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Travel times to health care and survival from cancers in Northern England

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ABSTRACT

The aim was to assess the effect of geographical accessibility on the stage of cancer at diagnosis and survival. Records of 117,097 cases of breast, colorectal, lung, ovary and prostate cancer diagnosed in Northern England between 1994 and 2002 were supplemented with estimates of travel times to the patients' general practitioners (GPs) and hospitals attended, together with measures of access to public transport. Logistic regression and Cox proportional hazards models were used, adjusting for age, sex, whether the first hospital visited was a cancer centre and deprivation of area of residence. Late stage at diagnosis was associated with increasing travel time to GP for breast and colorectal cancers and risk of death was associated with travel time to GP for prostate cancer. Travel times to hospital and other accessibility measures showed no consistent associations with stage at diagnosis or survival, so travel to GP was the only influential factor.

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1. Introduction

The Calman-Hine Report advocated a redistribution of cancer services in England away from smaller hospitals and towards the larger centres, to improve the quality of patient care.[1] In the years following the implementation of the report, there has been some concern that the concentration of services in larger, generally urban, hospitals might disadvantage patients living in more distant, rural localities.[2] Some studies have suggested that people living further from health services are less likely to use them.[3,4] If the costs, time and inconvenience of travel cause cancer patients living remote from services to delay seeking medical advice, their tumours might be more advanced at the time of diagnosis and might have a poorer prognosis.

Survival from most cancers is improved when diagnosis is made and treatment commenced at an early stage of the disease.[5] Several previous studies undertaken in France, the US and Scotland have shown that cancer patients living remote from specialist centres present with later stage disease and have shorter survival than patients closer to cancer centres,[6–9] though others have not found such an association.[10] In Scotland, for example, Campbell and colleagues found that increasing distance from a cancer centre was associated with greater chance of the patient being recorded as a 'death certificate only' case for stomach, breast and colorectal cancers and poorer survival after diagnosis for prostate and lung cancers.[8]

No similar study has been reported for England, although transport disadvantage is known to exist in English rural areas. While over 90% of rural households own a car, one-third of adults do not have personal access to a vehicle. Out of the main towns public transport is infrequent and expensive. In sparsely populated rural areas 28% of the

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population are over 60 years of age and this proportion is increasing.[11]

Most previous studies have relied on straight line distance from the patient's home to the nearest appropriate hospital or urban centre as a measure of patient travel effort. This has several shortcomings. The road network, governed by topography and other constraints, rarely runs directly from point A to point B, average travel speeds may vary on different sections of the road network and public transport may be available on some routes but not others. Individual patients may not attend the nearest hospital. Geographical access to the patients' general practitioner (GP), who is the gatekeeper to hospital services in the UK, has rarely been considered.

This study is, we believe, the first investigation of the effects of geographical accessibility on survival from a number of common cancers in a large region of England. It uses a more sophisticated methodology than previously adopted to estimate car travel times to primary care and to the hospital of first referral and takes into account the availability of public and community transport. The aim was to assess the effect of geographical accessibility on the stage of cancer at diagnosis and on subsequent survival. This was made possible by adding estimates of geographical accessibility to cancer registry records.

2. Methods

2.1. Setting

The study was located in northern England, the area covered by the Northern and Yorkshire Cancer Registry & Information Service (NYCRIS). The population covered is around 6.7 million. The area is very diverse, both geographically and demographically, encompassing large rural tracts together with major urban areas.

2.2. Subjects

NYCRIS supplied anonymous records of patients registered with breast, colorectal, lung, ovarian and prostate cancer from 1994 to 2002. Age at diagnosis, sex, stage at diagnosis, hospitals attended, general practitioner (GP) and outcome were included. The sites of cancer were chosen because they provided large numbers for analysis and were sites for which earlier studies had suggested access to services may be important.[7,8] NYCRIS was formed in 1998 following a merger of two cancer registries. Due to issues of data completeness, only records from the former Yorkshire Registry area were used for the first four years of the study. Patients with atypical pathology types, males with breast cancer, breast ductal carcinoma in situ and death certificate only cases were omitted from analysis, as were those not resident in England.

2.3. Derivation of access and other measures

We added the estimated travel time from the patient's home to their GP and to the hospital of first referral and the distance to the closest cancer centre to each record. Distances to services and travel times by car were estimated using a geographical information system (GIS). Travel times were calculated from average car travel speeds assigned to each section of the road network dependent on road class, whether it ran through a rural or urban location, and whether the road was a dual or single carriageway. Although the method is unable to account for variations in individual journey times that may be associated with, for example, traffic volumes, unusual delays or adverse weather conditions, it has been shown to produce estimates of travel times that are closely related to patients' own recollections of actual journey times to hospital.[12]

We also determined the availability of public bus, rail and community transport. Bus timetables from the various operating companies serving northern England were used to identify sections of the rural road network with a bus service running at least every hour in the daytime from Monday to Saturday. The GIS software identified the patients who lived within 800 m, a generally acceptable walking distance, of these routes.[13] Urban areas were all counted as having an hourly bus service available. A list of areas containing community transport that could be used by cancer patients to get to hospital was collected for every relevant local authority.

Whether the patient lived in an urban or a rural ward[14] and the average deprivation of the area of residence were also added to the cancer register information. Deprivation was measured for the appropriate lower level census super output area using the overall Index of Multiple Deprivation 2004.[15] We used the total index minus the access to services domain contribution to avoid duplication of our own access measures.

2.4. Outcomes

The primary outcome measured was whether the patient was alive or dead on 31st March 2005, the last date before abstraction at which records were considered to be complete. For each patient the time (days) from diagnosis until death or 31st March 2005, whichever was sooner, was calculated.

A second analysis investigated the associations between geographical accessibility and late stage at diagnosis. Stage data were only available for 1.1% of the lung and 0.5% of the prostate patients, so only the breast, colorectal and ovary cancer records were used for this part of the study. Tumour stages were coded in categories from one (localised tumour) to four (with distant metastases). Patients with tumours categorised stage one or stage two were classified as *early* patients; those with tumours staged three or four were classified as *late*. Records with no stage information were treated as missing data.

2.5. Analysis

Each tumour site was analysed separately. For the survival analysis, Cox proportional hazards models were fitted. The predictors were age, gender, whether initial treatment was given at a cancer centre, area deprivation score and several measures of geographical accessibility. Bowel sub-site (colon and rectum) and specific lung pathology (small and non-small cell) were also included as covariates in the models. Estimated travel times to the hospital of first referral and to the patient's GP were included together in the first run of the model. Subsequent runs omitted the travel time variables

and substituted alternative accessibility measures in turn. For the analysis of late stage diagnoses, logistic regression models were fitted using the same predictors.

3. Results

Characteristics of patients in the analyses are summarised in Table 1. The majority of breast and colorectal patients were diagnosed with early stage disease, while most ovarian cancer patients had advanced cancer at the time of diagnosis. Survival was most favourable for breast cancer patients and worst for lung cancers. Stage information was generally not well recorded. The patients in our study lived an average of 17 min travel time (range 0.5–254 min) from the first hospital, and 7 min (range 0.5–48 min) from the GP surgery.

Table 2 gives the results from the Cox proportional hazards model, with hazard coefficients indicating the risk of death associated with a unit increase in each predictor. Table 2 shows that each increasing year of age was significantly associated with increasing risk of death for all cancer sites. There was a 1.5% increase with each year for lung cancer and a 7% increase per year for prostate cancer, for example. Male sex was detrimental for survival for colorectal and lung cancer. The deprivation level of the area of residence was consistently and significantly related to survival for all sites, with worst survival in more deprived areas. Colorectal patients with tumours in the colon, caecum or appendix had a higher risk of death than those with tumours in the rectum or rectosigmoid junction. Likewise, patients with either non-small or small cell lung cancers had a greater risk of death than patients with lung tumours that were not specifically coded as small cell or non-small cell. Being treated first at a cancer centre rather than at another hospital was significantly associated with better survival for all sites except prostate cancer. The access variables showed weaker and less consistent effects. Estimated travel time to the first hospital was significantly associated with the risk of death for cancers of the breast and lung, but in the opposite direction to that anticipated. In these cases, patients further from hospital had a better chance of survival. Prostate cancer patients living further from their GP had a worse chance of survival than those living closer (the rate was 0.4% increase in risk per minute of

Table 1 – Characteristics of patients in the study

	Breast	Colorectal	Lung	Ovary	Prostate
Total cases	28,002	28,256	34,923	5228	20,688
No. (%) of males	–	15,556 (55.1)	20,983 (60.1)	–	20,688 (100)
Mean age (SD)	62.37 (14.6)	71.43 (11.6)	70.86 (10.1)	64.33 (14.5)	73.44 (8.8)
No. (%) of early stage tumours	6177 (22.1)	11,055 (39.1)	–	128 (2.4)	–
No. (%) of late stage tumours	1154 (4.1)	7166 (25.4)	–	994 (19.0)	–
No. (%) of patients with no stage information	20,671 (73.8)	10,035 (35.5)	–	4107 (78.6)	–
Cases died on or before 31.3.05	8,722	17,543	33,018	3,465	10,318
No. (%) of males	–	9705 (55.3)	19,926 (60.3)	–	10,318 (100)
Mean age (SD)	69.66 (15.5)	73.61 (11.3)	71.15 (10.1)	68.39 (13.0)	76.49 (8.5)

Table 2 – Associations between risk of death and travel times to hospital and GP surgery, controlling for age at diagnosis, gender, deprivation, tumour site/type and type of hospital where first treated: proportional hazard ratios and 95% confidence intervals

	Breast	Colorectal	Lung	Ovary	Prostate
Age at diagnosis (years)	1.050** (1.048–1.051)	1.036** (1.035–1.038)	1.015** (1.013–1.016)	1.047** (1.044–1.050)	1.072** (1.069–1.075)
Male sex	N/A	1.112** (1.077–1.148)	1.107** (1.082–1.134)	N/A	N/A
Area deprivation	1.008** (1.007–1.009)	1.005** (1.004 – 1.006)	1.001** (1.000–1.002)	1.003** (1.001–1.005)	1.006** (1.005–1.007)
Tumour sited in colon, caecum or appendix	N/A	1.052** (1.019 – 1.087)	N/A	N/A	N/A
Non-small cell lung cancer	N/A	N/A	0.568** (0.553–0.583)	N/A	N/A
Small cell lung cancer	N/A	N/A	0.798** (0.770–0.827)	N/A	N/A
First treated at Cancer Centre	0.915** (0.872–0.961)	0.949** (0.915–0.985)	0.926** (0.903–0.950)	0.909* (0.838–0.987)	0.965 (0.919–1.014)
Travel time to first hospital (min)	0.995** (0.993–0.997)	1.000 (0.998–1.001)	0.998** (0.998–0.999)	0.999 (0.996–1.002)	0.999 (0.998–1.001)
Travel time to GP surgery (min)	1.002 (0.999–1.006)	1.002 (0.999–1.005)	0.999 (0.997–1.002)	0.999 (0.993–1.005)	1.004* (1.000–1.007)

* $p < 0.05$.
** $p < 0.01$.

Table 3 – Associations between risk of death and the secondary access variables, controlling for age at diagnosis, gender, deprivation, tumour site/type and type of hospital where first treated: proportional hazard ratios and 95% confidence intervals

	Breast	Colorectal	Lung	Ovary	Prostate
Straight line distance to nearest cancer centre (km)	0.998** (0.997–1.000)	1.000 (0.999–1.001)	1.001 (1.000–1.001)	1.000 (0.998–1.002)	1.003** (1.002–1.004)
Car journey to closest railway station (min)	1.002 (0.999–1.005)	1.002 (1.000–1.004)	0.999 (0.998–1.001)	1.005* (1.001–1.010)	1.001 (0.999–1.004)
Close to hourly bus service	0.958 (0.886–1.036)	0.999 (0.946–1.055)	0.970 (0.926–1.016)	0.939 (0.835–1.056)	0.898** (0.840–0.960)
Ward with community transport	1.030 (0.986–1.076)	0.978 (0.949–1.009)	1.047** (1.024–1.070)	1.000 (0.933–1.072)	1.026 (0.985–1.068)
Rural ward	1.016 (0.965–1.070)	1.019 (0.982–1.057)	0.995 (0.967–1.024)	0.975 (0.900–1.057)	1.062* (1.013–1.113)

* $p < 0.05$.
** $p < 0.01$.

travel), but coefficients for other sites were not significantly different from 1.00.

Replacing the travel time to hospital and GP variables with alternative access variables, and continuing to control for age, deprivation, site in bowel, lung pathology type, first hospital and sex, where appropriate, did not identify strong effects (Table 3). While prostate cancer patients who lived greater distances from the nearest cancer centre appeared to be at a disadvantage compared with those nearer, breast cancer patients appeared to be at a relative advantage. Measures of access to public transport and rurality were also not consistently associated with the risk of death.

Table 4 identifies the variables which were significant predictors of late stage disease at diagnosis for the three sites with staging information. Diagnosis at a late stage was significantly associated with patient age for all three, but while age increased the chances of late stage diagnosis for breast cancer and ovarian cancer, it was younger patients with colorectal cancer who tended to present with late stage disease. For patients suffering from cancer of the ovary, age was the only significant predictor, perhaps indicating a lack of power associated with low numbers (only 128 patients were diagnosed at an early stage). The other associations were consistent across breast and colorectal cancer patients. Being treated in a hospital that was not a cancer centre and living in an area with high deprivation were significantly related to late stage presentations. For colorectal cancer patients, male sex and a tumour in the colon, caecum or appendix were additional significant factors associated with late stage disease. Travel time to the hospital was not significantly related to stage of the disease at diagnosis, but patients with longer travel times to their GP had a significantly increased risk of being diagnosed at a late stage compared with patients with short journeys. The risk coefficients were 1.1% and 0.8% per minute of travel for breast and colorectal cancer patients, respectively. The coefficient for ovary cancer patients (0.7% per minute) was comparable in magnitude but not statistically significant.

Table 5 shows the results when travel times to hospital and GP were omitted from the analysis and alternative access variables were added, each time controlling for the other factors, as in Table 4. No consistent associations were observed across the three sites. Colorectal cancer patients who lived further from their nearest cancer centre were significantly more likely to be diagnosed at a late stage compared with those closer. For breast and colorectal cancers, the availability of community transport was associated with a reduced risk of late stage diagnosis. However, the associations with time to a railway station and rural location, for ovary and colorectal cancers, respectively, were in the opposite direction to that hypothesised.

Table 4 – Associations between late stage tumour at diagnosis and travel times to hospital and GP surgery, controlling for age at diagnosis, gender, tumour site, deprivation and type of hospital where first treated: proportional hazard ratios and 95% confidence intervals

	Breast	Colorectal	Ovary
Age at diagnosis (years)	1.049** (1.043–1.054)	0.991** (0.988–0.993)	1.026** (1.011–1.042)
Male sex	N/A	1.108** (1.039–1.181)	N/A
Area deprivation	1.018** (1.014–1.021)	1.004** (1.002–1.006)	0.998 (0.987–1.009)
Tumour sited in colon, caecum or appendix	N/A	1.130** (1.059–1.207)	N/A
First treated at Cancer Centre	0.661** (0.570–0.766)	0.925* (0.859–0.996)	0.793 (0.526–1.196)
Travel time to first hospital (min)	0.996 (0.991–1.002)	1.000 (0.997–1.003)	0.988 (0.975–1.001)
Travel time to GP surgery (min)	1.011* (1.000–1.022)	1.008** (1.003–1.013)	1.007 (0.975–1.041)

* $p < 0.05$.
** $p < 0.01$.

Table 5 – Associations between late stage tumour at diagnosis and the secondary access variables, controlling for age at diagnosis, gender, deprivation, tumour site and type of hospital where first treated: proportional hazard ratios and 95% confidence intervals

	Breast	Colorectal	Ovary
Straight line distance to nearest cancer centre (km)	1.001 (0.998–1.005)	1.003** (1.001–1.004)	1.002 (0.991–1.013)
Car journey to closest railway station (min)	1.002 (0.994–1.010)	1.000 (0.996–1.004)	0.972** (0.955–0.989)
Close to hourly bus service	1.038 (0.812–1.326)	1.040 (0.933–1.159)	1.164 (0.639–2.122)
Ward with community transport	0.738** (0.646–0.844)	0.836** (0.787–0.888)	1.046 (0.715–1.532)
Rural ward	0.967 (0.822–1.138)	0.919* (0.854–0.988)	0.773 (0.497–1.201)

* $p < 0.05$.
** $p < 0.01$.

4. Discussion

The principal new finding of this work is that geographical accessibility to primary care appears to be more important for early diagnosis and survival than access to hospital. We found that travel time to hospital was not a significant factor influencing stage at diagnosis, suggesting that patients, once advised of the possibility of a life threatening illness, make every effort to attend appointments. There was no indication either that long journeys to hospital were detrimental to survival, but we did find some evidence of an adverse influence of travel to the GP who acts as the gatekeeper to secondary care in the UK. For breast and colorectal patients, those living at a greater distance from their GP surgery were significantly more likely to present with late stage disease after controlling for patient age, sex and deprivation. The probability of late stage detection increased by about one percent for every minute of car travel time. Survival analysis indicated very slightly raised hazard ratios with each additional minute of travel time to the GP for breast and colorectal cancer patients, but these were not statistically significant and could have been due to chance. Prostate cancer patients living further from their GP were, however, significantly less likely to survive than those living closer. This study was unable to identify the precise link between travel time and outcome, but it may be, for example, that people with a long journey to their doctor were less likely to seek an appointment for signs and symptoms that did not appear urgent compared with people who lived closer.

Greater travel times to hospital were associated with better chances of survival for breast and lung cancers. This was contrary to what might have been expected, but was perhaps in line with another study in part of the same region which found some evidence that breast cancer patients living over 30 min car journey from their radiotherapy unit had significantly shorter delays before radiotherapy was commenced.[16]

A number of alternative measures of geographical accessibility were included. Straight line distance to the nearest cancer centre was investigated to permit comparison with the results of Campbell and colleagues in Scotland.[8] Like Campbell, we found associations between distance to the nearest centre and both survival and stage of diagnosis for some cancer sites. The apparent contradiction with the results for travel to hospital is explained by the relatively low proportion of patients in our study (26.17% overall) who actually attended a cancer centre as their first hospital. Those who attended another type of hospital (probably those who lived further from a cancer centre) may well have had slightly reduced chances of early detection and survival.

Associations with the other access measures were not consistent across cancer sites. A parallel survey of cancer patients attending clinics in various hospitals across the same study area found that 87% had travelled to hospital by car. Only 5% had used a bus, and less than 1% had used community transport or travelled by train,[12] so car travel times are more likely to influence patient behaviour than the availability of other means of transport.

Overall, the possible risks associated with travel time to primary care were small compared with the other variables controlled, which were age, sex and tumour location (where appropriate), whether or not the first hospital was a cancer centre, and deprivation. The strong and consistent associations observed between area deprivation, late stage diagnosis and survival are another contribution of this research, confirming some earlier studies.[17,18] Living in a deprived area was associated with worse survival for all the cancers studied, and analyses of breast and colorectal cancers demonstrated that diagnosis at a later stage could account for some of this effect.

Deprivation of the area of residence was used as a surrogate for individual measures of socio-economic disadvantage, which were not available. The ecological fallacy is a possible pitfall: we do not know that cancer patients living in deprived areas were themselves deprived. The observed positive association between distance to hospital and better survival might have been an artefact of imperfect control of the effects of deprivation or something similar, since inner city populations tend to be more deprived and closer to hospitals than suburban or rural populations in the UK.

There were other limitations in this study. Access to health services depends on a wider range of factors than those associated with transport, such as the local ratio of doctors to patients and the availability of appointments.[19] Furthermore, presentation with advanced disease does not always imply delay but can reflect the aggressive nature of some tumours.[20] We had no information on waiting times and other such barriers, so these issues were not investigated. Our analysis of the ovary cancer records was restricted by low numbers, and the absence of reliable staging information for lung and prostate cancers meant that questions relating to the stage of disease at diagnosis could be followed up only for breast,

colorectal and ovary cancer patients. No information was available regarding patient co-morbidity, ethnicity or tumour grade. We were also not able to distinguish cancer-specific deaths, so the survival analysis could not avoid including some deaths due to other causes. These shortcomings are not unusual in studies of this type and are difficult to avoid.

This study has used more direct measures of patient travel effort than previous work and has investigated the potential effects of access to primary care as well as to hospital services. We found no evidence of detrimental effects of long car journeys to hospital on cancer survival in Northern England. This provides some reassurance that access to hospital cancer services is not seriously affected by transport difficulties in rural areas. There was some evidence of longer car journeys to GP surgeries being associated with detection of breast and colorectal cancer at a late stage and poorer survival from prostate cancer, so access to primary care might be an influential factor. The mechanisms which might explain why difficulties in travel to primary care are linked to outcome require further investigation.

Conflict of interest statement

None declared.

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