Risk factors for in-hospital mortality and prolonged hospitalization in patients with acute kidney injury or chronic kidney disease: a nationwide analysis of 327 833 hospitalizations in 2017–2021

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Abstract

Introduction: Kidney disease is recognized as a major global health burden. However, nationwide studies on hospitalization outcomes related to acute kidney injury (AKI) and chronic kidney disease (CKD) in Poland are lacking. The objective of this study was to identify risk factors for in-hospital mortality and prolonged length of stay among patients hospitalized due to AKI or CKD in Poland. It is the first nationwide analysis to evaluate these outcomes in this patient population.

Material and methods: This is a retrospective nationwide analysis of hospital discharge records of adult patients hospitalized due to a primary diagnosis of AKI (ICD-10 N17) or CKD (ICD-10 N18) between 2017 and 2021 in Poland. Risk factors for in-hospital mortality (death during hospitalization) and prolonged stay (≥ 8 days) were identified using logistic regression.

Results: Among 327 833 eligible hospitalizations, AKI accounted for 143 534 cases (mortality 21.3%; prolonged hospitalization 48%) and CKD for 184 299 cases (mortality 4.9%; prolonged hospitalization 24.7%). Significant risk factors for in-hospital mortality included female sex, age ≥ 70 years, neoplasms, and cardiovascular, respiratory, and digestive system diseases for both AKI and CKD. Prolonged hospitalization was associated with female sex, age ≥ 70 years, and hematologic, cardiovascular, respiratory, and digestive system diseases for AKI; and with age ≥ 70 years, neoplasms, and hematologic, endocrine, cardiovascular, respiratory, and digestive system diseases for CKD.

Conclusions: The study identified key risk factors for in-hospital mortality and prolonged hospitalization among patients with AKI or CKD. The findings may guide clinical risk stratification.

Key words: length of stay, patient discharge, retrospective studies, logistic models, Poland.

Introduction

In 2021, kidney disease was recognized by the World Health Organization (WHO) as the ninth most common cause of death globally [1]. Kidney disease comprises a range of conditions but is fundamentally classified as either acute kidney disease (AKD), if lasting less than three months, or chronic kidney disease (CKD), if persisting for longer [2]. While

AKD is a relatively recent classification [3], it subsumes acute kidney injury (AKI), which has long been recognized as a distinct clinical syndrome.

Reliable estimates of CKD's global impact have been consistently supplied by the Global Burden of Disease (GBD) Study for over three decades. In that time, the prevalence of CKD has risen by 30% to over 673.7 million cases in 2021, resulting in 1.5 million deaths accounting for 2.25% of all-cause mortality and over 529.6 disability-adjusted life years (DALYs) per 100,000 population [4]. In contrast, the clinical complexity and brief duration of AKI make its global burden difficult to quantify. In 2019, a collaborative effort led by the International Society of Nephrology (ISN) estimated the global incidence of AKI to be 13.3 million cases annually [5] and attributed 1.7 million deaths per year to the condition [6].

In Poland, the burden of kidney disease mirrors global patterns. The 2021 GBD Study indicated that the annual prevalence of CKD exceeded 3.8 million cases, of which nearly 5000 were fatal, contributing to almost 1% of deaths from all causes [4]. The DALY rate was 206.2, and the years of life lost (YLL) rate was 129.5 [4]. Data on the burden of AKI in Poland are lacking. One analysis concluded that the standard expected YLL rate of all-cause kidney disease, including AKI, was approximately 149.2 in 2019 [7].

The diagnosis and staging of AKI rely on a strictly defined increase in serum creatinine or decrease in urine output [3]. AKI's causes are diverse, but they all involve a prerenal, intrarenal, or postrenal mechanism. CKD is defined as a structural or functional abnormality of the kidneys, assessed by decreased glomerular filtration rate (GFR), which disrupts health [8]. Staging depends on the underlying cause, GFR, and severity of albuminuria. Similarly to AKI, CKD has many possible etiologies, with the most common being type 1 and type 2 diabetes mellitus, hypertension, and glomerulonephritis [9]. The approaches to treatment of AKI and CKD both depend on the underlying cause, and aim to prevent further dysfunction and life-threatening complications. Nonetheless, the treatment of AKI focuses on restoring kidney function, whereas the treatment of CKD prioritizes slowing the progression of the disease [10].

Hospitalization for AKI is indicated in cases of severe electrolyte imbalance, volume overload, acidosis, uremia, severe oliguria and anuria, or when AKI is superimposed on CKD stage 4 or higher [11]. Conversely, hospitalization for CKD is necessary with acute kidney failure, hemodynamic instability or exacerbation of comorbidities, especially cardiovascular, endocrine, and metabolic diseases [12]. Advanced age, lower eGFR, and extremely hot weather [13] increase hospitalization risk in both AKI and CKD. Female sex, higher proteinuria, higher albumin-creatinine ratio, and therefore higher stages are risk factors in CKD [14], while male sex, dehydration, inflammation, and exposure to nephrotoxic agents make hospitalization in AKI more likely [15].

There is a lack of nationwide studies on patients hospitalized with kidney disease in Poland. Nationwide analyses may provide data on hospitalization outcomes and the associated risk factors. The findings can be used by both clinicians and public health specialists to improve the quality of nephrological care in Poland.

The objective of this study was to identify risk factors for in-hospital mortality and prolonged hospitalization among patients hospitalized due to AKI or CKD between 2017 and 2021 in Poland.

Material and methods

Study design and population

This is a retrospective analysis of hospital discharge records of patients with a diagnosis of AKI or CKD. The study population comprised adult patients (aged 18 years and older) who were admitted to the hospital between 2017 and 2021 with a primary diagnosis (cause of hospital admission) of either AKI or CKD in the initial ward.

Data on hospitalizations in Poland come from the Nationwide General Hospital Morbidity Study (NGHMS) [16]. Reporting by hospitals is mandatory, which ensures that the data are complete and reliable. These data are routinely used for epidemiological summary reports but are also made available to researchers for in-depth analysis of hospitalization determinants and trajectories. The combination of patient-level demographic and medical information allows for the investigation of predictors of adverse clinical outcomes. Medical diagnosis is coded by physicians using the International Classification of Diseases, 10th Revision (ICD 10) [17]. Similar data source and methods have been used in previous population studies on hospitalizations in Poland [18–21].

Measures

AKI diagnosis was based on the ICD-10 code N17 (including N17.0; N17.1; N17.2; N17.8; and N17.9). CKD diagnosis was based on the ICD-10 code N18 (including N18.1; N18.2; N18.3; N18.4; N18.5 and N18.9).

Data on patients' characteristics included: sex, age, admission mode (emergency/scheduled), ward count, length of stay (in days), comorbidity count, and type of comorbidities based on ICD-10 groups.

In-hospital mortality was defined as death during hospitalization. A binary outcome variable

for prolonged hospitalization (defined by length of stay) was created by calculating the time from the initial admission date to the final discharge date, classifying hospitalizations as prolonged if the stay was equal to or longer than 8 days (given the mean length of stay of 7.31 days).

Data preprocessing and variable selection

All data preprocessing was conducted using the Python programming language (version 3.13.2). Records with missing critical values, such as patient sex, age, or initial admission date, were omitted from the analysis. Admissions that began prior to 2017 but continued into the study period were also excluded. In total, 327 833 unique, valid records were identified. Given that the data were anonymized, and re-hospitalizations could not be tracked, each record was assumed to represent a unique patient. This approach was appropriate as the measured outcomes (death/survival and prolonged hospitalization) were specific to individual hospital stays. In order to ensure that the results of this study could inform early risk stratification, only variables representing information available at the time of admission were included.

A season variable was derived from the admission date, classifying months as either cool (October–March) or warm (April–September) to explore the effect of seasonality on hospitalization outcomes.

A 5-year observation period (2017–2021) was selected to capture data from both before (2017–2019) and after (2020–2021) the onset of the COVID-19 pandemic in Poland.

Statistical analysis

Statistical analysis was carried out using the statsmodels Python module (version 0.14.4) [22]. All analyses were conducted separately for the AKI and CKD patient cohorts, as well as for each outcome of interest: in-hospital death and prolonged length of stay. The baseline characteristics of the study population were presented as categorical variables and summarized using raw counts and percentages. Group differences were assessed using the χ^2 test. Statistical significance was defined as a p-value of less than 0.05.

The association between potential predictors and the two outcomes was assessed using logistic regression. First, univariable logistic regression was used to estimate the unadjusted influence of each independent variable. Then, nine multivariable logistic regression models were constructed, combining three alternative versions of the comorbidity variable with three sequential adjustment strategies: (1) age and sex (Model A); (2) age, sex, and admission mode (Model B); and (3) age, sex, admission mode, and season (Model C). The results were expressed as odds ratios with 95% confidence intervals and the corresponding p-values. The best model was selected based on statistical significance and the Akaike information criterion (AIC), with lower AIC values indicating better fit. Clinical interpretability of the comorbidity definitions in relation to each outcome was also considered.

Results

Between 2017 and 2021, a total of 143 534 hospital admissions due to AKI and 184 299 hospital admissions due to CKD were reported in Poland (Tables I and II). In 2020 and 2021, compared to the years 2017–2019, a decrease in the number of hospital admissions due to AKI (Table I) and CKD (Table II) was observed. The characteristics of patients hospitalized due to AKI (AKI cohort) or CKD (CKD cohort) differed significantly across the analyzed years.

The in-hospital mortality rate was 21.3% in the AKI cohort and 4.9% in the CKD cohort (Table III). There were statistically significant differences in patients' characteristics by hospitalization outcome: death or survival (Table III). In both the AKI and CKD cohorts, those who died were older, more often admitted as emergencies, and had more comorbidities than survivors (Table III).

Hospitalization was prolonged (≥ 8 days) in 48% of patients hospitalized due to AKI and 24.7% of patients hospitalized due to CKD (Table IV). There were statistically significant differences in patient characteristics based on the duration of hospitalization (Table IV). Within the CKD cohort, patients hospitalized for ≥ 8 days, compared to those hospitalized for up to 7 days, were older, more often admitted in emergency mode, stayed in a greater number of wards, and had more comorbidities (Table IV). Among patients hospitalized due to AKI, these differences were less pronounced. Moreover, the AKI cohort showed no difference in the duration of hospitalization by admission mode (Table IV).

In the AKI cohort, female sex (OR = 1.071 [1.043–1.100], $p < 0.001$), age ≥ 70 years (OR = 1.853 [1.797–1.911], $p < 0.001$), comorbidities such as neoplasms (OR = 2.731 [2.624–2.842], $p < 0.001$), cardiovascular diseases (OR = 1.379 [1.342–1.417], $p < 0.001$), respiratory diseases (OR = 2.172 [2.097–2.249], $p < 0.001$), and diseases of the digestive system (OR = 1.191 [1.140–1.245], $p < 0.001$) were significantly associated with a higher risk of in-hospital mortality (Table V). Scheduled admission (OR = 0.542 [0.516–0.570], $p < 0.001$), admission during the warm season months (OR = 0.894 [0.871–0.918], $p < 0.001$), and comorbidities such as diseases of the blood

Table I. Characteristics of patients hospitalized due to acute kidney injury (AKI) by hospitalization year (2017–2021, Poland)

Acute kidney injury (N17)	2017 (*n* = 28711)	2018 (*n* = 31397)	2019 (*n* = 32106)	2020 (*n* = 25676)	2021 (*n* = 25644)	*P*-value
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	
Sex						
Men	14182 (49.4)	15806 (50.34)	16085 (50.1)	13117 (51.09)	13133 (51.21)	< 0.001
Women	14529 (50.6)	15591 (49.66)	16021 (49.9)	12559 (48.91)	12511 (48.79)	
Age						
18–29	342 (1.19)	329 (1.05)	396 (1.23)	295 (1.15)	335 (1.31)	< 0.001
30–39	567 (1.97)	592 (1.89)	662 (2.06)	522 (2.03)	579 (2.26)	
40–49	940 (3.27)	1051 (3.35)	1080 (3.36)	940 (3.66)	1078 (4.2)	
50–59	2336 (8.14)	2149 (6.84)	2193 (6.83)	1795 (6.99)	1806 (7.04)	
60–69	5654 (19.69)	6253 (19.92)	6365 (19.82)	5166 (20.12)	5167 (20.15)	
≥ 70	18872 (65.73)	21023 (66.96)	21410 (66.69)	16958 (66.05)	16679 (65.04)	
Admission mode						
Emergency	25891 (90.18)	28297 (90.13)	28666 (89.29)	22876 (89.09)	22324 (87.05)	< 0.001
Scheduled	2820 (9.82)	3100 (9.87)	3440 (10.71)	2800 (10.91)	3320 (12.95)	
Ward count						
1	24171 (84.19)	26584 (84.67)	26978 (84.03)	21213 (82.62)	20963 (81.75)	< 0.001
2	4004 (13.95)	4238 (13.5)	4493 (13.99)	3833 (14.93)	4098 (15.98)	
3–5	536 (1.87)	575 (1.83)	635 (1.98)	630 (2.45)	583 (2.27)	
Length of stay						
0	972 (3.39)	1033 (3.29)	982 (3.06)	871 (3.39)	866 (3.38)	< 0.001
1–3	4520 (15.74)	4887 (15.57)	4927 (15.35)	4287 (16.7)	4326 (16.87)	
4–7	9068 (31.58)	10277 (32.73)	10753 (33.49)	8523 (33.19)	8416 (32.82)	
8–14	9433 (32.86)	10091 (32.14)	10412 (32.43)	8109 (31.58)	8298 (32.36)	
15–21	2850 (9.93)	3134 (9.98)	3009 (9.37)	2382 (9.28)	2310 (9.01)	
22–29	1083 (3.77)	1142 (3.64)	1178 (3.67)	849 (3.31)	829 (3.23)	
≥ 30	785 (2.73)	833 (2.65)	845 (2.63)	655 (2.55)	599 (2.34)	
Comorbidity count						
0	7902 (27.52)	8591 (27.36)	9004 (28.04)	7435 (28.96)	7671 (29.91)	< 0.001
1	5641 (19.65)	5946 (18.94)	5987 (18.65)	5003 (19.49)	4904 (19.12)	
2	6104 (21.26)	7014 (22.34)	7054 (21.97)	5497 (21.41)	5311 (20.71)	
3	7176 (24.99)	7903 (25.17)	8041 (25.05)	5982 (23.3)	5538 (21.6)	
4 or more	1888 (6.58)	1943 (6.19)	2020 (6.29)	1759 (6.85)	2220 (8.66)	
Presence of at least one disease						
Neoplasms (C00-D49)						
Yes	2640 (9.2)	2921 (9.3)	3029 (9.43)	2432 (9.47)	2243 (8.75)	0.03
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (D50-D89)						
Yes	2976 (10.37)	3386 (10.78)	3526 (10.98)	2719 (10.59)	2971 (11.59)	< 0.001
Endocrine, nutritional, and metabolic diseases (E00-E89)						
Yes	7618 (26.53)	8396 (26.74)	8410 (26.19)	6521 (25.4)	6731 (26.25)	0.005
Diseases of the circulatory system (I00-I99)						
Yes	12579 (43.81)	13708 (43.66)	13755 (42.84)	10687 (41.62)	10554 (41.16)	< 0.001
Diseases of the respiratory system (J00-J99)						
Yes	3548 (12.36)	3955 (12.6)	4078 (12.7)	3109 (12.11)	3004 (11.71)	0.003
Diseases of the digestive system (K00-K95)						
Yes	2686 (9.36)	2958 (9.42)	3067 (9.55)	2621 (10.21)	2605 (10.16)	< 0.001
Diseases of the genitourinary system (N00-N99)						
Yes	6017 (20.96)	6622 (21.09)	6891 (21.46)	5513 (21.46)	5604 (21.85)	0.08
In-hospital death						
Yes	6105 (21.26)	6529 (20.79)	6512 (20.28)	5931 (23.1)	5565 (21.7)	< 0.001

Table II. Characteristics of patients hospitalized due to chronic kidney disease (CKD) by hospitalization year (2017–2021, Poland)

Chronic kidney disease (CKD)	2017 (*n* = 43460)	2018 (*n* = 40958)	2019 (*n* = 40145)	2020 (*n* = 29458)	2021 (*n* = 30278)	*P*-value
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	
Sex						
Men	23861 (54.9)	22840 (55.76)	22572 (56.23)	16990 (57.68)	17288 (57.1)	< 0.001
Women	19599 (45.1)	18118 (44.24)	17573 (43.77)	12468 (42.32)	12990 (42.9)	
Age						
18–29	1392 (3.2)	1383 (3.38)	1228 (3.06)	940 (3.19)	1025 (3.39)	< 0.001
30–39	2058 (4.74)	2043 (4.99)	2151 (5.36)	1764 (5.99)	1712 (5.65)	
40–49	3441 (7.92)	3298 (8.05)	3305 (8.23)	2459 (8.35)	2887 (9.53)	
50–59	5400 (12.43)	5167 (12.62)	4986 (12.42)	3524 (11.96)	3920 (12.95)	
60–69	11164 (25.69)	10463 (25.55)	9930 (24.74)	7506 (25.48)	7349 (24.27)	
≥ 70	20005 (46.03)	18604 (45.42)	18545 (46.2)	13265 (45.03)	13385 (44.21)	
Admission mode						
Emergency	25623 (58.96)	23261 (56.79)	22001 (54.8)	16812 (57.07)	16197 (53.49)	< 0.001
Scheduled	17837 (41.04)	17697 (43.21)	18144 (45.2)	12646 (42.93)	14081 (46.51)	
Ward count						
1	37248 (85.71)	34805 (84.98)	33772 (84.13)	24379 (82.76)	24998 (82.56)	< 0.001
2	5359 (12.33)	5326 (13.0)	5575 (13.89)	4264 (14.47)	4527 (14.95)	
3–5	853 (1.96)	827 (2.02)	798 (1.99)	815 (2.77)	753 (2.49)	
Length of stay						
0	7240 (16.66)	7360 (17.97)	7777 (19.37)	6468 (21.96)	7357 (24.3)	< 0.001
1–3	15424 (35.49)	14306 (34.93)	13795 (34.36)	9553 (32.43)	9969 (32.92)	
4–7	9845 (22.65)	9189 (22.44)	8810 (21.95)	5975 (20.28)	5694 (18.81)	
8–14	6800 (15.65)	6155 (15.03)	5985 (14.91)	4304 (14.61)	4289 (14.17)	
15–21	1957 (4.5)	1923 (4.7)	1726 (4.3)	1403 (4.76)	1355 (4.48)	
22–29	1073 (2.47)	1025 (2.5)	1042 (2.6)	858 (2.91)	805 (2.66)	
≥ 30	1121 (2.58)	1000 (2.44)	1010 (2.52)	897 (3.05)	809 (2.67)	
Comorbidity count						
0	19719 (45.37)	18574 (45.35)	18123 (45.14)	13384 (45.43)	14112 (46.61)	< 0.001
1	7673 (17.66)	7213 (17.61)	6879 (17.14)	5299 (17.99)	6107 (20.17)	
2	7038 (16.19)	6847 (16.72)	6775 (16.88)	5198 (17.65)	4826 (15.94)	
3	7173 (16.5)	6424 (15.68)	6321 (15.75)	4073 (13.83)	3795 (12.53)	
4 or more	1857 (4.27)	1900 (4.64)	2047 (5.1)	1504 (5.11)	1438 (4.75)	
Presence of at least one disease						
Neoplasms (C00-D49)						
Yes	1678 (3.86)	1488 (3.63)	1533 (3.82)	1122 (3.81)	1006 (3.32)	0.001
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (D50-D89)						
Yes	7969 (18.34)	7684 (18.76)	7454 (18.57)	5160 (17.52)	4807 (15.88)	< 0.001
Endocrine, nutritional, and metabolic diseases (E00-E89)						
Yes	8742 (20.12)	8414 (20.54)	8379 (20.87)	5846 (19.85)	5794 (19.14)	< 0.001
Diseases of the circulatory system (I00-I99)						
Yes	15557 (35.8)	14595 (35.63)	14682 (36.57)	10570 (35.88)	10556 (34.86)	< 0.001
Diseases of the respiratory system (J00-J99)						
Yes	1794 (4.13)	1650 (4.03)	1656 (4.13)	1299 (4.41)	1130 (3.73)	0.001
Diseases of the digestive system (K00-K95)						
Yes	1715 (3.95)	1626 (3.97)	1594 (3.97)	1157 (3.93)	1157 (3.82)	0.86
Diseases of the genitourinary system (N00-N99)						
Yes	5162 (11.88)	4826 (11.78)	4819 (12.0)	3618 (12.28)	3645 (12.04)	0.33
In-hospital death						
Yes	1940 (4.46)	1886 (4.6)	1829 (4.56)	1795 (6.09)	1610 (5.32)	< 0.001

Table III. Differences in patients' characteristics by hospitalization outcome: death or survival

Parameter	AKI *n* = 143534		*P*-value	CKD *n* = 184299		*P*-value
	Survived *n* = 112892	Died *n* = 30642		Survived *n* = 175239	Died *n* = 9060	
	n (%)	*n* (%)		*n* (%)	*n* (%)	
Sex						
Men	57574 (51.0)	14749 (48.13)	< 0.001	98933 (56.46)	4618 (50.97)	< 0.001
Women	55318 (49.0)	15893 (51.87)		76306 (43.54)	4442 (49.03)	
Age						
18–29	1649 (1.46)	48 (0.16)	< 0.001	5953 (3.4)	15 (0.17)	< 0.001
30–39	2717 (2.41)	205 (0.67)		9652 (5.51)	76 (0.84)	
40–49	4554 (4.03)	535 (1.75)		15209 (8.68)	181 (2.0)	
50–59	8831 (7.82)	1448 (4.73)		22582 (12.89)	415 (4.58)	
60–69	23753 (21.04)	4852 (15.83)		44844 (25.59)	1568 (17.31)	
≥ 70	71388 (63.24)	23554 (76.87)		76999 (43.94)	6805 (75.11)	
Admission mode						
Emergency	99433 (88.08)	28621 (93.4)	< 0.001	95778 (54.66)	8116 (89.58)	< 0.001
Scheduled	13459 (11.92)	2021 (6.6)		79461 (45.34)	944 (10.42)	
Ward count						
1	95967 (85.01)	23942 (78.13)	< 0.001	150296 (85.77)	4906 (54.15)	< 0.001
2	14969 (13.26)	5697 (18.59)		21678 (12.37)	3373 (37.23)	
3–5	1956 (1.73)	1003 (3.27)		3265 (1.86)	781 (8.62)	
Length of stay						
0	1856 (1.64)	2868 (9.36)	< 0.001	35556 (20.29)	646 (7.13)	< 0.001
1–3	11404 (10.1)	11543 (37.67)		60246 (34.38)	2801 (30.92)	
4–7	40451 (35.83)	6586 (21.49)		37611 (21.46)	1902 (20.99)	
8–14	40969 (36.29)	5374 (17.54)		25726 (14.68)	1807 (19.94)	
15–21	11464 (10.15)	2221 (7.25)		7557 (4.31)	807 (8.91)	
22–29	4029 (3.57)	1052 (3.43)		4321 (2.47)	482 (5.32)	
≥ 30	2719 (2.41)	998 (3.26)		4222 (2.41)	615 (6.79)	
Comorbidity count						
0	33508 (29.68)	7095 (23.15)	< 0.001	82428 (47.04)	1484 (16.38)	< 0.001
1	21773 (19.29)	5708 (18.63)		31556 (18.01)	1615 (17.83)	
2	23268 (20.61)	7712 (25.17)		28448 (16.23)	2236 (24.68)	
3	27175 (24.07)	7465 (24.36)		25552 (14.58)	2234 (24.66)	
4 or more	7168 (6.35)	2662 (8.69)		7255 (4.14)	1491 (16.46)	
Presence of at least one disease						
Neoplasms (C00-D49)						
Yes	8494 (7.52)	4771 (15.57)	< 0.001	5657 (3.23)	1170 (12.91)	< 0.001
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (D50-D89)						
Yes	13027 (11.54)	2551 (8.33)	< 0.001	31655 (18.06)	1419 (15.66)	< 0.001
Endocrine, nutritional, and metabolic diseases (E00-E89)						
Yes	30438 (26.96)	7238 (23.62)	< 0.001	34799 (19.86)	2376 (26.23)	< 0.001
Diseases of the circulatory system (I00-I99)						
Yes	45851 (40.61)	15432 (50.36)	< 0.001	60569 (34.56)	5391 (59.5)	< 0.001
Diseases of the respiratory system (J00-J99)						
Yes	11357 (10.06)	6337 (20.68)	< 0.001	5799 (3.31)	1730 (19.09)	< 0.001
Diseases of the digestive system (K00-K95)						
Yes	10899 (9.65)	3038 (9.91)	0.17	6522 (3.72)	727 (8.02)	< 0.001
Diseases of the genitourinary system (N00-N99)						
Yes	26495 (23.47)	4152 (13.55)	< 0.001	20052 (11.44)	2018 (22.27)	< 0.001

Table IV. Differences in patients' characteristics by duration of hospitalization

Parameter	AKI (*n* = 143534)		*P*-value	CKD (*n* = 184299)		*P*-value
	Hospitalization ≤ 7 days (*n* = 74708)	Hospitalization ≥ 8 days (*n* = 68826)		Hospitalization ≤ 7 days (*n* = 138762)	Hospitalization ≥ 8 days (*n* = 45537)	
	n (%)	*n* (%)		*n* (%)	*n* (%)	
Sex						
Men	38090 (50.99)	34233 (49.74)	< 0.001	78563 (56.62)	24988 (54.87)	< 0.001
Women	36618 (49.01)	34593 (50.26)		60199 (43.38)	20549 (45.13)	
Age						
18–29	1052 (1.41)	645 (0.94)	< 0.001	4942 (3.56)	1026 (2.25)	< 0.001
30–39	1710 (2.29)	1212 (1.76)		7712 (5.56)	2016 (4.43)	
40–49	2892 (3.87)	2197 (3.19)		12112 (8.73)	3278 (7.2)	
50–59	5552 (7.43)	4727 (6.87)		17951 (12.94)	5046 (11.08)	
60–69	14882 (19.92)	13723 (19.94)		36078 (26.0)	10334 (22.69)	
≥ 70	48620 (65.08)	46322 (67.3)		59967 (43.22)	23837 (52.35)	
Admission mode						
Emergency	66588 (89.13)	61466 (89.31)	0.28	70667 (50.93)	33227 (72.97)	< 0.001
Scheduled	8120 (10.87)	7360 (10.69)		68095 (49.07)	12310 (27.03)	
Ward count						
1	65081 (87.11)	54828 (79.66)	< 0.001	124624 (89.81)	30578 (67.15)	< 0.001
2	9214 (12.33)	11452 (16.64)		13500 (9.73)	11551 (25.37)	
3–5	413 (0.55)	2546 (3.7)		638 (0.46)	3408 (7.48)	
Comorbidity count						
0	23020 (30.81)	17583 (25.55)	< 0.001	71453 (51.49)	12459 (27.36)	< 0.001
1	14783 (19.79)	12698 (18.45)		24258 (17.48)	8913 (19.57)	
2	15903 (21.29)	15077 (21.91)		20988 (15.13)	9696 (21.29)	
3	17001 (22.76)	17639 (25.63)		17930 (12.92)	9856 (21.64)	
4 or more	4001 (5.36)	5829 (8.47)		4133 (2.98)	4613 (10.13)	
Presence of at least one disease						
Neoplasms (C00-D49)						
Yes	7094 (9.5)	6171 (8.97)	0.001	4336 (3.12)	2491 (5.47)	< 0.001
Diseases of the blood and blood-forming organs and certain disorders (D50-D89)						
Yes	6471 (8.66)	9107 (13.23)	< 0.001	22707 (16.36)	10367 (22.77)	< 0.001
Endocrine, nutritional, and metabolic diseases (E00-E89)						
Yes	19831 (26.54)	17845 (25.93)	0.008	25126 (18.11)	12049 (26.46)	< 0.001
Diseases of the circulatory system (I00-I99)						
Yes	30741 (41.15)	30542 (44.38)	< 0.001	44606 (32.15)	21354 (46.89)	< 0.001
Diseases of the respiratory system (J00-J99)						
Yes	7580 (10.15)	10114 (14.70)	< 0.001	3480 (2.51)	4049 (8.89)	< 0.001
Diseases of the digestive system (K00-K95)						
Yes	7016 (9.39)	6921 (10.06)	< 0.001	4068 (2.93)	3181 (6.99)	< 0.001
Diseases of the genitourinary system (N00-N99)						
Yes	13391 (17.92)	17256 (25.07)	< 0.001	11910 (8.58)	10160 (22.31)	< 0.001

and blood-forming organs (OR = 0.643 [0.614–0.673], $p < 0.001$) and endocrine, nutritional, and metabolic diseases (OR = 0.787 [0.763–0.811], $p < 0.001$) were significantly associated with a lower risk of in-hospital mortality in this cohort (Table V).

In the CKD cohort, female sex (OR = 1.093 [1.045–1.143], $p < 0.001$), age ≥ 70 years (OR = 2.797 [2.660–2.942], $p < 0.001$), comorbidities such as neoplasms (OR = 3.729 [3.470–4.007], $p < 0.001$), cardiovascular diseases (OR = 1.962

Table V. Risk factors for in-hospital mortality among patients hospitalized due to acute kidney injury (AKI) in Poland, 2017–2021

Parameter	Adjusted Model A			Adjusted Model B			Adjusted Model C			Univariable logistic regression		
	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Female sex	1.073	1.045–1.102	< 0.001	1.072	1.043–1.100	< 0.001	1.071	1.043 –1.100	< 0.001	1.122	1.094–1.150	< 0.001
Age ≥ 70, years	1.876	1.820–1.935	< 0.001	1.853	1.797–1.911	< 0.001	1.853	1.797–1.911	< 0.001	1.932	1.876–1.989	< 0.001
Scheduled vs. emergency admission	–	–	–	0.542	0.516–0.570	< 0.001	0.542	0.516–0.570	< 0.001	0.522	0.497–0.548	< 0.001
Warm vs. cool season months	–	–	–	–	–	–	0.894	0.871–0.918	< 0.001	0.878	0.856–0.900	< 0.001
Comorbidities												
Neoplasms (C00-D49)												
Yes	2.708	2.603–2.818	< 0.001	2.729	2.622–2.840	< 0.001	2.731	2.624–2.842	< 0.001	2.267	2.182–2.354	< 0.001
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (D50-D89)												
Yes	0.641	0.612–0.671	< 0.001	0.643	0.614–0.673	< 0.001	0.643	0.614–0.673	< 0.001	0.696	0.666–0.728	< 0.001
Endocrine, nutritional, and metabolic diseases (E00-E89)												
Yes	0.794	0.771–0.819	< 0.001	0.786	0.762–0.811	< 0.001	0.787	0.763–0.811	< 0.001	0.838	0.813–0.863	< 0.001
Diseases of the circulatory system (I00-I99)												
Yes	1.374	1.338–1.411	< 0.001	1.379	1.342–1.416	< 0.001	1.379	1.342–1.417	< 0.001	1.483	1.446–1.522	< 0.001
Diseases of the respiratory system (J00-J99)												
Yes	2.212	2.136–2.291	< 0.001	2.184	2.109–2.262	< 0.001	2.172	2.097–2.249	< 0.001	2.331	2.254–2.411	< 0.001
Diseases of the digestive system (K00-K95)												
Yes	1.203	1.152–1.257	< 0.001	1.190	1.139–1.244	< 0.001	1.191	1.140–1.245	< 0.001	1.030	0.987–1.074	0.17

Model A – adjusted for sex and age (AIC – 141566.90); Model B – adjusted for sex, age, and admission mode (AIC – 140914.12); Model C – adjusted for sex, age, admission mode and season (AIC – 140845.37); OR – odds ratio.

Table VI. Risk factors for in-hospital mortality among patients hospitalized due to chronic kidney disease (CKD) in Poland, 2017–2021

Parameter	Adjusted Model A			Adjusted Model B			Adjusted Model C			Univariable logistic regression		
	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Female sex	1.137	1.088–1.189	< 0.001	1.093	1.045–1.143	< 0.001	1.093	1.045–1.143	< 0.001	1.247	1.196–1.301	< 0.001
Age ≥ 70, years	3.192	3.036–3.355	< 0.001	2.792	2.654–2.936	< 0.001	2.797	2.660–2.942	< 0.001	3.850	3.668–4.042	< 0.001
Scheduled vs. emergency admission	–	–	–	0.208	0.194–0.223	< 0.001	0.207	0.193–0.222	< 0.001	0.140	0.131–0.150	< 0.001
Warm vs. cool season months	–	–	–	–	–	–	0.846	0.809–0.884	< 0.001	0.842	0.807–0.879	< 0.001
Comorbidities												
Neoplasms (C00-D49)												
Yes	4.137	3.852–4.442	< 0.001	3.717	3.459–3.995	< 0.001	3.729	3.470–4.007	< 0.001	4.445	4.158–5.753	< 0.001
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (D50-D89)												
Yes	0.648	0.610–0.688	< 0.001	0.627	0.590–0.666	< 0.001	0.627	0.590–0.666	< 0.001	0.842	0.795–0.893	< 0.001
Endocrine, nutritional, and metabolic diseases (E00-E89)												
Yes	1.006	0.956–1.060	0.81	0.947	0.899–0.997	0.04	0.948	0.900–0.998	0.04	1.435	1.367–1.506	< 0.001
Diseases of the circulatory system (I00-I99)												
Yes	2.219	2.118–2.325	< 0.001	1.959	1.870–2.053	< 0.001	1.962	1.872–2.055	< 0.001	2.782	2.664–2.904	< 0.001
Diseases of the respiratory system (J00-J99)												
Yes	4.972	4.673–5.290	< 0.001	4.069	3.822–4.331	< 0.001	4.031	3.787–4.291	< 0.001	6.896	6.504–7.312	< 0.001
Diseases of the digestive system (K00-K95)												
Yes	1.949	1.791–2.121	< 0.001	1.760	1.617–1.917	< 0.001	1.758	1.615–1.914	< 0.001	2.257	2.106–2.335	< 0.001

Model A – adjusted for sex and age (AIC – 63353.30); Model B – adjusted for sex, age, and admission mode (AIC – 60644.38); Model C – adjusted for sex, age, admission mode and season (AIC – 60591.73); OR – odds ratio.

[1.872–2.055], $p < 0.001$), respiratory diseases (OR = 4.031 [3.787–4.291], $p < 0.001$), and diseases of the digestive system (OR = 1.758 [1.615–1.914], $p < 0.001$) were significantly associated with a higher risk of in-hospital mortality (Table VI). Scheduled admission (OR = 0.207 [0.193–0.222], $p < 0.001$), admission during the warm season months (OR = 0.846 [0.809–0.884], $p < 0.001$), and comorbidities such as diseases of the blood and blood-forming organs (OR = 0.627 [0.590–0.666], $p < 0.001$) and endocrine, nutritional, and metabolic diseases (OR = 0.948 [0.900–0.998], $p = 0.04$) were significantly associated with lower risk of in-hospital mortality in this cohort (Table VI).

In the AKI cohort, female sex (OR = 1.042 [1.021–1.065], $p < 0.001$), age ≥ 70 years (OR = 1.082 [1.057–1.107], $p < 0.001$), comorbidities such as diseases of the blood and blood-forming organs (OR = 1.637 [1.582–1.694], $p < 0.001$), cardiovascular diseases (OR = 1.088 [1.065–1.112], $p < 0.001$), respiratory diseases (OR = 1.514 [1.466–1.564], $p < 0.001$), and diseases of the digestive system (OR = 1.065 [1.028–1.104], $p < 0.001$) were significantly associated with a higher risk of prolonged hospitalization (Table VII). There was no significant impact of admission mode or season of admission (warm vs. cold months) on the risk of prolonged hospitalization (Table VII). Comorbidities such as neoplasms (OR = 0.911 [0.879–0.945], $p < 0.001$) and endocrine, nutritional, and metabolic diseases (OR = 0.941 [0.919–0.964], $p < 0.001$) were significantly associated with a lower risk of prolonged hospitalization in this cohort (Table VII).

In the CKD cohort, age ≥ 70 years (OR = 1.204 [1.177–1.231], $p < 0.001$) and comorbidities such as neoplasms (OR = 1.441 [1.367–1.518], $p < 0.001$), diseases of the blood and blood-forming organs (OR = 1.249 [1.215–1.284], $p < 0.001$), endocrine, nutritional, and metabolic diseases (OR = 1.277 [1.243–1.312], $p < 0.001$), cardiovascular diseases (OR = 1.400 [1.367–1.433], $p < 0.001$), respiratory diseases (OR = 2.722 [2.594–2.855], $p < 0.001$), and diseases of the digestive system (OR = 1.969 [1.874–2.068], $p < 0.001$) were significantly associated with a higher risk of prolonged hospitalization (Table VIII). There was no significant impact of month of admission (warm vs. cold season) on the risk of prolonged hospitalization (Table VIII). Scheduled admission was associated with a lower risk of prolonged hospitalization (OR = 0.460 [0.449–0.471], $p < 0.001$) in this cohort (Table VIII).

Discussion

This nationwide study of Polish patients hospitalized due to AKI or CKD – two of the most prevalent kidney disorders – provides epidemiological profiles and identifies risk factors for in-hospital mortality and prolonged hospitalization. During the COVID-19 pandemic (2020–2021), the number of hospital admissions due to AKI or CKD decreased and the in-hospital mortality rate increased. Females hospitalized due to AKI or CKD, compared to males, were at a higher risk of in-hospital death. This study also showed that admission during the warm season (April–September) was associated with a lower risk of in-hospital death in patients admitted due to AKI and CKD. Moreover, the findings presented in this study provided detailed data on the contribution of particular comorbidities to the risk of in-hospital death and prolonged hospitalization among patients admitted due to AKI or CKD.

This 5-year observation presents detailed epidemiological characteristics of patients hospitalized due to AKI or CKD. Numerous studies have reported a decline in the number of hospital admissions during the COVID-19 pandemic [23–25]. Similarly, in this study, a decline in the number of hospital admissions due to AKI or CKD was observed in the years 2020–2021, compared to the years 2017–2019. Furthermore, in the first year of the COVID-19 pandemic, a significant increase in the in-hospital mortality rate among patients hospitalized due to AKI and CKD was observed. A similar trend was observed in diabetes-related hospital admissions in Poland [26]. There were statistically significant differences in the characteristics of patients hospitalized due to AKI or CKD in subsequent years, but these differences should be carefully analyzed, as they were not so pronounced and may have resulted from the large number of records included in the population dataset.

Risk factors for in-hospital mortality and prolonged hospitalization were analyzed with 3 different regression models. This analytical approach allowed for the precise identification of factors contributing to the risk of in-hospital mortality or prolonged hospitalization.

Female sex was significantly associated with a higher risk of in-hospital mortality among patients hospitalized due to AKI or CKD. Population-based studies indicate that females are more often affected by CKD than males [27]. Moreover, most of the research suggests that AKI is also more prevalent in females, but some research presents contrary data [28, 29]. Findings from this populational study showed sex differences in the burden of AKI and CKD, identifying females as a group at higher risk of in-hospital mortality.

Older age is a significant risk factor for kidney disease and its progression [30, 31]. A decline in kidney function is natural in the physiological course of aging [32]. In this study, age 70 years

Table VII. Risk factors for prolonged hospitalization among patients hospitalized due to acute kidney injury (AKI) in Poland, 2017–2021

Parameter	Adjusted Model A			Adjusted Model B			Adjusted Model C			Univariable logistic regression		
	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Female sex	1.042	1.021–1.065	< 0.001	1.042	1.021–1.065	< 0.001	1.042	1.021–1.065	< 0.001	1.051	1.030–1.073	< 0.001
Age ≥ 70, years	1.082	1.058–1.107	< 0.001	1.082	1.057–1.107	< 0.001	1.082	1.057–1.107	< 0.001	1.104	1.081–1.129	< 0.001
Scheduled vs. emergency admission	–	–	–	0.998	0.965–1.032	0.92	0.998	0.965–1.032	0.92	0.982	0.950–1.015	0.29
Warm vs. cool season months	–	–	–	–	–	–	0.990	0.970–1.011	0.37	0.980	0.960–1.000	0.054
Comorbidities												
Neoplasms (C00-D49)												
Yes	0.911	0.879–0.945	< 0.001	0.911	0.879–0.945	< 0.001	0.911	0.879–0.945	< 0.001	0.939	0.906–0.973	0.001
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (D50-D89)												
Yes	1.637	1.582–1.694	< 0.001	1.642	1.582–1.694	< 0.001	1.637	1.582–1.694	< 0.001	1.608	1.555–1.663	< 0.001
Endocrine, nutritional, and metabolic diseases (E00-E89)												
Yes	0.941	0.919–0.964	< 0.001	0.941	0.919–0.964	< 0.001	0.941	0.919–0.964	< 0.001	0.969	0.946–0.992	0.008
Diseases of the circulatory system (I00-I99)												
Yes	1.088	1.065–1.112	< 0.001	1.088	1.065–1.112	< 0.001	1.088	1.065–1.112	< 0.001	1.141	1.117–1.165	< 0.001
Diseases of the respiratory system (J00-J99)												
Yes	1.515	1.467–1.565	< 0.001	1.515	1.467–1.564	< 0.001	1.514	1.466–1.564	< 0.001	1.526	1.478–1.575	< 0.001
Diseases of the digestive system (K00-K95)												
Yes	1.065	1.028–1.104	< 0.001	1.065	1.028–1.104	< 0.001	1.065	1.028–1.104	< 0.001	1.079	1.042–1.117	< 0.001

Model A – adjusted for sex and age (AIC – 197058.62); Model B – adjusted for sex, age, and admission mode (AIC – 197060.61); Model C – adjusted for sex, age, admission mode and season (AIC – 197061.80); OR – odds ratio.

Table VIII. Risk factors for prolonged hospitalization among patients hospitalized due to chronic kidney disease (CKD) in Poland, 2017 2021

Parameter	Adjusted Model A			Adjusted Model B			Adjusted Model C			Univariable logistic regression		
	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Female sex	1.019	0.996–1.041	0.099	0.999	0.977–1.022	0.96	0.999	0.977–1.022	0.96	1.073	1.051–1.096	< 0.001
Age ≥ 70, years	1.314	1.285–1.343	< 0.001	1.204	1.177–1.231	< 0.001	1.204	1.177–1.231	< 0.001	1.443	1.413–1.474	< 0.001
Scheduled vs. emergency admission	–	–	–	0.460	0.449–0.471	< 0.001	0.460	0.449–0.471	< 0.001	0.384	0.376–0.394	< 0.001
Warm vs. cool season months	–	–	–	–	–	–	1.007	0.986–1.030	0.51	0.998	0.977–1.019	0.85
Comorbidities												
Neoplasms (C00–D49)												
Yes	1.584	1.503–1.668	< 0.001	1.441	1.368–1.518	< 0.001	1.441	1.367–1.518	< 0.001	1.794	1.706–1.887	< 0.001
Diseases of the blood and blood–forming organs and certain disorders involving the immune mechanism (D50–D89)												
Yes	1.288	1.253–1.323	< 0.001	1.249	1.215–1.284	< 0.001	1.249	1.215–1.284	< 0.001	1.507	1.468–1.546	< 0.001
Endocrine, nutritional, and metabolic diseases (E00–E89)												
Yes	1.336	1.301–1.372	< 0.001	1.277	1.243–1.312	< 0.001	1.277	1.243–1.312	< 0.001	1.627	1.587–1.668	< 0.001
Diseases of the circulatory system (I00–I99)												
Yes	1.502	1.467–1.537	< 0.001	1.400	1.367–1.433	< 0.001	1.400	1.367–1.433	< 0.001	1.864	1.824–1.905	< 0.001
Diseases of the respiratory system (J00–J99)												
Yes	3.148	3.002–3.302	< 0.001	2.720	2.593–2.854	< 0.001	2.722	2.594–2.855	< 0.001	3.794	3.621–3.975	< 0.001
Diseases of the digestive system (K00–K95)												
Yes	2.138	2.036–2.246	< 0.001	1.969	1.874–2.068	< 0.001	1.969	1.874–2.068	< 0.001	2.487	2.371–2.608	< 0.001

Model A – adjusted for sex and age (AIC – 197779.08); Model B – adjusted for sex, age, and admission mode (AIC – 193578.09); Model C – adjusted for sex, age, admission mode and season (AIC – 193579.66); OR – odds ratio.

and over was associated with a higher risk of in-hospital mortality among patients in both cohorts. This observation is in line with previously published data on the impact of aging on kidney function [30–32].

Comorbidities such as neoplasms, cardiovascular diseases, respiratory diseases, and diseases of the digestive system were significantly associated with a higher risk of in-hospital mortality among patients hospitalized due to AKI or CKD. Neoplasms had the highest impact on the risk of in-hospital mortality among patients hospitalized due to AKI, and the second highest impact among patients hospitalized due to CKD. Cancer mortality rates in Poland are among the highest in the European Union [33], and the overall clinical course of malignancies seems to explain the high impact of cancers on the risk of in-hospital mortality [34]. In addition, AKI is commonly experienced by patients with cancer [35], and CKD is linked to malignancies through several mechanisms [36, 37]. Conversely, respiratory diseases were the most important comorbidity affecting the risk of in-hospital mortality in patients with CKD, and the second most important comorbidity in patients with AKI. Due to their physiological functions, lungs and kidneys are linked in multiple ways, mostly due to their common roles in acid-base balance, fluid homeostasis, and blood pressure control [38, 39]. Growing evidence indicates that AKI contributes to dysfunction in distant organs and exacerbates remote organ injury [39, 40]. Patients with CKD have a higher prevalence of lung dysfunction regardless of the disease stage [41]. The findings from this study support previously published data and highlight the important role of respiratory function monitoring and respiratory disease management in patients hospitalized with AKI and CKD. Cardiovascular diseases and diseases of the digestive system were also associated with the risk of in-hospital mortality among these patient groups, but their contribution to the risk of death was lower than that of neoplasms and respiratory diseases. Nevertheless, the management of cardiovascular diseases remains an important part of inpatient care for these patients [42–44].

Scheduled admission mode was associated with a lower risk of in-hospital mortality. This observation may be explained by the fact that scheduled admissions typically involve stable patients admitted for diagnostic evaluation or pharmacotherapy planning, in contrast to emergency admissions, which often involve patients with acute health deterioration.

In this study, seasonal differences in in-hospital mortality risk were observed. Among patients admitted due to AKI or CKD in the warm season (April–September), the risk of in-hospital mortality was lower when compared to patients admitted in the cold season. Similar results were obtained in the study carried out in South Korea, where cold exposure was associated with higher mortality due to AKI [45]. This observation merits further investigation.

Two groups of comorbidities were found to be associated with a lower risk of in-hospital mortality. Endocrine, nutritional, and metabolic diseases were significantly associated with a lower risk of in-hospital mortality among patients hospitalized due to AKI or CKD, which could be due to the renoprotective effects of novel antidiabetic agents [46, 47]. Diseases of the blood and blood-forming organs were also associated with a lower risk of in-hospital mortality. The cause-effect relationship of this finding is unclear, and this result should be carefully analyzed and investigated in further research.

Factors associated with prolonged hospitalization were also examined in this study. Female sex, age ≥ 70 years, and comorbidities such as cardiovascular, respiratory diseases, and diseases of the digestive system were significantly associated with a higher risk of prolonged hospitalization among patients hospitalized due to AKI. These factors are in line with the factors associated with the risk of in-hospital mortality among patients with AKI reported in this study. However, when related to prolonged hospitalization, diseases of the blood and blood-forming organs were associated with a longer duration of stay. In patients admitted due to AKI, admission mode did not differentiate the risk of prolonged hospitalization, which may result from the fact that AKI is often an acute condition, and almost half of the patients were admitted via emergency mode. In patients with CKD, there were no sex differences in the risk of prolonged hospitalization. However, older age (≥ 70 years) and all 6 groups of comorbidities were associated with the risk of prolonged hospitalization. This observation may be explained by the fact that each comorbidity can compromise the health status of the patient and hinder treatment progress, necessitating a delay in hospital discharge. Admission month and season had no significant impact on prolonged hospitalization, which may be attributed to the consistent treatment conditions maintained throughout the year.

There are several practical implications for clinicians and policymakers resulting from this study. Firstly, this study showed that there was a decrease in hospital admissions due to AKI and CKD during the first 2 years of the COVID-19 pandemic, which may result in higher healthcare utilization in the subsequent years, as well as a delay in diagnosis, mostly in patients with CKD. Action should be taken to enhance monitoring of patients for CKD in outpatient care to ensure a timely diagnosis and to accommodate a potential surge in hos-

pitalizations in nephrology wards. Secondly, epidemiological characteristics of patients hospitalized due to AKI or CKD presented in this study may be used for the assessment of nephrological care in Poland. In-hospital mortality and prolonged length of stay statistics could be used as benchmarks to compare the quality of care in Poland with other countries. Thirdly, data on risk factors for in-hospital mortality and prolonged hospitalization may be used by clinicians to identify patients admitted due to AKI or CKD who are at a higher risk of death or prolonged hospitalization and may require additional treatment or care. Policymakers can use these data for planning and monitoring hospital-based healthcare services for patients with AKI or CKD.

Nationwide data from population registries [16] constitute an important basis for epidemiological analyses at the country level. Data from the NGHMS have previously been used in fields such as pulmonology, rheumatology, and ophthalmology [18–21, 48]. The growing burden of kidney diseases, especially CKD, supports the validity of providing population data on hospitalizations due to major nephrological diseases. In this study, hospital admissions due to AKI and CKD as a primary diagnosis were analyzed, as patients with AKI or CKD as a comorbidity were not included in the analysis. Two different diseases – AKI and CKD – were analyzed despite their different pathogenesis and clinical manifestations. However, the authors decided to present data on both diseases in one paper, because they are the most common causes of nephrology-related hospital admissions, and the side-by-side evaluation of AKI and CKD may have a greater impact on the clinical usefulness of this study.

This study is limited to data available in the NGHMS [16]. Data on treatment methods and medication used during the hospitalization were not available. Moreover, data on 90-day survival after hospitalization were also not collected, as anonymous registries were analyzed. Comorbidities were combined into groups of diseases according to the ICD-10, and only the best-fitting variables were included in the regression models. Patients with AKI and CKD were analyzed according to primary medical diagnoses, without subdivision into specific diagnostic sub-codes such as acute kidney failure with tubular necrosis (N17.0) or with acute cortical necrosis (N17.1) [17]. This is a nationwide analysis with a large number of records from the population-level hospital admission registry. Therefore, the findings on the protective effects of the diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (D50-D89) and endocrine, nutritional, and metabolic diseases (E00-E89) on the risk of in-hospital mortality should be interpreted carefully and require further investigation.

In conclusion, female sex, age ≥ 70 years, neoplasms, respiratory diseases, cardiovascular disease, and diseases of the digestive system were found to be risk factors for in-hospital mortality among patients admitted due to AKI or CKD. Hospital admission during the warm season (April–September) was associated with a lower risk of in-hospital mortality. Diseases of the blood and blood-forming organs and respiratory diseases were identified as comorbidities with the highest contribution to the risk of prolonged hospitalization among patients with AKI, while respiratory diseases and diseases of the digestive system were found to contribute the most to the risk of prolonged hospitalization among patients with CKD.

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Ethical approval

The study protocol was reviewed and approved by the Ethical Committee at the Centre of Postgraduate Medical Education in Warsaw (decision number 401/2023, dated August 23, 2023).

Conflict of interest

The authors declare no conflict of interest.

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