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Indicators of vaccination status in patients with chronic kidney disease: the importance of recommendations from healthcare providers

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Abstract

Background Influenza and pneumococcal vaccinations are strongly encouraged for individuals with chronic kidney disease (CKD); however, vaccination rates remain below the target. Establishing factors influencing vaccination status may guide approaches to enhance vaccine uptake among this vulnerable patient population.

Methods A cross-sectional study involved 307 patients diagnosed with CKD for at least one year (40.4% non-dialysis, 37.1% dialysis, and 22.5% kidney transplantation). Demographic data, clinical conditions, and social factors, such as nutritional status, frailty, and health literacy, were evaluated. The vaccination rates for influenza, and pneumococcus, along with the associated variables, have been analyzed.

Results The average age of the patients was 57 years (± 16), with a predominance of males (56.7%). The percentages of individuals unvaccinated for influenza, pneumococcus, and SARS-CoV-2 were 61.9%, 60.9%, and 5.9%, respectively, while only 11 patients (3.9%) received an annual influenza vaccine. Healthcare providers recommended influenza and pneumococcal vaccination to 60.3% and 37.1% of patients, 71% of whom visited a physician 5 or more times a year, respectively. The frequency of regular or infrequent influenza vaccination was significantly correlated with healthcare providers' recommendations (HR, 14.348; 95% CI, 6.842–30.086; $p < 0.001$), increased risk of malnutrition (HR, 2.722; 95% CI, 1.467–5.050; p:0.002), and previous pneumococcal vaccination (HR, 2.100; 95% CI, 1.180–3.737; p:0.012). Conversely, frailty was linked to reduced vaccination rates (HR, 0.198; 95% CI, 0.083–0.472; $p < 0.001$). In multivariable models, healthcare providers' recommendations (HR, 17.804; 95% CI, 9.353–33.892; $p < 0.001$) and advanced age (HR, 1.024; 95% CI, 1.001–1.046; p:0.040) were determined as factors associated with pneumococcal vaccination.

Conclusion The guidance of healthcare professionals is the key factor in improving immunization rates. Developing health policies that consider factors influencing vaccine hesitancy and engage healthcare providers in the decision-making process is essential.

Clinical trial number Not applicable.

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Keywords Chronic kidney disease, Infectious disease, Influenza, Pneumococcus, Vaccination

Background

Infections are the predominant cause of hospitalization and mortality in individuals with chronic kidney disease (CKD), following cardiovascular diseases [1]. Due to the vulnerability to infections caused by the immunosuppressive state that arises in CKD, which results from the interplay of innate and adaptive immune system impairment, chronic inflammation, oxidative stress, endothelial cell dysfunction, and uremic toxins, infection prevention in this patient group is crucial [2]. Vaccination is the main strategy in reducing the risk of vaccine-preventable diseases, including influenza and pneumococcus, which are the leading causes of pneumonia. Despite concerns about reduced seroconversion and vaccine effectiveness in CKD, it is recommended that patients with CKD, including those undergoing dialysis or kidney transplantation, receive an annual influenza vaccine and be appropriately vaccinated with pneumococcal vaccines according to the recommended schedule [3].

Patients with CKD and end-stage kidney disease (ESKD) who have been vaccinated against influenza and pneumococcus exhibit reduced rates of hospitalization caused by infections and cardiovascular diseases, along with lower overall and cardiovascular mortality rates [4–8]. Moreover, the concurrent administration of the vaccines enhances their beneficial effects [4, 9]. Although immunization rates have risen over the years, not all at-risk populations are receiving vaccinations [10]. In the United States, influenza vaccination rates rose from 57.3% in 2009 to 81.8% by 2020 [11]. The rate for the pneumococcal vaccine, however, is lower, reported to be between 21.0% and 41.8% [12].Both vaccines are advised and have been covered for high-risk patients, including individuals with CKD, in our country [13]. Nevertheless, local studies indicate a reduced immunization rate among patients with CKD in comparison to worldwide statistics [14–16]. Despite factors such as age, race, social characteristics, and underlying comorbidities have been demonstrated to affect vaccination rates against influenza and pneumonia in individuals without CKD, evidence regarding this issue in CKD patients remain inadequate [17]. We aimed to determine vaccination rates and the factors contributing to vaccination acceptance which is critical for enhancing vaccination rates and mitigating infection-associated risks.

Methods

Study population

A cross-sectional study was performed on CKD patients who presented to our hospital's nephrology outpatient or inpatient clinic from June 2024 to August 2024. Following the exclusion of patients without CKD, those diagnosed with CKD for less than one year, individuals under 18 years of age, those unable to respond to the questions, and those unwilling to participate, a total of 307 patients were included in the study. A questionnaire regarding vaccination status for influenza, pneumococcus, and severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), together with healthcare providers' recommendations for each vaccine, was administered to patients in person by the attending physicians. The immunization status was verified using the national vaccination database. Following the questionnaire, participants were informed regarding influenza and pneumococcal vaccines and were advised to receive the vaccination.

In Türkiye, inactivated influenza vaccines containing either three (trivalent) or four (quadrivalent) strains are used annually. Participants were categorized based on their influenza vaccination history: "*never-vaccinated*" for those who had never received the vaccine; "*annual-vaccination*" for individuals vaccinated for at least two consecutive years before current year; and "*infrequent-vaccination*" for those vaccinated at least once but not for two consecutive years. The pneumococcal conjugate vaccine (PCV13) is the only pneumococcal vaccine covered by reimbursement during the study period, and patients who received this vaccine were considered as the vaccinated group.

The study received approval from the Ankara University Non-Interventional Health Research Ethics Committee (Approval ID: İ05-375-24, 25.04.2024). All participants voluntarily provided a written informed consent. All protocols adhered to the ethical guidelines established by the 1975 Helsinki Declaration.

Potential determinants of vaccination

Demographics (age, sex), smoking status, alcohol consumption, and social determinants of health (educational status, monthly household income, marital status, family population, employment status, place of residence, health insurance coverage, health literacy) were derived from self-reported data. The short-form health literacy questionnaire (HLS-SF12), which has been validated in Turkish population, was employed to assess health literacy [18]. The index value for health literacy was determined, with 0 being the lowest and 50 the maximum. Participants were also asked "How easy do you find it to judge which vaccinations you may require?" and were instructed to scale it as very easy, easy, difficult, or very difficult. Monthly household incomes were categorized into quartiles (Q): Turkish lira (TL) Q1; <15,000, Q2; 15,000–24,499, Q3; 25,000–40,000, Q4; >40,000. Frailty was evaluated using FRAIL scale, which consists of five elements: fatigue, resistance, ambulation, illnesses, and loss of weight [19]. Frailty status was then classified as frail (exhibiting three or more of the characteristics), pre-frail (exhibiting one or two), and no frail (exhibiting none). Mini-Nutritional Assessment Short Form (MNA-SF) was used to evaluate nutritional status based on diminished food intake, weight loss, and psychological stress or acute illness within the past three months, mobility, neuropsychological problems, and body mass index [20]. Participants were categorized into two groups: risk of malnutrition (0–11 points), and normal (12–14 points). Data regarding the etiology of CKD, duration of CKD, and associated comorbidities including hypertension, diabetes, cardiovascular disease (CVD), chronic obstructive pulmonary disease (COPD), asthma, and history of malignancy were recorded. Estimated glomerular filtration rate (eGFR), and urine protein-to-creatinine ratio (UPCR) were acquired via the electronic medical record system. eGFR was determined utilizing the 2021 CKD Epidemiology Creatinine Equation (CKD-EPI). UPCR was established by the ratio of urinary protein to creatinine in spot urine samples.

Statistical analysis

The characteristics of individuals in response to the questionnaire were reported overall, categorized by the CKD status, and immunization status. Continuous data were expressed as mean (standard deviation [SD]) for normally distributed numerical variables or median (minimum-maximum) for non-normally distributed numerical variables. Categorical data were presented as number (n) and percentage (%). Comparative analyses employed Student's T-Test or One-Way ANOVA for normally distributed numerical variables, and the Mann-Whitney U test or Kruskal-Wallis test for non-normally distributed numerical variables. Chi-square tests or Fisher's exact tests were utilized for categorical variables. Variables exhibiting a p-value < 0.10 from univariate analyses were included as potential factors in the regression model. A multivariable logistic regression analysis was conducted to ascertain factors influencing vaccination status and with odds ratios (OR), 95% confidence intervals (CI), and Wald statistics calculated for each variable. Data analysis was executed utilizing IBM SPSS version 30 (IBM Corporation, Armonk, NY, USA), with a significance level set at $p < 0.05$.

Results

Baseline characteristics of the study population

The features of 307 participants, comprising 37.1% CKD-dialysis, 40.4% CKD non-dialysis, and 22.5% who had undergone a kidney transplant, in response to the questionnare were provided in Table 1. The mean age was 57 ± 16 years, with a predominance of males (56.7%). Among patients with a mean history of CKD over 8 years, the etiology of CKD was unidentified in 25.7%, attributed to chronic glomerulonephritis in 16.8%, diabetes in 12.7%, and hypertension in 10.4%. In non-dialysis patients, 25% had eGFR < 30 ml/min/1.73m^2 and 27% had UPCR ≥ 1 g/g. Approximately half of the patients were classified as no-frail, while 57% demonstrated normal nutritional status. The kidney transplant recipient cohort was younger, exhibited a greater prevalence of high school and university education, had increased employment rates, had lower marriage history, and demonstrated elevated health literacy scores. 71% of participants consulted a physician 5 or more times annually.

Vaccination rates

The rates of individuals never vaccinated for influenza, pneumococcus, and SARS-CoV-2 were 61.9%, 60.9%, and 5.9%, respectively (Figure 1). Only 11 patients (3.9%) received annual-vaccination for influenza. In the context of influenza vaccination, the recommendation of healthcare providers was notably higher among dialysis patients compared to other CKD groups ($p = 0.003$). However, the proportion of never-vaccinated individuals was significantly elevated ($p = 0.046$), and the vaccination rate in the previous year was considerably lower ($p = 0.013$) in dialysis patients. No differences were observed between CKD groups regarding pneumococcal and SARS-CoV-2 vaccination rates, as well as healthcare providers' recommendations. 41% of participants reported difficulty in determining the necessity of vaccination.

Factors affecting influenza vaccination

In comparison between the never-vaccinated and vaccinated (annual or infrequent) groups for influenza, the vaccinated group exhibited a higher likelihood of being currently or formerly married (40.5% vs. never married 24.5%, $p = 0.031$), increased risk of malnutrition (43.8% vs. normal nutrition 32.9%, $p = 0.061$), being less frail (40.4% vs. frail 23.4%, $p = 0.030$), being a non-active smoker (40.2% vs. active smoker 25.0%, $p = 0.050$), having diabetes (44.7% vs. no diabetes 34.3%, $p = 0.078$), having a history of pneumococcus and SARS-CoV-2 vaccination (52.5% vs. no vaccine 28.3%, $p < 0.001$, and 39.8% vs. no vaccine 5.6%, $p = 0.020$, respectively). While not receiving dialysis significantly improved influenza vaccination status in the previous year (OR 7.704, 95% CI 2.181–27.216, $p = 0.002$), this significance was not observed for individuals who were annually or infrequently vaccinated (Table 2).

Conversely, characteristics including age, sex, kidney function, health literacy, education, employment, place of residence, and household income were similar between the two groups. Among individuals recommended for

Table 1 Characteristics of the patients, accorging to chronic kidney disease subgroup

	Dialysis (n = 114, 37.1%)	**Non-dialysis (n = 124, 40.4%)**	**Kidney Tx (n = 69, 22.5%)**	***P* value**	**Total (n = 307, 100.0%)**
Age (years), mean ± SD	57.5 ± 14.7	62.4 ± 14.3	44.6 ± 13.0	**< 0.001**	56.6 ± 15.6
Sex, men n (%)	67, (58.8)	67, (54.0)	40, (58.0)	0.739	174, (56.7)
Comorbidities n (%)	88, (77.2)	105, (84.7)	40, (58.0)	**< 0.001**	233, (75.9)
Hypertension	36, (31.6)	50, (40.3)	17, (24.6)	0.074	103, (33.6)
Diabetes Mellitus	39, (34.2)	50, (40.3)	13, (18.8)	**0.010**	102, (33.2)
Cardiovascular disease	8, (7.0)	21, (16.9)	1, (1.4)	**0.001**	30, (9.8)
COPD/Asthma	8, (7.0)	17, (13.7)	1, (1.4)	**0.011**	26, (8.5)
Malignancy					
Current smoker n (%)	16, (14.0)	27, (21.8)	13, (19.1)	0.442	56, (18.3)
Current drinker n (%)	3, (3.5)	7, (5.6)	5, (7.2)	0.523	16, (5.2)
CKD duration (years), median (min-max)	11, (1–39)	5, (1–48)	16, (2–64)	**< 0.001**	8, (1–64)
eGFR (ml/min/1.73m^2) n, (%) (n = 193)		25, (20.2)	33, (47.8)	**< 0.001**	58, (30.0)
≥ 60		56, (45.2)	30, (43.5)		86, (44.6)
30–59		43, (34.7)	6, (8.7)		49, (25.3)
< 30					
UPCR (n = 193)		77, (62.6)	63, (91.3)	**< 0.001**	140, (72.9)
< 1 g/g		27, (22.0)	5, (15.6)		32, (16.7)
1–3 g/g		19, (15.4)	1, (1.4)		20, (10.4)
> 3 g/g					
Frailty n, (%)	63, (55.3)	57, (46.0)	35, (50.7)	0.650	155, (50.5)
No-frail	37, (32.5)	45, (36.3)	23, (33.3)		105, (34.2)
Pre-frail	14, (12.3)	22, (17.7)	11, (15.9)		47, (15.3)
Frailty					
≥ 5% unintentional weight loss in the last year n, (%) (n = 306)	13, (11.4)	25, (20.2)	13, (19.1)	0.161	51, (16.7)
Nutritional status n, (%) (n = 303)	75, (65.8)	71, (57.3)	27, (41.5)	**0.037**	173, (57.1)
Normal	39, (34.2)	53, (42.7)	38, (58.5)		130, (42.9)
Risk of malnutrition					
Doctor visit ≥ 5 times/year n, (%)	108, (94.7)	76, (61.3)	35, (50.7)	**< 0.001**	219, (71.3)
Social determinants					
Education, high school/university graduation, n (%)	54, (47.4)	47, (37.9)	48, (69.6)	**< 0.001**	149, (48.5)
Marital status, never married n (%)	22, (19.3)	9, (7.3)	22, (31.9)	**< 0.001**	53, (17.3)
Employed, yes n (%)	19, (16.7)	21, (16.9)	33, (47.8)	**< 0.001**	73, (23.8)
Urban residence, yes n (%)	112, (98.2)	118, (95.2)	58, (86.6)	**0,004**	288, (94.4)
Household income per month n (%)	27, (23.7)	34, (27.4)	17, (24.6)	**0.039**	78, (25.4)
Q1	37, (32.5)	35, (28.2)	8, (11.6)		80, (26.1)
Q2	30, (26.3)	29, (23.4)	22, (31.9)		81, (26.4)
Q3	20, (17.5)	26, (21.0)	22, (31.9)		68, (22.1)
Q4					
Health insurance, yes n (%)	102, (89.5)	109, (87.9)	66, (95.7)	0.208	277, (90.2)
Health Literacy index, mean ± SD	34.5 ± 15.0	29.5 ± 10.6	34.7 ± 9.3	**0.003**	30.9 ± 10.3
Vaccination status					
Influenza vaccination status n (%)	72, (63.2)	79, (63.7)	39, (56.5)	**0.046**	190, (61.9)
Never-vaccinated	42, (36.8)	38, (30.6)	26, (37.7)		106, (34.5)
Infrequent	0, (0,0)	7, (5.6)	4, (5.8)		11, (3.6)
Annual					
Influenza vaccination in the previous year n (%)	3, (2.6)	12, (9.7)	10, (14.5)	**0.013**	25, (8.1)
Pneumococcal vaccination n (%)	51, (44.7)	47, (37.9)	22, (31.9)	0.212	120, (39.1)
SARS-CoV-2 vaccination n (%)	108, (94.7)	118, (95.2)	63, (91.3)	0.519	289, (94.1)

Table 1 (continued)

	Dialysis (*n* = 114, 37.1%)	Non-dialysis (*n* = 124, 40.4%)	Kidney Tx (*n* = 69, 22.5%)	*P* value	Total (*n* = 307, 100.0%)
Healthcare providers' recommendation n (%)	83, (72.8)	65, (52.4)	37, (53.6)	**0.003**	185, (60.3)
Influenza vaccination	49, (43.0)	38, (30.6)	27, (39.1)	0.134	114, (37.1)
Pneumococcal vaccination	105, (92.1)	103, (83.1)	59, (85.5)	0.108	267, (87.0)
SARS-CoV-2 vaccination					
Judgement of vaccine requirement, difficult/very difficult n, (%) (*n* = 290)	48, (44.0)	50, (42.0)	20, (32.3)	**0.015**	118, (40.6)

CKD, chronic kidney disease; eGFR, estimated glomerular filtration rate (CKD-EPI 2021); COPD, chronic obstructive pulmonary disease; Q, quartile; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; Tx, transplantation; UPCR, spot urine protein/creatinine ratio

* Sample sizes are indicated in cases of missing data during the initial visit. FRAIL scale and Mini-Nutritional Assessment Short Form (MNA-SF) were used to assess frailty and nutritional status, respectively. Health literacy was measured using the short-form health literacy questionnaire (HLS-SF12), with higher scores indicating higher literacy levels; 50 is the highest health literacy. bold = $p < 0.05$

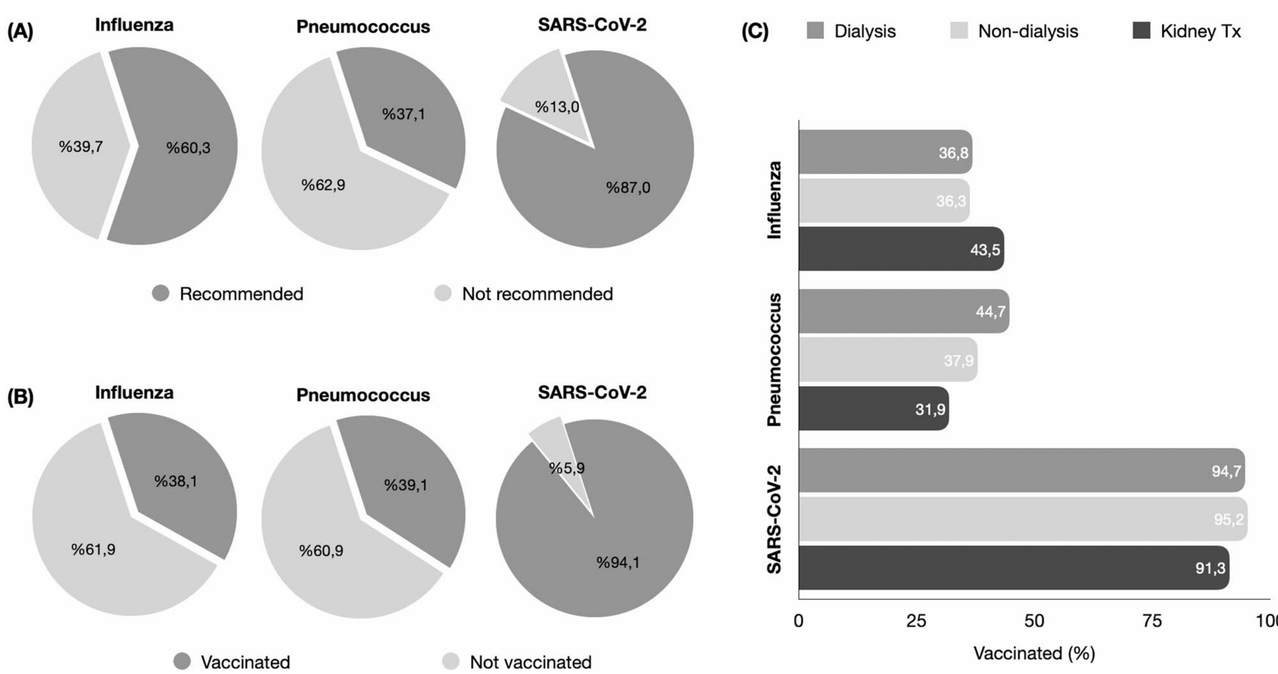

Fig. 1 The study cohort's (**A**) healthcare providers' recommendation rates, (**B**) vaccination rates, and (**C**) vaccination rates by chronic kidney disease subgroups for influenza, pneumococcus, and SARS-CoV-2 (*SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; Tx, transplantation)*

influenza vaccination by healthcare personnel, 56.8% were vaccinated, while only 9.0% of participants received the influenza vaccine without recommendation. The recommendation of healthcare providers was the primary factor influencing vaccination status, enhancing influenza vaccination rates by 14-fold and prior year vaccination rates by 10-fold. Other independent determinants of influenza vaccination include increased risk of malnutrition, absence of frailty, and prior pneumococcal vaccination.

Factors affecting Pneumococcal vaccination

39% of participants were vaccinated against pneumococcus with at least one pneumococcal vaccine dose. The evaluation of patients who received the pneumococcal vaccine revealed a higher prevalence among older adults (59.9 ± 14.8 vs. 54.5 ± 15.7 years, $p = 0.004$), women, (44.4% vs. men 35%, $p = 0.098$), individuals with a history of CVD (46.1% vs. no CVD 35.6%, $p = 0.077$), those with a history of pulmonary disease (60.0% vs. no pulmonary disease 36.8%, $p = 0.016$), the unemployed (42.3% vs. employed 38.8%, $p = 0.040$), and those who received the SARS-CoV-2 vaccine (40.8% vs. no vaccine 11.7%, $p = 0.024$). The variables regarding kidney functions, smoking, health literacy, education, place of residence, household income, frailty, and nutritional status were alike between the two groups. 75% of individuals who were recommended the pneumococcal vaccine received it, whereas only 17.6% of those who were not recommended had been vaccinated. Healthcare providers' recommendation was a crucial factor that impacted vaccination status for the pneumococcal vaccine, similar to

Table 2 Factors associated with vaccine uptake in multivariable analysis

	Odds ratio (%95 CI)	*P*-Value
Influenza vaccination in the previous year		
Healthcare providers' recommendation (reference: no recommendation)	9.891 (2.230-43.874)	**0.003**
Receiving dialysis (reference: non-dialysis)	7.704 (2.181–27.216)	**0.002**
Annual or infrequent influenza vaccination		
Healthcare providers' recommendation (reference: no recommendation)	14.348 (6.842–30.086)	**< 0.001**
Pneumococcal vaccination history (reference: no vaccination)	2.100 (1.180–3.737)	**0.012**
Frail (reference: no-frail or prefrail)	0.198 (0.083–0.472)	**< 0.001**
Risk of malnutrition (reference: normal nutritional status)	2.722 (1.467–5.050)	**0.002**
Pneumococcal vaccination at least once in a life time		
Healthcare providers' recommendation (reference: no recommendation)	17.804 (9.353–33.892)	**< 0.001**
Increased age	1.024 (1.001–1.046)	**0.040**

CI; confidence interval. bold = $p < 0.05$

influenza (HR, 17.804; 95% CI, 9.353–33.892; $p < 0.001$) (Table 2).

Discussion

Our research is noteworthy as it elucidates influenza and pneumococcus vaccination rates and the contributing factors within the entire CKD population in our country, encompassing non-dialysis patients, dialysis patients, and kidney transplant recipients. The overall vaccination ratios for influenza and pneumococcus were found to be 38.1% and 39.1%, respectively. Recommendations from healthcare providers, increased risk of malnutrition, lack of frailty, and previous pneumococcal vaccination history were correlated with an increased likelihood of influenza vaccination. Older adults and individuals who received recommendations from healthcare professionals exhibited a decreased probability of being unvaccinated against pneumococcus.

Previous studies indicated that seasonal influenza vaccine uptake among adults with CKD ranged from 63 to 72% [7, 11, 21], while it was below 50% for patients undergoing dialysis [5, 22, 23]. The pneumococcal vaccine rate was reported to be between 21% and 42% [12, 23, 24]. In Türkiye, annual influenza vaccination rates among dialysis patients range from 25 to 31%, while pneumococcus vaccination rates vary between 14% and 17% [15, 16]. The pneumococcal vaccination rates observed in our study align with existing literature. However, the higher influenza never-vaccinated rates noted in our study may be attributed to the fact that rates reported in other national studies relied on patient statements, whereas our data were sourced from the national vaccination database.

The factors contributing to vaccination rates against influenza and pneumonia for non-CKD individuals were previously determined as age, race, marital status, educational attainment, annual household income, health care coverage, employment, place of residence, smoking status, physical activity, underlying comorbidities, or perceived self-health status [17, 25–27]. Cross-sectional data of CKD patients from the National Health Interview Survey (NHIS) and the Chronic Renal Insufficiency Cohort (CRIC) indicate that younger individuals, black individuals, and those facing negative social determinants of health—such as low income, lack of insurance, and absence of a usual source of care—were less likely to receive an influenza vaccine [11, 21]. Conversely, individuals with diabetes, COPD, ESKD, and frailty exhibited a higher probability of being vaccinated against influenza. The absence of significant effects of social determinants on vaccination status in our study may be due to the predominance of patients with health insurance coverage and determined importance of healthcare providers' recommendation. Health literacy had no significant impact in our study, as vaccination rates were comparable between groups that perceived the vaccine decision-making process as easy or difficult. Conflicting studies regarding the impact of health literacy on vaccination status in the general population suggest that existing scales may not effectively measure beliefs and opinions related to vaccination [28, 29]. Previous research demonstrated that vaccination rates for influenza and pneumococcus are higher among individuals with deteriorating kidney function [11, 24]. Our study revealed that pneumococcal vaccination rates were higher in the dialysis group, though not statistically significant, whereas annual influenza vaccination rates were significantly lower. The fact that the influenza vaccine is a seasonal vaccine that needs to be renewed annually may also contribute to these findings. In this regard, we assert that physicians reminding patients about vaccination during visits coinciding with the beginning of the influenza season will help increase vaccination rates.

Our study identified healthcare providers' recommendations as the primary independent determinant influencing increased rates of influenza and pneumococcal vaccinations. Individuals cited inadequate knowledge about the vaccine, a perceived lack of necessity for vaccination, suspicion about its effectiveness, and concerns regarding potential side effects as factors influencing their decision to forgo vaccination [14, 16, 22, 30, 31]. Johnson and colleagues discovered that approximately 50% of individuals who had not received influenza and pneumococcal vaccines indicated that their physician had not advised them to get vaccinated [30]. 60% of our patients stated that healthcare providers suggested influenza vaccines, whereas 37% noted recommendations for pneumococcal vaccines. CKD patients frequently seek medical consultation; however, healthcare providers often fail to adhere to established adult vaccination guidelines [30], and exhibit reluctance towards vaccination themselves [32, 33]. The expertise and experience of healthcare professionals, along with their beliefs regarding disease risk and perceptions of vaccine safety, necessity, and effectiveness, positively influence their vaccination recommendations [34, 35]. Time constraints during patient consultations can restrict thorough discussions, particularly when faced with competing clinical demands. Institutional shortcomings, such as inadequate reminders or lack of decision-support tools, further exacerbate missed opportunities for vaccination. To address the rising vaccine skepticism during the SARS-CoV-2 period [36], it is essential to develop strategies that will mitigate doubts among both the general population and healthcare professionals. Interventions, such as educational programs, on-site vaccination, and recommendations from healthcare professionals, significantly enhance vaccine uptake among both the general population and specific groups such as immunocompromised individuals and dialysis patients [37–40]. In contrast to influenza and pneumococcal vaccination, the higher SARS-CoV-2 vaccination rates noticed in our study in the same patient group, reinforce the notion that substantial vaccination rates can be achieved through national initiatives and campaigns. Nephrologists, along with family physicians, are regarded as the most trustworthy sources of vaccination for patients with CKD [22]. Therefore, it is crucial to enhance coordination between nephrologists and family physicians by distributing workloads effectively and setting health policies that allocate adequate time and facilitate patient communication tailored to their cognitive levels [41, 42].

Frailty is widely recognized as a predictor of poor health outcomes and increased healthcare utilization in patients with CKD. Previous studies have indicated higher vaccination rates among frail individuals [11]; however, our findings reveal a contrary trend—frailty correlates with a decreased likelihood of receiving the influenza vaccine, while increased risk of malnutrition positively influences vaccination rates. This discrepancy raises important questions regarding the interplay between frailty, healthcare engagement, and vaccine uptake. One possible explanation for this paradox lies in the methodological differences in assessing frailty. Prior studies that reported higher vaccination rates in frail populations often defined frailty based on functional impairments or comorbidity burden rather than standardized frailty indices. In contrast, our study utilized the FRAIL scale, which identifies a broader population of vulnerable individuals, including those who may not yet have high healthcare engagement. This distinction could partly explain why frail patients in our cohort were less likely to be vaccinated. Patients identified as frail often have cognitive impairment, mobility restrictions, or dependency on caregivers, which could hinder vaccination uptake despite frequent medical visits. In outpatient CKD populations, as seen in our study, frail individuals may lack strong advocacy from caregivers or may prioritize managing their chronic illness over preventive measures like vaccination. Given concerns about accompanying comorbidities, potential adverse effects or perceived vaccine inefficacy, frail individuals might be more reluctant to receive vaccinations. Our findings underscore the need for targeted interventions to improve vaccine uptake in frail CKD patients. Given that healthcare provider recommendations significantly influence vaccination rates, tailored counseling strategies that address vaccine concerns in frail individuals and their caregivers should become an integral part of every physician visit, regardless of specialty.

The main strength of this study is the use of vaccination rates sourced from a national database rather than relying on self-reported data. Nonetheless, it possesses certain limitations. Given the cross-sectional study design, we were unable to speculate the changing conditions of the patients. Secondly, as our data were sourced from patients presented to a large reference hospital, they may not accurately reflect the entire CKD population in our country. Additionally, the potential for residual confounding cannot be dismissed. Due to the absence of validated assessment tools for frailty and malnutrition in adults, covering both those under and over 65 years of age, our study employed the FRAIL and MNA-SF scales. In a study, which encompassed slow walking speed, grip strength tests, and self-reported low physical activity, 50% of CKD patients aged between 57 and 71 years were classified as not frail, consistent with our findings [43]. This method also has limitations, particularly in its difficult application and its reliance on physical criteria. The development of easily applicable frailty scales for CKD patients at high risk of frailty, including those under the age of 65, is essential for the detection and management of this patient population. Future research should further explore how frailty assessment tools impact vaccine uptake and identify effective strategies to bridge this gap in preventive care.

Conclusions

Influenza and pneumococcus vaccination rates in patients with CKD are below established targets. Healthcare providers play a crucial role in improving vaccination rates and standard patient care needs to highlight and discuss the importance of vaccination with CKD patients. Developing health policies that consider the factors influencing vaccine hesitancy and incorporate nephrologists in the decision-making process is essential.

Abbreviations

CKD	Chronic Kidney Disease
COPD	Chronic Obstructive Pulmonary Disease
CRIC	Chronic Renal Insufficiency Cohort
CVD	Cardiovascular Disease
eGFR	Estimated Glomerular Filtration Rate
ESKD	End-Stage Kidney Disease
HLS-SF12	Short-Form Health Literacy Questionnaire
MNA-SF	Mini-Nutritional Assessment Short Form
NHIS	National Health Interview Survey
PCV13	Pneumococcal Conjugate Vaccine 13
SARS-CoV-2	Severe Acute Respiratory Syndrome Coronavirus-2
TL	Turkish Lira
UPCR	Urine Protein-to-Creatinine Ratio

Author contributions

GK and İA designed the main study plan and developed the dataset together with CGK. GK, İA, and CKD were involved in the data collection process, while GK performed the study analyses. All authors contributed to the manuscript's writing. KA, ŞE, GN, KK, SK, and ŞŞ revised and reviewed the manuscript. All authors have read and approved the final version of the manuscript.

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Data availability

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Ankara University Non-Interventional Health Research Ethics Committee (Approval ID: İ05-375-24, 25.04.2024). Written informed consent was obtained from all participants. All procedures were conducted in accordance with the ethical principles of the 1975 Helsinki Declaration and its later amendments.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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