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ORIGINAL ARTICLE

Access to primary care and mortality in excess for patients with cancer in France: Results from 21 French Cancer Registries

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ABSTRACT

Background: The impact of geographical accessibility on cancer survival has been investigated in few studies, with most research focusing on access to reference care centers, using overall mortality and limited to specific cancer sites. This study aims to examine the association of access to primary care with mortality in excess of patients with the 10 most frequent cancers in France, while controlling for socio-economic deprivation.

Methods: This study included a total of 151,984 cases diagnosed with the 10 most common cancer sites in 21 French cancer registries between 2013 and 2015. Access to primary care was estimated using two indexes: the *Accessibilité Potentielle Localisée* index (access to general practitioners) and the Scale index (access to a range of primary care clinicians). Mortality in excess was modelized using an additive framework based on expected mortality based on lifetables and observed mortality.

Findings: Patients living in areas with less access to primary care had a greater mortality in excess for some very common cancer sites like breast (women), lung (men), liver (men and women), and colorectal cancer (men), representing 46% of patients diagnosed in our sample. The maximum effect was found for breast cancer; the excess hazard ratio was estimated to be 1.69 (95% CI, 1.20–2.38) 1 year after diagnosis and 2.26 (95% CI, 1.07–4.80) 5 years after diagnosis.

Interpretation: This study revealed that this differential access to primary care was associated with mortality in excess for patients with cancer and should become a priority for health policymakers to reduce these inequalities in health care accessibility.

KEYWORDS
cancer, excess mortality, primary care, registries

INTRODUCTION

Cancer is the leading cause of premature death in France as well as in all industrialized countries. According to Globocan (the Global Cancer Observatory of the International Agency for Research on Cancer), the incidence rate of cancer in 2020 was 262.1 cases per 100,000 for both sexes (270.8 cases per 100,000 for men and 253.3 cases per 100,000 for women). The 5-year standardized net survival rate for the 10 most common cancer sites in France ranged from 93% for prostate cancer to 11% for pancreatic cancer.[1] In addition, clinical factors such as age, sex, tumor characteristics, and nonclinical factors have been shown to be associated with survival.

Among these factors, socioeconomic inequalities have been widely studied. In England, the deprivation gap in 1-year cancer survival has been clearly established and is estimated at 8 points for bowel cancer and 7.8 for lung cancer (National Disease Registration Service, NHS England). A similar pattern has been reported in France, showing a difference of almost 12 points in survival between patients residing in the lowest versus highest quintiles of deprivation with head and neck cancer and 6 points in survival for colorectal and bladder cancer.[2]

The impact of geographical accessibility on survival has been less studied, with most research focusing on access to reference care centers.[3–8] Kravdal et al., Jones et al., and Sjöström et al. found no significant association between travel time to the reference care center and survival. Unlike the previously mentioned studies, Dejardin et al., Murage et al., and more recently, Gardy et al. reported that longer travel times to reference care centers have a detrimental effect on survival.

The term “primary care” refers to local health care services (preventive, curative, palliative, and rehabilitation care) along with the corresponding health care professionals (nurses, pharmacists, general practitioners [GPs], physiotherapists, etc.). GPs in France play a crucial role in guiding patients through coordinated care pathways, as they do in many high-income countries. Patients are encouraged to seek care from their GP before seeking specialist care at a differential reimbursement rate because a higher reimbursement rate is applied when patients access specialist care through their GP. Before the diagnosis of cancer, health care costs are reimbursed jointly by the national health insurance and by private insurance. Although approximately 95% of the French population is covered by national health insurance, the rate of reimbursement varies greatly depending on the level of additional private insurance. Once cancer has been diagnosed, the national health insurance scheme fully covers cancer-related health expenditure. Insufficient access to primary care (GPs) may result in potentially creating inequalities with health expenditures reimbursement, particularly affecting economically deprived patients. These patients may be less inclined to seek treatment. Therefore, it is plausible that access to primary care influences cancer survival.

Some studies investigated the influence of access to GPs on the risk of death or survival.[4,9–11] However, previous studies investigating the influence of access to primary care on the mortality of cancer patients used all-cause mortality as their end point. Mortality in excess is necessary to clearly identify mortality related specifically to background mortality (i.e., related to other causes of death) from mortality related specifically to cancer, which is the mortality of relevance for our problems. In addition, these studies only used the distance (or travel time) to the GP. Travel time or distance does not take GP availability into account; therefore, recently created indices that combine offer and demand are very useful tools. Geographical indices that combine distance and accessibility with user pressure can provide useful information on the actual availability of medical resources. Although GPs are important caregivers, primary care also includes numerous health care professionals who contribute to the cancer care continuum. To the best of our knowledge, this approach has not been previously developed using cancer data.

To study socio-territorial inequalities, it is crucial to use exhaustive data for a given area. Because cohort or multicenter studies are frequently promoted by the largest health care centers, and more socioeconomically disadvantaged patients and patients living in remote areas have a lower probability of being treated in such centers,[12] the study of exhaustive data should be the preferred method to capture all situations. Therefore, the use of cancer registry data appears essential and can provide a large study population as well as data on many cancer sites.

This study aims to examine the influence of access to primary care on mortality in excess of patients with the 10 most frequent cancers in France, while controlling for socioeconomic deprivation.

MATERIAL AND METHODS

Study population

This study included a total of 151,984 cases. The cancer cases included in this study were based on the data from the French

Network of Cancer Registries, which combines all French population-based cancer registries (Figure S1). The cases selected are the 10 most common solid invasive cancer types diagnosed between January 1, 2013, and December 31, 2015, in France according to the 3rd edition of the International Classification of Diseases for Oncology; the included cancers were: breast (C50), colon-rectum and anal canal (C18-C21), lung (C33-C34), pancreas (C25), prostate (C61), skin melanoma (C44: morphology 87203–87803), bladder (C67), head and neck (C01-C06; C09-C14), kidney (C64), and liver (C22). Patients with hematological malignancies, male breast cancers (because of the limited sample size, $N = 309$), and pediatric cancers (aged <15 years, covered by a national pediatric registry) were excluded.

The area covered by the registries in our study represents approximately 20% of the French metropolitan population. The French departments covered (fully or partially) by a register and included in this study were Calvados, Charente, Charente-Maritime, Côte-d'Or, Doubs, Finistère, Gironde, Hérault, Isère, Loire-Atlantique, Manche, Nord, Haut-Rhin, Saône-et-Loire, Deux-Sèvres, Somme, Tarn, Vendée, Vienne, Haute-Vienne, and Territoire-de-Belfort. The completeness and data quality of the included registries were regularly assessed by the International Agency for Research on Cancer and the European Network of Cancer Registries. This study was approved by the Commission Nationale Informatique et Libertés (No. 921057).

Variables

The variables available for this study were sex, year of diagnosis, age, and primary tumour site. For each cancer case, patient addresses were geolocalized using geographic information systems (ArcGIS; ESRI, Redlands, CA, USA); the exact geographic positions (X and Y coordinates) of the patient's address and residential Ilôts Regroupés pour l'Information Statistique were available.

Accessibility to primary care resources

To measure accessibility to primary care in this study, two indices were used: the Spatial aCcessibility multiscALar index (SCALe) and the *Accessibilité Potentielle Localisée* (APL), dedicated to GPs.

The SCALe index provides an overall score for accessibility to primary care in Metropolitan France as previously described.[13] This index includes primary care clinicians and secondary specialists who can be reached without an initial referral by a GP (gynecologist, ophthalmologist, or pediatrician).

- The health care professionals included in this index are as follows: GPs, physiotherapists, nurses, pharmacists, dentists, medical obstetricians and gynecologists, maternity wards, pediatric specialists, ophthalmologists, short-stay care services, and accident and emergency departments (Permanent Facilities Database of 2013, INSEE). Access to primary care combines the proximity and availability of facilities.

The SCALe Index was computed for all residential areas (approximately 3 million) to obtain a detailed representation of the French metropolitan territory. Therefore, this index is multiscalar and can be used at different geographical levels. The SCALe Index is a distance-based index, where a higher scale implies a lower accessibility.

- The APL[14] is a measure of access to self-employed general practitioners developed by Direction de la recherche, des études, de l'évaluation et des statistiques and Institut de recherche et documentation en économie de la santé. This indicator considers the level of activity of GPs to measure supply and the rate of use differentiated by the age of the population to measure demand. It is calculated at the level of each commune (the smallest administrative division in France) but also considers the supply of GPs and demand in surrounding communes. Unlike the SCALe Index, APL is a density index and an increase in its value implies an increase in accessibility.

Further information on the study population and variables is available in a previous study that used similar methods.[8]

Measure of socioeconomic deprivation

Social deprivation was measured using the French version of the European Index of Deprivation (EDI), an ecological index that measures relative poverty in small geographical areas, based on information from the European Union Survey on Income and Living Conditions and censuses. According to census 2015, the EDI score was calculated for each residential Îlots Regroupés pour l'Information Statistique, which is the smallest geographical census unit available in France, using the following formula:

$$\begin{aligned} \text{EDI} = {} & 0.50 * \text{No access to a car} \\ & + 0.84 * \text{Nonowner} \\ & + 0.44 * \text{Overcrowding} \\ & + 0.64 * \text{Low level of education} \\ & + 0.97 * \text{Unskilled worker} \\ & + 0.73 * \text{Foreign nationality} \\ & + 1.11 * \text{Single - parent household} \\ & + 0.25 * \text{Household with two or more persons} \\ & + 0.97 * \text{Unemployed} \\ & + 0.39 * \text{Not married} \end{aligned}$$

The principles and methods used to construct this index have been described in previous articles.[15,16]

Statistical analyses

In this study, the net survival was based on an additive framework. Net survival corresponds to the survival that would be observed if the only possible cause of death was cancer. This theoretical survival rate reflects only the excess mortality associated with the cancer site. The observed mortality rate resulting from cancer (h_O) is defined as the mortality in excess because of cancer (h_E) added to the expected death rate of the general French population (h_p). The formula as follows:

$$h_O = h_E + h_p$$

The expected death rate h_p was obtained from the French general population mortality tables (INSEE), matched to the study population by age, year of death, and department.

Nonparametric 5-year net survival estimator presented in Table S1 was calculated using Pohar-Perme estimator.[17]

The mortality in excess was obtained by modelling the logarithm of excess hazards using a multidimensional penalized spline.[18,19]

Potential interactions were modelled by penalized tensor product splines.

Net survivals being highly different by sex for numerous cancer sites, the French national estimates[20] and systematic studies on socioeconomic inequalities[21,22] are reported according cancer site and sex.

Models were therefore computed separately for each cancer site and sex. They were constructed step-by-step by adding the covariates of interest and potential interactions. The model with the lowest corrected Akaike information criterion (AIC) was selected as the best-fitting model, considering a difference of at least four units between two AIC values.[23] To our knowledge, the influence of multiple testing was not considered when using the cutoff of AIC. As previously stated, we retained a 4-point difference which is usually considered as an important clinical effect.

Age at diagnosis, year of diagnosis, and APL were centered. The nine models tested and their clinical implications are described below.

$$M0 : tensor(time\ since\ diagnosis, age\ at\ diagnosis) + year\ of\ diagnosis$$

- The only significant effect was that of age and year of diagnosis on survival (no effect of EDI or access to primary care).

$$M1 : M0 + s(EDI)$$

- There is an effect of deprivation on survival (presumably nonlinear)

$$M2a : M0 + s(SCALE)$$

- Access to primary care measured by the SCALe has an effect on survival (presumably nonlinear).

$$M2b : M0 + s(APL)$$

- Access to general practitioners as measured by APL has an effect on survival (presumably nonlinear).

$$M3 : M0 + s(EDI) + tint(time\ since\ diagnosis * EDI)$$

- There was a nonproportional effect of deprivation, and no access variables were associated with survival.

$$M4 : M0 + s(EDI) + tint(time\ since\ diagnosis * EDI) + s(SCALE\ or\ APL)$$

- After adjusting for deprivation, access to primary care/general practitioners has an effect on survival (presumably nonlinear).

$$M5 : M0 + s(EDI) + tint(time\ since\ diagnosis * EDI) + s(SCALE\ or\ APL) + tint(time\ since\ diagnosis * SCALE\ or\ APL)$$

- After adjustment for deprivation, access to primary care/general practitioners had an effect on survival (presumably nonlinear), with an interaction with time.

$$M6 : M0 + s(EDI) + tint(time\ since\ diagnosis * EDI) + s(SCALE\ or\ APL) + tint(age\ at\ diagnosis * SCALE\ or\ APL)$$

- After adjusting for deprivation, there was an effect of access to primary care/general practitioners on survival (presumably nonlinear), with an interaction with age.

$$M7 : M0 + s(EDI) + tint(time\ since\ diagnosis * EDI) + s(SCALE\ or\ APL) + tint(EDI * SCALE\ or\ APL)$$

- After adjustment for deprivation, access to primary care/general practitioners had an effect on survival (presumably nonlinear), with an interaction with EDI.

The interaction between time and EDI was introduced into the model only if it was significant in M3 and in the following models.

In the models, the reference value for the SCALe index (distance-based index) was set to the minimum of its distribution, and the reference value for the APL index (density-based index) was set to the median of its distribution.

With regard to missing data, a complete case analysis was performed, and cases with missing EDI, SCALe Index or APL were removed ($N = 6380$; 3.9%).

All analyses were performed using R software (4.2.3) and RStudio software (2023.03.0) with the "survPen" package (1.5.2).[24]

RESULTS

In total, 57% (*N* = 86,591) of the study population were men and 43% (*N* = 65,393) were women. The median age was 67.9 years. A description of the study population is presented in Table 1.

Five-year nonparametric analysis

Nonparametric 5-year survival estimators according to SCALe Index and APL index are presented in more detail in Table S1 for all cancer sites. These 5-year nonparametric estimates did not take into account the potential effect of age and socioeconomic deprivation, which could only be included in parametric models. However, some net survivals could be highlighted. The 5-year survival estimators for head and neck cancer in women was estimated to 58.3% (51.8–65.6%) for patients with better primary care accessibility and 50.5% (44.4–57.3%) for the patients with lesser primary care accessibility. For liver cancer in women, the 5-year survival estimators was estimated to 21.8% (16.9–28.0%) for patients with better primary care accessibility and 15.1% (10.9–21.0%) for the patients with lesser primary care accessibility. Finally, for kidney cancer in men, the 5-year survival estimators was estimated to 77.0% (73.1–81.1%) for patients with better primary care accessibility and 69.5% (65.0–74.2%) for the patients with lesser primary care accessibility.

Parametric analysis

The effect of the SCALe Index or APL, adjusted on socioeconomic deprivation, on survival was significant for certain sites, including lung cancer in men, breast cancer in women, liver cancer in both men and women, and colorectal cancer in men (Table 2).

Lung cancer

Model 4 (tensor(t,age) + ydiag + s(edi) + s(scale)) was selected for men with lung cancer. Survival was longer in patients with better access to primary care than in those with lower accessibility. After adjustment, the SCALe Index was associated with excess hazard ratio (EHR) at 5 years (EHR_{median_scale} = 1.08 [1.04–1.13]) (Figure 1).

Breast cancer

Model 5 (tensor(t,age) + ydiag + s(edi) + s(scale) + tint(t,scale)) was selected for breast cancer. Survival was longer in patients with better access to primary care than in those with lower accessibility. Because the selected model contained an interaction between time and SCALe, a nonproportional effect of the SCALe Index was present; the effect of accessibility differed according to time since diagnosis. Thus, the SCALe Index was differentially associated with EHR at 1 year (EHR_{median_scale} = 1.69 [1.20–2.38]) and 5 years (EHR_{median_scale} = 2.26 [1.07–4.80]) (Figure 2).

TABLE 1 Description of the population.

Cancer sites	Sex		Age at diagnosis (median [Q1–Q3])	Year of diagnosis			EDI (median [Q1–Q3])	SCALe Index (median [Q1–Q3])	APL (median [Q1–Q3])
	Men	Women		2013	2014	2015			
Overall	86,591	65,393	67.90 [59.58–77.60]	49,806	51,111	51,067	−0.79 [−2.51 to 1.40]	−5.38 [−10.04 to −1.70]	4.20 [3.40–5.10]
Breast	0	32,401	63.10 [51.55–73.17]	10,601	11,043	10,757	−0.84 [−2.63 to 1.37]	−5.72 [−10.41 to −1.89]	4.30 [3.40–5.20]
Prostate	27,991	0	69.01 [63.59–75.99]	8975	9086	9930	−1.01 [−2.67 to 1.04]	−4.95 [−9.36 to −1.35]	4.20 [3.30–5.00]
Colon-rectum	14,520	12,488	73.05 [63.65–82.17]	8982	9136	8890	−0.81 [−2.46 to 1.27]	−5.25 [−9.79 to −1.62]	4.20 [3.30;5.00]
Lung	16,521	6877	66.66 [59.36–75.78]	7649	7931	7818	−0.39 [−2.26 to 1.96]	−5.66 [−10.35 to −1.81]	4.30 [3.40–5.20]
Pancreas	3827	3673	72.64 [63.62–81.54]	2462	2494	2544	−0.78 [−2.49 to 1.37]	−5.40 [−9.96 to −1.83]	4.20 [3.30–5.00]
Skin melanoma	3656	3752	63.81 [49.94–74.95]	2363	2537	2508	−1.26 [−2.92 to 0.70]	−5.38 [−10.02 to −1.77]	4.30 [3.40–5.10]
Bladder	5665	1300	75.03 [65.77–82.67]	2377	2345	2243	−0.67 [−2.44 to 1.49]	−5.49 [−10.24 to −1.68]	4.30 [3.40–5.10]
Head and neck	5177	1545	62.28 [55.73–70.00]	2277	2243	2202	−0.22 [−2.17 to 2.22]	−5.74 [−10.35 to −1.90]	4.30 [3.40–5.10]
Kidney	4287	2115	66.98 [57.89–77.02]	2060	2176	2166	−0.83 [−2.57 to 1.35]	−5.11 [−9.52 to −1.45]	4.20 [3.40–5.10]
Liver	4947	1242	70.19 [63.01–78.47]	2060	2120	2009	−0.71 [−2.46 to 1.53]	−5.12 [−9.73 to −1.57]	4.20 [3.30–5.00]

Note: APL index based on density; a higher value implies higher medical density.

Abbreviations: APL, *Accessibilité Potentielle Localisée*; EDI, European Index of Deprivation; Q, quartile.

TABLE 2 Model selection.

	N	M0	M1	M2a	M2b	M3	M4	M5	M6	M7	Selected model	Clinical meaning
Breast												
Female	32,401	80,576.89	80,525.27	80,569.43	80,575.04	80,526.58	80,504.88	80,490.62	80,492.57	80,486.81	M5 - tensor(t, age) + ydiag + s (edi) + s (scale) + tint(t,scale)	After adjustment for deprivation, access to primary care had an effect on survival, with the effect changing over time
Colon-rectum												
Male	14,520	10,6430.1	10,6408.4	10,6433.6	10,6426.8	10,6410.6	10,6402.4	10,6404.4	10,6403.3	10,6404.4	M4 - tensor(t, age) + ydiag + s (edi) + s(APL)	After adjusting for deprivation, access to general practitioners affects survival
Female	12,488	87,483.11	87,456.84	87,485.57	87,484.62	87,458.24	87,459.01				M1 - tensor(t, age) + ydiag + s(edi)	There is an effect of deprivation on survival
Lung												
Male	16,521	19,1295.1	19,1279.1	19,1285.1	19,1290.3	19,1281.0	19,1267.2	19,1264.6	19,1270.3	19,1269.3	M4 - tensor(t, age) + ydiag + s (edi) + s(scale)	After adjusting for deprivation, access to primary care affects survival
Female	6877	74,417.52	74,411.88	74,419.34	74,421.74	74,410.43	74,413.33				M1 - tensor(t, age) + ydiag + s(edi)	There is an effect of deprivation on survival
Liver												
Male	4947	57,168.11	57,169.75	57,164.35	57,166.22	57,165.42	57,159.50	57,162.93	57,159.28	57,161.89	M4 - tensor(t, age) + ydiag + s (edi) + tint(t,edi) + s (scale)	After adjusting for deprivation, access to primary care affects survival
Female	1242	14,366.16	14,363.70	14,361.11	14,362.94	14,363.78	14,357.57	14,359.18	14,359.19	14,357.26	M4 - tensor(t, age) + ydiag + s (edi) + s(scale)	After adjusting for deprivation, access to primary care affects survival
Pancreas												
Male	3827	46,750.76	46,747.43	46,753.65	46,752.78						M0 - tensor(t, age) + ydiag	The only significant effect on survival was age and year of diagnosis
Female	3673	44,586.04	44,584.16	44,588.52	44,587.77						M0 - tensor(t, age) + ydiag	The only significant effect on survival was age and year of diagnosis
Prostate												
Male	27,991	79817.13	79,775.37	79,818.17	79,815.95	79,775.06	79,772.57				M1 - tensor(t, age) + ydiag + s(edi)	There is an effect of deprivation on survival

TABLE 2 (Continued)

	N	M0	M1	M2a	M2b	M3	M4	M5	M6	M7	Selected model	Clinical meaning
Skin melanoma												
Male	3656	11,389.56	11,361.03	11,390.84	11,391.44	11,361.98	11,360.98				M1 - tensor(t, age) + ydiag + s(edi)	There is an effect of deprivation on survival
Female	3752	7481.483	7473.804	7481.434	7481.622	7473.388	7471.292				M1 - tensor(t, age) + ydiag + s(edi)	There is an effect of deprivation on survival
Bladder												
Male	5665	49,036.20	49,021.40	49,037.95	49,039.30	49,020.13	49,021.02				M1 - tensor(t, age) + ydiag + s(edi)	There is an effect of deprivation on survival
Female	1300	12,307.79	12,306.78	12,309.74	12,307.74						M0 - tensor(t, age) + ydiag	The only significant effect on survival was age and year of diagnosis
Head and neck												
Male	5177	48,723.91	48,711.44	48,726.15	48,725.06	48,715.11	48,710.52				M1 - tensor(t, age) + ydiag + s(edi)	There is an effect of deprivation on survival
Female	1545	12,044.13	12,045.76	12,043.90	12,046.10						M0 - tensor(t, age) + ydiag	The only significant effect on survival was age and year of diagnosis
Kidney												
Male	4287	22,965.30	22,966.44	22,966.49	22,966.24						M0 - tensor(t, age) + ydiag	The only significant effect on survival was age and year of diagnosis
Female	2115	10,682.96	10,684.31	10,684.94	10,681.72						M0 - tensor(t, age) + ydiag	The only significant effect on survival was age and year of diagnosis

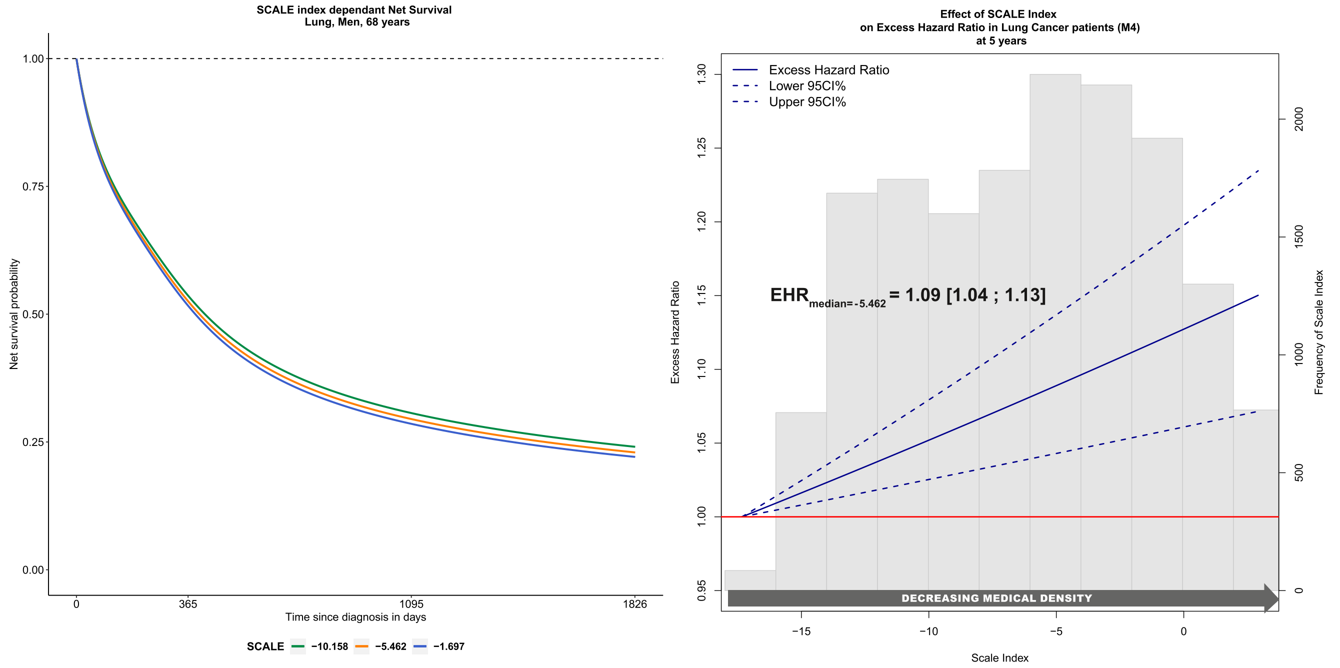

FIGURE 1 Excess hazard ratio and net survival curves in relation to access to primary care for lung cancer in men ($N = 16{,}521$).

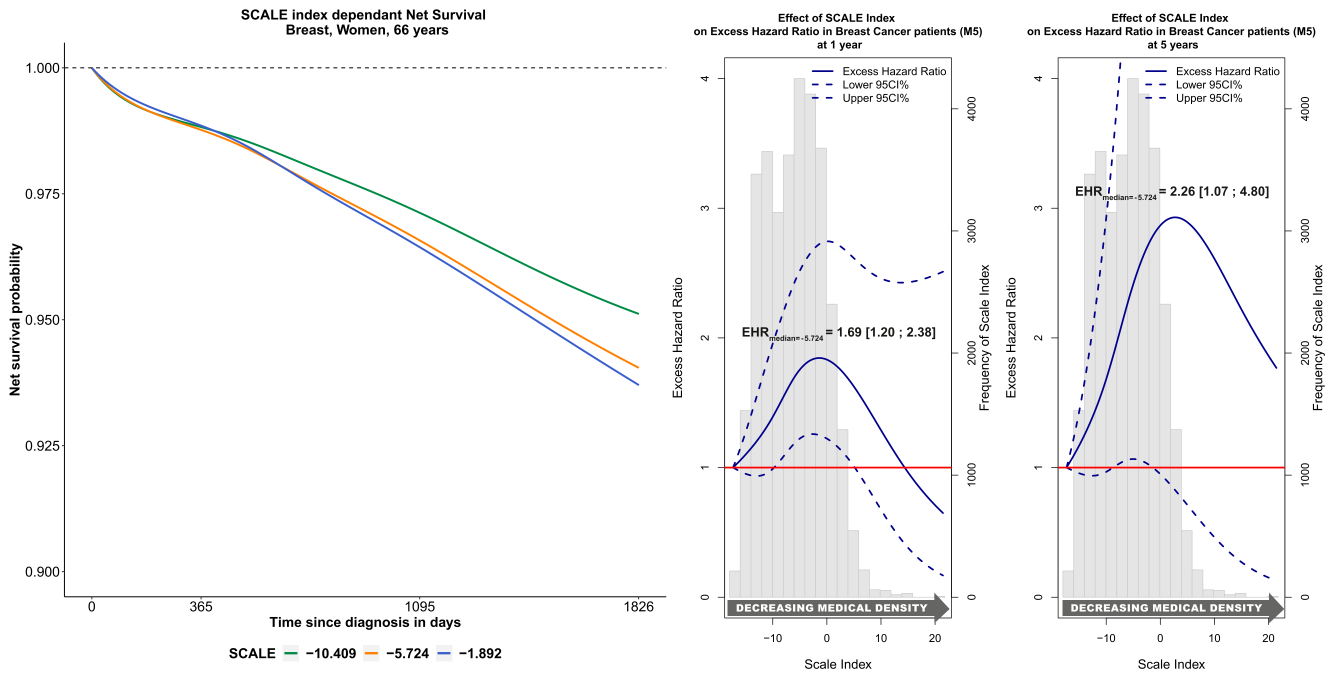

FIGURE 2 Excess hazard ratio and net survival curves in relation to access to primary care for breast cancer in women ($N = 32{,}401$).

Liver cancer

Model 4 (tensor(t,age) + ydiag + s(edi) + s(scale)) was selected for liver cancer in men and Model 4 with an interaction between time and EDI was selected for women (tensor(t,age) + ydiag + s(edi) + tint(t,edi) + s(scale)). In both men and women, survival was higher in patients with better accessibility to primary care than in those with lower accessibility. The SCALe Index was associated with EHR at 5 years (EHR_{median_scale} = 1.20 [1.01;1.43] for men; EHR_{median_scale} = 1.51 [1.12–2.04] for women) (Figure 3).

Colorectal cancer

Model 4 (tensor(t,age) + ydiag + s(edi) + s(APL)) was selected for the men with colorectal cancer. Unlike the SCALe Index, APL is a density

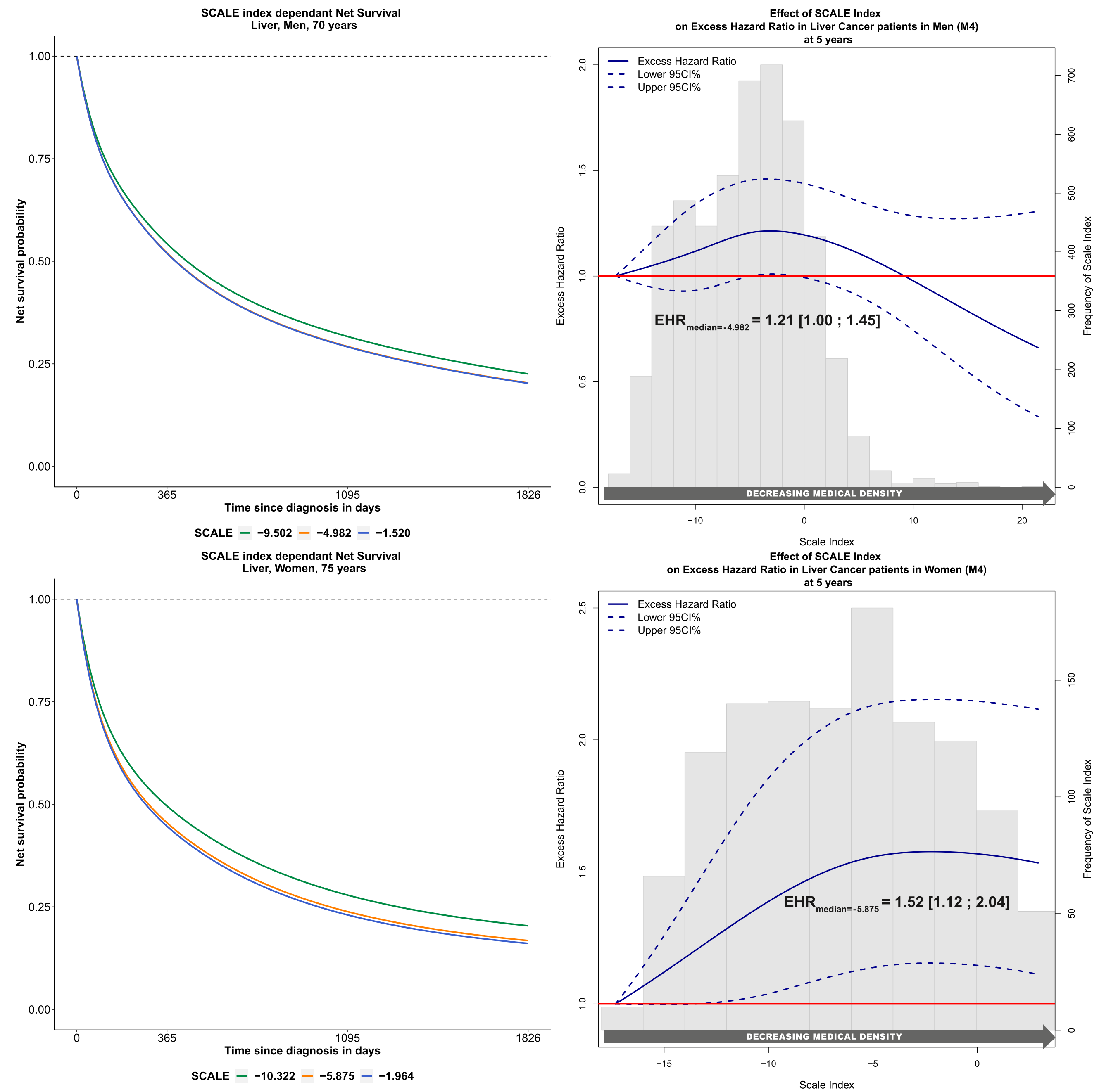

FIGURE 3 Excess hazard ratio and net survival curves in relation to access to primary care for liver cancer in men and women ($N = 6189$).

index and an increase in its value implies an increase in accessibility. Survival was better in patients with better access to general practitioners than in those with a limited access. APL was associated with EHR at 5 years ($EHR_{median\_APL} = 0.83$ [0.73–0.94]) (Figure 4).

For other cancer sites (colorectal cancer in women, lung cancer in women, prostate cancer, skin melanoma in men and women, bladder cancer in men, and head and neck cancer in men), there was only a significant effect of socioeconomic status (measured by EDI). For the remaining cancer sites (pancreas in men and women, bladder in women, head and neck in women and kidney in men and women), neither socioeconomic status nor the access to primary care demonstrated an effect on survival.

DISCUSSION

Access to primary care has an impact on cancer survival in France, and patients living in areas with less access to primary care have a higher mortality in excess. As these significant results are for very common cancer sites such as breast, lung, and colectal cancers

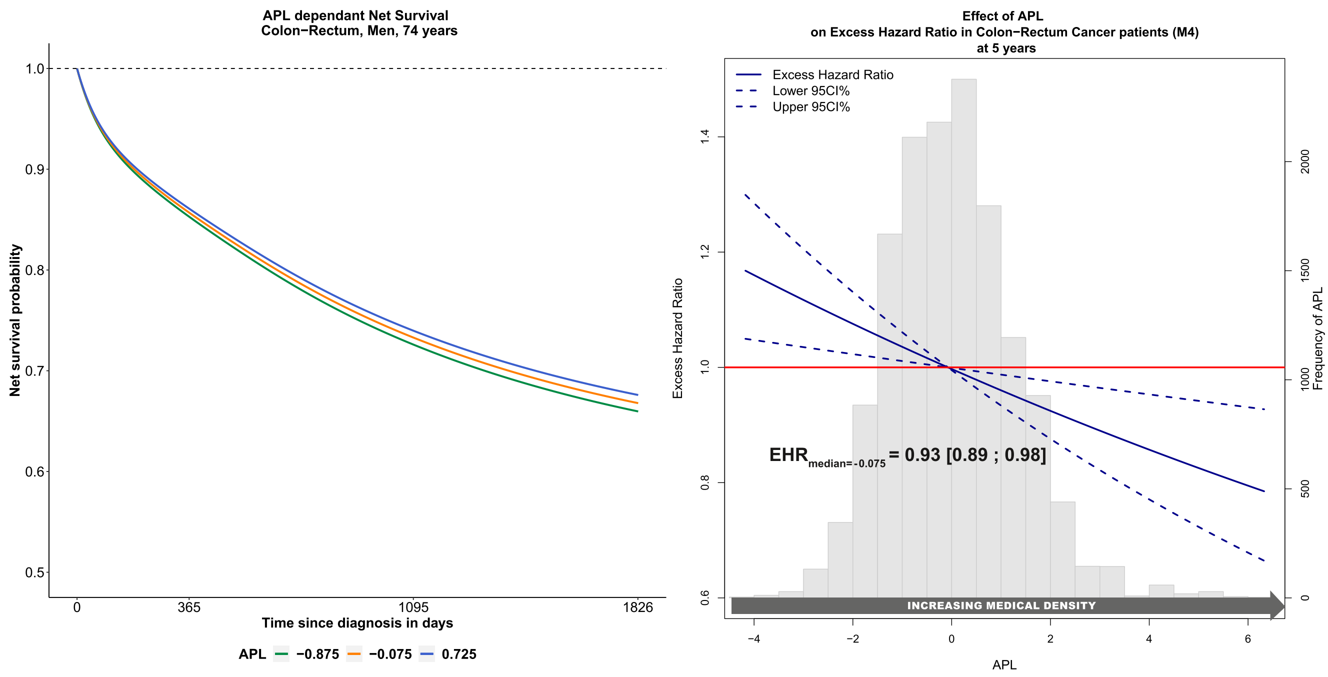

FIGURE 4 Excess hazard ratio and net survival curves in relation to access to primary care for colorectal cancer in men ($N = 14{,}520$).

among the ten most frequent cancer sites, this effect could be relevant for almost half (46%) of the patients diagnosed in metropolitan France.

Numerous studies in medical geography have reported an association with distance decay; the use of medical services decreases as distance increases. However, the consequences in terms of medical outcomes remain highly debated. Social and geographic inequalities are closely linked, and patients in areas with less access to primary care are frequently the most deprived.[25] Social inequalities have been studied extensively and are now being considered before establishing public health policies. Even if geographical inequalities are less significant than social inequalities, that the consequences of living in medically underserved areas are likely to be underestimated remains. Using two indices based either on the access to GPs (APL) or the access to primary care (SCALe), our study revealed that access to primary care was associated with survival for four out of the ten cancer localizations studied, even after the adjustment for socioeconomic deprivation. However, as illustrated by our model selection, deprivation was selected first regardless of the cancer site, showing a more significant association between deprivation and survival than health care accessibility.

Previous studies on the association between access to primary care, via distance to the GP, and risk of death or survival have been conducted in different health care systems, with conflicting results. In England, in 2007, Jones et al. analyzed data for breast, colorectal, lung, ovarian, and prostate cancers. A significant result was found only for prostate cancer, which showed that patients who lived far away from their GP had a poorer chance of survival than those who lived closer.[4] In 2008, Haynes et al. studied melanoma, colorectal, lung, breast, and prostate cancers in New Zealand. In this study, survival was not related to the travel time to primary care in most cases. The exception was travelling to primary care centers for prostate cancer once more.[9] More recently, in 2021, Murchie et al. studied colorectal cancer in Denmark and Scotland. Travel time to the GP was significantly associated with 1-year mortality. For example, patients with 20 minutes of travel time had 1.39 times higher 1-year mortality than patients with 5 minutes of travel time.[26]

Before cancer diagnosis, GPs are the first in line to increase patients' awareness of potential symptoms with health promotion and prevention and refer them to specialists. Thus, a difficulty in access to primary health care before, during and after initial treatment could have important consequences either from a later stage at diagnosis[27,28] or from difficulties to deal with treatment side effects.[29–31] The absence of association for some cancer sites is surprising. For example, we would expect access to primary care to be associated with survival for skin melanoma. However, the early detection of this cancer requires a detailed visual inspection, which is probably routinely difficult in daily practice. Moreover, beyond visual inspection, skin biopsies are the only way to confirm or exclude melanoma. Thus, access to a dermatologist could affect survival more significantly than access to primary, namely for early detection and diagnosis. In the same way, visual inspection of oral cavity for head and neck cancer is rarely performed.

In France, GPs are the cornerstone for mass screening; thus, the effect of access to primary care for colorectal and breast cancer is not surprising. In addition, some symptoms are highly alarming for a trained primary health clinician like jaundice, a suspect severe cough, rectal bleeding, or a suspicious lump. Therefore, the effect of access to primary care for colorectal, breast, and liver cancer is in line with our hypothesis.

To our knowledge, this is the first study to show such strong results in so many patients and to comprehensively include 10 major cancer sites (i.e., without a priori selection).

Our study had some limitations. Data on the stage at diagnosis, treatment received by patients, treatment location, and comorbidities are not routinely collected from cancer registries in France. We used the most comprehensive data available to investigate the association between access to primary care and patient survival. Distance to the nearest reference care has been associated with mortality in excess for lung, melanoma, breast, liver, colorectal, and head and neck.[8] However, in this study, distance to the nearest reference care center was used as a proxy for access to specialist care because of lack of information on the actual location of treatment. Further studies are necessary to address this potential confounder. Undoubtedly, the explanation of the mechanism of this association requires more detailed data which would only be available at a lower geographical scale or on fewer patients in France to further explain the associations found. Finally, French cancer registries do not include data from the three largest French cities: Paris, Lyon, and Marseille. Accessibility to patients in such large cities differs, with a larger proportion of noncar owners and more developed public transport systems. The absence of patients from these three cities in our study may limit the representation of the entire French population.

Nevertheless, this study has several strengths. To the best of our knowledge, only a few studies have used mortality in excess to investigate geographical inequalities in cancer survival. Geographical differences in general mortality are expected,[32] therefore it is crucial to study mortality in excess rather than overall mortality. Mortality in excess is the only way to ensure that geographical inequalities are related to deaths from other causes. Unlike previous studies that used linear associations, our methodology allowed us to model the association without prior hypotheses on the functional form. The use of innovative indices that consider not only distance but also the user pressure to measure accessibility to primary care is a strength of our study. Furthermore, similar to the measure of deprivation, the use of composite indices is preferable to a unique metric that is more sensitive to error measurements. Additionally, studies on primary care should not be limited to measuring access to GPs. We took into account access to GPs using the APL scale and most primary care facilities using the SCALe Index. Complementary studies comparing the influences of the two indices are required to explain the discrepancies between them. One explanation could be that the APL and SCALe Index are calculated at different geographic scales; therefore, the SCALe Index may offer a better statistical fit. For example, for lung cancer, the SCALe Index offers a better fit with a reduction of 10 points of AIC while using APL; the reduction of AIC was confined to 5 points, and thus, APL was also associated with poorer survival. Moreover, in addition to primary care clinicians, the SCALe Index included specialists who could be visited without any initial consultation with the GP. Consequently, for breast cancer, the inclusion of access to gynecologists in the SCALe Index could improve the evaluation of accessibility. Overall, the difference between the effects of the two indices can be explained by the combined effect of a lower geographic scale and the inclusion of more practitioners. In addition, as specified in the introduction, the use of cancer registries data constitutes a major strength as they guarantee the exhaustiveness and representativeness of included patients in the studied area.

In conclusion, this study revealed the potentially detrimental effects of access to primary care on cancer survival in France. Because a large proportion of the French population lives in medically underserved areas, access to primary care is challenging.[33] Various parliamentary reports have been published to address this issue by promoting teleconsultations, financial incitations, or measures to regulate the free choice of installation for primary care clinicians. However, to date, none of the measures tested in France have been effective. Our study revealed that this differential access to primary care has crucial consequences in terms of mortality in excess for cancer patients and should become a priority for health policymakers to reduce these inequalities in health care accessibility.

AUTHOR CONTRIBUTIONS

Anne-Valerie Guizard: Writing - review & editing; Validation; and Project administration. **Guy Launoy**: Writing - review & editing; Validation; and Supervision. **Josephine Bryere**: Validation; Writing - review & editing; Supervision; and Methodology. **Ludivine Launay**: Methodology and Writing - review & editing. **Olivier Dejardin**: Supervision; Writing - review & editing; Writing - original draft; Validation; and Methodology. **Arnaud Alves**: Writing - review & editing and Validation. **Veronique Bouvier**: Validation and Writing - review & editing. **Florence Molinie**: Validation and Writing - review & editing. **Sarah Wilson**: Methodology; Writing - original draft; Validation; Writing - review & editing; Software; and Formal analysis. **Josephine Gardy**: Conceptualization; Investigation; Writing - original draft; Methodology; Validation; Visualization; Writing - review & editing; Software; Formal analysis; Project administration; and Data curation. **Simona Bara**: Resources. **Anne-Marie Bouvier**: Resources. **Valerie Jooste**: Resources. **Arnaud Seigneurin**: Resources. **Gaelle Coureau**: Resources. **Anne Cowppli-Bony**: Resources. **Florent Hure**: Resources. **Laetitia Daubisse-Marliac**: Resources. **Gautier Defossez**: Resources. **Benedicte Lapotre-Ledoux**: Resources. **Karima Hammas**: Resources. **Jean-Baptiste Nousbaum**: Resources. **Sandrine Plouvier**: Resources. **Brigitte Tretarre**: Resources. **Anne-Sophie Woronoff**: Resources. **Sandrine Dabakuyo-Yonli**: Resources. **Nicolas Vigneron**: Resources. All authors contributed substantially to the conception and design, data acquisition, or data analysis and interpretation.

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CONFLICT OF INTEREST STATEMENT

None.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available because of privacy or ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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