

Medical practice patterns and socio-economic factors may explain geographical variation of end-stage renal disease incidence

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Abstract

Background. Incidence rates of renal replacement therapy (RRT) for end-stage renal disease (ESRD) vary geographically not only between but within countries. This study uses data from the French REIN registry to quantify the extent to which socio-economic environment, health care supply and medical practice patterns such as early dialysis initiation or greater propensity to accept frail or elderly patients for dialysis, may explain spatial patterns of ESRD incidence in 85 French districts.

Methods. The association between age- and sex-adjusted incidence rates of RRT in 2008–09 and 17 indicators was explored at the district level with geographically appropriate methods, before and after controlling for the effects of diabetes and the other significant indicators. Rate ratios (RR) and credible intervals (CI) were estimated for a 1-SD increase of each covariate.

Results. Crude RRT incidence by district ranged from 85.8 to 225.5 per million inhabitants. The age- and sex-adjusted RRT incidence increased with the proportion of people unemployed (RR: 1.05, 95% CI 1.01–1.09), the population density (RR: 1.07, 95% CI 1.02–1.12) and the prevalence of diabetes (RR: 1.08, 95% CI 1.03–1.12). It also increased with the proportions of incident ESRD patients >85 years (RR: 1.02, 95% CI 0.99–1.06), of deaths within the first 3 months of RRT (RR: 1.03, 95% CI 1.0–1.06) and of nephrologists in private practice (RR: 1.05, 95% CI 1.01–1.08) and with the median estimated glomerular filtration rate (eGFR) at dialysis initiation (RR: 1.06, 95% CI 1.02–1.09).

Conclusion. This study confirms that socio-economic factors and diabetes explain substantial between-area variations in RRT incidence and highlights the variability of practice patterns, especially decisions about RRT and their potential impact on incidence.

Keywords: diabetes; ESRD; RRT referral; spatial analysis; unemployment

Introduction

Reported incidence rates of renal replacement therapy (RRT) for end-stage renal disease (ESRD) vary widely both between and within countries [1–3]. In metropolitan France, they varied from 92 to 180 per million inhabitants (pmi) between regions in 2009 [4]. Because health care spending and resources explain such a large part of the international disparities [2], the least complicated way of identifying other determinants is to explore geographic patterns of RRT incidence within a country with national health insurance coverage.

The prevalence of various risk factors in the general population may influence the occurrence and progression of chronic kidney disease (CKD) and therefore RRT incidence [5–7]. Some, such as age, gender and diabetes, are well established [8–10]. A few studies have reported that deprivation is associated with higher incidence, regardless of the indicator used [11–15]. The association of urban or rural residence with ESRD incidence is more controversial [11, 16].

Health care resources such as the availability of dialysis centres or the market share of private for-profit haemodialysis facilities may also contribute to geographic variations [2, 14, 16–18]. Most interestingly, practice patterns reflecting broader indications for RRT may also contribute to geographic variations. In a previous study, we showed that starting dialysis at a higher estimated glomerular filtration rate (eGFR) level is associated with higher incidence of RRT [19]. Referral and acceptance to dialysis programmes of very old and frail patients, more likely than others to die shortly after initiation, may also explain the higher rates in some areas compared with areas where these patients are more likely to receive more conservative treatment [20].

Although some studies have investigated factors that may contribute to these geographic variations, they either explored large areas [2, 5, 14, 15, 18, 21–23] or did not take the possibility of local spatial dependence into account [14, 16, 24]. Here, we used appropriate geographic methods to

describe the spatial pattern of RRT incidence in 85 French districts and the extent to which it is explained by socio-economic environment, health care supply and medical practices. Because neighbouring districts tend to have similar rates and influence one another (the characteristics that define spatial dependence [25]), this approach has the twin advantages of capturing information from neighbours, thus strengthening rate ratio (RR) estimates for smaller districts and of adjusting for this spatial dependence to assess 'true' independent information. It provides a smoothed map and reduces the extreme incidence values due to imprecision.

Materials and methods

Sources of data

Information came from the French REIN registry, a national population-based registry of all patients receiving treatment for ESRD. This registry began in 2002 and is expanding progressively to include the entire country. The details of its organizational principles and quality control have been described elsewhere [26]. Districts were characterized by 17 different indicators from various sources, listed in Table 1. We used the most recent data available for all indicators. All patients with chronic renal failure are registered on the first day of RRT, which makes it possible to calculate an early mortality rate, defined as death during the first 3 months of RRT. Patients with a diagnosis of acute kidney failure are excluded, i.e. those who recover all or some renal function within 45 days or are considered as such by experts when they die before 45 days. Mean travel time to the nearest dialysis centre by car was calculated with ArcGis 9.3, its network analyst extension and the Tele Atlas® map database MultiNet® (June 2010).

Statistical analysis

The RRT incidence rate was defined as the number of new patients starting dialysis or receiving a renal graft as first treatment in 2008 and 2009 and living in the 85 districts covered (90% of the French population); the denominator used was the population on 1 January 2009, estimated from census data. Indirect standardized incidence ratios were based on the expected number of incident patients in each district; we multiplied the national 5-year age bands and sex-specific incidence rates in the 2-year period by the corresponding age- and sex-specific population-years at risk.

Hierarchical random-effect Poisson regression models [27, 28] were used to produce smoothed maps of RRT incidence rates and to investigate associations between incidence and district characteristics. The relative risk in each district was estimated by a model including an independent residual with no spatial structure and a spatially structured residual based on an intrinsic conditional autoregressive approach [29]. These models considered both global between-district variability and the tendency of neighbouring districts to have similar rates because of higher probability to have common risk factors than distant districts (local variability) [30–32]. The 85 districts analysed in this study are distributed in 19 regions (higher geographic-administrative level; metropolitan France includes 101 districts and 26 regions). Although all the indicators are collected at the district level, both health care supply planning and ESRD registry data collection and quality control are organized at the regional level. Accordingly, a multi-level model was used to consider both regional and district variability.

We also re-estimated smoothed RRs in each district after adjusting for the effect of district characteristics on RRT incidence rates, to assess both the amount of variability in incidence rates explained by these characteristics and any spatial patterns in residual variability. Associations with each characteristic were examined before and after controlling for the effect of all other significant characteristics in multivariable models and are expressed as RRs of incidence associated with an increase of 1 SD in the levels of each district characteristic. The posterior probability distribution was graphically summarized for each indicator and the median (point estimation) and its credible interval (CI; interval estimation) were calculated. An indicator was considered to be associated with incidence when the posterior distribution was skewed with regard to the value 1.

Models were fitted with an iterative stochastic algorithm, such as Markov chain Monte Carlo methods, in WinBUGS V.1.4.3 (Bayesian inference using Gibbs sampling) [33, 34]. The built-in conditional autoregressive distribution was used to smooth RRs towards the local

Table 1. List of indicators used to characterize the districts and the data source used for each^a

	Source	Year
Socio-economic indicators		
Proportion of people unemployed (%)	INSEE: National Institute of Statistics and Economic Studies	2008
Proportion of people aged 18–59 years receiving minimum guaranteed income allowances (%)	CAF: National familial allowance fund	2007
Proportion of people receiving free health care (%)	CNAM-TS: National Health Insurance Fund	2008
GDP per capita (€ per inhabitants/year)	INSEE: National Institute of Statistics and Economic Studies	2000
Low educational level (%)	INSEE: National Institute of Statistics and Economic Studies	2006
Demographic indicators		
Population density (inhabitants/km ²)	INSEE: National Institute of Statistics and Economic Studies	2007
Proportion of people living in rural area (%)	INSEE: National Institute of Statistics and Economic Studies	1999
Morbidity–mortality		
Age-adjusted ^b cardiovascular mortality rate	Inserm: National Institute of Health and Medical Research	2004
Age- and sex-adjusted ^b prevalence of treated diabetes (%)	CNAM-TS: National Health Insurance Fund	2009
Indicators of health care resources and supply		
Number of general practitioners per 100 000 inhabitants	DRESS: Health Ministry, Department of Research, Studies, Evaluation and Statistics	2008
Number of specialists per 100 000 inhabitants	DRESS: Health Ministry, Department of Research, Studies, Evaluation and Statistics	2008
Number of nephrologists per 100 000 inhabitants	Conseil Ordre des médecins: Medical board data base	2009
Proportion of nephrologists in private practice (%)	Conseil Ordre des médecins: Medical board data base	2009
Proportion of people with a mean travel time exceeding 45 min to reach a dialysis centre (minutes)	REIN registry + Tele Atlas® map database MultiNet®	2007
Indicators of clinical practices		
Median estimated glomerular filtration rate at RRT start (mL/min/1.73m ²)	REIN registry	2008–09
Proportion of incident patients >85 years (%)	REIN registry	2008–09
Proportion of incident patients who died within the first 3 months (%)	REIN registry	2008–09

^aExcept for data collected by the REIN registry, all the other data were download from the website of the National Federation of Regional Health Observatories: <http://www.score-sante.org/score2008/indicateurs.html>.

^bAdjusted on the French population in 2004 (cardiovascular mortality) and 2009 (diabetes).

mean. Vague distributions were chosen in all cases for prior probabilistic distributions, and sensitivity analyses with different specifications were conducted to assess the effect of the original choices [35]. The number of iterations was considered to be sufficient when the Monte Carlo error was <5% of the posterior SD of each parameter [36]. Model comparison was based on the deviance information criterion (DIC) [37]. The lower the DIC values, the better the model. We used each indicator's posterior density plot and CI to determine, if it was associated with RRT incidence. The CIs for the parameters were calculated directly from the estimated posterior distributions with a probability of 95%. To explore our model's goodness of fit in terms of the variability it explains, we compared observed and predicted variability based on a chi-square distance [38]. All maps were produced with Philcarto 5.05 (<http://philgeo.free.fr>) and Adobe Illustrator CS 5.

Results

This analysis covers 16 686 patients who began dialysis or received transplantation between 2008 and 2009 in the 85

districts. The crude annual district RRT incidence rate varied from 86 to 226 pmi, with higher rates in north-east and southern France and lower rates in the west (Figure 1). The ratio of observed to expected new patients in each district varied from 0.6 to 1.5 after adjustment for age and gender.

Distribution of socio-economic factors and medical practice patterns

Indicators of deprivation, including the percentage of people unemployed or receiving a minimum income allowance or free health care, showed substantial variability between districts (Table 2). All three were highly correlated (pairwise comparison of the Pearson correlation coefficients for all three indicators >0.8). Indicators of health care resources and medical practice patterns also

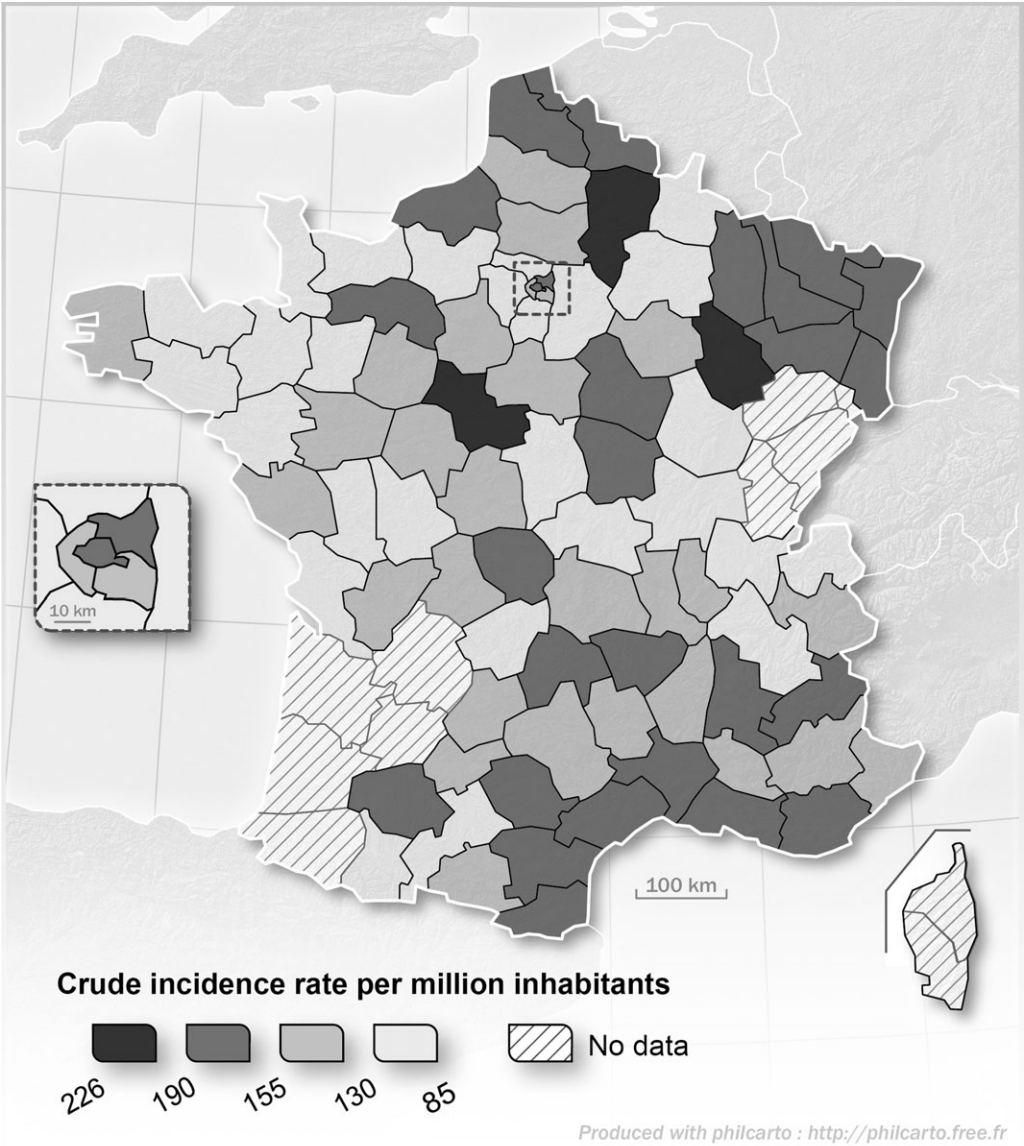


Fig. 1. Spatial distribution of crude annual district RRT incidence rate.

Table 2. Summary statistics of the distribution of the number of incident patients and district characteristics

	Mean	SD	Median	Min	Max
Incidence of RRT					
No. of patients (2008–09)	196.3	160.1	143.0	21.0	897.0
Crude incidence rate/year (pmi)	145.2	26.5	144.0	85.8	225.5
Socio-economic indicators					
Proportion of people unemployed (%)	7.3	1.6	6.9	4.1	11.2
Proportion of people aged 18–59 years receiving minimum guaranteed income allowances (%)	2.8	1.2	2.5	1.2	6.3
Proportion of people receiving free health care (%)	5.8	2.0	5.6	2.7	11.7
GDP per capita (k€ per inhabitants/year)	21.4	7.4	20.0	15.5	67.5
Low educational level (%)	36.7	6.2	37.0	12.0	47.0
Demographic indicators					
Population density (inhabitants/km ²) ^a	83.5	609.4	2566.2	14.9	20 842.9
Proportion of people living in rural area (%)	28.9	20.5	28.4	0.0	77.7
Morbidity–mortality					
Age-adjusted cardiovascular mortality rate per 100 000 inhabitants	238.6	25.3	238.0	143.0	287.0
Age- and sex-adjusted prevalence of treated diabetes (%)	4.3	0.6	4.3	2.8	5.8
Indicators of health care resources and supply					
Number of general practitioners per 100 000 inhabitants	156.5	30.4	155.0	25.0	296.0
Number of specialists per 100 000 inhabitants	145.3	62.8	135.0	19.0	526.0
Number of nephrologists per 100 000 inhabitants	1.7	0.9	1.6	0.0	6.2
Proportion of nephrologists in private practice (%)	16.9	26.3	4.0	0.0	100.0
Mean travel time to reach a dialysis centre (minutes)	21.0	7.0	20.3	1.8	43.4
Indicators of clinical practices					
Median estimated glomerular filtration rate at RRT start (mL/min/1.73m ²)	8.5	1.2	8.5	5.4	11.3
Proportion of incident patients >85 years (%)	9.1	3.6	8.8	2.5	17.4
Proportion of incident patients who died within the first 3 months (%)	5.2	2.6	5.1	0.0	13.7

^aBecause of the skewed distribution, the log-transformed levels of population density were used in all analyses.

varied widely across districts. Of note, the number of nephrologists ranged from 0 to 6.2 per 100 000 inhabitants and the proportion of those working in for-profit centres from 0 to 100%. Overall, 9% of ESRD patients started dialysis after they reached the age of 85 years and 5% died shortly after starting RRT, but significant geographic differences appeared (Pearson correlation coefficients = 0.17). Figures 2, 3 and 4 show the geographic distribution of some indicators: unemployment rates were higher in north-east and southern France, early deaths higher in the east and the proportion of nephrologists in private practice higher in southern and central France.

Association of socio-economic factors with adjusted RRT incidence

Table 3 shows the age- and gender-adjusted RRs of RRT incidence associated with an increase of 1 SD in the level of each factor, both before and after controlling for the effects of all other significant characteristics and adjusting for spatial autocorrelation in the variability of residuals. Each 0.6% increase in the proportion of people treated for diabetes in the general population was associated with an 8% increase in RRT incidence. The three indicators of deprivation that we studied were associated with higher ESRD incidence in the crude analyses. Because they were highly correlated, we introduced only the proportion of unemployed inhabitants into the multivariate analysis. Each

1.6% increase in this percentage was associated with a 5% increase in RRT incidence, independent of the other covariates studied. Using either the percentage of people receiving a minimum income allowance or free health care yielded similar results. In contrast, we found no association between ESRD incidence and gross domestic product (GDP) per capita or low educational level.

The ESRD incidence rate increased as the population density increased and the percentage of people living in rural areas decreased. Because these were highly correlated here (Pearson correlation coefficient = −0.76), only population density was included in the multivariate model.

Association of health resources and medical practice patterns with adjusted RRT incidence

Independent of the other covariates studied, each 26.3% increase in the proportion of nephrologists working in private practice was associated with a 5% increase in RRT incidence. Travel time for the general population to the nearest dialysis centre was inversely related to RRT incidence, but this relation was no longer significant after controlling for other covariates. None of the other indicators of health resources was associated with ESRD incidence.

In the multivariate analysis, each 3.6% increase in the proportion of incident patients >85 years was associated

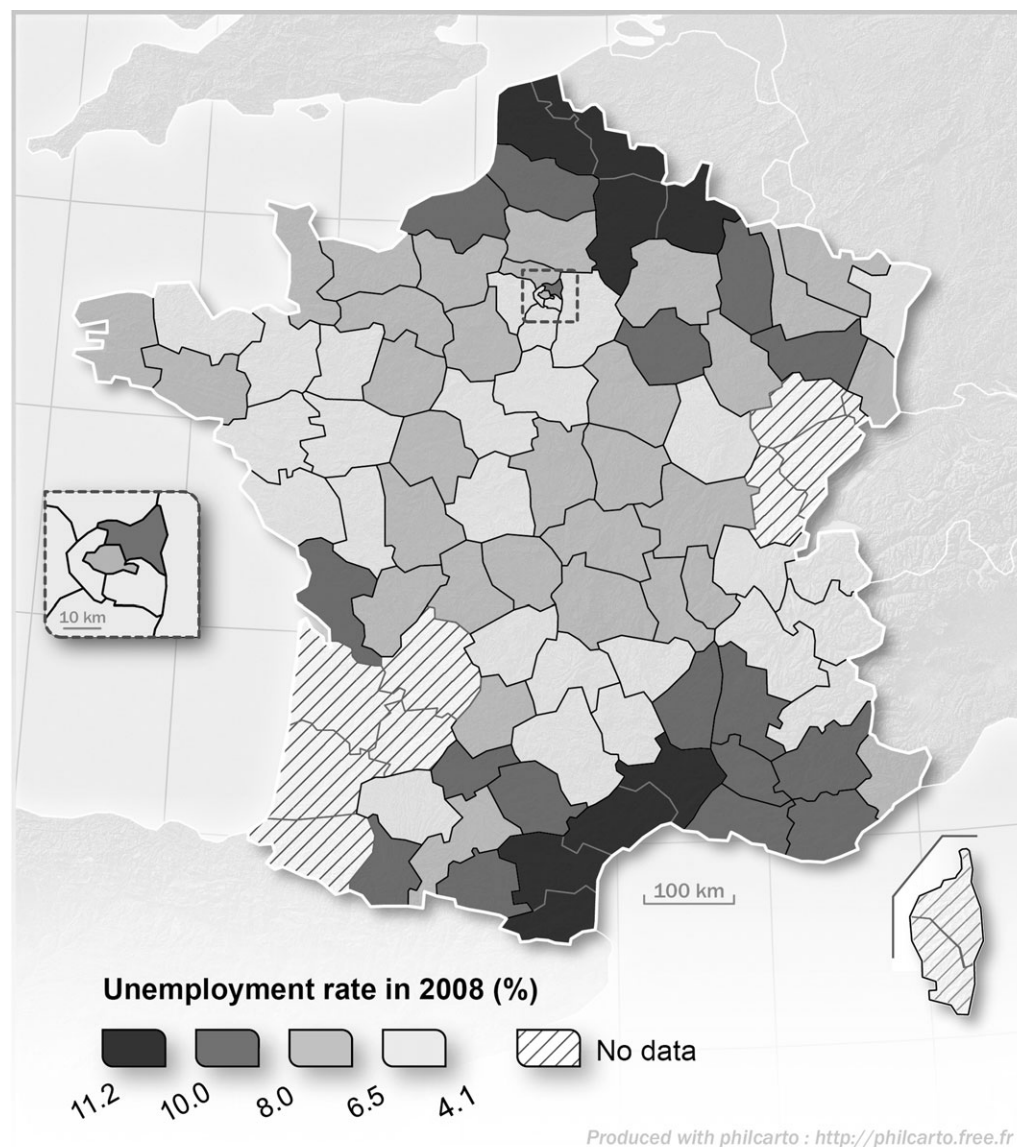


Fig. 2. Spatial distribution of unemployment rates.

with a 2% increase in RRT incidence and each 2.6% increase in the proportion of incident patients who died within the first 3 months with a 3% increase. An increase of 1.2 mL/min/1.73m² in the median eGFR at dialysis initiation in a district was associated with a 6% increase in RRT incidence.

Geographic patterns of the determinants of RRT incidence

The analysis of the geographic patterns of the relative risks, i.e. the ratio of the observed to expected number of new patients in each district, showed two non-contiguous areas of high risk in north-east and southern France and a low-risk area in the western part (Figure 5). In the north-east, higher prevalence of diabetes, higher unemployment rates and greater propensity to accept frail patients, as shown by higher

rates of death soon after dialysis initiation, may explain the higher incidence rates observed. In the south, higher unemployment rates, a larger for-profit sector and, again, greater propensity to accept frail patients, demonstrated by a higher number of elderly patients, were associated with higher age- and gender-adjusted incidence rates.

The decrease in the DIC from 726.5 without covariables to 716.2 in the final model indicates that our model was good in terms of deviance (quality of fit). Using various hyper prior distributions for the parameters produced similar results (data not shown). In the initial model, without covariables, the local residual variability was much greater than the global residual (0.056 versus 0.002), indicating that covariables with a somewhat similar spatial structure would be good candidates to explain the ratio variability. In the final model, local variability decreased from 0.056 to 0.006, but it nonetheless remained two times higher than

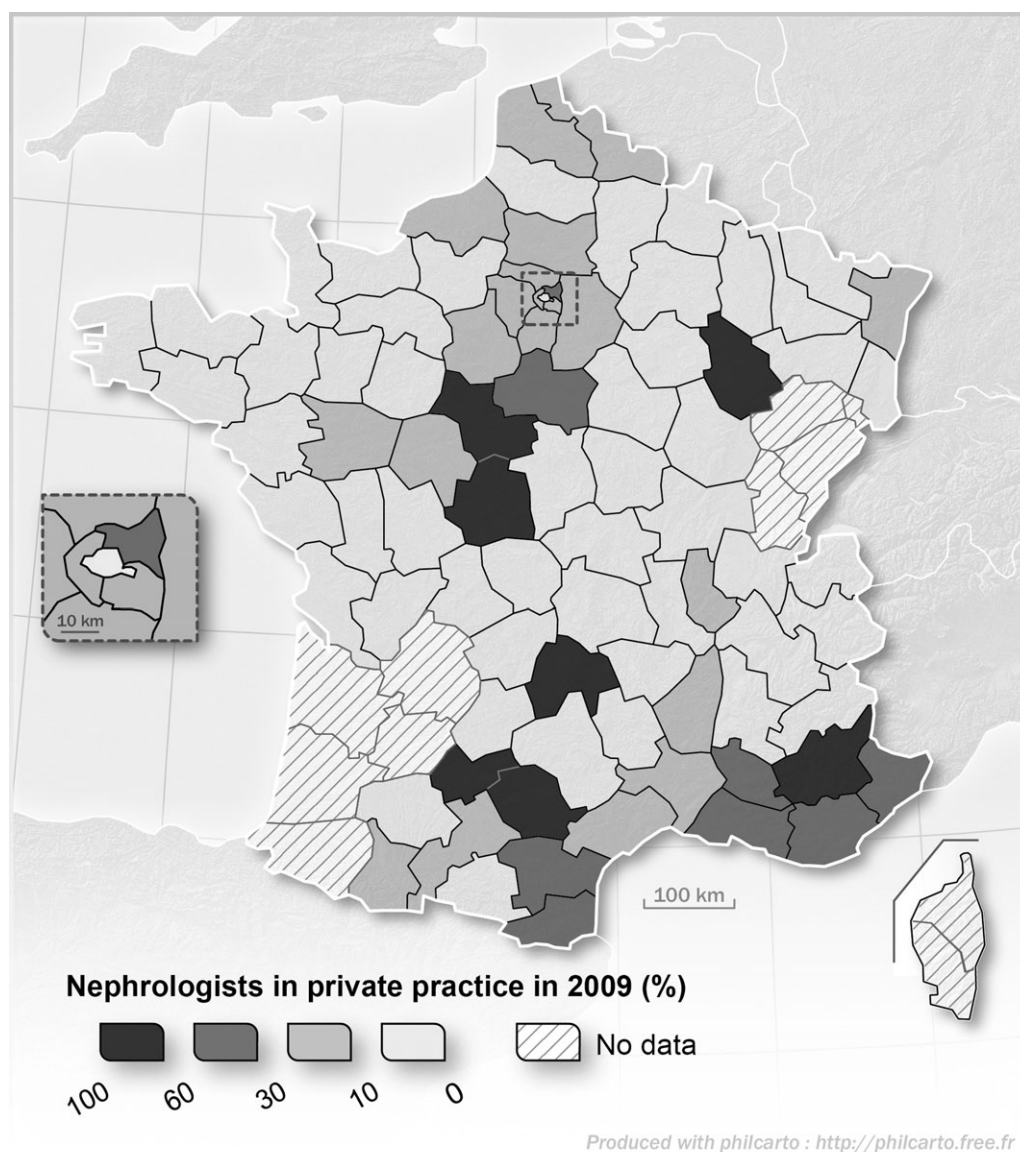


Fig. 3. Spatial distribution of the proportion of nephrologists in private practice.

the global residual and thus confirmed the need to take spatial correlation into account. The chi-square distance between the observed data and the replicated data from the model yielded a P-value of 0.39, which is close to 0.5 and thus indicates that the model explains the variability of the observed data.

Discussion

This study shows significant geographic differences in RRT incidence in 85 French districts and ecological associations between seven district-level explanatory variables and RRT incidence. Our results confirm the impact of diabetes on RRT incidence and add to the body of knowledge about its relation with socio-economic factors. The most original findings concern the potential impact of several

medical practice patterns on RRT incidence, independent of diabetes and socio-economic background. The importance of the study lies in the number of indicators we studied at the district level and the use of geographically appropriate methods.

RRT incidence RRs varied from 86 to 226 pmi among districts within the same country. These variations allowed us to analyse various determinants of this incidence. Similar gradients are observed in other countries. For example, in the USA, adjusted incidence rates varied from 256 to 441 pmi in 2008 [3], and in the UK, from 61 to 166 pmi [39]. Those countries also have different mean levels that might be due to the differences in the prevalence of risk factors in the general population (obesity, diabetes, ethnicity, etc.) but also factors described in our study, such as differences in dialysis acceptance rates and in the socio-economic environment.

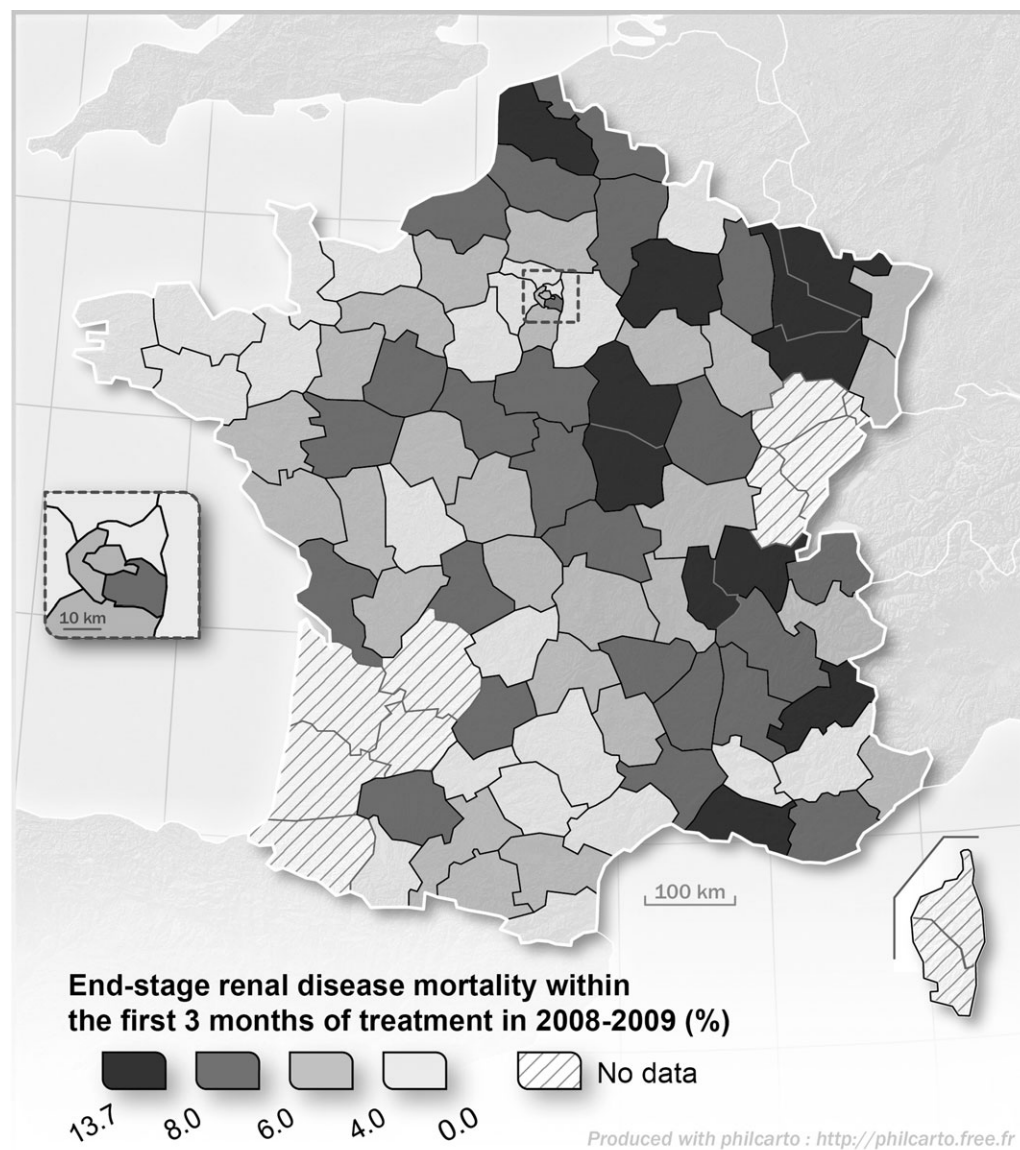


Fig. 4. Spatial distribution of early deaths rates.

As expected, the prevalence of treated diabetes in the general population explained a substantial part of the variability in ESRD incidence [8–10]. The spatial pattern of RRT incidence in France, with levels higher in the north-eastern and southern regions and lower in the west, is consistent with the spatial pattern of diabetes prevalence rates. In contrast, higher cardiovascular mortality was not associated with lower ESRD incidence, as Muntner *et al.* [10] previously observed. Improved survival after myocardial infarction and stroke, however, explained only a small portion of the increase in treated ESRD in their study [10].

The issue of wealth has been studied with different indicators. Young *et al.* [11], for example, showed that ESRD incidence in the USA declined as average per capita income of the county of residence rose, while Caskey *et al.* [2] found a positive association with GDP per capita in 46 countries and Hommel *et al.* [15] higher RRT incidence

rates in patients with low income in Denmark. We found no association between GDP per capita in a district and ESRD incidence. This indicator of global wealth may, however, mask large individual income disparities, and average per capita income may not be a good indicator for France [40]. Similarly, we found no association between ESRD incidence and low education level. The different study design may explain the discrepancy of our results with those of Hommel *et al.* [15], who found higher incident RRT rates in individuals with less education.

The association of a rural or urban environment with ESRD incidence remains controversial. While Young *et al.* [11] found that ESRD incidence in the USA was associated, at least among whites, with the fraction of the county population living in an urban area (RR 1.21, 95% CI 1.16–1.26), a more recent study in South Carolina found higher ESRD rates in rural than urban counties,

Table 3. RRs (and 95% CIs) of the incidence rates associated with an increase of 1 SD in levels of each district-level characteristic, adjusting for spatial autocorrelation in the residual variability

	Crude RR (95% CI)	Adjusted for all other factors RR (95% CI)
Socio-economic indicators		
Proportion of people unemployed (%) ^a	1.09 (1.04–1.14)	1.05 (1.01–1.09)
Proportion of people aged 18–59 years receiving minimum guaranteed income allowances (%) ^a	1.09 (1.05–1.13)	
Proportion of people receiving free health care (%) ^a	1.09 (1.05–1.13)	
GDP per capita (€ per inhabitants/year)	1.00 (0.96–1.04)	
Low educational level (%)	1.00 (0.97–1.04)	
Demographic indicators		
Population density (inhabitants/km ²) ^{b,c}	1.08 (1.03–1.14)	1.07 (1.02–1.12)
Proportion of people living in rural area (%) ^c	0.96 (0.91–1.00)	
Morbidity–mortality		
Age-adjusted cardiovascular mortality rate per 100 000 inhabitants	0.99 (0.94–1.04)	
Age- and sex-adjusted prevalence of treated diabetes (%)	1.09 (1.04–1.14)	1.08 (1.03–1.12)
Indicators of health care resources and supply		
Number of general practitioners per 100 000 inhabitants	1.01 (0.97–1.04)	
Number of specialists per 100 000 inhabitants	1.02 (0.98–1.05)	
Number of nephrologists per 100 000 inhabitants	1.02 (0.98–1.05)	
Proportion of nephrologists in private practice (%)	1.05 (1.01–1.09)	1.05 (1.01–1.08)
Mean travel time to reach a dialysis centre (minutes)	0.91 (0.87–0.96)	1.00 (0.95–1.04)
Indicators of clinical practices		
Median estimated glomerular filtration rate at RRT start (mL/min/1.73m ²)	1.07 (1.03–1.11)	1.06 (1.02–1.09)
Proportion of incident patients >85 years (%)	1.03 (1.00–1.07)	1.02 (0.99–1.06)
Proportion of incident patients who died within the first 3 months (%)	1.06 (1.02–1.10)	1.03 (1.00–1.06)

^aBecause of the correlations between these three variables (all Pearson correlation coefficients >0.8), only the percentage of people unemployed was entered in the final model.

^bBecause of the skewed distribution, the log-transformed levels of population density were used in all analyses.

^cBecause of the correlations between these two variables (Pearson correlation coefficients >0.7), only the population density was entered in the final model.

with an adjusted RR of 1.66 (95% CI 1.59–1.74) [16]. The authors suggested that the combination of rural residency with lower physician density might contribute to higher ESRD incidence because access to health care supply and

prevention might be more difficult. In France, a higher population density was associated with higher ESRD incidence and rural residence with a lower incidence, which may conversely reflect greater difficulties in starting RRT for those who live far from nephrology clinics. The finding by Roderick *et al.* [14] of an inverse relation between acceptance and road travel time in the UK is consistent with this observation. In our study, we did not observe an association between travel time and incidence after controlling for the other covariates. This contradictory result may be explained by the huge difference in the provision of renal services between France and the UK. With similarly sized populations, the UK has 75 main renal units (and their satellites), while there are >1200 dialysis units in France (~450 in-centre units and 750 out-centre units), and 98% of the French general population lives within 45 min of one.

Consistent with previous studies, we found that higher ESRD incidence was associated with deprivation. The association is consistent after controlling for the effects of other significant characteristics, regardless of which of the three deprivation indicators we used. Two ecological studies in the USA found higher ESRD incidence in areas in the lower quartiles of a composite seven-indicator measure of socio-economic status [13] or areas with higher neighbourhood poverty, defined as the percentage of the population below the poverty line [12]. A UK study observed similar results: more deprived populations had a higher acceptance rate onto RRT, regardless of the deprivation index used [14]. Although causality cannot be assumed in an ecological study, some hypotheses may be discussed. Socio-economic status is a potential determinant of several factors that may influence the occurrence and progression of CKD [41–43], including access to health care [9], diabetes [44, 45] and hypertension [46]. Because the national health insurance system covers the entire population in France, access to diagnosis and treatment of ESRD should not be limited by poverty. Medical and hospital costs for patients with CKD are completely covered (100%). Patients with ESRD are treated with dialysis in the public (30%), private for-profit (26%) and private non-profit (44%) sectors, while transplantation is provided only in the public sector. Reimbursement is regulated by uniform rates regardless of whether the patient is treated in the public or private sector. Nonetheless, people at higher socio-economic levels appear to have better preventive medical care, lower exposure to environmental risk factors, better nutritional behaviour and better access to treatment [13].

The finding by Fan *et al.* [16] that higher physician density in South Carolina was associated with lower RRT incidence (adjusted RR: 0.49, 95% CI 0.41–0.58) suggests that better access to care and thus to prevention and treatment slows down the progression of CKD and reduces RRT incidence [16]. Here, the density of physicians was not associated with ESRD incidence. Interestingly, however, the proportion of nephrologists in private practice was higher in districts with higher RRT incidence. Our data cannot determine whether this is a consequence of the failure of the public health system to meet RRT needs in areas at high risk of ESRD or a tendency of the private sector to start dialysis earlier than in the public sector or to have a

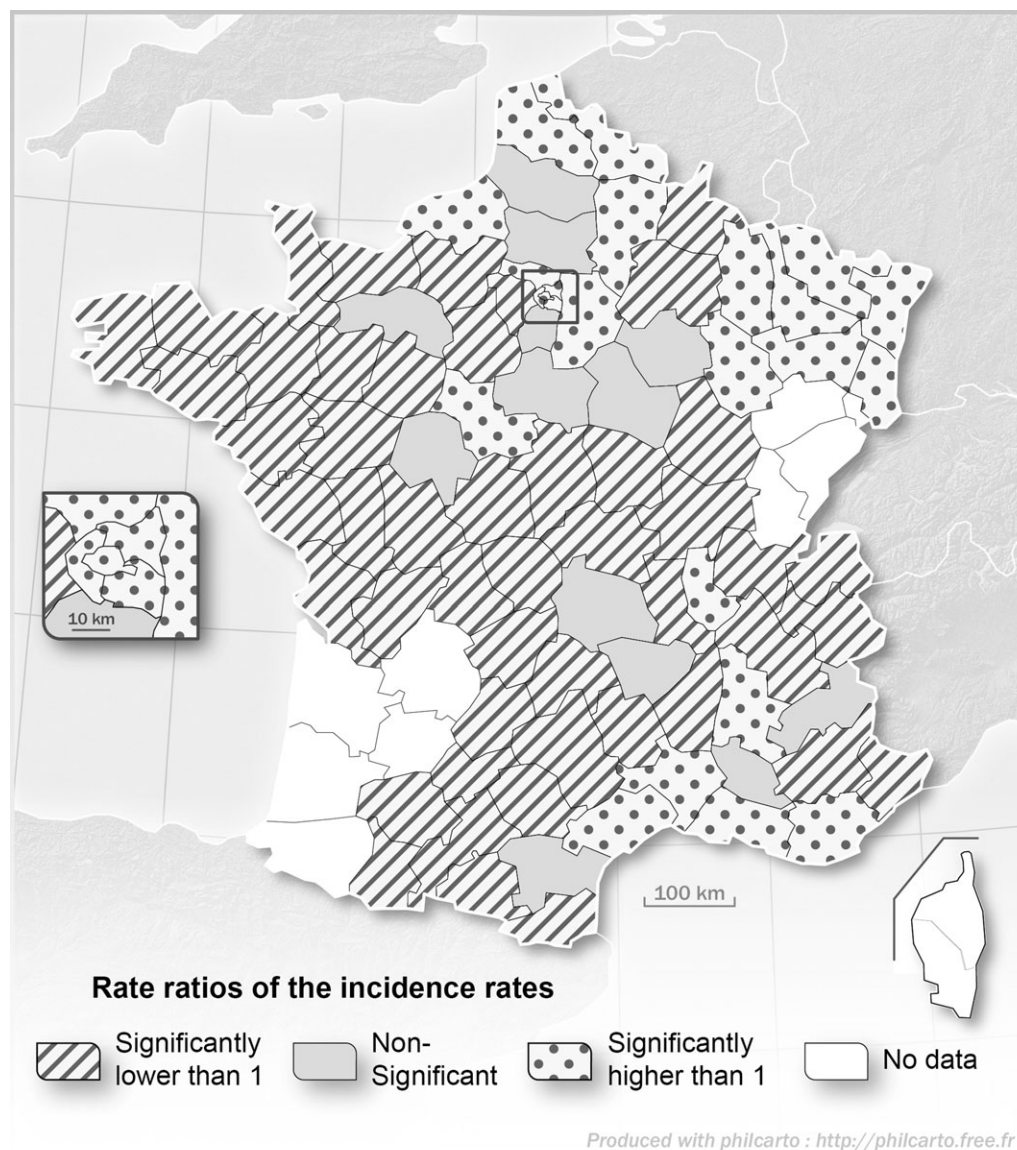


Fig. 5. Spatial distribution of adjusted relative risks (ratio of the observed to expected number of new patients in each district).

more ‘aggressive’ approach towards RRT. At the international level, Caskey *et al.* [2] showed that after taking into account the per capita GDP and the public share of health care expenditure, the higher the private/public ratio for dialysis was, the higher the RRT incidence. A previous study by Hörl *et al.* [18] also found higher take-on rates (that is, the number of patients per million population taken on to RRT in any given year) in countries with higher coverage by private providers but they did not take other potential confounders into account. Nevertheless, the persistence of the association after controlling for the effect of early dialysis start and medical practice patterns tends to favour the first hypothesis.

To analyse differences in clinical practices towards treatment acceptance by physicians and patients, we hypothesized that early death may be a surrogate marker for greater propensity to refer/accept for dialysis patients in especially

poor condition. A high proportion of very old patients (>85 years) was also considered a surrogate marker for such broader RRT indications. We observed that RRT incidence increased significantly as the proportion of very elderly patients and the number of deaths within the first 3 months of dialysis rose. To our knowledge, this is the first report to quantify with geographically appropriate methods the contribution to RRT incidence of practices and decisions related to dialysis indications and initiation.

Strengths and limitations

Major strengths of this study include its analysis of relatively small geographic areas within a country and of a large set of characteristics for each area and its use of an appropriate method to take spatial dependencies and the structure of the data into account.

Our findings, however, should be interpreted in light of the following limitations. The first is that it is an observational ecological study. Associations seen at an area level do not necessarily imply that the factors are associated with an individual's risk of ESRD. We cannot rule out a potential ecological bias associated with population measure. No inference can be drawn about causality. However, the design and purpose of the study was to investigate factors that may contribute to the geographic pattern of ESRD rather than measure individual risks. Secondly, we were unable to take race or ethnicity into account in our analysis because this indicator is not available from national statistics in France. It may indeed explain the higher ESRD incidence in areas with large African populations, such as the Paris area or the south of France. Finally, the district may still be too broad a geographic level to allow us to understand in detail the impact of some factors on CKD.

Conclusions

This study shows that the local socio-economic background, morbidity but also medical practices such as a more aggressive approach towards dialysis may explain variations in RRT incidence rates between areas. Better understanding of the local geography of these rates might help public officials to adjust supply and demand at the district level. It may also prove useful for devising and monitoring strategies for prevention, especially among subgroups with low socio-economic status. It highlights the impact of variations of practice within a single country and the lack of consensus on the criteria for acceptance on a RRT programme.

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Conflict of interest statement. None declared.

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