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Original Article

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Socioeconomic Costs of Chronic Kidney Disease: Evidence from Southwest Vietnam

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ABSTRACT

Introduction: Chronic Kidney Disease (CKD) has a high mortality in developing countries. This burden is increasing rapidly in Vietnam. The high cost of medication and haemodialysis are major barriers in the successful treatment of CKD.

Aim: To determine from a societal perspective the complete cost associated with CKD.

Materials and Methods: A cross-sectional study was conducted to estimate the total costs associated with the cost-of-illness, based on the prevalence of the disease at Kien Giang General Hospital. An electronic database provided information related to direct medical costs and biochemical parameters, whereas face-to-face interviews with CKD patients were conducted by questionnaire to collect demographic characteristics, direct non-medical costs and indirect costs. The population was divided into three groups based on the stages of CKD including the CKD 1–3 group, CKD 4–5 pre-dialysis group and haemodialysis group.

Results: A total of 327 patients were enrolled in the study. Costs varied among three groups of CKD patients. The annual cost per patient in the CKD 1–3 group, CKD 4-5 pre-dialysis group and haemodialysis group were USD 2,826.3 (95%CI: 2,592.3–3,077.1), USD 3,320.3 (95%CI: 2,765.2–3,913.8) and USD 9,498.3 (95%CI: 9,152.5–9,881.4), respectively. Direct medical costs represented the greatest proportion of total costs. The annual cost per patient in the CKD 1–3 group was affected by many characteristics such as age, residence, BMI, education level, exercise and number of comorbidities. In contrast to the CKD 1–3 group, in the haemodialysis group most results were not significantly different in the yearly cost per patient according to demographic and clinical characteristics. Whereas, patients in the CKD 4–5 pre-dialysis group were impacted by factors such as age, residence, occupation and the number of comorbidities.

Conclusion: The annual cost per patient in CKD 1–3, CKD 4–5 pre-dialysis and haemodialysis groups were substantial. Patients on haemodialysis incurred the highest cost, about three times compared with the other two groups. The differences in demographic and clinical characteristics affected the annual cost per patient, especially in the CKD 1–3 group.

Keywords: Cost-of-unit, Economic cost, Haemodialysis, Hospital, Social perspective

INTRODUCTION

CKD and End-Stage Renal Disease (ESRD) are two global health concerns with prevalence rates as high as 11–13% and 0.1% in the general population, respectively [1]. They pose a significant challenge for healthcare systems and many countries could be overwhelmed by the cost of meeting demands for all patients with CKD and ESRD [2]. Overall, approximately 10% of the global population has chronic kidney disease. The highest prevalence of CKD was reported in Latin America, Europe, East Asia and the Middle East, with approximately 12% of the population having CKD for each region [1]. The prevalence of CKD was lowest in South Asia (7%) and Sub-Saharan Africa (8%) [2]. In Asia, the number of ESRD patients receiving Renal Replacement Therapy (RRT) was forecasted to double from 2.6 million in 2010 to 5.4 million by 2030 [3]. According to the study implemented in Asian countries (Myanmar, Vietnam, Thailand, China and Japan), there were approximately 6 million people with chronic kidney disease in Vietnam, accounting for 6.73% of the population. Of those 6 million patients, about 800,000 progressed to end-stage and required RRT, but only 10% of those received dialysis treatment.

The economic burden of CKD is known to affect not only patients, but also their caregivers and payers. Significant healthcare costs are incurred annually to control the clinical complications of patients with CKD and ESRD, including costs related to detection, treatment and concurrent management of comorbidities (diabetes, congestive heart failure and high blood pressure, etc.,) [4]. In 2012, the total cost attributed to patients with CKD in Australia was estimated to be 9.6 billion Australian dollars (AUD), including 5.3 billion AUD in direct medical costs, 1.5 billion AUD in direct non-medical costs and 2.8 billion AUD in government subsidies [5]. Turchetti G et al., reported that in Italy the total annual social cost for 227,959 adult patients with CKD stages 4 and 5 pre-dialysis was 1,809,552,398 Euro (EUR), including EUR 1,001,955,049 in direct medical costs, EUR 690,312,531 in direct non-medical costs and EUR 117,284,819 in indirect costs [6]. The study of Eriksson JK et al., implemented in Sweden in 2016 reported that patients on haemodialysis had the highest mean annual cost with EUR 87,600, followed by peritoneal dialysis with EUR 58,600 and kidney transplantation with EUR 15,500 [7].

In Vietnam, the study of Bau PV et al., calculated the total annual cost for renal replacement therapy among patients in the 115 People's Hospital, as USD 13,480±1,214 and for CAPD, USD 10,755±840 [8]. In recent years, Vietnamese society has changed rapidly with economic growth and poverty reduction [9]. However, poverty is still a barrier in the management of CKD and ESRD [10]. Haemodialysis is an expensive treatment, which combined with low health insurance coverage leads many patients to discontinue treatment, dying within several weeks [10]. Despite the huge economic burden of CKD and ESRD, there are few studies on the costs of CKD and ESRD, particularly in southern Vietnam, hence this study was undertaken.

The aim of this study was to determine the complete costs associated with CKD at a general hospital from a societal perspective. These observations, coupled with evidence of an increasing global prevalence of chronic kidney disease, highlight the importance of understanding the socio-economic patterns of CKD.

MATERIALS AND METHODS

Study Design and Study Site: A cross-sectional study was conducted to estimate the total cost associated with the illness, based on the prevalence of the disease at Kien Giang General Hospital (Rach Gia city, Kien Giang province, southwest Vietnam). The calculations take a societal perspective, quantifying costs regardless of whether they fall on individuals, employers, governments, or others.

Population and Data Collection:

Sample Size: The study sample formula was based on the study of Charan and Biswas [11].

$$n = \frac{z_{1-\alpha/2}^2 SD^2}{d^2}$$

n= sample size

$z_{1-\alpha/2}$= standard normal variate (at 5% type 1 error ($p<0.05$) is 1.96 and 1% type 1 error ($p<0.001$) is 2.58). The p-values are considered significant below 0.05, hence 1.96 is used in the formula.

SD = Standard deviation of the variable. The value of standard deviation can be taken from previous studies or through pilot studies.

D = Absolute error: mean x precision, with precision decided by the researcher.

A pilot study was conducted with 40 patients [12] where results showed that the standard deviation of the annual cost per patient was USD 4,085.51 (d=594.80; 95% CI associated with $Z_{1-a/2}$ = 1.96). After calculation with the formula, the sample size was approximately 181 patients. In the process of collecting data there might have been some instances of incomplete questionnaires, so the minimum sample size was expanded by more than 10% to 200 patients.

The study included patients who received CKD treatment from the Kien Giang General Hospital in southwest Vietnam in the fiscal year 2017. Patients with CKD were identified using the International Classification of Disease, tenth revision (ICD-10 code) with disease diagnosis code N18, and classified into five stages based on GFR: G1 (≥90 mL/min/1.73 m^2), G2 (60–89 mL/min/1.73 m^2), G3a (45–59 mL/min/1.73 m^2), G3b (30–44 mL/min/1.73m^2), G4 (15–29 mL/min/1.73 m^2) and G5 (<15 mL/min/1.73 m^2) [13]. CKD comorbidities were also identified using ICD-10. The inclusion criteria for patients were those diagnosed with CKD stage 1–5 and ESRD undergoing haemodialysis, treated at Kien Giang General Hospital, older than 18 years and willing to participate. Patients who had impaired cognitive abilities, obvious psychiatric disorders, paralysis, were comatose, patients with acute renal failure and patients unable to complete the interview were excluded from this study. The population was divided into three groups based on the stages of CKD including the CKD 1–3 group, CKD 4–5 pre-dialysis group and haemodialysis group.

The relevant data were collected from an electronic database and interviews. The electronic database provided information related to direct medical costs and biochemical parameters, whereas face-to-face interviews with CKD patients were conducted by completing the questionnaire to collect demographic characteristics, direct non-medical costs and indirect costs. The structured questionnaire consisted of two parts. The first form included information about socio-demographic and clinical characteristics, namely age, gender, weight, height, diagnosis, dialysis status, marital status, education level, monthly income and occupation, residential area, lifestyle and presence of comorbidities (diabetes, hypertension, anaemia, hyperlipidaemia, etc.,). The second form was associated with transport expenses, supported accommodation costs, meals, working days lost, sources of funding and caregivers. The average time for completing the questionnaire was fifteen minutes.

Estimation of Costs:

Direct Costs: In this study, direct medical costs were collected from the hospital electronic database, including the cost of diagnostic screening, imaging, laboratory tests, hospitalisation, bed-days, medication, operations, pre-dialysis surgery (access placement), haemodialysis, medical supplies and others (blood transfusion or infusion). To standardize direct medical costs, the study used reference unit costs of medical services in Vietnam from the study of Trung Q et al., [14], with all unit costs of medical services being adjusted to their 2017 values $\frac{CPI_{2017}}{CPI_{2014}} = 1.549$ [15]. Self-reported illness-related items, such as meals, special foods, transportation to hospital, supported accommodation, and cost for caregivers, were collected from patients and their family members and were considered direct non-medical costs.

Indirect Costs: Absenteeism is the number of workdays lost due to dialysis or poor health [4]. The study recorded the total number of days off for routine dialysis, medical visits, as well as sick days based on information provided by patients. The productivity loss related to absenteeism in patients with CKD as well as caregivers was calculated by multiplying mean daily income and number of working days lost per year. Wherein, a month was considered 30 working days, so the mean daily income was calculated by dividing monthly income by 30.

Presenteeism is reduced work performance [4], meaning productivity loss while the employee is still at work but impaired due to health problems. The productivity loss related to presenteeism in patients with CKD was calculated based on the percentage of productivity reduced when compared to those not suffering from disease. According to the previous study of Eriksson D et al., the percentages of productivity loss in patients with CKD stage 1–3, CKD stage 4–5 pre-dialysis and haemodialysis are 7.4, 18.8 and 25.8, respectively [16].

Data Analysis and Statistical Analysis: Descriptive statistics were applied to summarise the distribution of socio-demographic, clinical and economic characteristics among CKD patients. Categorical variables were expressed using count and percentage, whereas continuous variables were expressed using mean (±SD, standard deviation) or median (IQR, Inter-Quartile Range), respectively, for normally or non-normally distributed continuous data. In addition, the cost data was calculated and described as means with a 95% Confidence Interval (CI) using bootstrapping procedures [17] with 5,000 replications (i.e., bias-corrected accelerated bootstrap CI), making no specific distributional assumptions regarding costs. The cost results were presented in US dollars at a 2017 value ($1 USD = 22,440 VND) [18]. Comparison of costs among patient characteristics was conducted using a t-test and One-Way Analysis Of Variance (ANOVA) for more than two samples. A p-value of less than 0.05 was considered statistically significant. The IBM SPSS Statistics version 22.0 (SPSS Inc., Chicago, IL) and Microsoft Excel version 2013 were used for data analysis.

Ethical Approval: The study protocols were approved by Kien Giang General Hospital. All participants gave their informed consent after receiving an explanation of the study. All the information is for research purposes only. During data collection each patient was identified anonymously by alphanumeric code.

RESULTS

[Table/Fig-1] shows the demographic and clinical characteristics of study respondents with CKD-associated illness and their households in Vietnam. A total of 327 patients were enrolled in the study- 146 men and 181 women, with a mean age of 54.7 years, the youngest 19 and the oldest 92 years of age. The number of patients on haemodialysis, at stages 4–5, pre-dialysis and stages 1–3 were 181 (55.4%), 54 (16.5%) and 92 (28.1%), respectively. The average duration of CKD was 4.46 years. In addition, HD patients had an average of 4.74 years of haemodialysis. More detail about the characteristics of the patients is shown in [Table/Fig-1].

Characteristics	Frequency {n (%)}	Characteristics	Frequency {n (%)}
Age in years		**Insurance status at index date % (n%)**	
≤49	116 (35.5)	80	71 (21.7)
50–59	79 (24.2)	95	20 (6.1)
60–69	68 (20.8)	100(*)	236 (72.2)
≥70	64 (19.5)	Stages of CKD	
Mean±SD	54.7 (16.4)	1–3	92 (28.1)
Median (IQR)	55.0 (43.0–67.0)	4–5 pre-dialysis	54 (16.5)
Range (Min–Max)	19.0–92.0	Hemodialysis	181 (55.4)
Gender		**Duration of CKD (years)**	
Male	146 (44.6)	Mean±SD	4.46 (3.46)
Female	181 (55.4)	Median (IQR)	3.0 (2.0–6.0)
Residence		Range (Min–Max)	0.3–20.0
Urban	64 (19.6)	**Duration of haemodialysis (years)**	
Rural	263 (80.4)	Mean±SD	4.74 (3.81)
Marital status		Median (IQR)	4.0 (2.0–7.0)
Single	34 (10.4)	Range (Min–Max)	0.2–20.0
Married	262 (80.1)	**Lifestyle**	
Separated or widowed	31 (9.5)	Cigarette smoking	43 (13.1)
BMI (kg/m^2)		Alcohol consumption	21 (6.4)
<18	28 (8.6)	Exercise	181 (55.4)
18–22.9	184 (56.2)	**History of family**	16 (4.9)
23–24.9	66 (20.2)	**Comorbidities**	
≥25	49 (15.0)	E11.22	71 (21.7)
Mean±SD	22.0 (3.4)	I12	252 (77.1)
Median (IQR)	21.6 (19.6–23.9)	E78.5	6 (1.8)
Range (Min–Max)	13.7–37.5	I50.2	22 (6.7)
Education level		D63.1	312 (95.4)
No school/ Illiterate	33 (10.1)	M79.2	14 (4.3)
Primary school	114 (34.9)	E83.5, E83.3	8 (2.4)
Junior high school	105 (32.1)	M10.9, K76.9 (others)	43 (13.1)
High school or over	75 (22.9)	**Transportation**	
Occupation		Walking	11 (3.4)
Unemployed	201 (61.5)	Bicycle	5 (1.5)
Employed	85 (26.0)	Motorcycle	209 (63.9)
Retired	17 (5.2)	On-demand motorcycle	24 (7.3)
Other	24 (7.3)	Car	3 (0.9)
Monthly income (US$)		Taxi	17 (5.2)
No income	233 (71.3)	Bus	26 (8.0)
≤200	58 (17.7)	Coach (bus for conveying passengers on longer-distance intercity coach services and usually has higher cost than bus)	25 (7.6)
200–400	33 (10.1)	Others (boat, ferry, high speed ship…)	7 (2.1)
>400	3 (0.9)		

[Table/Fig-1]: Demographic and clinical characteristics of study respondents with CKD-associated illness and their households in Vietnam {n= 327, n (%)}.
Abbreviations: BMI Body Mass Index; D63.1 Anemia in Chronic Kidney Disease, E11.22 Diabetes mellitus type 2 with diabetic chronic kidney disease; E78.5 Dyslipidemia; E83.5, E83.3 Canxi and phospho metabolic disorders; I12 Cardiovascular disease; I50.2 Congestive heart failure; M79.2 Nerve-related disease; M10.9 Gout; K76.9 Liver disease; IQR interquartile range; SD Standard Deviation, USD United State dollar; 100(*) means that insurer pays 100 percent of healthcare costs.

[Table/Fig-2] provides the annual cost per patient of chronic kidney disease at Kien Giang General Hospital in 2017, accompanied by the component cost per HD session in [Table/Fig-3]. Overall, costs varied among the three groups of CKD patients. In detail, the annual cost per patient in the CKD 1–3 group was USD 2,826.3 (95%CI: 2,592.3–3,077.1) with USD 3,320.3 (95%CI: 2,765.2–3,913.8) the yearly cost for a CKD 4–5 pre-dialysis patient, both much lower compared to USD 9,498.3 (95%CI: 9,152.5–9,881.4) spent for a HD patient per year. It is noteworthy that direct medical costs represented the greatest proportion of the total costs with 57.0%, 69.1% and 72.0% for CKD 1–3, CKD 4–5 pre-dialysis and haemodialysis groups, respectively. This was mainly attributable to medications (primarily concerned with ESAs), except for the haemodialysis group with 39.9% of total cost spent on haemodialysis surgeries. The findings show that the total cost per session was mostly derived from direct medical costs (71.9%), followed by direct non-medical costs (23.2%) and indirect cost (4.9%).

[Table/Fig-4-7] show the factors affecting the annual cost per patient in CKD individuals. The CKD 1–3 group was significantly affected by characteristics such as age, residence, BMI, education level, exercise and the number of comorbidities. In detail, the costs were significantly higher in patients over the age of 70 {USD 3,222.2 (95%CI: 2,753.9–3,728.3)}, living in rural areas {USD 3,050.4 (95%CI: 2,743.5–3,369.4)}, being of normal BMI {USD 3,121.0 (95%CI: 2,656.2–3,619.2)}, with a primary education level {USD 3,550.4 (95%CI: 3,005.7–4,150.2)}, having no physical exercise {USD 3,434.2 (95%CI: 2,860.4–4,058.5)} and suffering from multiple comorbidities (USD 6,596.8). In contrast to the CKD 1–3 group, in the haemodialysis group most results were not significantly different in yearly cost per patient according to demographic and clinical characteristics. Whereas the annual cost per patient in the CKD 4–5 pre-dialysis group were impacted by several factors such as age, residence, occupation and the number of comorbidities.

DISCUSSION

The results of this study showed the economic burden of CKD was considerable at all levels of the disease and the progression of CKD might cause direct costs to sharply increase. This creates significant impacts on patients, caregivers and society. By dividing patients into three groups including the CKD 1–3 group, CKD 4–5 pre-dialysis group and haemodialysis group, the findings revealed that patients on HD incurred the greatest cost, about three times compared with those of CKD 1–3 and CKD 4–5 pre-dialysis (p-value <0.001). The annual cost per patient of the HD group was USD 9,498.3 (95%CI: 9,152.5–9,881.4), being similar with the finding reported by Al-Shdaifat EA et al., of USD 9,977 cost per patient per year (cost/patient/year) [19], while the study of Bau PV et al., showed that the total annual cost per HD patient was USD 13,480±1,214 [8]. The different results between the study of Bau PV et al., and the present study might be due our study being conducted at a provincial hospital, whereas Bau PV et al., carried out their study at a general hospital in Ho Chi Minh City, the largest city in Vietnam. In general, the yearly cost per HD patient might vary from one country to another or from one region to other region in the same country. The cost per HD patient in developing countries had a variation from USD 3,000 to USD 7,700 per year [20]. Previous studies from many countries reported the annual cost per HD patient ranged from USD 6,240 in Indonesia to USD 36,220 in Sweden [7,21-27].

It is notable that direct medical costs in HD patients were significantly higher than those not on dialysis (p-value <0.001). This could be explained by the money spent on HD surgeries, erythropoietin and other medications. Anaemia was the most common complication in patients with CKD, especially in individuals being treated by RRT. The findings of our study were confirmed when the cost of the ESAs showed an upward trend from USD 654.8 (95% CI: 561.6–749.6) in the CKD 1–3 group to USD 844.6 (95%CI: 722.5–967.6) in CKD 4–5 pre-dialysis and USD 2,075.9 (95%CI: 1,973.2–2,174.0) in the haemodialysis group. Direct non-medical costs for CKD reached a

Parameter	CKD 1–3 (n=92)	Percentage of total cost	CKD 4–5 pre-dialysis (n=54)	Percentage of total cost	Haemodialysis (n=181)	Percentage of total cost	P-value
Direct costs	2,358.9 (2,150.9–2574.7)	83.5	2,859.8 (2,332.1–3,432.7)	86.1	9,028.5 (8,697.6–9,391.0)	95.1	<0.001*
Direct medical costs	1,611.1 (1,491.1–1,742.3)	57.0	2,294.9 (1,788.0–2,854.1)	69.1	6,832.3 (6,705.6–6,973.7)	72.0	<0.001*
Hospitalisations	13.6 (10.2–17.4)	0.5	8.7 (8.1–9.3)	0.3	14.8 (12.1–18.3)	0.2	0.155
Laboratory test	107.8 (90.9–127.6)	3.8	90.2 (81.5–100.1)	2.7	203.8 (169.2–251.4)	2.1	0.001*
Medical supplies and others (blood transfusion or infusion)	19.7 (12.4–27.6)	0.7	616.3 (219.3–1,057.4)	18.6	415.4 (351.1–494.6)	4.4	<0.001*
Hemodialysis or surgery	21.0 (18.2–24.1)	0.7	21.3 (19.2–23.1)	0.6	3,788.1 (3,775.0–3,813.7)	39.9	<0.001*
Medications	1,449.2 (1,334.5–1,571.7)	51.3	1,558.4 (1,406.1–1,712.5)	46.9	2,410.2 (2,313.5–2,510.9)	25.4	<0.001*
Cardiovascular disease	338.6 (296.8–386.5)	12.0	302.4 (269.9–333.0)	9.1	241.2 (224.4–258.5)	2.5	<0.001*
ESAs	654.8 (561.6–749.6)	23.2	844.6 (722.5–967.6)	25.4	2,075.9 (1,973.2–2,174.0)	21.9	<0.001*
Protein supplement	358.4 (316.2–400.5)	12.7	325.0 (274.2–369.8)	9.8	–	0.0	<0.001*
Other drugs	97.4 (83.6–112.1)	3.4	86.4 (74.0–99.0)	2.6	93.1 (62.3–132.2)	1.0	0.951
Direct non-medical costs	747.8 (615.1–893.6)	26.5	564.9 (462.6–672.7)	17.0	2,196.2 (1,897.6–2,526.0)	23.1	<0.001*
Transportation to hospital	257.2 (196.1–325.9)	9.1	175.2 (130.8–229.3)	5.3	880.8 (710.4–1,085.1)	9.3	<0.001*
Meals, special foods	194.3 (171.7–217.2)	6.9	178.0 (149.2–208.0)	5.4	351.1 (310.8–395.2)	3.7	<0.001*
Supported accommodation	32.6 (6.6–67.0)	1.2	39.6 (5.3–83.6)	1.2	69.3 (48.7–91.9)	0.7	0.139
Caregivers	263.7 (199.7–335.2)	9.3	172.1 (116.0–232.1)	5.2	894.9 (680.2–1,128.3)	9.4	<0.001*
Indirect costs	467.4 (379.6–561.0)	16.5	460.5 (328.6–610.2)	13.9	469.8 (372.4–572.4)	4.9	0.996
Absenteeism	371.4 (303.0–443.1)	13.1	271.6 (191.0–360.4)	8.2	346.4 (276.5–419.4)	3.6	0.399
Presenteeism	96.0 (69.0–125.3)	3.4	188.9 (108.7–277.7)	5.7	123.4 (83.3–167.0)	1.3	0.130
Total costs	2,826.3 (2,592.3–3,077.1)	100.0	3,320.3 (2,765.2–3,913.8)	100.0	9,498.3 (9,152.5–9,881.4)	100.0	<0.001*

[Table/Fig-2]: The annual cost per patient of chronic kidney disease at Kien-Giang General Hospital {2017, USD, mean (95% CI)}
ESA Erythropoiesis-Stimulating Agent, CKD Chronic Kidney Disease, CI Confidence Interval (bias corrected)
p-value calculated with one-way Anova test; *p-value <0.05 ; **p-value <0.001

Parameter	Mean (95%CI)	Median (IQR)	Percentage of total cost (%)
Direct cost	57.9 (55.8–60.1)	54.0 (48.7–61.9)	95.1%
Direct medical cost	43.8 (43.0–44.7)	44.1 (40.3–46.4)	71.9%
Direct non-medical cost	14.1 (12.3–16.1)	9.2 (4.8–18.0)	23.2%
Indirect cost	3.0 (2.4–3.7)	0.1 (0.1–5.4)	4.9%
Total cost	60.9 (58.7–63.6)	57.1 (50.7–66.3)	100.0%

[Table/Fig-3]: The component costs of a haemodialysis session {2017, USD, mean (95% CI)}.
CI Confidence Interval (bias corrected)
IQR Interquartile Range

peak when patients went on HD because they needed to be in the dialysis centre three times per week and experienced an increase in the cost of transportation, meals and supported accommodations as well as caregivers.

The cost of a HD session also varied from one country to another. Previous studies from other countries reported the cost per session ranged from USD 45 in Malaysia to USD 157 in Barbados [21-27]. The results of our study were also in this range, with the total cost per session USD 60.1 (95%CI: 58.0–62.4), including USD 43.8 (95%CI: 43.0–44.7), USD 14.1 (95%CI: 12.3–16.1) and USD 2.2 (95%CI: 1.8–2.7) of direct medical costs, direct non-medical costs and indirect costs, respectively.

As to the CKD 1–3 group, the annual cost per patient was significantly affected by many factors such as age, residence, BMI, education level, exercise and the number of comorbidities. The yearly cost per patient was significant higher in patients with >4 comorbidities in comparison to patients with ≤ 2 comorbidities. Our findings have been supported by the study of Ahlawat R et al., and the study of Suja A et al., in which the presence of comorbidities drove the cost of treatment to increase [28,29]. This could be explained in that the more comorbidities, the more treatment that was required. In addition, there was a significant difference between patients who exercised and those who did not. In particular, the annual cost per patient of individuals who were physically active was about 1.5 times lower than those who were not {USD 2,532.2 (95%CI: 2,319.1–2,749.3), USD 3,434.2 (95%CI: 2,860.4–4,058.5), respectively}. Physical exercise might play an important role in preventing the progression of CKD and its complications, especially in the early stages of CKD when the disease has not yet impacted physical abilities. There was a significantly higher cost in rural patients when compared to urban patients {USD 3,050.4 (95%CI: 2,743.5–3,369.4), USD 2,191.5 (95%CI: 1,981.8–2,367.4), respectively}. It is possible that Kien Giang General Hospital was further from rural areas than urban areas, so patients experienced higher costs including transportations, meals, accommodations and caregivers. There was a significant difference in annual cost per patient between age groups, wherein patients over 70 incurred the highest cost as a result of more comorbidities and more patients who required caregivers.

As to the CKD 4–5 pre-dialysis group, there was a conflicting result with the CKD 1–3 group when the annual cost per patient with two comorbidities was approximately two times higher than those with three comorbidities. This could occur as costs also depended on the progression of comorbidities. In addition, patients aged ≤59 showed significantly higher costs than others. Practically, most patients aged ≤59 in this group were employed, leading to an impact on indirect costs as the result of work impairment. These findings were similar to the CKD 1–3 group, when rural patients also showed higher costs than urban individuals.

As to the HD group, results were not significantly different in annual cost per patient according to demographic and clinical characteristics. It could be that most patients were severely affected by treatment.

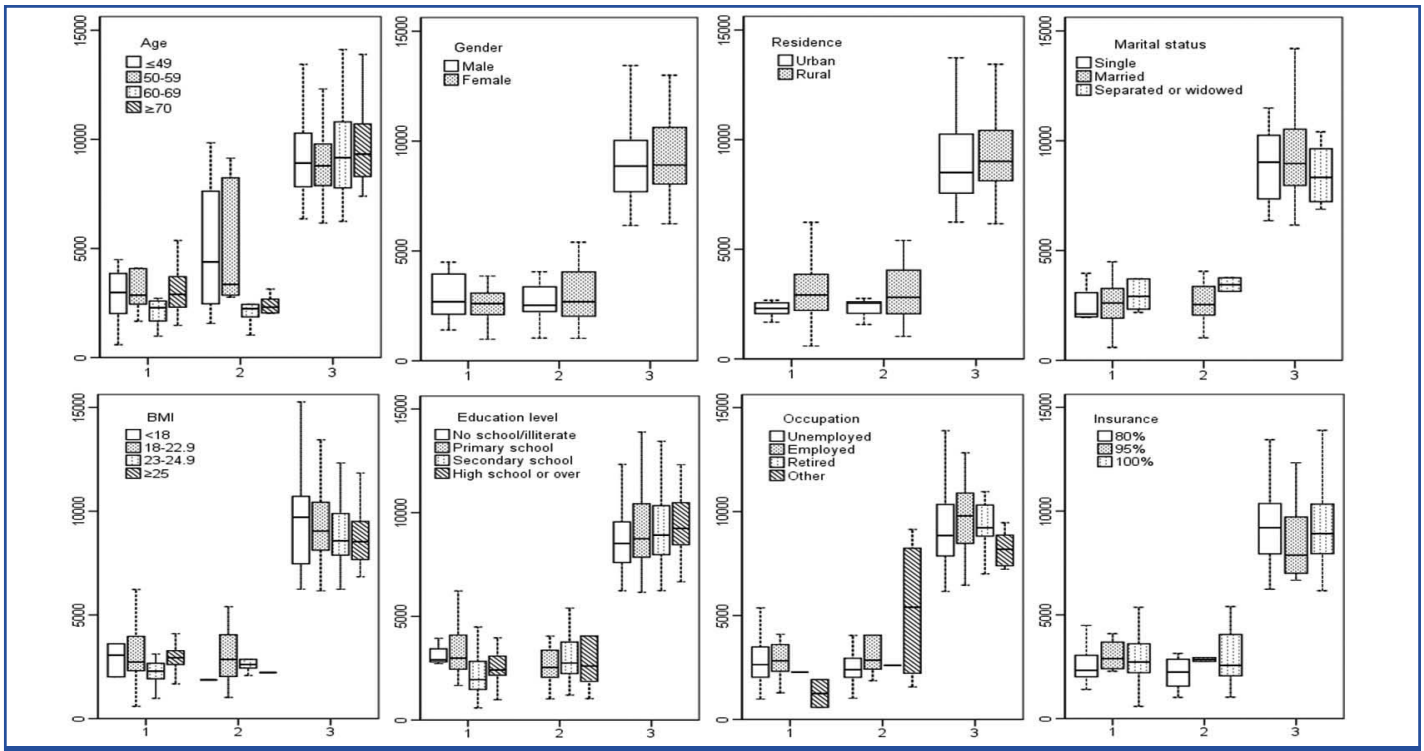
Characteristics	CKD 1–3 (n=92)	p-value	CKD 4–5 pre-dialysis (n=54)	p-value	Hemodialysis (n=181)	p-value
Age in years						
≤49	2,770.8 (2,287.6–3,228.5)	0.004*	5,044.7 (2,974.8–7,284.0)	<0.001**	9,459.6 (8,999.0–9,966.9)	0.959
50–59	3,006.0 (2,569.8–3,442.9)		4,950.8 (3,506.0–6,508.4)		9,465.7 (8,777.3–10,242.1)	
60–69	2,089.8 (1,848.1–2,312.9)		2,392.3 (1,948.8–2,858.4)		9,499.0 (8,725.8–10,331.5)	
≥70	3,222.2 (2,753.9–3,728.3)		2,279.3 (1,941.2–2,572.7)		9,857.6 (8,768.2–11,053.4)	
Gender						
Male	2,844.6 (2,536.6–3,169.6)	0.892	2,708.0 (2,301.1–3,113.8)	0.078	9,408.7 (8,942.4–9,931.0)	0.642
Female	2,814.6 (2,491.3–3,166.8)		3,626.4 (2,829.7–4,498.4)		9,590.8 (9,107.8–10,143.5)	
Residence						
Urban	2,191.5 (1,981.8–2,367.4)	<0.001**	2,308.0 (2,018.2–2,583.5)	0.014*	9,049.3 (8,313.2–9,898.5)	0.249
Rural	3,050.4 (2,743.5–3,369.4)		3,550.4 (2,869.4–4,308.6)		9,587.5 (9,218.0–9,996.7)	
Marital status						
Single	2,535.7 (2,028.8–3,157.9)	0.183	–	0.906	9,077.7 (8,388.5–9,782.0)	0.201
Married	2,752.6 (2,488.6–3,029.4)		3,309.8 (2,722.3–3,970.7)		9,663.8 (9,261.3–10,100.2)	
Separated or widowed	3,361.1 (2,722.9–4,156.1)		3,451.7 (3,266.1–3,637.2)		8,531.6 (7,843.0–9,217.1)	
BMI (kg/m2)						
<18	2,891.1 (2,361.2–3,421.0)	0.034*	1,866.5 †	0.697	9,462.9 (8,506.4–10,513.2)	0.606
18–22.9	3,121.0 (2,656.2–3,619.2)		3,357.2 (2,714.4–4,053.0)		9,665.9 (9,204.2–10,160.8)	
23–24.9	2,250.3 (2,006.0–2,479.4)		3,589.5 (2,493.4–5,108.1)		8,916.6 (8,304.3–9,585.9)	
≥25	2,949.0 (2,606.7–3,287.3)		2,224.9 †		9,431.5 (8,537.4–10,554.7)	
Education level						
No school/Illiterate	3,120.7 (2,819.2–3,474.8)	0.001*	–	0.838	8,837.1 (8,136.7–9,643.4)	0.366
Primary school	3,550.4 (3,005.7–4,150.2)		3,094.0 (2,479.7–3,804.6)		9,524.8 (8,930.3–10,215.1)	
Junior high school	2,348.7 (1,933.6–2,768.3)		3,474.5 (2,495.9–4,635.9)		9,469.3 (8,952.4–10,043.8)	
High school or over	2,552.5 (2,301.6–2,812.8)		3,477.7 (2,212.7–5,074.1)		10,068.8 (9,164.6–11,198.8)	
Occupation						
Unemployed	2,951.3 (2,551.2–3,366.1)	0.052	2,373.6 (2,064.5–2,675.8)	0.002*	9,407.9 (8,989.8–9,878.3)	0.147
Employed	2,862.4 (2,613.2–3,125.2)		3,892.8 (2,752.9–5,362.6)		10,183.1 (9,299.9–11,163.2)	
Retired	2,284.4 †		2,603.0 †		9,649.1 (8,775.1–10,614.2)	
Other	1,254.5 (855.0–1,654.1)		5,313.1 (3,263.3–7,281.5)		8,171.2 (7,718.2–8,613.7)	

[Table/Fig-4]: The annual cost per patient according to demographic and clinical characteristics {2017, USD, mean (95% CI)}.
BMI Body Mass Index, CKD Chronic Kidney Disease, CI Confidence Interval (bias corrected), 100(*) means that insurer pays 100 percent of health care costs.
p-value calculated with t-test and one-way Anova test (more than two samples)
*p-value <0.05; **p-value <0.001; † cost/year/patient is constant

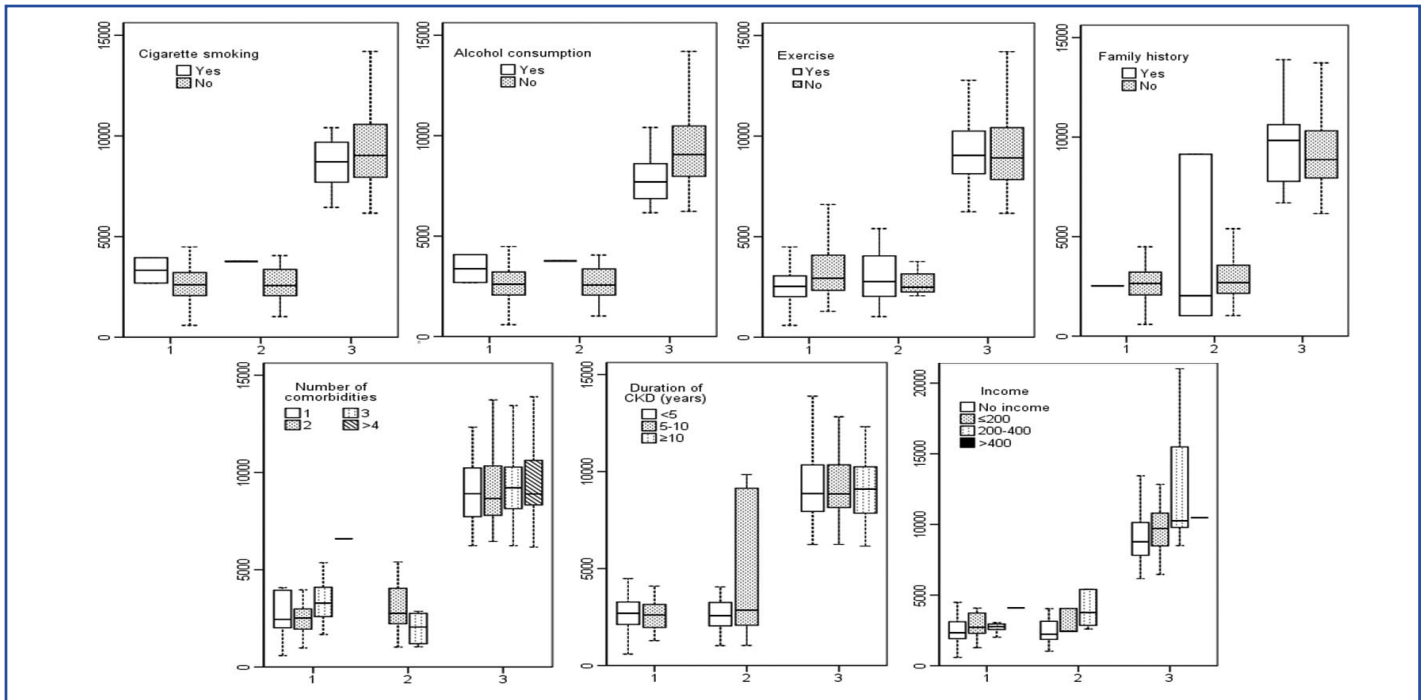
Characteristics	CKD 1–3 (n=92)	p-value	CKD 4–5 pre-dialysis (n=54)	p-value	Hemodialysis (n=181)	p-value
Monthly income (USD)						
No income	2,669.7 (2,339.1–3,020.8)	0.251	2,961.2 (2,374.9–3,634.6)	0.05	9,276.3 (8,912.5–9,684.3)	0.002*
≤200	2,832.0 (2,472.6–3,189.8)		2,972.3 (2,428.3–3,647.2)		9,761.3 (9,075.3–10,472.3)	
200–400	3,148.2 (2,599.4–3,845.2)		4,893.7 (3,310.1–6,762.3)		12,902.9 (9,716.8–16,537.6)	
>400	4,097.4 †		–		10,484.4 †	
Insurance status at index date % (n%)						
80	2,766.8 (2,403.0–3,189.5)	0.846	2,261.0 (1,848.1–2,628.9)	0.094	9,842.0 (8,647.5–11,275.1)	0.451
95	3,045.6 (2,532.7–3,571.5)		2,850.2 (2,793.9–2,906.4)		8,525.1 (7,320.1–9,962.1)	
100(*)	2,831.6 (2,494.0–3,180.8)		3,784.5 (2,981.8–4,711.8)		9,497.5 (9,151.6–9,876.5)	
Lifestyle						
Cigarette smoking						
Yes	3,319.1 (2,942.4–3,695.8)	0.138	3,760.9 †	0.188	9,147.5 (8,566.1–9,818.8)	0.264
No	2,803.9 (2,562.4–3,053.5)		3,303.4 (2,732.4–3,935.1)		9,588.4 (9,199.7–10,020.8)	
Alcohol consumption						
Yes	3,385.8 (2,969.1–3,802.5)	0.127	3,760.9 †	0.188	7,872.7 (7,289.7–8,484.7)	<0.001**
No	2,800.9 (2,544.9–3,067.7)		3,303.4 (2,732.4–3,935.1)		9,645.1 (9,280.5–10,042.5)	
Exercise						
Yes	2,532.2 (2,319.1–2,749.3)	0.009*	3,428.4 (2,795.4–4,117.8)	0.098	9,639.3 (9,072.8–10,254.9)	0.561
No	3,434.2 (2,860.4–4,058.5)		2,698.9 (2,286.2–3,182.1)		9,402.9 (8,987.1–9,853.8)	
Family history						
Yes	2,524.9 †	0.726	4,065.1 (1,360.5–7,108.4)	0.613	9,532.5 (8,655.5–10,498.0)	0.944
No	2,833.0 (2,578.1–3,095.6)		3,227.2 (2,720.9–3,798.4)		9,494.9 (9,136.5–9,890.4)	
Number of Comorbidities						

1	2,616.9 (1,680.3–3,496.6)	<0.001**	–	0.002*	9,676.6 (8,819.3–10,647.6)	0.926
2	2,583.3 (2,358.4–2,823.4)		3,699.4 (3,024.0–4,461.7)		9,485.1 (8,897.8–10,179.1)	
3	3,360.7 (2,857.9–3,886.3)		1,993.3 (1,587.8–2,400.4)		9,328.1 (8,854.1–9,849.4)	
> 4	6,596.8 †		–		9,632.6 (8,888.9–10,461.7)	
Duration of CKD (years)						
<5	2,873.7 (2,588.6–3,173.1)	0.321	2,843.3 (2,459.2–3,276.2)	0.072	9,381.6 (8,942.6–9,889.0)	0.803
5–10	2,601.3 (2,161.1–3,042.4)		4,683.1 (3,012.6–6,490.7)		9,580.8 (8,965.9–10,264.8)	
≥10	–		–		9,689.4 (8,858.1–10,715.0)	

[Table/Fig-5]: The annual cost per patient according to demographic and clinical characteristics {2017, USD, mean (95% CI)}.
CKD Chronic Kidney Disease, CI Confidence Interval (bias corrected)
p-value calculated with t-test and one-way Anova test (more than two samples)
*p-value <0.05; **p-value <0.001; † cost/year/patient is constant



[Table/Fig-6]: Cost/year/patient of each group according to demographic and clinical characteristics {2017, USD}.
Notes: 1, CKD 1–3 group; 2, CKD 4–5 pre-dialysis group; 3, haemodialysis group; CKD, Chronic Kidney Disease; BMI, Body Mass Index; Insurance 100% means that insurer pays 100 percent of healthcare costs.



[Table/Fig-7]: Cost/year/patient of each group according to demographic and clinical characteristics {2017, USD}.
Notes: 1, CKD 1–3 group; 2, CKD 4–5 pre-dialysis group; 3, haemodialysis group; CKD, chronic kidney disease.

The strength of this study is that it encompassed all stages of CKD from stage 1 to stage 5 and haemodialysis. In addition, this study considered costs from a social perspective, including direct medical costs, direct non-medical costs and indirect costs alike, resulting

in an assessment of the economic burden of CKD on society. Nevertheless, this study had several limitations. Firstly, the subjective information provided by the respondents might be biased. Secondly, the study was implemented at a single hospital in southern Vietnam with a small sample size, and therefore these outcomes cannot be generalised with respect to Vietnamese CKD patients.

CONCLUSION

The annual cost per patient in the CKD 1–3, CKD 4–5 pre-dialysis and haemodialysis groups was substantial. Patients on haemodialysis incurred the highest costs, about three times compared with the other groups. Of the total costs in each group, direct medical costs contributed the most. The differences in demographic and clinical characteristics affected the annual cost per patient, especially in the CKD 1–3 group. Although CKD is generally progressive and irreversible, patients should heed advice regarding nutrition, lifestyle changes and compliance with treatment. This might slow progression, enabling patients to live longer without complications or the need for renal replacement therapy. Since the higher stages of CKD were, the larger economic burden of CKD posed on society, especially the stage of haemodialysis. Therefore, it is important for the policymakers to decide health policy strategies and resources allocation suitably with the stages of CKD in order to ensure that healthcare services are sufficient for all patients.

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ABBREVIATION

BMI: Body Mass Index; CKD: Chronic Kidney Disease; CI: Confident Interval; HD: Hemodialysis; D63.1 Anemia In Chronic Kidney Disease; E11.22 Diabetes Mellitus Type 2 With Diabetic Chronic Kidney Disease; E78.5 Dyslipidemia; E83.5, E83.3 Canxi and Phospho Metabolic Disorders; I12 Cardiovascular Disease; I50.2 Congestive Heart Failure; M79.2 Nerve-Related Disease; M10.9 Gout; K76.9 Liver Disease; SD Standard Deviation, USD United State Dollar; 100(*) means that insurer pays 100 percent of health care costs.

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