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The impact of travel time to cancer treatment centre on post-diagnosis care and mortality among cancer patients in Scotland

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ABSTRACT

Limited data exist on the effect of travelling time on post-diagnosis cancer care and mortality. We analysed the impact of travel time to cancer treatment centre on secondary care contact time and one-year mortality using a data-linkage study in Scotland with 17369 patients. Patients with longer travelling time and island-dwellers had increased incidence rate of secondary care cancer contact time. For outpatient oncology appointments, the incidence rate was decreased for island-dwellers. Longer travelling time was not associated with increased secondary care contact time for emergency cancer admissions or time to first emergency cancer admission. Living on an island increased mortality at one-year. Adjusting for cancer-specific secondary care contact time increased the hazard of death, and adjusting for oncology outpatient time decreased the hazard of death for island-dwellers. Those with longer travelling times experience the cancer treatment pathway differently with poorer outcomes. Cancer services may need to be better configured to suit differing needs of dispersed populations.

1. Introduction

Increased patient travel time to health care facilities is associated with negative outcomes following cancer diagnosis (Turner et al., 2017; Murage et al., 2017; Segel et al., 2020) and as a potential barrier to equitable cancer care (Jones et al., 2008; Onega et al., 2011; Lin et al., 2015; Wan and Jubelirer, 2015; Obrochta et al., 2022). Referral guidelines and targets for timeliness has resulted in efficiencies, but centralising cancer services in cities has increased travelling times for those living further away (NHS Scotland, 2016; National Institute for Health and Care Excellence (NICE), 2016). Researchers have commented on the importance of considering geography, including travel time, in the planning and delivery of cancer services to potentially improve services and identify disparities within vulnerable groups (Murage et al., 2017; Afshar et al., 2019; McCullough and Flowers, 2018; Dobson et al., 2020; Frosch, 2022; Bhatia et al., 2022). In Scotland and the UK, for nearly all people diagnosed with symptomatic cancer the route to diagnosis and treatment begins with a consultation with a general practitioner (GP), who provides medical care in the community. The GP will then either directly admit the patient to hospital or refer them to a secondary care specialist at a hospital. Several studies have shown that both initial and continuing treatment decisions can be influenced by traveltime (Longacre et al., 2020; Aggarwal et al., 2022). Currently, limited data exist on potential disparities in secondary care contact time (defined as hospital admission or hospital outpatient clinic appointment) in the first year post cancer diagnosis (Pethick et al., 2021), specifically with relevance to travelling time.

The Northeast and Aberdeen Scottish Cancer and Residence NASCAR study conducted in Northeast Scotland, including 12339 patients diagnosed between 2007 and 2014 with one of eight common cancers, reported those living more than 30 min from the main cancer treatment centre were significantly more likely to die within one year than those living less than 15 min away (Turner et al., 2017). Paradoxically, those living more than 30 min from the main cancer treatment centre were significantly more likely to begin treatment within 62 days of GP referral, within the current Scottish Government target for timely treatment (Turner et al., 2017; The Scottish Government, 2008). Further, patients with longer travelling times to the cancer treatment

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centre were no more likely than those with shorter travelling times to be diagnosed with advanced cancer (Turner et al., 2017). The importance of Turner et al.'s (Turner et al., 2017) paper was that it contradicted, for the Northeast of Scotland at least, two commonly-held explanations for negative survival outcomes in relation to traveltime: first, that patients with a longer travelling time are more likely to delay presenting until their cancer is more advanced, and second, that they are more likely to experience delays in receiving diagnosis and treatment after being referred to hospital (Murage et al., 2017).

Cancer survivorship care is complex, predominantly secondary care led, and extends beyond primary presentation, resultant diagnosis, and initial cancer treatment. Patients with increased travel time may face multiple challenges in cancer care beyond diagnosis, including less access to specialised interdisciplinary services, different decision-making on initial and continuing treatment, and limited financial resources which could affect cancer survival. With the previous NASCAR study showing that patients with longer travelling times were not disadvantaged by presentation or treatment delays it is conceivable that secondary care access, specifically contact time, beyond diagnosis and initial treatment may contribute to the survival disadvantage for these patients.

In this paper, we report a unique exploration of the association between travelling time and post diagnostic secondary care contact time, both inpatient (routine and emergency) and outpatient. Our hypothesis was that patients with longer travelling times received less specialist follow-up care in the treatment and early post-treatment stage. This could result in differences in cancer treatment such as reduced chemotherapy dose intensity, or less timely identification of complications and increased emergency cancer admissions following diagnosis. This could also contribute to the higher mortality rate previously observed in those with longer travelling times.

The aims of this study were, first to explore the association between travelling time to the regional cancer treatment centre and the incidence rate of secondary care contact time. Secondly, to explore the time to first emergency cancer admission in relation to travelling time. Third, to determine whether incidence rates of secondary care contact in the post-diagnostic period were associated with one-year mortality.

2. Materials and methods

2.1. Study design and population

This was a retrospective population-level data-linkage study. The study cohort captured all patients diagnosed with one of eight common cancers (colorectal, lung, breast, prostate, melanoma, oesophagogastric, cervical, and ovarian) between 2007 and 2017 within the Northeast Scotland health region. This health region comprises the NHS health boards of Grampian, a mainland area, and NHS Orkney and NHS Shetland, two communities of islands. The population of approximately 585 000 is served by 105 GP practices, and has a single specialist cancer treatment centre based at Aberdeen Royal Infirmary (Fig. 1). The study was approved by the Privacy and Public Benefit Panel (PBPP) of NHS Scotland and the Caldicott Guardian of NHS Grampian, and data were managed in the Grampian Data Safe Haven (DaSH) (Wilde and DaSH, 2013; The Scottish Government, 2015).

2.2. Data sources

The NHS Grampian Cancer Care Pathway (CCPd) database was the primary data source for NASCAR+. CCPd is an electronic clinical database collecting information from several sources to form a complete record of secondary care activity in individual cancer cases, from receipt of GP referral, for all people diagnosed with cancer in NHS Grampian, NHS Orkney and NHS Shetland, Scotland (Turner et al., 2017). CCPd records information about cancer referral, diagnosis, subsequent investigations and secondary care appointments, intra-secondary care referrals, investigations, routine and emergency hospital admissions, hospital discharges, operations, and treatment. The original NASCAR database comprised data from January 1, 2007 to December 5, 2014 and a new data extraction was undertaken on July 3, 2019 to include all patients diagnosed between January 1, 2007 to May 31, 2017.

Relevant data were obtained from the Scottish Morbidity Record databases (Datasets, 2020). The Scottish Cancer Registry (SMR06) provided data on cancer type, date of diagnosis, stage at diagnosis, and treatment received which also allowed cross-reference with the primary data source for variables such as cancer type and date of diagnosis (Healthcare Improvement Scotland, 2019). Data quality of the Scottish Cancer Registry is monitored using routine indicators, computer validations, and ad-hoc studies of data accuracy and completeness of ascertainment (Information Services Division, 2017a, 2017b). Hospital episode data on hospital outpatient attendances and admissions were obtained from the Scottish Morbidity Records SMR 00 (outpatients) and SMR 01 (inpatients) (Datasets, 2020). The data quality is regularly assessed and validated (Information Services Division Assessment of, 2012). A weighted Charlson comorbidity score was calculated for each patient based on their hospital episode data (Charlson et al., 1987). The score was calculated from principal and supplementary diagnostic ICD 10 codes from hospital attendances and admissions for 10 years before cancer diagnosis for each patient and excluded cancer or metastatic cancer. This allowed for adjustment in the statistical analysis for co-morbidity. Data on dates and principal and secondary causes of death were provided from death records held by the National Records of Scotland (NRS). Quality checks are automatically carried out at the point of entry and when the information is passed onto the National Records of Scotland Vital Events statistical database (National Records of Scotland, 2017).

Using residential postcodes, Scottish Index of Multiple Deprivation (SIMD) and the Scottish Government Urban-Rural Classification were assigned to the data set. SIMD is an area-based measure of deprivation that assumes deprivation is not one dimensional (The Scottish Government, 2018a). The SIMD is measured across seven domains: current income, employment, health, education, skills and training, housing, geographic access to services and unemployment counts (which are averaged to take account of seasonal fluctuations in employment patterns) (The Scottish Government, 2018a). The Scottish Government Urban-Rural Classification provides a standard definition of rural areas in Scotland, defined as areas with a population of less than 3000 people, and this information was used to assign each Scottish postcode to a two-fold category of urban or rural (The Scottish Government, 2016, 2018b).

2.3. Data linkage

The CCPd extract was transferred to analysts at Electronic Data Research and Innovation Service (eDRIS) of Public Health Scotland (PHS), who linked records from the relevant SMR and death datasets using the community health index (CHI), a unique identifier for all residents in Scotland [ScottisH Informatics Project (SHIP) (SHIP, 2013). Data were then pseudo-anonymised and individuals' residential postcodes were used to assign deprivation (SIMD) and two-fold Urban Rural classifications (The Scottish Government, 2016, 2018a, 2018b).

2.4. Exposure: burden of travel expressed as travel times

Travel times from place of residence to the main regional cancer treatment centre (Aberdeen Royal Infirmary) were calculated using Google API. Each unique postcode pairing (patient's residence and Aberdeen Royal Infirmary) was fed into the distance matrix API (Google API) to produce a travelling time in seconds and subsequently converted into decimal time (Kai and Wei-sheng, 2011). Google API measures time for the routes and assumes modes of transport that individuals will most likely use for their travel. Given the geographical diversity within the

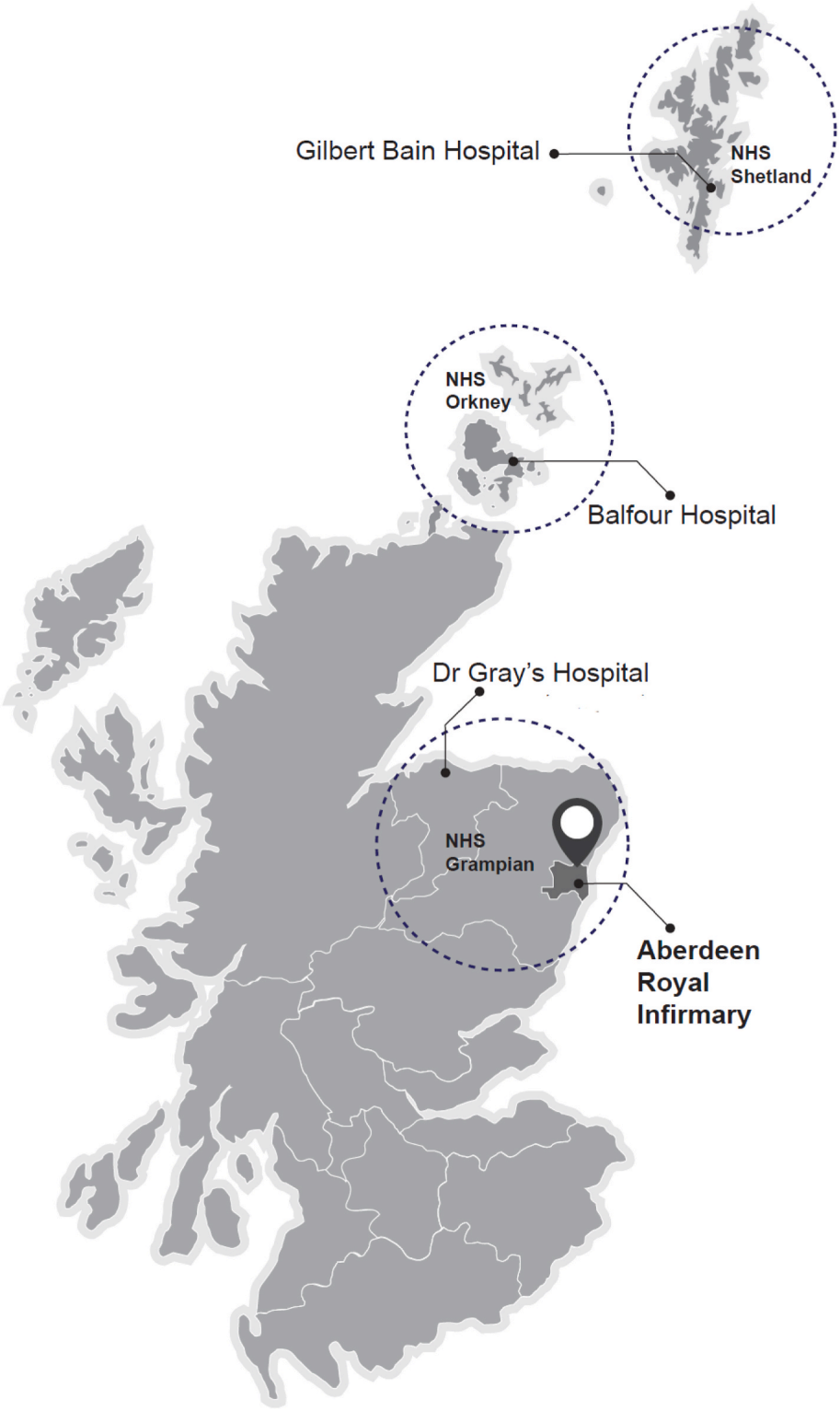

Fig. 1. Location of hospitals in the NHS health boards of Grampian, Orkney, and Shetland.
Balfour Hospital is a small rural general hospital with 48 beds located in Kirkwall, Orkney and managed by NHS Orkney. Patients requiring specialist treatment are transferred to the Scottish mainland, usually Aberdeen Royal Infirmary.
Gilbert Bain Hospital is a remote and rural hospital with 56 beds located in Lerwick, Shetland and managed by NHS Shetland. Patients requiring specialist treatment are transferred to the Scottish mainland, usually Aberdeen Royal Infirmary.
Dr Gray's Hospital, located in Elgin, is a district general hospital managed by NHS Grampian with 210 beds. In-patient services are provided for geriatric assessment, gynaecology, medicine, obstetrics, ophthalmology, orthopaedics, paediatrics, and general surgery.
Aberdeen Royal Infirmary (ARI), located in the city of Aberdeen, is the largest hospital within NHS Grampian. It contains approximately 900 beds and provides care for the complete range of medical and clinical specialities. ARI is the regional cancer treatment centre for patients from NHS Grampian, NHS Orkney, and NHS Shetland.

study region this represented a considerable advance on previous research based upon straight line distance. Results were linked back to individual participants and process checks were carried out to ensure that postcode matches were consistent and correct. Travelling time to the regional cancer treatment centre was categorised as follows: >15.0 min for mainland residents, 15.0–29.9 min for mainland residents, 30.0–59.9 min for mainland residents, >60.0 min for mainland residents and a category for all island residents. NHS Shetland and NHS Orkney are communities of islands to the north of the Scottish mainland and are a straight-line distance of approximately 230 and 130 miles, respectively, from the main regional cancer treatment centre, Aberdeen Royal Infirmary. Having a distinct island category allows for analysis of the complexity of additional factors that could influence accessibility for this group of patients. The reference category for all analyses refers to the travelling time category closest to the main regional cancer treatment centre (<15.0 min).

2.5. Outcomes

2.5.1. Engagement with post-diagnosis secondary care

The primary outcome was the rate of secondary care contact time (scheduled outpatient attendances and hospital day case and inpatient admissions) as a measure of intensity/engagement with post-diagnosis secondary care in the year following diagnosis. This was calculated as the number of distinct days of secondary care contact in relation to the number of days a patient was alive during the one-year follow-up. Hospital admissions were categorised as cancer-related if the main condition code in SMR01 contained an ICD-10 cancer code. Hospital admissions were further categorised as elective or emergency. SMR00 outpatient data lacks accurate diagnosis data we therefore identified cancer-related visits as those coded as medical/clinical oncology. For outpatient attendances, the rate of attendance was calculated based on patients home-time (follow-up time minus time spent as a hospital inpatient), as hospital inpatients are not available to attend outpatient appointments. The associations between travelling time and secondary care contact time were explored using the following categorisations.

1) All patient secondary care contact time defined as days spent in hospital and outpatient appointments.
2) Patient secondary care contact time for cancer defined as days spent in hospital where cancer was the main admission code and medical/clinical oncology outpatient appointments.
3) Patient secondary care contact time for elective cancer defined as days spend in hospital where cancer was the main admission code, and medical/clinical oncology outpatient appointments.
4) Patient secondary care contact time for inpatient elective/routine cancer admissions defined as days spent in hospital where admission is elective/routine and cancer is main admission code.
5) Patient secondary care contact time for inpatient emergency care admissions defined as days spent in hospital where admission is emergency and cancer is the main admission code.
6) Patient secondary care contact time for all outpatient appointments defined as days spent at outpatient appointments as a ratio of available days.
7) Patient secondary care contact time for medical/clinical oncology appointments defined as days spent at hospital as a ratio of available days.
8) Patient secondary care contact time for surgical outpatient appointments defined as days spent at hospital as a ratio of available days

2.6. Time to emergency cancer admission

A secondary outcome in our analysis was time to emergency cancer admission from date of diagnosis and the association with travelling time.

2.7. Mortality

Cancer-specific and all-cause one-year mortality was calculated from date of diagnosis (from CCPd) to date of death (derived from NRS death records). Those not registered as dead during follow-up were assumed to be still alive. Patients were followed from diagnosis, until date of death or end of one-year follow up period at which point they were censored.

2.8. Co-variates of interest

Data were reported on age, sex, deprivation (SIMD quintiles), rurality (based on the Scottish two-fold urban rural classification), Charlson score, urgency/referral status (urgent suspected cancer, urgent, routine, screening, emergency, and other), cancer type, diagnostic procedure (imaging, endoscopy/endoscopic biopsy, operative biopsy/surgery, or other) and main or first treatment type (surgery, chemotherapy/radiotherapy, or other). Cancer staging data was not complete in the Scottish Cancer Registry, largely because stage was not collected for some of the included cancer sites during the time frame of this study. Metastatic cancer information taken from hospital episode data was used as a proxy for stage of cancer, as has been used previously (Turner et al., 2017; Parks et al., 2004).

2.9. Statistical analysis

Data management and statistical analyses were performed using SPSS version 25 (IBM, Armonk, NY, USA), and SAS version 9.3 (SAS Institute, Dary, NC, USA). Complete data were available for all outcome measures. Using standard descriptive statistics, baseline characteristics for the study cohort at the time of GP referral were calculated.

The reference category for all analyses refers to the travelling time category closest to the main regional cancer treatment centre (<15.0 min).

Zero-inflated negative binomial regression models were used to explore the association between secondary care contact time and travelling time to the main regional cancer treatment centre. The use of a zero-inflated model takes account of data that has an incidence of zeros greater than expected for the underlying probability distribution (Mwalili et al., 2008). The models were adjusted for the following independent covariates: age, gender, two-fold urban/rural classification, deprivation (SIMD), urgency/referral status, cancer type, procedure type, Charlson Comorbidity Index (CCI) score, treatment type, and metastatic status. To capture additional treatment for end-of-life care, as these patients are known to require more hospital treatment (Ni Chroinin et al., 2018), adjustment for vital status of the patient (dead or alive) at the end of 365 days was also carried out.

Competing risk analysis using a Fine and Gray sub-distribution hazards model was carried out to explore the time to first emergency hospital admission for cancer according to travelling time categories, with death being the competing risk.

To explore one-year cancer-specific mortality, competing risk analysis using a Fine and Gray sub-distribution hazards model was carried out, with other causes of death being the competing risk. Adjustment was made for the effect of independent covariates. Adjustment was also made for the incidence ratio for secondary care contact time. This was calculated as secondary care contact days (according to different categorisations) divided by the log of available follow-up time. For outpatient appointments, this follow-up time was the time available to attend outpatient appointments defined as total follow-up time minus time spent in hospital as an inpatient.

Sensitivity analysis was carried out for all outcomes using an ICD-10 code of cancer present in either the main condition or any of the five other condition codes. With respect to one-year mortality, sensitivity analysis using Cox proportional hazards model was used to explore all-cause mortality across travelling time categories to the regional cancer centre.

3. Results

3.1. Extraction and linkage

Data on 20 530 patients was extracted from the CCPd dataset and linked to the relevant SMR and death datasets. A total of 17 369 patients were included in the final cohort (Fig. 2). 89.8% of the cohort had at least one secondary care admission or outpatient appointment in their first year following diagnosis. Of these patients, 65.3% had at least one cancer-related admission or outpatient appointment.

3.2. Patient characteristics

Table 1 shows patient and care pathway characteristics for the cohort at the time of GP referral for all patients and according to travelling time categories. 28.9% had travelling time less than 15 min to the nearest cancer centre; 17.1% travelled 15.0–29.9 min; 22.4% travelled 30.0–59.9 min; 23.8% travelled more than 60 min; and island patients made up the remaining 7.8% of the cohort.

The median (IQR) age of patients was 68 (59–77) years. Over half the cohort were female (53.1%), 80% were in the least three deprived quintiles and nearly two-thirds were urban dwellers (65.8%). Breast cancer accounted for 25% of cancers, with 20.3% colorectal, 18.2% lung, 16.5% prostate and the remaining 20% split across other included cancer sites. Metastatic cancer was diagnosed in 11.5% of patients.

Urgent suspected cancers (USC) referrals by GPs accounted for 29.2% of routes to diagnosis with 14.2% presenting as emergencies. Most (72.5%) had no comorbidities, 15.4% had one comorbidity and the remaining 12.1% had two or more comorbidities. Nearly half the cohort (47.4%) had surgery as their main first treatment with chemotherapy/radiotherapy at 37.8%.

3.3. Secondary care contact time

After adjustment for other factors, increasing travelling time was associated with an increase in the incidence rate of all patient secondary care contact time (Table 2); 30–59 min IR 1.09 (95% CI 1.04–1.13); greater than 60 min IR 1.08 (95% CI (1.04–1.23). Island residents did not show an increased incidence, IR 1.01 (95% CI 0.96–1.08).

Increasing travelling time was also associated with an increase in the incidence rate of patient secondary care contact time for cancer (Table 2); 30–59 min IR 1.06 (95% CI 1.01–1.11); greater than 60 min IR 1.08 (95 % CI 1.03–1.13). Living on an island also showed an increased incidence rate IR 1.09 (95% CI 1.01–1.17).

Specifically looking at elective or routine hospital admissions and outpatient appointments for cancer showed the same trend (Table 2); 30–59 min IR 1.07 (95 % CI 1.02–1.12); greater than 60 min IR 1.14 (95% CI 1.10–1.20); islands IR 1.11 (1.04–1.18).

Separating elective or routine hospital admissions for cancer from outpatient cancer appointments showed that increasing travelling time or living on an island increased the incidence rate for elective or routine hospital admissions for cancer.

Increasing travelling time or living on an island was not associated with an increase in the incidence rate of secondary care contact time for inpatient emergency cancer admission.

No difference in incidence rates was observed across the travelling time categories for outpatient appointments. For outpatient medical/clinical oncology appointments, the incidence rate was increased only for those travelling more than 60 min (IR 1.10 (95% CI 1.06–1.52). Of these patients (n = 4202), 31.0% had at least one appointment at a smaller general district hospital. Island patients had a decreased incidence rate for outpatient medical/clinical oncology appointments (IR 0.63 (95% CI 0.59–0.67). This pattern was also seen for outpatient surgical appointments.

3.4. Time to emergency cancer admission

Competing risk analysis showed no association with time to first emergency cancer admission and increasing travelling time or living on an island community (Table 3).

3.5. One-year mortality

Adjusting for secondary care contact time in the year post-cancer diagnosis increased the hazard of cancer-specific death for island dwellers from HR 1.16 (95% CI 0.99–1.36) to 1.18 (95% CI 1.01–1.38) (Table 4) For cancer-specific secondary care contact time this increased to HR 1.19 (95% CI 1.02–1.39). Adjusting for secondary care contact time specifically for emergency admissions where cancer was the main condition increased the HR for island dwellers to 1.21 (95% CI 1.03–1.41).

Adjusting for secondary care contact time specifically for medical/clinical oncology outpatient time decreased the hazard of death for island dwellers to HR 1.09 (95% CI 0.93–1.28).

This effect was not seen when adjusting for secondary care contact time specifically for surgical appointments.

3.6. Sensitivity analyses

A sensitivity analysis for all outcomes was conducted where a cancer admission was defined if an ICD-10 code for cancer was included in either the main condition or any of the 5 other condition codes (Supplementary Tables 1–3). There were no significant differences in the results seen. Further sensitivity analysis was carried out for all-cause mortality to account for deaths where the main cause of death was a secondary cause of cancer (Supplementary Tables 4-5).

5. Discussion

5.1. Summary of main findings

This is the first study to our knowledge exploring how travelling time impacts secondary care contact time following a cancer diagnosis. Patients with longer travelling times or who are island dwellers spend more time in hospital in the first year following a cancer diagnosis. Those with the longest mainland travelling time (>60 min from the cancer treatment centre) had more relevant outpatient appointments than those living closer by. In contrast, island dwellers have fewer relevant appointments and are more likely to die within one year. Longer travelling times or living on an island does not increase the hazard of emergency admission for cancer or time to first emergency cancer admission. However, when more remote patients have an emergency cancer admission they are more likely to die within the first year.

5.2. Context with wider literature

Travelling time has previously been shown to affect patients' initial treatment choices. A discrete choice experiment study investigating centralisation of services showed that participants with cancer were willing to travel, on average, 75 min longer to reduce their risk of surgical complications by one per cent, and over 5 h longer to reduce their risk of death by one per cent (Vallejo-Torres et al., 2018). Breast cancer patients with longer travelling timesare more likely to select mastectomy which requires travel for surgery only as opposed to breast conservation surgery requiring travel for both surgery and adjuvant radiotherapy (Longacre et al., 2020). Studies have also shown that patients were less likely to receive radiotherapy for breast, colon, rectal, and prostate cancer when they had longer time and distance to travel (Lin et al., 2015, 2016; Goyal et al., 2015; Muralidhar et al., 2016) and treatment nonadherence to radiotherapy is associated with rural

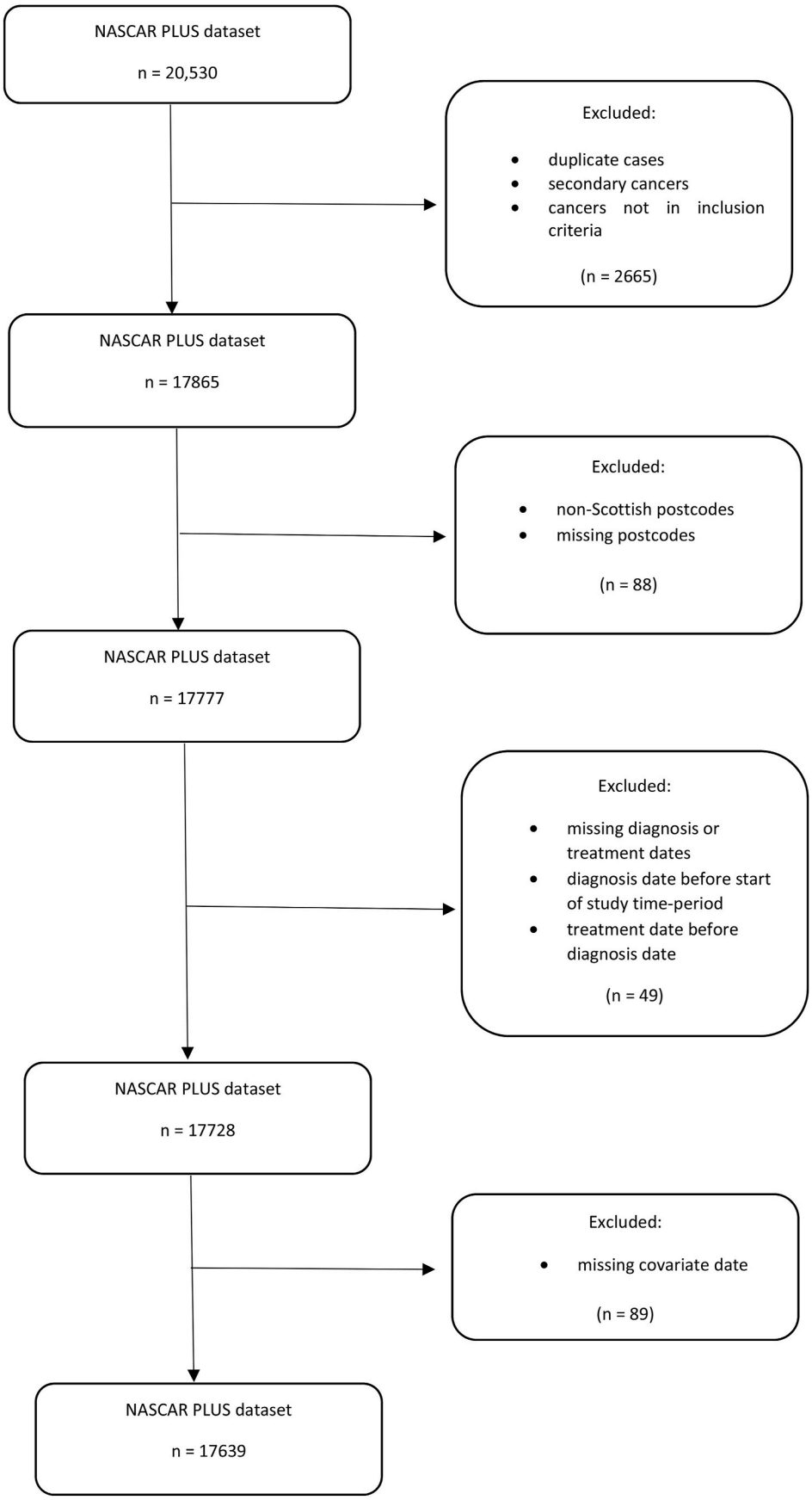

Fig. 2. Study flow diagram.

Table 1
Patient and care pathway characteristics at the time of referral.

		Travelling time category (min)				
	Total n (%)	<15 n (%)	15–29.9 n (%)	30.0–59.9 n (%)	>60.0 n (%)	Islands n (%)
	17 639 (100)	5093 (28.9)	3013 (17.1)	3959 (22.4)	4202 (23.8)	1372 (7.8)
Variable						
Age (years)						
Median (IQR)	68 (59–77)	69 (59–77)	67 (58–75)	68 (58–76)	69 (60–77)	69 (60–76)
Sex						
Male	8279 (46.9)	2308 (45.3)	1345 (44.6)	1907 (48.2)	2069 (49.2)	650 (47.4)
Female	9360 (53.1)	2785 (54.7)	1668 (55.4)	2052 (51.8)	2133 (50.8)	722 (52.6)
Deprivation (quintiles based on SIMD)						
SIMD Q1 (most)	958 (5.4)	659 (12.9)	147 (4.9)	<60 (<1.5)	92 (2.2)	<10 (<0.7)
SIMD Q2	2476 (14.0)	1123 (22.0)	94 (3.1)	332 (8.4)	733 (17.4)	194 (14.1)
SIMD Q3	4228 (24.0)	960 (18.8)	335 (11.1)	783 (19.8)	1707 (40.6)	443 (32.3)
SIMD Q4	4919 (27.9)	452 (8.9)	957 (31.8)	1589 (40.1)	1245 (29.6)	676 (49.3)
SIMD Q5 (least)	5058 (28.7)	1899 (37.3)	1480 (49.1)	1195 (30.2)	425 (10.1)	<60 (<4.3)
Rurality (based on Scottish two-fold URC)						
Urban	11 611 (65.8)	5051 (99.2)	2238 (74.3)	1614 (40.8)	2257 (53.7)	451 (32.9)
Rural	6028 (34.2)	42 (0.8)	775 (25.7)	2345 (59.2)	1945 (46.3)	921 (67.1)
Urgency/referral status						
Urgent Suspected Cancer (USC)	5154 (29.2)	1518 (29.8)	959 (31.8)	1191 (30.1)	1064 (25.3)	422 (30.8)
Urgent	3061 (17.4)	874 (17.2)	467 (15.5)	670 (16.9)	862 (20.5)	188 (13.7)
Routine	1947 (11.0)	540 (10.6)	285 (9.5)	488 (12.3)	510 (12.1)	124 (9.0)
Screening	2168 (12.3)	564 (11.1)	422 (14.0)	485 (12.3)	476 (11.3)	221 (16.1)
Emergency	2506 (14.2)	798 (15.7)	408 (13.5)	495 (12.5)	631 (15.0)	174 (12.7)
Other	2803 (15.9)	799 (15.7)	472 (15.7)	630 (15.9)	659 (15.7)	243 (17.7)
Cancer type						
Breast	4401 (25.0)	1229 (24.1)	821 (27.2)	1031 (26.0)	926 (22.0)	394 (28.7)
Cervical	219 (1.2)	66 (1.3)	29 (1.0)	46 (1.2)	65 (1.5)	13 (0.9)
Colorectal	3578 (20.3)	1013 (19.9)	600 (19.9)	790 (20.0)	894 (21.3)	281 (20.5)
Lung	3203 (18.2)	1106 (21.7)	514 (17.1)	624 (15.8)	740 (17.6)	219 (16.0)
Melanoma	1268 (7.2)	343 (6.7)	247 (8.2)	299 (7.6)	291 (6.9)	88 (6.4)
Ovarian	506 (2.9)	144 (2.8)	84 (2.8)	98 (2.5)	141 (3.4)	39 (2.8)
Prostate	2916 (16.5)	739 (14.5)	471 (15.6)	756 (19.1)	702 (16.7)	248 (18.1)
Oesophageal	1548 (8.8)	453 (8.9)	247 (8.2)	315 (8.0)	443 (10.5)	90 (6.6)
Charlson Comorbidity Index (CCI) (excluding cancer and metastatic cancer)						
0	12 796 (72.5)	3545 (69.6)	2234 (74.1)	3048 (77.0)	2957 (70.4)	1012 (73.8)
1	2722 (15.4)	863 (16.9)	430 (14.3)	514 (13.0)	695 (16.5)	220 (16.0)
2	1118 (6.3)	353 (6.9)	177 (5.9)	218 (5.5)	296 (7.0)	74 (5.4)
3	535 (3.0)	167 (3.3)	98 (3.3)	103 (2.6)	133 (3.2)	34 (2.5)
4	283 (1.6)	99 (1.9)	38 (1.3)	45 (1.1)	81 (1.9)	20 (1.5)
5	108 (0.6)	37 (0.7)	<25 (<0.8)	<20 (<0.5)	21 (0.5)	<20 (<0.5)
6+	77 (0.4)	29 (0.6)	<15 (<0.5)	<15 (<0.4)	19 (0.5)	<15 (<0.1)
Diagnostic Procedure						
Endoscopy/Endoscopic Biopsy	7867 (44.6)	2096 (41.2)	1328 (44.1)	1780 (45.0)	1949 (46.4)	714 (52.0)
Imaging	3721 (21.1)	1184 (23.2)	586 (19.4)	776 (19.6)	917 (21.8)	258 (18.8)
Operative Biopsy/Surgery	5201 (29.5)	1553 (30.5)	957 (31.8)	1209 (30.5)	1151 (27.4)	331 (24.1)
Other/Unknown	850 (4.8)	260 (5.1)	142 (4.7)	194 (4.9)	185 (4.4)	69 (5.0)
Main cancer treatment						
Surgery	8358 (47.4)	2270 (44.6)	1504 (49.9)	1921 (48.5)	1983 (47.2)	680 (49.6)
Chemotherapy/Radiotherapy	6668 (37.8)	2015 (39.6)	1096 (36.4)	1469 (37.1)	1601 (38.1)	487 (35.5)
Other[a]	2613 (14.8)	808 (15.9)	413 (13.7)	569 (14.4)	618 (14.7)	205 (14.9)
Metastatic cancer						
Yes	2031 (11.5)	621 (12.2)	326 (10.8)	436 (11.0)	492 (11.7)	156 (11.4)
No	15 608 (88.5)	4472 (87.8)	2687 (89.2)	3523 (89.0)	3710 (88.3)	1216 (88.6)

(Abbreviations: CCI = Charlson Comorbidity Index; SIMD = Scottish Index of Multiple Deprivation; SD = standard deviation; URC = urban rural classification).
[a] Other treatment includes hormone therapy, palliative treatment, watch and wait, patient died before treatment, patient declined treatment, no treatment, and unknown.

residence (Morris et al., 2023). In our study, we adjusted for initial treatment and cancer type but did not have relevant data to ascertain treatment choices over time which may influence secondary care contact time. We did find that those living over 60 min travelling time to their regional cancer centre had increased incidence of outpatient medical/clinical oncology contact time. This could result from a 'hub and spoke' model for approximately one-third of these patients, where they receive most outpatient appointments at the main regional cancer centre, but some additional outpatient appointments maybe at a smaller general district hospital. Another possible reason for this increased incidence could be the method of calculating treatment nonadherence, with previous studies not accounting for days available for outpatient contact time (follow-up time minus inpatient hospital time) which we have done in this study.

Cancer care is predominantly secondary care outpatient led, and along with differences in treatment between cancer types, there are also many clinical differences in the symptoms and complications that patients experience and their need for secondary care use. It has been shown that those with cancer who are in their last year of life, are consistently the most frequent users of secondary healthcare (Diernberger et al., 2021; Luta et al., 2022) but that those living in remote rural areas have an exceptionally low use of outpatient appointments in their last year of life (Diernberger et al., 2021). Hospitalisation rates have been shown to be higher in older patients with cancer who travel longer than 60 min to their hospital facility (Rocque et al., 2019). In our study those living over 30 min from their regional cancer centre and island patients had increased secondary care cancer elective inpatient contact time. In some cases this may simply be related to combining

Table 2
Zero-inflated negative binomial estimations, showing the association between travelling time to regional cancer centre and incidence rate of secondary care contact time during one-year follow-up.

Travelling time (min)	<15.0	15.0–29.9	30.0–59.9	>60.0	Islands
n	5093	3013	3959	4202	1372
All patient secondary care contact time (days spent in hospital and outpatient appointments)					
Incidence rate (95% CI)	1.00	1.04 (0.99–1.08)	1.09 (1.04–1.13)	1.08 (1.04–1.23)	1.01 (0.96–1.08)
p-value	–	0.076	<0.001	<0.001	0.664
Patient secondary care contact time for cancer (days spent in hospital where cancer is main admission code and medical/clinical oncology outpatient appointments)					
Incidence rate (95% CI)	1.00	1.03 (0.98–1.08)	1.06 (1.01–1.11)	1.08 (1.03–1.13)	1.09 (1.01–1.17)
p-value	–	0.269	0.022	0.002	0.020
Patient secondary care contact time for elective cancer (days spent in hospital where admission is elective/routine and cancer is main admission code, and medical/clinical oncology appointments)					
Incidence rate (95% CI)	1.00	1.05 (1.00–1.10)	1.07 (1.02–1.12)	1.14 (1.10–1.20)	1.11 (1.04–1.18)
p-value	–	0.105	<0.001	<0.001	<0.001
Patient secondary care contact time for inpatient elective/routine cancer admissions (days spent in hospital where admission is elective/routine and cancer is main admission code)					
Incidence rate (95% CI)	1.00	1.05 (0.99–1.16)	1.09 (1.02–1.16)	1.17 (1.10–1.24)	1.23 (1.16–1.37)
p-value	–	0.119	0.007	<0.0001	<0.0001
Patient secondary care contact time for inpatient emergency cancer admissions (days spent in hospital where admission is emergency and cancer is main admission code)					
Incidence rate (95% CI)	1.00	1.14 (0.94–1.38)	1.12 (0.92–1.35)	1.02 (0.85–1.22)	1.23 (0.95–1.60)
p-value	–	0.177	0.268	0.859	0.123
Patient secondary care contact time for all outpatient appointments (days spent at outpatient appointments as a ratio of available days)					
Incidence rate (95% CI)	1.00	1.00 (0.97–1.03)	0.96 (0.93–0.99)	1.03 (1.01–1.07)	0.64 (0.61–0.67)
p-value	–	0.804	0.016	0.018	<0.0001
Patient secondary care contact time for medical/clinical oncology appointments (days spent at appointments as a ratio of available days)					
Incidence rate (95% CI)	1.00	1.03 (0.99–1.08)	0.99 (0.95–1.03)	1.10 (1.06–1.52)	0.63 (0.59–0.67)
p-value	–	0.132	0.67	<0.0001	<0.0001
Patient secondary care contact time for surgical appointments (days spent at appointments as a ratio of available days)					
Incidence rate (95% CI)	1.00	0.99 (0.95–1.05)	0.99 (0.94–1.04)	1.19 (1.13–1.24)	0.93 (0.86–0.99)
p-value	–	0.956	0.758	<0.0001	0.043

Adjusted for age, sex, urban/rural code, deprivation, urgency/referral status, cancer type, procedure type, CCI score, treatment type, metastatic cancer, and death within one year.

treatment with assessment imaging in one stay. Other reasons for this could include restraints on health and social care in the community for patients with longer travelling times, resulting in them being kept in hospital for longer. Further reasons could include a delay in seeking help for treatment complications for those with longer travelling times causing them to require lengthier hospital stays. Interestingly although those with travelling times longer than 60 min had an increased incidence rate of outpatient medical/clinical oncology contact time, island patients had decreased contact time compared to those with the shortest travelling times. Reasons for this are unclear but could relate to island patients having treatment during their time spent in hospital, removing the necessity for them to travel back to the regional cancer centre for an outpatient appointment. In our previous study, we showed that island patients were more likely to be diagnosed and start treatment on the same or next day (Turner et al., 2017) which supports this theory.

There is limited research on patterns or reasons for emergency hospital admission following a cancer diagnosis in relation to travelling time. Emergency admissions for cancer are most commonly due to pain, dyspnea, nausea and/or vomiting (Mayer et al., 2011; Vandyk et al., 2012; Koch et al., 2022). Cancer patients have been shown to experience a higher number of emergency admissions in the final year of their life compared with those who die from non-cancer conditions (Marie-Curie, 2016). In our study longer travelling times did not increase the secondary care contact time for emergency admissions nor the time to first emergency cancer admission following diagnosis. If a patient did however have an emergency admission which was cancer related this increased the hazard of death for those with a longer travelling times and those living on an island community.

Treatment related time toxicity and perceived 'over medicalisation' is relevant in cancer patients and has been shown to be linked with a lower quality of life (Gupta et al., 2022; Finucane et al., 2019). Reducing length of hospital stay improves the wellbeing of patients, quality of care, and reduces financial burden for patients (Lewis and Edwards, 2015; Macmillan Cancer Support, 2013). We previously showed that increasing travelling time to a cancer treatment centre was associated with increased mortality to 1 year (Turner et al., 2017). In this study, using a different patient cohort, we have shown that the risk of dying in the year following cancer diagnosis is only higher in island patients compared to those with the shortest travelling times to hospital. Increased secondary care inpatient contact time increased this risk of dying while increased amount of outpatient medical/clinical oncology contact time removed this survival disadvantage. This suggests that outpatient contact time in particular may be an important factor in terms of patient mortality for this distinct group of patients. Increased inpatient contact time could relate more to symptoms and complications due to cancer and/or cancer treatment, whereas outpatient contact time, now often remotely via videolink, could relate more to treatment choice and subsequent adherence to treatment. This may be underpinning the differences seen between elective/routine inpatient admissions versus outpatient clinic attendance in our study and their effect on patient mortality. Island patients also have the complexity of additional factors, including topography and infrastructure, that could influence accessibility. In addition to travel to the mainland, island dwellers also potentially have intra-island travelling time. Orkney Islands are approximately 990 km^2, 42.5 km long by 22.7 km width and include 20 inhabited islands. Shetland Islands are approximately 1,468 km^2, 113 km in length and consists of 16 inhabited islands. Multidimensional factors affect healthcare in remote and rural areas with each area having its own interweaving socio-spatial, emotional, and economic factors (Castelden et al., 2010). These increase the complexity of health care and the concept of 'place' being about more than physical distance (Hanlon et al., 2016). Rural residents may view distance and travelling time as a normal part of rural life, with a willingness to travel even longer distances to access healthcare they trust rather than access closer facilities they mistrust (Statz and Evers, 2020). However, palliative care patients living rurally have expressed the negative emotional,

Table 3
Competing risk analysis for emergency admission for cancer during one-year follow-up.

Travelling time (min)	<15.0	15.0–29.9	30.0–59.9	>60.0	Islands
n	5093	3013	3959	4202	1372
n event (%)	922 (18.1)	516 (17.1)	666 (16.8)	672 (16.0)	219 (16.0)
n competing event (%)	627 (12.3)	294 (9.8)	417 (10.5)	536 (12.8)	155 (11.3)
HR (95% CI)	1.00	1.06 (0.95–1.19)	1.07 (0.95–1.19)	0.89 (0.80–0.99)	1.04 (0.89–1.23)

Adjusted for age, sex, urban/rural code, deprivation, urgency/referral status, cancer type, procedure type, CCI score, treatment type, and metastatic cancer.

Table 4
Competing risk analysis for cancer-specfic mortality, showing association between travelling time to regional cancer centre for rate of secondary care contact time during one-year follow-up.

Travelling time (min)	All	<15.0	15.0–29.9	30.0–59.9	>60.0	Islands
n	17639	5093	3013	3959	4202	1372
Cancer-specific mortality						
n event (%)	3431 (19.5)	1049 (20.6)	527 (17.4)	737 (18.6)	864 (20.6)	256 (18.7)
n competing event (%)	444 (2.5)	143 (2.8)	71 (2.4)	92 (2.3)	107 (2.5)	31 (2.3)
HR (95% CI)		1.00	0.98 (0.87–1.10)	1.08 (0.97–1.22)	1.07 (0.96–1.19)	1.16 (0.99–1.36)
All patient secondary care contact time (days spent in hospital and outpatient appointments)						
HR (95% CI)		1.00	0.98 (0.87–1.10)	1.07 (0.95–1.20)	1.08 (0.96–1.19)	1.18 (1.01–1.38)
HR for contact time (one-unit increase) (95% CI)	1.03 (1.02–1.04)					
Patient secondary care contact time for cancer (days spent in hospital where cancer is main admission code and medical/clinical oncology outpatient appointments)						
HR (95% CI)		1.00	0.98 (0.86–1.10)	1.08 (0.96–1.21)	1.09 (0.97–1.21)	1.19 (1.02–1.39)
HR for contact time (one-unit increase) (95% CI)	1.06 (1.05–1.07)					
Patient secondary care contact time for elective cancer (days spent in hospital where admission is elective/routine and cancer is main admission code, and medical/clinical oncology appointments)						
HR (95% CI)		1.00	0.99 (0.88–1.11)	1.09 (0.97–1.22)	1.08 (0.97–1.20)	1.17 (0.99–1.37)
HR for contact time (one-unit increase) (95% CI)	0.97 (0.94–0.99)					
Patient secondary care contact time for inpatient elective/routine cancer admissions (days spent in hospital where admission is elective/routine and cancer is main admission code)						
HR (95% CI)		1.00	0.98 (0.87–1.11)	1.08 (0.97–1.22)	1.07 (0.96–1.20)	1.17 (0.99–1.37)
HR for contact time (one-unit increase) (95% CI)	0.99 (0.97–1.01)					
Patient secondary care contact time for inpatient emergency cancer admissions (days spent in hospital where admission is emergency and cancer is main admission code)						
HR (95% CI)		1.00	0.99 (0.87–1.12)	1.10 (0.98–1.23)	1.11 (0.99–1.24)	1.21 (1.03–1.41)
HR for contact time (one-unit increase) (95% CI)	1.08 (1.06–1.09)					
Patient secondary care contact time for all outpatient appointments (days spent at outpatient appointments as a ratio of available days)						
HR (95% CI)		1.00	0.99 (0.87–1.12)	1.06 (0.95–1.20)	1.06 (0.96–1.19)	0.99 (0.84–1.16)
HR for contact time (one-unit increase) (95% CI)	0.61 (0.57–0.65)					
Patient secondary care contact time for medical/clinical oncology appointments (days spent at appointments as a ratio of available days)						
HR (95% CI)		1.00	0.99 (0.88–1.12)	1.08 (0.96–1.21)	1.08 (0.97–1.20)	1.09 (0.93–1.28)
HR for contact time (one-unit increase) (95% CI)	0.72 (0.66–0.78)					
Patient secondary care contact time for surgical appointments (days spent at appointments as a ratio of available days)						
HR (95% CI)		1.00	0.98 (0.87–1.11)	1.09 (0.97–1.22)	1.10 (0.99–1.22)	1.15 (0.98–1.35)
HR for contact time (one-unit increase) (95% CI)	0.03 (0.02–0.05)					

Adjusted for age, sex, urban/rural code, deprivation, urgency/referral status, cancer type, procedure type, CCI score, treatment type and metastatic cancer.

socio-political and financial impacts of travelling for healthcare (Castelden et al., 2010). In our study, island dwellers who spend an increased amount of time in hospital are away from their social and community support. This may adversely affect their health through increased psychosocial and physical distress (Levit et al.; Fitch et al., 2021; Egilsdóttir et al., 2022) and could increase the risk of negative outcomes, including mortality. Further research is needed to understand the interplay between inpatient versus outpatient contact time in relation to the risk of dying, taking into account that increasingly a significant number of oncology outpatient contact time for island pateitns will be virtual (via videolink).

The current study should be interpreted in the light of the bulk of global evidence to date and the consensus that the mechanisms are multifactorial (Carriere et al., 2018). The current data suggest that differential rates of hospital attendance in the year following a diagnosis of cancer could be playing a role in observed trends. Considering the COVID-19 pandemic, it would be important to investigate the impact of the growing reliance on virtual consulting in both primary and secondary care, and on the experience of those with longer travelling times. It could be that effective and well-organised digital healthcare in the immediate cancer survivorship phase offers the best chance of addressing the existing short term cancer survival disadvantage.

5.3. Strengths and limitations

The NASCAR + dataset was derived from several comprehensive and high-quality clinical datasets accurately linked using the Community Health Index (CHI) number (SHIP, 2013). This study was based in a geographically large and diverse area providing the full range of residential settings, urban, rural and island. Good quality routinely collected information on hospital inpatient admission and outpatient attendance enabled exploration of an issue receiving little previous attention, the relationship between cancer mortality, place of residence and engagement with post-diagnostic secondary care. Although inequalities in cancer care due to geography and travelling time have been observed worldwide, international comparisons are difficult due to differing topography, infrastructure, and cultural factors, and it is predominantly a complex local and regional issue (Afshar et al., 2019). Region-specific research is therefore important and the strength of our study lies in its granularity. The study benefitted from advances in methods to calculate realistic travelling times since Google API measures time for routes and assumes modes of transport most likely to be used for travel. Given the geographical diversity within the study region this represented a considerable advance on previous research based upon straight line distance. The caveat, of course, is that Google API cannot yet account for road works, traffic delays, and weather conditions, which could extend travelling times further for the most remote patients. In addition, there are access and cost factors which can affect travelling time.

A limitation of the dataset, like most observational studies, was that information on potential confounders, such as lifestyle, details of employment, and availability of community support was not available. Furthermore, analysis was based-upon area-based markers of socioeconomic deprivation, a potential problem in rural areas where datazones are larger and may comprise a more socioeconomically diverse population than urban datazones. Against this the original NASCAR cohort was previously linked to data from the UK census, and concluded that analysis based on individual individual-level SES measures rather than area-based SES measures (SIMD), had little impact on the overall results in relation to timeliness to treatment (Murchie et al., 2021). Secondary care also represents only one dimension of healthcare so our study does not reflect the whole spectrum of health and social care which could influence post-diagnosis secondary care contacts and mortality, including the extent to which patients may have chosen to accept further treatments or accessed palliative care. Our study involves pre-COVID-19 pandemic data, so we cannot yet investigate resultant impacts on cancermortality. Conversely we are unable to measure any increased reliance in virtual consulting in secondary care during and after the COVID-19 pandemic.

6. Conclusions, implications, and further research

Overall our results suggest that fewer outpatient contacts in the year following diagnosis are associated with higher one year mortality for island-dwellers. They also suggest that when patients with longer travelling times or who are island-dwellers have a cancer-related emergency admission they are more likely to die within the first year following diagnosis. Taken together these results rather suggest that the impact of acute complications on mortality is greater for patients with longer travelling times, and emphasize the need for good quality secondary care contact. If this cannot be provided physically efforts to optimize digital consulting are urgently required. Although these findings require greater exploration in future mixed-methods studies they suggest that medical and clinical oncology outpatient clinic appointments, including virtual for the island patients, are important in terms of cancer survivorship following diagnosis for those with longer travelling times or living on an island community.

In light of our findings, a detailed study is needed to determine if the variation in secondary care contact in relation to travelling time is due to varying community support, patient preferences, or a consequence of disease-specific needs and complications for an individual. Further, it would be important to discover the impact of a growing reliance on virtual consulting in both primary and secondary care since the COVID-19 pandemic, on the experience of those with longer travelling times. It could be that effective and well-organised digital healthcare in the immediate cancer survivorship phase offers the best chance of addressing the existing short-term cancer survival disadvantage.

Ethics approval and consent to participate

The NASCAR + study was reviewed and approved by the Privacy and Public Benefit Panel (PBPP) of NHS Scotland (Application Number 1617-0181) and the Caldicott Guardian of NHS Grampian. (Reference Number NF/lc/0228).

Data availability

The data that support the findings of this study are not openly available due to ethical and legal restrictions. Data are located in controlled access data storage. Data from SMR06, SMR01, SMR00 and NRS Deaths are available on a Public Benefit and Privacy Panel (PBPP) application to Electronic Data Research and Innovation Service (eDRIS), Public Health Scotland, Edinburgh, Scotland.

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Declaration of competing interests

None declared.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.healthplace.2023.103139.

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