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Are Cancer Survivors who are Eligible for Social Security More Likely to Retire than Healthy Workers? Evidence from Difference-in-Differences

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ABSTRACT

Despite the fact that there are over a million new cancer cases detected in the U.S. every year, none of retirement-health literature focuses specifically on the effect that cancer has on retirement. Social Security may offer a pathway to retirement for eligible workers but the separate effects of both cancer, and Social Security, on retirement, need to be accounted for. I use the fact that some workers will be eligible for Social Security when they are diagnosed with cancer, while some will not, as a source of exogenous variation to identify the joint effect of cancer diagnosis and Social Security eligibility on retirement. With data from the Health and Retirement Study (HRS), I use a difference-in-differences model to show that being eligible for Social Security, and surviving cancer, increases the probability of retirement by 11.2% for male workers. Given the increase in both cancer survival rates, and the number of older workers in the labour force, it is important to know if cancer is causing permanent exits, in a population who otherwise would continue working.

Keywords: Cancer; Employment; Retirement; Labour market

JEL classification: I10, I18, J21, J26

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1. INTRODUCTION

While the literature surrounding the effects of health shocks on retirement is large and comprehensive, very little is known about how cancer affects the decision of workers to retire. Knowing the specific impact that cancer has on retirement is significant for two main reasons. The first reason is the sheer quantity of diagnoses. Each year, there are approximately 1.7 million new cancer cases detected (American Cancer Society, 2014a). For comparison, every year 735,000 Americans have a heart attack, while 795,000 have a stroke (American Heart Association, 2015). Even taken together, this lags some 200,000 cases behind new cancer diagnoses. The second reason is that more of the at-risk cancer group are now working. The percentage of the labour force made up of older workers (55 and older) is growing, and is predicted to be 25% by 2020 (Bureau of Labor Statistics, 2012). Since old age is one of the main risk factors in developing cancer, and the percentage of the labour market composed of older workers is growing, this will lead to an increase in the number of cancer cases being detected among workers who are considering retirement. It is important to know if cancer is causing permanent exits from the labour force in a population who otherwise would continue working.

For workers who survive cancer diagnosis, the availability of Social Security may offer an important pathway to retirement. However, estimating the effect that Social Security has in aiding cancer survivors to retire is likely to prove difficult. To begin with, eligibility for Social Security is also expected to make healthy workers retire, thus masking the effects that it has in helping cancer survivors to retire. In addition, cancer survivors who are not eligible for Social Security may be retiring as well, and Social Security may not induce any extra retirements over and above this. Ultimately, the question of whether cancer survivors, who

are eligible for Social Security, are more likely to retire than eligible healthy workers, or ineligible survivors, will have to be answered empirically.

I use the fact that some workers will be eligible for Social Security when they are diagnosed with cancer, while some will not, as a source of exogenous variation to identify the joint effect on cancer diagnosis and Social Security eligibility on retirement. While one would expect cancer diagnosis to be correlated with unobserved variables, if the cancer related unobservables are the same for both the eligible and ineligible workers, a difference-in-differences estimator should give an unbiased estimate of the joint effect. Using data from the Health and Retirement Study, I find that men who are diagnosed with cancer, and who are eligible for Social Security, are 11.2% ($p<0.01$) more likely to retire than control respondents who are eligible for Social Security. They also work 5.3 fewer hours ($p<0.01$) per week. The respondents who do return to employment, work 2.5 fewer hours ($p<0.1$) per week. These effects are larger for full-time workers and robust to numerous other types of analysis.

Given the popularity of the health-retirement nexus as a research topic, it is perhaps surprising that there is a dearth of studies specifically focusing on the effect of cancer on retirement, with only a study by Markowski (2010) finding that male cancer survivors were less likely to retire than their healthy counterparts. Even with regards to general employment measures, such as working and hours of work, there are only a handful of studies which focus on the effect of cancer on labour market outcomes for U.S. men. Bradley et al. (2005) and Bradley et al. (2007) show that older men (mean age of 56), who been diagnosed with prostate cancer are less likely to work, and work fewer hours, in the 6 months following prostate cancer diagnosis than healthy controls. These effects are not present at 12 and 18 months after diagnosis. For older workers (aged 55 to 65), there seem to be no long-term

adverse consequences. Short et al. (2008) shows that, between two to six years after diagnosis, there is no significant difference in employment or hours of work for male cancer free survivors versus healthy workers, though they are less likely to work full-time. The longer term impact for younger workers is less favourable, however, with Moran et al. (2011) showing that survivors (mean age of 45) are less likely to be employed than control subjects, in the two to six years following diagnosis.

This paper fills a gap in the literature by providing a specific estimate of the effect on cancer on retirement. If cancer survivors are more likely to retire once Social Security becomes available, then it could be indicative of a permanent reduction in the stock of health. This means that the cancer survivors who can't retire because of Social Security ineligibility may be risking further health complications by returning to work. Given the lack of studies focusing on the retirement behaviour of cancer survivors, and the potential increase in the number of cases that will be detected in the work force in the future, these results should be of interest to all parties in the labour market. Also, unlike every other paper that examines the effect of cancer on labour supply, I provide an estimate which does not rely on the selection on observables assumption.

The rest of the paper is organised as follows. In Section 2, I discuss the ways in which cancer and Social Security affect labour supply. Sections 3 and 4 contain information on the data and the methodology used. In Section 5, I present the main results of the analysis. Section 6 examines how the effect changes when looking at different subgroups. Section 7 presents the results of two falsification tests. Finally, in Section 8, I offer some explanation of the mechanism through which the interaction between cancer and Social Security affects labour supply and provide evidence to support the theory. Section 9 then concludes.

2. RETIREMENT, SOCIAL SECURITY AND CANCER

Assessing the impact that cancer may have on retirement is theoretically ambiguous. In a simple consumption-leisure model of labour supply, workers who have survived cancer may now find that their consumption bundle requires the purchase of certain cancer related goods to maintain their health status. This has the same effect as a decrease in the wage rate because, by having to purchase extra goods, consumers can no longer afford their old consumption bundle. This moves the cancer survivors to a lower indifference curve. Assuming that leisure is a normal good, the reduction in income from this "wage decrease" will cause workers to demand less leisure and more work. However, this "wage decrease" will also produce a substitution effect, and now that leisure is relatively cheaper compared to work, workers will substitute work for leisure. In this case, it is unclear whether the income effect or the substitution effect dominates[1]. By making the simplifying assumption that, for older workers, leisure and retirement are equivalent, it is hard to argue whether surviving cancer should increase or decrease the probability of retirement.

In the U.S., Social Security is a federal social insurance programme, designed to provide benefits to retired workers. Workers are eligible for Social Security if they are at least 65 years of age, provided they have paid Social Security taxes for at least 40 non-consecutive quarters. They are also eligible for a reduced rate of benefits from the age of 62. In relation to the consumption-leisure (consumption-retirement) model, if workers are eligible for Social Security, it allows them to reduce their hours of work to zero, but they still maintain a positive level of consumption. If this eligibility shifts them to a higher indifference curve, then they will retire. However, this simple age-based eligibility for Social Security is also

[1] It could be argued that, even in the absence of a requirement to purchase cancer related goods, workers may have their work/leisure preferences changed by the health shock. This violates the assumption that preferences are consistent over time. However, the argument of whether the income effect or substitution effect should dominate is still unresolved as, if it is unclear which effect dominates with consistent preferences, it will remain unclear with inconsistent preferences.

available for healthy workers. If this eligibility allows them to shift to a higher indifference curve then they too will retire. Given that cancer survivors will now be on a lower indifference curve than the healthy workers (due to the previously mentioned "wage decrease"), we can hypothesise that it would require a smaller level of Social Security payments, relative to the healthy workers, in order for them to retire. Though, this would suggest that cancer survivors should be more likely to retire, this question will have to be answered empirically. To do this, I use a difference-in-differences model to show that workers who are eligible for Social Security, and who survive cancer, are more likely to retire than healthy workers who are also eligible for Social Security.

3. DATA

For this analysis, I use data from the U.S. Health and Retirement Study (HRS). The HRS is a large, longitudinal data set which contains information on the respondents' labour force status, marriage status, health, wealth and other demographic information. The first wave was collected in 1992 using a nationally representative sample of 51 to 61 year olds and, since then, it has been collected every two years. I construct my sample using data from the first 10 waves, which covers 1992 to 2010.

As with any study which examines the impact that cancer has on the labour force, it is important to observe the respondents' pre-cancer behaviour. To do this, information on the respondents, both before and after they are diagnosed with cancer, is required. This means that information in two different time periods is required for each observation. Having 10 waves of data allows me to observe 9 potential non-cancer to cancer transitions: wave 1 to wave 2, wave 2 to wave 3, . . . , wave 9 to wave 10. I then 'stack' these 9 time periods into

two simple before and after periods, hereafter referred to as Period 1 and Period 2[2]. Combining these periods in the HRS gives a total of 146,173 observations. Table 1 provides more information on how I restrict the sample.

I first remove respondents who have reported having cancer in Period 1 as we cannot observe their pre-cancer behaviour. Reporting having cancer is defined as having answered yes to the question "Has a doctor ever told you that you have one of the following conditions?" of which, one is cancer. Next, I keep respondents who identify themselves as either working full-time, working part-time or part-retired, meaning that I exclude respondents who are unemployed, out of the labour force, sick / disabled or already retired in Period 1. Respondents who are not married / partnered or who are above age 68 or below age 55 in Period 1 are also removed[3]. The effects of potential extreme observations or outliers are reduced by removing respondents who live outside the U.S. or in a U.S. territory, who work more than 80 hours a week in either Period 1 or 2, and respondents who work quadruple the amount of hours in Period 2 compared to Period 1[4]. If respondents provide contradictory information then they are also removed. This includes reporting working but missing values for the hours of work, not reporting employer provided health insurance but reporting that employer provided health insurance covers spouse and vice versa. I also exclude respondents who are not eligible for Social Security but who are claiming Medicare in Period 1, who have worked for less than 10 years, and respondents who, in Period 2, will be unemployed, disabled, or out of the labour force. This means that the transitions that I observe in Period 2

[2] While Bertrand et al. (2004) show that difference-in-differences models with many years of data can result in inconsistent standard errors, they recommend collapsing the data into "pre" and "post" treatment periods to correct them.

[3] These restrictions are there to make the sample as comparable as possible. Because there may be specific unobserved labour market tendencies for respondents who are married / partnered, the sample is restricted to these respondents. Also, because the prospect of retirement is usually only an issue for older workers, the sample is restricted to respondent between the ages of 55 – 68.

[4] Because the change in hours of work is an outcome that will be examined, unusually large changes in hours of work from Period 1 to Period 2 that may dominate or distort the distribution are excluded.

Table 1. Sample Information

Exclusion criteria	**Observations**
Unrestricted sample	146,173
Cancer in Period 1	16,888
Not working in Period 1	71,991
Aged below 55 or above 68 in Period 1	23,641
Not married in Period 1	7,857
Works more than 80 hours a week in Period 1 or Period 2	809
Census division not in U.S. or U.S. territory in Period 1	13
7 or more people living in household in Period 1	330
Contradictory health insurance information	541
Receiving Medicare and below age 62 in Period 1	77
Missing hours of work information	255
Respondent's Period 2 hours of work more than quadruple Period 1 hours of work	175
Job tenure less than 10 years in Period 1	307
Unemployed, out of the labour force, or sick and disabled in Period 2	905
Female	8,893
Missing or incomplete survey records[a]	1,146
Restricted sample	12,345

Note: [a] This includes answers such as refusal, don't know and other non-coded responses.

will only be from employment to retirement[5]. I also exclude female respondents since there are not enough cancer cases to perform extensive subgroup analysis. Finally, respondents who have missing observations for the variables which will be used in the analysis are excluded.

After these restrictions are imposed, the final sample is 12,345 observations, some of which will have cancer in Period 2. Because this is a 'stacked' panel, some individuals will appear more than once. Out of the final 12,345 observations, there are 4,540 unique individuals. As discussed in Candon (2014), the limitations of using data from retirement surveys, and not specific cancer registries, is lack of information on the type and severity of cancer as well as the small number of cancer observations. However, the retirement surveys offer many

[5] While there may be cancer survivors who transition from working to disabled, unemployment, or out of the labour force, I exclude these in order to capture the effect of Social Security on the workers who have a choice of whether to retire. While not the focus of this paper, a model which includes these respondents is available in the Appendix (Table A5). While the coefficients decrease slightly in magnitude they still maintain their statistical significance.

benefits over registry data, such as the respondents are interviewed before any potential selection into a treatment, they are administered the same questionnaire, and are drawn from the same labour market. According to Heckman et al. (1999), this attenuates much of the bias from using non-experimental methods.

4. METHODOLOGY

In order to estimate the effect that eligibility for Social Security (ESS) and cancer survival has on retirement, I adopt a standard difference-in-differences model (DD). The estimate of the effect that cancer survival and ESS has on retirement is calculated by subtracting the effect of cancer (the difference between the cancer and non-cancer groups) on retirement for the non-ESS group away from the effect of cancer on retirement for the ESS group. If the total effect of cancer in the non-ESS group is equal to the direct effect of cancer in the ESS group, I can isolate the effect that cancer survival and ESS has on retirement. This can be expressed more concisely with the following DD model

$$Y_i = \alpha + ESS_i\gamma + Cancer_i\lambda + (ESS_i * Cancer_i)\delta + \varepsilon_i \quad (1)$$

where Y_i is the outcome of the respondent in Period 2, ESS_i is whether the respondent is ESS in Period 2, and $Cancer_i$ is whether the respondent, in Period 2, reports having been diagnosed with cancer at some point since Period 1. Following Tunceli et al. (2009), we can obtain an estimate of the parameter δ using the following formulae:

$$E[Y_i|ESS, Cancer] - E[Y_i|ESS, NoCancer] = \lambda + \delta + E[\varepsilon_i|ESS, Cancer] - E[\varepsilon_i|ESS, NoCancer] \quad (2)$$

$$E[Y_i|NoESS, Cancer] - E[Y_i|NoESS, NoCancer] = \lambda + E[\varepsilon_i|NoESS, Cancer] - E[\varepsilon_i|NoESS, NoCancer] \quad (3)$$

$$(E[Y_i|ESS, Cancer] - E[Y_i|ESS, NoCancer]) - (E[Y_i|NoESS, Cancer] - E[Y_i|NoESS, NoCancer]) = \delta + (E[\varepsilon_i|ESS, Cancer] - E[\varepsilon_i|ESS, NoCancer]) - (E[\varepsilon_i|NoESS, Cancer] - E[\varepsilon_i|NoESS, NoCancer]) \quad (4)$$

Equation 2 calculates the expected difference in outcome between respondents with cancer and respondents without cancer (*NoCancer*), given that the respondents are ESS. Equation 3 calculates the expected difference in outcome between respondents with cancer and respondents without cancer, given that the respondents are not ESS (*NoESS*). Equation 4 is the expected difference in these differences.

In Equation 4, the estimate of δ will be unbiased if the expected values of the error terms are zero. The benefit from using the DD approach is that I do not need to know the unobservable labour market tendencies of both the cancer and non-cancer groups as they can be differenced out. This should happen if the cancer related unobservables which affect employment are the same for both the ESS and non-ESS groups. The benefit of this approach over the "selection-on-observables" approach adopted by Markowski (2010) is that it does not require that correlation between the cancer variable and the unobservables be zero. The main threat to the validity of the DD estimate is the existence of some unobservable tendencies which make the respondents who are ESS, and who survive cancer, more likely to retire. Given that ESS is exogenous, the likelihood of this being an issue is reduced.

With regards to Equation 1, the variable Y_i is the outcome variable. In this analysis, I look at three different outcomes: whether the respondent is working, their hours of work (per week), and their hours of work (per week) conditional on employment in Period 2. The working

variable is a binary variable which is equal to 1 if the respondent is working full-time, part-time, or is part-retired and is set to 0 if they are fully retired[6]. The variable ESS_i is equal to 1 if the respondent is eligible for Social Security (aged 62 or over[7]) in Period 2 and is set to 0 if they are not and the variable $Cancer_i$ is equal to 1 if the respondent reports having cancer in Period 2 and is set to 0 if they do not. The parameter δ is the combined effect of reporting cancer and being eligible for Social Security in Period 2.

In some specifications, I also add in a vector of explanatory variables, X_i, which contains all variables that were measured in Period 1, before the respondents are diagnosed with cancer. It includes age, age squared, whether the respondent is non-white, in poor (or fair) health, has some or a full college education, is a smoker, has more than two people living in the household, has a partner but is not married, has a working spouse, is self-employed, their earnings quartile, their household income quartile, insurance status, pension status, wave identifier and census division[8]. The respondents' hours of work in Period 1 are also included, meaning that both of the hours of work models contain a lag of the dependent variable. While not perfect, this should also account for some of the unobserved differences between the cancer and non-cancer groups. Because an individual can appear in more than one observation, the standard errors are clustered at the individual level.

[6] Retirement in this case is based on the Labour Force Status variable (RwLBRF) which is itself derived from other variables. The difference between what is considered retirement and what is considered part-retirement is defined as follows: If the respondent is not looking for a job and there is any mention of retirement, RwLBRF is set to retired; If he/she is working part-time and mentions retirement, RwLBRF is set to partly retired.

[7] It is possible for widows/widowers to claim Social Security at the earlier age of 60. However, if the widows / widowers remarry before the age of 60 then they are ineligible for Social Security. Since the respondents left in the sample are either married (11,946) or living with a partner (399) in Period 1, it is not likely that this is a problem.

[8] The earnings and income measures are adjusted to 2009 dollars using the Bureau of Labor Statistics inflation calculator.

5. RESULTS

5.1 Descriptive Statistics

The descriptive statistics are presented in Table 2. Here I compare the cancer group to the non-cancer group for respondents who are ESS and respondents who are not ESS. In column 1, we can see that the respondents who get cancer in Period 2 are more likely to be older, in poor health and smokers. These differences are absent when the cancer group is compared to the non-cancer group for respondents who are not ESS. As stated earlier, one of the benefits of using survey data, as opposed to registry data, is the similarity of the respondents in the survey. This is borne out by the relatively few significant differences between in the cancer and non-cancer groups.

Comparing the Period 2 differences, we can see that for the ESS respondents, the cancer group work more than 10 percentage points less than the non-cancer group ($p<0.01$). They also work 5.5 hours fewer per week ($p<0.01$). The respondents, who do return to work, work 2.1 hours fewer per week. For the respondents who are not ESS, there are no statistically significant differences between the two groups across any of the Period 2 outcomes.

Table 2. Descriptive Statistics: Period 1

Variable	ESS in Period 2		Not ESS in Period 2	
	Cancer Group (1)	Non-Cancer Group (2)	Cancer Group (3)	Non-Cancer Group (4)
Demographics				
Age	**63.53	63.08	57.06	57.00
Age squared	**4043	3986	3258	3250
Non-white	13.90%	11.94%	13.71%	12.34%
Poor health	*17.65%	13.08%	12.10%	11.76%
College (some or full)	49.73%	47.08%	57.26%	52.48%
Smoker	*20.32%	15.10%	16.13%	20.19%
More than 2 people living at home	34.22%	29.28%	41.13%	43.37%
Partnered, not married	3.21%	2.54%	5.65%	3.89%
Employment				
Spouse working	55.08%	56.72%	67.74%	69.04%
Self-employed	29.95%	28.59%	20.97%	19.79%
Hours of work (per week)	38.11	38.30	43.43	44.25
Earnings Quartiles (First omitted)				
Second earnings quartile	24.60%	26.31%	**16.13%	23.77%
Third earnings quartile	19.79%	21.03%	30.65%	28.85%
Fourth earnings quartile	22.46%	19.47%	31.45%	30.95%
HI Quartiles (First omitted)				
Second HI quartile	23.53%	25.13%	22.58%	24.96%
Third HI quartile	24.06%	23.12%	30.65%	26.80%
Fourth HI quartile	25.67%	23.24%	28.23%	26.74%
Insurance and Pensions				
Covered by EPI	56.68%	62.07%	69.35%	73.65%
Spouse covered by EPI	18.18%	14.33%	15.32%	14.66%
Spouse covered by spouse's EPI	39.04%	35.14%	35.48%	36.80%
Covered by spouse's EPI	38.50%	41.24%	52.42%	51.39%
Defined benefit pension	18.18%	19.60%	29.84%	31.68%
Defined contribution pension	24.60%	21.43%	24.19%	27.05%
Both types of pensions	2.14%	2.49%	7.26%	4.43%
Covered by Medicare	**32.09%	25.69%	0.00%	0.00%
Wave number (1, 2, or 3 omitted)				
Wave 4, 5, or 6	39.04%	38.92%	*37.10%	29.05%
Wave 7, 8, or 9	32.62%	30.48%	27.42%	24.37%
Census District (New England Omitted)				
Mid-Atlantic	12.30%	11.54%	12.10%	11.27%
East North Central	12.83%	16.65%	20.16%	18.47%
West North Central	7.49%	10.10%	*4.03%	8.94%
South Atlantic	27.27%	24.52%	26.61%	24.09%
East South Central	5.88%	6.32%	3.23%	6.09%
West South Central	11.23%	10.66%	12.10%	9.54%
Mountain	6.42%	5.19%	6.45%	5.02%
Pacific	12.30%	10.82%	11.29%	12.73%
Observations	187	6,072	124	5,962

Note:
*** Significantly different from the non-cancer sample at the 1% level (when comparing (1) with (2) or (3) with (4)).
** Significantly different from the non-cancer sample at the 5% level (when comparing (1) with (2) or (3) with (4)).
* Significantly different from the non-cancer sample at the 10% level (when comparing (1) with (2) or (3) with (4)).
ESS – Eligible for Social Security.
HI – Household Income.
EPI – Employer provided health insurance.

Table 2. Descriptive Statistics: Period 2

Variable	ESS in Period 2		Not ESS in Period 2	
	Cancer Group (1)	Non-Cancer Group (2)	Cancer Group (3)	Non-Cancer Group (4)
Employment				
Working	***64.17%	76.05%	91.93%	91.75%
Hours of work (per week)	***21.66	27.30	39.12	39.77
Hours of work (per week [if working])	33.76	35.90	42.94	43.35
Observations	187	6,072	124	5,962

Note:
*** Significantly different from the non-cancer sample at the 1% level (when comparing (1) with (2) or (3) with (4)).
** Significantly different from the non-cancer sample at the 5% level (when comparing (1) with (2) or (3) with (4)).
* Significantly different from the non-cancer sample at the 10% level (when comparing (1) with (2) or (3) with (4)).
ESS – Eligible for Social Security.
EPI - Employer provided health insurance.

5.2 Main Results

The first panel of Table 3 presents the results from the estimation of Equation 1 by OLS regression. The regressions are performed with and without the control variables that are listed in Table 2. The main outcome that I am interested in is the probability of retiring. However, because I wish to capture the negative effects that cancer and ESS has on the hours of work, I specify the main outcome as working rather than retiring in the first two columns. This means that sign of the coefficient is consistent throughout all the models. If we wanted to interpret the results in terms of retiring, we would simply reverse the sign. The coefficient would remain unchanged since 'Working' in Period 2 is defined as being equal to 1 if the respondent works and equal to 0 if the respondent is retired. Because the 'Working' variable is binary, I also estimate these models with probit regressions, where the interaction effects are calculated using the method developed by Ai and Norton (2003). These estimates are available in the Appendix (Table A6).

While the direct effect of being diagnosed with cancer is negative for employment outcomes, the effect is small in every model, and none are statistically significant. Respondents who are ESS and not diagnosed with cancer are 10.3% (p<0.01) less likely to work (or 10.3% more

Table 3. Effect of Cancer and ESS on Employment in Period 2:
Main Results

Panel A: Full Sample

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	-0.006	-0.003	-0.644	-0.042	-0.413	0.634
	(0.026)	(0.026)	(1.551)	(1.397)	(1.190)	(0.826)
ESS	-0.157***	-0.103***	-12.472***	-5.710***	-7.454***	-1.890***
	(0.007)	(0.013)	(0.358)	(0.607)	(0.326)	(0.414)
Cancer*ESS	-0.113***	-0.112***	-4.994**	-5.330***	-1.726	-2.490*
	(0.044)	(0.043)	(2.140)	(1.943)	(1.791)	(1.283)
Controls	No	Yes	No	Yes	No	Yes
Observations	12,345	12,345	12,345	12,345	10,321	10,321
R-squared	0.048	0.090	0.105	0.313	0.071	0.465

Panel B: Respondents Working Full-Time in Period 1

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	0.006	0.007	1.607	1.694	1.417	1.603**
	(0.025)	(0.025)	(1.443)	(1.385)	(0.941)	(0.794)
ESS	-0.147***	-0.116***	-9.286***	-6.483***	-3.481***	-2.086***
	(0.007)	(0.013)	(0.388)	(0.678)	(0.282)	(0.444)
Cancer*ESS	-0.134***	-0.131***	-8.123***	-7.850***	-3.311**	-3.215**
	(0.049)	(0.048)	(2.356)	(2.263)	(1.606)	(1.495)
Controls	No	Yes	No	Yes	No	Yes
Observations	9,660	9,660	9,660	9,660	8,306	8,306
R-squared	0.048	0.096	0.067	0.192	0.023	0.253

Note: Control variables are the same as those listed in Table 2 including age, age squared, whether the respondents is non-white, in fair, poor or very poor health, has some or a full college education, is non-smoker, has more than two people living in the household, has a partner but is not married, has a working spouse, is self-employed, their hours of work, their earnings quartile, their household income quartile, insurance status, pension status, wave identifier and census division.
ESS – Eligible for Social Security.
(C) – Conditional on working in Period 2.
Clustered standard errors (by person) in parentheses.
* Result significant at the 10% level.
** Result significant at the 5% level.
*** Result significant at the 1% level.

likely to retire) than respondents who are not ESS. They also work almost 6 (p<0.01) fewer hours per week. Even the workers who remain working in Period 2 work almost 2 (p<0.01) fewer hours, possibly reflecting the fact that while they are still working, they now only work part-time or are part-retired. The respondents who are diagnosed with cancer and are ESS work 11.2% (p<0.01) less then respondents with ESS who do not have cancer. They also work 5.3 (p<0.01) fewer hours per week. The workers who remain working also work 2.5

(p<0.1) fewer hours per week. This table is replicated in the Appendix along with the coefficients for the control variables which are used in the adjusted model (Table A7).

Because working in Period 1 is defined working full-time, part-time, or part-retired, it is possible that the respondents who get cancer are working part-time or are part-retired. In this situation, because they may not face the same time constraints as full-time workers, cancer diagnosis may not cause them to retire, and it may lead to underestimating the effect of cancer on retirement. I re-do the analysis where I restrict the respondents to those who are working full-time in Period 1. The results are presented in the second panel of Table 3. As expected, the coefficients on the cancer and ESS interaction increase in every model, indicating that it is likely that the estimates obtained with the full sample are an underestimate of the true effect. A reassuring element of the analysis is that, in both panels, the addition of the control variables lead to very small changes in the value of the interaction coefficients, suggesting that there is little correlation between the interaction term and the other variables.

6. SUBGROUP ANALYSES

6.1 Decomposing Eligibility

As stated earlier, the variable ESS is defined as being eligible for Social Security (aged 62) in Period 2. Because of this, the ESS variable includes two different types of respondents: The respondents who were already ESS in Period 1 and the respondents who are not ESS in Period 1, but will become ESS in Period 2. If we consider the first group (respondents who were already ESS in Period 1), we know that they have made a decision to work past the age of 62. Since we know that they have chosen to work rather than retire, it should be easier to detect respondents who are diagnosed with cancer and retire. In contrast, the second group

(respondents who are not ESS in Period 1 but will be in Period 2) may contain both workers who are planning to work past 62 and workers who are not planning to work past 62. If some of this group are diagnosed with cancer and retire, it may be hard to detect the effect, since many of this group may be retiring anyway. If this is the case, the negative interaction coefficient observed in Table 3 should be larger for the first group (since the non-cancer group are more likely to stay working) and smaller for the second group (since the non-cancer group are also retiring). To capture these two potentially different effects, I create two new variables and include them, and their interaction with cancer, into the model. The variable $OVER_i$ signifies respondents who are already over the eligibility threshold in Period 1 and the variable $CROSS_i$ signifies respondents who cross the eligibility threshold and will be ESS in Period 2.

The results are presented in Table 4. The interaction with cancer and OVER leads to a 10.5 % (p<0.05) reduction in the probability of working and a 4.7 hour (p<0.01) reduction in hours worked. The interaction of CROSS with cancer leads to a 12.5% (p<0.10) reduction in the probability of working and a 6.6 hour (p<0.05) reduction in hours worked. While the employment coefficients differ from what was hypothesised in the previous paragraph, they remain within one percentage point of the results in Table 3. However, when the analysis is restricted to the full-time workers, the interaction with cancer and OVER leads to a 13.9 % (p<0.05) reduction in the probability of working and the interaction of CROSS with cancer only leads to an 11.6% reduction, which is in line with the previous prediction.

6.2 Discontinuity Approach

Given the large age range of the sample used in the analysis (55 – 68), it is possible that the effect of cancer varies depending on the age of the respondents. For example, we may find

Table 4. Effect of cancer and ESS on employment in Period 2:
Decomposing Eligibility

Panel A: Full Sample

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	-0.006	-0.003	-0.644	-0.032	-0.413	0.644
	(0.026)	(0.026)	(1.551)	(1.399)	(1.190)	(0.825)
OVER	-0.156***	-0.069***	-13.641***	-3.628***	-9.010***	-0.703
	(0.008)	(0.018)	(0.420)	(0.816)	(0.397)	(0.555)
Cancer*OVER	-0.109**	-0.105**	-4.712**	-4.726**	-1.773	-2.549*
	(0.050)	(0.048)	(2.296)	(2.019)	(1.934)	(1.304)
CROSS	-0.158***	-0.105***	-10.210***	-5.816***	-4.435***	-2.010***
	(0.010)	(0.013)	(0.477)	(0.612)	(0.355)	(0.421)
Cancer*CROSS	-0.122*	-0.125*	-5.235	-6.572**	-1.003	-2.406
	(0.070)	(0.069)	(3.309)	(3.198)	(2.841)	(2.406)
Controls	No	Yes	No	Yes	No	Yes
Observations	12,345	12,345	12,345	12,345	10,321	10,321
R-squared	0.048	0.091	0.109	0.313	0.082	0.465

Panel B: Respondents Working Full-Time in Period 1

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	0.006	0.007	1.607	1.694	1.417	1.608**
	(0.025)	(0.025)	(1.443)	(1.387)	(0.941)	(0.794)
OVER	-0.139***	-0.100***	-9.071***	-4.743***	-3.616***	-0.716
	(0.009)	(0.020)	(0.478)	(1.007)	(0.354)	(0.644)
Cancer*OVER	-0.147**	-0.139**	-8.949***	-7.938***	-3.850**	-3.529**
	(0.058)	(0.055)	(2.675)	(2.467)	(1.742)	(1.578)
CROSS	-0.158***	-0.117***	-9.588***	-6.544***	-3.285***	-2.176***
	(0.011)	(0.014)	(0.528)	(0.679)	(0.361)	(0.448)
Cancer*CROSS	-0.115	-0.116	-6.713*	-7.651**	-2.309	-2.802
	(0.074)	(0.074)	(3.578)	(3.630)	(2.650)	(2.640)
Controls	No	Yes	No	Yes	No	Yes
Observations	9,660	9,660	9,660	9,660	8,306	8,306
R-squared	0.049	0.097	0.067	0.192	0.023	0.253

Note: See notes for Table 3 for information on control variables.
OVER – Was already eligible for Social Security in Period 1.
CROSS – Was not already eligible for Social Security in Period 1 but will be eligible in Period 2.
(C) – Conditional on working in Period 2.
Clustered standard errors (by person) in parentheses.
* Result significant at the 10% level.
** Result significant at the 5% level.
*** Result significant at the 1% level.

that the effect of cancer and ESS declines for the oldest members of the sample since they could be retiring anyway. If this is the case, the previous results may be underestimating the effect of cancer and ESS on retirement. In order to make the samples as comparable as possible, I adopt a regression discontinuity approach and restrict the sample to respondents

Table 5. Effect of Cancer and ESS on Employment in Period 2:
Discontinuity Approach

Panel A: Full Sample

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	0.097**	0.085*	4.886	1.937	0.871	-0.927
	(0.038)	(0.044)	(3.045)	(2.930)	(2.692)	(1.925)
ESS	-0.100***	-0.099***	-5.744***	-5.164***	-2.046***	-1.474**
	(0.016)	(0.023)	(0.812)	(1.063)	(0.606)	(0.719)
Cancer*ESS	-0.292***	-0.266**	-13.687**	-11.314**	-2.732	-1.560
	(0.102)	(0.104)	(5.338)	(5.141)	(5.172)	(3.923)
Controls	No	Yes	No	Yes	No	Yes
Observations	2,334	2,334	2,334	2,334	1,906	1,906
R-squared	0.023	0.095	0.027	0.250	0.007	0.412

Panel B: Respondents Working Full-Time in Period 1

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	0.111***	0.104***	7.010***	5.202**	2.131	0.463
	(0.010)	(0.024)	(2.252)	(2.079)	(2.216)	(1.968)
ESS	-0.114***	-0.117***	-6.284***	-6.236***	-1.640***	-1.762**
	(0.017)	(0.023)	(0.864)	(1.164)	(0.582)	(0.767)
Cancer*ESS	-0.277***	-0.248**	-14.368***	-12.689**	-2.745	-1.536
	(0.103)	(0.105)	(5.453)	(5.304)	(4.702)	(4.094)
Controls	No	Yes	No	Yes	No	Yes
Observations	1,978	1,978	1,978	1,978	1,649	1,649
R-squared	0.030	0.106	0.033	0.176	0.006	0.252

Note: See notes for Table 3 for information on control variables.
ESS – Eligible for Social Security.
(C) – Conditional on working in Period 2.
Clustered standard errors (by person) in parentheses.
* Result significant at the 10% level.
** Result significant at the 5% level.
*** Result significant at the 1% level.

who are not ESS in Period 1 but will be either 61 (not ESS) or 62 (ESS) in Period 2. This means that I will only be using respondents who are just either side of the exogenous age limit. The results from this discontinuity approach are presented in Table 5. The respondents who are diagnosed with cancer and are ESS work 26.6% (p<0.05) less then respondents with ESS who do not have cancer and work 11 (p<0.05) fewer hours per week. When restricting this analysis to the full-time workers, the models are still significant at the 5% level. Given the large increase in the magnitude of the coefficients in this model, it may mean that the results in Table 3 are underestimates of the true effect of cancer survival and ESS.

7. FALSIFICATION TESTS

7.1 False Social Security

In order to make sure that the effect that I am observing is due to the income provided by Social Security, I create a fake Social Security assignment mechanism. In this model, I define false Social Security (FSS) to be equal to 1 for respondents who are 60 or 61 in Period 2 (and thus not ESS) and equal to 0 if they are younger. If the effect that we have been observing is simply due to respondents being diagnosed with cancer and being older, rather than cancer and Social Security, we should still find a negative coefficient for the cancer and FSS interaction. In Table 8, we can see the coefficient of the interaction term is actually positive in some cases, meaning respondents diagnosed with cancer who are 60 and 61 are more likely to work than younger cancer respondents, though the standard errors are so large that none of the results are significant.

7.2 False Outcome

I also perform another falsification test in which I use a false outcome. This is an outcome that we would expect cancer and ESS to not have an effect on. In this case, I use the respondents' hours of work in Period 1 as the outcome. Because the respondents are not diagnosed until Period 2, this outcome is unaffected by cancer diagnosis, and therefore, unaffected by the interaction. In Table 9, the coefficients are both economically and statistically insignificant. By passing these two falsification tests, it lends more credence to idea that it is the combination of ESS and cancer which is causing the increase in retirement.

Table 6. Effect of Cancer and ESS on Employment in Period 2:
Falsification Test using False Eligibility for Social Security

Panel A: Full Sample

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	-0.030	-0.016	-2.211	-0.469	-1.007	0.693
	(0.035)	(0.035)	(2.046)	(1.841)	(1.527)	(1.036)
FSS	-0.039***	0.018	-3.125***	0.463	-1.588***	-0.119
	(0.008)	(0.014)	(0.408)	(0.745)	(0.279)	(0.495)
Cancer*FSS	0.059	0.047	3.996	1.885	1.587	-0.143
	(0.051)	(0.052)	(3.136)	(2.811)	(2.435)	(1.697)
Controls	No	Yes	No	Yes	No	Yes
Observations	6,086	6,086	6,086	6,086	5,583	5,583
R-squared	0.005	0.053	0.009	0.239	0.004	0.373

Panel B: Respondents Working Full-Time in Period 1

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	-0.018	-0.013	-0.217	0.565	0.655	1.630*
	(0.034)	(0.034)	(1.880)	(1.907)	(1.117)	(0.960)
FSS	-0.033***	0.006	-2.370***	0.091	-0.978***	-0.148
	(0.008)	(0.015)	(0.423)	(0.787)	(0.273)	(0.496)
Cancer*FSS	0.063	0.064	4.715	3.409	1.972	0.012
	(0.049)	(0.049)	(2.925)	(2.731)	(1.994)	(1.655)
Controls	No	Yes	No	Yes	No	Yes
Observations	5,397	5,397	5,397	5,397	5,000	5,000
R-squared	0.004	0.045	0.006	0.162	0.002	0.288

Note: See notes for Table 3 for information on control variables.
FSS – False Social Security eligibility.
(C) – Conditional on working in Period 2.
Clustered standard errors (by person) in parentheses.
* Result significant at the 10% level.
** Result significant at the 5% level.
*** Result significant at the 1% level.

Table 7. Effect of Cancer and ESS on Employment in Period 2:
Falsification Test using False Outcome (Period 1 Hours of Work)

Panel A: Full Sample

	Hours	Hours	Hours (C)	Hours (C)
Cancer	-0.822	-0.551	-1.399	-1.223
	(1.080)	(1.064)	(1.071)	(1.062)
ESS	-5.948***	-0.423	-5.465***	-0.487
	(0.268)	(0.355)	(0.299)	(0.384)
Cancer*ESS	0.627	0.657	1.028	1.349
	(1.524)	(1.438)	(1.671)	(1.585)
Controls	No	Yes	No	Yes
Observations	12,345	12,345	10,321	10,321
R-squared	0.050	0.171	0.045	0.150

Panel B: Respondents Working Full-Time in Period 1

	Hours	Hours	Hours (C)	Hours (C)
Cancer	0.013	0.022	-0.276	-0.292
	(0.860)	(0.853)	(0.865)	(0.852)
ESS	-0.721***	-0.024	-0.446**	0.124
	(0.193)	(0.275)	(0.220)	(0.310)
Cancer*ESS	-0.178	-0.068	-0.236	-0.123
	(1.144)	(1.122)	(1.280)	(1.246)
Controls	No	Yes	No	Yes
Observations	9,660	9,660	8,306	8,306
R-squared	0.002	0.103	0.001	0.105

Note: See notes for Table 3 for information on control variables.
Period 1 Hours of Work is removed from the list of controls for this model.
(C) – Conditional on working in Period 2.
Clustered standard errors (by person) in parentheses.
* Result significant at the 10% level.
** Result significant at the 5% level.
*** Result significant at the 1% level.

8. MECHANISM

8.1 Social Security Payments

In Section 2, I hypothesised that cancer survivors would retire if Social Security payments were big enough to move them to a higher indifference curve in the consumption-retirement model. However, if Social Security payments are small, they may not be enough to move a respondent to a higher indifference curve, and the respondent will remain working. The effect that we are observing should, therefore, be caused by the magnitude of the Social Security payments. I test this theory by restricting the sample to respondents in both the first and second earnings quartile (low earners) and the third and fourth earnings quartile (high earners). For this test, I assume the low earners will have small Social Security payments but high earners will have big Social Security payments. If the mechanism is working in the way that the theory suggests, then we would expect to see a negative effect when the low earners are excluded and no effect when the high earners are excluded.

In Table 10, the results are presented for the removal of the high earners from the analysis. As expected, the coefficient in the working models is statistically insignificant and close to zero. There is a significant reduction in the number of hours worked by the respondents who do return. Because complete retirement may not be an option for these respondents, the reduction in labour supply takes place at the internal margin. In Table 11, the results are presented for the removal of the low earners from the analysis. These results stand in direct contrast to those in Table 10. Again, as expected, the coefficient in the working models is negative and statistically significant. It is also larger in absolute terms than the coefficient from Table 3. There is also no significant difference in hours of work for the respondents who return to work, and the coefficients are relatively small, suggesting that this group either retire completely or return to work as normal.

Table 8. Effect of Cancer and ESS on Employment in Period 2:
Excluding Respondents who are in the 3rd and 4th Earnings Quartile in Period 1

Panel A: Full Sample

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	-0.098*	-0.090*	-5.533*	-3.149	-1.739	1.422
	(0.055)	(0.053)	(3.126)	(2.529)	(2.658)	(1.763)
ESS	-0.163***	-0.107***	-13.389***	-5.997***	-8.596***	-2.299***
	(0.009)	(0.018)	(0.500)	(0.853)	(0.462)	(0.669)
Cancer*ESS	-0.000	-0.003	0.505	-1.434	-0.905	-3.961*
	(0.072)	(0.069)	(3.665)	(3.038)	(3.289)	(2.271)
Controls	No	Yes	No	Yes	No	Yes
Observations	6,165	6,165	6,165	6,165	5,097	5,097
R-squared	0.046	0.089	0.113	0.372	0.080	0.498

Panel B: Respondents Working Full-Time in Period 1

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	-0.111*	-0.118*	-1.170	-0.901	4.451**	4.729***
	(0.066)	(0.061)	(3.657)	(3.178)	(2.058)	(1.713)
ESS	-0.135***	-0.126***	-8.969***	-7.413***	-3.696***	-2.832***
	(0.010)	(0.019)	(0.566)	(0.993)	(0.438)	(0.730)
Cancer*ESS	-0.027	-0.009	-5.257	-5.491	-5.719*	-6.737**
	(0.089)	(0.085)	(4.608)	(4.158)	(3.044)	(2.818)
Controls	No	Yes	No	Yes	No	Yes
Observations	3,996	3,996	3,996	3,996	3,508	3,508
R-squared	0.047	0.085	0.066	0.204	0.025	0.258

Note: See notes for Table 3 for information on control variables.
ESS – Eligible for Social Security.
(C) – Conditional on working in Period 2.
Clustered standard errors (by person) in parentheses.
* Result significant at the 10% level.
** Result significant at the 5% level.
*** Result significant at the 1% level.

8.2 Health of the Respondents

Understanding the mechanism by which the increase in retirement takes place is important because it is possible that the workers who are not ESS are forced to continue working after a health shock, even though it may prove harmful to their future health. In Table 12, I examine the effect of cancer on the respondents' health in Period 2. As expected cancer diagnosis increases the probability of being in poor health in every adjusted (which accounts for Period 1 poor health) model.

Table 9. Effect of Cancer and ESS on Employment in Period 2:
Excluding Respondents who are in the 1st and 2nd Earnings Quartile in Period 1

Panel A: Full Sample

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	0.050**	0.055**	2.282	2.011	0.056	0.227
	(0.023)	(0.024)	(1.474)	(1.589)	(1.121)	(0.844)
ESS	-0.156***	-0.100***	-10.391***	-5.415***	-4.579***	-1.406***
	(0.010)	(0.018)	(0.513)	(0.865)	(0.417)	(0.535)
Cancer*ESS	-0.197***	-0.194***	-8.942***	-8.242***	-1.410	-1.296
	(0.060)	(0.058)	(2.740)	(2.713)	(1.783)	(1.426)
Controls	No	Yes	No	Yes	No	Yes
Observations	6,180	6,180	6,180	6,180	5,224	5,224
R-squared	0.051	0.105	0.077	0.230	0.034	0.363

Panel B: Respondents Working Full-Time in Period 1

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	0.060***	0.065***	2.863**	3.037**	0.179	0.483
	(0.020)	(0.021)	(1.333)	(1.418)	(1.019)	(0.843)
ESS	-0.166***	-0.109***	-9.755***	-5.844***	-3.039***	-1.453***
	(0.010)	(0.019)	(0.531)	(0.915)	(0.368)	(0.561)
Cancer*ESS	-0.178***	-0.179***	-9.430***	-8.782***	-2.705	-1.919
	(0.062)	(0.059)	(2.816)	(2.758)	(1.702)	(1.491)
Controls	No	Yes	No	Yes	No	Yes
Observations	5,664	5,664	5,664	5,664	4,798	4,798
R-squared	0.055	0.111	0.070	0.193	0.019	0.248

Note: See notes for Table 3 for information on control variables.
ESS – Eligible for Social Security.
(C) – Conditional on working in Period 2.
Clustered standard errors (by person) in parentheses.
* Result significant at the 10% level.
** Result significant at the 5% level.
*** Result significant at the 1% level.

Reassuringly, the coefficient on the interaction term in the adjusted models, while positive, is statistically insignificant, suggesting that there is no over reporting of poor health from the Social Security eligible respondents. However, it does show that that both ESS and non-ESS cancer survivors have their health stock affect by the shock, but only the ESS survivors have the pathway to retirement.

Table 10. Effect of Cancer and ESS on Poor Health in Period 2

Panel A: Full Sample

	Table 3 Sample		Table 5 Sample	
	Poor Health	Poor Health	Poor Health	Poor Health
Cancer	0.188***	0.192***	0.114	0.169**
	(0.042)	(0.037)	(0.085)	(0.081)
ESS	0.018***	0.005	0.012	0.012
	(0.007)	(0.011)	(0.015)	(0.020)
Cancer*ESS	0.041	0.014	0.211	0.076
	(0.055)	(0.051)	(0.129)	(0.118)
Controls	No	Yes	No	Yes
Observations	12,343	12,343	2,333	2,333
R-squared	0.010	0.225	0.011	0.266

Panel B: Respondents Working Full-Time in Period 1

	Table 3 Sample		Table 5 Sample	
	Poor Health	Poor Health	Poor Health	Poor Health
Cancer	0.195***	0.205***	0.165*	0.214**
	(0.046)	(0.042)	(0.097)	(0.091)
ESS	0.012	0.010	0.014	0.013
	(0.008)	(0.012)	(0.016)	(0.021)
Cancer*ESS	0.043	0.015	0.182	0.057
	(0.063)	(0.059)	(0.144)	(0.136)
Controls	No	Yes	No	Yes
Observations	9,658	9,658	1,977	1,977
R-squared	0.010	0.220	0.013	0.277

Note: See notes for Table 3 for information on control variables.
Clustered standard errors (by person) in parentheses.
* Result significant at the 10% level.
** Result significant at the 5% level.
*** Result significant at the 1% level.

9. CONCLUSION

With cancer survival rates continuing to rise, combined with the increasing participation of older workers in the labour force, the role that cancer plays in retirement is one which needs to be examined. For workers who survive cancer diagnosis, the availability of Social Security may offer an important pathway to retirement. However, estimating the effect that Social Security has on retirement is likely to prove difficult because of the separate effects that both cancer diagnosis and Social Security availability have on retirement. Because of this, I use a DD estimator to examine their interaction and see if workers who are ESS, and who survive cancer, are more likely to retire than healthy ESS workers.

I find that respondents who have been diagnosed with cancer and are ESS are 11% ($p<0.01$) more likely to retire. This leads to a 5 hour ($p<0.01$) reduction in hours of work. The workers who remain working work 2.5 fewer hours ($p<0.1$) than non-cancer respondents. I then separate the effect of ESS between respondents who were ESS in Period 1, and respondents who become ESS in Period 2. The DD estimators again show a 10.5% ($p<0.10$) and 12.5% ($p<0.05$) increase in the probability of retirement. By restricting the sample to the respondents who are just either side of the ESS threshold, I find that respondents who are ESS and diagnosed with cancer are 27% ($p<0.05$) more likely to retire than respondents who are ESS but were not diagnosed with cancer. Given that this discontinuity approach is a better method of identification, it is likely that the 11 percentage point increase in the probability of retirement observed in Table 3 is a lower bound, while the coefficient in Table 5 is a truer estimate of the effect.

When I perform falsification tests on the results, I find that the interaction of being diagnosed with cancer and being 60 or 61 is insignificant, making it more likely that it is the interaction of cancer with ESS that is causing the increase in retirement. The interaction of cancer with ESS also has no effect on a false outcome (Period 1 hours of work), as we would expect. Another encouraging aspect of the different specifications is that the DD estimator remains largely unchanged when the set of control variables is added to the model. The fact that the interaction term has little correlation with the rich set of controls is a strong indicator that the DD estimator is uncorrelated with any omitted unobservables. Finally, the mechanism by which retirement takes places is confirmed to be large Social Security payments as low earners are unaffected by the cancer ESS interaction, whereas high earners are affected.

While using data from the HRS has many benefits over using registry data, one of the limitations with this approach is the absence of data on the type of cancer that the respondents have. This prevents a direct comparison to results of Bradley et al. (2005) and Bradley et al. (2007) who specially focused on prostate cancer. Nevertheless, there have been numerous papers which look at the effect of cancer on employment and pool all types of cancer together (Short et al., 2008; Tunceli et al., 2009; Markowski, 2010; Moran et al, 2011; Candon, 2014). I am also not able to control for the severity of the respondents' cancer which may be important as it is possible that respondents with metastasized cancer may be more likely to retire and reduce their labour supply than respondents with localized cancer. However, as mentioned in Candon (2014), respondents with the most severe forms of cancer may be more likely to drop out of these longitudinal surveys. If this type of bias is present, it would only serve to strengthen the results that are found, as the probability of retirement or reduction in hours worked would increase if the more severe cases had been included.

A problem when using an age related variable as a discontinuity is anticipatory effects. This happens when workers suspend their retirement until they reach the discontinuity point, even though they would have a preference to retire now. This can lead to the overestimation of treatment effects. In this scenario, the presence of anticipatory effects is likely to *underestimate* the true treatment effect. If the ineligible healthy workers remain working (even though they would like to retire) then the difference in the probability of employment between them and the ineligible cancer survivors is greater than it should be. However, the larger this difference is, the smaller the interaction coefficient will be. This means that, if the model does contain anticipatory effects, the interaction coefficient is likely an underestimate of the true value.

Of the 860,000 new cancer cases that will be detected in U.S. males in 2014, almost 40% (320,000) will be detected in the between 45 – 65 age range (American Cancer Society, 2014b). Given the number of new cases that will be detected in males of primary working age, these results could provide essential information for the main protagonists in the labour market. For employers, it is important for them to know that if an older worker is ESS, and is diagnosed with cancer, they will be more than 25% more likely to retire (Table 5) than other workers who are ESS, allowing them to plan the restructuring of their work force. They should also realise that the survivors who are not ESS may still be struggling with health issues and should aim to reintegrate them accordingly. For employees who are diagnosed with cancer while ESS, it is important for them to be aware that a permanent exit from the labour market is a viable option, if they so wish. In terms of monetary implications, cancer survivors who are ESS could lead to an extra $22 – $30 million being spent every year on Social Security[9]. While this number is trivial compared to the total amount in the Social Security Trust Fund (almost $3 trillion), it may contribute to smaller surpluses (when inflow is greater than outflow) in the future, as the number of older workers in the work force rises.

[9] If we assume that the number of new diagnoses are uniformly distributed across the age range, then there will be 16,000 (320,000 / 65 – 45) new cases detected in people who are 62 years of age. If we also assume that these people are working, then 36% of them are expected to take early retirement anyway (Social Security Administration, 2013). Since being diagnosed with cancer and being ESS makes male workers more than 25% (Table 5) more likely to retire, this would lead to an extra 1,500 (0.25*0.36*16,000) males a year taking early retirement. If workers taking early retirement claim $14,300 a year (70% of the average $20,400 [Social Security Administration, 2014]) then this is an extra $21.5 million dollars which could be claimed by early male retirees. With the number of older workers in the labour force growing, this problem is likely to be exacerbated. In 2010, the number of older workers (55 and older) in the labour force was 30 million (Bureau of Labor Statistics, 2012). In 2020, this number is expected to increase by over a third to 41 million (Bureau of Labor Statistics, 2012). This would increase the amount claimed by early retiring cancer survivors to almost $30 million.

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APPENDIX

A1. Respondents with Employer Provided Health Insurance

For this subgroup analysis, I restrict the sample to respondents who have employer provided health insurance (EPI). EPI has been shown to 'lock' people in their jobs who have cancer because their health insurance is dependent on continued employment, implying that EPI is suppressing the natural turnover when workers get sick (Bradley et al., 2007b; Bradley et al., 2013). For the respondents who are not ESS, the effect of this job lock will lead to little difference in the probability of employment between the cancer and non-cancer group. This is different from the entire sample where we *would* expect to see a difference in employment between the cancer and non-cancer respondents who are not ESS. For the respondents who are ESS, there may still be differences in the probability of employment between the cancer and non-cancer group, as ESS moderates the effects of job lock by allowing them to retire but still maintain a flow of income for both medical expenses and general consumption. If this is the case, we would expect to see a larger coefficient on the ESS and cancer interaction term for the EPI group, as compared to the main results, since the difference in employment between the cancer and non-cancer groups for the non-ESS respondents is now smaller.

In Table A1, the results of this analysis are presented. An interesting finding from this analysis is that, not only are the coefficients from the working model and hours model are larger than those in Table 3, but the coefficient in the conditional hours model is also bigger. Because switching to part-time or part-retired may cause respondents to lose their EPI status, this could indicate that respondents are reducing their labour supply to the minimum amount to maintain their insurance status.

A.2 Respondents with Retiree Health Insurance as Part of EPI

A further subgroup of the EPI group is the respondents who have retiree health insurance as part of their insurance plan. This means that even if they retire, their employment plan will still provide coverage. While these respondents, as a group, should be more likely to retire than the original EPI group (because their insurance coverage does not depend on their employment status) the combined of effect of ESS and being diagnosed with cancer could actually be lower. In this case, the joint effect of cancer and ESS is reduced by the fact that a large number of respondents may be retiring anyway, meaning the difference in propensity to work between those respondents with ESS and cancer and those without cancer is narrowed.

The results of this analysis are presented in Table A2 and seem to support this hypothesis. While the ESS coefficients are still large and statistically significant, the interaction coefficients are smaller than those in both Table 3 and Table A1 and are statistically insignificant. This suggests that, for people with retiree health insurance who get diagnosed with cancer, ESS is of little use.

A.3 Excluding Respondents who are Eligible for Medicare in Period 2

Again, because the age range of the sample of respondents is quite large, some of the respondents will be over 65 in Period 2 and, thus, will be eligible for Medicare. It is possible that the reduction in employment for respondents who are both ESS and have cancer is being driven by respondents who have access to Medicare, since they now have access to health insurance which allows them to retire. If this is the case, then we would expect the size of the coefficients to fall compared to the original results in Table 3 if these respondents are excluded.

In Table A3, I re-estimate the models excluding the respondents who are aged 65 or over and are eligible for Medicare. As we can see from the results, the coefficients in the working model, when compared to the results in Table 3, actually increase when these respondents are excluded. They are also statistically significant at the 5% level. The reason for this is likely to be the exclusion of older workers for whom the interaction between cancer and ESS has the least effect.

A.4 Excluding Respondents who are Self-Employed in Period 1

I now remove respondents who are self-employed. Because self-employed respondents may be more attached to their jobs we would expect the magnitude of the coefficient to increase with their exclusion. Presented in Table A4, the results show that the removal of this subgroup has little effect on the interaction coefficients. The fact that there is not a large jump in the size of the coefficients may mean that the interaction is having a similar effect for self-employed and employees alike.

A.5 Including Respondents who are Unemployed, Disabled, or Out of the Labour Force in Period 2

Another topic that is not the focus of this paper, but which is examined for completeness, is the effect that the interaction of ESS and cancer has when the disabled, unemployed, other workers who are out of the labour force are included. Originally, these respondents were excluded in order to capture the effect of Social Security on the workers who have a choice of whether to retire. The results are presented in Table A5. The coefficients in the working and hours of work models are slightly smaller than in the main results but they are still statistically significant at the 5% level.

Table A1. Effect of Cancer and ESS on Employment in Period 2:
Respondents with EPI

Panel A: Full Sample

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	0.030	0.033	1.886	1.823	0.600	1.065
	(0.026)	(0.027)	(1.676)	(1.625)	(1.317)	(0.933)
ESS	-0.161***	-0.118***	-11.965***	-6.299***	-6.642***	-1.837***
	(0.008)	(0.016)	(0.431)	(0.734)	(0.384)	(0.471)
Cancer*ESS	-0.196***	-0.190***	-9.279***	-8.946***	-2.826	-3.522**
	(0.054)	(0.054)	(2.550)	(2.420)	(2.090)	(1.421)
Controls	No	Yes	No	Yes	No	Yes
Observations	8,352	8,352	8,352	8,352	6,974	6,974
R-squared	0.052	0.091	0.102	0.274	0.065	0.452

Panel B: Respondents Working Full-Time in Period 1

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	0.032	0.030	2.939*	2.792*	1.621	1.723*
	(0.025)	(0.026)	(1.535)	(1.530)	(1.070)	(0.910)
ESS	-0.164***	-0.127***	-9.839***	-6.790***	-3.401***	-1.824***
	(0.009)	(0.016)	(0.456)	(0.799)	(0.321)	(0.502)
Cancer*ESS	-0.190***	-0.172***	-11.168***	-9.923***	-4.499**	-4.025**
	(0.060)	(0.058)	(2.736)	(2.638)	(1.853)	(1.574)
Controls	No	Yes	No	Yes	No	Yes
Observations	7,087	7,087	7,087	7,087	6,008	6,008
R-squared	0.056	0.105	0.076	0.187	0.025	0.254

Note:
See notes for Table 3 for information on control variables.
ESS – Eligible for Social Security.
EPI – Employer provided health insurance.
Clustered standard errors (by person) in parentheses.
(C) – Conditional on working in Period 2.
* Result significant at the 10% level.
** Result significant at the 5% level.
*** Result significant at the 1% level.

Table A2. Effect of Cancer and ESS on Employment in Period 2:
Respondents with Retiree Health Insurance as Part of EPI

Panel A: Full Sample

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	0.005	0.021	-0.134	0.113	-0.389	0.342
	(0.047)	(0.050)	(2.666)	(2.754)	(1.986)	(1.336)
ESS	-0.188***	-0.132***	-12.609***	-7.013***	-6.603***	-2.187***
	(0.012)	(0.023)	(0.596)	(1.051)	(0.531)	(0.711)
Cancer*ESS	-0.027	-0.040	-1.816	-1.028	-1.324	-1.712
	(0.085)	(0.082)	(3.929)	(3.669)	(3.084)	(1.932)
Controls	No	Yes	No	Yes	No	Yes
Observations	4,430	4,430	4,430	4,430	3,554	3,554
R-squared	0.055	0.098	0.100	0.253	0.060	0.441

Panel B: Respondents Working Full-Time in Period 1

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	0.007	0.018	1.313	1.388	1.099	1.094
	(0.048)	(0.050)	(2.552)	(2.732)	(1.522)	(1.345)
ESS	-0.199***	-0.134***	-11.077***	-7.248***	-3.360***	-1.986**
	(0.014)	(0.025)	(0.660)	(1.181)	(0.474)	(0.795)
Cancer*ESS	0.035	0.022	-1.104	-0.620	-3.132	-2.095
	(0.091)	(0.087)	(4.174)	(4.028)	(2.498)	(2.075)
Controls	No	Yes	No	Yes	No	Yes
Observations	3,727	3,727	3,727	3,727	3,039	3,039
R-squared	0.062	0.114	0.078	0.180	0.022	0.238

Note:
See notes for Table 3 for information on control variables.
ESS – Eligible for Social Security.
(C) – Conditional on working in Period 2.
Clustered standard errors (by person) in parentheses.
* Result significant at the 10% level.
** Result significant at the 5% level.
*** Result significant at the 1% level.

Table A3. Effect of Cancer and ESS on Employment in Period 2:
Excluding Respondents Eligible for Medicare (over 65) in Period 2

Panel A: Full Sample

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	-0.006	-0.001	-0.644	0.092	-0.413	0.631
	(0.026)	(0.026)	(1.551)	(1.396)	(1.190)	(0.821)
ESS	-0.149***	-0.121***	-9.995***	-6.682***	-4.591***	-2.366***
	(0.009)	(0.017)	(0.437)	(0.787)	(0.356)	(0.541)
Cancer*ESS	-0.149**	-0.148**	-6.614**	-8.085***	-1.629	-3.101
	(0.062)	(0.062)	(2.928)	(2.840)	(2.475)	(2.092)
Controls	No	Yes	No	Yes	No	Yes
Observations	9,061	9,061	9,061	9,061	7,857	7,857
R-squared	0.046	0.092	0.067	0.273	0.027	0.402

Panel B: Respondents Working Full-Time in Period 1

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	0.006	0.008	1.607	1.775	1.417	1.635**
	(0.025)	(0.025)	(1.443)	(1.385)	(0.941)	(0.790)
ESS	-0.150***	-0.129***	-8.921***	-7.332***	-2.830***	-2.470***
	(0.009)	(0.018)	(0.477)	(0.878)	(0.333)	(0.581)
Cancer*ESS	-0.159**	-0.153**	-9.228***	-9.832***	-3.345	-3.765
	(0.068)	(0.067)	(3.191)	(3.225)	(2.331)	(2.376)
Controls	No	Yes	No	Yes	No	Yes
Observations	7,789	7,789	7,789	7,789	6,847	6,847
R-squared	0.049	0.096	0.058	0.198	0.014	0.276

Note:
See notes for Table 3 for information on control variables.
ESS – Eligible for Social Security.
(C) – Conditional on working in Period 2.
Clustered standard errors (by person) in parentheses.
* Result significant at the 10% level.
** Result significant at the 5% level.
*** Result significant at the 1% level.

Table A4. Effect of Cancer and ESS on Employment in Period 2:
Excluding Respondents who are Self-Employed in Period 1

Panel A: Full Sample

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	0.008	0.011	0.429	0.381	0.068	0.516
	(0.028)	(0.028)	(1.615)	(1.538)	(1.164)	(0.774)
ESS	-0.175***	-0.116***	-12.881***	-6.447***	-7.239***	-2.087***
	(0.008)	(0.015)	(0.403)	(0.701)	(0.356)	(0.434)
Cancer*ESS	-0.125**	-0.126**	-5.759**	-5.838***	-1.917	-2.235*
	(0.051)	(0.050)	(2.357)	(2.242)	(1.852)	(1.356)
Controls	No	Yes	No	Yes	No	Yes
Observations	9,347	9,347	9,347	9,347	7,708	7,708
R-squared	0.056	0.090	0.118	0.274	0.081	0.458

Panel B: Respondents Working Full-Time in Period 1

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	0.014	0.013	1.704	1.324	1.162	0.980
	(0.027)	(0.027)	(1.510)	(1.495)	(0.941)	(0.757)
ESS	-0.176***	-0.132***	-10.402***	-7.122***	-3.538***	-2.054***
	(0.009)	(0.016)	(0.437)	(0.767)	(0.298)	(0.466)
Cancer*ESS	-0.136**	-0.132**	-8.102***	-7.391***	-3.532**	-2.804*
	(0.056)	(0.055)	(2.566)	(2.510)	(1.667)	(1.545)
Controls	No	Yes	No	Yes	No	Yes
Observations	7,709	7,709	7,709	7,709	6,496	6,496
R-squared	0.061	0.099	0.083	0.176	0.028	0.249

Note:
See notes for Table 3 for information on control variables.
ESS – Eligible for Social Security.
EPI – Employer provided health insurance.
(C) – Conditional on working in Period 2.
Clustered standard errors (by person) in parentheses.
* Result significant at the 10% level.
** Result significant at the 5% level.
*** Result significant at the 1% level.

Table A5. Effect of cancer and ESS on employment in Period 2:
Including Respondents who are Unemployed, Disabled, or Out of the Labour Force in Period 2

Panel A: Full Sample

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	-0.023	-0.018	-1.351	-0.809	-0.413	0.634
	(0.030)	(0.030)	(1.658)	(1.531)	(1.190)	(0.826)
ESS	-0.144***	-0.096***	-11.755***	-5.451***	-7.454***	-1.890***
	(0.007)	(0.013)	(0.364)	(0.624)	(0.326)	(0.414)
Cancer*ESS	-0.097**	-0.096**	-4.294*	-4.609**	-1.726	-2.490*
	(0.046)	(0.046)	(2.207)	(2.045)	(1.791)	(1.283)
Controls	No	Yes	No	Yes	No	Yes
Observations	12,725	12,725	12,725	12,725	10,321	10,321
R-squared	0.037	0.075	0.089	0.279	0.071	0.465

Panel B: Respondents Working Full-Time in Period 1

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	-0.022	-0.019	0.247	0.420	1.417	1.603**
	(0.032)	(0.031)	(1.679)	(1.616)	(0.941)	(0.794)
ESS	-0.137***	-0.108***	-8.757***	-6.149***	-3.481***	-2.086***
	(0.008)	(0.014)	(0.398)	(0.700)	(0.282)	(0.444)
Cancer*ESS	-0.110**	-0.105**	-6.872***	-6.642***	-3.311**	-3.215**
	(0.053)	(0.051)	(2.493)	(2.404)	(1.606)	(1.495)
Controls	No	Yes	No	Yes	No	Yes
Observations	9,960	9,960	9,960	9,960	8,306	8,306
R-squared	0.037	0.080	0.055	0.170	0.023	0.253

Note:
See notes for Table 3 for information on control variables.
ESS – Eligible for Social Security.
(C) – Conditional on working in Period 2.
Clustered standard errors (by person) in parentheses.
* Result significant at the 10% level.
** Result significant at the 5% level.
*** Result significant at the 1% level.

Table A6. Effect of Cancer and ESS on Employment in Period 2:
Interaction Coefficients for Probit Models

Panel A: Full Sample

	Working (Table 3)	Working (Table 4✚)	Working (Table 4◆)	Working (Table 5)	Working (Table 8)
Without controls	-0.113***	-0.110**	-0.125*	-0.292***	0.059
	(0.044)	(0.053)	(0.074)	(0.102)	(0.051)
With controls	-0.096**	-0.079	-0.121*	-0.271**	-0.037
	(0.045)	(0.051)	(0.071)	(0.114)	(0.049)
Observations	12,345	12,345	12,345	2,334	6,086

Panel B: Respondents Working Full-Time in Period 1

	Working (Table 3)	Working (Table 4✚)	Working (Table 4◆)	Working (Table 5)	Working (Table 8)
Without controls	-0.134***	-0.152**	-0.122	-0.277***	0.063
	(0.049)	(0.062)	(0.079)	(0.103)	(0.049)
With controls	-0.116**	-0.117**	-0.119	-0.254**	0.050
	(0.048)	(0.057)	(0.074)	(0.110)	(0.047)
Observations	9,660	9,660	9,660	1,978	5,397

Note:
See notes for Table 3 for information on control variables.
Clustered standard errors (by person) in parentheses.
✚ Cancer*OVER.
◆ Cancer*CROSS.
* Result significant at the 10% level.
** Result significant at the 5% level.
*** Result significant at the 1% level.

Table A7. Effect of Cancer and ESS on Employment in Period 2:
Main Results including Control Variables

Panel A: Full Sample

	Working	Working	Hours	Hours	Hours (C)	Hours (C)
Cancer	-0.006	-0.003	-0.644	-0.042	-0.413	0.634
	(0.026)	(0.026)	(1.551)	(1.397)	(1.190)	(0.826)
ESS	-0.157***	-0.103***	-12.472***	-5.710***	-7.454***	-1.890***
	(0.007)	(0.013)	(0.358)	(0.607)	(0.326)	(0.414)
Cancer*ESS	-0.113***	-0.112***	-4.994**	-5.330***	-1.726	-2.490*
	(0.044)	(0.043)	(2.140)	(1.943)	(1.791)	(1.283)
Age		-0.126***		-7.172***		-1.137
		(0.037)		(1.672)		(1.186)
Age squared		0.001***		0.055***		0.007
		(0.000)		(0.014)		(0.010)
Non-white		0.016		0.543		-0.045
		(0.010)		(0.461)		(0.311)
Poor health		-0.070***		-3.080***		-0.359
		(0.011)		(0.479)		(0.326)
College (some or full)		0.035***		0.654**		-0.880***
		(0.007)		(0.325)		(0.228)
Smoker		-0.048***		-1.953***		-0.321
		(0.009)		(0.413)		(0.277)
More than 2 people living at home		0.014**		1.120***		0.779***
		(0.007)		(0.311)		(0.204)
Partnered, not married		-0.042**		-1.698**		-0.086
		(0.019)		(0.804)		(0.557)
Spouse working		0.035***		1.214***		-0.014
		(0.008)		(0.345)		(0.243)
Self-employed		0.044***		1.962***		0.331
		(0.010)		(0.436)		(0.353)
Hours of work		0.003***		0.641***		0.675***
		(0.000)		(0.014)		(0.011)
2nd earnings quartile		0.045***		1.837***		0.914***
		(0.011)		(0.458)		(0.353)
3rd earnings quartile		0.021*		1.767***		1.701***
		(0.012)		(0.536)		(0.405)
4th earnings quartile		0.015		1.814***		1.826***
		(0.013)		(0.604)		(0.455)
2nd household income quartile		-0.001		-0.474		-0.421
		(0.010)		(0.434)		(0.298)
3rd household income quartile		-0.008		-0.853*		-0.335
		(0.011)		(0.488)		(0.356)
4th household income quartile		0.007		-0.114		-0.209
		(0.013)		(0.582)		(0.414)
Covered by EPI		0.010		-0.018		-0.454
		(0.011)		(0.493)		(0.368)
Spouse covered by EPI		-0.006		-0.460		-0.265
		(0.012)		(0.559)		(0.401)
Spouse covered by spouse's EPI		-0.010		-0.478		-0.153
		(0.011)		(0.462)		(0.332)
Covered by spouse's EPI		-0.019*		-1.103**		-0.280
		(0.011)		(0.484)		(0.336)
Defined benefit pension		-0.089***		-3.718***		0.268
		(0.010)		(0.455)		(0.301)
Defined contribution pension		-0.005		0.306		0.726**
		(0.009)		(0.413)		(0.285)

Both types of pensions		-0.070***		-2.987***		-0.124
		(0.019)		(0.895)		(0.593)
Covered by Medicare		0.003		0.141		-0.202
		(0.020)		(0.843)		(0.634)
Wave 4, 5, or 6		0.006		0.511		0.409*
		(0.008)		(0.356)		(0.241)
Wave 7, 8, or 9		0.012		0.456		0.134
		(0.008)		(0.373)		(0.258)
Mid-Atlantic		-0.056***		-1.906**		0.326
		(0.016)		(0.787)		(0.563)
East North Central		-0.051***		-1.421*		0.468
		(0.015)		(0.767)		(0.544)
West North Central		-0.052***		-1.290		0.734
		(0.017)		(0.844)		(0.610)
South Atlantic		-0.043***		-1.141		0.554
		(0.015)		(0.743)		(0.537)
East South Central		-0.070***		-2.495***		0.239
		(0.018)		(0.882)		(0.643)
West South Central		-0.039**		-0.559		1.278**
		(0.017)		(0.847)		(0.604)
Mountain		-0.063***		-2.502***		0.299
		(0.019)		(0.926)		(0.672)
Pacific		-0.049***		-1.399*		0.558
		(0.016)		(0.809)		(0.578)
Constant	0.917***	4.827***	39.773***	242.622***	43.351***	53.080
	(0.004)	(1.106)	(0.239)	(50.111)	(0.196)	(35.431)
Observations	12,345	12,345	12,345	12,345	10,321	10,321
R-squared	0.048	0.090	0.105	0.313	0.071	0.465

Note:
Details for control variables can be found in Table 2.
ESS – Eligible for Social Security.
(C) – Conditional on working in Period 2.
Clustered standard errors (by person) in parentheses.
* Result significant at the 10% level.
** Result significant at the 5% level.
*** Result significant at the 1% level.

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