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Relationship between socioeconomic status and prostate cancer (incidence, aggressiveness, treatment with curative intent, and mortality): a spatial analysis using population-based cancer registry data.

Relation entre le statut socioéconomique et le cancer de la prostate (incidence, agressivité, traitement à visée curative et mortalité) : une analyse spatiale à partir des données du registre de cancer de la Somme

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ABSTRACT

Background: Morbidity and mortality associated with prostate cancer in a given geographic area might be related to the level of socioeconomic deprivation. The Somme area (a region of northern France) is considered economically disadvantaged, with major territorial disparities. The aim of this study was to assess the impact of the socioeconomic level on prostate cancer, using data from a population-based cancer registry. **Methods**: The source of data on cases of prostate cancer between 2006 and 2010 was the Somme cancer registry (Amiens, France). Socioeconomic status was measured according to the European Deprivation Index (EDI), which was used to classify each geographical "IRIS" unit (the smallest sub-municipal geographical entity for which French census data are available) according to its level of social deprivation. For spatial analysis, we considered a hierarchical generalized linear model. **Results:** In the spatial analysis, prostate cancer incidence was higher in the less disadvantaged areas and treatment frequency with curative intent was lower in the most disadvantaged areas. Cancer aggressiveness and mortality were higher in the most disadvantaged areas: relative risk (RR) = 1.36; 95% CI: [1.09; 1.73] and RR=3.09 [1.70; 5.59], respectively. **Conclusion:** Our results evidenced a significant association between socioeconomic deprivation and prostate cancer, with worse outcomes among men with the lowest socioeconomic status.

Keywords: Prostate Cancer. Spatial analysis. Socioeconomic status.

Position du problème : La morbidité et la mortalité associées au cancer de la prostate dans une zone géographique donnée peuvent être liées au niveau de privation socio-économique. Le département de la Somme est considéré comme une zone économiquement défavorisée, avec de grandes disparités territoriales. L'objectif de cette étude était d'évaluer l'impact du niveau socio-économique sur le cancer de la prostate. **Méthodes :** Les données sur les cas de cancer de la prostate, entre 2006 et 2010, ont été obtenues à partir du registre du cancer de la Somme (Amiens, France). Le statut socio-économique a été évalué selon l'indice européen de défavorisation (EDI) qui a été utilisé pour classer chaque unité géographique IRIS (plus petite entité géographique sous-communale pour laquelle les données du recensement français sont disponibles) en fonction de son niveau de défavorisation socio-économique. Pour l'analyse spatiale, un modèle linéaire généralisé hiérarchique a été adopté. **Résultats :** L'incidence du cancer de la prostate était plus élevée dans les zones les moins défavorisées et la fréquence du traitement à visée curative était plus faible dans les zones les plus défavorisées. L'agressivité et la mortalité par cancer étaient plus élevées parmi les patients vivant dans les zones les plus défavorisées : les risques relatifs étaient de 1,36, IC à 95% [1,09; 1,73]

et de 3,09 [1,70; 5,59], respectivement. **Conclusion:** Notre étude a mis en évidence une association significative entre la privation socio-économique et le cancer de la prostate, avec des résultats moins bons chez les hommes ayant le statut socio-économique le plus bas.

Mots-clés: Cancer de la prostate. Analyse spatiale. Statut socio-économique.

1. Introduction

Worldwide, prostate cancer is the second most common cancer in men after lung cancer. According to GLOBOCAN, the estimated number of cases of prostate cancer for 2018 was 1.27 million; the majority of these cases (70%) were diagnosed in developed countries [1]. In France, prostate cancer is at the top of the list of the most common cancers in men. Its standardized incidence in 2015 was 81.5 cases per 100,000 person-years. In terms of mortality, prostate cancer is the third leading cause of death in men after lung and colorectal cancers [2].

The established risk factors for prostate cancer are age, heredity, and certain gene polymorphisms. Other factors incriminated in increased risk for this cancer include dietary habits, obesity, and socioeconomic status [3–7]. While many authors have studied the association between socioeconomic status and prostate cancer, there exists no consensus on the impact of social inequality on the characteristics of prostate cancer [8–14].

According to the literature, disparities in diagnosis and treatment have a direct bearing on disparities in prostate cancer outcomes.

Some studies have shown differential rates of prostate-specific antigen (PSA) testing and PSA screening between urban areas and rural areas that are considered to be less socioeconomically advantaged [15,16]. In their paper, Pitman et al showed that patients' clinical features (comorbid cardiovascular disease), divorced status and lower income were associated with longer treatment-time lag [17]. In France, the reduction of social inequalities in health has become a priority of public health programs and the fight against inequalities in cancer was one of the main objectives of the 2014-2019 Cancer Plan. As regards possible association between socioeconomic status and cancer, particularly breast cancer and colorectal cancer, several studies have been published in France, by

different authors [18,19]. Regarding prostate cancer, this link has been only briefly mentioned in studies largely dedicated to other topographies [20,21].

The main aim of this study was to assess the impact of socioeconomic status on the incidence of prostate cancer in the Somme area (a region of northern France) from 1982 until 2014. The secondary objectives of this study were to study the impact of socioeconomic level on the mortality and the grade at diagnosis of prostate cancer, on type of treatment received by the patients and on treatment-time lag.

2. Material and Methods

The study area: the Somme department

Somme is a department in northern France area located in the Hauts-de-France region. There are four important districts in the Somme: Amiens, Abbeville, Albert, and Peronne. The area covers 6168.4 km² and according to the 2017 census has 572,443 inhabitants. Population density is 92.6 inhabitants per km² with a major phenomenon of peri-urbanization entailing socioeconomic disparities between territories. The Somme poverty rate in 2013 was 16.9%, compared to 14.2% in metropolitan France for the same period [22]. In the community of Amiens on January 1, 2007, the share of higher intellectual professions among active people with a job was 17.7%, whereas it was only 8.1% in the rest of the Somme territory. There also exist differences between Amiens and the rest of the territory as regards average annual income per household [23].

The prostate cancer dataset

The source of data on prostate cancer (2006 to 2010) was the Somme area's general cancer registry. Data reflect changes over time in cancer incidence and survival rates in the Somme area of northern France (with 571,632 inhabitants, according to the 2014 national census).

The registry carries out an active, continuous and exhaustive census of all the incidental cancers in the Somme area by querying several sources (pathology and cytology laboratories, public- and private-sector health facilities, health insurance agencies, and the county organization for breast cancer and colorectal cancer screening (ADEMA 80)). The mandatory data collected include name, gender, address at the time of diagnosis, date of cancer diagnosis, tumor topography, and pathology assessment results.

The data are coded according to the International Classification of Diseases for Oncology, 3rd edition (ICD-03) [24] and the rules of the FRANCIM network of French cancer registries and the European Network of Cancer Registries. Data quality is ensured through systematic continuous screening for duplicates. Consistency checks are performed with DepEdit software developed by the International Agency for Research on Cancer.

Inclusion criteria

All cases of prostate cancer recorded in the Somme cancer registry between 2006 and 2010 were included in the study.

Exclusion criteria

Cases without a complete address were excluded.

Study variables

- Primary outcome and secondary outcomes:

    - Crude incidence/mortality rates were defined as the total number of new cancer cases/deaths diagnosed in a specific year within an age group (17 five-year age groups, ranging from [0; 4] to [80+]). We calculated age standardization incidence/mortality rates (ASIR/ASMR) using direct standardization based on 2010 standard European and world populations.

    - Aggressive prostate cancer was defined as cancer with a Gleason score above seven [25].

    - For treatment with curative intent or not, a binary variable was defined for each case of prostate cancer [26].

    - Waiting time for treatment with curative intent was defined as the time between diagnosis and treatment. We computed median waiting time for cancer patients who received treatment with curative intent, and it was chosen as the threshold to define a binary variable for the corresponding cases.

- Exposure and covariates:

We assessed socioeconomic status using the European Deprivation Index (EDI), an aggregate index that measures social deprivation similarly in each European country [27]. In the present study, the EDI was analyzed as both a continuous variable (range: -5.33 to 20.52), a high EDI means a high level of social deprivation, and a categorical variable (in quintiles, where Q1 is the most favored category

and Q5 is the most disadvantaged) [28]. The EDI is an aggregate index equal to the sum of the standardized logarithmic values of different variables assessing socioeconomic status [29]. We used the EDI to classify geographical units (IRIS) according to level of social deprivation. The IRIS is the smallest sub-municipal geographical entity for which French census data are available; it contains between 1800 and 5000 inhabitants). The Somme area has 854 IRISs. We allocated each case of prostate cancer to the corresponding IRIS by geolocalizing the addresses with a geographic information system operated by MAPINFO software (version 16.0).

Age structure of the population at the IRIS level, proportion of cancer cases with Gleason score above 7 and presence of metastasis at diagnosis represented the covariates in models assessing mortality and time to treatment. Age structure of the population was the covariate used in models assessing incidence.

Statistical analysis

Hierarchical generalized linear modeling using a Bayesian approach took into account the spatial structure of the variables. The Bayesian hierarchical model included residual spatial autocorrelation by augmenting the linear predictor with spatially auto-correlated random effects.

Due to the socioeconomic and geographical characteristics of the study region, data were likely to exhibit different levels of local spatial autocorrelation; hence, models based on a single level of spatial autocorrelation smoothing would probably not have been appropriate for our data. Accordingly, we used the approach presented by Lee et al by applying a localized conditionally autoregressive (CAR) model for spatial random effects based on dissimilarity metrics [30].

Moran's I test was used to check for spatial autocorrelation. Depending on the response variable, a Poisson or binomial distribution was fitted. We estimated the model's parameters using the Markov Chain Monte Carlo algorithm; 10,000 samples were generated, with 2000 being discarded as the burn-in period and the level of thinning set at 10 to reduce autocorrelation.

The fitted Poisson model is given by (Yi ~ Poisson (μi) and ln (μi) =X_i^T+ β + Oi +ψi), where Yi is the observed number of cases of prostate cancer in the ith geographic area, Xi is the vector of the covariate of interest, Oi is a vector of known offsets, β is the vector of regression parameters, and ψi represents the spatial structure component. The binomial model is given by (Yi ~ Binomial (ni, Θi) and ln (Θi/(1- Θi))= + β + Oi +ψi), where i is the number of trials in the ith area, and Θi is the probability of success in a single trial.

Descriptive statistics on the clinical and therapeutic features of prostate cancer patients were drawn up using frequencies and proportions for categorical variables and mean, standard deviation (SD),

median and interquartile range (IQR) for continuous variables. We assessed associations with the socioeconomic deprivation level (considering the categorical version of EDI by quintiles) through the chi-square test and ANOVA.

In spatial analysis, we performed univariate and multivariate analyses to estimate the effect of socioeconomic deprivation level on prostate cancer, controlling for age at diagnosis and grade of prostate cancer. Other covariates such as marital status and comorbidities were not included in the model since the variables were collected retrospectively and those variables are not mandatory in the registration process carried out by French cancer registries. For all the analyses a p-value less than 5% was the threshold for statistical significance.

Ethical considerations

The data included in this study were collected by the Somme area cancer registry and stored by the French Data Registry Surveillance Unit for service monitoring and quality improvement. The French National institute for health and medical research (INSERM) and the French National data protection commission (CNIL) approved the use of these data for research purposes.

Declaration of conflict of interest

The authors have no conflict of interest to declare.

3. Results

A total of 2405 incident cases of prostate cancer for which the EDI score was available were registered in the Somme department during the study period. Median follow-up was 4.9 years (interquartile range (IQR): [3 years; 8 years]), 262 patients (10.9%) were lost to follow-up. The crude incidence rate was 174.2 cases per 100,000 person-years (PY), and ASIR came to 145.1 cases per 100,000 PY (European population) and 98.2 cases per 100,000 PY (world population). The crude mortality rate was 61.9 deaths per 100,000 PY, and ASMR was 45.5 deaths/100,000 PY (European population) and 28.1 deaths/100,000 PY (world population).

Mean age at diagnosis was 69.5 years (standard deviation (SD): 9.5 years, range: 44 years to 98 years). With regard to the grade of prostate cancer, 11.6% of the patients had a Gleason score above 7.

Data about the extent of prostate cancer (in terms of distance) were available for 767 patients (32% of the cases), of whom 51 cases (6.6%) had metastasis at diagnosis. Median waiting time for

treatment with curative intent was 8 weeks (IQR: [0; 13.8 weeks]). Mean EDI in the Somme area was 0.762 ±1.754, range: -3.74 to 14.69, and median EDI was 0.786, IQR: [-0.41; 1.72].

Distribution of prostate cancer patients' clinical and therapeutic features according to EDI quintiles are shown in Table 1 (A, B). A total of 1071 patients (44.5%) lived in the most socioeconomically disadvantaged areas; i.e. quintile 5 (Figure 1) with a mean age of 68.8 ±9.6 years. There was no significant association between age and social deprivation level (Table1). The proportion of patients with a Gleason score above 7 was 10.2% in quintile 1 and 13.1% in quintile 5, with no significant difference (Table1). The frequency of curative surgery was 62.1% in quintile 1 and 54.7% in quintile 5, with no significant difference.

Table 1: Distribution of prostate cancer patients' clinical (A) and therapeutic (B) features according to EDI quintiles (Q5 represents the most disadvantaged quintile) (N=2405)

(A)

		Total population N (%)	Age (years) Mean (SD)	Case of prostate cancer by age n (%)			ASIR*(10^5 PY)	ASMR*(10^5 PY)
				<60 years	60-74 years	>74 years		
EDI	**Q1**	209(8.7%)	69.1(9.5)	34(16.2%)	110(52.4%)	66(31.4%)	165.4	28.1
	Q2	221(9.2%)	68.8(8.9)	38(17.3%)	121(55%)	61(27.7%)	120.2	20.0
	Q3	339(14.1%)	68.9(9.6)	64(18.8%)	182(53.5%)	94(27.6%)	100.5	47.4
	Q4	565(23.5%)	69.9(9.5)	90(16%)	293(52%)	181(32.1%)	82.2	55.0
	Q5	1071(44.5%)	68.8(9.6)	187(17.5%)	567(52.9%)	317(29.6%)	58.3	62.0
p			0.24	0.89				

EDI: European Deprivation Index ; PY: person-years

* Age standardization incidence/mortality rates (ASIR/ASMR) using direct standardization based on 2010 standard European population

(B)

		Type of treatment n (%)			Waiting time (weeks) (for treatment with curative intent) Median (IQR)	Gleason grade n (%)		
		curative surgery	curative radiotherapy	palliative or surveillance		<7	7	[8-10]
EDI	Q1	90(62.1%)	17(11.7%)	38(26.2%)	7(1.2-12.7)	73(39%)	95(50.8%)	19(10.2%)
	Q2	93(55.4%)	15(8.9%)	60(35.7%)	8(0-15.7)	76(38.6%)	93(47.2%)	28(14.2%)
	Q3	133(54.7%)	38(15.6%)	72(29.6%)	9(0-15)	126(41.4%)	138(45.4%)	40(13.2%)
	Q4	207(50.2%)	51(12.4%)	154(37.4%)	8(0-13)	248(48.2%)	201(39.1%)	65(12.6%)
	Q5	416(54.7%)	89(11.7%)	256(33.6%)	7(0-13)	450(46.2%)	396(40.7%)	127(13.1%)
p		0.13			0.78	0.08		

EDI: European Deprivation Index

Spatial analysis

Prostate cancer incidence and the EDI

Moran's I test showed a positive spatial autocorrelation of prostate cancer incidence (0.18; p<10-3). The coefficient associated with the EDI in the spatial analysis was negative: -0.348; 95%CI: [-0.0831; -0.0190], which indicates that prostate cancer incidence decreased as the EDI increased (Figures 2, 3). The relative risk (RR) associated with the EDI of the fifth quintile (compared to reference category quintile 1) was 0.42; 95%CI: [0.32; 0.57] (Table 2 and Figures 2, 3).

Table 2: Prostate cancer incidence, mortality, aggressiveness, treatment modality, and treatment waiting time, and the relative risk (RR) associated with the socioeconomic deprivation index (quintile 5(Q5)/quintile 1(Q1)) in the Somme area (2006-2010) (N=2405)

	RR (Q5/Q1)	[95%CI]	p
Incidence*	0.42	[0.32;0.57]	$<10^{-3}$
Aggressiveness*	1.36	[1.09;1.73]	$<10^{-6}$
Waiting time to treatment**	1.05	[0.88;1.24]	0.08
Treatment modality (whether with curative intent or not)**	0.52	[0.41;0.66]	$<10^{-3}$
Mortality**	3.09	[1.70;5.59]	$<10^{-3}$

*Adjusted to age at diagnosis

**Adjusted to incidence, age at diagnosis and grade of prostate cancer at diagnosis.

Table 3: Prostate cancer relative risk of aggressiveness associated with each quintile of the socioeconomic deprivation index in the Somme area (2006-2010) (N=2405)

EDI Quintile	RR*	95%CI	P
Q1	1	-	$<10^{-6}$
Q2	1.05	[0.87;1.42]	
Q3	1.11	[1.07;1.65]	
Q4	1.22	[1.12;1.80]	
Q5	1.36	[1.09;1.73]	

*Adjusted to age at diagnosis
EDI: European Deprivation Index

Table 4: Prostate cancer relative risk of mortality associated with each quintile of the socioeconomic deprivation index in the Somme area (2006-2010) (N=2405)

EDI Quintile	RR*	95%CI	P
Q1	1	-	$<10^{-6}$
Q2	0.98	[0.51;1.84]	
Q3	1.4	[0.74;2.59]	
Q4	2.02	[1.11;3.69]	
Q5	3.09	[1.70;5.59]	

*Adjusted to incidence, age at diagnosis and grade of prostate cancer at diagnosis.
EDI: European Deprivation Index

Prostate cancer aggressiveness and the EDI

The coefficient associated with the EDI was 0.0493; 95%CI: [0.0162; 0.0810], and RR was 1.05; 95%CI: [1.016; 1.084]. The Q5/Q1 RR was 1.36; 95%CI: [1.09; 1.73], which indicates that patients living in the most disadvantaged areas were more likely to be diagnosed with high-grade prostate cancer. Table 3 shows that the relative risk associated with aggressiveness increased with increased deprivation level.

Time-to-treatment of prostate cancer and the EDI

Moran's I test showed a positive spatial autocorrelation in time-to-treatment of prostate cancer. The coefficient associated with the EDI in multivariate analysis of time-to-treatment was 0.0268; 95%CI: [-0.0665; 0.1218], and the Q5/Q1 RR was 1.05; 95%CI: [0.88; 1.24] (Table 2). There was no significant association between time to treatment and social deprivation.

Treatment of prostate cancer with curative intent and the EDI

The coefficient associated with the EDI for the proportion of cases having received treatment with curative intent versus those having received palliative treatment was -0.1089; 95%CI: [-0.1505; -0.0693]. Moran's I test showed a positive spatial autocorrelation in this variable. The RR associated with the EDI (after adjustment for age at diagnosis and prostate cancer grade) was 0.89; 95%CI: [0.86; 0.93], which indicates that patients living in less disadvantaged areas were more likely to receive treatment with curative intent than patients living in more disadvantaged areas. The Q5/Q1 RR was 0.52; 95%CI: [0.41; 0.66] (Table 2).

Prostate cancer mortality and the EDI

Moran's I test showed positive spatial autocorrelation in prostate cancer mortality. The coefficient associated with the EDI in the spatial analysis was positive, which indicates that prostate cancer mortality increased as the EDI increased (Figure 4). Table 4 shows that the relative risk associated with mortality increased with the increase of deprivation level. The Q5/Q1 RR was 3.09; 95%CI: [1.70; 5.59] (Table 2 and Figure 4).

4. Discussion

In our study, a proxy variable, the EDI, was used to assess the level of social deprivation [27,28]. Analysis of the data using this measure showed a positive association between social deprivation and the risk of a late diagnosis and a poor prognosis of prostate cancer. Published studies of socioeconomic status patterns among prostate cancer patients have yielded contrasting results. Divergence in the conclusions of these studies may be explained by the heterogeneity in the methodology used to assess the level of socioeconomic deprivation. The argument that supported our decision to use EDI is that this index appears to be able to capture deprivation in both rural and urban areas [31,32].

Although the Somme area is particularly disadvantaged [68% of people belong to the EDI quintiles 4 and 5, compared for example with the Calvados area (33%)], it was interesting to analyze the effect of the socioeconomic status on prostate cancer in this area for several reasons. First, the cartographic analysis of the socioeconomic disparities at the territorial level shows remarkable heterogeneity that stemming from a major phenomenon of peri-urbanization. This has led to concentration of the disadvantaged areas in the large districts of Abbeville and Amiens and the least

dense areas of the east and west of the Somme. Second, medical demography in the Somme also suffers from substantial disparities. The density of private general practitioners is characterized by unbalanced distribution, which increases average access time to health care, and territorial disparities are considerable. The density of urologists is 1.5 per 100,000 inhabitants, which is below the national average (1.7 per 100,000 inhabitants). The national demography of urologists is characterized by a paradoxical pattern; the areas with the highest proportions of elderly persons present the lowest density of urologists [33].

In the Somme, 58% of the urologists are private and their distribution underscores a disparity between territories [34]. Finally, the Somme area has above-average mortality for several types of cancer, when compared with French national data and western European data [32,35].

Our study found an inverse association between deprivation and prostate cancer incidence. Although some studies have shown disparate results, more recent studies have found a lower incidence of prostate cancer in high-deprivation areas [8,10,36,37]. This result may be explained by greater health awareness among men with higher socioeconomic status [36].

Patient preferences, particularly about PSA screening, may differ from one socioeconomic group to another [29,38]. The association between regional variability (urban vs. rural) and access to healthcare may also influence incidence rates [29,39], particularly in the Somme area, where local disparities in the distribution of general practitioners and specialists and in access time to health care are substantial. Nevertheless, when adjusted for screening rates, some studies have found a positive association between socioeconomic level and incidence rate, suggesting that other risk factors might have a concomitant effect [5,8].

Our study revealed an association between social deprivation and prostate cancer aggressiveness with a socioeconomic gradient. The aggressiveness of prostate cancer was assessed by the Gleason grade, which is the strongest predictor of survival after initial treatment of prostate cancer [25]. The Gleason grade was correlated with the EDI, and our result is consistent with other studies having found that low-grade and early-stage disease was more frequent in men with high socioeconomic status [29,31,37,40,41]. One explanation put forward by some authors consisted in geographic differences in PSA screening [8,36,1,42].

Time to treatment has also been established as a key determinant of cancer outcomes and specific mortality [32]. According to the literature, a high level of education, as well a higher income, are associated with a lower risk of delayed access to health care [31]. In contrast with a previous report, in our EDI-based study, low socioeconomic status was not related to longer time to treatment. This might reflect difficulties in evaluating equal access to medical care [32].

Our study found an inverse association between deprivation and the frequency of cancer treatment with curative intent. Despite different study settings and healthcare systems, our results are in line with findings from other countries: patients with low socioeconomic status are less likely to receive treatment with curative intent [13,29,31,36,41,44–46]. High socioeconomic status is probably associated with greater health awareness, better navigation through the healthcare system, and fewer concomitant diseases [41].

Many studies have shown that men living in more disadvantaged areas have a higher mortality risk from prostate cancer [10,13,31,36]. Social variations in mortality may reflect several tumor-, host-, and healthcare-system-related factors. Lifestyle factors (environmental hazards, chronic stressors, and ethnic differences) related to socioeconomic status, might also have an influence on the mortality rate [10,29,41]. Moreover, a social gradient in mortality may reflect the acceptance of treatment options and patient-physician interactions [41,46]. Attendant physicians' expertise might differ from one socioeconomic group to another, and local variation in disease management may account for some differences in survival [29].

Study strengths and limitations

Our study included an exhaustive survey of prostate cancer cases in a population-based general cancer registry encompassing more than 570,000 citizens (according to the 2014 census). The general cancer registry is a reliable epidemiological dataset, with detailed, ready-to-use information about cancer patients. The availability and the quality of the data provided by cancer registries make them a cost-effective source of data, enable relevant national and international comparisons, and provide an opportunity to perform ecological studies aimed at generating hypotheses on the determinants of cancer (such as socioeconomic status) [47].

Several methodological and statistical limitations related to the use of EDI in our study bear mentioning. These include the difficulty to control for individual and other confounding factors [28]. Furthermore, individual and EDI characteristics might influence one another. In addition, the EDI's effect might have been underestimated by not accounting for length of residence at a person's present address [48].

Another limitation was our reliance on an area-level rather than individual-level measure for socioeconomic deprivation; it may have led us to underestimate the strength of association between socioeconomic status and prostate cancer [29,49]. This risk, however, is reduced by our having used indexed social deprivation with regard to a precise geographic area (the IRIS). In addition, the index allows comparisons over time and between European countries, measuring poverty levels from both objective and subjective viewpoints, with a low degree of ecological bias. Information regarding

medical density at the level of the IRIS was not available at the time of this data analysis, hence; we could not use it for adjustment in spatial analysis.

French cancer registries do not collect certain types of data, a factor that prevented us from addressing the effects of other factors like lifestyle, health beliefs, health awareness, cancer stage, healthcare-seeking behavior, medical practices (e.g. PSA screening), and patient comorbidities. The presence of other chronic conditions could further reduce survival by interacting with cancer treatment [29, 46, 50]. However, it has been shown that comorbidities increased the risk of other-cause mortality but not prostate cancer-specific mortality [51].

Conclusion

The results of our study supported the hypothesis of an association between socioeconomic level and outcome and management of prostate cancer in a relatively disadvantaged region where there are local disparities in terms of both socioeconomic level and density of specialist physicians. Using the EDI as a socioeconomic deprivation level index enabled us to estimate the effect of socioeconomic status while limiting ecological bias; hence, it represents a useful area-based index for ecological analyses.

The observed increase in mortality and the reduced frequency of curative-intent treatment associated with a disadvantaged socioeconomic status should spur further investigations at the individual level aimed at providing potential explanations of this pattern.

The collaboration of family physicians in educating their patients about prostate cancer could increase the likelihood that the patient will be diagnosed at an early stage and consequently receive curative treatment, which could reduce mortality from this cancer.

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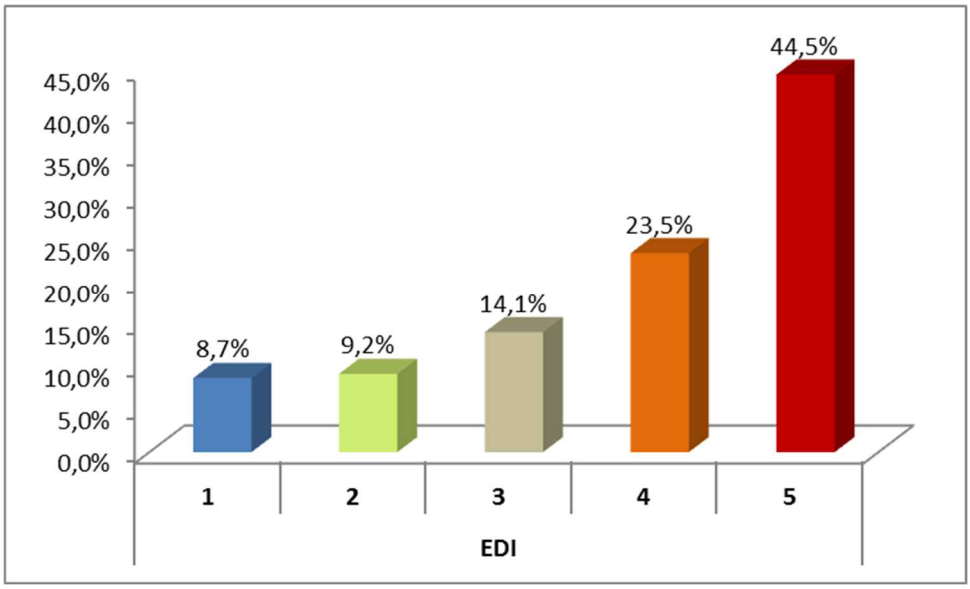

Figure 1: Distribution of cancer cases according to the EDI in the Somme area (2006-2010) (the least disadvantaged quintile 1 is the reference category)

EDI: European Deprivation Index

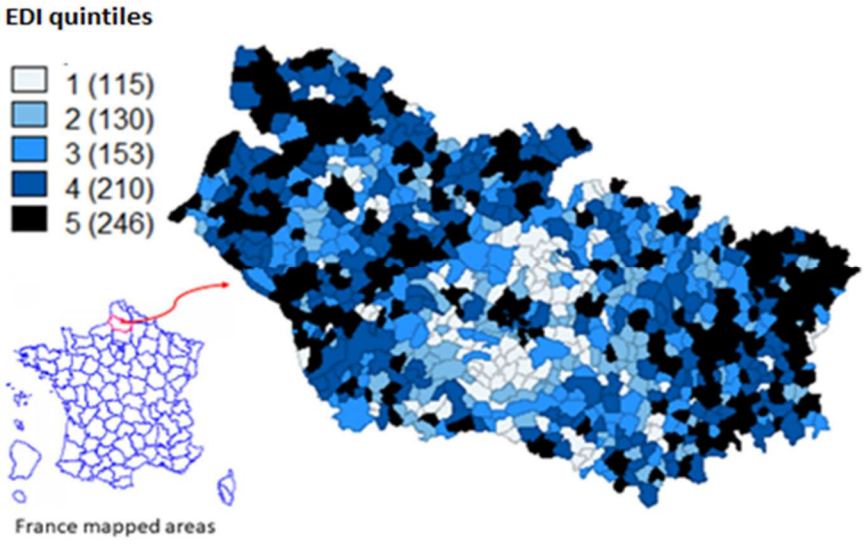

Figure 2: Map showing the socioeconomic level by EDI quintile in the Somme (quintile 1 represents the least disadvantaged areas and quintile 5 represents the most disadvantaged areas) (the legend represents the number of geographical entities (IRIS) by EDI).

EDI: European Deprivation Index

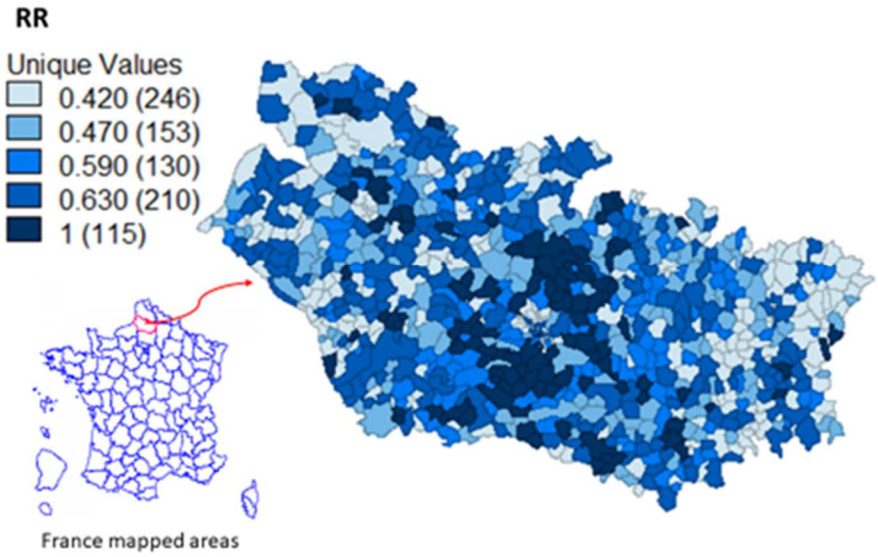

Figure 3: Map showing the relative risk of prostate cancer incidence associated with the EDI in the Somme area (2006-2010) (the least disadvantaged quintile 1 is the reference category) (Number of geographical entities (IRIS) by EDI is represented into brackets)

EDI: European Deprivation Index

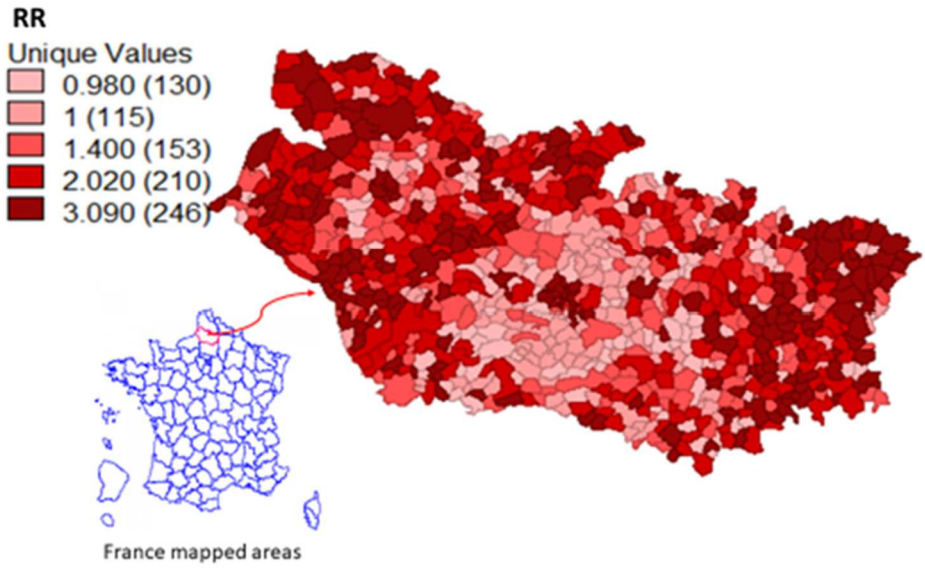

Figure 4: Map showing the relative risk of prostate cancer mortality associated with the EDI in the Somme area (2006-2010) (the least disadvantaged quintile 1 is the reference category) (Number of geographical entities (IRIS) by EDI is represented into brackets)

EDI: European Deprivation Index