The Impact of Vaccination on Incidence and Outcomes of SARS-CoV-2 Infection in Patients with Kidney Failure in Scotland

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ABSTRACT

Background Patients with kidney failure requiring KRT are at high risk of complications and death following SARS-CoV-2 infection, with variable antibody responses to vaccination reported. We investigated the effects of COVID-19 vaccination on the incidence of infection, hospitalization, and death from COVID-19 infection.

Methods The study design was an observational data linkage cohort study. Multiple health care datasets were linked to ascertain all SARS-CoV-2 testing, vaccination, hospitalization, and mortality data for all patients treated with KRT in Scotland from the start of the pandemic over a period of 20 months. Descriptive statistics, survival analyses, and vaccine effectiveness were calculated.

Results As of September 19, 2021, 93% (n=5281) of the established KRT population in Scotland had received two doses of an approved SARS-CoV-2 vaccine. Over the study period, there were 814 cases of SARS-CoV-2 infection (15.1% of the KRT population). Vaccine effectiveness rates against infection and hospitalization were 33% (95% CI, 0 to 52) and 38% (95% CI, 0 to 57), respectively. Within 28 days of a SARS-CoV-2–positive PCR test, 9.2% of fully vaccinated individuals died (7% patients on dialysis and 10% kidney transplant recipients). This compares to <0.1% of the vaccinated general Scottish population admitted to the hospital or dying due to COVID-19 during that period.

Conclusions These data demonstrate that a primary vaccine course of two doses has limited effect on COVID-19 infection and its complications in patients with KRT. Adjunctive strategies to reduce risk of both COVID-19 infection and its complications in this population are urgently required.

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Patients requiring KRT with dialysis or kidney transplantation are at high risk of death following severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection, with case fatality at 28 days reported at 16.9% in kidney transplant recipients (KTRs) and 23.9% in patients requiring hemodialysis (HD) in the European Renal Association coronavirus disease 2019 (COVID-19) registry. Similarly, poor outcomes are reported globally.[1–4] Vaccination against COVID-19 reduces mortality and risk of hospitalization from COVID-19 in the general population.[5] KTRs on immunosuppression have been demonstrated to have attenuated serologic response to conventional two-dose COVID-19 vaccination schedules.[6,7] Serologic response to vaccination in patients treated with HD is variable, with most studies suggesting that vaccination induces anti-Spike antibodies.[8,9] Many countries recognized patients undergoing HD and KTRs as "clinically extremely vulnerable" and prioritized early vaccination of patients requiring KRT. In Scotland, 90% of first doses of a COVID-19 vaccine were administered by February 28, 2021 to patients requiring KRT.

The emergence of more transmissible SARS-CoV-2 variants of concern (VOCs), in particular the Delta (B.1.617.2) variant, which became the dominant strain in the United Kingdom in May 2021, has driven rapid increases in the incidence of COVID-19.[10] Differences in induction of neutralizing antibodies to the Delta VOC in patients treated with HD after vaccination with BNT162b2 (Pfizer–BioNTech) or ChAdOx1 (Oxford–AstraZeneca) vaccines have been demonstrated.[11] Vaccination with two doses of BNT162b2 in patients undergoing HD induces similar neutralizing antibody titers to those in healthy individuals. However, vaccination with two doses of ChAdOx1 in patients undergoing HD who are COVID-19 seronaive induces

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suboptimal neutralizing antibodies to the Delta variant. Therefore, there is reduced serologic response to vaccination in KTRs and differential efficacy of BNT162b2 and ChAdOX1 in patients undergoing HD against the dominant Delta VOC. The clinical implications of these combined findings on COVID-19 infection, hospitalization, and death are unknown. We investigated the effects of SARS-CoV-2 vaccination on incidence and clinical outcomes of COVID-19.

METHODS

Data Sources

The study design was an observational data linkage cohort study. The following national datasets were linked using a unique patient identifier (Community Health Index) by Public Health, Scotland. The Scottish Renal Registry is a national registry of all patients receiving KRT for kidney failure in Scotland (HD, peritoneal dialysis, and transplant). It collates data from all nine adult renal units in Scotland and 28 satellite HD units serving a population of 5.4 million. The Scottish Renal Registry was established in 1991 with data backfilled to 1960 from the European Renal Association– European Dialysis and Transplant Association (ERA-EDTA; the first patient was dialyzed for kidney failure in Scotland in 1960). It has 100% unit and patient coverage. Data held by the registry include patient demographics, including historical postcodes (for calculating the Scottish Index of Multiple Deprivation [SIMD]), full KRT history (for kidney failure), primary renal diagnosis (using ERA-EDTA codes), and linkage with the National Health Service (NHS) Blood and Transplant for transplant status. The primary renal diagnosis groupings used in the analyses are described on the Scottish Renal Registry website.[12] The Scottish Government provides online calculators that allow use of patient postcode to generate divisions of socioeconomic deprivation, the SIMD.[13] Using patient postcode, deprivation quintiles were calculated, with one corresponding to most deprived and five corresponding to least deprived. Data on SARS-CoV-2 testing were obtained from the Electronic Communication of Surveillance in Scotland, with date of test and result reported. Testing for SARS-CoV-2 was carried out by real-time PCR on a combined nasal and pharyngeal throat swab only in symptomatic patients. The period from March 1, 2020 to February 28, 2021 was defined as wave 1 + 2, whereas wave 3 commenced on March 1, 2021 and included data until September 21, 2021.

Information on hospital admissions was obtained from the Scottish Morbidity Record and Rapid Preliminary Inpatient Data. Data on deaths were obtained from the National Records of Scotland. Finally, details on vaccination type and date were obtained from the Turas Vaccination Management Tool, which holds all vaccination records in Scotland.[5] No patients were offered a third primary dose of vaccine prior to September 27, 2021, and no antibody monitoring of response to vaccination was performed with research studies.

Definitions of Outcomes

An infection was considered a "breakthrough infection" if it occurred 14 days or later after receiving the second dose of vaccine. Hospitalization with SARS-CoV-2 was defined as admission within 14 days of testing positive for SARS-CoV-2 *via* PCR test and included those testing positive within 2 days after discharge. Death from SARS-CoV-2 was defined as death within 28 days of first testing positive for SARS-CoV-2 *via* PCR test.

Statistical Methods

Data were linked and analyzed by an analyst at Public Health Scotland. Baseline characteristics of continuous variables were displayed as mean and SD if normally distributed or using median and interquartile range (IQR) otherwise. Categorical variables were summarized as percentages. Crude survival was measured at 28 days since first SARS-CoV-2 test using Kaplan–Meier survival curves. For each outcome (hospitalization and SARS-CoV-2 infection), the risk ratio (RR) comparing the vaccinated group with the nonvaccinated group was computed. The vaccine effectiveness was then derived from the RR using the following formula: vaccine effectiveness $=1-\mathrm{RR}$.[14] The 95% confidence interval (95% CI) for vaccine effectiveness was obtained using the nonparametric percentile bootstrap method with 10,000 repetitions. This method has been used previously for investigating vaccine effectiveness.[15,16] Univariable and multivariable Cox proportional hazards models were fitted to examine predictors of breakthrough infections with time from 14 days after second vaccine to first positive test and time from second vaccine to October 19, 2021or death (whichever occurred first) in those who did not test positive between March 1, 2021 and October 19, 2021.

All data were analyzed using the R statistical programming language (version 3.6.2, Vienna, Austria).

Ethical Statement

Formal ethical approval was waived according to Public Health Scotland

Significance Statement

Patients with kidney failure requiring KRT are at high risk of poor outcomes following SARS-CoV-2 infection, with variable antibody responses to vaccination reported. Ninety-three percent of patients on KRT in Scotland received a SARS-CoV-2 vaccine. The effectiveness of two vaccine doses was only 33% (95% CI, 0 to 52) against SARS-CoV-2 infection and 38% (95% CI, 0 to 57) against hospitalization in patients requiring KRT. Within 28 days of a positive SARS-CoV-2 PCR test, 9.2% of fully vaccinated patients died (7% patients on dialysis and 10% transplant recipients). These data suggest that a primary vaccine course of two doses does not provide adequate protection in patients receiving KRT and highlight the urgent need for adjunctive strategies to reduce risk of both SARS-CoV-2 infection and its complications.

Table 1. Patient demographics

Patient Characteristics	Whole Adult KRT Population (on September 19, 2021)	Total No. of Patients Testing Positive (until October 19, 2021)	Patients on Dialysis Testing Positive (% of HD Population)	Patients with Transplants Testing Positive (% of Transplant Population)	COVID-19 Deaths (until September 19, 2021)
KRT modality					
Dialysis	2072 (38%)	368 (45%)	368 (18%)	—	78 (61%)
KTR	3315 (62%)	446 (55%)	—	446 (13%)	49 (39%)
Sex					
Men	3266 (61%)	477 (59%)	219 (17%)	258 (20%)	70 (55%)
Age, yr, median (IQR)	60 (49–69)	64 (50–71)	64 (52–78)	62 (50–70)	68 (60–75)
Primary renal diagnosis					
Diabetic nephropathy	919 (17%)	180 (22%)	125 (24%)	55 (14%)	38 (30%)
GN	1188 (22%)	172 (21%)	62 (18%)	110 (13%)	23 (18%)
Interstitial	1675 (31%)	260 (32%)	69 (17%)	191 (15%)	28 (22%)
Multisystem	817 (15%)	96 (12%)	60 (14%)	36 (9%)	19 (15%)
Unknown	788 (14%)	106 (13%)	52 (14%)	54 (13%)	19 (15%)
SIMD					
1 (most deprived)	1290 (24%)	268 (33%)	136 (23%)	132 (19%)	37 (29%)
2	1173 (22%)	202 (25%)	102 (21%)	100 (15%)	39 (31%)
3	993 (19%)	110 (14%)	45 (13%)	65 (10%)	22 (17%)
4	1024 (19%)	130 (16%)	52 (16%)	78 (11%)	13 (10%)
5 (least deprived)	830 (16%)	104 (13%)	33 (14%)	71 (12%)	16 (13%)
Hospitalization	—	244 (31%)	100 (5%)	144 (4%)	93 (76%)

—, not applicable.

Information Governance as analysis of routinely collected data. As the analysis used routinely collected and anonymized data, individual patient consent was not sought. Access and use of the data for the purpose of this work were approved following a Public Health Scotland Information Governance review of linking internal datasets. Only the Public Health Scotland analyst had access to the linked patient data, which could only be accessed *via* an NHS secure network.

RESULTS

Characteristics of Patients Positive for SARS-CoV-2

Between March 1, 2021 and October 19, 2021, there were 814 cases of SARS-CoV-2 infection in patients established on KRT, amounting to approximately 15% of the prevalent adult KRT population in Scotland. Of these, 339 (42%) were undergoing in-hospital dialysis, 29 (4%) were in home therapy, and 446 (55%) were KTRs; 15.6% who tested positive died within 28 days. Of those dying following a positive SARS-CoV-2 test, the majority (61%, $n=78$) were undergoing dialysis, whereas 39% ($n=49$) were KTRs. Table 1 shows demographics of patients by infection, dialysis modality, and vaccination status. Patients dying following SARS-CoV-2 infection were older and were more likely to be on dialysis, have primary kidney disease of diabetic nephropathy, and live in more deprived areas.

Supplemental Figure 1 depicts unadjusted Kaplan–Meier survival curves in patients undergoing dialysis (Supplemental Figure 1A) and in KTRs (Supplemental Figure 1B) stratified by wave of infection (wave 1 + 2 versus wave 3). In patients treated with dialysis, survival improved between waves 1 + 2 (survival at day 28: 0.72; 95% CI, 0.68 to 0.78) and wave 3 (survival at day 28: 0.96; 95% CI, 0.92 to 1.00). This was not observed in KTRs, with similar survival at day 28 for wave 1 + 2 (0.86; 95% CI, 0.82 to 0.92) and wave 3 (0.87; 95% CI, 0.82 to 0.93).

Vaccination Rates

As of September 19, 2021, 5281 patients (93% of the KRT population) received two doses of a SARS-CoV-2 vaccine (3522 [64%] received ChAdOx1, and 1759 [29%] received mRNA vaccine); 2080 patients on dialysis received at least two doses of a SARS-CoV-2 vaccine (1283 [62%] received ChAdOx1, and 797 [38%] received mRNA vaccine). In total, 3201 KTRs received at least two vaccine doses (2239 [70%] received ChAdOx1, and 962 [30%] received mRNA vaccine). The vaccination time line in patients with chronic KRT in Scotland is presented in Figure 1. Characteristics of vaccinated patients compared with unvaccinated patients are shown in Table 2, with unvaccinated patients more likely to be younger, be male, and have a transplant.

Vaccine Effectiveness

Vaccine effectiveness rates against SARS-CoV-2 infection and hospitalization for any vaccine were estimated as 33% (95% CI, 0 to 52) and 38% (95% CI, 0 to 57), respectively (Table 3, Supplemental Tables 1 and 2). Vaccine effectiveness rates for patients with transplants only were estimated at 39% (95% CI, 2 to 58) against infection and 40% (95% CI, 0 to 59) against hospitalization (Supplemental Tables 3 and 4).

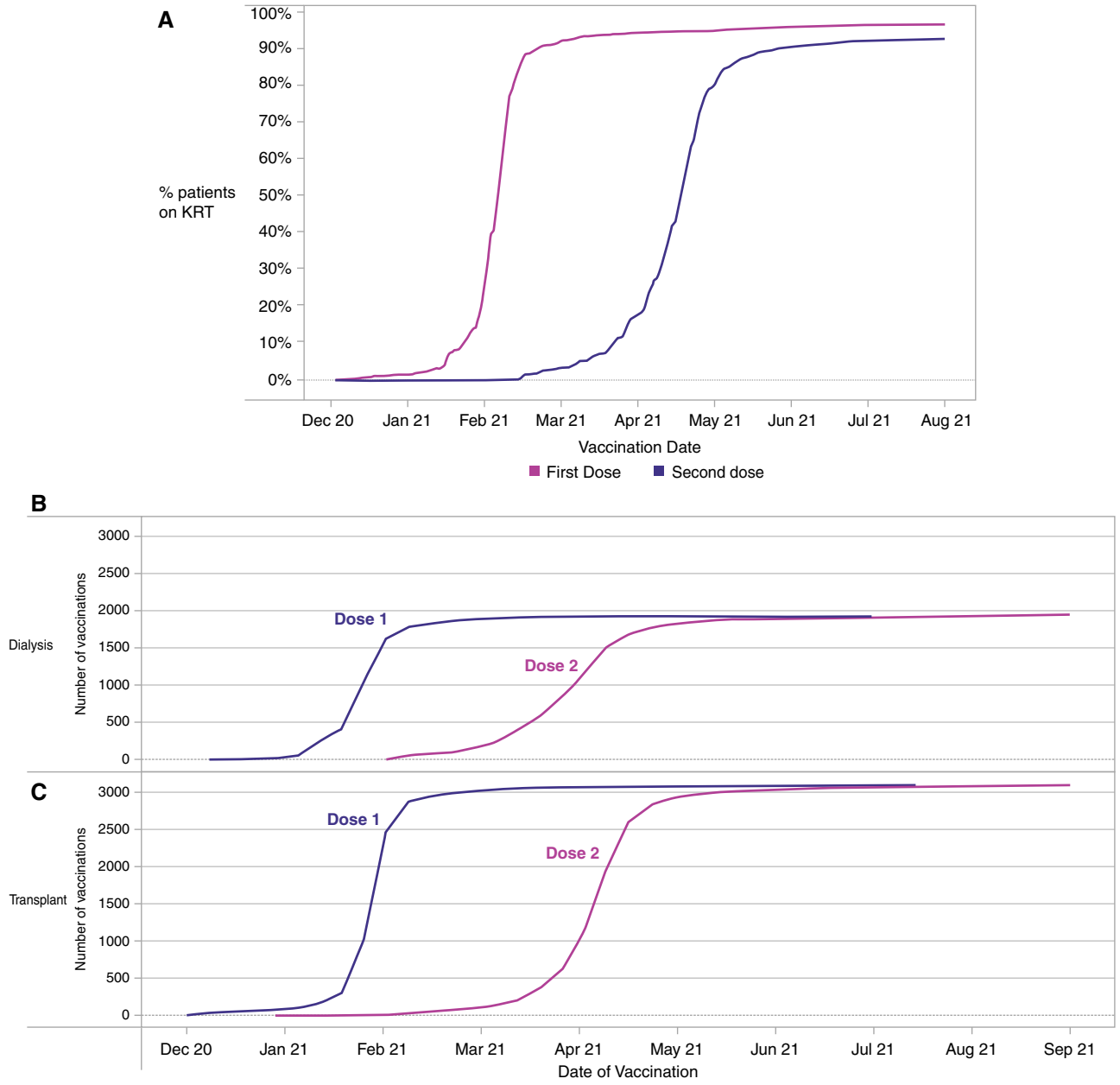

Figure 1. Vaccination time line for patients on KRT in Scotland. (A) Uptake of first and second doses of vaccine in all patients on KRT in Scotland. (B) Uptake of vaccination in dialysis patients. (C) Uptake of vaccination in kidney transplant patients.

Supplemental Figure 2 displays the bootstrap distribution (histogram of bootstrap replicates) for each outcome. Until October 19, 7.1% (n=357) of patients tested positive for SARS-CoV-2 following two doses of SARS-CoV-2 vaccine (73% [n=259] ChAdOx1, 27% [n=98] mRNA vaccine). Median time from second dose to positive PCR was 129 days (IQR, 100–140) for an mRNA vaccine, 124 days (IQR, 93–139) for the ChAdOx1 vaccine, 131 days (IQR, 101–148) in patients on dialysis, and 123 days (IQR, 91–137) in KTRs. Univariable and multivariable Cox proportional hazards models of predictors for breakthrough infections after two doses of a SARS-CoV-2 vaccine are shown in Table 4. Predictors for breakthrough infection include transplant and deprivation.

In total, 9.2% (33 of 357) of fully vaccinated patients who tested positive for SARS-CoV-2 died within 28 days, representing 7% (seven of 98) of patients undergoing dialysis and 10% (26 of 259) of KTRs. Prior to the availability of vaccination, 22.5% of patients on chronic KRT died within 28 days of a SARS-CoV-2–positive PCR test during waves 1 and 2. Overall, around 0.6% of the fully vaccinated chronic KRT population died from COVID-19, contrasting with a mortality of about 0.025% in the general Scottish population of fully vaccinated individuals (954 deaths for 3.837 million

Table 2. Characteristics of vaccinated compared with unvaccinated individuals

Patient Characteristics	*n* (%) of Unvaccinated	*n* (%) of Doubly Vaccinated
Modality		
Dialysis	83 (34)	1933 (38)
Transplant	161 (66)	3119 (62)
Sex		
Women	84 (34)	2006 (40)
Men	160 (64)	3046 (60)
Age group, yr		
75 and over	31 (13)	647 (13)
65–74	24 (10)	1125 (22)
45–64	103 (42)	2392 (47)
18–44	86 (35)	888 (18)
PRD		
Diabetic nephropathy	28 (11)	883 (17)
GN	57 (23)	1106 (22)
Interstitial	74 (30)	1576 (31)
Multisystem	26 (11)	772 (15)
Unknown	59 (24)	715 (14)
SIMD		
1 (most deprived)	71 (32)	1198 (24)
2	49 (22)	1093 (22)
3	34 (16)	944 (19)
4	43 (20)	960 (19)
5 (least deprived)	22 (10)	802 (16)

PRD, primary renal diagnosis.

fully vaccinated people).[17] September 2021 also saw the largest number of positive SARS-CoV-2 cases reported in the KRT population during the pandemic (Figure 2A, Supplemental Figures 1A and 1B). This rise was greatest in KTRs, in whom the highest number of COVID-19–related hospital admissions was recorded since the pandemic began (Figure 2B).

DISCUSSION

We present data showing the effect of vaccination in patients treated with KRT in Scotland. In this group, mortality remains high following double vaccination, with 9% of patients testing positive for SARS-CoV-2 dying within 28 days. Vaccine efficacy of a two-dose vaccine regimen was disappointing, with a 33% reduction in the risk of testing positive for SARS-CoV-2 and a 38% reduction in the risk of hospitalization in those testing positive compared with the United Kingdom general population, where vaccine efficacy against infection is reported as 80% (95% CI, 77% to 83%) for BNT162b2 (Pfizer–BioNTech) and 67% (95% CI, 62% to 71%) for ChAdOx1 against the B.1.617.2 variant.[18] We found no improvement in survival between the first and latest SARS-CoV-2 infection waves in KTRs, and the latest data (August and September 2021) showed an alarming increase in the number of SARS-CoV-2 cases and hospitalizations in this group. These data suggest that a primary vaccine course

Table 3. Breakthrough infections (data until October 19 2021)

Patient Characteristics	Total No. of Breakthrough Infections (Positive PCR Test >14 d after 2 Doses)	Patients on Dialysis Testing Positive (with % of Total Prevalent HD Population)	Patients with Transplants Testing Positive (with % of Total Prevalent Transplant Population)
KRT modality			
Dialysis	98 (27%)	98 (5%)	—
KTR	259 (73%)	—	259 (8%)
Sex			
Men	210 (59%)	58 (5%)	152 (8%)
Age, yr, median (IQR)	57 (44–65)	65 (54–72)	54 (40–62)
Primary renal diagnosis			
Diabetic nephropathy	65 (18%)	32 (6%)	33 (8%)
GN	87 (24%)	21(6%)	66 (8%)
Interstitial	125 (35%)	14 (3%)	111 (9%)
Multisystem	38 (11%)	19 (4%)	19 (5%)
Unknown	42 (12%)	12 (3%)	30 (7%)
SIMD			
1 (most deprived)	108 (30%)	32 (5%)	76 (11%)
2	84 (24%)	28 (6%)	56 (8%)
3	54 (15%)	13 (4%)	41 (6%)
4	57 (16%)	16 (5%)	41 (6%)
5 (least deprived)	54 (15%)	9 (4%)	45 (8%)
Vaccine type			
ChAdOx1	268 (75%)	68 (6%)	200 (9%)
mRNA	89 (25%)	30 (4%)	59 (6%)
Hospitalization	110 (34%)	29 (1%)	81 (2%)
Death	33 (9%)	7 (0.3%)	26 (0.8%)

—, not applicable.

Table 4. Univariable and multivariable Cox proportional hazard model of predictors of breakthrough infection following two doses of SARS-CoV-2 vaccine

Patient Characteristics	HR (Univariate; 95% CI; *P* Value)	HR (Multivariate; 95% CI; *P* Value)
Modality		
Dialysis	—	—
Transplant	1.9 (1.5 to 2.5; $P<0.001$)	1.80 (1.41 to 2.34; $P<0.001$)
Sex		
Women	—	—
Men	0.96 (0.80 to 1.20; $P=0.70$)	0.99 (0.80 to 1.22; $P=0.90$)
Age, yr		
75 and over	—	—
65–74	0.96 (0.60 to 1.54; $P=0.80$)	0.81 (0.51 to 1.31; $P=0.40$)
45–64	1.73 (1.17 to 2.56; $P=0.006$)	1.32 (0.88 to 1.98; $P=0.17$)
18–44	2.33 (1.53 to 3.55; $P\leq0.001$)	1.68 (1.08 to 2.60; $P=0.01$)
PRD		
Diabetic nephropathy	—	—
GN	1.10 (0.80 to 1.52; $P=0.50$)	0.98 (0.71 to 1.37; $P=0.93$)
Interstitial	1.13 (0.83 to 1.53; $P=0.40$)	0.98 (0.72 to 1.32; $P=0.91$)
Multisystem	0.64 (0.42 to 0.96; $P=0.02$)	0.68 (0.45 to 1.03; $P=0.07$)
Unknown	0.78 (0.52 to 1.16; $P=0.20$)	0.75 (0.50 to 1.13; $P=0.18$)
SIMD		
1 (most deprived)	—	—
2	0.81 (0.60 to 1.07; $P=0.15$)	0.81 (0.60 to 1.06; $P=0.13$)
3	0.54 (0.38 to 0.75; $P<0.001$)	0.53 (0.38 to 0.75; $P<0.001$)
4	0.59 (0.43 to 0.82; $P<0.001$)	0.56 (0.40 to 0.78; $P<0.001$)
5 (least deprived)	0.68 (0.49 to 0.95; $P=0.02$)	0.64 (0.46 to 0.89; $P<0.001$)

HR, hazard ratio; —, not applicable; PRD, primary renal diagnosis.

of two doses is insufficient to protect individuals on KRT. These striking adverse outcomes from COVID-19 infection in patients on KRT contrast with those in the general population, with <0.1% of the Scottish population admitted to the hospital or dying due to COVID-19 >14 days after a first COVID-19 vaccine dose.[19]

We provide the first estimates of vaccine effectiveness against SARS-CoV-2 infection and hospitalization in KRT. The Scottish Renal Registry has 100% coverage of patients on chronic KRT, hence representing the epidemiology and effect of vaccination in Scotland. Our data capture a 20-month period of the pandemic, including 10 months since vaccination commenced. With 93% of the KRT population "fully" vaccinated in Scotland, these data allow conclusions to be drawn regarding the efficacy of a two-dose vaccination regimen.

Knowledge surrounding the management of COVID-19 has increased, with interventions, such as dexamethasone and tocilizumab, reducing mortality in patients hospitalized with COVID-19.[20,21] However, mortality remains high even following vaccination in patients on KRT in Scotland, with 9% of patients testing positive for SARS-CoV-2 dying within 28 days, much higher than in cases series reported elsewhere.[22,23] This highlights the urgent need for adjunctive strategies to reduce the risk of SARS-CoV-2 infection and its complications. It is not possible to state whether the high incidence of breakthrough infection and adverse outcomes reflects failure to induce protective immunity, waning immunity, increasing transmissibly of the Delta variant over the period of study, or wider relaxation of COVID-19 restrictions. General population data combining Brazilian and Scottish vaccination records suggest that waning immunity with ChAdOx1 significantly contributes to the increased risk of hospitalization and death from COVID-19.[24] A large US cohort study ($n=4791$) demonstrated rapid waning of serologic protection to SARS-CoV-2 in patients on dialysis associated with risk of breakthrough infection.[25] We note much lower incidence of vaccination in the United States, with only 53.4% vaccinated as of September 14, 2021 compared with 93% of our KRT cohort over an almost identical timescale. Strategies to address elevated the risk of SARS-CoV-2 infection may include a third dose of vaccine, which induces a greater immunologic response in KTRs,[26,27] and neutralizing SARS-CoV-2 mAbs as either prophylactic or therapeutic agents.

Since completion of these analyses, the Omicron SARS-CoV-2 variant has emerged with greater propensity for evading vaccines. Booster vaccination programs have been widely instigated. Ongoing establishment of vaccine efficacy in patients requiring KRT is nevertheless required. The basic tenet of our data will remain: that patients receiving KRT are at higher risk of breakthrough infection and adverse outcomes. These patients should be prioritized for enhanced vaccination strategies and therapies, such as with sotrovimab as SARS-CoV-2 neutralizing antibody with the greatest proposed efficacy against Omicron.[28,29(preprint)] Our analyses were performed prior to the widespread instigation of neutralizing antibody therapy with casirivimab plus imdevimab in patients at elevated

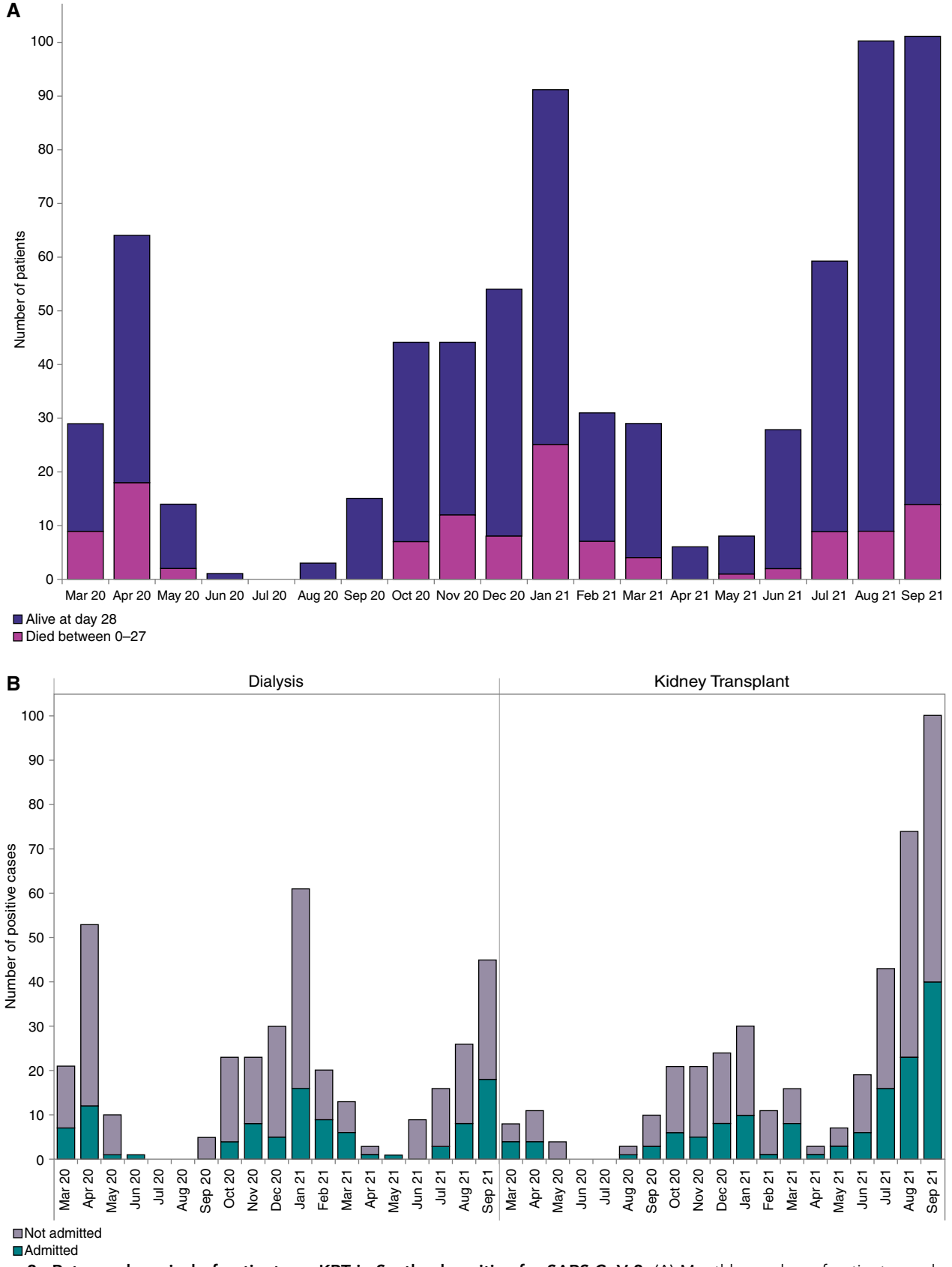

Figure 2. Rates and survival of patients on KRT in Scotland positive for SARS-CoV-2. (A) Monthly number of patients on chronic KRT positive for SARS-CoV-2 in Scotland split by status at day 28. (B) Rates and hospitalization of patients on KRT by modality in Scotland positive for SARS-CoV-2.

risk of death from COVID-19.[30,31(preprint)] The role of oral antiviral therapy with molnupiravir or other agents is yet to be established, although we note that eGFR<30 ml/min per 1.73m^2 or requiring dialysis was an exclusion criterion in at least one clinical trial.[32]

Several limitations must be acknowledged. The numbers are too low to calculate vaccine effectiveness against death or to separate by vaccine type. About 3% of the cohort had only received one dose of an approved vaccine at the time the data were analyzed. These were excluded from the analysis, resulting in a minor loss of statistical power. No SARS-CoV-2 antibody testing was performed. Data on mortality were available until September 21, 2021, whereas SARS-CoV-2 test results were updated until October 19, 2021. Consequently, the proportion of patients dying within 28 days of their positive PCR test may be slightly underestimated. Finally, although it had been reported that antibody response varies according to age, degree of immunosuppression, and eGFR,[7,8,11] we did not conduct any adjusted analysis in this study and only report crude outcomes.

Despite the promising effects of COVID-19 vaccination at a population level, for vaccinated patients requiring KRT the risks of SARS-CoV-2 infection and subsequent complications remain high. Two doses of approved vaccines fail to provide sufficient protection. Further strategies to mitigate risk are required, which may include nonpharmacologic interventions, optimization of vaccination regimens, prophylactic therapies, and improved COVID-19 treatment strategies.

DISCLOSURES

S. Bell reports personal fees from AstraZeneca, outside the submitted work. P.B. Mark reports grants from Boehringer Ingelheim; personal fees from Astellas, AstraZeneca, Janssen, and Novartis; and personal fees and nonfinancial support from Napp, Pharmacosmos, and Vifor, outside the submitted work. P. Thomson reports research funding from Proteon Therapeutics and honoraria from W.L. Gore & Associates. All remaining authors have nothing to disclose.

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AUTHOR CONTRIBUTIONS

S. Bell conceptualized the study; A. Almond, K. Buck, J. Campbell, L. Clark, Z. Cousland, M. Findlay, N. Joss, P.B. Mark, W. Metcalfe, S. Methven, M. Petrie, V. Sanu, E. Spalding, P. Thomson, J.P. Traynor, and C. Watters were responsible for data curation; S. Bell, E.J. Carr, and P.B. Mark were responsible for investigation; J. Campbell, E. Lambourg, and M. O'Neil were responsible for formal analysis; S. Bell, J. Campbell, E.J. Carr, E. Lambourg, and M. O'Neil were responsible for methodology; C. Watters was responsible for project administration; S. Bell, E.J. Carr, and P.B. Mark wrote the original draft; and A. Almond, S. Bell, K. Buck, J. Campbell, E.J. Carr, L. Clark, Z. Cousland, M. Findlay, N. Joss, E. Lambourg, P.B. Mark, W. Metcalfe, S. Methven, M. O'Neil, M. Petrie, V. Sanu, E. Spalding, P. Thomson, J.P. Traynor, and C. Watters reviewed and edited the manuscript.

SUPPLEMENTAL MATERIAL

This article contains the following supplemental material online at http://jasn.asnjournals.org/lookup/suppl/doi:10.1681/ASN.2022010046/-/DCSupplemental.

Supplemental Figure 1. Monthly number of patients on dialysis positive for SARS-CoV-2 in Scotland split by status at day 28 (alive in dark blue and dead in purple) and monthly number of patients with a kidney transplant positive for SARS-CoV-2 in Scotland split by status at day 28 (alive in dark blue and dead in purple).

Supplemental Figure 2. Kaplan–Meier curve of 28-day survival following a positive SARS-CoV-2 PCR test in patients on dialysis in Scotland split by wave and Kaplan –Meier curve of 28-day survival following a positive SARS-CoV-2 PCR test in patients with a functioning kidney transplant in Scotland split by wave.

Supplemental Figure 3. Bootstrap distribution with 95% confidence intervals for relative risks of hospitalization and testing positive in vaccinated versus unvaccinated individuals.

Supplemental Table 1. Vaccine effectiveness for testing positive for COVID-19 (COVID-19 tests results from January 1, 2021 to October 19, 2021) in the adult KRT population as of September 19, 2021.

Supplemental Table 2. Vaccine effectiveness for hospitalization within 14 days of positive COVID-19 test results from March 1, 2021 to October 5, 2021.

Supplemental Table 3. Vaccine effectiveness (patients with transplants only) for testing positive for COVID-19 (COVID-19 tests results from January 1, 2021 to October 19, 2021) in the adult KRT population as of September 19, 2021.

Supplemental Table 4. Vaccine effectiveness (patients with transplants only) for hospitalization within 14 days of positive COVID-19 tests results from March 1, 2021 to October 5, 2021.

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