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Original Article

Hospital Factors Influencing the Mobility of Patients for Systemic Therapies in Breast and Bowel Cancer in the Metastatic Setting: A National Population-based Evaluation

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Abstract

Aims: This national study investigated hospital quality and patient factors associated with treatment location for systemic anticancer treatment (SACT) in patients with metastatic cancers.

Materials and methods: Using linked administrative datasets from the English NHS, we identified all patients diagnosed with metastatic breast and bowel cancer between 1 January 2016 and 31 December 2018, who subsequently received SACT within 4 months from diagnosis. The extent to which patients bypassed their nearest hospital was investigated using a geographic information system (ArcGIS). Conditional logistic regression models were used to estimate the impact of travel time, hospital quality and patient characteristics on where patients underwent SACT.

Results: 541 of 2,364 women (22.9%) diagnosed with metastatic breast cancer, and 2,809 of 10,050 (28.0%) patients diagnosed with metastatic bowel cancer bypassed their nearest hospital providing SACT. There was a strong preference for receiving treatment at hospitals near where patients lived ($p < 0.001$). However, patients who were younger ($p = 0.043$ for breast cancer; $p < 0.001$ for bowel cancer) or from rural areas ($p = 0.001$ for breast cancer; $p < 0.001$ for bowel cancer) were more likely to travel to more distant hospitals. Patients diagnosed with rectal cancer were more likely to travel further for SACT than patients with colon cancer ($p = 0.002$). Patients were more likely to travel to comprehensive cancer centres ($p = 0.019$ for bowel cancer) and designated Experimental Cancer Medicine Centres (ECMCs) although the latter association was not significant. Patients were less likely to receive SACT in hospitals with the highest readmission rates ($p = 0.046$ for bowel cancer).

Conclusion: Patients with metastatic cancer receiving primary SACT are prepared to travel to alternative more distant hospitals for treatment with a preference for larger comprehensive centres providing multimodal care or hospitals which offer early phase cancer clinical trials.

Key words: Bowel cancer; Breast cancer; Geographic information system (ArcGIS); Patient choice; Quality indicators; Systemic anticancer treatment (SACT)

Introduction

Systemic anticancer therapy (SACT) is developing at pace, and now includes cytotoxic chemotherapies, targeted therapies, and immunotherapy. The pace of innovation in the biopharmacuetical industry and accelerated regulatory approval has seen a dramatic increase in new SACT regimens over the last decade [1]. For example, 2,800 mappable SACT regimens could be recognised in the English National Health Service (NHS) in 2023. In the next five years, an increasing role for the routine use of cell and gene therapies in selected tumour types can be anticipated [2].

Given this rapidly increasing complexity, it is important to ensure the quality of the delivery of SACT. This is because they are often associated with significant toxicity, which can be minimised by adherence to strict protocols, careful patient selection, and the specialist management of significant side effects [3,4].

Many countries have also introduced policies that enable patients, often together with their general practitioner or their secondary care physician, to choose a hospital for diagnosis or treatment [5]. Cancer patients have been observed to travel further to hospitals that are perceived to

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offer better quality of care even though the same therapies are available locally [6]. This has been reported for different treatment modalities (surgery, radiotherapy) and populations (prostate, breast and colorectal cancer) [7,8].

Factors associated with patterns of patient mobility for treatment included the availability of advanced technologies or techniques (e.g., robotic surgery, intensity-modulated radiotherapy), being a 'comprehensive cancer centre' (i.e., a centre that offers cancer surgery, radiotherapy and systemic therapies), and the overall quality grading of hospitals [7,9]. In addition, patients travelling to alternative more distant centres (defined as patient mobility) for treatment are more likely to be younger, fitter, and more affluent [6,10].

Mobility may be limited for patients with metastatic disease, given the need to commence treatment expediently and also the highly standardised approach to management. However, factors which may influence their mobility include type of SACT being offered, the staff's experience, and expertise in treating particular cancers [11].

In this national population-based study, we investigate the extent to which patients with newly diagnosed metastatic breast and colorectal cancer who receive first-line SACT bypass their nearest hospital providing SACT for treatment as well as the patient and hospital factors associated with treatment location. These cancers have been chosen as they are both high-incidence tumours, categorised by differences in age profile and use of different types of SACT.

Methods

Data Sources and Study Population

This study used the English Cancer Registry, Hospital Episode Statistics (HES) and the Systemic Anti-Cancer Therapy (SACT) datasets linked at patient-level to identify all patients who were diagnosed with breast or colorectal cancer during the study period from 1 January 2016 to 31 December 2018, and subsequently underwent SACT at NHS hospitals in England. The International Classification of Diseases 10th Edition (ICD-10) code 'C50' was used to identify women diagnosed with breast cancer, and the codes 'C18', 'C19', and 'C20' were used to identify patients diagnosed with colorectal cancer from the Cancer Registry Dataset [12]. This data source also provided patient's age at diagnosis, date of diagnosis, and cancer stage.

The linked Hospital Episode Statistics (HES), the administrative database of all care episodes in English NHS hospitals [13], provided information on the patients' ethnicity and number of comorbidities in the two years prior to diagnosis according to the RCS Charlson Score [14]. In addition, HES also provided a measure of the patients' socioeconomic deprivation, expressed in terms of quintiles of the national distribution of the Index of Multiple Deprivation (IMD) of neighbourhoods represented by 32,844 Lower Super Output Areas (LSOA), typically including 1500 people and 650 households [15].

HES also provided information on the treating NHS hospital, the date and mode of admissions (i.e., 'elective' or 'emergency'), and diagnostic ICD-10 codes as well as procedure codes according to the Office of Population Censuses and Surveys Classification of Surgical Operations and Procedures 4th Revision (OPCS-4) [16]. We used such information to identify chemotherapy regimens following diagnosis and hospital readmissions caused by chemotherapy toxicity in a period across and up to two months following a chemotherapy regimen.

The SACT dataset provides information on the date, type and provider of all chemotherapy treatments in the English NHS. The regimens identified from this dataset were compared and combined with records identified from HES to improve data accuracy and coverage [17]. We used the source with the most complex regimen details if it had been identified in both HES and SACT datasets. The start date of chemotherapy and the hospital site where it was delivered were extracted from the earliest regimen following diagnosis.

Patients were included if they were diagnosed with metastatic breast or colorectal cancer between 2016 and 2018, started chemotherapy within 4 months from the date of diagnosis in NHS hospitals that routinely provide chemotherapy and if their data could be linked to our pre-estimated travel time datasets (Appendix Figures 1-2). Patients who received cancer treatments in the private sector were not included in the analysis (approximately 5–10% of patients treated in England).

Variables

Patient Characteristics

Five patient characteristics were included in the analysis of breast cancer and used to undertake key comparisons in the later analysis including age at diagnosis ($\geq$70 years old vs. $<$70), ethnicity (non-White vs. White), socioeconomic deprivation (IMD quintiles 3–5 vs. IMD quintiles 1–2), the presence of comorbidities (with vs. without), and rurality of residential areas (rural vs.urban vs. London). For patients with colorectal cancer, sex and site of tumour (colon vs. rectal) were also included.

Hospital Characteristics

We estimated the impact of five hospital characteristics that may make a hospital more attractive to patients and their general practitioner or secondary care physician when considering where to receive chemotherapy. These variables were informed by the peer-reviewed literature, and the study's Patient and Public Involvement group and its Steering Committee.

The five hospital characteristics include:

- *Treatment availability:* we identified 49 'comprehensive cancer centers' for breast cancer and 51 for colorectal cancer, defined as those hospitals that offer cancer surgery, radiotherapy and systemic therapies.
- *Specialist drug development and delivery units*: we identified 15 hospitals for breast cancer and 17 for

colorectal cancer, that participated in the Experimental Cancer Medicine Centres (ECMC) network. This network aims to benefit patients through the delivery of early-phase cancer studies.

- *Overall hospital performance rating*: we identified 9 hospitals for breast cancer and 10 for colorectal cancer, as providing 'inadequate care' according to the performance rating system of the UK Care Quality Commission (CQC) in 2016, which provides a composite metric for hospital quality and is published online.
- *Research activity*: we defined 20 'high-research activity' hospitals for breast cancer and 27 for colorectal cancer, using an established method [7] based on trial recruitment at each hospital per year to studies funded by the National Institute for Health Research in 2018/19.
- *Cancer waiting times*: we identified 95 hospitals for breast cancer and 127 for colorectal cancer, which met cancer waiting time targets (i.e., to start treatment within 31 days from the decision to treat date) between January 2016 and December 2018.

As a sensitivity analysis, an indicator for the 13 hospitals (10%) with the highest readmission rate in 2016 following SACT was added to the conditional logistic regression models for patients diagnosed with colorectal cancer between 2017 and 2018 using established methods (further detail in supplementary material) [18]. Readmission rate was not estimated for breast cancer due to the low case numbers at each hospital level.

Travel Time

The location of patient residence was represented by the population-weighted centroids of their LSOAs. Travel times from the patients' residence to the address of the hospital (according to their full postcodes) providing chemotherapy was estimated using a geographic information system (ArcGIS). Travel time by car was defined as the time (in minutes) of the fastest route according to the Ordnance Survey Master Map Highways Network.

Statistical Analyses

Bypassing Hospitals

Patients who were treated in another hospital than the one nearest to them were classified as 'bypassers'. The number of hospitals bypassed by these patients was calculated as well. We also determined the 'net gain' or 'net loss' of patients as the difference in the number of patients who were observed to be treated in a hospital minus the number of patients expected to be treated in that hospital if all patients had received their treatment at the nearest chemotherapy provider [19].

The Association of Travel Time, Hospital and Patient Characteristics with Treatment Location

We applied conditional logistic regression models, frequently used in econometric research to evaluate choice behaviour, to estimate the impact of travel time, hospital, and patient characteristics on where patients received chemotherapy [20,21]. We used all hospitals that delivered chemotherapy as the choice set and included in the model the additional travel time relative to the nearest hospital, grouped into four categories: 10 minutes or less, between 11 and 30 minutes, between 31 and 60 minutes, and 60 minutes or more. Patient characteristics were included in the model as interactions with travel time to investigate to what extent the associations with travel time were modified by patient characteristics. We obtained robust standard errors to take into account potential clustering around the 42 regional Sustainability and Transformation Plans (STPs) (now known as Integrated Care Systems), which are responsible for the coordination of services provided by the English NHS.

Multiple imputations using chained equations were applied to create ten complete datasets with imputated values for observations with missing data [22]. Regression estimates for each of the imputed datasets were combined using Rubin's rules.

Results

Descriptive Statistics on Patient Characteristics

We identified 2,364 women diagnosed during the 3-year study period with metastatic breast cancer who subsequently received chemotherapy within 4 months of their diagnosis (Appendix Figure 1). The mean age of this cohort was 60.3 years old (SD = 14.4) and 10.5% had at least one comorbidity recorded in the two years immediately before diagnosis (Table 1). 10,050 patients were diagnosed with metastatic colorectal cancer who started chemotherapy within 4 months (Appendix Figure 2). The mean age of this cohort was 63.4 years old (SD = 12.3), and 11.4% had at least one comorbidity (Table 1). We found that 104 hospitals provided chemotherapy for breast cancer and 139 for colorectal cancer.

Hospital Bypassing

541 of the 2,364 women with breast cancer (22.9%) and 2,809 of the 10,050 patients with colorectal cancer (28.0%) bypassed their nearest hospital providing chemotherapy (Appendix Table 1). For example, Figure 1 shows the area of residence for patients with colorectal cancer who had their systemic therapy at a hospital in the North East of England. This included patients who lived in this area as well as the patients that arrived from outside to receive their chemotherapy in hospitals in this area.

The net gain or net loss of patients for each hospital due to patient mobility is presented in Figure 2. Approximately ten hospitals were treating at least 50 fewer patients than expected if all patients had been treated at the hospital providing chemotherapy for colorectal cancer nearest to them. The net gain or loss of patients for breast cancer is presented in Appendix Figure 3.

Table 1
Descriptive statistics of patients diagnosed with metastatic breast or colorectal cancer between 2016 and 2018 who underwent chemotherapy within 4 months from the date of diagnosis

	Metastatic breast cancer		Metastatic colorectal cancer	
	n	%	n	%
Number of patients	2,364	100	10,050	100
Age at diagnosis in years (mean and SD)	60.34 (14.37)		63.41 (12.29)	
18-49	619	26.2	1,367	13.6
50-59	509	21.5	2,100	20.9
60-69	510	21.6	3,012	30.0
70-79	511	21.6	2,902	28.9
80+	215	9.1	669	6.7
Sex				
Male	-	-	5,976	59.5
Female	2,364	100	4,074	40.5
Ethnicity				
White	1,999	84.6	9,104	90.6
Asian	94	4.0	190	1.9
Black	86	3.6	189	1.9
Mixed	22	0.9	56	0.6
Other	67	2.8	172	1.7
Missing	96	4.1	339	3.4
Index of Multiple Deprivation (quintiles of national distribution)				
1st quintile (least deprived)	448	19.0	2,232	22.2
2nd quintile	504	21.3	2,345	23.3
3rd quintile	521	22.0	2,035	20.3
4th quintile	461	19.5	1,811	18.0
5th quintile (most deprived)	430	18.2	1,627	16.2
Number of comorbidities according to the RCS Charlson Score				
0	2,116	89.5	8,909	88.7
1	147	6.2	639	6.4
2 or more	101	4.3	502	5.0
Rural-urban classification				
Rural	516	21.8	2,255	22.4
Urban, outside London	1,511	63.9	6,677	66.4
London	337	14.3	1,118	11.1
Site of tumour				
Colon	-	-	7,336	73.0
Rectal	-	-	2,714	27.0
Comprehensive cancer centre	1,349	57.1	5,535	55.1
Breast cancer: 49 hospitals; Colorectal cancer: 51 hospitals				
Experimental cancer medicine centre	610	25.8	2,784	27.7
Breast cancer: 15 hospitals; Colorectal cancer: 17 hospitals				
Hospital meeting 31-day waiting time target	2,166	91.6	9,166	91.2
Breast cancer: 95 hospitals; Colorectal cancer: 127 hospitals				
Overall Care Quality Commission (CQC) hospital rating				
Outstanding	196	8.3	1,159	11.5
Breast cancer: 5 hospitals; Colorectal cancer: 10 hospitals				
Good	626	26.5	2,650	26.4
Breast cancer: 30 hospitals; Colorectal cancer: 35 hospitals				
Requires improvement	1,351	57.2	5,596	55.7
Breast cancer: 60 hospitals; Colorectal cancer: 84 hospitals				
Inadequate	191	8.1	645	6.4
Breast cancer: 9 hospitals; Colorectal cancer: 10 hospitals				
Hospital research activity				
1st to 4th quintiles (lower 80%)	1,762	74.5	6,914	68.8
Breast cancer: 84 hospitals; Colorectal cancer: 112 hospitals				
5th quintile (top 20%)	602	25.5	3,136	31.2
Breast cancer: 20 hospitals; Colorectal cancer: 27 hospitals				

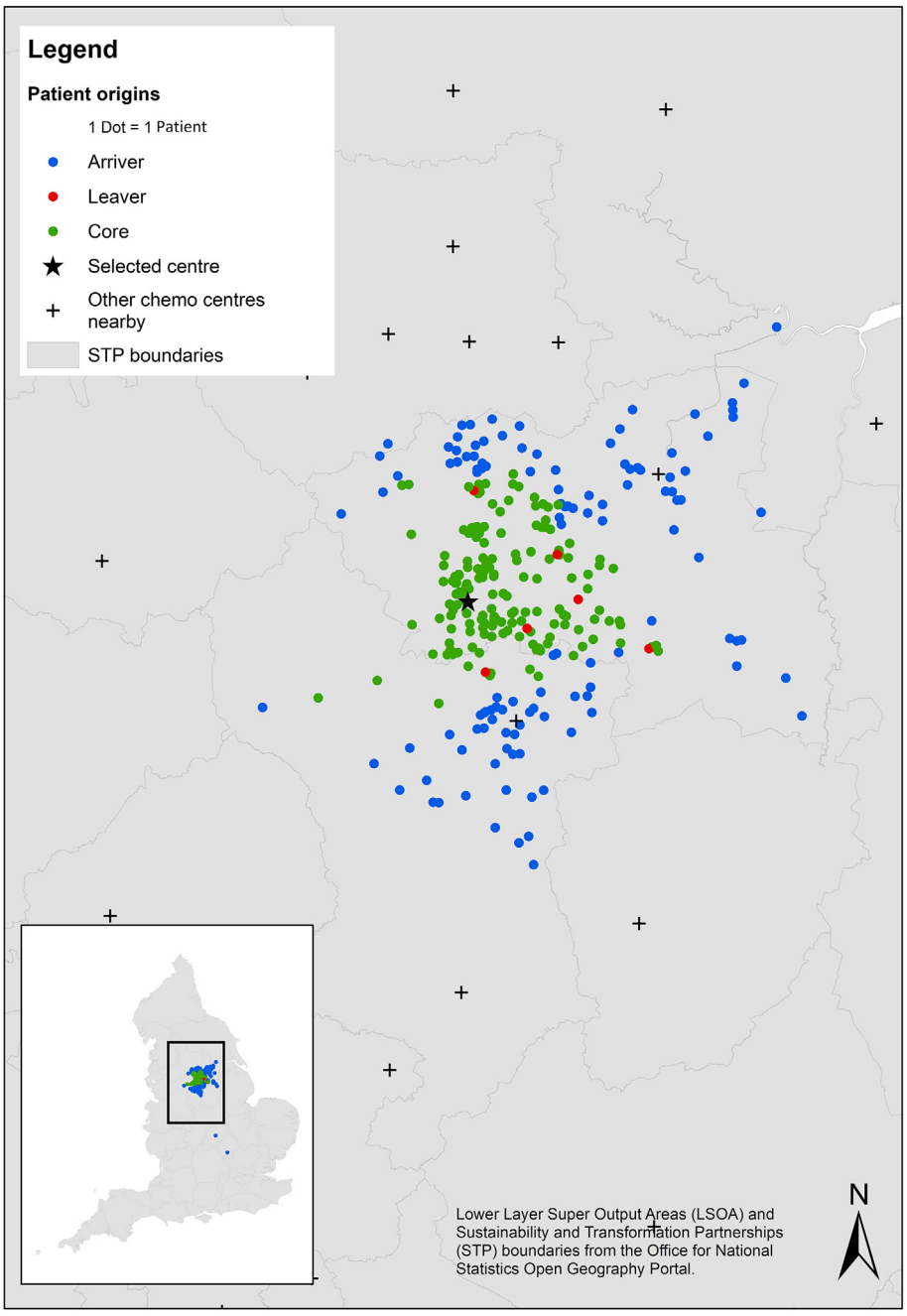

Fig 1. Mobility patterns of patients receiving systemic anticancer therapy for colorectal cancer at a selected hospital in England. Notes: Map of the North East Region of England (UK), illustrating the mobility patterns of patients who received systemic anticancer therapy for colorectal cancer at a selected NHS hospital (star symbol). The crosses represent other hospitals providing systemic anticancer therapy in the area and the coloured dots represent the residence of the individual patients. Patients treated at the selected hospital who travelled from an area where another hospital was nearer ('arrivers') are represented as blue dots. Patients from the hospital's local area (i.e., patients for whom this was their nearest hospital) are represented as green dots and patients who travelled to other hospitals for surgery are represented as red dots (leavers). The map includes a scaled magnification of the region inset and a national overview. Contains National Statistics and National Records of Scotland data (source: Northern Ireland Statistics and Research Agency) as well as Ordnance Survey data. ©Crown copyright and database right 2022.

Determinants of Treatment Location

In the multivariable analysis, overall patients were less likely to travel to hospitals that had a longer travel time, in keeping with the majority of patients receiving care at their nearest hospital ($p < 0.001$ for both cancers) (Table 2). Patients were more likely to travel to hospitals that provided comprehensive cancer services ($p = 0.001$ for colorectal cancer). Albeit not reaching statistical significance, there is also some evidence that patients were more likely to travel

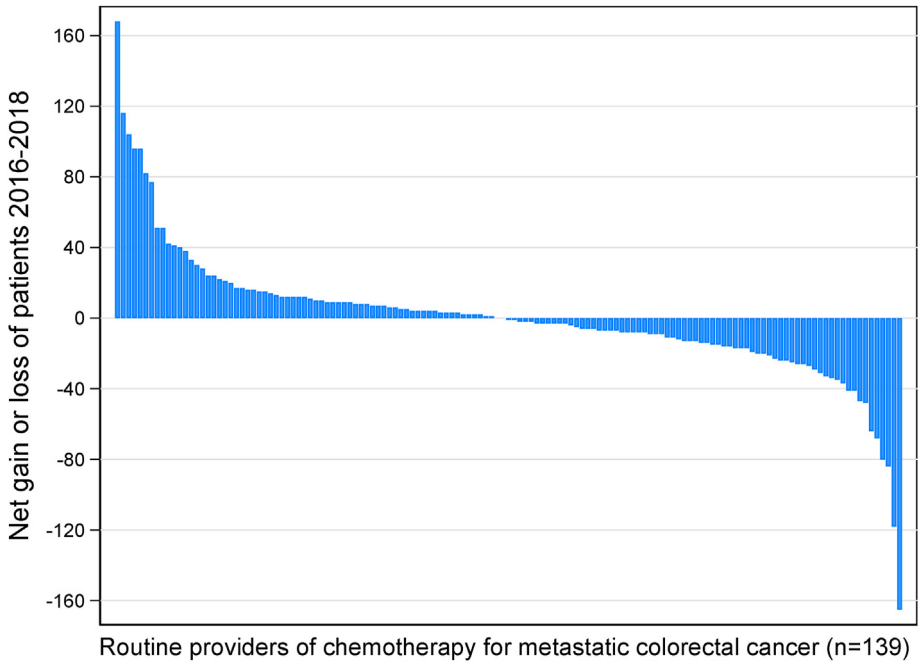

Fig 2. Net gain or loss of patients for hospitals routinely providing chemotherapy for metastatic colorectal cancer, 2016–2018.

to hospitals that participated in the ECMC network ($p = 0.074$ for breast cancer; $p = 0.067$ for colorectal cancer).

A sensitivity analysis with hospital-level post-chemotherapy readmission rates showed that patients diagnosed with colorectal cancer between 2017 and 2018, were less likely to receive SACT at the 13 hospitals identified as having the highest readmission rates (adjusted OR: 0.57; 95% CI: 0.33–0.99; $p = 0.046$) compared with other hospitals (Appendix Table 2).

Results of the models with patient characteristics demonstrate that the association of travel time and where a patient received SACT was significantly modified by patient age, both in patients with breast cancer and in patients with colorectal cancer (Table 3). Compared with patients below 70, patients aged 70 or above were even less likely to travel to other hospitals than the nearest hospital or a hospital with an additional travel of 10 minutes or less, (all ORs representing the interaction term for hospitals with an additional travel time of more than 10 minutes are smaller than 1; $p = 0.043$ for breast cancer; $p < 0.001$ for colorectal cancer). Compared with patients living in urban areas outside London, patients living in rural areas were more likely to travel to a hospital other than their nearest (ORs representing the interaction term are larger than 1; $p = 0.001$ for breast cancer; $p < 0.001$ for colorectal cancer). Again, compared with patients living in urban areas outside London, breast cancer patients living in London were less likely to travel to a hospital other than their nearest (ORs representing the interaction term are larger than 1; $p = 0.001$ for breast cancer). Finally, patients with rectal cancer seemed to show a greater willingness to travel than patients with colon cancer (some of ORs representing the interaction term, especially the one for hospitals with an additional travel time between 11 and 30 minutes, are larger than 1; $p = 0.002$).

Discussion

Our study demonstrates that approximately 1 in 4 patients with metastatic breast cancer and metastatic colorectal cancer receive their first-line SACT at a hospital other than their nearest SACT provider. Patients were more likely to travel to comprehensive cancer centres and designated Experimental Cancer Medicine Centres (ECMCs) although the latter association was not significant. For colorectal cancer, we also find that patients were less likely to receive treatment in hospitals with the highest rates of severe SACT toxicities. Finally, we did not find that the mobility of patients was associated with whether hospitals met the waiting time targets for SACT, the research activity of the hospitals or its overall quality rating score by the national care regulator.

From a policy and service delivery perspective, the finding that elderly patients were more likely to receive care at their nearest hospital than younger patients is important as SACT treatments especially Advanced Cell Therapy Medicinal Products (https://www.england.nhs.uk/commissioning/spec-services/advanced-therapy-medicinal-products/) are increasingly expected to be centralised to fewer selected centres. In addition, there is a variation in the availability of trials and therapies across NHS hospitals, and longer travel times to access these, may disproportionately act as a barrier to elderly patients [23,24]. This is important given the expected increase in the proportion of patients aged over 65 living in the UK [25], many of which will be susceptible to cancer, and that marginalised groups already face barriers to receiving high-quality care [26–28].

Second, we find that patients were more likely to receive treatment at comprehensive cancer centres and ECMCs. This is likely to reflect the better expertise and greater

Table 2
Adjusted association between travel time and hospital characteristics and choice of hospital for patients diagnosed with metastatic breast or colorectal cancer 2016–2018 who underwent chemotherapy within 4 months

	Metastatic breast cancer			Metastatic colorectal cancer		
	Adjusted OR[a]	95% CI[b]	*p* value	Adjusted OR[a]	95% CI[b]	*p* value
Association of additional travel time beyond the nearest hospital						
0 min (nearest hospital)	1			1		
1–10 mins	0.24	[0.19–0.32]	<0.001	0.25	[0.20–0.32]	<0.001
11–30 mins	0.02	[0.01–0.03]		0.02	[0.02–0.03]	
31–60 mins	0.00	[0.00–0.00]		0.00	[0.00–0.00]	
>60 mins	0.00	[0.00–0.00]		0.00	[0.00–0.00]	
Impact of hospital characteristics						
Comprehensive cancer centre	1.32	[0.80–2.18]	0.276	1.79	[1.11–2.89]	0.018
Experimental cancer medicine centre	1.77	[0.95–3.30]	0.074	2.07	[0.95–4.51]	0.067
Inadequate CQC hospital rating	0.87	[0.24–3.12]	0.828	0.90	[0.37–2.21]	0.824
High research activity hospital	1.09	[0.70–1.70]	0.708	1.06	[0.64–1.76]	0.822
Hospital meeting cancer waiting time target	0.70	[0.36–1.35]	0.290	0.53	[0.26–1.11]	0.094
Number of observations	245,856			1,396,950		
Pseudo R^2 (McFadden)	0.828			0.793		

[a] Odds ratio.
[b] 95% confidence interval accounting for clustering around Integrated Care Systems (ICS).

availability of oncology services (both treatment and ancillary services) at these hospitals. The likelihood for patients to travel to ECMCs (https://www.ecmcnetwork.org.uk/) for care may reflect the provision of trial options, the visibility of these centres in print and web media and the fact that these are often high-volume cancer units. Similar findings have been observed in a previous study [29].

Third, we find that patients with colorectal cancer were less likely to travel to hospitals with the highest rates of post-SACT toxicity. At present these indicators are not publicly reported, but our results suggest that patients may be responding to other aspects of quality or expertise in cancer management, or that information regarding toxicities and care is being disseminated through informal knowledge networks. The National Bowel Cancer Audit in the UK will be publishing centre-level toxicity rates of SACT observed 2 years after the cancer diagnosis routinely in 2024. As a consequence, it is important to repeat the analysis in the future to see to what extent this public reporting of hospital-level post-SACT toxicity is associated with patient mobility.

Fourth, we find that at present 104 hospitals routinely provide SACT for breast cancer chemotherapy and 139 for colorectal cancer. Due to patient mobility, we find that some SACT centres are delivering more or fewer SACT treatments than if all patients were treated in their nearest SACT centre. As well factors such as perceived quality of treatment this may also reflect the role of multimodal treatment with patients receiving radiotherapy or surgery as part of their palliative SACT regimen. Radiotherapy in particular tends to be centralised and therefore these mobility trends potentially map pathways of care.

However, given the move towards greater specialisation of SACT services in the immunotherapy era, and the need for adequate capacity including pharmacy, if hospitals are not using all available capacity, consideration should be given to consolidation of these services to fewer hospitals [30]. Alternatively, given current waiting lists, one can consider the regional allocation of patients to hospitals to ensure capacity is used effectively as has been suggested previously [31].

Our modelling of patient mobility does highlight conceptual and methodological challenges. In this paper, we have studied where patients had their treatment in relation to where they live and not actual patient choice. Decisions are made by patients together with their general practitioner or secondary care physicians in the context of pre-existing referral patterns. However, distinguishing between the preferences of the patients or the physicians who advise them is beyond the scope of this analysis and requires further qualitative investigation [32–34].

The study used centroids of small geographical areas, typically representing 650 households, to represent the location of the patients' residences. This could have masked variation in travel times which would have attenuated rather than enhanced the observed associations between travel time and patient mobility [21]. In addition, we only considered the patient's residential address and not that of their place of work or care givers.

In conclusion, we find that there is evidence that around one in four patients bypasses the nearest SACT provider. This is more likely for younger patients and those living in rural areas. There was no evidence of any disparities associated with socioeconomic deprivation, ethnicity or comorbidity. Patients were more likely to travel to hospitals that were comprehensive cancer centres or ECMCs for their care, which could relate to perceived quality, availability of a greater choice of trials, or referral patterns to hospitals in circumstances where patients require multimodal treatments. Hospitals losing patients from their catchment area to other hospitals may have additional capacity for treatment.

Table 3
Adjusted association between travel time, patient and hospital characteristics and choice of hospital for patients diagnosed with metastatic breast or colorectal cancer 2016–2018 who underwent chemotherapy within 4 months

	Metastatic breast cancer			Metastatic colorectal cancer		
	Adjusted OR[a]	95% CI[b]	*p* value	Adjusted OR[a]	95% CI[b]	*p* value
Association of additional travel time						
0 min (nearest hospital)	1			1		
1–10 mins	0.20	[0.13–0.29]	<0.001	0.24	[0.16–0.35]	<0.001
11–30 mins	0.02	[0.01–0.03]		0.02	[0.01–0.03]	
31–60 mins	0.00	[0.00–0.00]		0.00	[0.00–0.00]	
>60 mins	0.00	[0.00–0.00]		0.00	[0.00–0.00]	
Interaction between patient characteristics and travel time						
Age ≥ 70 (vs. age < 70)						
1–10 mins	1.05	[0.78–1.42]	0.043	1.01	[0.87–1.18]	<0.001
11–30 mins	0.70	[0.52–0.94]		0.88	[0.77–1.01]	
31–60 mins	0.20	[0.02–2.02]		0.58	[0.40–0.84]	
>60 mins	0.25	[0.05–1.30]		0.49	[0.31–0.79]	
Female (vs. male)						
1–10 mins				0.99	[0.87–1.12]	0.792
11–30 mins				0.96	[0.83–1.12]	
31–60 mins				1.24	[0.85–1.80]	
>60 mins				1.07	[0.69–1.66]	
Non-white ethnicity (vs. white ethnicity)						
1–10 mins	0.97	[0.72–1.29]	0.790	1	[0.76–1.32]	0.402
11–30 mins	1.21	[0.79–1.86]		1.11	[0.79–1.56]	
31–60 mins	1.66	[0.18–15.73]		0.53	[0.18–1.56]	
>60 mins	2.07	[0.25–16.90]		1.57	[0.54–4.56]	
Less deprived neighbourhoods (vs. more deprived neighbourhoods)						
1–10 mins	1.21	[0.94–1.55]	0.133	1.04	[0.81–1.33]	0.239
11–30 mins	1.16	[0.86–1.57]		1.17	[0.88–1.57]	
31–60 mins	1.13	[0.33–3.83]		0.68	[0.40–1.15]	
>60 mins	3.33	[1.11–10.03]		1.24	[0.76–2.04]	
Rural residents (vs. urban outside London)						
1–10 mins	2.70	[1.64–4.47]	0.001	1.85	[1.35–2.54]	<0.001
11–30 mins	1.83	[1.18–2.85]		1.99	[1.46–2.71]	
31–60 mins	2.66	[0.74–9.54]		2.70	[1.82–4.03]	
>60 mins	0.71	[0.14–3.49]		2.10	[1.31–3.38]	
London residents (vs. urban outside London)						
1–10 mins	0.71	[0.40–1.25]	<0.001	0.63	[0.36–1.09]	0.309
11–30 mins	0.65	[0.27–1.55]		0.68	[0.41–1.13]	
31–60 mins	0.00	[0.00–0.00]		0.78	[0.39–1.54]	
>60 mins	0.00	[0.00–0.00]		1.13	[0.54–2.37]	
With comorbidities (vs. without comorbidity)						
1–10 mins	1.53	[0.98–2.38]	0.239	0.98	[0.84–1.15]	0.972
11–30 mins	0.88	[0.43–1.80]		1.02	[0.77–1.34]	
31–60 mins	3.37	[0.54–21.04]		1.09	[0.58–2.06]	
>60 mins	1.44	[0.27–7.60]		0.79	[0.38–1.64]	
Rectal cancer (vs. colon cancer)						
1–10 mins				1.09	[0.97–1.21]	0.002
11–30 mins				1.34	[1.13–1.58]	
31–60 mins				1.29	[0.85–1.94]	
>60 mins				0.51	[0.28–0.95]	
Impact of hospital characteristics						
Comprehensive cancer centre	1.32	[0.81–2.15]	0.264	1.76	[1.10–2.82]	0.019
Experimental cancer medicine centre	1.86	[0.99–3.53]	0.056	2.14	[0.98–4.67]	0.057
Inadequate CQC hospital rating	0.90	[0.27–3.04]	0.866	0.92	[0.38–2.25]	0.860
High research activity hospital	1.08	[0.71–1.64]	0.720	1.07	[0.65–1.77]	0.791
Hospital meeting cancer waiting time target	0.65	[0.32–1.31]	0.231	0.52	[0.25–1.09]	0.084
Number of observations	245,856			1,396,950		

[a] Odds ratio.
[b] 95% confidence interval accounting for clustering around Integrated Care Systems (ICS).

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Author contributions

Guarantor of integrity of the entire study: AA and LH.
Study concepts and design: AA and JvdM.
Acquisition, analysis, or interpretation of data: AA, LH and JvdM.
Statistical analysis: LH and JvdM.
Manuscript preparation: AA and LH.
Manuscript editing: all co-authors.
Obtained funding: AA. Supervision: AA and JvdM.

Conflict of Interest

The authors declare no conflict of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clon.2024.06.050.

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