Title: Geographical access to general practitioners and modes of cancer diagnosis in England: a cross-sectional study

Running title: - Geographical access and routes to diagnosis

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Key messages

- Poor access to GPs may influence the route to a cancer diagnosis
- Longer travel to a GP increased the risk of diagnosis via less desirable routes
- Longer travel to a GP reduced the risk of diagnosis via more desirable routes

Abstract

Background

Poor geographical access to health services and routes to a cancer diagnosis such as emergency presentations have previously been associated with worse cancer outcomes. However, the extent to which access to general practitioners (GPs) determines the route that patients take to obtain a cancer diagnosis is unknown.

Methods

We used a linked dataset of cancer registry and hospital records of patients with a cancer diagnosis between 2006 and 2010 across eight different cancer sites. Primary outcomes were defined as 'desirable routes to diagnosis' (screen-detected and two week wait (TWW) referrals), and 'less desirable routes' (emergency presentations and death certificate only (DCO)). All other routes (GP Referral, Inpatient Elective and Other Outpatient) were specified as the reference category. Geographical access was measured as travel time in minutes from patients to their GP, and multinomial logistic regression was used to estimate Relative Risk Ratios (RRR).

Results

Longer travel was associated with increased risk of diagnosis via emergency and DCO, but decreased risk of diagnosis via screening and TWW. Patients travelling over 30 minutes had the highest risk of a DCO diagnosis, which was statistically significant for breast, colorectal, lung, prostate, stomach and ovarian cancers (compared to patients with travel times $\leq$ 10 minutes: RRR 5.89, 7.02, 2.30, 4.75, 10.41; $p<0.01$ and 3.51, $p<0.05$).

Discussion

Poor access to general practitioners may discourage early engagement with health services, decreasing the likelihood of screening uptake, and increasing the likelihood of emergency presentations. Extra effort is needed to promote early diagnosis in more distant patients.

Keywords: Early diagnosis, emergency admissions, health services accessibility, primary health care, screening

Introduction

Identifying the pathways that lead to a cancer diagnosis is an important approach to improving access to care and consequent health outcomes such as survival. This is because the route that a patient takes to obtain a cancer diagnosis has been shown to predict survival (1,2). Routes such as emergency presentations are associated with poorer

survival (2), whereas tumours detected via screening programmes generally have better outcomes (3,4). There is also evidence associating increases in the use of two week wait (TWW) referrals by general practitioners (GPs) with better cancer survival (5).

In addition to the potential effects on survival, there are likely cost-effectiveness benefits or losses associated with specific diagnostic routes. Emergency presentations represent approximately 65% of all hospital bed-days in England, incurring heavy costs and causing significant disruption to planned inpatient admissions (6). They also account for an estimated 24% of all cancer diagnoses in England, ranging from around 5% in breast cancer to 62% in cancers of the central nervous system (1). Two specific diagnostic routes have been credited with the reduction of emergency admissions; diagnosis following screening for certain cancers, and TWW referrals from GPs. The former increases the chances of cancer detection at the earliest stage whilst the latter helps ensure that patients with expedited GP referrals are seen by a specialist within a two-week window. The decline in emergency presentations England for lung cancer from 39% in 2006 to 35% in 2013 may be due to increases in TWW referrals from 22% to 28% in the same period (7). Similarly, the 3% drop in colorectal cancer emergency presentations may be explained by corresponding 4% and 10% increases in TWW referrals and screen detected diagnosis (8).

Preventing avoidable emergency admissions and other less desirable routes to diagnosis requires an understanding of factors that determine diagnostic routes. Some emergency admissions are unavoidable as they may result from aggressive tumours that require

sudden critical attention; these do not necessarily indicate failure of earlier diagnosis (9,10). However, many emergency admissions are potentially avoidable and are likely related to a combination of factors that operate at patient and health services levels. Patient level factors such as being elderly, female, ethnic minority and deprived have been associated with higher risk of emergency admissions (9,11). Health system level factors such as difficulties in obtaining GP appointments are also associated with increase in emergency visits (12,13). Geographical access to services may also determine how a cancer diagnosis is obtained. Two previous studies showed an association between poor access to hospital, screening sites and reduced participation in screening programmes (14,15). Another study found that hospital inaccessibility increased the odds of a post-mortem cancer diagnosis (16).

There is limited evidence showing the relationship between access to the GP and prompt diagnosis. Previous work has shown that primary care inaccessibility impinges on GP consultation rates (17), suggesting that poor access may determine how a cancer diagnosis is attained; by lowering the likelihood of patients to engage with early diagnosis services, or by influencing GPs decision to refer patients to secondary care for diagnosis (17,18).

This is the first study to use individual patient level data to comprehensively examine and compare how travelling time to a GP is associated with the routes that patients take for a cancer diagnosis. We hypothesise that poor access will increase the likelihood of

obtaining a diagnosis from less desirable routes (emergency presentations and DCO), but will increase the likelihood of obtaining a diagnosis from routes of better prognosis (screen-detected and TWW). It is hoped the findings will support early diagnosis efforts, by showing how the prospect of longer travel determines how patients' engage with services for a cancer diagnosis, or GPs decisions to make onward referrals to secondary care.

Methods

The analysis uses cancer registry records of cases diagnosed between 2006 and 2010 in England. Eight cancer sites were examined; breast (International Classification of Disease (ICD)-10 code C50), brain (C71), cervical (C53), colorectal (C18- C20), lung (C33-34), ovarian (C56-57), prostate (C61) and stomach (C16). These were selected to include rare and common tumours, those that are amenable to screening, and tumours with varying degrees of diagnostic difficulty (19). Each record contained information on the route that the patient would have taken prior to obtaining a diagnosis. This was obtained by linking data from routine datasets to provide details on interactions between the patient and health services before the diagnosis (1,20).

Record level data were retrieved from English cancer registries, and linked with Hospital Episodes Statistics (HES) inpatient and outpatient records, the National Cancer Waiting Times (NCWT) monitoring dataset, and the NHS Breast Screening Programme data. Screening information for cervical cancer was obtained from screening status held by

cancer registries. Up to 71 distinct route combinations were identified by categorising contacts between the patient and health services according to the setting of diagnosis, the presence of inpatient and outpatient status, and the referral route (1). These were aggregated to give the following seven broad routes; screen-detected, TWW, GP Referral, Inpatient Elective, Other Outpatient, Emergency Presentations, DCO and Unknown. Public Health England (PHE) has produced a detailed description of the data linkage and methods (1,20).

Information on routes to diagnosis, age, gender, deprivation and the Charlson Comorbidity Index (21) was retrieved from this linked dataset. Further linkages were made with estimated travel time in minutes from the patients' home to their GP of registration. These travel times were computed using the Spatial Analyst module of the Geographical Information System (GIS) software (ArcGIS 10.3, Esri Inc.). Road travel time was selected as the most appropriate measure of accessibility because over 87% of cancer patients travel to hospital by motor vehicle (22).

The outcome variable was coded into five categories: the two less desirable routes to diagnosis, 'emergency presentations' and 'DCO'; the two routes associated with good prognosis, 'TWW' and 'screen-detected'; and 'all other routes', which included routes such as 'inpatient elective', 'other outpatients' and 'non-urgent GP referrals'. Patients with unknown routes and with secondary tumours were excluded from the analysis.

Data were analysed using Stata Version 13 (23). For the primary analysis, estimated travel times were grouped into four categories; '<10 minutes', '≥10-20 minutes', '>20-30 minutes' and '>30 minutes'. Multinomial logistic regression was used to simultaneously estimate the association between travel time and each primary outcome relative to the reference group which was set as 'all other routes'. The models were adjusted for potentially confounding variables deemed to be associated with travel times and the outcomes: age, deprivation, comorbidity, and gender (where applicable). Relative risk ratios (RRRs) and 95% confidence intervals (CI) were computed for all models.

In a sensitivity analysis to test for trend, travel times were modelled as a continuous variable, and a relative risk ratio of each outcome relative to the reference group was calculated for every ten minutes increase in travel time.

Results

We identified 737,495 unique records with a primary diagnosis of the specified cancers in England diagnosed between 2006 and 2010 (Table 1). An estimated 88% of the population had access to their GPs within an estimated 10-minute drive (Table 1). Those with the poorest access (over 30 minutes) comprised of just 0.7% of the population. Routes to diagnosis varied considerably by tumour type. For example, breast cancer had the lowest percentage of emergency presentations and brain cancer had the highest; 4.5% and 63% respectively. Lung cancer had the highest percentage of DCOs with 0.5% being diagnosed post mortem (Table 1).

Longer travel was associated with increased likelihood of both emergency presentations (Table 2) and DCO routes (Table 3). The relative risk ratios progressively increased from the lowest travel time category to the highest. For example, for colorectal cancer, increases in travel time from $\leq$10.0 minutes to 10.1-20.0, 20.1-30.0 and >30.0 minutes, were independently associated with increased relative risk ratios of emergency diagnosis, relative to the reference category, of RRR 1.01, p=0.62, RRR 1.22, p<0.01, and RRR 1.39, p<0.01, respectively (Table 2).

The relative risk ratios were highest when the outcome was DCO. For example, among stomach cancer patients, an increase in travel time from 10 minutes or less to over 30 minutes led to a tenfold increase in likelihood of having a DCO diagnosis (RRR 10.41, p<0.01) (Table 3). Corresponding findings were a sevenfold (RRR 7.02, p<0.01), and a sixfold (RRR 5.89, p<0.01) elevated risk for colorectal and breast cancer patients respectively (Table 3). The RRRs for cervical cancer when the outcome was DCO could not be estimated due to small numbers.

In contrast to the above findings, longer travel time was associated with a lower risk of obtaining a diagnosis following a two week wait referral. The relative risk ratios progressively decreased from the lowest travel category to the highest (Table 4). The associations were statistically significant for breast, colorectal, lung, prostate and ovarian cancers; for those travelling over 30 minutes, the relative risk of diagnosis via TWW for

these sites were: RRR 0.64, 0.72, 0.74, 0.77, ($p<0.01$) and RRR 0.63 ($p=0.03$), respectively compared to those with under 10 minutes of travel (Table 4). Longer travel was also associated with lower odds of diagnosis via screening for breast and colorectal cancer, (RRR 0.52 and RRR 0.36 ($p<0.01$), respectively) (Table 5).

The patterns above also persisted when travel times were modelled as a continuous variable to test for trend (Supplementary Table S1). Taking the example of breast cancer, every ten minutes increase in travel time was associated with an increase in diagnosis via the emergency route of RRR 1.03, $p<0.01$, and DCO routes RRR 1.38, $p<0.01$ and a decline in diagnosis via Two Week Wait referrals RRR 0.95, $p<0.01$ and screening RRR 0.97, $p=0.01$ (Supplementary Table S1).

Discussion

This study provides new evidence of how access to GPs in England is associated with the routes that lead to a cancer diagnosis. Earlier diagnosis is recognised as an important approach to improving cancer survival (24), and the role of GPs is central because most cancer patients will present their symptoms to primary care (25). Across the eight cancer sites studied, longer travel to the patients GP significantly increased the likelihood of having a cancer diagnosis through less desirable routes such as emergency or post mortem diagnosis. Conversely, longer travel significantly decreased the likelihood of obtaining a diagnosis following routes that are associated with good prognosis such as screening or two week wait.

These findings may support the work of the National Awareness and Early Diagnosis Initiative (NAEDI) on achieving earlier presentation (26). Efforts to improve earlier diagnosis should take consideration of geographical accessibility; GPs should be vigilant of accessibility issues that some of their patients face, as they may determine receipt of earlier diagnosis.

This study responds to requests for evidence to establish the role of access in explaining variations in the mode of diagnosis (27,28). We believe it is the first study to simultaneously investigate four different routes to diagnosis and their association with geographical access to GPs. Previous studies have focused on access to hospital or screening sites or have examined single routes to diagnosis (13–15). One study found longer travel times to hospital increased the odds of post mortem diagnosis (16). Two previous studies showed that poor access to hospital and screening sites was associated with low participation in breast cancer screening programmes (14,15). Both studies used a smaller regional population, and so it is likely that their sample was homogenous. They both also estimated geographical access using road distance rather than travel time; the latter is a better measure because it is closest to what is experienced by patients in reality (29).

Our results suggest that travel to the GP may be an important factor of how patients' engage with all health services, and not just the services offered in primary care. This is

because the impact of longer travel was evident in the uptake of services such as colorectal and breast cancer screening that are not offered by GPs. Poor access to GPs may also be an indication of disconnection from primary care such as failure to register with a GP after relocation. Prolonged disengagement with primary care compounded by poor accessibility, reduces the likelihood of seeking healthcare, or of reporting symptoms that may be related to cancer. Although only 0.7 percent of our sample travelled longer than 30 minutes to see their GP, the poor outcomes amongst these patients is concerning. The magnitude of apparent effect for risk of diagnosis at death is particularly alarming; tenfold in stomach cancer (RRR 10.41, $p<0.01$), sevenfold in colorectal cancer (RRR 7.02, $p<0.01$), sixfold in breast cancer (RRR 5.89, $p<0.01$) and almost fivefold in prostate cancer (RRR 4.75, $p<0.01$).

It is likely that the prospect of longer travel influences how patients interact with primary care for a cancer diagnosis. Geographical inaccessibility may discourage engagement with health services, which may decrease the likelihood of health seeking behaviour such as participation in screening. Poor access may also reduce the likelihood of reporting symptoms that may be related to cancer (30), which may consequently increasing emergency presentations or post mortem diagnosis. It is also likely that inaccessibility may influence GPs decisions to refer for further investigation; previous work has shown that distance to hospital may be one of the things GPs consider when making referrals (17,18). Conversely, it is plausible that when GPs do make urgent referrals, patients delay attending appointments due to barriers in access.

This study as several strengths. The use of a national dataset provided sufficient statistical power and adequate variation of explanatory variables, which enabled control for covariates. The large dataset also enabled comparisons across cancer sites that may vary in rarity and ease of detection. This also made it possible to undertake stratified analysis to investigate how variation in access to early diagnosis differs by cancer type. The linking of routine datasets made it possible to examine the four different routes in parallel, comparing routes associated with good and poor outcomes. Lastly, the inclusion of all cases registered in England over five years enhances generalisability.

There are some limitations to the study. Firstly, it is a cross-sectional study hence the direction of causality cannot be inferred. However, it is implausible that routes to diagnosis would have influenced place of residence. Secondly, our measure of geographical access (travel time) is estimated and may not necessarily represent the actual journey time that each patients takes, although previous work suggests that estimated travel times closely match actual journeys (22). We did not consider other forms of transport such as public transport, but these are infrequently used for health service appointments, (22). Lastly, cervical screening findings should be interpreted with caution because this data may be of poorer quality due to variations in reporting screen detected records (20).

The most recent strategy on cancer has identified earlier diagnosis and narrowing inequalities as key mechanisms to improving cancer survival rates in England (31). The strategy has also issued a call for evaluating the impact of cancer outcomes on patients living different distances from a cancer centre (31). Our findings indicate that this evaluation should be extended to primary care. The gatekeeping role of GPs means they control non-emergency access to other services and therefore it is likely that issues in access observed in secondary care may originate from poor primary care access (32,33). We found that an estimated 0.7% patients experiencing the highest odds of delayed diagnosis are more likely to live over 30 minutes from their GP, which represents approximately 2,100 annual cases of all cancers diagnosed in England; based on the Cancer Research UK statistics of annual cancer cases in UK countries in 2015 (34). Targeted action on improving access amongst these patients may help meet the goals to reduce cancer mortality and narrow inequalities; poor access is disproportionally felt by those who are either elderly, have a disability or a chronic condition that renders them unable to drive, or are too deprived to be able to afford a car (32,35). Supporting these groups of patients to engage with the health services may include use of telephone consultations or other aspects of telehealth that have been successfully implemented in geographically isolated patients (36–38).

Recent developments in early diagnosis awareness following the auspices of the National Awareness and Early Diagnosis Initiative (NAEDI) may have measurable impact on patients' access to primary care for diagnosis. The dataset used in this study pre-dates

NAEDI's work and therefore is an appropriate baseline against which progress on access to early diagnosis can be measured in future studies. Future research should examine the underlying mechanisms that may explain the association between longer travel and outcomes. Further research should also examine rural urban differences in routes to diagnosis, and the extent of travel time moderation on rural and urban outcomes. Rural areas have poorer geographical access to services (39), but this does not necessarily translate to higher emergency department visits (13,40), suggesting that rurality may be a distinct variable that measures a different parameter to travel time. This needs to be tested empirically.

Ethics

Institutional ethics approval was obtained from the University of East Anglia's University Ethics Committee (reference # 2014/2015 07)

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Disclosures

No conflict of interest

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Table 1 - Characteristics of the study cohort; patients with a cancer diagnosis between 2006 and 2010 in England across eight cancer sites. The table gives a summary by cancer site, exposure, predictor and confounding variables.

			Number of cases (% percentage)							
		All cancers No. (%)	Breast No. (%)	Colorectal No. (%)	Cervical No. (%)	Lung No. (%)	Prostate No. (%)	Stomach No. (%)	Ovarian No. (%)	Brain No. (%)
Age groups	Under 59 years	183,394 (24.9)	80,872 (44.4)	26,366 (17.8)	8,594 (74.1)	24,053 (15.3)	20,745 (12.9)	4,501 (15.1)	10,088 (36.8)	8,175 (45.3)
	60 - 69 years	199,941 (27.1)	45,380 (24.9)	38,967 (26.0)	1,094 (9.4)	42,794 (27.1)	54,272 (33.8)	6,260 (20.9)	6,897 (25.1)	4,277 (23.7)
	70 - 79 years	212,077 (28.7)	30,037 (16.5)	48,086 (32.1)	1,034 (8.9)	54,713 (34.7)	57,982 (36.1)	10,469 (35.0)	6,076 (22.2)	3,680 (20.4)
	80 years plus	142,083 (19.3)	25,745 (14.1)	36,635 (24.4)	877 (7.6)	36,213 (23.0)	27,669 (17.2)	8,668 (29.0)	4,374 (15.9)	1,902 (10.6)
Gender	Male	363,018 (49.2)	1,366 (0.8)	83,363 (55.6)	11,599 (100.0)	89,162 (56.5)	160,668	19,440 (65.0)	27,435 (100.0)	10,385 (57.6)
	Female	374,477 (50.8)	182,034 (99.2)	66,691 (44.4)		68,611 (43.5)	(100.0)	10,458 (35.0)		7,649 (42.4)
Travel time in minutes to the GP *	<= 10	650,283 (88.2)	159,910 (87.9)	132,383 (88.2)	10,276 (88.6)	141,112 (89.4)	140,337 (87.4)	26,743 (89.5)	24,063 (87.7)	15,459 (85.7)
	10.1 – 20	73,778 (10.0)	18,782 (10.3)	15,003 (10.0)	1,105 (9.5)	14,016 (8.9)	17,385 (10.8)	2,675 (9.0)	2,786 (10.2)	2,026 (11.2)
	20.1 – 30	8,639 (1.2)	2,167 (1.2)	1,705 (1.1)	126 (1.1)	1,626 (1.0)	2,010 (1.3)	317 (1.1)	365 (1.3)	323 (1.8)
	Over 30	4,795 (0.6)	1,175 (0.7)	963 (0.6)	92 (0.8)	1,019 (0.7)	936 (0.6)	163 (0.6)	221 (0.8)	226 (1.3)
Deprivation quintile	1 least deprived	146,123 (19.8)	40,263 (22.1)	30,754 (20.5)	1,728 (14.9)	21,328 (13.5)	37,743 (23.5)	4,805 (16.1)	5,571 (20.3)	3,931 (21.8)
	2	158,288 (21.4)	41,430 (22.8)	33,103 (22.1)	2,006 (17.3)	27,546 (17.5)	38,355 (23.9)	5,770 (19.3)	5,993 (21.8)	4,085 (22.7)
	3	154,219 (20.9)	38,620 (21.2)	32,021 (21.3)	2,254 (19.4)	31,853 (20.2)	33,692 (21.0)	6,093 (20.4)	5,928 (21.6)	3,758 (20.8)
	4	144,981 (19.7)	33,895 (18.6)	29,177 (19.4)	2,575 (22.2)	35,766 (22.7)	28,329 (17.6)	6,475 (21.7)	5,411 (19.7)	3,353 (18.6)
	5 most deprived	133,884 (18.2)	27,826 (15.3)	24,999 (16.7)	3,036 (26.2)	41,280 (26.2)	22,549 (14.0)	6,755 (22.6)	4,532 (16.5)	2,907 (16.1)
Comorbidities	0 comorbidity	624,769 (84.7)	164,919 (90.6)	125,664 (83.8)	10,706 (92.3)	122,784 (77.8)	136,301 (84.8)	23,980 (80.2)	24,433 (89.1)	15,982 (88.6)
	1-2 comorbidities	96,068 (13.0)	15,230 (8.4)	20,636 (13.8)	792 (6.8)	29,154 (18.5)	20,920 (13.0)	4,911 (16.4)	2,645 (9.6)	1,780 (9.9)
	3+ comorbidities	16,658 (2.3)	1,885 (1.0)	3,754 (2.5)	101 (0.9)	5,835 (3.7)	3,447 (2.2)	1,007 (3.4)	357 (1.3)	272 (1.5)
Routes to diagnosis **	Screen detected	61,148 (8.3)	50,843 (27.9)	7,445 (5.0)	2,860 (24.6)					
	Two week wait	217,495 (29.5)	77,541 (42.6)	40,307 (26.8)	1,933 (16.7)	37,780 (24.0)	46,275 (28.8)	6,958 (23.3)	6,520 (23.8)	181 (1.0)
	Emergency	148,237 (20.1)	8,093 (4.5)	36,553 (24.4)	1,288 (11.1)	58,825 (37.3)	14,418 (9.0)	9,511 (31.8)	8,288 (30.2)	11,261 (62.5)
	DCO	2,324 (0.3)	408 (0.2)	496 (0.3)	11 (0.1)	837 (0.5)	270 (0.2)	125 (0.4)	121 (0.4)	56 (0.3)
	Unknown	25,889 (3.5)	7,322 (4.0)	4,815 (3.2)	414 (3.6)	3,744 (2.4)	7,219 (4.5)	831 (2.8)	1031 (3.8)	513 (2.8)
	All other routes	282,402 (38.3)	37,827 (20.8)	60,438 (40.3)	5.093 (43.9)	56,587 (35.9)	92,486 (57.6)	12,473 (41.7)	11,475 (41.8)	6,023 (33.4)

** For brevity, only 4 routes to diagnosis are shown in this table. To determine the associations between routes and travel times, the four routes were individually compared to the rest of routes including 'all other routes'.

Table 2 – Association between travel times (categorical) to the GP and cases diagnosed via emergency presentations, for breast, colorectal, cervical, lung, prostate, stomach, ovarian and brain cancer between 2006 and 2010. Models adjusted for age, gender (where applicable), deprivation and comorbidity. Results are reported as relative risk ratios (95% CI), p-value, in comparison to the reference category (<=10 minutes).

	Travel times (minutes)			
	<=10	**10.1 – 20**	**20.1 – 30**	**Over 30**
Breast	1	1.18 (1.09-1.28), p<0.01	1.45 (1.18-1.79), p<0.01	1.24 (0.94-1.62), p=0.13
Colorectal	1	1.01 (0.97-1.06), p=0.62	1.22 (1.08-1.37), p<0.01	1.39 (1.19-1.62), p<0.01
Cervical	1	1.14 (0.91-1.42), p=0.26	1.69 (0.96-2.96), p=0.07	0.70 (0.30-1.63), p=0.41
Lung	1	1.09 (1.05-1.14), p<0.01	1.13 (1.01-1.27), p=0.04	1.03 (0.89-1.19), p=0.73
Prostate	1	1.01 (0.95-1.08), p=0.71	1.24 (1.05-1.45), p=0.01	1.68 (1.36-2.07), p<0.01
Stomach	1	1.06 (0.96-1.16), p=0.27	1.31 (1.01-1.72), p=0.05	1.14 (0.78-1.67), p=0.51
Ovarian	1	1.01 (0.91-1.11), p=0.90	1.17 (0.92-1.50), p=0.21	1.44 (1.05-1.98), p=0.03
Brain	1	1.07 (0.97-1.18), p=0.20	1.07 (0.84-1.36), p=0.60	1.07 (0.80-1.44), p=0.64

Table 3 – Association between travel times (categorical) to the GP and cases diagnosed via Death Certificate Only route, for breast, colorectal, cervical, lung, prostate, stomach, ovarian and brain cancer between 2006 and 2010. Models adjusted for age, gender (where applicable), deprivation and comorbidity. Results are reported as relative risk ratios (95% CI), p-value, in comparison to the reference category (<=10 minutes).

	Travel times (minutes)			
	<= 10	**10.1 – 20**	**20.1 – 30**	**Over 30**
Breast	1	1.95 (1.46-2.60), p<0.01	4.98 (3.07-8.09), p<0.01	5.89 (3.45-10.05), p<0.01
Colorectal	1	1.36 (1.02-1.80), p=0.03	1.90 (0.97-3.71), p=0.06	7.02 (4.33-11.37), p<0.01
Cervical		n/a	n/a	n/a
Lung	1	1.21 (0.96-1.53), p=0.11	2.78 (1.76-4.38), p<0.01	2.30 (1.28-4.11), p<0.01
Prostate	1	1.48 (1.04-2.10), p=0.03	2.31 (1.08-4.98), p=0.03	4.75 (2.27-9.92), p<0.01
Stomach	1	2.57 (1.60-4.13), p<0.01	3.11 (0.96-10.08), p=0.06	10.41 (4.29-25.26), p<0.01
Ovarian	1	1.50 (0.86-2.61), p=0.16	1.22 (0.29-5.09), p=0.78	3.51 (1.06-11.62), p=0.04
Brain	1	1.62 (0.76-3.49), p=0.21	2.67 (0.63-11.21), p=0.18	1.88 (0.25-13.86), p=0.54

Table 4 – Association between travel times (categorical) to the GP and cases diagnosed via Two Week Wait referral, for breast, colorectal, cervical, lung, prostate, stomach, ovarian and brain cancer between 2006 and 2010. Models adjusted for age, gender (where applicable), deprivation and comorbidity. Results are reported as relative risk ratios (95% CI), p-value, in comparison to the reference category (<=10 minutes).

	Travel times (minutes)			
	<= 10	**10.1 – 20**	**20.1 – 30**	**Over 30**
Breast	1	1.01 (0.97-1.05), p=0.77	0.87 (0.77-0.97), p<0.02	0.64 (0.55-0.74), p<0.01
Colorectal	1	1.02 (0.97-1.06), p=0.50	1.01 (0.89-1.14), p=0.87	0.72 (0.60-0.86), p<0.01
Cervical	1	1.06 (0.88-1.28), p=0.57	0.81 (0.45-1.46), p=0.48	0.64 (0.31-1.30), p=0.22
Lung	1	1.04 (0.99-1.09), p=0.14	0.98 (0.86-1.12), p=0.75	0.74 (0.62-0.88), p<0.01
Prostate	1	1.02 (0.98-1.06), p=0.30	0.97 (0.87-1.07), p=0.54	0.77 (0.65-0.91), p<0.01
Stomach	1	1.02 (0.92-1.13), p=0.68	1.05 (0.78-1.42), p=0.74	0.91 (0.59-1.40), p=0.67
Ovarian	1	1.07 (0.97-1.18), p=0.20	0.76 (0.57-1.02), p=0.07	0.63 (0.41-0.96), p<0.03
Brain	1	1.42 (0.93-2.16), p=0.10	0.99 (0.31-3.16), p=0.99	1.50 (0.47-4.83), p=0.50

Table 5 – Association between travel times (categorical) to the GP and cases diagnosed via screening, for breast, colorectal, cervical, lung, prostate, stomach, ovarian and brain cancer between 2006 and 2010. Models adjusted for age, gender (where applicable), deprivation and comorbidity. Results are reported as relative risk ratios (95% CI), p-value, in comparison to the reference category (<=10 minutes).

	Travel times (minutes)			
	<=10	**10.1 – 20**	**20.1 – 30**	**Over 30**
Breast	1	1.10 (1.05-1.15), p<0.01	0.87 (0.77-0.98), p=0.03	0.52 (0.44-0.62), p<0.01
Colorectal	1	1.12 (1.04-1.21), p=0.01	0.94 (0.75-1.19), p=0.61	0.36 (0.23-0.57), p<0.01
Cervical	1	1.05 (0.89-1.23), p=0.60	0.70 (0.43-1.12), p=0.14	0.86 (0.50-1.48), p=0.59

Supplementary Table S1 – Association between travel times (continuous) to the GP and cases diagnosed via emergency presentations, Death Certificate Only, Two Week Wait and screen detected; for breast, colorectal, cervical, lung, prostate, stomach, ovarian and brain cancer between 2006 and 2010. These models are adjusted for age, gender (where applicable), deprivation and comorbidity Results are reported as relative risk (95% CI), p-value, for every 10 minutes increase in travel time.

	Emergency	DCO	TWW	Screening
Breast	1.07 (1.03-1.11), p<0.01	1.38 (1.28-1.49), p<0.01	0.95 (0.93-0.97), p<0.01	0.97 (0.95-0.99), p=0.01
Colorectal	1.04 (1.02-1.07), p=0.01	1.35 (1.26-1.44), p<0.01	0.98 (0.96-1.00), p<0.06	1.00 (0.96-1.04), p=0.81
Cervical	1.04 (0.94-1.15), p=0.44	n/a	0.98 (0.90-1.08), p=0.73	0.94 (0.87-1.02), p=0.14
Lung	1.03 (1.01-1.05), p<0.01	1.22 (1.14-1.31), p<0.01	1.00 (0.98-1.03), p=0.77	
Prostate	1.07 (1.04-1.11), p<0.01	1.35 (1.22-1.49), p<0.01	0.98 (0.96-1.00), p=0.10	
Stomach	1.05 (1.00-1.11), p=0.06	1.50 (1.33-1.69), p<0.01	1.02 (0.97-1.08), p=0.41	
Ovarian	1.05 (1.01-1.10), p=0.02	1.21 (1.04-1.42), p=0.02	0.97 (0.92-1.02), p=0.24	
Brain	1.02 (0.98-1.07), p=0.35	1.13 (0.86-1.48), p=0.38	1.05 (0.87-1.26), p=0.65	