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Annual healthcare expenditure and associated factors among patients with chronic kidney disease under Thailand's Universal Coverage Scheme: A nationwide cross-sectional study

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Abstract

Background

Thailand expanded dialysis coverage under the Universal Coverage Scheme (UCS) in 2022, raising concerns about healthcare expenditure and financial sustainability. However, nationwide evidence on chronic kidney disease (CKD)-related expenditure and its associated factors remains limited.

Objective

To characterize annual CKD-related healthcare expenditure and examine associated patient, clinical, health service, and geographic factors among UCS beneficiaries in Thailand during fiscal year 2023.

Methods

This nationwide cross-sectional study analyzed National Health Security Office (NHSO) administrative data for 231,160 patients with CKD identified using ICD-10 codes N18.1–N18.5 and N18.9. Annual CKD-related healthcare expenditure per patient was assessed from the hospital perspective using actual expenditure reported by hospitals to the NHSO. Univariable and multiple linear regression analyses were conducted using log(Cost + 1) as the outcome. Model fit was assessed using the coefficient of determination (R^2).

Results

Total annual expenditure was THB 15.77 billion. Mean expenditure per patient was THB 68,216 (standard deviation, THB 119,204), and median expenditure was THB 27,963 (interquartile range, THB 86,061). Mean expenditure was higher among patients with stage 5 CKD than among those without stage 5 CKD (THB 86,780 vs. THB 12,125) and among patients with complications than among those without complications (THB 131,293 vs. THB 61,079). Higher mean expenditure was also observed among patients receiving care in private hospitals, those receiving inpatient services, and those with recorded hospital stays. In separate univariable models, visit frequency explained the largest proportion of variation in log-transformed expenditure (R^2 = 41.9%), followed by stage 5 CKD (27.0%) and combined hospital–service type (19.9%). NHSO zone explained 7.1% of the variation. The multiple linear regression model explained 75.4% of the variation in log-transformed expenditure.

Conclusion

CKD-related healthcare expenditure varied by disease stage, complications, healthcare utilization, and geographic location. Although these cross-sectional associations do not establish causality, the findings

may inform CKD service planning and resource allocation under the UCS. Longitudinal studies incorporating treatment pathways and clinical outcomes are needed to evaluate strategies for managing expenditure while maintaining access to essential care.

Introduction

Chronic kidney disease (CKD) is a major global public health challenge associated with substantial morbidity, premature mortality, and growing demand for healthcare resources. In 2021, CKD affected an estimated 673–674 million people worldwide and caused approximately 1.5 million deaths, with a disproportionate burden in low- and middle-income settings [1–3]. As the disease progresses, the increasing need for intensive care, management of complications, and kidney replacement therapy places substantial financial pressure on patients and healthcare systems.

The economic burden of CKD varies considerably by disease stage and treatment modality. A review covering 31 countries and regions reported mean annual direct medical costs per patient of USD 3,060 for CKD stage G3a and USD 8,736 for stage G5 without kidney replacement therapy, compared with USD 49,490 for peritoneal dialysis and USD 57,334 for hemodialysis [4]. Evidence from Asian countries similarly indicate substantial treatment costs, particularly among patients receiving kidney replacement therapy [5]. These findings highlight the financial implications of advanced CKD and the importance of understanding expenditure patterns to support sustainable healthcare financing and equitable access to treatment [6].

In Thailand, financing CKD care is an important consideration for the Universal Coverage Scheme (UCS), which provides publicly funded healthcare to most of the population and aims to promote equitable access and financial protection [7]. The inclusion of kidney replacement therapy in the UCS benefit package in 2008, initially through a peritoneal dialysis-first policy, expanded access to life-saving treatment and reduced financial barriers for patients with kidney failure ([8–10]. In February 2022, the National Health Security Office (NHSO) introduced a patient-choice policy allowing eligible beneficiaries to initiate either peritoneal dialysis or hemodialysis [11, 12]. This policy transition heightened the importance of monitoring expenditure because dialysis modality has implications for service delivery and healthcare financing. Thai economic evaluations have found that a peritoneal dialysis-first strategy is more cost-effective than a hemodialysis-first strategy under the assumptions and willingness-to-pay thresholds examined [13, 14].

Evidence on expenditure across the spectrum of CKD care is needed to complement evaluations of specific treatments and care programs. Previous studies have linked higher CKD-related costs to worsening kidney function and coexisting conditions, including heart failure, anemia, and diabetes [15]. Differences in access to care, service organization, and geographic location may also influence healthcare utilization and expenditure [16, 17]. In Thailand, previous research has examined treatment costs in specific settings, including predialysis CKD care at a district hospital [18]. However, findings from individual facilities or selected patient groups may not fully capture expenditure patterns across the

UCS population. Nationwide evidence remains limited on how annual CKD-related expenditure varies by patient characteristics, disease severity, complications, healthcare utilization, provider setting, and geographic area.

This study therefore aimed to characterize annual CKD-related healthcare expenditure among UCS beneficiaries in Thailand and examine associated sociodemographic, clinical, health service, and geographic factors using nationwide hospital-reported expenditure data submitted to the NHSO for fiscal year 2023.

Material and Methods

Data Source

This nationwide cross-sectional study used administrative healthcare data from the NHSO for fiscal year 2023. The dataset included records of patients receiving care at public and private healthcare facilities registered with the NHSO throughout Thailand. Patients with CKD were identified using International Classification of Diseases, 10th Revision (ICD-10) codes N18.1–N18.5 and N18.9, corresponding to CKD stages 1–5 and unspecified CKD, respectively.

CKD-related healthcare expenditure was examined from the hospital perspective using hospital-reported expenditure data submitted to the NHSO. For CKD stages 1–4, the reported amounts represented actual hospital expenditure. The NHSO finances these services through prospective capitation payments made monthly to hospitals, with payment amounts determined by a predefined capitation rate and the number of beneficiaries covered. For CKD stage 5, the NHSO uses a fee-for-service payment mechanism based on established fee schedules.

The Primary Health Care Management Program at the ASEAN Institute for Health Development, Mahidol University, obtained the dataset through a formal request to the NHSO. The request specified the variables and expenditure components required for the study. Following approval, the NHSO securely transferred the anonymized dataset to the research team in accordance with applicable data protection requirements. The data were subsequently cleaned and validated before analysis.

Data Management

The original dataset comprised 452,695 healthcare service records. During data cleaning, 444 records with missing age information and three records with negative age values were excluded. The remaining records were aggregated at the patient level, yielding a final analytical dataset of 231,160 patients. The primary outcome was total annual CKD-related healthcare expenditure per patient during fiscal year 2023, calculated by summing expenditure across all included service records for each patient and expressed in Thai baht (THB).

Explanatory variables were grouped into four domains: sociodemographic, clinical, health service, and geographic characteristics. Sociodemographic variables included gender and age group. Clinical variables comprised indicators of stage 5 CKD, comorbidities, and complications. Health service variables included hospital type, service type, the presence of a recorded hospital stay, and the number of healthcare visits. Geographic variation was assessed across the 13 NHSO zones. Although labeled “length of stay” in the source dataset, the hospital-stay variable was analyzed as a binary indicator of whether a hospital stay was recorded and did not capture admission duration. Table 1 illustrates the operational definitions and categories of the study variables.

Table 1
Operational definitions and categorization of study variables.

Variable	Type	Operational definition and categorization
Outcome variable		
CKD-related expenditure	Ratio	Total annual CKD-related healthcare expenditure per patient during fiscal year 2023, expressed in THB
Sociodemographic factors		
Gender	Binary	Male; Female
Age group (years)	Ordinal	0–44; 45–54; 55–64; 65–74; 75–84; ≥85 years
Clinical factors		
CKD Stage 5	Binary	No; Yes
Comorbidities	Binary	No; Yes
Complications	Binary	No; Yes
Health service factors		
Hospital type	Binary	Government; Private
Service type	Binary	Outpatient department (OPD); Inpatient department (IPD)
Length of stay	Binary	No; Yes
Number of visits	Ordinal	1; 2; 3–4; 5–7; 8–18; 19–49; 50–203; 204–383 visits
NHSO zone	Nominal	Zones 1–13

Statistical Analysis

Descriptive statistics were used to summarize sociodemographic, clinical, health service, and geographic characteristics, as well as annual CKD-related healthcare expenditure. Categorical variables were presented as frequencies and percentages. Expenditure was summarized using the mean and standard deviation (SD), median and interquartile range (IQR), and minimum and maximum values.

The distribution of annual CKD-related expenditure was examined using quantile–quantile (Q–Q) plots. Because expenditure was highly right-skewed, a natural logarithmic transformation was applied. The transformed outcome was defined as log(Cost + 1), where Cost represents annual expenditure per patient in THB. Adding a constant of one allowed patient with zero expenditure to be retained. The transformed outcome was used as the dependent variable in all regression analyses.

Univariable linear regression models were fitted to examine associations between individual explanatory factors and log-transformed annual CKD-related expenditure. These factors included combined gender–age group, stage 5 CKD, comorbidity, complication, combined hospital–service type, recorded hospital stay, number of healthcare visits, and NHSO zone. Although labeled “length of stay” (LOS) in the source dataset, the hospital-stay variable was analyzed as a binary indicator rather than a measure of admission duration. Each factor was entered into a separate model, and the coefficient of determination (R^2) was calculated to quantify the proportion of variation in the transformed outcome explained by that factor alone.

A multiple linear regression model incorporating all eight factors was then fitted to estimate their associations with log-transformed annual CKD-related expenditure after mutual adjustment. Categorical factors were coded using sum-to-zero contrasts [19]. The model was specified as:

$$\log(\text{CKD Cost} + 1) = \beta_0 + \beta_1(\text{Gender_Age}) + \beta_2(\text{Stage 5}) + \beta_3(\text{Comorbidity})$$

$$+ \beta_4(\text{Complication}_i) + \beta_5(\text{Hospital_Service}_i) + \beta_6(\text{LOS}_i) + \beta_7(\text{Visits}_i)$$

$$+ \beta_8(\text{NHSO Zone}_i) + \varepsilon_i$$

where $Cost_i$ denotes total annual CKD-related expenditure for patient (i), β_0 is the intercept, and ε_i is the error term. The vectors X_{1i}-X_{8i} represent the coded variables for combined gender–age group, stage 5 CKD, comorbidity, complication, combined hospital–service type, recorded hospital stay, number of healthcare visits, and NHSO zone, respectively. The corresponding coefficient vectors are denoted by β_1–β_8. For categorical factors, sum-to-zero coding constrains the category effects to sum to zero. These effects therefore represent deviations from the unweighted mean of the category effects, rather than comparisons with a designated reference category.

Statistical significance was defined as a two-sided p-value < 0.05. Model fit was summarized using R^2, representing the proportion of variation in log-transformed annual expenditure explained by the included factors. Crude means of log(Cost + 1) and their 95% confidence intervals (CIs) were plotted alongside the overall mean of the transformed outcome to illustrate variation across patient, health service, and geographic characteristics. All analyses were performed using R version 4.5.2 [20].

Results

Descriptive results

Table 2 illustrates annual CKD-related healthcare expenditure among 231,160 patients by sociodemographic, clinical, health service, and geographic characteristics. Total annual expenditure was THB 15,768,894,832. Mean expenditure per patient was THB 68,216 (SD, THB 119,204), and median expenditure was THB 27,963 (IQR, THB 86,061). Expenditure ranged from THB 0 to THB 9,613,519, with three patients having zero recorded expenditure. The substantially higher mean than median indicated a right-skewed distribution.

Females accounted for 52.4% of the study population and males for 47.6%. Mean annual expenditure was similar between females and males (THB 68,674 and THB 67,713, respectively). Mean expenditure decreased across successive age groups, from THB 90,498 among patients aged 0–44 years to THB 33,663 among those aged ≥ 85 years.

Mean annual expenditure varied substantially by clinical characteristics. Patients with stage 5 CKD accounted for 75.1% of the study population and had higher mean expenditure than those without stage 5 CKD (THB 86,780 vs. THB 12,125). Mean expenditure differed only slightly between patients with and without comorbidities (THB 68,353 vs. THB 67,874). A more pronounced difference was observed by complication status, with mean expenditure of THB 131,293 among patients with complications compared with THB 61,079 among those without complications.

Mean annual expenditure also varied by health service characteristics. Patients receiving care in private hospitals had higher mean expenditure than those receiving care in public hospitals (THB 99,211 vs. THB 55,524). Patients classified as receiving inpatient services had higher mean expenditure than those classified as receiving outpatient services (THB 83,376 vs. THB 55,032). Similarly, patients with a recorded hospital stay had higher mean expenditure than those without a recorded stay (THB 79,596 vs. THB 63,916).

Mean annual expenditure generally increased across healthcare visit-frequency categories, from THB 18,127 among patients with one visit to THB 234,748 among those with 204–383 visits. However, the pattern was not strictly increasing: patients with 19–49 visits had lower mean expenditure than those with 8–18 visits (THB 49,006 vs. THB 78,559). Geographic variation was also observed across the 13 NHSO zones, with mean expenditure ranging from THB 47,400 in Zone 13 to THB 85,187 in Zone 4.

Table 2
Annual CKD-related healthcare expenditure by sociodemographic, clinical, health service, and geographic characteristics (N = 231,160).

Variables	n (%)	CKD cost (THB)		
		Mean (SD)	Median (IQR)	Min - Max
Gender				
Male	110,053 (47.6)	67,713.2 (99,918.6)	27,580 (90,120)	0–5,461,546
Female	121,107 (52.4)	68,673.6 (134,348.2)	28,256.5 (82,613.5)	0–9,613,519
Age group (years)				
0–44	25,045 (10.8)	90,498.2 (135,029.2)	43,460 (158,380)	0–6,332,637
45–54	30,893 (13.4)	82,778.6 (113,201)	41,228.2 (132,373)	3–4,550,048
55–64	57,503 (24.9)	74,823.3 (110,858.5)	35,812.9 (108,840.1)	0–4,916,348
65–74	66,143 (28.6)	66,047.1 (127,178.3)	25,943.6 (81,066.4)	1–6,406,166
75–84	38,521 (16.7)	47,623.1 (106,506.1)	15,327.5 (47,394.6)	1–6,691,056
85+	13,055 (5.6)	33,663.3 (112,435.7)	9,973.3 (32,419.9)	3–9,613,519
Stage 5				
No	57,481 (24.9)	12,125.4 (27,974.8)	1,534.7 (15,265.4)	1–2,358,721
Yes	173,679 (75.1)	86,780.3 (131,406)	43,200 (136,303.6)	0–9,613,519
Comorbidities				
No	65,988 (28.5)	67,874 (91,744)	16,000 (139,920)	0–1,326,980
Yes	165,172 (71.5)	68,353.1 (128,545)	30,386 (79,162)	2–9,613,519
Complications				
No	207,663 (89.8)	61,079.2 (89,170.6)	23,355.7 (71,409.8)	0–4,772,383
Yes	23,497 (10.2)	131,293.3 (255,132)	76,756.8 (132,200.8)	30 – 9,613,519
Hospital type				
Government	164,003 (70.9)	55,524.4 (117,205.2)	22,000 (50,860)	0–9,613,519
Private	67,157 (29.1)	99,211.1 (118,362.5)	56,640 (165,540)	0–6,406,166
Service type				
OPD	123,631 (53.5)	55,031.5 (87,572)	8,000 (47,280)	0–1,476,800
IPD	107,529 (46.5)	83,375.6 (145,946)	44,367.7 (89,182.3)	10 – 9,613,519

Variables	n (%)	CKD cost (THB)		
		Mean (SD)	Median (IQR)	Min - Max
Length of stay				
No	167,758 (72.6)	63,915.6 (88,825)	16,642.4 (99,635)	0–1,567,060
Yes	63,402 (27.4)	79,596 (175,365.7)	41,697.4 (62,242.4)	2,603-9,613,519
Number of visits				
1	62,640 (27.1)	18,126.8 (50,927)	5,827.1 (20,415.4)	0–4,805,232
2	30,022 (13)	30,709.7 (128,186.9)	7,000 (32,639.6)	0–6,691,056
3–4	28,582 (12.4)	41,078.2 (105,203.9)	11,448.4 (47,488.1)	26 – 5,636,777
5–7	18,849 (8.2)	60,229.7 (173,171.5)	18,361.5 (62,694.2)	47 – 6,406,166
8–18	22,262 (9.6)	78,558.7 (162,987.3)	28,980 (86,307.2)	225-9,613,519
19–49	22,593 (9.8)	49,006 (59,008.5)	42,800 (10,263.4)	560-2,286,602
50–203	23,377 (10.1)	136,269.4 (60,927)	142,100 (80,760)	1,740-1,567,060
204–383	22,835 (9.9)	234,747.8 (27,009.1)	245,640 (23,280)	75,937–997,700
NHSO zone				
1	21,654 (9.4)	76,188.4 (118,985.8)	38,470 (103,003.1)	0–6,332,637
2	9,376 (4.1)	67,877.2 (122,605.7)	34,085.1 (67,690.5)	3–4,649,021
3	6,446 (2.8)	82,143.7 (110,089.7)	40,466.3 (113,403.6)	5 – 3,702,478
4	12,587 (5.4)	85,187 (120,543.5)	40,500 (141,722.4)	3–5,461,546
5	14,650 (6.3)	76,823.9 (118,516.6)	38,640 (106,783.7)	2–4,916,348
6	16,724 (7.2)	80,708.9 (126,284)	38,965.8 (137,580)	2–9,613,519
7	19,073 (8.3)	72,854.4 (106,062.6)	36,486.4 (93,760)	3–4,631,089
8	21,899 (9.5)	65,131.3 (104,477.7)	28,640 (79,595.7)	3–4,591,043
9	22,486 (9.7)	63,610.6 (105,076.1)	24,130 (72,860.8)	1–3,695,558
10	23,091 (10)	75,135.6 (154,276.9)	35,151.5 (81,909)	2–6,074,456
11	12,566 (5.4)	64,248.4 (106,354.4)	25,813.5 (72,091)	2–4,553,551
12	8,398 (3.6)	73,400.7 (127,672.5)	34,700 (97,449.2)	3–5,953,810
13	42,210 (18.3)	47,400.4 (113,367.2)	4,400 (39,469.8)	1–6,691,056
Total	231,160	68,216.4 (119,204)	27,963.4 (86,061)	0–9,613,519

Modeling results

Annual CKD-related healthcare expenditure was highly right-skewed. Following natural logarithmic transformation using log(Cost + 1), the distribution became more symmetric and showed closer agreement with the theoretical normal distribution, although some deviations remained (Fig. 1). The transformed outcome was used in the univariable and multiple linear regression analyses. Adding a constant of one allowed the three patients with zero expenditure to be retained.

The multiple linear regression model explained 75.4% of the variation in log-transformed annual CKD-related expenditure (R^2 = 75.4%). Figure 2 illustrates crude category means and their 95% CIs, together with factor-specific summaries from the univariable models, across sociodemographic, clinical, health service, and geographic characteristics. The factor-specific R^2 values indicate the proportion of variation explained by each factor when considered separately.

All eight explanatory factors were associated with log-transformed expenditure in the univariable analyses ($p < 0.001$ for each factor), although the proportions of variation explained differed. The combined gender–age factor explained 3.5% of the variation. Crude mean log-transformed expenditure was generally similar between males and females and decreased across successive age groups.

Among the clinical factors, stage 5 CKD explained the largest proportion of variation (R^2 = 27.0%). Patients with stage 5 CKD had higher crude mean log-transformed expenditure than those without stage 5 CKD. Comorbidity and complication status explained 1.5% and 4.2% of the variation, respectively. Patients with complications had higher crude mean log-transformed expenditure than those without complications.

The combined hospital–service factor explained 19.9% of the variation in log-transformed expenditure. Crude means were generally higher among patients receiving care in private hospitals and those receiving inpatient services than among patients receiving care in public hospitals and those receiving outpatient services, respectively. The binary hospital-stay indicator explained 7.7% of the variation, with higher crude mean log-transformed expenditure among patients with a recorded hospital stay.

Visit frequency explained the largest proportion of variation among all factors examined (R^2 = 41.9%). Crude mean log-transformed expenditure generally increased across visit-frequency categories. This pattern reflects differences on the transformed scale and should be distinguished from the arithmetic mean expenditures reported in Table 2.

NHSO zone explained 7.1% of the variation in log-transformed expenditure, indicating geographic differences. Overall, visit frequency, stage 5 CKD, and combined hospital–service type had the largest factor-specific R^2 values. These values are not additive and do not represent the unique contribution of each factor after adjustment for the other factors.

The red horizontal line in Fig. 2 illustrates the overall mean of log(Cost + 1). Crude category means were above this overall mean among patients with stage 5 CKD, complications, and recorded hospital stays, as well as those in the five highest visit-frequency categories (5–7, 8–18, 19–49, 50–203, and 204–383 visits). Crude category means also varied across hospital–service groups and NHSO zones.

Spatial distribution of expenditure

Figure 3 illustrates the provincial distribution of mean annual CKD-related healthcare expenditure per patient in fiscal year 2023, with the boundaries of the 13 NHSO zones overlaid. Mean expenditure varied both within and across regions, with differences also evident between neighboring provinces.

Several provinces in the northern, central, western, and southern regions had higher mean expenditure, whereas several northeastern provinces and provinces elsewhere had lower mean expenditure. These patterns indicate geographic variation at both the provincial and regional levels.

At the NHSO-zone level, mean annual expenditure was highest in Zone 4 (THB 85,187), followed by Zone 3 (THB 82,144) and Zone 6 (THB 80,709). Mean expenditure was lowest in Zone 13 (THB 47,400), followed by Zone 9 (THB 63,611) and Zone 11 (THB 64,248). Zone-level expenditure summaries are presented in Table 2. In the univariable analysis, NHSO zone was associated with log-transformed annual expenditure ($p < 0.001$), explaining 7.1% of the variation.

Discussion

This nationwide study examined annual CKD-related healthcare expenditure among 231,160 UCS beneficiaries in fiscal year 2023 using hospital-reported expenditure data submitted to the NHSO. Mean annual expenditure was THB 68,216 per patient, compared with a median of THB 27,963, indicating a markedly right-skewed distribution. In separate univariable models, visit frequency explained the largest proportion of variation in log-transformed expenditure (41.9%), followed by stage 5 CKD (27.0%) and combined hospital–service type (19.9%). The multiple linear regression model explained 75.4% of the variation. The factor-specific R^2 values represent the proportion of variation explained by each factor when considered separately; they do not quantify its unique contribution after adjustment for other factors or establish causal relationships.

Mean annual expenditure was approximately 2.4 times the median, and the maximum exceeded THB 9.61 million. This distribution suggests that a subset of patients incurred particularly high expenditure. Advanced disease, complications, hospitalization, and intensive treatment may contribute to these high values, although the present analysis did not directly investigate extreme expenditure. International reviews similarly indicate that healthcare costs increase with CKD progression, particularly among patients receiving kidney replacement therapy [4, 21, 22]. Studies from the United States and the United Kingdom have also reported greater healthcare utilization and higher costs with declining kidney function and increasing albuminuria [23, 24]. However, direct comparisons of monetary estimates

require caution because healthcare systems, payment arrangements, included cost components, and patient populations differ across settings.

Visit frequency explained the largest proportion of variation in log-transformed expenditure among the factors examined. Mean annual expenditure ranged from THB 18,127 among patients with one visit to THB 234,748 among those with 204–383 visits, although arithmetic mean expenditure did not increase consistently across all visit-frequency categories. Previous studies have likewise linked greater healthcare utilization to higher CKD-related costs [18, 23, 25]. This association is partly expected because annual expenditure accumulates across healthcare encounters. Frequent visits may also reflect necessary dialysis treatment or the management of complications. Visit frequency alone therefore cannot establish whether care is inappropriate. Examining the purpose, timing, and coordination of encounters may help identify opportunities to improve service delivery.

Patients with stage 5 CKD had substantially higher mean annual expenditure than those without stage 5 CKD (THB 86,780 vs. THB 12,125). This finding is consistent with international evidence linking advanced CKD to higher healthcare costs and greater hospitalization [23, 24, 26]. Thai studies have similarly reported higher treatment costs and greater hospitalization among patients with advanced CKD [18, 27]. These findings highlight the importance of evaluating strategies to prevent or delay disease progression. However, the present study did not estimate the expenditure reductions achievable through such interventions.

Mean annual expenditure was higher among patients classified as receiving inpatient services than among those classified as receiving outpatient services (THB 83,376 vs. THB 55,032). It was also higher among patients receiving care in private hospitals than among those receiving care in public hospitals (THB 99,211 vs. THB 55,524). These differences may reflect variation in case mix, treatment intensity, service availability, or payment arrangements. Previous studies have identified inpatient care as an important contributor to CKD-related expenditure [28, 29]. However, the observed differences do not establish differences in provider efficiency or the appropriateness of care.

Patients with a recorded hospital stay also had higher mean annual expenditure than those without a recorded stay (THB 79,596 vs. THB 63,916), consistent with evidence linking hospitalization to higher CKD-related costs [28]. Hospitalization may reflect advanced disease or complications requiring intensive treatment. Because hospital stay was represented by a binary indicator, this analysis could not assess how expenditure varied with admission duration. Further research incorporating admission diagnoses and duration is needed to distinguish necessary admissions from potentially preventable hospitalizations.

Geographic variation was evident at both the provincial and NHSO-zone levels. Mean annual expenditure ranged from THB 47,400 in Zone 13 to THB 85,187 in Zone 4, and NHSO zone explained 7.1% of the variation in log-transformed expenditure when considered separately. Differences in disease burden, access to care, dialysis provision, referral patterns, and facility characteristics may contribute to this variation, although these explanations were not directly tested. Lower expenditure should not

automatically be interpreted as greater efficiency because it may also reflect differences in healthcare needs or access to services [30, 31].

Patients with complications had more than twice the mean annual expenditure of those without complications (THB 131,293 vs. THB 61,079). Previous studies have similarly linked CKD-related complications and cardiovascular conditions to greater healthcare utilization and higher costs [23, 32]. This finding highlights the importance of complication prevention and management. Nevertheless, the cross-sectional design prevents assessment of the temporal relationship between complications and expenditure and does not allow estimation of the savings achievable through prevention.

The combined gender–age factor explained less variation in log-transformed expenditure than disease stage or healthcare utilization. Mean expenditure was similar between males and females but decreased across age groups, from THB 90,498 among patients aged 0–44 years to THB 33,663 among those aged ≥ 85 years. A Dutch study also reported lower healthcare costs among older patients with CKD, particularly for hospital care and medications [33]. Differences in treatment intensity, including the use of dialysis and conservative kidney management, may contribute to this pattern [34]. Treatment preferences, eligibility, and access may also play a role. The observed age pattern should therefore not be interpreted as evidence of a lower disease burden among older patients.

Comorbidity status explained only 1.5% of the variation in log-transformed expenditure, and arithmetic mean expenditure differed little between patients with and without recorded comorbidities. These findings do not imply that comorbidities have limited clinical or economic importance. A binary indicator cannot capture differences in the number, type, or severity of coexisting conditions, while incomplete coding may further limit its explanatory value. More detailed comorbidity measures are needed to clarify these relationships [35, 36].

Strengths

A major strength of this study is its large nationwide administrative dataset, which enabled the examination of CKD-related healthcare expenditure across sociodemographic, clinical, health service, and geographic characteristics. Its broad coverage complements Thai studies conducted in individual facilities or selected patient groups [31, 35]. Nevertheless, the findings apply to patients identified in UCS administrative records and should not be generalized to all people with CKD in Thailand. The dataset does not include beneficiaries of other health insurance schemes or people with CKD who were not identified in the administrative records [30, 36].

The findings identify priorities for reviewing service delivery rather than establish a basis for ranking interventions to reduce expenditure [37]. Higher expenditure among patients with advanced CKD and complications highlights the importance of early detection and coordinated disease management. Associations with frequent visits and inpatient care also indicate a need to examine clinical indications, referral pathways, and continuity of care. Assessments of differences between providers and geographic areas should account for case mix, payment arrangements, access to services, and clinical outcomes.

However, this analysis cannot determine which encounters were avoidable or whether changes in service use would reduce expenditure without compromising the quality of care.

These priorities are consistent with international evidence and the KDIGO 2024 recommendations emphasizing early detection, risk-based management, and prevention of CKD progression and complications [4, 21, 38]. Evidence from Thailand also supports the economic value of integrated CKD care [39]. Efforts to manage expenditure should preserve financial protection, as patients with advanced CKD may incur substantial out-of-pocket costs despite universal coverage [40]. Policy responses should therefore maintain equitable access to essential services, including dialysis, while evaluating opportunities to improve care coordination and reduce avoidable expenditure.

Limitations

Several limitations should be considered. First, administrative data are collected primarily for reimbursement purposes, and their accuracy depends on the completeness and consistency of coding. Second, the cross-sectional design precludes causal inference and assessment of changes over time. Third, expenditure was assessed from the hospital perspective using recorded expenditure and therefore does not represent the full economic cost of care. Patient payments, direct non-medical costs, and indirect costs were not included. Evidence from Thailand indicates that patients with advanced CKD may face substantial travel costs, catastrophic health expenditure, and medical impoverishment despite universal coverage [40].

Fourth, the findings may not be directly generalizable to beneficiaries of the Social Security Scheme or the Civil Servant Medical Benefit Scheme. Fifth, binary indicators of comorbidities and complications may obscure differences in the number, type, and severity of these conditions. Similarly, the binary hospital-stay indicator does not capture admission duration. Sixth, the analyses did not distinguish expenditure by dialysis modality or other specific treatment pathways, limiting the interpretation of differences associated with healthcare utilization. Finally, clinical outcomes, including mortality, quality of life, kidney function decline, and treatment effectiveness, were unavailable. Higher expenditure therefore cannot be interpreted as evidence of better outcomes. Although the model explained a substantial proportion of variation in log-transformed expenditure, this does not establish its predictive accuracy for expenditure expressed in THB.

Conclusions

This nationwide study of 231,160 beneficiaries of Thailand's Universal Coverage Scheme (UCS) found that mean annual CKD-related healthcare expenditure was THB 68,216 per patient in fiscal year 2023. Mean expenditure was higher among patients with stage 5 CKD, complications, inpatient service use, private hospital care, and recorded hospital stays. Expenditure also varied across visit-frequency categories and NHSO zones. In separate univariable analyses, visit frequency explained the largest proportion of variation in log-transformed expenditure, followed by stage 5 CKD and combined hospital–

service type. The multiple linear regression model explained 75.4% of the variation in log-transformed annual expenditure.

These findings may inform CKD service planning and resource allocation under the UCS and highlight priorities for evaluating strategies to prevent disease progression and complications and improve care coordination. However, the cross-sectional associations do not establish causality or identify avoidable healthcare utilization. Longitudinal studies incorporating treatment pathways, clinical outcomes, and patient costs are needed to evaluate strategies for managing expenditure while maintaining equitable access to essential care.

Abbreviations

CKD	Chronic Kidney Disease
UCS	Universal Coverage Scheme
NHSO	National Health Security Office
RRT	Renal Replacement Therapy
LOS	Length of stay
R^2	The coefficient of determination
CI	Confidence Interval
THB	Thai baht

Declarations

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Author Contributions R.N. Conceptualization, Methodology, Formal analysis, Data curation, and Writing – review and editing. O.L. Supervision, Methodology, Formal analysis, and Writing – review & editing. P.J. Supervision, and Writing – review & editing. P.K. Supervision, Writing – original draft preparation, and Writing – review & editing. S.B. Supervision, Methodology, Formal analysis, Data curation, Data analysis, Visualization, Writing – original draft preparation, and Writing – review and editing. All authors have read and agreed to the published version of the manuscript.

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Data availability The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate This study used anonymized, aggregated secondary data and involved no direct interaction with human participants. The dataset was obtained from the National Health Security Office (NHSO). The study protocol was reviewed and approved by the Mahidol University Central Institutional Review Board (MU-CIRB; Approval No. 2025/394.0711) on 7 November 2025. All data were handled in accordance with applicable ethical guidelines and data privacy regulations. No personally identifiable information was included in or accessible through the dataset used in this study.

Consent for publication Not applicable.

Generative AI AI-assisted tools were used to improve English language and readability. The author reviewed and edited the content and takes full responsibility for the final manuscript.

Competing interests The author declares no conflicts of interest related to this study.

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Figures

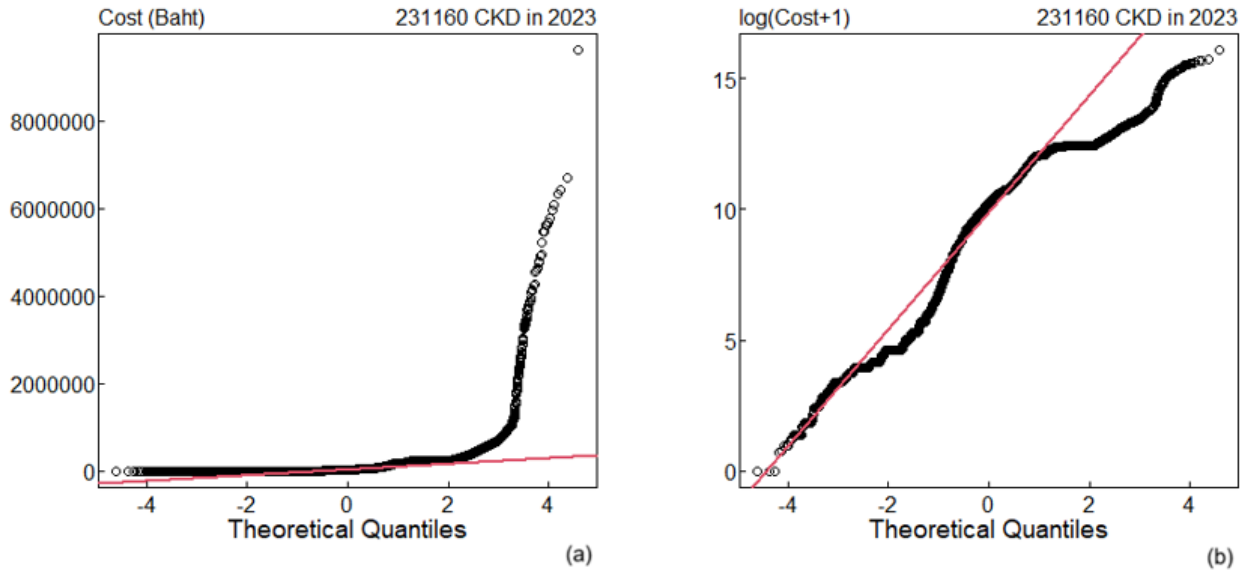

Figure 1

Q–Q plots of annual CKD-related expenditure before and after transformation: (a) expenditure in THB and (b) log(Cost + 1).

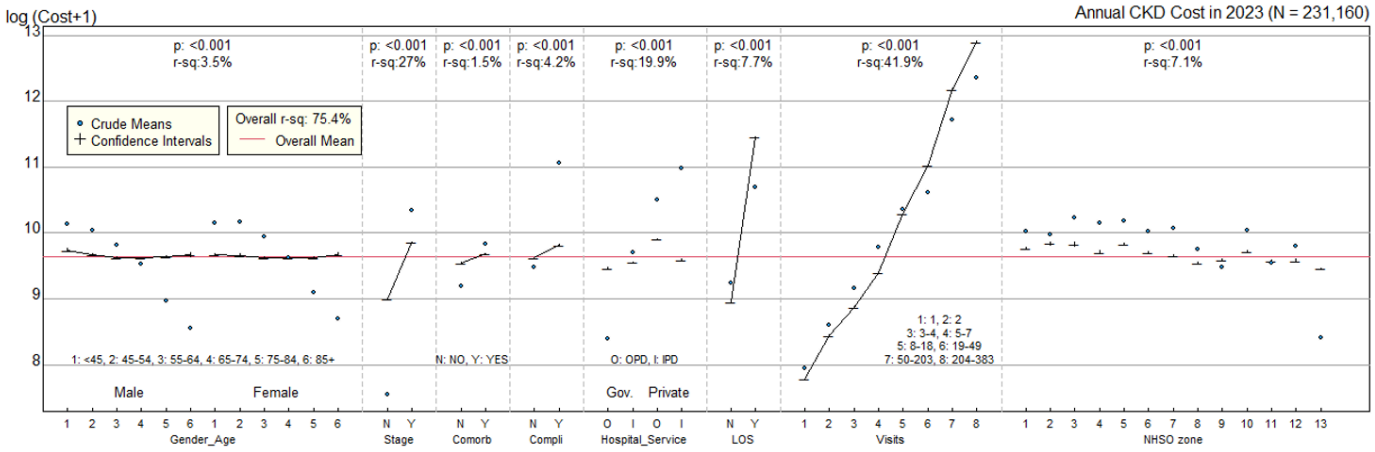

Figure 2

Log-transformed annual CKD-related expenditure across patient, health service, and geographic characteristics.

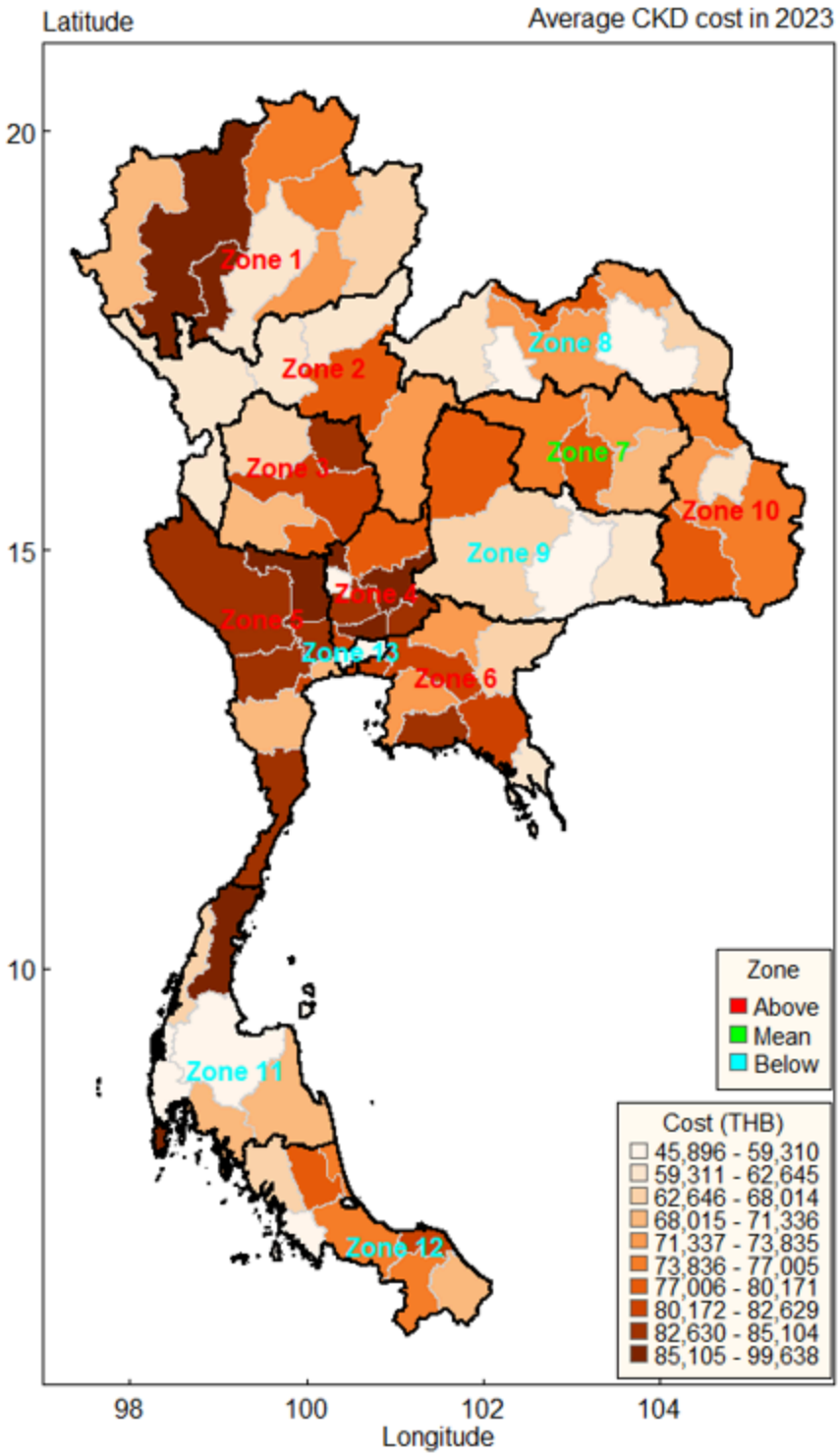

Figure 3

Geographic distribution of mean annual CKD-related healthcare expenditure per patient in Thailand, fiscal year 2023.