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How did the COVID-19 pandemic affect cancer patients in England who had hospital appointments cancelled?☆

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1. Introduction

The COVID-19 pandemic severely disrupted NHS services, including widespread cancellation of elective surgeries. This was done to free up and reallocate hospital resources for those infected with COVID-19 and to protect both patients and healthcare workers from potential COVID-19 exposure (NHS England, 2020). This situation would have been distressing for all affected patients, but particularly so for those patients with cancer. Whilst the NHS tried to safeguard cancer care during the pandemic, (Glasbey et al., 2021) showed that services around cancer surgery were unable to function fully during lockdowns. One in seven patients who were in regions with full lockdowns had planned surgery cancelled or delayed, and experienced longer preoperative delays.

The impacts of the COVID-19 pandemic on healthcare systems and patient outcomes have been well-documented in the literature, with many studies focusing on the immediate disruptions to service provision and direct health consequences. There is literature that demonstrates how the COVID-19 pandemic led to a reallocation of resources (e.g. (McCabe et al., 2020), (Winkelmann et al., 2022)), and debate about how reallocation of resources should be done fairly so that the impacts are minimised (e.g. (Roadevin and Hill, 2021)). However, there remains a need to investigate the potential longer-term and more systemic effects that the pandemic-induced reorganisation of care may have had on patients' ongoing access to treatment and health outcomes.

Our study aims to address this gap by examining a specific cohort of cancer patients who experienced cancelled outpatient appointments during the initial COVID-19 outbreak in England. In this paper, we explore the consequences of cancelled appointments during the pandemic for patients with an existing cancer diagnosis residing in England to test whether the short-term disruption seen in healthcare provision affected the health of cancer patients. We study their subsequent hospital use and survival rates. We focus on the outcomes of those who had an appointment cancellation during the initial stage of the COVID-19 pandemic and compare their outcomes with those from a similarly-defined pre-pandemic control cohort.

The consequences of cancelled appointments can be significant for patients. Delays in diagnosis and treatment can allow cancer to progress, potentially reducing the chances of successful treatment. In some cases, delays can even be life-threatening. For cancer patients, cancelled appointments can also be emotionally difficult. The uncertainty and lack of control can cause anxiety and stress. It can also be frustrating and disheartening to have to wait longer for treatment and resolution. There is extensive literature demonstrating the issues associated with delayed treatment for cancer patients. For example, (Hanna et al., 2020) show in a systematic review that even a four-week delay in a variety of cancer treatments is associated with increased mortality for seven cancers.

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Table 1
Descriptive statistics by cohort.

Variable	*Covid cohort*		*Pre-Covid cohort*	
	Mean	Standard deviation	Mean	Standard deviation
Male	0.41	0.49	0.42	0.49
Age at cancer diagnosis	61.8	17.7	60.5	18.1
Indian/Pakistani/Bangladeshi	0.04	0.20	0.04	0.20
Asian	0.02	0.13	0.02	0.14
Black	0.05	0.21	0.05	0.21
Appt. cancelled by doctor	0.34	0.47	0.16	0.37
First appointment cancelled	0.52	0.50	0.38	0.49
Cancer duration at cancellation (days)	139.5	85.4	148.4	84.8
Time to first appointment (days)	42.4	53.4	27.2	38.5
No. of outpatient visits in 7 months after cancellation	7.15	8.68	8.37	9.32
No. of outpatient cancer visits in 7 months after cancellation	0.42	3.36	0.56	4.12
No. of inpatient admiss. in 7 months after cancellation	4.48	9.42	6.93	12.14
No. of inpatient cancer admiss. in 7 months after cancellation	1.39	4.91	1.97	6.26
Length of first admission after cancellation (days)	1.17	3.19	1.74	4.12
Observations	7,654		9,005	
Died during the study period	459 (6.0%)		682 (7.6%)	
Had a cancer appt. between diagnosis & cancellation	1,385 (18.1%)		1,937 (21.5%)	

Notes: Data comes from QResearch database. Covid cohort – a random sample of NHS patients from England diagnosed with cancer between June 15, 2019, and March 14, 2020 (with an appointment cancellation between March 15, 2020, and May 14, 2020). Pre-Covid cohort – a random sample of NHS patients from England diagnosed with cancer between June 15, 2017, and March 14, 2018 (with an appointment cancellation between March 15, 2018, and May 14, 2018). Male – binary var. equal to 1 if individual is male, and 0 otherwise. Age at diagnosis – patient's age at the time of cancer diagnosis. White – binary var. equal to 1 if individual self-identifies as being of white race/ethnicity, and 0 otherwise. Indian/Pakistani/Bangladeshi – binary var. equal to 1 individual self-identifies as being of Indian/Pakistani/Bangladeshi race/nationality, and 0 otherwise. Asian – binary var. equal to 1 individual self-identifies as being of Asian race/ethnicity, and 0 otherwise. Black – binary var. equal to 1 individual self-identifies as being of black race/ethnicity, and 0 otherwise. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Time to first appointment (days) – length of time (in days) between the cancellation and the next non-cancelled appointment. No. of outpatient visits in 7 months after cancellation – no. of all outpatient visits during the first 7 months after the cancellation. No. of outpatient cancer visits in 7 months after cancellation – no. of cancer-related outpatient visits during the first 7 months after the cancellation. No. of inpatient admiss. in 7 months after cancellation – no. of all inpatient admission during the first 7 months after the cancellation. No. of inpatient cancer admiss. in 7 months after cancellation – no. of cancer-related inpatient admission during the first 7 months after the cancellation. Length of first admission after cancellation (days) – length (in days) of the first inpatient admission after the cancellation.

Additionally (Ng et al., 2021) show a large increase in the risk of new metastases and local tumour growth as a result of delays in treatment for patients with cancer and (Sud et al., 2020) find that even modest delays in surgery for cancer have a significant impact on survival.

This study utilises administrative health data from QResearch from 2017 to 2021 to examine subsequent health care utilization and survival of cancer patients who had appointments cancelled during the course of their treatment, regardless of whether those cancelled appointments were related to their cancer or for the treatment of other conditions. QResearch provides Hospital Episode Statistics (HES) data of inpatient records and information on appointments scheduled and subsequently cancelled by hospitals. Patients were identified as having cancer based on cancer-related ICD-10 diagnosis codes recorded in the data. QResearch link the HES data to primary care data to obtain additional information on the identified cancer patients, such as demographic details. We were able to define a comprehensive cohort of cancer patients and examine rates and reasons for cancelled hospital appointments within this group. Looking specifically at cancelled appointments provides insights into issues with access to timely care among cancer patients.

We estimate a series of ordinary least squares (OLS) and Cox proportional-hazards models to understand how long patients wait for their hospital appointment after a delay, their subsequent resource use, and the impact on their short-term mortality. The analysis shows that cancer patients who suffered a cancelled appointment during the initial stage of the pandemic had to wait, on average, an additional 19 days (55% of the sample mean) for their rescheduled appointment, compared to the patients in a similarly defined pre-pandemic cohort. During the seven months following the initial cancellation, the pandemic cohort patients received fewer appointments compared to the control group – namely one fewer outpatient visit (14% of the mean) and almost two fewer inpatient admissions (32% of the mean). They also spent less time in the hospital (almost a full-day less, or 50% of the mean) during their first admission after the cancellation. Despite using less resources, our results suggest that, if anything, the risk of mortality was lower for the COVID-19 cohort, although the estimate is not statistically significant once we account for other factors. The analysis also provides evidence showing that cancellations later in the course of the disease might be less disruptive to patient's treatment, and that having the appointment cancelled by a medical provider (as opposed to a self-cancellation) is associated with significantly higher survival rates. This latter finding suggests that clinicians are good at prioritizing the patients most in need of treatment.

Our paper contributes to two strands of literature. Firstly, we add to the growing literature that looks at the impact of the COVID-19 pandemic on cancer patients. In England, studies have found a decline in GP consultations and urgent referrals for cancer clinical features (Nicholson et al., 2022); a substantial increase in the expected number of deaths due to diagnostic delays for breast, oesophageal, and lung cancers (Maringe et al., 2020) and increased COVID-19 fatality rate among cancer patients (Li et al., 2021). There is also relevant literature from Scotland where services experienced a large reduction in cancer patient attendance (28.7%), although attendance responded rapidly following service redesign (Baxter et al., 2021). Stage of cancer at diagnosis is related to survival; in cancers where patients typically present at later stages (e.g. oesophagogastric cancer in (Baxter et al., 2023)), survival rates were lower. We consider a large sample of patients with a specific disruption in care, and estimate the impact on both subsequent health care use and survival.

By studying the consequences of interruptions in cancer care during the COVID-19 pandemic, we also contribute to the literature that

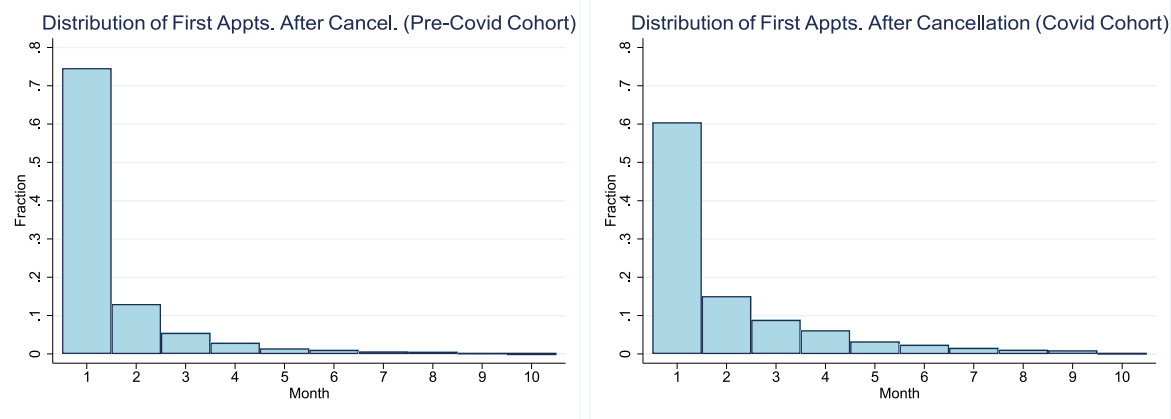

Fig. 1. First Appointment Following Cancellation – Distribution by Cohort (First 10 Months)
Notes -Data comes from QResearch database. The event of interest is the first doctor's appointment after the cancellation. *Pre-Covid* cohort – a random sample of NHS patients from England diagnosed with cancer between June 15, 2017, and March 14, 2018, and with an appointment cancellation between March 15, 2018, and May 14, 2018. *Covid* cohort – a random sample of NHS patients from England diagnosed with cancer between June 15, 2019, and March 14, 2020, and with an appointment cancellation between March 15, 2020, and May 14, 2020.

considers the impact of health care disruptions on patient outcomes. There are studies that look particularly at Covid-related disruptions such as (Jain and Dupas, 2022) which found a sharp increase in non-COVID morbidity and mortality among dialysis patients in India, and (Fetzer and Rauh, 2022) show that providers in England under COVID-19 pressures experienced notably more excess deaths among non-COVID related hospital episodes. There have been mixed results from studies that look at the effect of hospital closures on patient outcomes. There is evidence that US rural hospital closures increase patient mortality (Gujral and Basu, 2019) and decrease overall patient welfare (Mcnamara, 1999) in rural settings, and similar findings for urban hospitals (Buchmueller et al., 2006). However, (Joynt et al., 2015) find no link between hospital closures and patient outcomes.

The rest of the paper is structured as follows. In the next section, we discuss the empirical strategy, detailing the data used and the regressions estimated. Section 3 presents the results for our main variables of interest and robustness checks. The final section concludes and discusses our results.

2. Data and empirical strategy

2.1. Data, estimation sample, and descriptive statistics

The data used in the empirical analysis comes from the QResearch database based at the University of Oxford.[1] QResearch holds anonymized health records of more than 35 million patients from across England. The confidential data links patient records from the GP patient registry with those from the Hospital Episode Statistics (HES), and the National Death Register. Information provided includes detailed patient histories with respect to the utilization of primary, secondary, and emergency health care services. In addition, the dataset contains a range of patient demographics as well as socio-economic details relating to each patient's local area of residence.Our estimation sample consists of two cohorts of patients. First, we define our "treatment" cohort (also referred to as the Covid cohort) as a random sample of NHS patients from England diagnosed with cancer between June 15, 2019, and March 14, 2020, who had an appointment cancelled at some point between March 15, 2020, and May 14, 2020, regardless of whether those cancelled appointments were related to their cancer or for the treatment of other conditions. One important limitation of our data is that we cannot determine whether cancelled outpatient appointments for the cancer patients in our sample were explicitly for cancer treatment or for other, unrelated conditions. Our dataset only contains information on whether a patient had an existing cancer diagnosis. As a result, our analysis captures the effects of any appointment cancellations experienced by this patient population during the pandemic, regardless of whether the appointment was directly linked to their cancer care pathway. While this limitation prohibits us from making strong inferences about disruptions to cancer treatment specifically, our study still provides valuable insights into the broader impacts on overall healthcare access and engagement for cancer patients during this period. However, we acknowledge that the interpretation of our results is weakened in terms of attributing the observed effects solely to disruptions in cancer care provision. Future work with more granular data on appointment types would help disentangle these pathways. Furthermore, our dataset lacks detailed clinical information on cancer characteristics such as tumor stage or severity. While we have data on cancer diagnoses, we do not have measures to determine the stage or severity level of each patient's cancer at the time of their cancelled appointments. This is an important limitation, as cancer stage could moderate the impact of cancelled appointments on outcomes.

Thus, the treatment cohort comprises patients who were already in the system at the start of the pandemic and who experienced a cancellation during the period of particularly severe disruption in NHS services. The "control" cohort is defined in a similar manner for an earlier timeframe; we consider a random sample of NHS patients from England who were diagnosed with cancer between June 15, 2017, and March 14, 2018, and who experienced an appointment cancellation at some point between March 15, 2018, and May 14, 2018. In the cancer survival analysis, due to data limitations, we are able to follow the treatment cohort patients only until January 31, 2020. Thus, we follow the control cohort patients until January 31, 2019. The diagnosis years for the control cohort (i.e. 2017-2018) were therefore selected to ensure its survival period does not overlap with the diagnosis period of the treatment cohort. As an important robustness check, we further extend the treatment/control cohorts to all patients with an appointment cancellation between March 15 and December 31 (of 2018 and 2020, respectively).Table 1 presents the descriptive statistics separately by cohort, while Table A1 shows them for the pooled sample. As expected, the two groups are similar in terms of the basic demographics, such as sex, age,

[1] QResearch is a not for profit collaboration between the University of Oxford and EMIS – the main software supplier for GP practices across the UK.

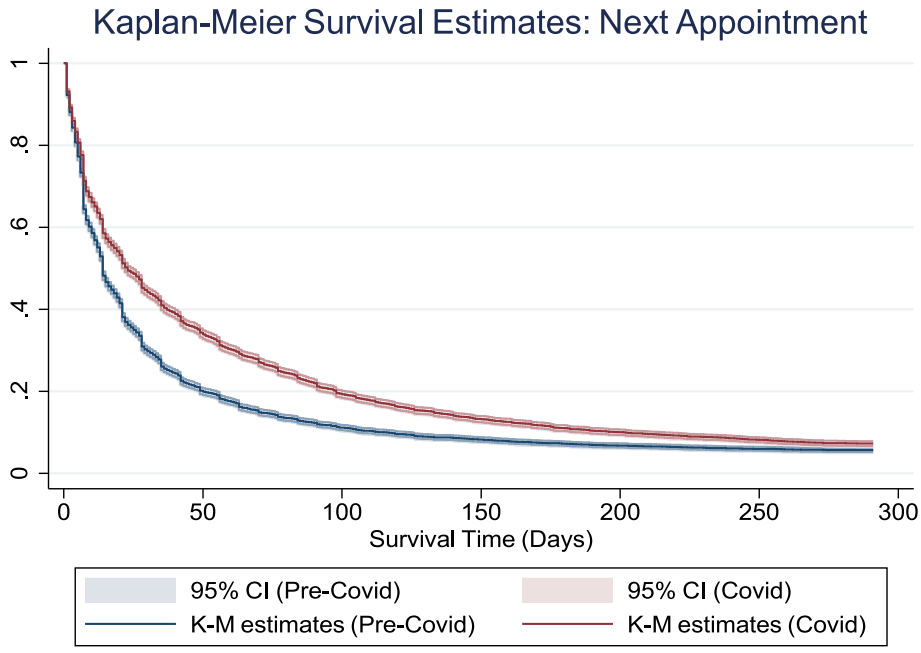

Fig. 2. Kaplan-Meier Survival Estimates – First Appointment Following Cancellation
Notes -Data comes from QResearch database. The event of interest is the first doctor's appointment after the cancellation. Survival time is measured in days. *Pre-Covid* cohort – a random sample of NHS patients from England diagnosed with cancer between June 15, 2017, and March 14, 2018, and with an appointment cancellation between March 15, 2018, and May 14, 2018. *Covid* cohort – a random sample of NHS patients from England diagnosed with cancer between June 15, 2019, and March 14, 2020, and with an appointment cancellation between March 15, 2020, and May 14, 2020.

and race/ethnicity (Table 1). In addition, we carry out a placebo test where we estimate the differences in pre-cancellation healthcare utilization[2] between the two cohorts. Findings are shown in Table A2. Considering all appointments, we do not observe a systematic pattern of differences between the two groups (Table A2, cols. 1–2). While the coefficient for inpatient care is marginally statistically significant (at 10% level), its counterpart for the outpatient care is not statistically significant. Furthermore, the two estimates are different in their sign which means neither cohort had a systematic advantage in healthcare utilization before the study period. This assertion is further supported by the analysis of cancer-related appointments (Table A2, cols. 3–4), where we estimate null effects for both inpatient and outpatient care. Overall, the evidence suggests the two cohorts were fairly similar to each other before the study period.

On the other hand, the cohorts are different in terms of the cancellation characteristics. In particular, 34% of cancellations in the Covid cohort were made by the physician's office – as opposed to the patients themselves – compared to only 16% in the pre-Covid cohort. It is important to note that patient no-shows are counted as patient-initiated cancellations. This provides some evidence of effective prioritization by the medical providers during the pandemic. 52% of cancellations were initial appointments in the Covid cohort versus 38% in the pre-Covid cohort. Cancer duration between diagnosis and cancellation was, on average, 9 days shorter for the Covid cohort. This is indicative of front-loading of the cancellations at the start of the first nationwide lockdown compared to more evenly distributed cancellations two years prior (Figure A1). Finally, the two groups differ in terms of their post-cancellation health care access and utilization, as shown by the

[2] Defined as the number of appointments between cancer diagnosis and March 1, 2018 (2020, respectively). March 1 is chosen as the cutoff date to ensure that any potential Covid-related disruptions in healthcare — which could have already started in the first half of March 2020 – are not driving the placebo estimates.

Table 2
Cox proportional-hazards analysis – first appointment following cancellation.

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	_t	_t	_t
Covid cohort	0.730[a]	0.716[a]	0.714[a]
	(0.031)	(0.034)	(0.034)
Cancer duration at cancellation	0.999[a]	0.998[b]	0.998[a]
	(0.000)	(0.001)	(0.001)
Appt. cancelled by doctor		0.976	0.977
		(0.024)	(0.024)
First appointment cancelled		1.039[c]	1.038[c]
		(0.022)	(0.022)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	16,658	16,480	16,480

Notes: Hazard ratios reported. Standard errors in parentheses. Data comes from QResearch database. *Covid cohort* – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. *Cancer duration at cancellation* – no. of days since diagnosed with cancer at the time of the cancelled appointment. *Appt. cancelled by doctor* – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. *First appointment cancelled* – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity.
[a] Significant at the 1% level.
[b] Significant at the 5% level.
[c] Significant at the 10% level.

Table 3
Time to first appointment following cancellation (OLS).

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	Time to first appt.	Time to first appt.	Time to first appt.
Covid cohort	16.93******	18.65******	18.70******
	(1.93)	(2.16)	(2.16)
Cancer duration at cancellation	0.023	0.084****	0.085****
	(0.019)	(0.035)	(0.035)
Appt. cancelled by doctor		4.269******	4.209******
		(1.097)	(1.100)
First appointment cancelled		−3.189******	−3.233******
		(0.917)	(0.918)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	15,554	15,386	15,386
R-squared	0.038	0.039	0.040
Mean of dependent variable	34.11	34.11	34.11
Std. dev. of dependent variable	46.50	46.50	46.50

Notes: Regression analysis estimated using ordinary least squares (OLS). Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. Time to first appt. – length of time (in days) between the cancellation and the next non-cancelled appointment. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

differences in means (and standard deviations) for the last six variables in Table 1.

2.2. Empirical specifications

While difference-in-differences designs can be valuable for estimating the causal effects of policy changes or shocks, we did not have a suitable control group available for implementing this approach in our study. The COVID-19 pandemic and resulting lockdowns affected all regions of England simultaneously, leaving no clear comparison group unaffected by the disruptions to healthcare provision. A key requirement of difference-in-differences is having a set of untreated units that can represent the counterfactual outcome trend. Without such a control group, any difference-in-differences estimation would suffer from potential biases. Therefore, we opted for methods that could estimate associations between the pandemic disruptions and patient outcomes without requiring an untreated comparison. While these methods cannot definitively establish causality, they are well-suited for characterising potential relationships in observational data when a control group is unavailable. We acknowledge this limitation and interpret our findings as associations rather than causal effects.

To analyze the consequences of the first COVID-19 lockdown on cancer patients in England, we estimate a series of ordinary least squares (OLS) and Cox proportional-hazards models, comparing the two cohorts defined in Section 2.1 across a range of outcomes. First, we consider a survival analysis where the event of interest is the first doctor's appointment following the initial cancellation. The Cox proportional hazards regression specification for patient i has the following form:

$$h_i(t) = h_0(t)\exp(\beta \text{Covid}_i + X_i'\gamma + Z_i'\delta + \lambda_y + \eta_m + \theta_c + \psi_d + \varphi_r) \quad (1)$$

where $h_i(t)$ is the hazard function,[3] $h_0(t)$ is the baseline hazard rate (with all the predictors set to zero), and $Covid_i$ – the main independent variable of interest – is a binary variable equal to 1 if the patient belongs to the Covid cohort, and 0 otherwise. Eq. (NHS England, 2020) further controls for the following set of covariates: (NHS England, 2020) patient-specific characteristics (X_i), such as sex, age, age-squared, race/ethnicity, and the duration of cancer at the time of the appointment cancellation; (Glasbey et al., 2021) characteristics of the cancelled appointment (Z_i), namely the type of cancellation (i.e. whether by the physician's office or by the patient)as well as the order of the cancelled appointment (i.e. first vs follow-up appointment); (McCabe et al., 2020) year and month of diagnosis fixed effects (λ_y, η_m); (Winkelmann et al., 2022) month of cancellation fixed effects (θ_c); (Roadevin and Hill, 2021) township deprivation quintile fixed effects (ψ_d); and (Hanna et al., 2020) region of residence fixed effects (φ_r), where region is taken from the formal Government Office Region data, the highest tier of sub-national regions used in England. The parameter of interest – β – represents the difference in the instantaneous probability of having the first appointment (given no appointment to date) between the two cohorts, holding all of the other predictors constant. In practice, we are interested in the estimated hazard ratio (e^{β}), which is the ratio of hazard rates for the two cohorts. A hazard ratio of less than 1 would indicate that a patient in the covid cohort would expect their next appointment to occur more quickly than a patient in the control cohort.

Second, to evaluate the disparities in health care utilization following the cancelled appointment, we estimate the following ordinary least squares (OLS) model:

$$Y_i = \alpha + \beta \text{Covid}_i + X_i'\gamma + Z_i'\delta + \lambda_y + \eta_m + \theta_c + \psi_d + \varphi_r + \epsilon_i \quad (2)$$

where the following outcomes of interest (Y_i) are considered: (NHS England, 2020) time (in days) to the first appointment following the cancellation; (Glasbey et al., 2021) the number of outpatient visits (all; cancer-specific) in the first seven months after the cancellation[4]; (McCabe et al., 2020) the number of inpatient admissions (all; cancer-specific) in the first seven months after the cancellation; (Winkelmann et al., 2022) the length (in days) of the first inpatient admission after the cancellation. The right-hand side variables are defined in the same manner as in eq. (NHS England, 2020), while the ϵ_i is the heteroskedasticity-robust error term. The coefficient of interest – β – captures the differences in the average health care utilization between the two cohorts, in a model which controls for the variation in all the other predictors.

Finally, to understand the impact of the covid-related disruptions in health care on cancer survival, we estimate a Cox proportional hazards model identical to that in eq. (NHS England, 2020), but with the patient's death as the event of interest. Due to data limitations, the analysis focuses only on short-term survival (i.e. up to 19.5 months) from the time of diagnosis.[5] Furthermore, due to data limitations, we cannot single out cancer as a cause of death, hence our survival analysis captures all deaths, not just cancer-related deaths.

[3] The instantaneous probability of having the first appointment after cancellation, given that up until time t, the appointment has not yet taken place.

[4] The length of this period is determined by data availability, as the data on inpatient/outpatient care is only available until December 31, 2020.

[5] And up to 10.5 months after the appointment cancellation.

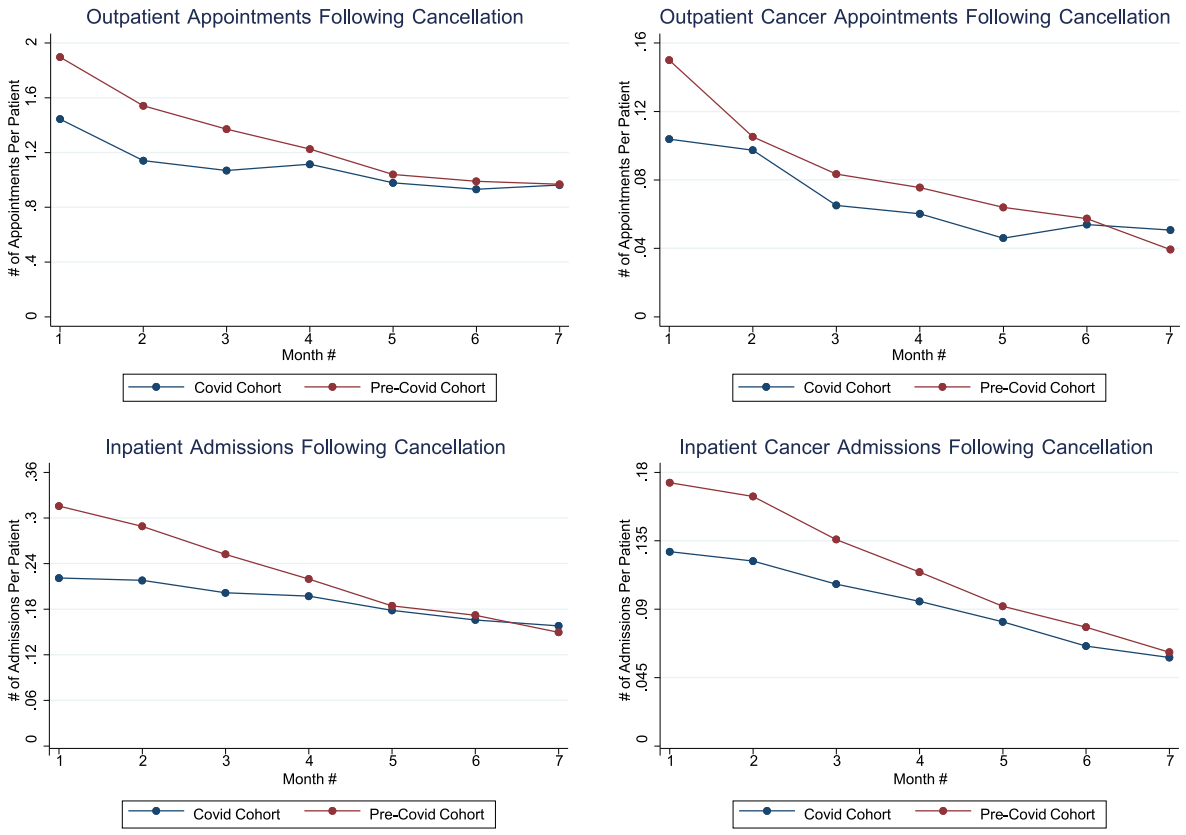

Fig. 3. Outpatient & Inpatient Care Following Appointment Cancellation
Notes -Data comes from QResearch database. *Pre-Covid Cohort* – a random sample of NHS patients from England diagnosed with cancer between June 15, 2017, and March 14, 2018, and with an appointment cancellation between March 15, 2018, and May 14, 2018. *Covid Cohort* – a random sample of NHS patients from England diagnosed with cancer between June 15, 2019, and March 14, 2020, and with an appointment cancellation between March 15, 2020, and May 14, 2020.

3. Results

The results are presented in two parts. First, we discuss the disparities in healthcare access and utilization between the two cohorts, which occurred as a consequence of the first COVID-19 lockdown in England. Then, we turn attention to the ultimate outcome of interest – cancer survival.

3.1. Main results

3.1.1. Health care utilization following the cancellation

We begin by analyzing the time to the first attended appointment following the initial lockdown-related cancellation. Fig. 1 shows the cohort-specific distributions of the first appointment over the initial 10 months after the cancellation. While nearly 75% of cancellations in the pre-Covid (control) cohort were rescheduled within the first 30 days, this number drops to 60% for the Covid cohort. Nevertheless, in both cohorts, virtually all cancellations were successfully rescheduled within the first 7 months. Fig. 2 plots the Kaplan-Meier estimates from the survival analysis in which the event of interest is the first appointment after the cancellation. These show the cumulative probabilities of not yet having the first appointment at a given time since the cancellation. We can also think of the Kaplan-Meier estimate as the share of patients without an attended appointment at a given point in time. The pre-Covid cohort appears to fare better, as these patients were generally able to attend their next appointments more quickly. Indeed, the formal log-rank test suggests the two survival functions in Fig. 2 are different from each other (p-value of 0.000).The hazard ratio estimates from the Cox proportional-hazards model further reinforce the finding of longer delays for the Covid cohort. As shown in Table 2 being in the Covid cohort is associated with a decreased hazard of having their appointment rescheduled promptly. This key coefficient remains statistically significant at the 1% level even after controlling for cancer duration, cancellation reason, demographic characteristics, and a comprehensive set of fixed effects (Table 2, col. 3). To quantify the magnitude of the differential waiting times between cohorts, we estimate equation (Glasbey et al., 2021) using the time elapsed between cancellation and the next scheduled appointment as the outcome variable. Table 3 presents the results. Covid cohort patients had to wait for the next appointment, on average, an additional 19 days (55% of the sample mean) compared to the patients in the control cohort (Table 3, col. 3).

Next, we explore the differences in healthcare utilization during the first seven months following the cancellation. Fig. 3 plots the trends by cohort in the number of appointments per patient across this period. For both outpatient visits and inpatient admissions, we observe a gap between the two cohorts, with the Covid cohort experiencing fewer appointments on average. This gap appears to close by the fifth month, although when focusing specifically on cancer-related appointments, some disparity in health care utilization persists for longer. Similarly, when looking at the total number of cancer-related appointments for each cohort during the 7-month period between March 15 and October 15, we observe a clear drop in appointment numbers for the treatment group, which persists until the end of the sixth month (Figure A2).

To quantify this difference in healthcare utilization, we estimate ordinary least squares models in which we regress various health care utilization outcomes on a Covid cohort binary variable, while controlling for the same set of variables as in the Cox model above. Being diagnosed with cancer just before the COVID-19 pandemic is associated with one fewer outpatient appointment (14% of the sample mean) during the first seven months following the cancellation (Table 4, col. 3).

Table 4
Outpatient visits during 7 Months following cancellation (OLS).

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	No. of outpatient visits	No. of outpatient visits	No. of outpatient visits
Covid cohort	−1.206******	−1.092****	−1.093****
	(0.387)	(0.430)	(0.430)
Cancer duration at cancellation	−0.006	−0.006	−0.006
	(0.004)	(0.007)	(0.007)
Appt. cancelled by doctor		0.114	0.124
		(0.202)	(0.203)
First appointment cancelled		−0.722******	−0.718******
		(0.179)	(0.179)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	16,511	16,336	16,336
R-squared	0.019	0.020	0.021
Mean of dependent variable	7.811	7.815	7.815
Std. dev. of dependent variable	9.053	9.046	9.046

Notes: Regression analysis estimated using ordinary least squares (OLS). Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. No. of outpatient visits – no. of all outpatient visits during the first 7 months after the cancellation. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table 5
Outpatient cancer-related visits during 7 Months following cancellation (OLS).

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	No. outpatient cancer visits	No. outpatient cancer visits	No. outpatient cancer visits
Covid cohort	−0.040	0.018	0.012
	(0.168)	(0.183)	(0.183)
Cancer duration at cancellation	0.000	0.002	0.002
	(0.001)	(0.003)	(0.003)
Appt. cancelled by doctor		0.098	0.110
		(0.088)	(0.088)
First appointment cancelled		−0.125**	−0.121**
		(0.071)	(0.071)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	16,652	16,474	16,474
R-squared	0.007	0.007	0.012
Mean of dependent variable	0.496	0.500	0.500
Std. dev. of dependent variable	3.792	3.809	3.809

Notes: Regression analysis estimated using ordinary least squares (OLS). Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. No. of outpatient cancer visits – no. of cancer-related outpatient visits during the first 7 months after the cancellation. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

However, this effect seems to disappear once we focus on cancer-related outpatient visits (Table 5, col. 3). Considering the inpatient admissions, we observe an even larger disparity between the two cohorts. More specifically, Covid-cohort patients experienced almost two fewer admissions (32% of the mean) during the first seven months following the cancellation (Table 6, col. 3). The gap is similar (31% of the mean) when we restrict the analysis to cancer-specific admissions (Table 7, col. 3). Lastly, we consider the cohort-disparity in the duration of the first admission after the cancellation. Table 8 reports the results. The main estimate (Table 8, col. 3) suggests that cancer patients diagnosed before the pandemic spent almost a full day less in hospital (50% of the mean). Overall, these findings suggest that the Covid cohort had a substantially diminished use of health care services during the first seven months following their lockdown-induced appointment cancellation.

3.1.2. Cancer survival

The ultimate outcome of interest is post-diagnosis survival. Due to data limitations, we consider just short-term survival, as we are only able to follow patients for up to 19.5 months after the diagnosis. As illustrated in Fig. 4, the simple Kaplan-Meier analysis suggests improved survival for the Covid cohort, as the two survival curves begin to diverge at around 6 months after the diagnosis. The log-rank test confirms the survival functions are different from each other (p-value of 0.000). However, the Cox analysis further reveals the difference in the risk of death between the two cohorts is not statistically significant once we control for patient characteristics and a range of fixed effects (Table 9, cols. 1–3). Interestingly, Table 9 also shows that cancer duration at the time of the cancellation is positively associated with cancer survival, suggesting that cancellations later in the course of the disease might be less disruptive to patient's treatment. Similarly, having the appointment cancelled by a medical provider (as opposed to a self-cancellation) substantially improves survival. On the other hand, whether the cancelled appointment was the first appointment in a patient's treatment pathway or later in the course of their treatment does not appear to be associated with a significant change in the risk of death (Table 9).

3.2. Robustness checks

We conduct robustness checks to test the sensitivity of the results to different sample selection criteria and estimation methods. First, to improve the power of the analysis, we extend the estimation sample to those with an appointment cancellation between mid-March and the end of December.[6] The Cox estimates from the survival analysis of the first appointment after cancellation (Table A3) are largely consistent with

[6] 2020 for the Covid cohort and 2018 for the pre-Covid cohort, respectively.

Table 6
Inpatient admissions during 7 Months following cancellation (OLS).

	(1)	(2)	(3)
	No. of inpatient admiss.	No. of inpatient admiss.	No. of inpatient admiss.
Covid cohort	−2.147******	−1.852***	−1.839***
	(0.405)	(0.465)	(0.466)
Cancer duration at cancellation	−0.003	0.003	0.003
	(0.005)	(0.008)	(0.008)
Appt. cancelled by doctor		−0.138	−0.128
		(0.232)	(0.233)
First appointment cancelled		−0.614***	−0.613***
		(0.219)	(0.220)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	16,593	16,415	16,415
R-squared	0.021	0.022	0.023
Mean of dependent variable	5.803	5.790	5.790
Std. dev. of dependent variable	11.04	11.06	11.06

Notes: Regression analysis estimated using ordinary least squares (OLS). Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. No. of inpatient admiss. – no. of all inpatient admission during the first 7 months after the cancellation. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table 7
Inpatient cancer-related admissions during 7 Months following cancellation (OLS).

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	No. inpatient cancer admiss.	No. inpatient cancer admiss.	No. inpatient cancer admiss.
Covid cohort	−0.536****	−0.519**	−0.523**
	(0.213)	(0.242)	(0.243)
Cancer duration at cancellation	−0.002	−0.004	−0.004
	(0.002)	(0.004)	(0.004)
Appt. cancelled by doctor		−0.174	−0.173
		(0.124)	(0.124)
First appointment cancelled		−0.285**	−0.279**
		(0.115)	(0.115)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	16,622	16,444	16,444
R-squared	0.011	0.012	0.013
Mean of dependent variable	1.703	1.705	1.705
Std. dev. of dependent variable	5.684	5.687	5.687

Notes: Regression analysis estimated using ordinary least squares (OLS). Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. No. inpatient cancer admiss. – no. of cancer-related inpatient admission during the first 7 months after the cancellation. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level

the original results (Table 2), although the advantage felt by the pre-Covid cohort diminishes to some extent. Similarly, we observe smaller – albeit still positive and statistically significant – OLS estimates on the time to the first appointment (Table A4). The OLS coefficients from the analysis of the length of the first admission (Table A5) are virtually indistinguishable from their main sample counterparts (Table 8), while the Cox estimates from the cancer survival analysis (Table A6) are also not statistically different from the main coefficients in Table 9. Unfortunately, due to data limitations,[7] we are unable to re-estimate – using the larger sample – the analysis of health care utilization in the seven months following the cancellation.

Second, we re-estimate eq. (Glasbey et al., 2021) using a Poisson regression, which is often employed in models where the outcome is a count variable that follows the Poisson distribution. Regression estimates are reported as the adjusted incidence rate ratios (IRR), which indicate a higher incidence rate for the Covid cohort if the estimated value is larger than one. Across all outcomes, Poisson regressions deliver estimates that are consistent with their OLS counterparts (Tables A7-A12).

Third, we re-estimate the full OLS and Cox specifications while adding a non-parametric control for the location of the primary tumor. Findings are presented in Table A13. The main coefficient of interest remains virtually unchanged across all outcomes (A.13, cols. 1–8). Lastly, to better control for the intensity of cancer treatment between the diagnosis and the cancellation, we replace *cancer duration* in eq. (Glasbey et al., 2021) with either a binary variable equal to 1 if the patient had any cancer-specific appointment between the diagnosis and the cancellation, or the total number of cancer-related appointments during this period. The estimates, shown in Tables A14 and A15, are largely consistent with the main coefficients. A notable difference can be observed for the hazard ratio from the cancer survival analysis, which rises above 1 in both cases. This indicate worses survival prospects for the Covid cohort but the coefficient is not statistically significant (Tables A14-A15, col. 8).

3.3. Heterogeneity analyses

Next, we explore the effect of heterogeneity in health care utilization and cancer survival with respect to patient's sex and age. First, we consider the impact of Covid-induced cancellations on men and women separately. Results are shown in Tables A16, A17, and A18. While the effect size relative to the mean is somewhat larger for men in the majority of outcomes, we do observe a stronger effect for women in the total outpatient visits (Table A16, cols. 1–2) as well as the length of the first admission after cancellation (Table A17, cols. 3–4). The Cox model

[7] As mentioned earlier, data on inpatient/outpatient care is only available until December 31, 2020.

Table 8
Length of first inpatient admission following cancellation (OLS).

	(1)	(2)	(3)
	Length of first admission	Length of first admission	Length of first admission
Covid cohort	−0.809******	−0.767***	−0.765***
	(0.232)	(0.265)	(0.266)
Cancer duration at cancellation	−0.004**	−0.006	−0.006
	(0.002)	(0.004)	(0.004)
Appt. cancelled by doctor		−0.466***	−0.459***
		(0.131)	(0.131)
First appointment cancelled		0.095	0.089
		(0.125)	(0.125)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	7,012	6,920	6,920
R-squared	0.031	0.034	0.036
Mean of dependent variable	1.517	1.523	1.523
Std. dev. of dependent variable	3.794	3.803	3.803

Notes: Regression analysis estimated using ordinary least squares (OLS). Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. Length of first admission – length (in days) of the first inpatient admission after the cancellation. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

hazard ratio from the survival analysis rises above 1 for men, though the estimate is not statistically significant (Table A18, col. 4).

Second, we split the sample age-wise into three categories: (NHS England, 2020) ages 0–40; (Glasbey et al., 2021) ages 41–64; (McCabe et al., 2020) ages 65 or above. As far as the number of outpatient/inpatient visits is concerned, across all four outcomes, we observe the most substantial disruption (relative to the mean) in the youngest age group (Table A19, cols. 1–12). However, for both the time to the first (non-cancelled) appointment and the length of the first admission after cancellation, the effect is strongest among the eldest (Table A20, cols. 1–6; Table A21, cols. 1–3). The Cox survival hazard ratios are, again, all not statistically significant (Table A21, cols. 4–6).

Finally, we study the effect of heterogeneity in cancer survival with respect to the cancer type. However, given data limitations, the information on the cancer site is available only for 39.2% of the sample. Nevertheless, we consider the effects of the cancellations by four most common types of cancer: (NHS England, 2020) cancer of the digestive organs; (Glasbey et al., 2021) melanoma and other skin cancers; (McCabe et al., 2020) cancer of the (fe)male genital organs; and (Winkelmann et al., 2022) breast cancer. Results are shown in Table A22. While the direction of the effect varies between the types, all Cox hazard ratios are not statistically significant, owing largely to the limited sample size in the individual sub-analyses (Table A22, cols. 1–4).

4. Conclusions and discussion

In this paper we study the impact of disruptions in care caused by the COVID-19 pandemic on the health-care utilization and survival prospects of cancer patients in the NHS. We use a unique dataset of administrative data to compare certain outcomes of patients who had an appointment cancellation during the initial phase of the pandemic with those of a similarly defined pre-Covid control cohort. We observe a measurably diminished level of health care use after the initial cancellation among the Covid cohort patients relative to the control group. However, we find no differences in the short-term cancer survival rates. The finding that pandemic-related appointment cancellations did not appear to significantly worsen mortality outcomes for cancer patients suggests hospitals effectively prioritized these patients during the COVID-19 crisis. This enabled critical treatments and surgeries to continue despite restrictions and capacity limitations. However, the reduced hospital usage in the pandemic cohort points to concerning delays in care resulting from appointment cancellations.

This is in-line with some suggestive evidence that disruptions in cancer care don't necessarily worsen patient survival prospects, at least if the delays are short. For example, (Hangaard Hansen et al., 2018) studied the survival rates of patients with colon cancer from five observational studies. Their data showed no association between treatment delay and reduced overall survival. (Bleicher, 2018) find that delays have a measurable but small impact on outcomes amongst breast cancer patients. Other studies mentioned in the introduction, namely (Hanna et al., 2020), (Ng et al., 2021) and (Sud et al., 2020) have found delays to have more harmful impacts. We believe our results were due to doctors accurately selecting patients during the pandemic whose outcomes would not be materially impacted by missing appointments. We propose that the cancelled appointments in non-pandemic situations studied in other literature were more likely to occur randomly and thus will have impacted on patients less able to cope with delayed care. Our results are important for two reasons. Firstly, if disruption was significant, those who were affected could suffer worse health in the future, which would have undesirable consequences for them and may put additional stress on the NHS. Secondly, the current, well-advertised supply-side issues in the NHS could cause continued interruptions to services. Our analysis could shed light on the likely consequences of these disruptions.

There are important caveats to our results. The data we have does not allow us to determine whether there was substitution of care in other settings. For example, it may be that patients were able to receive some treatment in primary care instead. Nor does it allow us to identify precisely whether the cancelled appointments were only related to their cancer treatment. Also, it is possible that oncologists prioritized those patients who were least able to cope with disruption to their treatment, for example, those whose cancer had developed into later stages. It is worth highlighting that we could only study quite a short time horizon. As such, we cannot comment on the long-term survival prospects of the cohort who were affected by Covid-related disruption. Finally, we only focus on a particular subset of cancer patients. In particular, we cannot comment on how the pandemic affected the outcomes of cancer sufferers who waited longer before seeking care.

While we did not find a statistically significant increase in mortality risk for the pandemic cohort after accounting for other factors, the consequences of these care disruptions should not be underestimated. Delays in diagnosis and treatment can allow cancers to progress, potentially reducing the chances of successful treatment outcomes. The emotional toll of cancelled appointments, including increased anxiety and loss of control, can also severely impact patient well-being. However, our findings highlight some important nuances. Cancellations that occurred later in the disease course appeared less disruptive, suggesting early diagnosis and treatment may be most vulnerable to pandemic-induced delays. Additionally, appointments cancelled by medical providers rather than patient self-cancellations were associated with

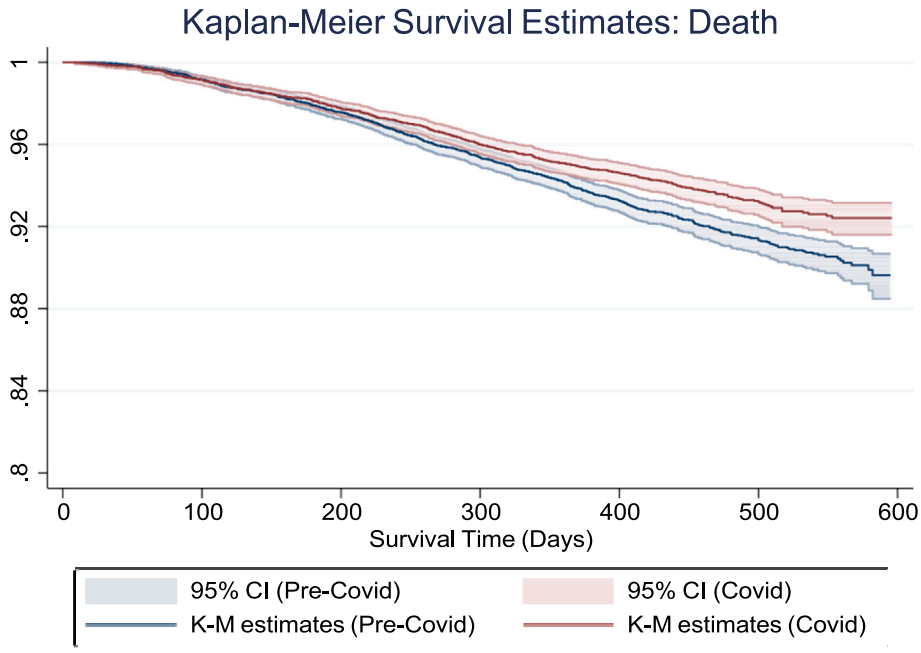

Fig. 4. Kaplan-Meier Survival Estimates – Death
Notes -Data comes from QResearch database. Survival time is measured in days. *Pre-Covid* cohort – a random sample of NHS patients from England diagnosed with cancer between June 15, 2017, and March 14, 2018, and with an appointment cancellation between March 15, 2018, and May 14, 2018. *Covid* cohort – a random sample of NHS patients from England diagnosed with cancer between June 15, 2019, and March 14, 2020, and with an appointment cancellation between March 15, 2020, and May 14, 2020.

Table 9
Cox proportional-hazards analysis – death.

	(1)	(2)	(3)
	_t	_t	_t
Covid cohort	0.821	0.922	0.930
	(0.124)	(0.157)	(0.159)
Cancer duration at cancellation	0.994******	0.995**	0.995****
	(0.002)	(0.003)	(0.003)
Appt. cancelled by doctor		0.531******	0.531****
		(0.052)	(0.053)
First appointment cancelled		1.109	1.109
		(0.081)	(0.081)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	16,658	16,480	16,480

Notes: Hazard ratios reported. Standard errors in parentheses. Data comes from QResearch database. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

significantly higher survival rates. This implies that clinicians were able to effectively prioritise patients most in need of urgent care during the crisis.

The COVID-19 pandemic exposed vulnerabilities in our healthcare system's ability to maintain continuity of care for cancer patients during public health emergencies. Our results underscore the importance of safeguarding cancer screening, diagnosis, and treatment services, even amid crisis situations that strain health resources.

Policymakers should develop comprehensive emergency preparedness plans that account for the needs of cancer patients and other vulnerable populations. Strategies could include stockpiling essential medical supplies, cross-training staff to expand patient care capacity, and establishing regional care coordination networks to facilitate patient transfers when local facilities are overburdened.

We are encouraged that the results we present suggest the disruptions caused by Covid did not lead to negative outcomes for those with cancer. Further research should examine long-term impacts on outcomes and strategies to minimize treatment delays during healthcare crises.

CRediT authorship contribution statement

Jakub Lonsky: Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Catia Nicodemo:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Stuart Redding:** Writing – review & editing, Writing – original draft, Supervision, Data curation, Conceptualization.

Data availability

The data that has been used is confidential.

Appendix

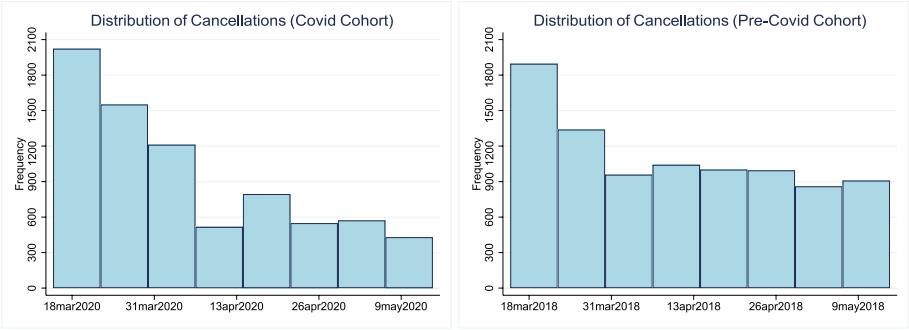

Fig. A.1. Weekly Appointment Cancellations – Distribution by Cohort (March 15 - May 14)
Notes -Data comes from QResearch database. The event of interest is the appointment cancellation. *Pre-Covid* cohort – a random sample of NHS patients from England diagnosed with cancer between June 15, 2017, and March 14, 2018, and with the appointment cancellation between March 15, 2018, and May 14, 2018. *Covid* cohort – a random sample of NHS patients from England diagnosed with cancer between June 15, 2019, and March 14, 2020, and with the appointment cancellation between March 15, 2020, and May 14, 2020. .

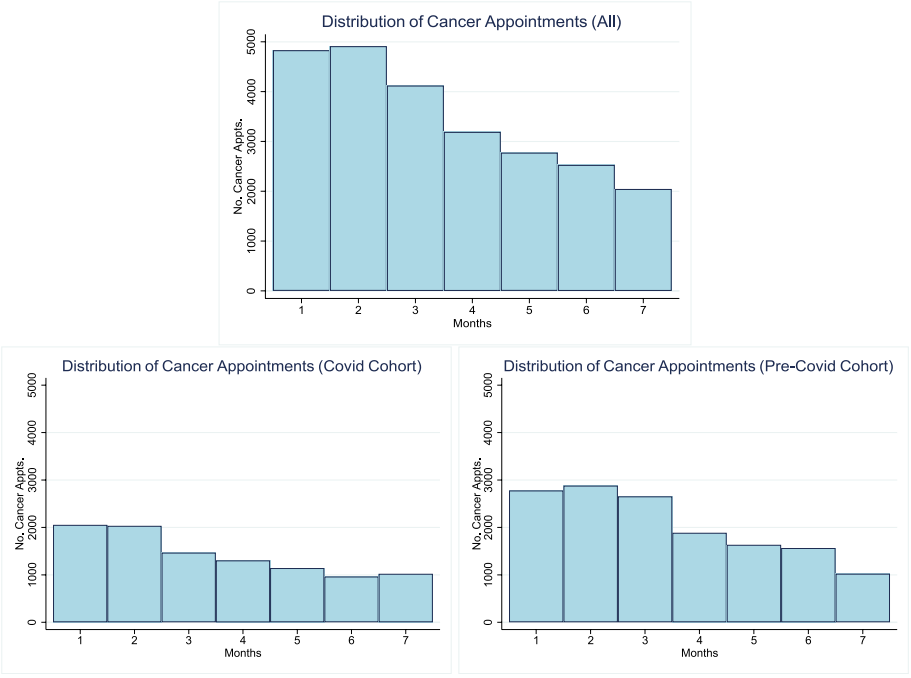

Fig. A.2. Monthly Cancer-Related Appts. – All, Covid Cohort, Pre-Covid Cohort (March 15 - October 15)
Notes -Data comes from QResearch database. The event of interest is any cancer-related appointment (inpatient & outpatient) observed between March 15, 2018 (2020, resp.), and October 15, 2018 (2020, resp.). *Pre-Covid* cohort – a random sample of NHS patients from England diagnosed with cancer between June 15, 2017, and March 14, 2018, and with the appointment cancellation between March 15, 2018, and May 14, 2018. *Covid* cohort – a random sample of NHS patients from England diagnosed with cancer between June 15, 2019, and March 14, 2020, and with the appointment cancellation between March 15, 2020, and May 14, 2020. .

Table A.1
Descriptive Statistics – Full Sample

Variable	No. of observations	Mean	Standard deviation
Male	16,658	0.42	0.49
Age at cancer diagnosis	16,659	61.1	17.9
White	16,659	0.66	0.48
Indian/Pakistani/Bangladeshi	16,659	0.04	0.20
Asian	16,659	0.02	0.13
Black	16,659	0.05	0.21
Appt. cancelled by doctor	16,659	0.24	0.43
First appointment cancelled	16,481	0.45	0.50
Cancer duration at cancellation (days)	16,659	144.3	85.2
Time to first appointment (days)	15,554	34.11	46.50
No. of outpatient visits in 7 months after cancellation	16,511	7.81	9.05
No. of outpatient cancer visits in 7 months after cancellation	16,652	0.50	3.79

(*continued on next page*)

Table A.1 (*continued*)

Variable	No. of observations	Mean	Standard deviation
No. of inpatient admiss. in 7 months after cancellation	16,593	5.80	11.0
No. of inpatient cancer admiss. in 7 months after cancellation	16,622	1.70	5.68
Length of first admission after cancellation (days)	7,012	1.52	3.79
Died during the study period	1,141 (6.85%)		
Had a cancer appt. between diagnosis & cancellation	3,322 (19.9%)		

Notes: Data comes from QResearch database. Estimation sample defined as a random sample of NHS patients from England diagnosed with cancer between June 15, 2017, and March 14, 2018 (with an appointment cancellation between March 15, 2018, and May 14, 2018), as well as those diagnosed with cancer between June 15, 2019, and March 14, 2020 (with an appointment cancellation between March 15, 2020, and May 14, 2020). Male – binary var. equal to 1 if individual is male, and 0 otherwise. Age at diagnosis – patient's age at the time of cancer diagnosis. White – binary var. equal to 1 if individual self-identifies as being of white race/ethnicity, and 0 otherwise. Indian/Pakistani/Bangladeshi – binary var. equal to 1 individual self-identifies as being of Indian/Pakistani/Bangladeshi race/nationality, and 0 otherwise. Asian – binary var. equal to 1 individual self-identifies as being of Asian race/ethnicity, and 0 otherwise. Black – binary var. equal to 1 individual self-identifies as being of black race/ethnicity, and 0 otherwise. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Time to first appointment (days) – length of time (in days) between the cancellation and the next non-cancelled appointment. No. of outpatient visits in 7 months after cancellation – no. of all outpatient visits during the first 7 months after the cancellation. No. of outpatient cancer visits in 7 months after cancellation – no. of cancer-related outpatient visits during the first 7 months after the cancellation. No. of inpatient admiss. in 7 months after cancellation – no. of all inpatient admission during the first 7 months after the cancellation. No. of inpatient cancer admiss. in 7 months after cancellation – no. of cancer-related inpatient admission during the first 7 months after the cancellation. Length of first admission after cancellation (days) – length (in days) of the first inpatient admission after the cancellation.

Table A.2
Placebo Test – Healthcare Utilization Between Cancer Diagnosis and the Following March 1

	All appts.		Cancer-related appts.	
	Outpatient visits	Inpatient admiss.	Outpatient visits	Inpatient admiss.
	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)	Winkelmann et al. (2022)
Covid cohort	−0.262	0.222*	0.056	0.114
	(0.297)	(0.125)	(0.128)	(0.092)
No. days between diagnosis & March 1	Yes	Yes	Yes	Yes
Demographic characteristics	Yes	Yes	Yes	Yes
Year & month of diagnosis FE	Yes	Yes	Yes	Yes
Township deprivation quintile FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	16,658	16,658	16,658	16,658
R-squared	0.369	0.182	0.049	0.210
Mean of dependent variable	6.440	1.297	0.335	0.671
Std. dev. of dependent variable	9.420	3.747	3.284	2.815

Notes: Regression analysis estimated using ordinary least squares (OLS). Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. Outpatient visits (all) – no. of all outpatient visits between cancer diagnosis & March 1, 2018 (2020, resp.); Inpatient admiss. (all) – no. of all inpatient admissions between cancer diagnosis & March 1, 2018 (2020, resp.); Outpatient visits (cancer-related) – no. of cancer-related outpatient visits between cancer diagnosis & March 1, 2018 (2020, resp.); Inpatient admiss. (cancer-related) – no. of cancer-related inpatient admissions between cancer diagnosis & March 1, 2018 (2020, resp.); Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.3
Cox Analysis – First Appointment After Cancellation (Extended Sample)

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	_t	_t	_t
Covid cohort	0.842***	0.820***	0.819***
	(0.022)	(0.025)	(0.025)
Cancer duration at cancellation	0.999***	0.999***	0.999***
	(0.000)	(0.000)	(0.000)
Appt. cancelled by doctor		0.987	0.988
		(0.016)	(0.016)
First appointment cancelled		1.071***	1.072***
		(0.015)	(0.015)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	41,629	41,211	41,211

Notes: Hazard ratios reported. Standard errors in parentheses. Data comes from QResearch database. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.4
Time to First Appointment Following Cancellation (OLS; Extended Sample)

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	Time to first appt.	Time to first appt.	Time to first appt.
Covid cohort	4.771***	8.580***	8.606***
	(0.992)	(1.143)	(1.143)
Cancer duration at cancellation	−0.084***	0.018	0.018
	(0.002)	(0.017)	(0.017)
Appt. cancelled by doctor		2.907***	2.903***
		(0.616)	(0.616)
First appointment cancelled		−2.486***	−2.522***
		(0.487)	(0.487)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	35,849	35,482	35,482
R-squared	0.045	0.048	0.049
Mean of dependent variable	28.71	28.73	28.73
Std. dev. of dependent variable	38.38	38.39	38.39

Notes: Regression analysis estimated using ordinary least squares (OLS). Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. Time to first appt. – length of time (in days) between the cancellation and the next non-cancelled appointment. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.5
Length of First Inpatient Admission Following Cancellation (OLS; Extended Sample)

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	Length of first admission	Length of first admission	Length of first admission
Covid cohort	−0.733***	−0.786***	−0.778***
	(0.149)	(0.183)	(0.183)
Cancer duration at cancellation	−0.001**	−0.004	−0.004
	(0.000)	(0.003)	(0.003)
Appt. cancelled by doctor		−0.438***	−0.427***
		(0.097)	(0.097)
First appointment cancelled		0.103	0.096
		(0.088)	(0.088)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	13,621	13,445	13,445
R-squared	0.029	0.031	0.032
Mean of dependent variable	1.519	1.524	1.524
Std. dev. of dependent variable	3.806	3.812	3.812

Notes: Regression analysis estimated using ordinary least squares (OLS). Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. Length of first admission – length (in days) of the first inpatient admission after the cancellation. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.6
Cox Proportional-Hazards Analysis – Death (Extended Sample)

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	_t	_t	_t
Covid cohort	0.999	1.082	1.088
	(0.107)	(0.137)	(0.138)
Cancer duration at cancellation	0.995***	0.994***	0.994***
	(0.000)	(0.002)	(0.002)
Appt. cancelled by doctor		0.585***	0.589***
		(0.045)	(0.046)
First appointment cancelled		0.999	1.000
		(0.056)	(0.056)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	41,697	41,279	41,279

Notes: Hazard ratios reported. Standard errors in parentheses. Data comes from QResearch database. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.7
Time to first appointment following cancellation (Poisson regression).

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	Time to first appt.	Time to first appt.	Time to first appt.
Covid cohort	1.665***	1.749***	1.751***
	(0.093)	(0.108)	(0.108)
Cancer duration at cancellation	1.001	1.002**	1.002**
	(0.001)	(0.001)	(0.001)
Appt. cancelled by doctor		1.136***	1.133***
		(0.037)	(0.037)
First appointment cancelled		0.905***	0.904***
		(0.026)	(0.026)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	15,554	15,386	15,386

Notes: Results from Poisson regression. Adjusted incidence rate ratios (IRR) reported. Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. Time to first appt. – length of time (in days) between the cancellation and the next non-cancelled appointment. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.8
Outpatient visits during 7 Months following cancellation (Poisson regression).

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	No. of outpatient visits	No. of outpatient visits	No. of outpatient visits
Covid cohort	0.857***	0.869***	0.868***
	(0.041)	(0.046)	(0.046)
Cancer duration at cancellation	0.999	0.999	0.999
	(0.000)	(0.001)	(0.001)
Appt. cancelled by doctor		1.014	1.016
		(0.028)	(0.028)
First appointment cancelled		0.911***	0.912***
		(0.021)	(0.021)
Demographic characteristics	Yes	Yes	Yes

(*continued on next page*)

Table A.8 (*continued*)

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	No. of outpatient visits	No. of outpatient visits	No. of outpatient visits
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	16,511	16,336	16,336

Notes: Results from Poisson regression. Adjusted incidence rate ratios (IRR) reported. Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. No. of outpatient visits – no. of all outpatient visits during the first 7 months after the cancellation. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.9
Outpatient Cancer-Related Visits During 7 Months Following Cancellation (Poisson Regression)

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	No. outpatient cancer visits	No. outpatient cancer visits	No. outpatient cancer visits
Covid cohort	0.886	0.976	0.960
	(0.229)	(0.287)	(0.283)
Cancer duration at cancellation	1.001	1.003	1.003
	(0.003)	(0.006)	(0.006)
Appt. cancelled by doctor		1.229	1.252
		(0.227)	(0.230)
First appointment cancelled		0.769*	0.779
		(0.119)	(0.120)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	16,652	16,474	16,474

Notes: Results from Poisson regression. Adjusted incidence rate ratios (IRR) reported. Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. No. outpatient cancer visits – no. of cancer-related outpatient visits during the first 7 months after the cancellation. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.10
Inpatient Admissions During 7 Months Following Cancellation (Poisson Regression)

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	No. of inpatient admiss.	No. of inpatient admiss.	No. of inpatient admiss.
Covid cohort	0.678***	0.712***	0.713***
	(0.050)	(0.060)	(0.060)
Cancer duration at cancellation	0.999	1.001	1.001
	(0.001)	(0.001)	(0.001)
Appt. cancelled by doctor		0.967	0.968
		(0.043)	(0.043)
First appointment cancelled		0.901***	0.901***
		(0.034)	(0.035)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	16,593	16,415	16,415

Notes: Results from Poisson regression. Adjusted incidence rate ratios (IRR) reported. Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. No. of inpatient admiss. – no. of all inpatient admission during the first 7 months after the cancellation. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled

appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.11
Inpatient cancer-related admissions during 7 Months after cancellation (Poisson regression).

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	No. inpatient cancer admiss.	No. inpatient cancer admiss.	No. inpatient cancer admiss.
Covid cohort	0.720**	0.725**	0.719**
	(0.093)	(0.106)	(0.105)
Cancer duration at cancellation	0.999	0.998	0.998
	(0.001)	(0.003)	(0.003)
Appt. cancelled by doctor		0.881	0.881
		(0.075)	(0.075)
First appointment cancelled		0.847**	0.851**
		(0.058)	(0.058)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	16,622	16,444	16,444

Notes: Results from Poisson regression. Adjusted incidence rate ratios (IRR) reported. Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. No. inpatient cancer admiss. – no. of cancer-related inpatient admission during the first 7 months after the cancellation. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.12
Length of First Inpatient Admission Following Cancellation (Poisson Regression)

	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)
	Length of first admission	Length of first admission	Length of first admission
Covid cohort	0.574***	0.591***	0.592***
	(0.094)	(0.109)	(0.109)
Cancer duration at cancellation	0.997*	0.996	0.996
	(0.002)	(0.003)	(0.003)
Appt. cancelled by doctor		0.711***	0.714***
		(0.066)	(0.066)
First appointment cancelled		1.054	1.050
		(0.078)	(0.077)
Demographic characteristics	Yes	Yes	Yes
Year of diagnosis FE	Yes	Yes	Yes
Month of diagnosis FE	Yes	Yes	Yes
Cancellation month FE		Yes	Yes
Township deprivation quintile FE			Yes
Region FE			Yes
Observations	7,012	6,920	6,920

Notes: Results from Poisson regression. Adjusted incidence rate ratios (IRR) reported. Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. Length of first admission – length (in days) of the first inpatient admission after the cancellation. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Cancer duration at cancellation – no. of days since diagnosed with cancer at the time of the cancelled appointment. Appt. cancelled by doctor – binary var. equal to 1 if the appointment cancelled by physician's office, and 0 otherwise. First appointment cancelled – binary var. equal to 1 if the cancelled appointment was the first appointment, and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.13
Controlling For Cancer Site (OLS & Cox Models)

	First Appt. (_t)	Time to first appt.	Outpatient visits	Outpatient cancer visits
	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)	Winkelmann et al. (2022)
Covid cohort	0.765***	17.59***	−1.009**	0.023
	(0.036)	(2.081)	(0.401)	(0.180)
Cancer site	Yes	Yes	Yes	Yes

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Table A.13 (*continued*)

	First Appt. (_t)	Time to first appt.	Outpatient visits	Outpatient cancer visits
	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)	Winkelmann et al. (2022)
Demographic characteristics	Yes	Yes	Yes	Yes
Cancellation characteristics	Yes	Yes	Yes	Yes
Year & month of diagnosis FE	Yes	Yes	Yes	Yes
Township deprivation quintile FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	16,477	15,384	16,336	16,474
R-squared		0.093	0.139	0.038
Mean of dependent variable		34.12	7.815	0.500
Std. dev. of dependent variable		46.50	9.046	3.809

	Inpatient admiss.	Inpatient cancer admiss.	Length of first admiss.	Death (_t)
	Roadevin and Hill (2021)	Hanna et al. (2020)	Ng et al. (2021)	Sud et al. (2020)
Covid cohort	−1.851***	−0.521**	−0.898***	0.932
	(0.453)	(0.224)	(0.261)	(0.160)
Cancer site	Yes	Yes	Yes	Yes
Demographic characteristics	Yes	Yes	Yes	Yes
Cancellation characteristics	Yes	Yes	Yes	Yes
Year & month of diagnosis FE	Yes	Yes	Yes	Yes
Township deprivation quintile FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	16,415	16,444	6,926	16,477
R-squared	0.091	0.174	0.050	
Mean of dependent variable	5.790	1.705	1.545	
Std. dev. of dependent variable	11.06	5.687	3.888	

Notes: OLS estimates with heteroskedasticity-robust standard errors in parentheses (cols. 2–7). Cox model hazard ratios with standard errors in parentheses (cols. 1 and 8). Data comes from QResearch database. First Appt. (_t) – first appointment following the cancellation (Cox model event). Time to first appt. – length of time (in days) between the cancellation and the next non-cancelled appointment. Outpatient visits – no. of all outpatient visits during the first 7 months after the cancellation. Outpatient cancer visits – no. of outpatient cancer visits during the first 7 months after the cancellation. Inpatient admiss. – no. of all inpatient admission during the first 7 months after the cancellation. Inpatient cancer admiss. – no. of inpatient cancer admission during the first 7 months after the cancellation. Length of first admission — length (in days) of the first inpatient admission after the cancellation. Death (_t) – patient's death (Cox model event). Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. Cancellation characteristics: cancellation month FE, cancer duration at cancellation (# days since diagnosed with cancer at the time of cancellation), appt. cancelled by doctor (binary var. equal to 1 if appointment cancelled by physician's office), first appointment cancelled (binary var. equal to 1 if cancelled appointment was the first appointment). *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.14
Controlling For Any Cancer Appointment (OLS & Cox Models)

	First Appt. (_t)	Time to first appt.	Outpatient visits	Outpatient cancer visits
	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)	Winkelmann et al. (2022)
Covid cohort	0.786***	14.93***	−0.562*	0.035
	(0.031)	(1.786)	(0.333)	(0.156)
Any cancer appt.	Yes	Yes	Yes	Yes
Demographic characteristics	Yes	Yes	Yes	Yes
Cancellation characteristics	Yes	Yes	Yes	Yes
Year & month of diagnosis FE	Yes	Yes	Yes	Yes
Township deprivation quintile FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	16,477	15,384	16,336	16,474
R-squared		0.068	0.110	0.042
Mean of dependent variable		34.12	7.815	0.500
Std. dev. of dependent variable		46.50	9.046	3.809

	Inpatient admiss.	Inpatient cancer admiss.	Length of first admiss.	Death (_t)
	Roadevin and Hill (2021)	Hanna et al. (2020)	Ng et al. (2021)	Sud et al. (2020)
Covid cohort	−1.636***	−0.146	−0.574***	1.246
	(0.353)	(0.172)	(0.212)	(0.176)
Any cancer appt.	Yes	Yes	Yes	Yes
Demographic characteristics	Yes	Yes	Yes	Yes
Cancellation characteristics	Yes	Yes	Yes	Yes
Year & month of diagnosis FE	Yes	Yes	Yes	Yes
Township deprivation quintile FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	16,415	16,444	6,926	16,477
R-squared	0.082	0.176	0.037	
Mean of dependent variable	5.790	1.705	1.545	
Std. dev. of dependent variable	11.06	5.687	3.888	

Notes: OLS estimates with heteroskedasticity-robust standard errors in parentheses (cols. 2–7). Cox model hazard ratios with standard errors in parentheses (cols. 1 and 8). Data comes from QResearch database. Any cancer appt. – binary var equal to 1 if patient had any cancer-related appointment between the diagnosis and the

cancellation, and 0 otherwise. First Appt. (_t) – first appointment following the cancellation (Cox model event). Time to first appt. – length of time (in days) between the cancellation and the next non-cancelled appointment. Outpatient visits – no. of all outpatient visits during the first 7 months after the cancellation. Outpatient cancer visits – no. of outpatient cancer visits during the first 7 months after the cancellation. Inpatient admiss. – no. of all inpatient admission during the first 7 months after the cancellation. Inpatient cancer admiss. – no. of inpatient cancer admission during the first 7 months after the cancellation. Length of first admission — length (in days) of the first inpatient admission after the cancellation. Death (_t) – patient's death (Cox model event). Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. Cancellation characteristics: cancellation month FE, appt. cancelled by doctor (binary var. equal to 1 if appointment cancelled by physician's office), first appointment cancelled (binary var. equal to 1 if cancelled appointment was the first appointment). *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.15
Controlling For Number of Cancer Appointments (OLS & Cox Models)

	First Appt. (_t)	Time to first appt.	Outpatient visits	Outpatient cancer visits
	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)	Winkelmann et al. (2022)
Covid cohort	0.764***	15.71***	−0.859**	−0.015
	(0.030)	(1.811)	(0.350)	(0.154)
Number of cancer appts.	Yes	Yes	Yes	Yes
Demographic characteristics	Yes	Yes	Yes	Yes
Cancellation characteristics	Yes	Yes	Yes	Yes
Year & month of diagnosis FE	Yes	Yes	Yes	Yes
Township deprivation quintile FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	16,477	15,384	16,336	16,474
R-squared		0.053	0.063	0.073
Mean of dependent variable		34.12	7.815	0.500
Std. dev. of dependent variable		46.50	9.046	3.809

	Inpatient admiss.	Inpatient cancer admiss.	Length of first admiss.	Death (_t)
	Roadevin and Hill (2021)	Hanna et al. (2020)	Ng et al. (2021)	Sud et al. (2020)
Covid cohort	−1.870***	−0.344*	−0.573***	1.133
	(0.358)	(0.180)	(0.212)	(0.159)
Number of cancer appts.	Yes	Yes	Yes	Yes
Demographic characteristics	Yes	Yes	Yes	Yes
Cancellation characteristics	Yes	Yes	Yes	Yes
Year & month of diagnosis FE	Yes	Yes	Yes	Yes
Township deprivation quintile FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	16,415	16,444	6,926	16,477
R-squared	0.079	0.153	0.037	
Mean of dependent variable	5.790	1.705	1.545	
Std. dev. of dependent variable	11.06	5.687	3.888	

Notes: OLS estimates with heteroskedasticity-robust standard errors in parentheses (cols. 2–7). Cox model hazard ratios with standard errors in parentheses (cols. 1 and 8). Data comes from QResearch database. Number of cancer appts. – total number of cancer-related appointments between the diagnosis and the cancellation. First Appt. (_t) – first appointment following the cancellation (Cox model event). Time to first appt. – length of time (in days) between the cancellation and the next non-cancelled appointment. Outpatient visits – no. of all outpatient visits during the first 7 months after the cancellation. Outpatient cancer visits – no. of outpatient cancer visits during the first 7 months after the cancellation. Inpatient admiss. – no. of all inpatient admission during the first 7 months after the cancellation. Inpatient cancer admiss. – no. of inpatient cancer admission during the first 7 months after the cancellation. Length of first admission — length (in days) of the first inpatient admission after the cancellation. Death (_t) – patient's death (Cox model event). Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. Cancellation characteristics: cancellation month FE, appt. cancelled by doctor (binary var. equal to 1 if appointment cancelled by physician's office), first appointment cancelled (binary var. equal to 1 if cancelled appointment was the first appointment). *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.16
Heterogeneity By Sex – Outpatient Visits & Inpatient Admissions (OLS)

	Outpatient visits		Outpatient cancer visits		Inpatient admiss.		Inpatient cancer admiss.	
	Women	Men	Women	Men	Women	Men	Women	Men
	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)	Winkelmann et al. (2022)	Roadevin and Hill (2021)	Hanna et al. (2020)	Ng et al. (2021)	Sud et al. (2020)
Covid cohort	−1.162**	−1.002	0.258	−0.335	−1.577**	−2.236***	−0.429	−0.636*
	(0.566)	(0.665)	(0.235)	(0.291)	(0.621)	(0.712)	(0.318)	(0.378)
Demographic characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cancellation characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year & month of diagnosis FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Township deprivation quintile FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

(continued on next page)

Table A.16 (*continued*)

	Outpatient visits		Outpatient cancer visits		Inpatient admiss.		Inpatient cancer admiss.	
	Women	Men	Women	Men	Women	Men	Women	Men
	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)	Winkelmann et al. (2022)	Roadevin and Hill (2021)	Hanna et al. (2020)	Ng et al. (2021)	Sud et al. (2020)
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,551	6,785	9,620	6,854	9,595	6,820	9,611	6,833
R-squared	0.023	0.025	0.013	0.014	0.026	0.022	0.015	0.018
Mean of dependent variable	7.635	8.069	0.455	0.562	5.528	6.160	1.610	1.839
Std. dev. of dependent variable	8.974	9.140	3.629	4.047	10.85	11.33	5.559	5.860

Notes: Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. Outpatient visits – no. of all outpatient visits during the first 7 months after the cancellation. Outpatient cancer visits – no. of outpatient cancer visits during the first 7 months after the cancellation. Inpatient admiss. – no. of all inpatient admission during the first 7 months after the cancellation. Inpatient cancer admiss. – no. of inpatient cancer admission during the first 7 months after the cancellation. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Demographic characteristics: age, age-squared, race/ethnicity. Cancellation characteristics: cancellation month FE, cancer duration at cancellation (# days since diagnosed with cancer at the time of cancellation), appt. cancelled by doctor (binary var. equal to 1 if appointment cancelled by physician's office), first appointment cancelled (binary var. equal to 1 if cancelled appointment was the first appointment). *** Significant at the 1% level. ** Significant at the 5% level. * Signifi- cant at the 10% level.

Table A.17
Heterogeneity by sex – time to first appt. & length of first admission (OLS).

	Time to first appt.		Length of first admission	
	Women	Men	Women	Men
	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)	Winkelmann et al. (2022)
Covid cohort	18.23***	20.08***	−0.929***	−0.661
	(2.906)	(3.208)	(0.333)	(0.419)
Demographic characteristics	Yes	Yes	Yes	Yes
Cancellation characteristics	Yes	Yes	Yes	Yes
Year & month of diagnosis FE	Yes	Yes	Yes	Yes
Township deprivation quintile FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	8,979	6,405	3,846	3,080
R-squared	0.037	0.049	0.041	0.036
Mean of dependent variable	34.72	33.27	1.341	1.800
Std. dev. of dependent variable	47.13	45.58	3.558	4.257

Notes: Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. Time to first appt. – length of time (in days) between the cancellation and the next non-cancelled appointment. Length of first admission – length (in days) of the first inpatient admission after the cancellation. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Demographic characteristics: age, age-squared, race/ethnicity. Cancellation characteristics: cancellation month FE, cancer duration at cancellation (# days since diagnosed with cancer at the time of cancellation), appt. cancelled by doctor (binary var. equal to 1 if appointment cancelled by physician's office), first appointment cancelled (binary var. equal to 1 if cancelled appointment was the first appointment). *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.18
Heterogeneity By Sex – First Appt. & Death (Cox Proportional-Hazards Analysis)

	First Appt. (_t)		Death (_t)	
	Women	Men	Women	Men
	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)	Winkelmann et al. (2022)
Covid cohort	0.729***	0.678***	0.818	1.045
	(0.046)	(0.050)	(0.211)	(0.239)
Demographic characteristics	Yes	Yes	Yes	Yes
Cancellation characteristics	Yes	Yes	Yes	Yes
Year & month of diagnosis FE	Yes	Yes	Yes	Yes
Township deprivation quintile FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	9,621	6,856	9,621	6,856

Notes: Hazard ratios reported. Standard errors in parentheses. Data comes from QResearch database. First Appt. (_t) – first appointment following the cancellation (Cox model event). Death (_t) – patient's death (Cox model event). Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Demographic characteristics: age, age-squared, race/ethnicity. Cancellation characteristics: cancellation month FE, cancer duration at cancellation (# days since diagnosed with cancer at the time of cancellation), appt. cancelled by doctor (binary var. equal to 1 if appointment cancelled by physician's office), first appointment cancelled (binary var. equal to 1 if cancelled appointment was the first appointment). *** Signifi- cant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.19
Heterogeneity By Age – Outpatient Visits & Inpatient Admissions (OLS)

	Outpatient visits			Outpatient cancer visits		
	Ages 0-40	Ages 41-64	Ages 65 plus	Ages 0-40	Ages 41-64	Ages 65 plus
	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)	Winkelmann et al. (2022)	Roadevin and Hill (2021)	Hanna et al. (2020)
Covid cohort	−1.552	−1.757**	−0.532	−0.531	0.124	0.065
	(1.123)	(0.725)	(0.598)	(0.373)	(0.328)	(0.250)
Demographic characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Cancellation characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Year & month of diagnosis FE	Yes	Yes	Yes	Yes	Yes	Yes
Township deprivation quintile FE	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,238	6,564	7,534	2,265	6,630	7,579
R-squared	0.021	0.021	0.041	0.021	0.015	0.015
Mean of dependent variable	7.315	8.294	7.548	0.336	0.588	0.471
Std. dev. of dependent variable	9.129	9.668	8.420	2.788	4.237	3.674
	Inpatient admiss.			Inpatient cancer admiss.		
	Ages 0-40	Ages 41-64	Ages 65 plus	Ages 0-40	Ages 41-64	Ages 65 plus
	Ng et al. (2021)	Sud et al. (2020)	Nicholson et al. (2022)	Maringe et al. (2020)	Li et al. (2021)	Baxter et al. (2021)
Covid cohort	−2.449*	−2.007***	−1.690***	−0.997	−0.674*	−0.271
	(1.371)	(0.769)	(0.642)	(0.849)	(0.398)	(0.307)
Demographic characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Cancellation characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Year & month of diagnosis FE	Yes	Yes	Yes	Yes	Yes	Yes
Township deprivation quintile FE	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,253	6,605	7,557	2,258	6,620	7,566
R-squared	0.034	0.021	0.043	0.041	0.013	0.029
Mean of dependent variable	5.280	5.861	5.882	1.896	1.933	1.448
Std. dev. of dependent variable	11.63	11.51	10.46	6.710	6.062	4.958

Notes: Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. Outpatient visits – no. of all outpatient visits during the first 7 months after the cancellation. Outpatient cancer visits – no. of outpatient cancer visits during the first 7 months after the cancellation. Inpatient admiss. – no. of all inpatient admission during the first 7 months after the cancellation. Inpatient cancer admiss. – no. of inpatient cancer admission during the first 7 months after the cancellation. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. Cancellation characteristics: cancellation month FE, cancer duration at cancellation (# days since diagnosed with cancer at the time of cancellation), appt. cancelled by doctor (binary var. equal to 1 if appointment cancelled by physician's office), first appointment cancelled (binary var. equal to 1 if cancelled appointment was the first appointment). *** Significant at the 1% level. ** Significant at the 5% level. * Signifi- cant at the 10% level.

Table A.20
Heterogeneity By Age – Time to First Appt. & Length of First Admission (OLS)

	Time to first appt.			Length of first admission		
	Ages 0-40	Ages 41-64	Ages 65 plus	Ages 0-40	Ages 41-64	Ages 65 plus
	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)	Winkelmann et al. (2022)	Roadevin and Hill (2021)	Hanna et al. (2020)
Covid cohort	23.11***	14.39***	21.72***	−0.437	−0.369	−1.177***
	(6.324)	(3.438)	(3.091)	(0.529)	(0.329)	(0.447)
Demographic characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Cancellation characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Year & month of diagnosis FE	Yes	Yes	Yes	Yes	Yes	Yes
Township deprivation quintile FE	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,050	6,189	7,145	838	2,721	3,366
R-squared	0.046	0.035	0.056	0.050	0.022	0.047
Mean of dependent variable	36.86	33.19	34.13	0.875	1.172	2.026
Std. dev. of dependent variable	48.20	46.29	46.16	2.093	2.843	4.900

Notes: Heteroskedasticity-robust standard errors in parentheses. Data comes from QResearch database. Time to first appt. – length of time (in days) between the cancellation and the next non-cancelled appointment. Length of first admission – length (in days) of the first inpatient admission after the cancellation. Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. Cancellation characteristics: cancellation month FE, cancer duration at cancellation (# days since diagnosed with cancer at the time of cancellation), appt. cancelled by doctor (binary var. equal to 1 if appointment cancelled by physician's office), first appointment cancelled (binary var. equal to 1 if cancelled appointment was the first appointment). *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.21
Heterogeneity By Age – First Appt. & Death (Cox Proportional-Hazards Analysis)

	First Appt. (_t)			Death (_t)		
	Ages 0-40	Ages 41-64	Ages 65 plus	Ages 0-40	Ages 41-64	Ages 65 plus
	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)	Winkelmann et al. (2022)	Roadevin and Hill (2021)	Hanna et al. (2020)
Covid cohort	0.778*	0.716***	0.685***	0.682	1.374	0.804
	(0.106)	(0.053)	(0.048)	(0.701)	(0.450)	(0.165)
Demographic characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Cancellation characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Year & month of diagnosis FE	Yes	Yes	Yes	Yes	Yes	Yes
Township deprivation quintile FE	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,264	6,630	7,583	2,264	6,630	7,583

Notes: Hazard ratios reported. Standard errors in parentheses. Data comes from QResearch database. *First Appt. (_t)* – first appointment following the cancellation (Cox model event). *Death (_t)* – patient's death (Cox model event). *Covid cohort* – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. Cancellation characteristics: cancellation month FE, cancer duration at cancellation (# days since diagnosed with cancer at the time of cancellation), appt. cancelled by doctor (binary var. equal to 1 if appointment cancelled by physician's office), first appointment cancelled (binary var. equal to 1 if cancelled appointment was the first appointment). *** Signifi- cant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

Table A.22
Heterogeneity By Cancer Site – Death (Cox Proportional-Hazards Analysis)

	Death (_t)			
	Digestive organs	Melanoma & other skin	Genital organs	Breast
	NHS England (2020a)	Glasbey et al. (2021)	McCabe et al. (2020)	Winkelmann et al. (2022)
Covid cohort	0.590	0.741	1.615	1.171
	(0.205)	(1.042)	(1.295)	(1.469)
Demographic characteristics	Yes	Yes	Yes	Yes
Cancellation characteristics	Yes	Yes	Yes	Yes
Year & month of diagnosis FE	Yes	Yes	Yes	Yes
Township deprivation quintile FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Observations	940	885	869	797

Notes: Hazard ratios reported. Standard errors in parentheses. Data comes from QResearch database. Four most-represented cancer sites depicted: (1) cancers of digestive organs; (2) Melanoma & other skin cancers; (3) cancers of (fe)male genital organs; (4) breast cancer. Death (_t) – patient's death (Cox model event). Covid cohort – binary var, equal to 1 if individual diagnosed with cancer between June 15, 2019, and March 14, 2020, and had an appointment cancelled at some point between March 15, 2020, and May 14, 2020; and 0 otherwise. Demographic characteristics: sex, age, age-squared, race/ethnicity. Cancellation characteristics: cancellation month FE, cancer duration at cancellation (# days since diagnosed with cancer at the time of cancellation), appt. cancelled by doctor (binary var. equal to 1 if appointment cancelled by physician's office), first appointment cancelled (binary var. equal to 1 if cancelled appointment was the first appointment). *** Significant at the 1% level. ** Significant at the 5% level. * Significant at the 10% level.

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