castells, A. (2014). Programas de Detección Precoz Del Cáncer Colorrectal: Un Reto de Integración y Calidad Asistencial, *Revista de Calidad Asistencial*, vol. 29, no. 4, pp.185–187.

Hardcastle, J. D., Chamberlain, J. O., Robinson, M. H. E., Moss, S. M., Amar, S. S., Balfour, T. W., James, P. D. & Mangham, C. M. (1996). Randomised Controlled Trial of Faecal-

Occult-Blood Screening for Colorectal Cancer, *Lancet*, vol. 348, no. 9040, pp.1472–1477.

Heitman, S. J., Hilsden, R. J., Au, F., Dowden, S. & Manns, B. J. (2010). Colorectal Cancer Screening for Average-Risk North Americans: An Economic Evaluation, *PLoS Medicine*, vol. 7, no. 11.

Howard, D. H. (2005). Life Expectancy and the Value of Early Detection, *Journal of Health Economics*, vol. 24, no. 5, pp.891–906.

Instituto Nacional de Estadística. (2019). Estadística de Defunciones Según La Causa de Muerte.

Kadiyala, S. & Strumpf, E. (2016). How Effective Is Population-Based Cancer Screening? Regression Discontinuity Estimates from the US Guideline Screening Initiation Ages, *Forum Health Econ Policy.*, vol. 19, no. 1, pp.87–139.

Kim, H. B. & Lee, S. mi. (2017). When Public Health Intervention Is Not Successful: Cost Sharing, Crowd-out, and Selection in Korea's National Cancer Screening Program, *Journal of Health Economics*, [e-journal] vol. 53, pp.100–116, Available Online: http://dx.doi.org/10.1016/j.jhealeco.2017.02.006.

Kronborg, O., Fenger, C., Olsen, J., Jørgensen, O. D. & Søndergaard, O. (1996). Randomised Study of Screening for Colorectal Cancer with Faecal-Occult-Blood Test, *Lancet*, vol. 348, no. 9040, pp.1467–1471.

López-Abente Ortega, G., Pollán Santamaría, M., Aragonés Sanz, N., Pérez Gómez, B., Valentín Hernández, B., Lope Carvajal, V., Suárez Rodríguez, B. & Cárdaba Arranz, M. (2005). La Situación Del Cáncer En España.

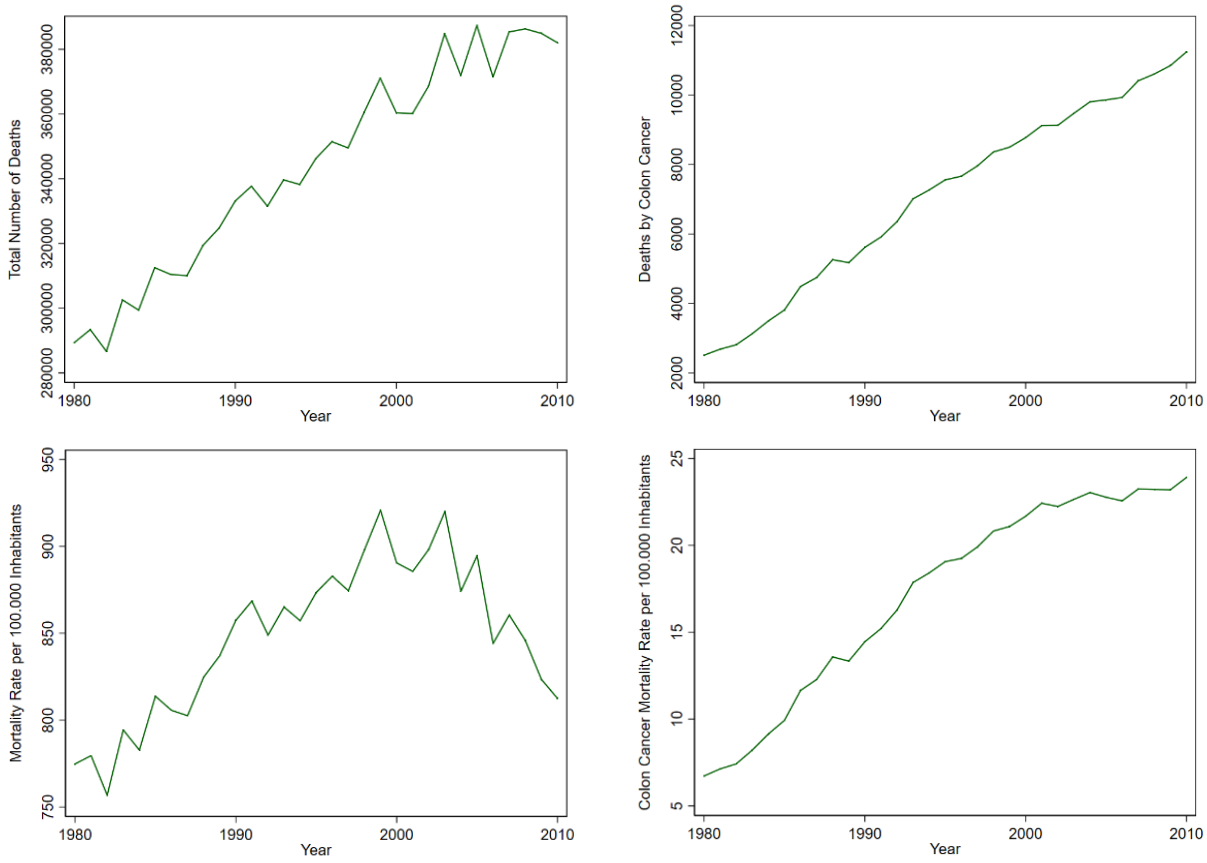
Mandel, J. S., Bond, J. H., Church, T. R., Snover, D. C., Bradley, G. M., Schuman, L. M. & Ederer, F. (1993). Reducing Mortality from Colorectal Cancer by Screening for Fecal Occult Blood, *New England Journal of Medicine*, [e-journal] vol. 328, no. 14, pp.977–986, Available Online: http://content.nejm.org/cgi/content/abstract/329/14/977%5Cnhttp://www.nejm.org/doi/abs/10.1056/NEJM199309303291401.

Red de Programas de Cribado de Cáncer. (2017). Evaluación Programas de Cribado de Cancer Colorrectal.

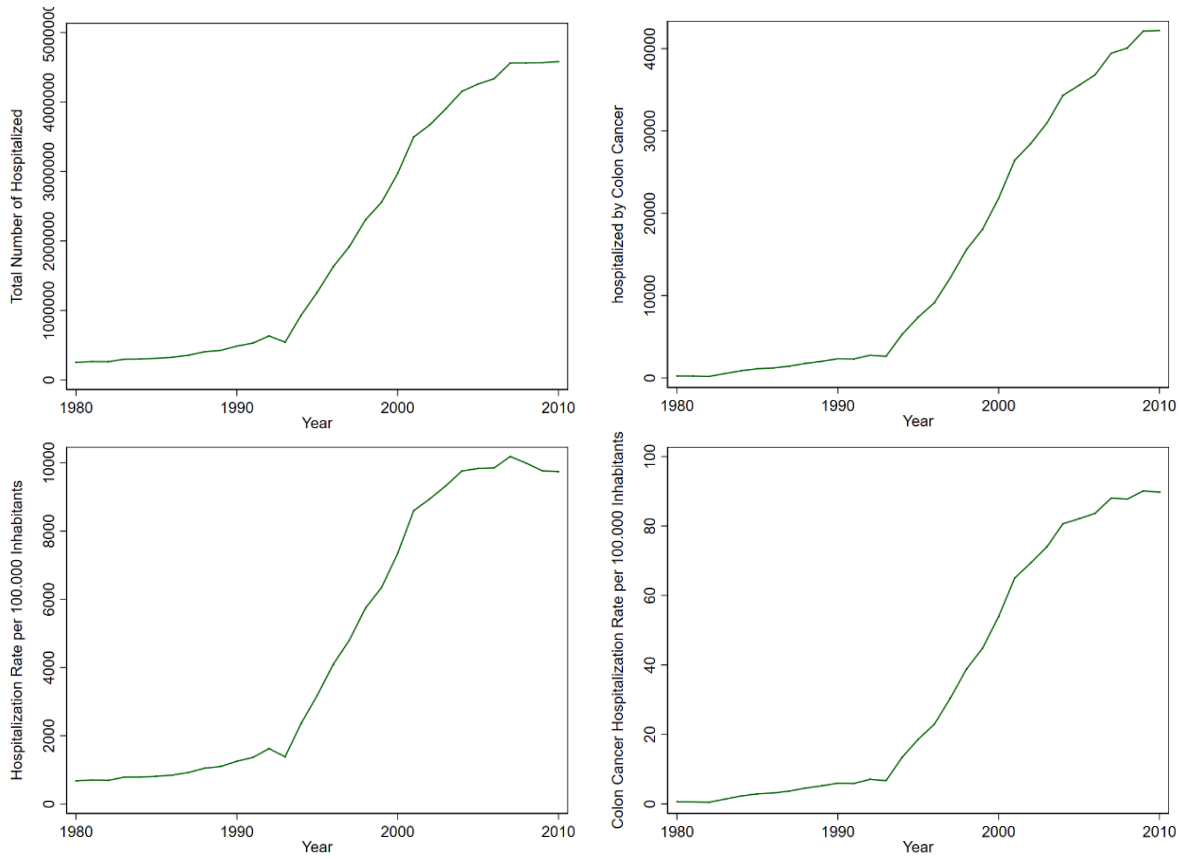
Salas Trejo, D., Sala Felis, T., Málaga López, A., Pérez Sanz, E., Goicoechea Sáez, M., Molina Barceló, A., Alberich Martí, C., Torrella Ramos, A. & Ponce Romero, M. (2012). Programa de Prevención de Cáncer Colorrectal de La Comunitat Valenciana.

Stock, J. H., Wright, J. H. & Yogo, M. (2002). A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments, *Journal of Business and Economic Statistics*, vol. 20, no. 4, pp.518–529.

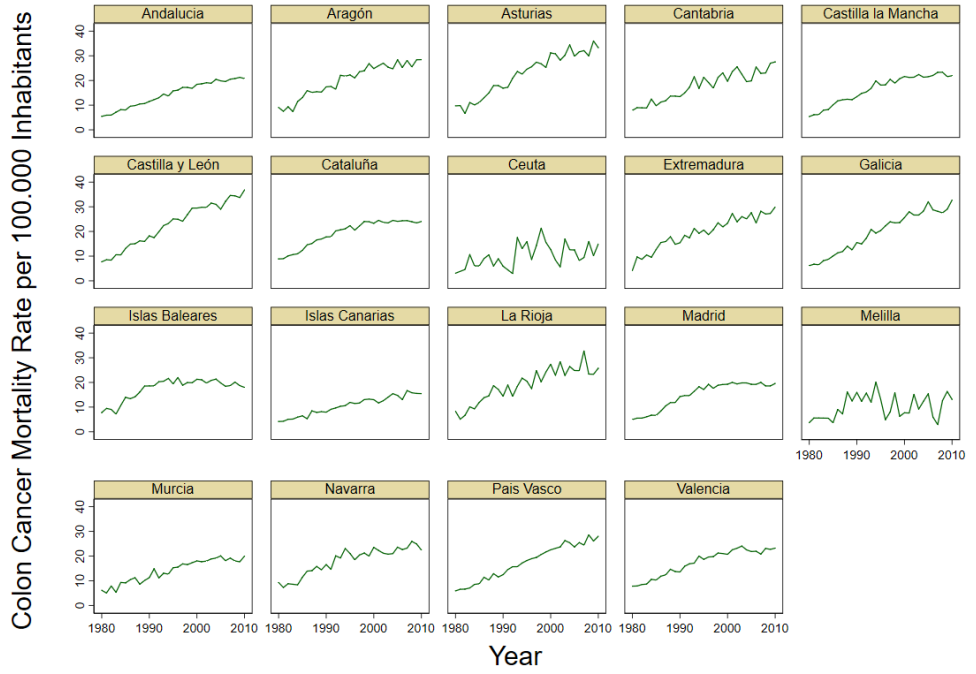
Appendix

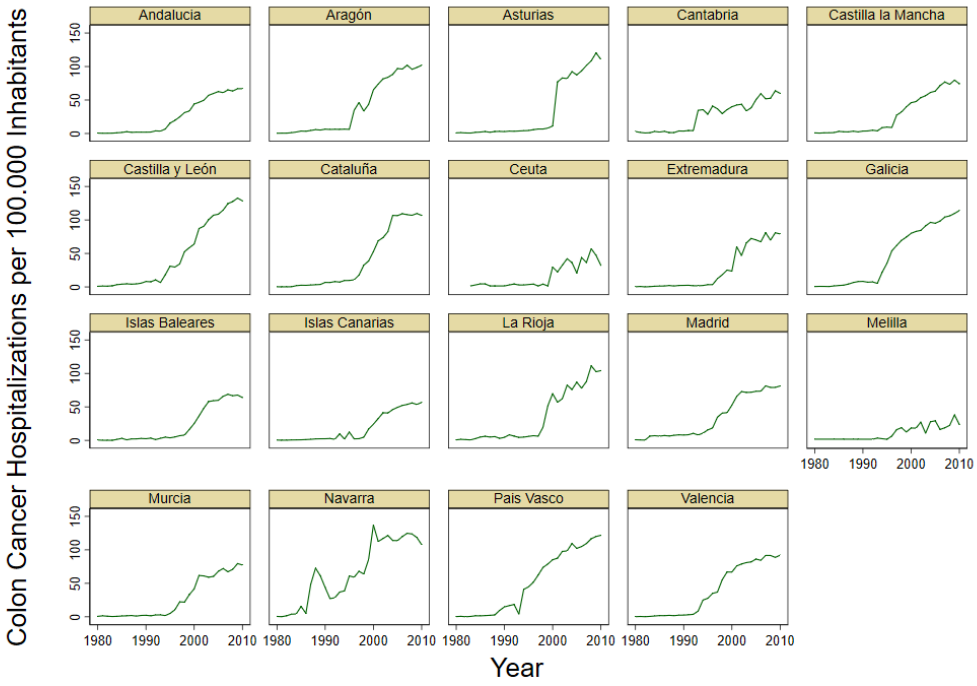


Appendix Figures 1 to 4: Yearly data on: Absolute Number of Deaths (Top Left), Absolute Number of Deaths by Colon Cancer (Top Right), Total Mortality Rate (Bottom Left) and Colon Cancer Mortality Rate (Bottom Right).



Appendix Figures 5 to 8: Yearly data on: Absolute Number of Hospitalisations (Top Left), Absolute Number of Hospitalisations by Colon Cancer (Top Right), Total Hospitalisation Rate (Bottom Left) and Colon Cancer Hospitalisation Rate (Bottom Right).





Appendix Figures 9 and 10: Yearly Data on Regional Colon Cancer Mortality Rate (Top) and Colon Cancer Hospitalisation Rate (Bottom)

Appendix Table 1: Treatment Group: Before and After the Implementation of the Program

Dependent Variable	(1) Before Treatment	(2) After Treatment	(3) Treatment Effect	(4) Counterfactual	(5) Percentage Change
CC Mortality Rate	16.07	23.84	-1.939	25.779	-7.52%
	(5.85)	(3.59)	(0.891)		
CC Hospitalisation Rate	26.37	84.15	14.22	69.93	20.33%
	(32.43)	(25.37)	(7.267)		
Days of Stay at Hospital	20.63	13.60	-2.156	15.756	-13.68%
	(8.39)	(1.56)	(1.275)		
Observations	364	70	-	-	-

Note: Columns 1 and 2 show the mean and std. Deviation (in parenthesis) of the variables before and after the implementation of the programs. Column 3 shows the coefficients and std. errors of the treatment effects estimated from the augmented equation 8. Column 4 shows the counterfactual estimates, which are calculated by subtracting the treatment effect value from column 3 with the mean from column 2. Column 5 shows the percentage change from the counterfactual values and the after-treatment values.

Appendix Table 2: Estimated effect of the Colon Cancer Screening Program Implementation on Days Hospitalised

Dependent Variable	(1) Days Hospitalised	(2) Days Hospitalised
Pre-Program	-1.060	
	(1.052)	
Post-Program	-2.156*	
	(1.275)	
Pre-Program(t-10)		-1.148
		(0.913)
Pre-Program(t-9)		-1.535*
		(0.921)
Pre-Program(t-8)		-0.208
		(0.856)
Pre-Program(t-7)		0.205
		(1.036)
Pre-Program(t-6)		0.145
		(0.723)
Pre-Program(t-5)		-1.138
		(1.001)
Pre-Program(t-4)		-1.006
		(1.174)
Pre-Program(t-3)		-0.767
		(0.765)
Pre-Program(t-2)		-1.692
		(1.051)
Pre-Program(t-1)		-1.629*
		(0.939)
Post-Program(t+1)		-2.017*
		(1.188)
Post-Program(t+2)		-2.027*
		(1.081)
Post-Program(t+3)		-1.174
		(1.039)
Post-Program(t+4)		-1.763
		(1.147)
Post-Program(t+5)		-3.193***
		(0.959)
Post-Program(t+6)		-2.320***
		(0.810)
Post-Program(t+7)		-2.565***
		(0.941)
Post-Program(t+8)		-2.351**
		(0.931)
Post-Program(t+9)		-1.902**
		(0.802)
Post-Program(t+10)		-1.557*
		(0.905)
Province Fixed Effects	YES	YES
Year Fixed Effects	YES	YES
Observations	1,613	1,613

Robust standard errors (clustered by provinces) are reported in parentheses
*** p<0.01, ** p<0.05, * p<0.1