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Low incidence of SARS-CoV-2, risk factors of mortality and the course of illness in the French national cohort of dialysis patients

see commentary on page 1402

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The aim of this study was to estimate the incidence of COVID-19 disease in the French national population of dialysis patients, their course of illness and to identify the risk factors associated with mortality. Our study included all patients on dialysis recorded in the French REIN Registry in April 2020. Clinical characteristics at last follow-up and the evolution of COVID-19 illness severity over time were recorded for diagnosed cases (either suspicious clinical symptoms, characteristic signs on the chest scan or a positive reverse transcription polymerase chain reaction) for SARS-CoV-2. A total of 1,621 infected patients were reported on the REIN registry from March 16th, 2020 to May 4th, 2020. Of these, 344 died. The prevalence of COVID-19 patients varied from less than 1% to 10% between regions. The probability of being a case was higher in males, patients with diabetes, those in need of assistance for transfer or treated at a self-care unit. Dialysis at home was associated with a lower probability of being infected as was being a smoker, a former smoker, having an active malignancy, or peripheral vascular disease. Mortality in diagnosed cases (21%) was associated with the same causes as in the general population. Higher age, hypoalbuminemia and the presence of an ischemic heart disease were statistically independently associated with a higher risk of death. Being treated at a selfcare unit was associated with a lower risk. Thus, our study showed a relatively low frequency of COVID-19 among dialysis patients contrary to what might have been assumed.

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¹¹Nephrologists of the French REIN registry are listed in the [Appendix](#).

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Due to their frequent contact with hospitals and their comorbid condition, dialysis patients are identified as high-risk patients for severe forms of infection from severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Guidelines to mitigating risks have been published.^{1–7} However, few studies, including case reports and the experience of centers, have included sufficient numbers of patients to have a complete overview of their real risk and course of illness.^{8–16} In those studies, case fatality varied from 14% to 31%.

On March 16th, 2020, the French national end-stage kidney disease renal epidemiology and information network (REIN) registry began to record all patients on dialysis in France who were diagnosed with coronavirus disease 2019 (COVID-19).

The aim of this first report from the French REIN registry is to describe the population of infected dialysis patients and their course of illness, estimate the incidence and lethality of COVID-19, and identify the risk factors associated with the probability of death.

Editor's Note

This is one of several articles we think you will find of interest that are part of our special issue of *Kidney International* addressing the challenges of dialysis and transplantation during the COVID-19 pandemic. Please also find additional material in our commentaries and letters to the editor sections. We hope these insights will help you in the daily care of your own patients.

RESULTS

From March 16th, 2020 to May 4th, 2020, a total of 1621 patients were listed as being infected with SARS-CoV-2 in the REIN registry. This number represents 3.3% of all 48,669 dialysis patients treated in 1245 dialysis units in metropolitan France and overseas territories.

The clinical and care situation for the first report in the registry was “hospitalized—moderate disease” for 48%, “mild disease treated at home” for 39%, “severe disease in an intensive care unit” for 5%, “death” for 2%, and “asymptomatic” for 2% of cases. The first diagnosis was made in 73% of cases with a polymerase chain reaction analysis on a nasopharyngeal swab, 17% on characteristic signs on the computed tomography scan, and 8% on suspicious clinical symptoms. Finally, a positive polymerase chain reaction analysis was available for 1269 patients (79%).

In all, 38% were treated at home. Outpatients, compared with inpatients, were younger (median age: 68.7 years, interquartile range [IQR] 56.7–80.4 vs. 73.7 years, IQR 63.7–81.6, respectively), were more often nonsmokers, and had less dysrhythmia and incapacity for transfer ([Supplementary Table S1](#)). Their mortality level was lower (8.5%) compared to that for patients who were hospitalized (22.4%).

In all, 9% of patients were admitted to an intensive-care unit. Those patients were younger than the others (median age 67.2 years, IQR 58.3–74.5 vs. 72.4, IQR 61.3–81.6), less often had cerebrovascular disease, had a higher body mass index, and were less often treated by hospital-based hemodialysis ([Supplementary Table S2](#)). Among the 87 patients for whom information was available, 51% received invasive mechanical ventilation ([Supplementary Figure S1](#)). The mortality level of intensive-care unit patients was higher (34%) than that for patients who were not admitted to intensive-care units (15.5%).

The clinical situation at the last report in the registry for patients who were still alive was “hospitalized—moderate disease” for 11%, “mild disease treated at home” for 16%, “in intensive care” for 2%, “recovered” for 67%, and “asymptomatic” for 4%, with a median follow-up of 19 days (IQR 6–28).

Not all parts of France were affected in the same way. The prevalence of COVID-19 patients varied from less than 1% in the 5 overseas territories and 8 metropolitan regions to over 5% in 3 northeastern regions (especially in Alsace, at 10%, one of the first French clusters) and in the Île-de-France (9%), the most densely populated region ([Figure 1](#)). These variations were not explained by age and were parallel to those in the general population ([Figure 1](#)). At that time, the percentage of infected persons in the French population was 0.2%, and the mortality level among confirmed cases was 19% (no systematic screening). The cumulative incidence of new cases, after an exponential increase, has now stabilized ([Figure 2](#)).

The control group, selected from dialysis units where there was at least 1 COVID-19 patient, included 25,455 dialysis patients in 689 dialysis units. In these dialysis units, the incidence of COVID-19 infection was 6%.

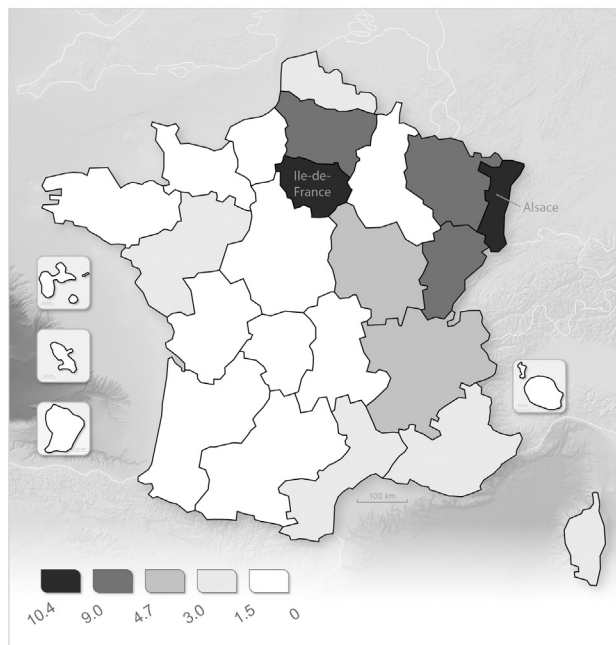
The clinical characteristics of infected dialysis and control populations are represented in [Table 1](#). Compared to the 25,455 selected controls (treated in centers where at least 1 patient was infected), the probability of being a case was higher in male patients (odds ratio [OR] 1.2, 95% confidence interval [CI] 1.1–1.4), patients with diabetes (OR 1.3, 95% CI 1.1–1.4), those in need of assistance for transfer (OR 1.5, 95% CI 1.3–1.8), and those being treated in a self-care unit (OR 1.3, 95% CI 1.0–1.6), compared with those receiving hospital-based dialysis (stepwise logistics regression). Age was not associated with the probability of being infected. Undergoing dialysis at home was associated with a lower probability of being infected (OR 0.6, 95% CI 0.4–0.8), as was being a smoker (OR 0.5, 95% CI 0.4–0.7) or former smoker (OR 0.8, 95% CI 0.47–0.98), having an active malignancy (OR 0.8, 95% CI 0.7–0.99), and having peripheral vascular disease (OR 0.8, 95% CI 0.7–0.9). Adjusted for age, comorbidities, and modality of treatment, compared to living in Rhône-Alpes, living in the Île-de-France (OR 3.1, 95% CI 2.4–4.0) or the northeast—Alsace (OR 3.2, 95% CI 2.3–4.3), Lorraine (OR 1.7, 95% CI 1.2–2.4), Picardy (OR 1.6, 95% CI 1–2.3), and Franche-Comté (OR 1.8, 95% CI 1.0–3.0)—was associated with a higher probability of being infected.

Among the infected patients, 344 died due to a cause related to SARS-CoV-2, after a median time of 6 days (IQR 3–13). The lethality in diagnosed cases was 21%. In the univariate analysis, higher age, being a former smoker, having a chronic respiratory disease, cardiovascular comorbidities (e.g., peripheral vascular disease, ischemic heart disease, congestive heart failure, and dysrhythmia), and frailty (hypoalbuminemia or inability to walk) were associated with a higher risk of death in SARS-CoV-2-infected dialysis patients. Receiving dialysis in self-care units or outpatient centers, as well as being a current smoker, was associated with a lower risk of death. In fact, most of these clinical characteristics and care were associated with older age. In the multivariate model, only older age, hypoalbuminemia, and the presence of an ischemic heart disease were statistically independently associated with a higher risk of death ([Table 2](#)). Being treated in a self-care unit was associated with a lower risk of death. Chronic respiratory disease, obesity, diabetes, and smoking status were not associated with a higher risk of death. The sensitivity analysis including the region of treatment gave similar results.

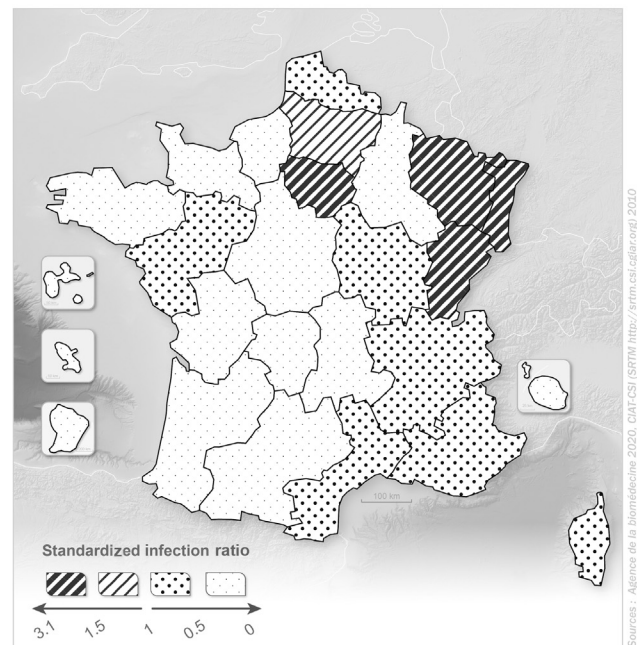
The trajectory of care is represented in [Figure 3](#) for the 287 deceased patients for whom at least 2 different clinical situations were reported in the registry. For severe cases hospitalized in intensive-care units, the median time until death was 7 days (IQR 4–14), whereas the median time for hospitalized patients until death was 5 days (IQR 3–9) and, for patients at home, 6 days (IQR 3–11).

The trajectory of care is represented in [Figure 4](#) for the 799 patients who recovered (clinical situation coded as recovery or asymptomatic). The median time in hospital until recovery

Percentage of dialyzed patients infected with SARS-CoV-2 among dialyzed patients, according to their region of residence



Age-standardized ratio of dialyzed patients infected with SARS-CoV-2 among all dialyzed patients, according to their region of residence



Hospital mortality rate (per 10 000 inhabitants) in the general population

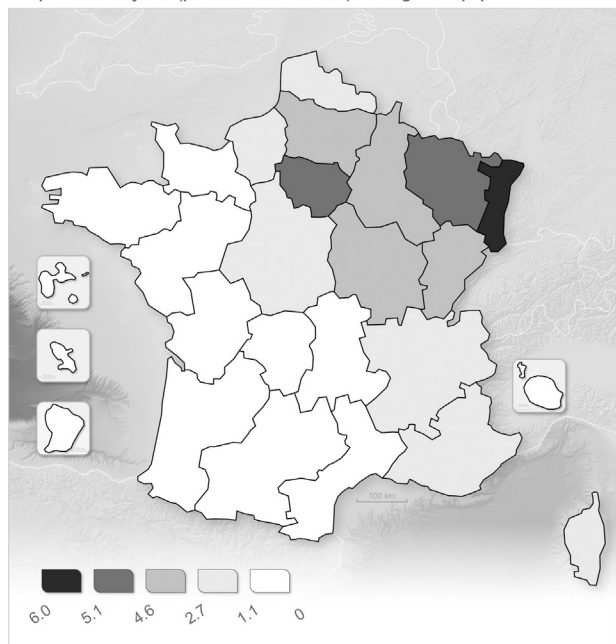


Figure 1 | Spatial distribution of infected patients on dialysis and in the general population. SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

was 15 days (IQR 10–21), similar to that for patients who were at home (16 days, IQR 11–21).

DISCUSSION

So far, more than 1600 dialysis patients have been diagnosed with SARS-CoV-2 infection in France. Our study shows that the prevalence of SARS-CoV-2 infection in dialysis patients varied throughout the country, from 0% to 10%. The mortality level in this population of diagnosed cases is high, at

21%, and is mainly associated with higher age (13% mortality level in patients aged <75 years compared with 30% in patients aged >75 years).

The trend of the SARS-CoV-2 epidemic in patients on dialysis shows a development parallel to that in the general French population, with northeastern regions and the Île-de-France being more affected. Our global prevalence is 3% of dialysis patients, but this reaches 10% in the most-affected regions. In the absence of other population-based data, the

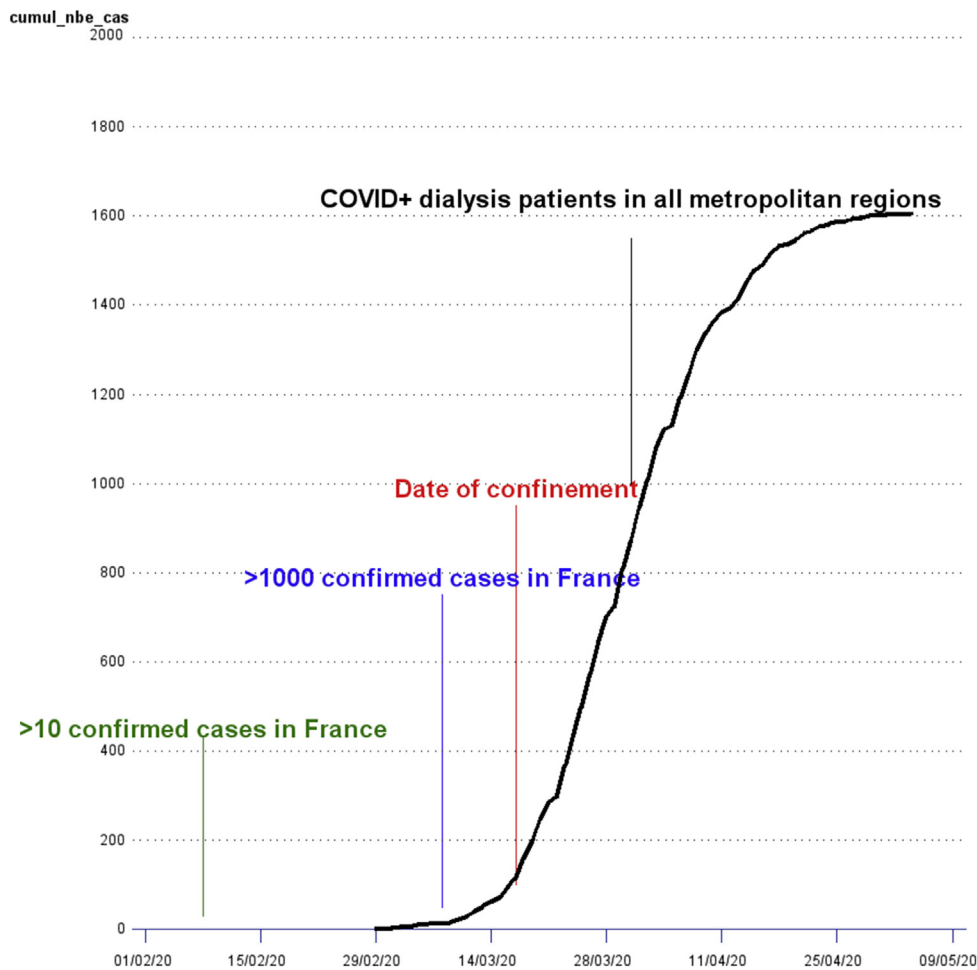


Figure 2 | Cumulative number of dialysis patients with coronavirus disease (COVID) 2019.

prevalence can be compared with only the 14% of the Hemodialysis Center of Wuhan No.1 Hospital at the epicenter of the Chinese epidemic.¹² However, the nonsystematic detection of asymptomatic patients in France may lead to an underestimation of the true distribution of SARS-CoV-2 in the French dialysis population.

Although the lockdown seemed to have significantly reduced the amount of contact among the general population, dialysis patients have to leave confinement to go to their dialysis units and are consequently still in contact with a large number of people. The risk of exposure may occur during transport, at the dialysis unit, or during hospitalization, but also at home with family or caregivers. Home dialysis was associated with a lower probability of being infected, suggesting a protective effect of staying at home. Dialysis centers that were affected later on learned from units contaminated early on in the epidemic's progression and reorganized their patients' circulation and care.^{14,17} Indeed, since the beginning of the epidemic, protective strategies have been broadcast by the Société Francophone de Néphrologie Dialyse Transplantation, with weekly COVID-19 webinars inviting all French nephrologists to discuss the overall COVID-19 themes and topics available on the the organization's

website.¹⁸ Thanks to this collaboration, the worst may have been avoided. However, we must now remain vigilant and protect our healthcare workers.

The initial incidence of the disease in some dialysis units seemed very high, especially in the initially affected regions. The incidence in dialysis units is now decreasing, mirroring the decrease in the general population. This decrease also can be associated with the implementation of all the necessary preventive actions promoted by the Société Francophone de Néphrologie Dialyse Transplantation, including (i) wearing a mask during transport and for the entire period of care, (ii) systematic tracking of patients and screening at the entrance to dialysis units based on fever and symptoms or contact with an infected person, and (iii) restricting areas in which there are COVID-19 cases.¹⁹

As in the general population, male gender, diabetes, and frailty, but not age, were associated with a higher risk of being infected. Selection bias, due to the fact that these patients may have a more severe form of the disease and therefore are more easily diagnosed, cannot be ruled out. As in the cohort of 627 hemodialysis patients at the hemodialysis center in Wuhan, diabetes was associated with a higher risk of infection. This result was still significant when introducing regions in the

Table 1 | Clinical characteristics and method of treatment for COVID-19 patients and for the 2 control groups (selection of patients from dialysis units with at least 1 confirmed COVID-19 patient and all non-COVID-19 patients)

Patients' characteristics	Cases	Selected non-COVID-19 controls	All non-COVID-19 dialysis patients	Missing data
n	1621	25,455	47,048	
Age, yr	71.9 (60.8–81.0)	72.6 (62.2–81.7)	72.1 (61.4–81.2)	0
RRT duration, yr	3.3 (1.4–6.9)	3.6 (1.6–7.3)	3.8 (1.8–7.7)	0
Women	36.2	39.2	39.0	0.0
Age, yr				
0–64	32.6	30.3	31.8	0.0
65–74	26.3	26.5	26.9	0.0
75–84	26.2	27.6	26.7	0.0
≥85	15.1	15.7	14.7	0.0
Smoker	7.5	11.9	12.3	13.2
Former smoker	23.1	26.9	26.6	13.2
Chronic respiratory disease	15.5	16.3	15.8	2.9
Cancer	9.3	11.5	10.6	2.3
Peripheral vascular disease	23.0	24.3	24.4	3.4
Cerebrovascular disease	12.7	12.9	12.5	2.4
Ischemic heart disease	27.2	28.1	27.1	2.7
Dysrhythmia	21.7	25.0	23.6	2.4
Congestive heart failure	22.6	24.4	23.2	2.5
Totally dependent for transfer	4.6	4.9	4.1	6.6
Need assistance for transfer	15.7	12.7	11.2	6.6
Diabetes	50.8	45.3	44.5	1.0
BMI, kg/m ²				
<18.5	4.0	5.6	5.2	7.9
18.5–25	37.9	39.6	39.5	7.9
25–30	31.4	30.6	30.8	7.9
≥30	26.6	24.2	24.5	7.9
Albuminemia, g/l				
>35	63.1	65.1	67.8	7.2
30–35	25.8	24.2	22.9	7.2
≥35	11.2	10.7	9.3	7.2
Hemodialysis				
Hospital	65.0	64.1	54.1	0.0
Outpatient center	22.0	21.4	23.6	0.0
Self-care unit	9.7	7.9	15.9	0.0
Home (includes PD also)	3.3	6.6	6.4	0.0

BMI, body mass index; COVID-19, coronavirus disease 2019; PD, peritoneal dialysis; RRT, renal replacement therapy.

Values are % or median (interquartile range), unless otherwise indicated.

model to take into account the fact that the epidemic was mainly located in northeast France where the prevalence of diabetes is higher. Smoking, even after taking comorbidities into account, was associated with a lower risk of infection, as discussed, in the general population.²⁰ Surprisingly, being treated in a self-care unit was associated with a higher risk of being infected. At self-care units, care is provided without

supervision by an onsite nephrologist.¹⁶ The presence of a nurse is mandatory, and patients are helped with the hemodialysis process. All these units collaborate with a hospital-based dialysis unit. Moreover, these units treat younger patients, who may have had more contact risk than elderly patients. These small units, with fewer caregivers on site, may have been slower to implement protection strategies, as proposed by others.¹ Further analyses are required to evaluate the impact of other risk factors, such as living in an institution or in a deprived neighborhood area associated with overcrowded housing.

International comparison of case fatalities should be made with caution, given the case mix, the various healthcare arrangements, and the various dynamics of the epidemic. Our mortality level among diagnosed cases, 21% so far, is higher than the 13% reported for the dialysis center in Wuhan.¹² The older age and more-frequent comorbidities of French dialysis patients may explain a higher mortality level than that in China.^{21,22} Furthermore, the nonsystematic detection of asymptomatic patients favors more seriously ill patients. In France, the case fatality rate was lower than the 29% reported in 4 outpatient dialysis facilities in Italy,¹⁴ the 30% in a single center in Madrid,¹⁵ or the 31% in a single center in New York.¹⁶ A higher mortality level in these studies may be explained by a selection bias for more severely ill hospitalized patients. Compared to that in the general population, the dialysis lethality rate observed in our cohort was similar to the 20% case fatality rate observed in Italy among patients aged >80 years.²¹ It is also similar to the mortality rate for confirmed cases in the French general population, where at least 84% of the people who died had a comorbid condition, and 92% were aged ≥65 years.

Apart from age, which seems to be the major factor in the general population,²³ nutritional status, indirectly assessed by albumin levels and the presence of ischemic heart disease, seems to be the main risk factor. Further in-depth analyses are planned in order to better estimate the excess mortality level among these dialysis patients, taking into account the underlying mortality risk compared with another period and the non-COVID-19 mortality level. Being treated in a self-care unit was associated with a lower mortality level, even after taking into account age and comorbidities. After adjustment, the mortality level for those on home dialysis did not differ from the mortality rate for those on hospital-based hemodialysis. However, the small number of patients with home dialysis has not allowed us to make an in-depth analysis so far. Other factors (such as living conditions, delay in alerting, and other home-based care), which are not available in our registry, need to be explored.

Although data are incomplete, the illness trajectory seems to show rapid worsening and a slow healing process. The short lapse of time before death could corroborate the physiopathology with the delay in host inflammatory response phase reported 7 to 10 days after the initial infection.²⁴ This rapid negative development raises the question of

Table 2 | Clinical characteristics and method of treatment in COVID patients according to their living status and risk factors associated with the probability of death (stepwise logistics regression)

Patients' characteristics	Living cases	Deceased cases	Death	Crude OR			Final model		
	(col %)	(col %)	(row %)	Inf	Sup	Inf	Sup	Sup	
Female	36.6	34.9	20.4	Ref					
Male	63.4	65.1	21.7	1.1	0.8	1.4			
Age, yr									
0–44	9.8	2.0	5.3	Ref			Ref		
45–64	37.8	13.4	9.9	2.0	0.9	4.5	1.6	0.6	
65–74	26.7	25.0	20.1	4.5	2.0	10.0	3.7	1.4	
75–84	23.4	36.9	29.9	7.6	3.5	16.8	5.4	2.1	
≥85	12.4	25.2	35.4	9.8	4.4	21.9	6.2	2.4	
Never smoker	8.5	3.7	20.0	Ref					
Ex-smoker	24.8	33.7	26.9	1.5	1.1	1.9			
Smoker	8.5	3.7	10.5	0.5	0.3	0.9			
Chronic respiratory disease	14.3	20.4	27.6	1.5	1.1	2.1			
Cancer	9.5	8.8	19.9	0.9	0.6	1.4			
Peripheral vascular disease	21.2	29.9	27.5	1.6	1.2	2.2			
Cerebrovascular disease	12.3	14.1	23.4	1.1	0.8	1.6			
Ischemic heart disease	24.7	36.4	28.2	1.8	1.4	2.3	1.6	1.1	
Dysrhythmia	19.4	30.6	29.7	2.0	1.5	2.7			
Congestive heart failure	21.2	27.9	26.0	1.5	1.1	2.1			
Totally dependent for transfer	3.8	7.7	35.7	2.2	1.3	3.9			
Need assistance for transfer	14.1	21.6	29.3	1.9	1.4	2.7			
Walk without help	80.2	68.2	18.7	Ref					
Diabetes	49.5	55.5	23.2	1.2	1.0	1.6			
BMI, kg/m ²									
<18.5	4.0	4.1	21.8	1.1	0.5	2.2			
18.5–25	38.2	37.1	20.8	Ref					
25–30	30.4	35.4	24.0	1.2	0.8	1.6			
≥30	27.5	23.4	18.7	0.8	0.5	1.1			
Albuminemia, g/l									
>35	65.1	55.7	18.5	Ref			Ref		
30–35	25.1	28.2	22.9	1.5	1.1	2.0	1.3	0.9	
≥35	9.8	16.2	30.3	2.2	1.4	3.5	1.8	1.1	
Hemodialysis									
Hospital	62.7	73.3	24.0	Ref			Ref		
Outpatient center	23.4	17.2	16.5	0.6	0.4	0.9	0.8	0.5	
Self-care unit	11.2	4.1	8.9	0.3	0.1	0.5	0.4	0.2	
Home (includes PD also)	2.7	5.5	35.2	1.5	0.7	3.0	1.8	0.8	

BMI, body mass index; col, column; COVID, coronavirus disease; Inf, inferior; OR, odds ratio; PD, peritoneal dialysis; Ref, referent; RRT, renal replacement therapy; Sup, superior.

whether provision can be made for reinforced surveillance at home and during dialysis sessions, and preventive hospitalization in a safe environment. Our definition of recovery should be assessed with caution, as the definition of recovery is still under debate. Some patients were maintained in the hospital under isolation for 15 days.

Very soon after the start of the epidemic, the French-speaking Society of Nephrology, helped by infectious disease specialists, made the recommendation that for each dialysis patient with fever, a viral syndrome, pulmonary symptoms, or diarrhea, a computed tomography scan be prescribed, as well as a polymerase chain reaction test on a nasopharyngeal swab. Contact subjects were also tested in the later period, explaining the occurrence of a few asymptomatic patients. These recommendations applied to all hospitalized patients and outpatients as well, throughout the country. However, due to possible variations in diagnosis strategies, day 1 for each patient may vary from one unit to another. Access to intensive-care units was a concern for nephrologists in certain areas. Some tensions could be noted in highly affected regions, but in general,

dialysis patients could be transferred to intensive care as required depending on their age and comorbidities.

The strength of this study is its national scale, including the whole population of French dialysis patients. However, these results must be interpreted bearing the following limitations in mind. Various screening strategies may influence the detection of the disease. This could especially be the case for patients treated at home or asymptomatic patients or those undergoing sudden death, but mild cases and hospitalized patients can be considered exhaustive. Nonsystematic screening favors the collection of more-severe cases and leads to an overestimation of lethality. The second limitation is the lack of granular data on clinical presentation, laboratory results and treatment, and the precise protective strategy implemented in the units. Our study is based on a registry, which gives an exhaustive national overview but with a limited dataset—not on medical records, which could give more detailed data on treatment and clinical presentation, but on a limited number of patients with a risk of selection bias. Third, due to the confinement of registry research assistants,

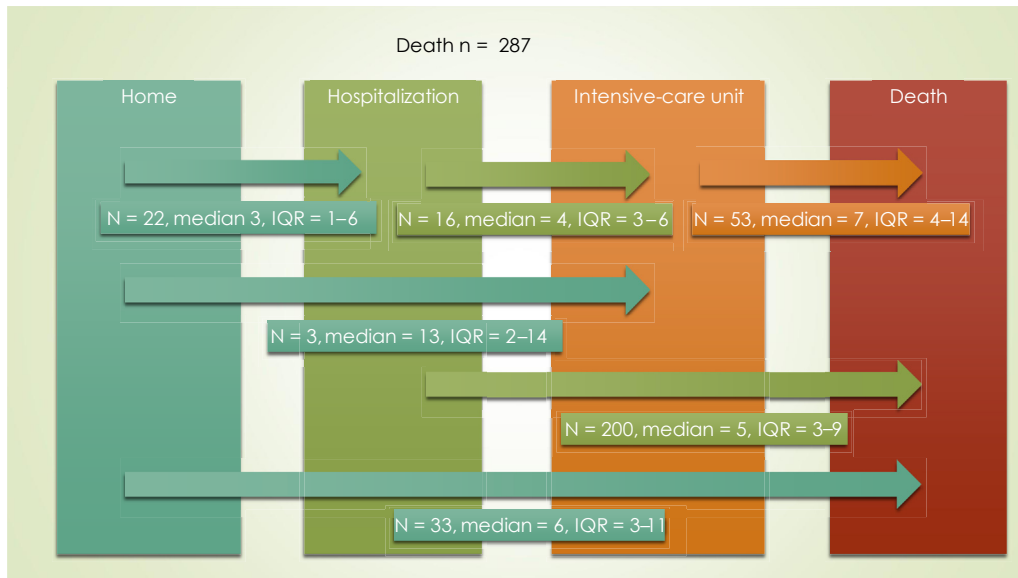


Figure 3 | Care trajectory, before death, for 287 patients (number of patients and median and interquartile range [IQR] number of days before transfer).

the data-quality control procedure was limited. Post hoc controls will be taking place to complete the data. Fourth, the total number of patients tested and not considered to be COVID positive is unknown. As in the general population, the true lethality of COVID-19 in infected dialysis patients needs to be confirmed by a longer follow-up and deployment of screening methods.

Conclusion

Despite the difficulty of having a “true” estimation, this preliminary report of the French registry shows a relatively low frequency of COVID-19 among dialysis patients, contrary to what might have been feared, but as in the general

population, the epidemic did not evenly affect the whole territory. The mortality level in diagnosed cases (21%) is associated with the same causes as in the general population, namely, advanced age, frailty, and comorbid conditions.

METHODS

Population

The French REIN registry is intended to include all end-stage renal disease patients on renal replacement therapy living in France, including overseas territories. Patients with a diagnosis of acute renal failure were excluded, that is, those who recovered all or some renal function within 45 days or were considered by experts to have acute failure when they died before 45 days. The details of organizational

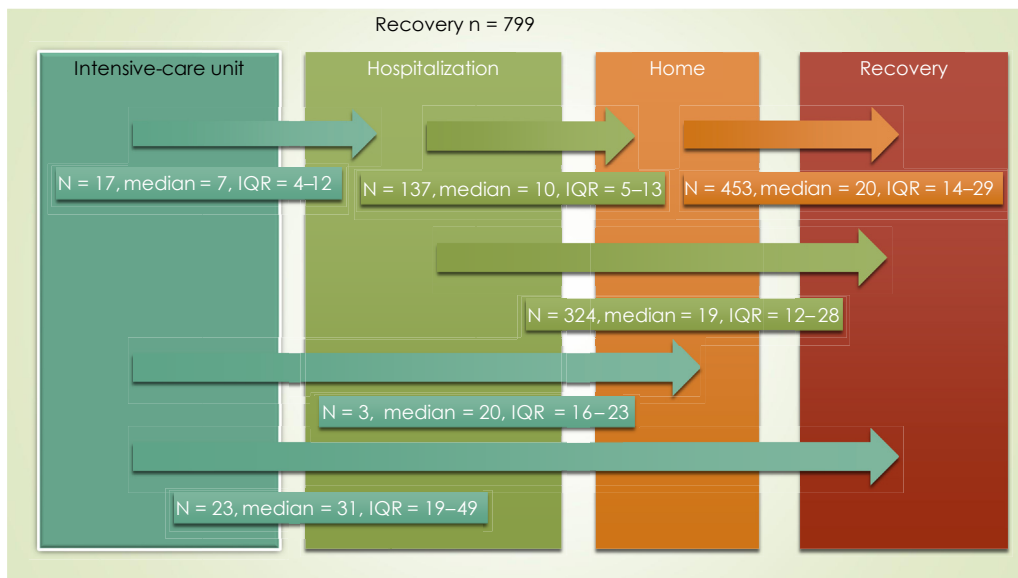


Figure 4 | Care trajectory, before recovery, for 799 patients (number of patients and median and interquartile range [IQR] number of days before transfer).

principles and quality control are described elsewhere.²⁵ The REIN network includes nephrologists, nurses, patients, public health representatives, and epidemiologists coordinated within regional and national steering committees. The national coordination center is based at the Agence de la Biomédecine, a public health agency that oversees the activity of organ and tissue procurement and transplantation. The REIN registry is supported by the National Health Insurance Funds and the Ministry of Health. Although participation in the registry is not mandatory, dialysis centers are strongly encouraged to participate, as new regulations on renal replacement therapy require the regular provision of data to administrative agencies. The participation rate of centers in all contributing regions is 100%. Thirty-two clinical research assistants regularly visit each dialysis center to check the completeness of patient and event registration and to ensure the quality of data. This study included all patients on dialysis on the French mainland and French overseas territories in April 2020. Data were extracted on May 4th, 2020. A new extraction was made on June 22nd to update patients' follow-up.

Information

Clinical characteristics at last follow-up included age, gender, comorbidities, mobility status (walks without help, needs assistance for transfers, or is totally dependent for transfers), body mass index, tobacco use, hemoglobin and serum albumin levels, dialysis technique (hemodialysis or peritoneal dialysis) and location (hospital-based, outpatient center, self-care unit, home). This study analyzed 10 comorbidities: diabetes, congestive heart failure, ischemic heart disease, peripheral vascular disease, aortic aneurysm, cerebrovascular disease, dysrhythmia, active malignancy, cirrhosis, and severe behavioral disorders (defined as including dementia, psychosis, or severe neurosis that may have affected the functional status or adherence to treatment).

The last residence and last dialysis unit before February 15, 2020 were taken into account to avoid misclassification of patients transferred to another dialysis center due to their infection status.

With the help of the REIN clinical research assistants, in the presence of either suspicious clinical symptoms, characteristic signs on the chest scan, or a positive reverse transcription polymerase chain reaction for SARS-CoV-2 on a nasopharyngeal swab, the nephrologists declared infection by SARS-CoV-2 on the registry.

The clinical and care status declaration was categorized into 7 groups measuring the severity of the illness over time: asymptomatic; mild disease treated at home; hospitalized—moderate disease; severe disease in an intensive-care unit; death; recovered; other. The date of the first report to the registry was the date of diagnosis. Each modification to the clinical status was reported on occurrence. For the purpose of this study, recovery was defined as either asymptomatic or recovered. Patients were also classified according to the ordinal scale proposed by the World Health Organization.²⁶

Analysis

The clinical characteristics of patients were expressed as frequencies and percentages for qualitative variables, and medians with interquartile ranges for quantitative variables.

The percentage of infected patients in the dialysis units of each region was adjusted on age (indirect standardization) to take into account the underlying age distribution of the dialyzed patients. The crude ratio and the standardized ratio are presented on a map, according to the patients' area of residence. To give an overview of the

epidemic in France, the hospital mortality level due to COVID-19 in April 2020, extracted from the platform of the national public health agency—Santé Publique France²⁷—was reported.

We also presented the cumulative number of infected patients on a day-to-day graph for the whole country.

To describe the characteristics of infected patients, we compared this population with 2 control groups. The first one included all the dialysis patients in France who were not infected. The second, to take into account the heterogeneity of the distribution of the epidemic in the country, included only patients treated in the dialysis units where at least one infected patient had been declared. Risk factors associated with being a case in those units were analyzed by logistics regression with a stepwise selection of variables. The final model is based on complete data (no imputation). A *P*-value of <0.05 (2-sided) was considered statistically significant. Results are reported as OR with 95% confidence interval.

Lethality was estimated from the proportion of deceased patients among the diagnosed cases. To identify the risk factors associated with death in SARS-CoV-2 dialysis patients, a logistics regression with stepwise selection of variables was used. Interactions between age and other factors were explored. A *P*-value of <0.05 (2-sided) was considered statistically significant. Results are reported as OR with 95% confidence interval. Sensitivity analyses were made including the region of treatment, either as a fixed effect or with a random intercept.

Finally, when available, the course of illness was represented on a graph to describe the process of care for patients who died and for those who recovered. For each transition between the various care statuses, the number of patients and the median duration before transfer were calculated.

APPENDIX

Nephrologists of the French REIN registry

Abdelhamid Abbassi, Alain Debure, Abdallah Guerraoui, Abdelatif Benmoussa, Abdelaziz Hamani, Abdelaziz Ziane, Abdelhamid Nefti, Abdelkader Hadj, Abderrahim El Amari, Abderrahmane Ghazali, Abo Bakr Abd El Fatah Mohamed, Achour Laradi, Adel Ben Ahmed, Adel Sahar, Adele Pillet, Adeline Lacraz, Adnan Moinat, Afshin Massoumi, Agathe Pardon, Agnes Caillette Beaudoin, Agnes Chapelet Debout, Agnes Mariot, Ahmed Rachi, Aida Afiani, Aime Remy Boula, Al Jalaby, Alain Cremault, Alain Fournier, Alain Jeanson, Alain Lyon, Alain Nony, Alain Robert, Alain Slingeneyer, Alanor Agnes Labatide, Albane Brodin Sartorius, Albert Bensman, Albert Fournier, Alex Ranlin, Alex Vido Sandor, Alexandra Colombo, Alexandra Duhem, Alexandra Stancu, Alexandre Dufay, Alexandre Dumoulin, Alexandre Ebel, Alexandre Klein, Alexandre Martin, Alexandre Mouneimne, Alexandre Seidowsky, Alfio De Martin, Alfredo Zannier, Ali Aizel, Ali Hafi, Ali Zineddine Diddaoui, Alim Heyani, Alina Mocanu, Alina Preda, Aline Hafi, Aline Talaszka, Alyette Duquesne, Amar Amaouche, Amel Ghemmour, Amelie Simon, Amina Skalli, Amine Boukadda, Amr Ekkhass Ragab Eid, Ana Fedorca, Anabelle Baillet, Anais Poyet, Ancuta Bouffandeau Giorgita, Anderson Ratsimbazafy, Andre Pruna, Angel Argiles, Angelo Testa, Ann Karolien Vandoreen, Anne Jolivot, Anne Kolko Labadens, Anne Lataste, Anne Maisin, Anne Paris, Anne Sechet, Anne Wuillai, Anne Elisabeth Heng, Anne Gaëlle Josse, Anne Helene Querard, Anne Helene Reboux, Anne Laure Adra, Anne Laure Faller, Anne Laure Leclerc, Anne Laure Poitou, Annie Lahoche Manucci, Antoine Jacquet, Antoine Pommereau, Antoine Thierry, Arezki Adem, Arielle Chapelet, Arnaud Del Bello, Arnaud Delezire, Arnaud Garnier, Arnaud Guerdar, Arnaud Klisnick, Arnaud Lionet, Arnaud Roccabianca, Arnaud Stolz, Arthur Capdeville, Asma Allal, Assem Alrifai, Assetou Diarrassouba, Assia Djema, Assia Ferhat Carre, Astrid Godron Dubrasquet, Atman Haddj Elmrabet, Audrey Jegado, Aurelia Bertholet Thomas, Aurelie Davourie Salandre, Aurelie Pajot, Aurelien Lorthioir, Aurelien Tiple, Aurore Sury, Ayman Abokasem, Ayman Sarraj, Bachir Henaoui, Baher Chaghouri, Bassem Wehbe, Beatrice Ball, Beatrice Viron, Belkassem Issad, Benedicte Hodemon Corne, Benedicte Janbon, Benjamin Deroure, Benjamin Savenkoff, Benoit Jonon, Benoit Vendrely, Benyakoub Djelaledine, Bernard Ohry, Bernard Painchart, Bernard Strullu, Bernard Temperville, Bertin Ebikili,

Bertrand Hacq, Bertrand Morel, Bilal Aoun, Blanca Muniz, Bouchra Chlih, Brahim Amara, Brice Mayor, Brigitte Gilson, Brigitte Llanas, Brigitte Zins, Bruno Bourgeon, Bruno Coevoet, Bruno Guery, Bruno Legallier, Bruno Paris, Bruno Ranchin, Bruno Seigneuric, Camelia Ghiciuc Dita, Camelia Prelipcean, Carine Achard Hottelart, Carine Diet, Carlos Frangie, Carlos Vela, Carmina Muresan, Carole Deprele, Caroline Araujo, Caroline Bidault, Caroline Creput, Caroline Delclaux, Caroline Du Halgouet, Caroline Favennec, Caroline Freguin, Caroline Gourraud Vercel, Caroline Mesguen, Caroline Ndomo Obama, Caroline Poitou, Caroline Preissig Dirhold, Caroline Roubiou, Catherine Albert, Catherine Bessin, Catherine De Marhon Gaja, Catherine Godart, Catherine Lasseur, Catherine Leocardi, Catherine Lumbroso, Catherine Melander, Catherine Michel, Catherine Quere Maouraud, Catherine Rouannet, Catherine Taddei, Cathy Verove, Cecile Guiraud, Cecile Tafelin, Cecile Turc Baron, Cedric Formet, Cedric Pinier, Celia Lessore De Ste Foy, Celine Granolleras, Chaouki Bennini, Charles Cartou, Charles Chazot, Charlotte Jouzel, Cherif Badid, Christa Roubicek, Christel Viaud, Christelle Verrier, Christian Chuet, Christian Combe, Christian Dabot, Christian Duvic, Christian Emond, Christian Lagarde, Christian Lamotte, Christian Pain, Christiane Mousson, Christie Lorrtaux, Christine Beauchamp, Christine Fumeron, Christine Le Gurun, Christine Leroy, Christine Pietrement, Christine Richer, Christophe Bouaka, Christophe Charasse, Christophe Goupy, Christophe Ridet, Cindy Castrale, Cindy Detourne, Clair Francois, Claire Presne, Claire Trivin, Clarissa Von Kotze, Claude Bernard, Claude Bonniol, Claude Desvergnès, Claude Raharivelina, Claudia Nistor, Claudine Gueret, Claudine Lloret, Claudine Salties, Clelia Rosati, Clementine Rabate, Corina Stanesco, Corinne Ferrandini, Corinne Guibergia, Corinne Lemoine, Corinne Passeron, Cynthia Kahil, Cyril Garrouste, Cyril Vo Van, Cyrille Jolimoy, Dalila Kesraoui, Damien 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Lebhout, Francis Schillingier, Franck Berge, Franck Bourdon, Franck Bridoux, Franck Reynaud, Francois Babinet, Francois Basse, Francois Chantrel, Francois Clair, Francois Coulomb, Francois De Cornelissen, Francois Glowacki, Francois Marchal, Francois Maurice, Francois Nobili, Francois Pourreau, Francois Provot, Francois Roux Amani, Francoise Broux, Francoise Bulte, Francoise Heibel, Francoise Leonetti, Francoise Mousson Schott, Frank Le Roy, Frederic Besson, Frederic Lavainne, Frederic Tollis, Frederique Bocquentin, Frederique Meeus, Frederique Vecina, Friederike Von Ey, Gabriel Balit, Gabriel Choukroun, Gabriel Gruget, Gabriel Huchard, Gabriella Golea, Gabrielle Duneau, Gaëlle Lefrançois, Gaëlle Pelle, Gaëtan Lebrun, Genevieve Dumont, Georges Brillet, Georges Deschenes, Georges Mourad, Georges Stamatakis, Geraldine Cazajous, Geraldine D'ythurbide, Geraldine Robitaille Wiart, Gerard Cardon, Gerard Champion, Gerard Deschodt, Gerard Mangenot, Gerard Motte, Gerard Schortgen, Ghada 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DISCLOSURE

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AUTHOR CONTRIBUTIONS

CC, FB, AC, BC, BP, CF, FL, GR, HM, LE, LT, ML, and MO contributed to the design of the study, to the analysis of the results, and to the writing of the manuscript. All authors read and approved the final version of the manuscript.

SUPPLEMENTARY MATERIAL

Supplementary File (PDF)

Table S1. Comparison of outpatients with other patients.

Table S2. Comparison of the patients that were admitted to an intensive-care unit, with the other patients.

Figure S1. Distribution of the higher level on the ordinal World Health Organization scale (except death) for 87 intensive-care unit patients.

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