Recovery of dialysis patients with COVID-19: Health outcomes 3 months after diagnosis in ERACODA

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ABSTRACT

Background. COVID-19-related short-term mortality is high in dialysis patients, but longer-term outcomes are largely unknown. We therefore assessed patient recovery in a large cohort of dialysis patients three months after their COVID-19 diagnosis.

Methods. We analyzed data on dialysis patients diagnosed with COVID-19 from February 1st, 2020-March 31st, 2021 from the European Renal Association COVID-19 Database (ERACODA). The outcomes studied were patient survival, residency, and functional- and mental health status (estimated by their treating physician) three months after COVID-19 diagnosis. Complete follow-up data was available for 854 surviving patients. Patient characteristics associated with recovery were analyzed using logistic regression.

Results. In 2449 hemodialysis patients (mean±SD age: 67.5±14.4 years, 62% male) survival probabilities at three months after COVID-19 diagnosis were 90% for non-hospitalized patients (N=1087), 73% for patients admitted to the hospital but not to an ICU (N=1165) and 40% for those admitted to an ICU (N=197). Patient survival hardly decreased between 28 days and three months after COVID-19 diagnosis. At three months, 87% functioned at their pre-existent functional and 94% at their pre-existent mental level. Only few of the surviving patients were still admitted to the hospital (between 0.8 and 6.3%) or a nursing home (approximately 5%). Higher age and frailty score at presentation and ICU admission were associated with worse functional outcome.

Conclusions. Mortality between 28 days and 3 months after COVID-19 diagnosis was low, and the majority of patients who survived COVID-19 recovered to their pre-existent functional and mental health level at three months after diagnosis.

Keywords: COVID-19, dialysis, functional health status, mental health status, survival
KEY LEARNING POINTS

What is already known about this subject?

- Previous studies have shown that COVID-19-related short-term mortality is high in dialysis patients.
- Data on the longer-term recovery of dialysis patients after COVID-19 are scarce.
- We therefore studied different health outcomes, including patient survival, residency (home/hospital/nursing home), and functional- and mental health status in a large group of dialysis patients three months after a COVID-19 diagnosis.

What this study adds?

This study demonstrates that 78% of the dialysis patients survived COVID-19 with the large majority recovering to their pre-existent functional and mental health level at three months after diagnosis. Patients who had not yet recovered were mostly those who had been ICU-admitted.

What impact this may have on practice or policy?

Our findings show that if dialysis patients survive COVID-19, the outcome at 3 months is rather good. This implicates that optimal treatment of COVID-19 in this high risk group is recommended without restrictions. Treating physicians may use this information during consultation with patients, for instance when in doubt whether or not to admit them to the hospital and/or an intensive care unit.
INTRODUCTION

The COVID-19 pandemic has a major impact around the world, with dialysis patients being among the patient groups with the highest mortality (1,2). If infected with SARS-CoV-2, these patients often develop a serious course of COVID-19 which requires in-hospital care. The European Renal Association COVID-19 Database (ERACODA) Working Group previously reported a 28-day mortality of 25% in dialysis patients during the first pandemic wave (3). In these patients, age and frailty were the dominant factors independently associated with higher mortality (3). These findings were confirmed in larger cohorts of patients receiving dialysis (4-6).

Notwithstanding the high short-term mortality in dialysis patients, most patients were alive at 28 days after the diagnosis of COVID-19, but data on longer-term health outcomes in dialysis patients who survived COVID-19 are virtually absent. It could well be that a relevant proportion of patients experience functional deterioration without recovery or die at a later stage due to the long-term complications of COVID-19 (7). The aim of this study was to assess the recovery of dialysis patients at three months after COVID-19 diagnosis, in terms of patient survival, residency, and functional- and mental health status. Here, we present the first results on these outcomes, as well as their associations with patient and COVID-19 characteristics.
MATERIALS AND METHODS

Study population

This study is based on data from ERACODA, which contains granular data on adult patients (aged >18 years) with kidney failure who were treated with dialysis or living with a functioning kidney allograft and who developed COVID-19 (8). The COVID-19 diagnosis was based on a positive result on a real-time polymerase chain reaction (PCR) assay or a rapid antigen test of nasal and/or pharyngeal swab specimens, and/or compatible findings on CT scan or chest X-ray of the lungs.

The database uses REDCap software, a secure web application for building and managing online databases (Research Electronic Data Capture, Vanderbilt University Medical Center, Nashville, TN, USA) (9) and is hosted at the University Medical Center Groningen (UMCG), the Netherlands. Patient information is stored pseudonymized. The study was approved by the Institutional Review Board of the UMCG, who deemed the collection and analysis of data exempt from ethics review regarding the Medical Research Involving Human Subjects Act (WMO). Data on outpatients and hospitalized patients were voluntarily reported by physicians responsible for their care.

A total of 225 physicians from 141 centers in 33 countries, mostly in Europe and bordering the Mediterranean Sea, entered data in ERACODA. For the current study, we included all dialysis patients who presented with COVID-19 between February 1, 2020 and March 31, 2021 for whom information on age, sex, hospitalization, intensive care unit (ICU) admission, and three-month vital status were available. The inclusion started at the start of the COVID-19 pandemic in Europe with the predominant original SARS-CoV-2 genotype, whereas it ended when the effect of the vaccination campaign in Europe became of influence. For 80 patients (3.3%) the dialysis modality was unknown, and we assumed that these patients received in-center
hemodialysis, because this was by far the most common dialysis modality in ERACODA and also in general within Europe (10).

**Data collection**

We collected detailed information on patient characteristics, including age, sex, ethnicity, frailty, comorbidities, hospitalization, and medication use, and on COVID-19 related characteristics such as symptoms, vital signs, and laboratory test results. Frailty was assessed using the Clinical Frailty Score (11), which ranges from 1, representing very fit, to 9, representing terminally ill. Comorbidities were recorded at presentation from patient charts and obesity was defined as a Body Mass Index (BMI) >30 kg/m².

Information on functional and mental health outcomes was collected once at three months after first presentation with COVID-19. Due to the study design, we had no options to invite individual patients to report on their functional and mental outcome. Since nephrologists generally meet their hemodialysis patients every week and know their patients well, we asked them to report on these outcomes. We composed a standardized questionnaire for this purpose (Appendix 1). If patients had not recovered at three months, we asked which limiting factors were judged to be responsible for not reaching the pre-COVID-19 functional and mental health status and how long they estimated the interval to reach the pre-COVID status.

**Statistical analysis**

All baseline patient and disease characteristics are presented for the total population, and separately for the categories: not hospitalized, hospitalized but not ICU admitted, and hospitalized and ICU admitted. Continuous data are presented as mean (standard deviation; SD) or median (interquartile interval; IQR) if the data were not normally distributed. Categorical data
are presented as percentages. We used ANOVA-tests to compare continuous variables between the three subgroups (Kruskal Wallis test for non-normally distributed data) and Pearson Chi-2 tests to compare categorical variables. Hemodialysis and peritoneal dialysis patients were analyzed separately, but the main focus in this paper is on hemodialysis because of the small sample size of the peritoneal dialysis group.

Unadjusted cumulative survival probability curves by hospitalization and ICU admission status were created using the Kaplan-Meier method and compared using Log-rank tests. Unadjusted and adjusted hazard ratios (HRs) with 95% confidence interval (CI) were calculated to compare the risk of mortality in hemodialysis and peritoneal dialysis patients.

We analyzed functional and mental health outcomes in those who were alive at three months after COVID-19 diagnosis. Numbers and proportions are presented for the total group and by hospital- and ICU admission status. Pearson chi-2 tests was used to compare proportions between patient groups.

Unadjusted and adjusted logistic regression models were applied to calculate odds ratios (ORs) with 95% CI for the likelihood of reaching the pre-COVID-19 functional or mental health status. A broad set of variables, including demographics, comorbidities, COVID-19 symptoms and admission to hospital and/or ICU, was included in the crude analysis. Selection of variables for the multivariable model was based on statistical significance in the crude analysis. The multivariable models included age, sex, frailty score, heart failure, respiration rate, shortness of breath, hospitalization, and ICU admission for functional status and all these variables plus coronary artery disease for mental health status. Missing data in the multivariable models were handled by multiple imputation (10 imputed datasets created with 100 interactions) with the chained equations method using all variables included in the model (12,13).
All analyses were performed using Stata version 14.0 (Stata Corp LP, College Station, TX, USA). A 2-sided \( P \)-value \(<0.05\) indicated statistical significance.

**RESULTS**

**Study population and patient characteristics**

During the study period, 3331 dialysis patients in the ERACODA database presented with COVID-19. Information on age, sex, hospitalization, ICU admission, and three-month vital status was available for 2617 patients (2449 hemodialysis and 168 peritoneal dialysis). There were 1087 hemodialysis patients (44\%) who were not hospitalized, 1165 (48\%) who were hospitalized but not admitted to the ICU and 197 (8\%) who were admitted to the ICU. Table 1 shows the baseline patient and disease characteristics for these subgroups and for the total group. For almost all patients (99.8\%) the COVID-19 diagnosis was based on a positive PCR test. Patients who were admitted to the ICU were younger, less often Caucasian, less frail and had higher BMI, longer dialysis vintage, less previous transplantations and more severe COVID-19 symptoms in comparison to the two other subgroups. Characteristics of peritoneal dialysis patients are presented in Table S1.

**Survival at three months**

Overall, 1909 of the 2449 hemodialysis patients (78\%) survived the first three months after presentation with COVID-19. Those who survived were younger, had a lower frailty score, less comorbid conditions and less symptoms and signs of COVID-19 at presentation than those who died the first three months (Table S2).

At day 28, the survival probability of hemodialysis patients was 90\% in the patients who were not hospitalized, 75\% in those who were hospitalized but not admitted to the ICU and 47\%
in those who were admitted to the ICU. At three months after COVID-19 diagnosis, survival probabilities were 90%, 73% and 40%, respectively. This indicates that there is just a limited effect on survival between 28 days and 3 months after diagnosis. Survival was lower in patients admitted to the ICU when compared with those who were not (P-value Log-rank test <0.0001). Kaplan-Meier curves for the three groups are presented in Figure 1.

Among peritoneal dialysis patients survival probabilities at three months were 86% for patients not hospitalized, 61% for patients hospitalized but not admitted to the ICU, and 67% for those ICU-admitted (Figure S1). The survival probability was lower (P=0.006) in those who were hospitalized but not admitted to the ICU, when compared to those admitted to the ICU.

**Residence at three months**

Figure 2 presents the residence of survivors at three months after the COVID-19 diagnosis. Although this variable was unknown for a relatively large proportion of patients (58% of patients who were not admitted, 27% of those hospitalized and 28% of those admitted to the ICU), we observed that in case residence was known, most patients were at home at three months of follow-up (36%, 65% and 61%, respectively). Approximately 5% of the patients (in all 3 groups) lived in a nursing home, whereas the proportion of patients that were in the hospital varied between 0.8% in those that were initially not hospitalized to 6.3% in patients that had been ICU-admitted.

**Functional and mental health status**

Data on functional and mental health status were collected at the time point three months after COVID-19 diagnosis and were available for 854 of the 1014 hemodialysis patients (84%) who were alive at this time point and had follow-up data available (Figure S2). The residence status of
these patients is presented in Figure S3. Characteristics of patients who were excluded from this analysis because of missing values did not differ from those of the included patients, except for active malignancy as comorbidity which was more frequent in patients with missing data and respiration rate which was lower in those with missing data (Table S3).

At three months after COVID-19 diagnosis, according to their nephrologist functional status had recovered to the pre-COVID-19 level in 87% of the patients (Figure 3A), whereas this was not the case in 111 patients (13%). The proportion of patients who did not recover was higher in the subgroup admitted to the ICU compared to the other two subgroups. Among those who had not yet recovered, the most important limiting factors were reduced muscle strength (48%), reduced mobility (41%) and tiredness (37%). For 58% of these patients, their nephrologist estimated that they would reach their pre-COVID-19 functional status within one year after diagnosis, while they estimated that this would never happen in 28%. Patients for whom a late (>1 year) or no functional recovery was expected, were older, had a higher frailty score, more often had coronary artery disease as comorbidity and had a lower O$_2$ saturation (data not shown). There were no statistically significant differences in limiting factors for recovery between patients who were not hospitalized, those hospitalized but not admitted to the ICU, and those admitted to the ICU (Table 2). In a multivariable logistic regression analysis, older age (OR: 0.98 per year; 95%CI: 0.97-1.0), higher frailty score (OR: 0.79 per unit; 95%CI: 0.70-0.90), and ICU admission (OR: 0.43; 95%CI: 0.18-0.99) were associated with a lower likelihood to reach pre-COVID-19 functional status (Table 4).

Treating nephrologists indicated that 94% of their patients had reached their pre-COVID-19 mental health status at three months after COVID-19 diagnosis (Figure 3B). Although mental health tended to be more often impaired in the subgroup of patients admitted to the ICU, this was not statistically different compared to the other 2 subgroups. Among the 51 patients (6%) who
had not reached their pre-COVID-19 mental health status, the most commonly mentioned limiting factors were memory loss (35%), depression (31%), and anxiety (18%). For 56% of these patients, their nephrologist expected that the pre-COVID-19 mental status would be reached within the upcoming year, whereas 27% were expected to never fully recover their mental health state. There were no statistically significant differences between the subgroups based on hospital admission (Table 3). For mental health status, only a higher frailty score (OR: 0.75 per unit; 95% CI: 0.63-0.90) was associated with a lower likelihood of reaching the pre-COVID-19 status (Table 4).

There was considerable overlap in the recovery of functional and mental status. Among the 743 patients in whom the functional status had recovered within 3 months, there were only 5 patients (0.67%) in whom the mental status had not yet recovered. Conversely, almost half (N=46; 41.4%) of the 111 patients who had not yet recovered functionally, also had not recovered mentally after 3 months.

Finally, the residence status differed between patients who had and those who had not yet recovered. Among those whose functional status had not recovered, 17.2% lived in a nursing home and 11.8% was still hospitalized after 3 months, versus 9.6% and 1.8%, respectively in those who had recovered. For mental status, 24% of those not recovered lived in a nursing home and 20% was still hospitalized, whereas this was 9.7% and 2%, respectively for those who had reached their pre-COVID-19 mental status.

In the subgroup of peritoneal dialysis patients, data on functional and mental health status were available in 52 of the 168 patients. At three months, 42 peritoneal dialysis patients (81%) had reached their pre-COVID-19 functional status and 46 (88%) their pre-COVID-19 mental health status. The low numbers of patients who did not reach their previous functional (N=10)
and mental health (N=6) status precluded a meaningful analysis of the time needed to recover and factors that limited recovery in this group.

DISCUSSION

This study shows that functional and mental health had recovered to the pre-existent level according to their nephrologists in the majority of dialysis patients who were alive at three months after COVID-19 diagnosis. Impaired functional outcome was associated with older age, higher frailty score, and ICU admission, whereas impaired mental outcome was associated only with higher frailty score. Among those who had not fully recovered at three months after COVID-19 diagnosis, 58% of patients were expected to recover functionally and 56% to recover mentally within 1 year. Together, our results show that although the short-term mortality of COVID-19 in hemodialysis patients is high, surviving patients have a good prognosis to recover from COVID-19, both functionally and mentally.

We demonstrated that in dialysis patients who were alive at three months after a COVID-19 diagnosis only 13% still had an impaired functional status compared to their pre-COVID-19 status. Not unexpectedly, non-recovery to pre-COVID-19 functional status was more frequent in patients who were admitted to the ICU. The most prevalent limiting factors for functional recovery were reduced muscle strength (48%), reduced mobility (41%) and tiredness (37%). In a French general population cohort, 51% of patients that were admitted for COVID-19 reported in a telephone interview to have at least one persistent symptom, of which 31% had fatigue (14). In a study from China, patients who survived COVID-19 were interviewed after hospital admission with a series of questionnaires (15). Fatigue or muscle weakness were reported by as many as 63% of patients six months after COVID-19 onset. A report from Italy demonstrated that 54% of
COVID-19 survivors had some form of functional impairment after hospital admission as measured by a short physical performance battery and 2-minute walking test (16). The frequency of non-recovery of functional health after surviving COVID-19 seems less distinct in our dialysis cohort. The difference in findings may-at least in part-be explained by the fact that dialysis patients already have been adapted to having limited pre-existent functional capacity. (17). In addition, mortality is high in these patients, which may also lead to the most fit patients to survive. Lastly, differences between these previous studies and our study in the way of assessing functional status may have played a role.

Notably, the COVID-19 pandemic has raised levels of anxiety and depression in the general population and in patients with various chronic conditions (18-21). In contrast, Bonenkamp et al. showed that mental health of a small group of chronic dialysis patients without a diagnosis of COVID-19 was not affected during the pandemic as measured by the mental component summary score of Short Form 12 and items of the Dialysis Symptom Index (22). This suggests that the dialysis population may be different from other populations with respect to the impact of the COVID-19 pandemic on mental health, maybe because patients already suffer greatly from their kidney disease and treatment (23). Many dialysis patients have developed coping mechanisms in order to maintain satisfactory mental health. In a French cohort of COVID-19 survivors from the general population, 21% of patients reported cognitive disturbances four months after COVID-19 diagnosis (14). In a Chinese cohort COVID-19 survivors from the general population, sleep difficulties, anxiety or depression were reported by 26% and 23% of patients (15). No other data have previously been published on the recovery of mental health status after surviving COVID-19 in dialysis patients. In the present study, mental health had not yet recovered to the pre-COVID-19 level at three months after COVID-19 diagnosis in only 6% of hemodialysis patients. In contrast with functional recovery, mental health
recovery to pre-COVID-19 status was not significantly worse in hemodialysis patients that had been admitted to the ICU compared to the other two subgroups in our analysis. The most frequently reported limiting factors for mental health recovery were memory loss (35%), depression (31%), and anxiety (18%).

Survival at three months was almost identical to the survival at 28 days after presentation with COVID-19. Only in patients that at any time had been admitted to the ICU, a moderate decrease in survival probability from 47 to 40% was observed between 28 days and three months after COVID-19 diagnosis. Survival in patients admitted to the ICU (40%) was much lower than in those that were not admitted (90%) and in those that were admitted to the hospital but not to the ICU (73%). The lower survival in dialysis patients that were admitted to the ICU is remarkable, especially considering the fact that these patients were younger and had a lower frailty score. In our opinion, this indicates that physicians in times of limited resources are in general more inclined to accept younger patients to an ICU, while they tend to be more hesitant to admit older and more frail patients, of whom it is assumed that they have a lower chance of survival. Together with the relatively low proportion of patients that were admitted to the ICU, this suggests that strict triage has been performed. After ICU admission, 26% of the surviving hemodialysis patients had impaired functional outcome at three months follow up, whereas there was no association between ICU admission and mental health recovery at three months. This observation suggests that it is important to consider physical revalidation after discharge, especially after ICU discharge.

A strength of our study is that we collected data on functional and mental health outcome at three months after diagnosis in a large cohort of dialysis patients. The ERACODA database of patients with kidney replacement treatment admitted for COVID-19 contains specifically collected granular data at individual patient level, which enables detailed analysis of long-term
effects of COVID-19. Data on outcome were complete for 84% of the patients with a known vital status at three months. Our analysis was not adversely influenced by selection bias on long term outcome, because no significant or clinically relevant differences could be observed between patients with missing data on outcome and patients with complete data on outcome. We therefore consider our results representative for measuring functional and mental health outcome in relation to the course of COVID-19 in hemodialysis patients.

This study also has limitations. Firstly, not all dialysis patients with COVID-19 in the participating hospitals were recorded in ERACODA. Secondly, due to the design of the study the assessment of functional and mental health status was performed by physicians, because we could not contact patients. This may have led to misclassification. However, the assessment by physicians was performed using a structured questionnaire, and nephrologists meet their hemodialysis patients on a regular basis in the dialysis facilities as part of a multidisciplinary team including social workers. Because they know their patients well, they in general are able to detect important differences in performance. Indeed, we found that non-recovery of both functional and mental status at three months after COVID-19 diagnosis was associated with clinical characteristics and disease severity parameters at admission, as well as with a greater likelihood of still being hospitalized and living in a nursing home. This reflects that the clinical judgement of treating nephrologists on these outcomes is valid.

In summary, survival in dialysis patients who survive after the initial COVID-19 episode is relatively preserved. The surviving patients recovered to the pre-existent level of functional and mental health within three months, and most of them were living at home. Only patients who were admitted to the ICU have a substantial risk of mortality between 28 days and 3 months after diagnosis and of functional impairment. These are important clinical observations for dialysis patients to find consolation in a rather uncertain period of time.
CONFLICT OF INTEREST-STATEMENT

The results presented in this paper have not been published previously in whole or part, except in abstract format.

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The ERACODA collaboration is an initiative to study prognosis and risk factors for mortality due to COVID-19 in patients with a kidney transplant or on dialysis that is endorsed by the ERA. The organizational structure contains a Working Group assisted by a Management Team and Advisory Board.

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Data Sharing Statement: Collaborators that entered data in ERACODA remain owner of these data. The database can therefore not be disclosed to any third party without the prior written consent of all data providers, but the database will be made available to the editorial offices of medical journals when requested. Research proposals can be submitted to the Working Group via COVID.19.KRT@umcg.nl. If deemed of interest and methodological sound by the Working Group and Advisory Board, the analyses needed for the proposal will be carried out by the Management Team.

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APPENDIX

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Table 1. Baseline demographic and clinical characteristics of hemodialysis patients with COVID-19 by hospitalization and intensive care unit (ICU) admission status

| Variable                             | Total* (N=2449) | Not hospitalized (N=1087) | Hospitalized, No ICU (N=1165) | Hospitalized, ICU (N=197) | p-value |
|---------------------------------------|-----------------|--------------------------|-------------------------------|---------------------------|---------|
| **Patient characteristics**           |                 |                          |                               |                           |         |
| Male sex, N (%)                       | 1509 (62)       | 645 (59)                 | 740 (64)                      | 124 (63)                  | 0.12    |
| Age, year (years)                     | 67.5 ± 14.4     | 67.4 ± 15.1              | 68.0 ± 13.9                   | 65.0 ± 12.5               | 0.03    |
| BMI, kg/m²                            | 26.6 ± 5.5      | 26.9 ± 5.8               | 26.3 ± 5.4                    | 27.0 ± 5.2                | 0.05    |
| Race, N (%)                           |                 |                          |                               |                           | 0.006   |
| White or Caucasian                    | 1976 (85)       | 850 (86)                 | 976 (85)                      | 150 (77)                  |         |
| Non-white                             | 357 (15)        | 141 (14)                 | 171 (15)                      | 45 (23)                   |         |
| Tobacco use                           |                 |                          |                               |                           | <0.001  |
| Current                               | 158 (6.5)       | 42 (3.9)                 | 100 (8.6)                     | 16 (8.1)                  |         |
| Prior                                 | 459 (19)        | 139 (13)                 | 270 (23)                      | 50 (25)                   |         |
| Never                                 | 879 (36)        | 269 (25)                 | 519 (45)                      | 91 (46)                   |         |
| Unknown                               | 953 (39)        | 637 (59)                 | 276 (24)                      | 40 (20)                   |         |
| Clinical frailty scale, AU            | 4.0 ± 1.8       | 3.9 ± 1.8                | 4.1 ± 1.9                     | 3.8 ± 1.5                 | 0.04    |
| **Reason for screening, N (%)**       |                 |                          |                               |                           | <0.001  |
| Symptoms only                         | 1132 (62)       | 295 (51)                 | 707 (66)                      | 130 (68)                  |         |
| Symptoms & contact                    | 280 (15)        | 59 (10)                  | 175 (16)                      | 46 (24)                   |         |
| Contact only                          | 218 (12)        | 110 (19)                 | 103 (19)                      | 5 (2.6)                   |         |
| Routine screening                     | 207 (11)        | 110 (19)                 | 88 (8.2)                      | 9 (4.7)                   |         |
| COVID-19 diagnosis                    |                 |                          |                               |                           |         |
| Positive PCR, N (%)                   | 2383 (99.8)     | 1079 (99.8)              | 1113 (99.7)                   | 191 (100)                 | 0.94    |
| Abnormal X-ray, N (%)a                | 562 (60)        | 39 (80)                  | 434 (64)                      | 89 (78)                   | <0.001  |
| Abnormal CT-scan, N%(b)               | 475 (81)        | 23 (47)                  | 353 (82)                      | 99 (88)                   | <0.001  |
| **Comorbidities, N (%)**              |                 |                          |                               |                           |         |
| Obesity                               | 464 (23)        | 205 (24)                 | 215 (21)                      | 46 (26)                   | 0.25    |
| Hypertension                          | 1979 (81)       | 836 (77)                 | 986 (85)                      | 157 (80)                  | <0.001  |
| Diabetes Mellitus                     | 1046 (43)       | 409 (38)                 | 542 (47)                      | 95 (48)                   | <0.001  |
| Coronary artery disease               | 825 (34)        | 325 (30)                 | 425 (36)                      | 75 (38)                   | 0.002   |
| Heart failure                         | 57 (23)         | 200 (18)                 | 321 (28)                      | 50 (25)                   | <0.001  |
| Chronic lung disease                  | 317 (13)        | 107 (10)                 | 178 (15)                      | 32 (16)                   | <0.001  |
| Active malignancy                     | 136 (5.6)       | 44 (4.1)                 | 82 (7.0)                      | 10 (5.1)                  | 0.008   |
| Auto-immune disease                   | 88 (3.6)        | 27 (2.5)                 | 54 (4.6)                      | 7 (3.6)                   | 0.02    |
| Primary kidney disease, N(%)          |                 |                          |                               |                           |         |
| Prim. Glomerulonephritis              | 308 (13)        | 112 (11)                 | 165 (14)                      | 31 (16)                   | 0.06    |
| Pyelonephritis                        | 37 (1.6)        | 16 (1.6)                 | 20 (1.7)                      | 1 (0.5)                   | 0.44    |
| Interstitial nephritis                | 69 (3.0)        | 31 (3.1)                 | 34 (3.0)                      | 4 (2.0)                   | 0.71    |
| Hereditary kidney disease             | 160 (6.7)       | 87 (8.8)                 | 63 (5.5)                      | 10 (5.1)                  | 0.006   |
| Congenital diseases                   | 33 (1.4)        | 18 (1.8)                 | 14 (1.2)                      | 1 (0.5)                   | 0.27    |
| Vascular diseases                     | 420 (18)        | 214 (22)                 | 174 (15)                      | 32 (16)                   | <0.001  |
| Secondary glomerular dis.             | 200 (8.6)       | 131 (13)                 | 60 (5.2)                      | 9 (4.6)                   | <0.001  |
| Diabetic kidney disease               | 542 (23)        | 153 (16)                 | 322 (28)                      | 67 (34)                   | <0.001  |
| Other                                 | 378 (16)        | 166 (17)                 | 187 (16)                      | 25 (13)                   | 0.37    |
| Unknown                               | 184 (7.9)       | 59 (6.0)                 | 109 (9.5)                     | 16 (8.2)                  | 0.01    |
| Hemodialysis modality                 |                 |                          |                               |                           | 0.03    |
| Centre HD | 2290 (99) | 975 (98) | 1122 (99) | 193 (99) |
|----------|-----------|----------|-----------|----------|
| Home HD  | 28 (1)    | 19 (1.9) | 8 (0.7)   | 1 (0.5)  |
| Dialysis vintage (years) | 4 [2, 8] | 4 [2, 8] | 4 [2, 8] | 5 [3, 9] | 0.07 |
| Previous transplantation, N (%) | 195 (8.6) | 105 (10.9) | 79 (7.0) | 11 (5.7) | 0.002 |

**Medication use**

|                        | RAAS inhibition, N (%) | 503 (27) | 185 (32) | 269 (25) | 49 (27) | 0.01 |
|------------------------|------------------------|----------|----------|----------|---------|------|
|                        | Imunosuppressives, N (%) |          |          |          |         |      |
| Prednisone             | 126 (5.1)              | 37 (3.2) | 79 (6.8) | 10 (5.1) | 0.027 |
| Tacrolimus             | 33 (1.3)               | 17 (1.6) | 14 (1.2) | 2 (1.0)  | 0.05   |
| Mycophenolate          | 16 (0.7)               | 7 (0.6)  | 8 (0.7)  | 1 (0.5)  | 0.66   |

**COVID-19 related characteristics**

| Presenting symptoms, N(%) | 252 (14) | 73 (12) | 141 (13) | 38 (22) |
|---------------------------|----------|---------|-----------|---------|
| Cough                     | 920 (47) | 222 (36)| 574 (50)  | 124 (66) |
| Shortness of breath      | 621 (32) | 73 (12) | 423 (37)  | 125 (65) |
| Fever                    | 1067 (54)| 218 (36)| 698 (60)  | 151 (77) |
| Headache                 | 193 (10) | 51 (8.7)| 114 (10)  | 28 (16)  |
| Nausea or vomiting       | 184 (9.5)| 39 (6.5)| 119 (10)  | 26 (14)  |
| Diarrhea                | 236 (12) | 60 (9.9)| 146 (13)  | 30 (16)  |
| Myalgia or arthralgia    | 404 (22) | 85 (14) | 267 (24)  | 52 (30)  |

**Vital signs**

| Temperature, °C          | 37.4 ± 1.0 | 37.0 ± 1.0 | 37.5 ± 1.0 | 37.8 ± 1.0 |
|--------------------------|------------|------------|------------|------------|
| Respiration rate, /min   | 18.4 ± 4.9 | 15.9 ± 3.7 | 19.1 ± 4.8 | 21.3 ± 5.3 |
| O₂ saturation room air, %| 93.9 ± 5.4 | 96.6 ± 2.7 | 93.5 ± 5.2 | 90.0 ± 7.8 |
| Systolic BP, mmHg        | 136.4±25.4 | 139.4 ± 24.9 | 136.0 ± 25.5 | 130.8 ± 25.2 |
| Diastolic BP, mmHg       | 73.6 ± 15.1 | 72.5 ± 14.9 | 73.9 ± 15.5 | 75.4 ± 13.6 |
| Pulse rate, BPM          | 81.1 ± 15.0 | 75.8 ± 13.0 | 82.6 ± 15.3 | 86.9 ± 14.0 |

**Laboratory test results**

| Lymphocytes, x1000/µL | 0.9 (0.6, 1.3) | 0.9 (0.7, 1.2) | 0.9 (0.6, 1.4) | 0.7 (0.5, 1.1) | 0.0013 |
|-----------------------|----------------|----------------|----------------|----------------|-------|
| CRP, mg/L             | 41 (9.9, 94)  | 5 (3, 30)      | 43 (12, 95)    | 71 (24, 124)   | <0.001 |
| Hospitalization duration, days | 14 (8, 23) | 14 (8, 21) | 24 (18, 40) | <0.001 |
| ICU admission duration, days | 6 (2, 11) | - | 6 (2, 11) | - |

*Numbers may not add up to total because of missing values.

a X-rays were performed for 933 of 2,449 patients (38%), including 138 in the non-hospitalized group, 681 in the group admitted to the hospital (not ICU) and 114 in patients admitted to the ICU.
b CT-scans were performed for 589 of 2,449 patients (24%), including 49 in the non-hospitalized group, 428 in the group admitted to the hospital (not ICU) and 112 in patients admitted to the ICU.

Continuous variables are reported as mean ± SD or median (IQR). Groups were compared using one way ANOVA, Kruskal Wallis test or Chi-square test, as appropriate. Obesity is defined as BMI > 30 kg/m². **Abbreviations:** RAAS, renin angiotensin aldosterone system; BMI, body mass index; °C, degree Celsius; BP, blood pressure; CRP, C-reactive protein; O₂, oxygen; ICU, intensive care unit.
Table 2. Functional status at three months after COVID-19 diagnosis in hemodialysis patients

| Functional status                                      | Total (N=854) | Not hospitalized (n=363) | Hospitalized, no ICU (N=448) | Hospitalized, ICU (N=43) | P-value |
|--------------------------------------------------------|---------------|-------------------------|-----------------------------|--------------------------|---------|
| Reached pre-COVID-19 status                            |               |                         |                             |                          | 0.005   |
| Yes, N (%)                                             | 743 (87)      | 328 (90)                | 383 (85)                    | 32 (74)                  |         |
| No, N (%)                                              | 111 (13)      | 35 (9.6)                | 65 (15)                     | 11 (26)                  |         |
| Limiting factor*, N (%)                                |               |                         |                             |                          |         |
| o Thromboembolic events a                             | 1 (0.9)       | 0                       | 1 (1.5)                     | 0                        | 0.7     |
| o Impaired lung function                               | 10 (9.0)      | 4 (11)                  | 4 (6.2)                     | 2 (18)                   | 0.36    |
| o Reduced mobility                                     | 45 (41)       | 14 (40)                 | 26 (40)                     | 5 (45)                   | 0.94    |
| o Reduced muscle strength                              | 53 (48)       | 16 (46)                 | 29 (45)                     | 8 (73)                   | 0.22    |
| o Tiredness                                            | 41 (37)       | 10 (29)                 | 28 (43)                     | 3 (27)                   | 0.28    |
| o Disturbed mental status                              | 8 (7.2)       | 2 (5.7)                 | 5 (7.7)                     | 1 (9.1)                  | 0.91    |
| o Declined cognitive function                          | 12 (11)       | 4 (11)                  | 8 (12)                      | 0                        | 0.31    |
| o Other b                                              | 82 (74)       | 25 (71)                 | 47 (72)                     | 10 (91)                  | 0.40    |
| Estimated time needed to reach pre-COVID-19 status, N (%)* |               |                         |                             |                          | 0.52    |
| o 0-3 months                                           | 18 (16)       | 6 (17)                  | 12 (18)                     | 0                        |         |
| o 3-6 months                                           | 27 (24)       | 8 (23)                  | 15 (23)                     | 4 (36)                   |         |
| o 6-12 months                                          | 20 (18)       | 6 (17)                  | 10 (15)                     | 4 (36)                   |         |
| o >1 year                                              | 11 (10)       | 4 (11)                  | 7 (11)                      | 0                        |         |
| o Never                                                | 31 (28)       | 9 (26)                  | 20 (31)                     | 2 (18)                   |         |
| o Missing                                              | 4 (3.6)       | 2 (5.7)                 | 1 (1.5)                     | 1 (9.1)                  |         |

*Including stroke, pulmonary embolism, etc.; a including anxiety, depression, post-traumatic stress disorder. * Figures do not add up to 100% since more than one answer was possible.
Table 3. Mental health status in hemodialysis patients at three months after COVID-19 diagnosis

| Mental health status                                                                 | Total (N=854) | Not hospitalized (N=363) | Hospitalized, no ICU (N=448) | Hospitalized, ICU (N=43) | P-value |
|-------------------------------------------------------------------------------------|---------------|--------------------------|------------------------------|---------------------------|---------|
| Reached pre-COVID-19 status                                                        |               |                          |                              |                           | 0.08    |
| Yes, N (%)                                                                          | 803 (94)      | 343 (94)                 | 423 (94)                     | 37 (86)                   |         |
| No, N (%)                                                                           | 51 (6.0)      | 20 (5.5)                 | 25 (5.6)                     | 6 (14)                    |         |
| Limiting factor*, N (%)                                                             |               |                          |                              |                           |         |
| o Depression                                                                        | 16 (31)       | 9 (45)                   | 6 (24)                       | 1 (17)                    | 0.23    |
| o Anxiety                                                                           | 9 (18)        | 5 (25)                   | 3 (12)                       | 1 (17)                    | 0.52    |
| o Bereavement/grief                                                                 | 2 (3.9)       | 0                        | 1 (4)                        | 1 (17)                    | 0.18    |
| o Memory loss                                                                       | 18 (35)       | 7 (35)                   | 10 (40)                      | 1 (17)                    | 0.56    |
| o Delirium                                                                          | 2 (3.9)       | 0                        | 2 (8)                        | 0                         | 0.34    |
| o Sleep disturbances                                                                | 5 (9.8)       | 2 (10)                   | 1 (4)                        | 2 (33)                    | 0.10    |
| o Other*                                                                            | 9 (18)        | 2 (10)                   | 5 (20)                       | 2 (33)                    | 0.38    |

Estimated time needed to reach pre-COVID-19 status, N (%)*

| o 0-3 months                                                                       | 6 (12)        | 2 (10)                   | 4 (16)                       | 0                         |         |
| o 3-6 months                                                                       | 12 (24)       | 7 (35)                   | 3 (12)                       | 2 (33)                    |         |
| o 6-12 months                                                                      | 10 (20)       | 5 (25)                   | 4 (16)                       | 1 (17)                    |         |
| o >1 year                                                                          | 5 (9.8)       | 0                        | 4 (16)                       | 1 (17)                    |         |
| o Never                                                                            | 14 (27)       | 4 (20)                   | 9 (36)                       | 1 (17)                    |         |
| o Missing                                                                          | 4 (7.8)       | 2 (10)                   | 1 (4)                        | 1 (17)                    |         |

*Including for example: itchy skin, diabetes mellitus type 1 complications and pain.
* Figures do not add up to 100% since more than one answer was possible.
### Table 4. Crude and adjusted odds ratios (ORs) with 95% confidence interval (CI) for the likelihood that functional and mental health status recover three months after COVID-19 diagnosis (yes versus no), among hemodialysis patients who survived three months after COVID-19 diagnosis

| Variables                              | Recovery of pre-COVID-19 functional status (N=854) | Recovery of pre-COVID-19 mental health status (N=854) |
|----------------------------------------|---------------------------------------------------|---------------------------------------------------|
|                                        | Crude OR (95% CI)                                  | Adjusted* OR (95% CI)                              |
| Age (per year)                          | 0.97 (0.96 to 0.99)                                | 0.98 (0.97 to 1.0)                                |
|                                        | 0.99 (0.97 to 1.0)                                | 0.97 (0.95 to 0.99)                                |
|                                        | 0.94 (0.92 to 1.02)                                | 0.81 (0.78 to 0.84)                                |
|                                        | 0.76 (0.74 to 0.78)                                | 0.75 (0.68 to 0.83)                                |
|                                        | 0.76 (0.74 to 0.78)                                | 0.75 (0.68 to 0.83)                                |
|                                        | 0.7 (0.54 to 0.81)                                 | 0.49 (0.36 to 0.64)                                |
|                                        | 0.36 (0.31 to 0.43)                                | 0.52 (0.46 to 0.58)                                |
|                                        | 0.31 (0.14 to 0.67)                                | 0.17 (0.14 to 0.95)                                |
|                                        | 0.81 (0.51 to 1.28)                                | 0.68 (0.36 to 1.31)                                |
|                                        | 0.43 (0.31 to 0.43)                                | 0.52 (0.36 to 0.68)                                |
|                                        | 1.31 (0.68 to 2.51)                                | 1.57 (0.68 to 2.61)                                |

Abbreviations: OR, odds ratio; 95% CI, 95% confidence interval; ICU, intensive care unit.

*All variables analyzed crude were included in the multivariable models.
Figure 1: Kaplan-Meier curves presenting cumulative three month survival probability (in days) among hemodialysis patients with COVID-19.
Figure 2: Flow diagram of hospitalization, intensive care unit (ICU) admission, vital status at three months after COVID-19 diagnosis, and residence at three months after COVID-19 diagnosis.
Figure 3: Functional and mental health status in hemodialysis patients at three months after COVID-19 diagnosis, as judged by their treating nephrologist.