Original Article

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Public Health Section

Chronic Kidney Diesease-Economic Impact: A Vietnamese Hospital Perspective, 2014–2017

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ABSTRACT

Introduction: Chronic Kidney Disease (CKD) has a high morbidity and mortality in developing countries. A cost analysis is needed to inform the economic evaluations for prevention strategies and treatment options. The unaffordable price of medication and haemodialysis remains one of the major barriers to the successful treatment of CKD.

Aim: To estimate the direct costs associated with treating CKD at the outpatient and inpatient departments of a general hospital in Vietnam.

Materials and Methods: A retrospective cost-of-illness study measured the economic burden of CKD outpatient and inpatient care in Vietnam based on a patient, provider, and payer perspective. Data on 4,429 individuals with CKD treated at the Kien Giang General Hospital for the years 2014–2017 was analysed. Description statistics for different types of direct medical costs and medications were evaluated and the differences between direct costs identified by characteristic were compared using the independent sample t-test or the one-way analysis of variances test.

Results: The direct medical costs per year, per patient receiving either haemodialysis or not at the outpatient department were US $2,401 and US $957, respectively; the corresponding figures for a patient receiving treatment at the inpatient department were US $611 and US $202, respectively. Treatment costs were found to be statistically significantly higher for patients on haemodialysis, for patients whose treatment was supported by insurance and for patients living in rural areas. Erythropoietin stimulating agents and cardiovascular disease-related medicines were the most costly medications.

Conclusions: CKD is a significant contributor to the financial burden of patients and society. Our study provides a baseline estimate of CKD cost that can be used by future studies for comparison.

Keywords: Costs of illness, Illness burden, Hospital, Vietnam

INTRODUCTION

CKD, previously known as chronic renal failure, is defined by the global non-profit Kidney Disease: Improving Global Outcomes (KDIGO) as the loss of kidney structure or function lasting more than three months with deteriorating health implications [1]. Glomerular Filtration Rate (GFR) is recognised as the best overall measure of kidney function and is frequently used in the diagnosis, staging and management of CKD [2]. Based on GFR levels, KDIGO has classified CKD into five stages, with the higher stages [3–5] representing lower GFR levels and an increasing severity in renal damage, eventually necessitating dialysis [3]. In the fifth stage, the patient would progress to End-stage Renal Disease (ESRD) and undergo renal replacement therapy (RRT) [4]. RRT including Kidney transplantation, Haemodialysis (HD) and Peritoneal Dialysis is necessary for the treatment of ESRD patients. Without dialysis, the prognosis of ESRD patients is varied, between six months to two years [5,6].

CKD is a significant health issue in many regions of the world, contributing to global morbidity and mortality [7,8]. According to World Kidney Day, 10% of the global population is affected by CKD, meaning that about 1 in 10 people have CKD. Millions die each year, because they do not have access to affordable treatment [9]. The 2013 Global Burden of Disease study estimated that nearly one million people died that year 2013 from CKD, a 134 % increase from 1990, one of the largest increases among the top causes of death [7]. As per the 2015 Global Burden of Disease study, CKD was the 12th most common cause of death, making it one of the fastest rising major causes of death alongside diabetes and dementia [7]. Overall, approximately 10% of the global population has CKD, but the prevalence varies geographically [11]. The prevalence of CKD is highest in Latin America, Europe, East Asia and the Middle East, with the figures for each region being approximately 12% of the population [12]. Meanwhile, the lowest prevalence is reported in South Asia (7%) and Sub-Saharan Africa (8%) [12].

CKD places a huge economic burden on health care systems [13]. The CKD cost to the English National Health Service (NHS) in 2009–2010 was estimated to be £1.44 to £1.45 billion, about 1.3 % of all NHS spending for that period. Data from the United States Renal Data System shows that Medicare spending for CKD rose from US $41.2 billion in 2010 to US $50.4 billion in 2014, representing a 22.3% increase [14-16]. The 2013 cost of CKD care in the United States exceeded the entire national budget of many countries in sub-Saharan Africa, Latin America and Central and East Asia [14]. In Italy, Turchetti G et al., reported that the overall annual social cost of CKD was over €1 billion, representing 0.11% of the country's gross domestic product [17]. Specifically, the direct medical costs related to CKD stage 4 and stage 5 treatment per patient, per year were €3,978 and €5,229; respectively. Meanwhile in India, the government's Planning Commission Report disclosed that about 286 million people in that country live below the poverty line and could not afford the high cost of treatment associated with CKD [18]. Ahlawat R et al., carried out a cross-sectional study in India that estimated the annual average CKD treatment costs for patients on medication alone and for patients on HD plus medication were US $386 and US $3,181; respectively [19].

Vietnam is a Southeast Asian country with a current population of over 92 million people [20]. In 2008, Ito J et al., estimated that the prevalence of CKD stage 3 and stage 5 in Vietnam was 3.1% and

3.6%, respectively [21]. The burden of CKD costs on total health care spending in Vietnam is likely to increase and will have important consequences on the sustainability of health care financing. Yet, there are few comprehensive studies assessing the economic and health-related costs of this disease. To fill this research gap, the current study measured CKD utilisation of healthcare resources and estimated CKD's economic impacts on healthcare using real-world patients from a Vietnamese hospital during the period of 2014 to 2017.

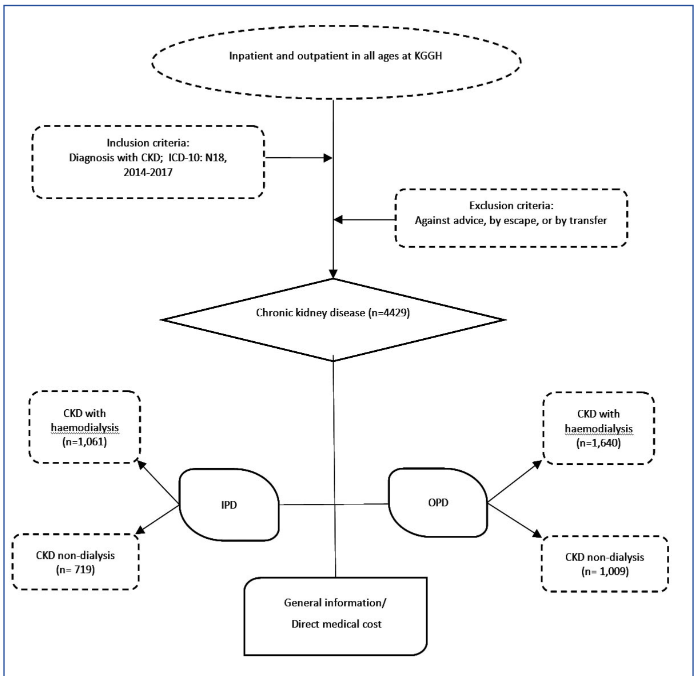
MATERIALS AND METHODS

A retrospective cost-of-illness study assessed CKD's economic healthcare impacts using administrative hospital data for the four years between January 2014 and December 2017.

Kien-Giang General Hospital (KGGH) is situated in Rach-Gia city, the centre of Kien-Giang province (KGp) (population 1.78 million), which is famous for its culture and tourism. KGGH is a level I provincial hospital with a capacity of nearly 1,000 beds. As KGp's largest hospital, KGGH is responsible for the care and treatment of over one million inhabitants [22]. The hospital has 820 permanent staff, including 158 doctors with university and postgraduate degree in various departments [22].

Sample Selection: The KGGH financial and medical databases were searched for CKD-related records identified by the World Health Organization's International Classification of Diseases, tenth Revision (ICD-10) of N18. The search included the records for all inpatients treated at the hospital's kidney department (Inpatient Department-IPD) and the records for all outpatients treated at the dialysis unit of the outpatient department (OPD). The database contained information on patient demographics (age, gender, region and healthcare insurance) and healthcare utilisation (medical services, medications and charges). Information was obtained on the number of CKD patients who were treated at KGGH from January 2014 to December 2017, and the direct medical costs per patient. All KGGH patients who were diagnosed with CKD (N = 4,429) were identified at the time of their diagnosis with ICD code. The cases of all CKD patients that did not meet the research criteria were excluded (e.g., patients with missing information, patients whose diagnosis changed during treatment, and patients who were transferred to another hospital) [Table/Fig-1].

Cost Components: The total direct medical costs related to CKD treatment included clinic visit costs (outpatient visits and hospitalizations), diagnostic costs (laboratory tests and procedures), drug costs (antiviral drugs and other medicines) and other services (transportation, alternative materials, blood and fluid).



[Table/Fig-1]: Selection and classification of the studied patients.
Abbreviation: IPD-Inpatient Department; OPD-Outpatient Department; CKD-Chronic Kidney Disease

To standardize the direct medical costs, the study used reference unit costs of medical services in Vietnam from the study of Trung Q et al., [23]. In determining the per person costs between 2014 and 2017, all calculations were reported in US dollars, using the currency exchange rate on March, 2018 (1 US $ = 22,445 VND).

Data Analysis and Cost Estimates:

Descriptive statistics were used to analyse patient demographics, resource utilisation, component cost and total cost of illness. Patients were divided into four age groups: less than 49-year-old, 50 to 59-year-old, 60 to 69-year-old and over 70-year-old.

The hospital database was used to estimate the annual direct medical costs of a patient with CKD. The values extracted from the hospital database were stratified by age, sex, region, healthcare insurance, type of service (inpatient or outpatient care) and year. Direct medical costs included diagnosis, hospitalisation, treatment drugs, laboratory tests and other costs (such as medical supplies, infusions and specialised services). Cost components were calculated by multiplying the number of services times by the cost per service.

STATISTICAL ANALYSIS

The study applied a bottom up approach, which measures and values each resource item used by an individual. The annual costs per person for direct healthcare and government subsidies were reported by CKD status, with or without HD. Categorical variables were expressed using count and percentage, whereas continuous variables were expressed using Mean ± Standard Deviation (SD) or median (inter-quartile range (IQR)). A t-test and one-way analysis of variance (ANOVA) were performed to compare costs between the CKD groups, with P<0.05 considered statistically significant. In addition, bootstrapping procedures [24] with 5,000 replications (i.e., bias-corrected accelerated bootstrap confidence intervals) were used to calculate the mean and to estimate 95% confidence intervals around the cost estimate. The IBM SPSS Statistics version 20.0 program and Microsoft Excel version 2013 were used for data analysis.

Ethical Approval: The study protocol was approved by KGGH. As the study utilised data from medical records that did not include the patients' personal information, KGGH waived the need for written informed consent from the participants.

RESULTS

The study sample consisted of hospital medical records from 4,429 individuals. [Table/Fig-2] provides the demographic characteristics of the CKD patients at KGGH from 2014 to 2017. The mean age was 56.4±17.0 years. The majority of the CKD patients were female and originally came from rural areas. Over the half the patients were fully covered by healthcare insurance.

[Table/Fig-3] provides an estimate of the total economic burden of CKD patients and the cost per CKD patient according to patient, provider and payer perspective, with and without dialysis at the IPD. Cost estimates for outpatient treatment are contained in [Table/Fig-4]. Overall, the direct medical cost per CKD patient with HD was higher than those without HD. The period from 2014 to 2017 also experienced an increase in CKD treatment expenditures.

[Table/Fig-5] depicts the relative proportions of the direct medical costs. This pie chart demonstrates that medications and operations accounted for the highest percentage of total costs, whilst Erythropoietin Stimulating Agents (ESAs) were the most costly medicine used to treat CKD, followed by cardiovascular disease-related medicines.

[Table/Fig-6,7] show the factors that impacted the direct medical

IPD	2014 (N=385)		2015 (N=419)		2016 (N=519)		2017 (N=457)		2014-2017 (N=1780)	
	HD (N=211)	Non-HD (N=174)	HD (N=251)	Non-HD (N=168)	HD (N=321)	Non-HD (N=198)	HD (N=278)	Non-HD (N=179)	HD (N=1061)	Non-HD (N=719)
Age										
Mean±SD	53.4±17.5	68.0±17.0	52.9±15.9	65.3±16.8	53.0±15.3	64.6±16.2	51.5±16.3	62.2±18.4	52.7±16.2	65.0±17.2
Median (Q1-Q3)	54 (39.5-65)	68.5 (58.3-79.8)	54 (40-66)	66 (55-78.3)	54 (40-65)	67 (53-76)	51 (37-64)	63 (52-76.5)	54 (39-65)	66 (55-78)
Range (Min-Max)	15-103	5-102	19-90	10-107	17-88	16-99	12-95	16-98	12-103	5-107
≤49	82 (38.9)	19 (10.9)	102 (40.6)	28 (16.6)	120 (37.4)	32 (16.2)	128 (46.1)	38 (21.2)	432 (40.7)	117 (16.3)
50-59	53 (25.1)	28 (16.1)	58 (23.2)	28 (16.7)	88 (27.4)	34 (17.1)	51 (18.3)	34 (19.1)	250 (23.6)	124 (17.2)
60-69	43 (20.4)	44 (25.3)	52 (20.7)	43 (25.6)	67 (20.9)	52 (26.3)	55 (19.8)	50 (27.9)	217 (20.5)	189 (26.3)
≥70	33 (15.6)	83 (47.7)	39 (15.5)	69 (41.1)	46 (14.3)	80 (40.4)	44 (15.8)	57 (31.8)	162 (15.2)	289 (40.2)
Gender										
Male	108 (51.2)	60 (34.5)	110 (43.8)	64 (38.1)	151 (47.0)	76 (38.4)	137 (49.3)	77 (43.0)	506 (47.7)	277 (38.5)
Female	103 (48.8)	114 (65.5)	141 (56.2)	104 (61.9)	170 (53.0)	122 (61.6)	141 (50.7)	102 (57.0)	555 (52.3)	442 (61.5)
Healthcare insurance										
0(a)	11 (5.2)	13 (7.5)	10 (4.0)	21 (12.5)	14 (4.4)	17 (8.6)	9 (3.2)	12 (6.7)	44 (4.2)	63 (8.8)
80	95 (45.0)	44 (25.3)	75 (29.9)	46 (27.3)	114 (35.5)	72 (36.4)	76 (27.3)	55 (30.7)	360 (33.9)	217 (30.2)
95	-	-	14 (5.6)	8 (4.8)	17 (5.3)	8 (4.0)	15 (5.4)	7 (3.9)	46 (4.3)	23 (3.2)
100(b)	105 (49.8)	117 (67.2)	152 (60.5)	93 (55.4)	176 (54.8)	101 (51.0)	178 (64.1)	105 (58.7)	611 (57.6)	416 (57.8)
Region										
Rural	171 (81.0)	110 (63.2)	203 (80.9)	129 (76.8)	241 (75.1)	152 (76.8)	225 (80.9)	136 (76.0)	840 (79.2)	527 (73.3)
Urban	40 (19.0)	64 (36.8)	48 (19.1)	39 (23.2)	80 (24.9)	46 (23.2)	53 (19.1)	43 (24.0)	221 (20.8)	192 (26.7)
OPD	**2014 (N=549)**		**2015 (N=600)**		**2016 (N=738)**		**2017 (N=762)**		**2014-2017 (N=2649)**	
	HD (N=326)	**Non-HD (N=223)**	**HD (N=344)**	**Non-HD (N=256)**	**HD (N=476)**	**Non-HD (N=262)**	**HD (N=494)**	**Non-HD (N=268)**	**HD (N=1640)**	**Non-HD (N=1009)**
Age										
Mean±SD	49.9±14.5	66.9±14.5	50.1±14.5	66.0±15.2	50.8±14.6	63.5±16.2	49.3±14.5	61.9±16.4	50.0±14.5	64.5±15.8
Median (Q1-Q3)	51.0 (39-60)	68.0 (58-78)	50.5 (39-60.3)	67.0 (56-78)	51.0 (40-62)	64.5 (53-75)	49.0 (37-59)	64.0 (51.8-74)	50.0 (39-60.3)	66.0 (54-76)
Range (Min-Max)	15-89	19-99	19-90	19-95	17-89	16-118	17-95	16-98	15-95	16-118
≤49	155 (47.5)	24 (10.8)	164 (47.7)	34 (13.3)	218 (45.8)	48 (18.3)	253 (51.2)	59 (22.0)	790 (48.2)	165 (16.4)
50-59	85 (26.1)	38 (17.0)	91 (26.5)	47 (18.4)	124 (26.1)	44 (16.8)	119 (24.1)	49 (18.3)	419 (25.5)	178 (17.6)
60-69	62 (19.0)	61 (27.4)	59 (17.2)	65 (25.3)	82 (17.2)	76 (29.0)	78 (15.8)	72 (26.9)	281 (17.2)	274 (27.1)
≥70	24 (7.4)	100 (44.8)	30 (8.6)	110 (43.0)	52 (10.9)	94 (35.9)	44 (8.9)	88 (32.8)	150 (9.1)	392 (38.9)
Gender										
Male	179 (54.9)	70 (31.4)	169 (49.1)	81 (31.6)	208 (43.7)	96 (36.6)	245 (49.6)	95 (35.4)	801 (48.8)	342 (33.9)
Female	147 (45.1)	153 (68.6)	175 (50.9)	175 (68.4)	268 (56.3)	166 (63.4)	249 (50.4)	173 (64.6)	839 (51.2)	667 (66.1)
Healthcare insurance										
0(a)	4 (1.2)	1 (0.4)	7 (2.0)	3 (1.2)	8 (1.7)	1 (0.4)	10 (2.0)	2 (0.7)	29 (1.8)	7 (0.7)
80	214 (65.6)	46 (20.7)	76 (22.1)	93 (36.3)	119 (25.0)	114 (43.5)	89 (18.0)	99 (36.9)	498 (30.4)	352 (34.9)
95	0 (0.0)	0 (0.0)	22 (6.4)	10 (3.9)	28 (5.9)	12 (4.6)	32 (6.5)	13 (4.9)	82 (5.0)	35 (3.4)
100(b)	108 (33.2)	176 (78.9)	239 (69.5)	150 (58.6)	321 (67.4)	135 (51.5)	363 (73.5)	154 (57.5)	1031 (62.8)	615 (61.0)
Region										
Rural	261 (80.1)	123 (55.2)	273 (79.4)	159 (62.1)	363 (76.3)	185 (70.6)	393 (79.6)	191 (71.3)	1290 (78.7)	658 (65.2)
Urban	65 (19.9)	100 (44.8)	71 (20.6)	97 (37.9)	113 (23.7)	77 (29.4)	101 (20.4)	77 (28.7)	350 (21.3)	351 (34.8)

[Table/Fig-2]: The socio-demographic characteristics of chronic kidney disease patients treated at the Kien Giang General Hospital from 2014 to 2017 {n (%)}.
Abbreviations: OPD: Outpatient Department; IPD: Inpatient Department; SD: standard deviation; Q1:the first quartile; Q3: the third quartile; HD: Haemodialysis; Non-HD: Non-haemodialysis
Notes (a): Out-of-pocket; (b): No payment

costs for treating CKD individuals. There was a statistically significant difference between age and the direct medical cost of treating CKD patients with dialysis at the IPD and the OPD ($P<0.05$). Living in a rural area or a megacity also affected the direct medical cost of treating CKD patients without dialysis at the OPD ($P<0.001$).

DISCUSSION

CKD remains a major cause of morbidity in the developing world [7]. In the current study, records for a total of 4,429 Vietnamese CKD patients at KGGH were screened for the four-year period under review (2014–2017). Previous studies have revealed that the mean age of CKD patients on HD in developing countries (32–42 years) was lower than those in developed countries (60–63 years) [25,26]. Our study calculated a mean age of HD patients treated in the OPD of 50.0 ± 14.5, which is higher than that reported in one Indian study (49.72 ± 13.2) [28], but lower than that reported in another Indian study (55.7 ± 10.1) [19]. An earlier progression to renal failure may be due to delays in detecting renal disease, late medical referrals, and failures to introduce preventive measures [27]. The present study indicates that the median age of CKD patients without HD was younger compared to those in Italy [17] (66.0 and 74.5, respectively). The mean age of CKD patients without HD who were treated at either the OPD or the IPD was approximately 65-year-old. This value is higher than that reported for Australia of roughly 56-year-old [28]. In the present study, the proportion of female CKD patients without HD (64.2%) is higher than that of Australia (54.3%) and the United States (57.3%), whereas male CKD patients with HD constituted around 49%, which is lower than that of India [27]. The proportion of patients coming from rural areas was three times as high as those coming from urban areas; the opposite was true of those in a study of Ozieh MN et al., United States [28].

Inpatient Department			Hospitalization	Operation	Labor test/ Ima Methods	Medicines	Others	Total burden	Total per patient
2014	HD	Provider	12,289.1	37,553.4	18,720.3	36,851.1	31,402.4	136,816.3	648.4 (573.0-726.8)
		Payer	10,632.2	32,196.3	15,924.1	31,754.8	27,766.7	118,274.1	560.5 (495.0-628.9)
		Patient	1,656.9	5,357.1	2,796.2	5,096.3	3,635.7	18,542.2	87.9 (68.0-109.1)
	Non-HD	Provider	4,020.1	1,016.4	8,625.9	9,222.2	10,175.8	33,060.4	190.0 (159.9-223.2)
		Payer	3,596.7	832.8	7,283.8	8,086.2	8,860.5	28,660.0	164.7 (136.5-195.4)
		Patient	423.4	183.6	1,342.1	1,136.0	1,315.3	4,400.4	25.3 (17.5-34.3)
2015	HD	Provider	15,368.9	50,894.4	21,037.8	42,433.6	35,011.3	164,746.0	656.4 (571.8-750.6)
		Payer	14,100.6	46,358.5	18,728.5	38,660.4	32,598.3	150,446.3	599.4 (518.0-692.7)
		Patient	1,268.3	4,535.9	2,309.3	3,773.2	2,413.0	14,299.7	57.0 (42.5-74.3)
	Non-HD	Provider	3,863.8	1,054.4	8,970.0	7,954.2	10,227.5	32,069.9	190.9 (157.3-228.2)
		Payer	3,322.3	862.8	7,391.5	6,649.1	8,472.5	26,698.2	158.9 (129.1-191.5)
		Patient	541.5	191.6	1,578.5	1,305.1	1,755.0	5,371.7	32.0 (19.4-48.2)
2016	HD	Provider	22,924.7	67,659.8	22,636.3	37,755.3	26,715.7	177,691.8	553.6 (496.4-612.4)
		Payer	20,779.3	60,285.9	19,481.9	33,791.1	23,207.2	157,545.4	490.8 (435.8-548.6)
		Patient	2,145.4	7,373.9	3,154.4	3,964.2	3,508.5	20,146.4	62.8 (50.2-76.5)
	Non-HD	Provider	7,249.8	2,768.9	9,949.3	10,221.8	9,333.3	39,523.1	199.6 (173.1-228.6)
		Payer	6,361.3	2,646.6	8,580.1	8,784.0	8,133.7	34,505.7	174.3 (148.7-202.5)
		Patient	888.5	122.3	1,369.2	1,437.8	1,199.6	5,017.4	25.3 (19.0-32.6)
2017	HD	Provider	35,856.0	63,058.5	16,816.5	31,746.0	21,941.0	169,418.0	609.4 (529.0-697.6)
		Payer	33,684.2	58,662.6	15,416.3	29,372.3	20,592.1	157,727.5	567.3 (487.8-654.5)
		Patient	2,171.8	4,395.9	1,400.2	2,373.7	1,348.9	11,690.5	42.1 (33.0-52.0)
	Non-HD	Provider	10,189.9	4,266.4	7,055.9	10,014.1	8,914.6	40,440.9	225.9 (189.6-267.4)
		Payer	9,317.7	4,013.6	6,206.8	8,955.0	8,422.4	36,915.5	206.2 (171.2-247.1)
		Patient	872.2	252.8	849.1	1,059.1	492.2	3,525.4	19.7 (14.4-25.5)
2014-2017	HD	Provider	86,438.7	219,166.1	79,210.9	148,786.0	115,070.4	648,672.1	611.4 (574.6-649.8)
		Payer	79,196.3	197,503.3	69,550.8	133,578.6	104,164.3	583,993.3	550.4 (514.8-587.0)
		Patient	7,242.4	21,662.8	9,660.1	15,207.4	10,906.1	64,678.8	61.0 (53.5-69.0)
	Non-HD	Provider	25,323.6	9,106.1	34,601.1	37,412.3	38,651.2	145,094.3	201.8 (184.6-220.4)
		Payer	22,598.0	8,355.8	29,462.2	32,474.3	33,889.1	126,779.4	176.3 (160.3-193.1)
		Patient	2,725.6	750.3	5,138.9	4,938.0	4,762.1s	18,314.9	25.5 (21.1-30.4)

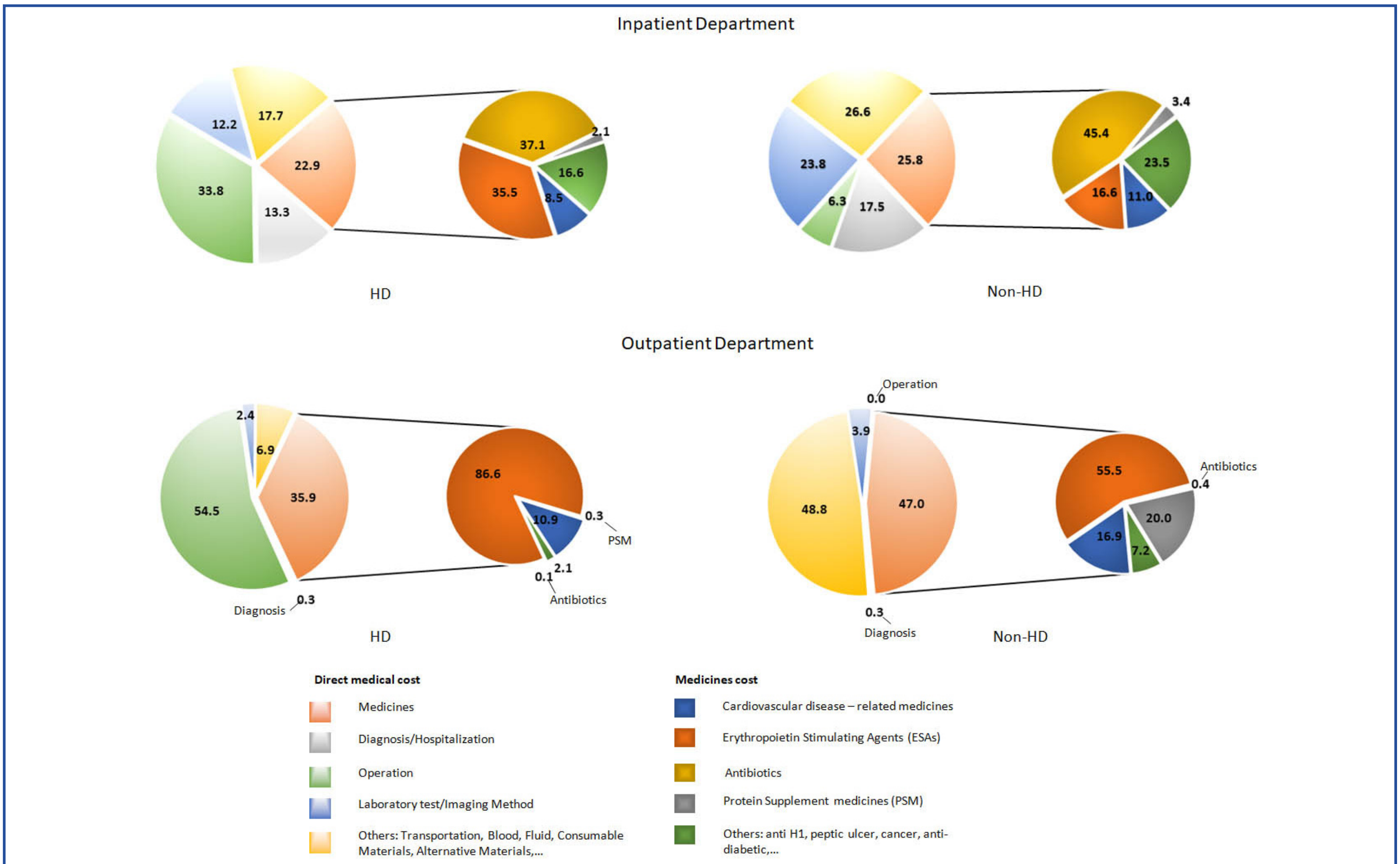
[Table/Fig-3]: The economic burden and direct medical cost by cost component per chronic kidney disease patient treated at the inpatient department, with and without haemodialysis {2018, USD, Arithmetic mean (bootstrap 95% CI)}
Abbreviation: HD: Haemodialysis; Non-HD: Non-Haemodialysis; Labor tests: Laboratory tests; Ima Methods: Imaging Methods
Note: Others: Transportation, Blood, Fluid, Consumable Materials, Alternative Materials,…

Regarding direct medical costs, our results show an increasing trend in total medical cost at the OPD, in contrast to a downward trend in total medical cost at the IPD. The annual cost for a CKD patient with HD was estimated to be US $2,401, which is two times higher than the corresponding figure (US $1315) from a study by Kothandan et al in Indian [30], but approximately the same as a report from India [28]. The annual cost per CKD patient with non-HD is estimated to be US $956.6, dramatically higher than the US

Outpatient Department			Diagnosis	Operation	Labor test/Ima Methods	Medicines	Others	Total burden	Total per patient
2014	HD	Provider	8,744.7	268,747.8	15,250.1	245,634.0	53,878.7	592,255.3	1816.8 (1687.6-1946.7)
		Payer	7,422.5	228,455.1	12,950.8	209,993.7	45,371.2	504,193.3	1546.7 (1439.4-1653.7)
		Patient	1,322.2	40,292.7	2,299.3	35,640.3	8,507.5	88,062.0	270.1 (242.2-299.7)
	Non-HD	Provider	1,593.2	-	8,362.3	94,724.2	67,550.1	172,193.8	772.4 (637.6-918.8)
		Payer	1,500.4	-	7,923.9	89,340.6	61,014.1	159,779.0	716.6 (594.5-848.0)
		Patient	92.8	-	438.4	5,383.6	6,536.0	12,450.8	55.8 (34.8-79.1)
2015	HD	Provider	707.9	426,690.2	20,905.4	347,410.1	55,676.1	851,389.7	2475.0 (2312.6-2637.3)
		Payer	668.9	409,211.8	20,025.2	332,829.1	53,035.5	815,770.5	2371.4 (2212.7-2533.6)
		Patient	39.0	17,478.4	880.2	14,581.0	2,640.6	35,619.2	103.5 (91.2-116.8)
	Non-HD	Provider	345.4	-	10,640.4	97,258.2	107,924.2	216,168.2	844.4 (685.6-1010.6)
		Payer	322.7	-	9,955.9	91,675.2	103,921.4	205,875.2	804.2 (650.2-966.5)
		Patient	22.7	-	684.5	5,583.0	4,002.8	10,293.0	40.2 (28.8-53.1)
2016	HD	Provider	1,448.8	795,148.9	32,452.0	456,445.7	84,586.1	1,370,081.5	2878.3 (2707.5-3049.3)
		Payer	1,355.4	758,796.7	31,000.5	437,694.7	80,884.9	1,309,732.2	2751.5 (2582.7-2922.4)
		Patient	93.4	36,352.2	1,451.5	18,751.0	3,701.2	60,349.3	126.8 (107.7-146.7)
	Non-HD	Provider	440.8	-	10,251.3	138,277.1	175,804.6	324,773.8	1244.9 (1017.6-1482.4)
		Payer	403.8	-	9,374.2	129,176.6	166,936.0	305,890.6	1172.6 (955.3-1404.6)
		Patient	37.0	-	877.1	9,100.5	8,868.6	18,883.2	72.4 (51.5-95.8)

2017	HD	Provider	1,962.9	653,690.6	25,528.0	366,036.3	76,860.8	1,124,078.6	2275.4 (2144.3-2406.6)
		Payer	1,869.4	629,672.5	24,390.6	353,486.7	73,991.3	1,083,410.5	2193.1 (2062.6-2323.6)
		Patient	93.5	24,018.1	1,137.4	12,549.6	2,869.5	40,668.1	82.3 (67.8-97.9)
	Non-HD	Provider	656.9	-	8,402.9	121,857.5	117,755.6	248,672.9	935.1 (774.5-1112.6)
		Payer	610.3	-	7,775.1	114,083.0	112,198.5	234,666.9	882.3 (724.6-1054.7)
		Patient	46.6	-	627.8	7,774.5	5,557.1	14,006.0	52.8 (38.0-70.0)
2014-2017	HD	Provider	12,864.3	2,144,277.5	94,135.5	1,415,526.1	271,001.7	3,937,805.1	2401.1 (2324.6-2476.0)
		Payer	11,316.2	2,026,136.1	88,367.1	1,334,004.2	253,282.9	3,713,106.5	2264.1 (2186.8-2337.6)
		Patient	1,548.1	118,141.4	5,768.4	81,521.9	17,718.8	224,698.6	137.0 (126.6-147.7)
	Non-HD	Provider	3,036.3	-	37,656.9	452,117.0	469,034.5	961,844.7	956.6 (862.6-1050.9)
		Payer	2,837.2	-	35,029.1	424,275.4	444,070.0	906,211.7	901.2 (810.1-993.9)
		Patient	199.1	-	2,627.8	27,841.6	24,964.5	55,632.0	55.4 (46.4-64.9)

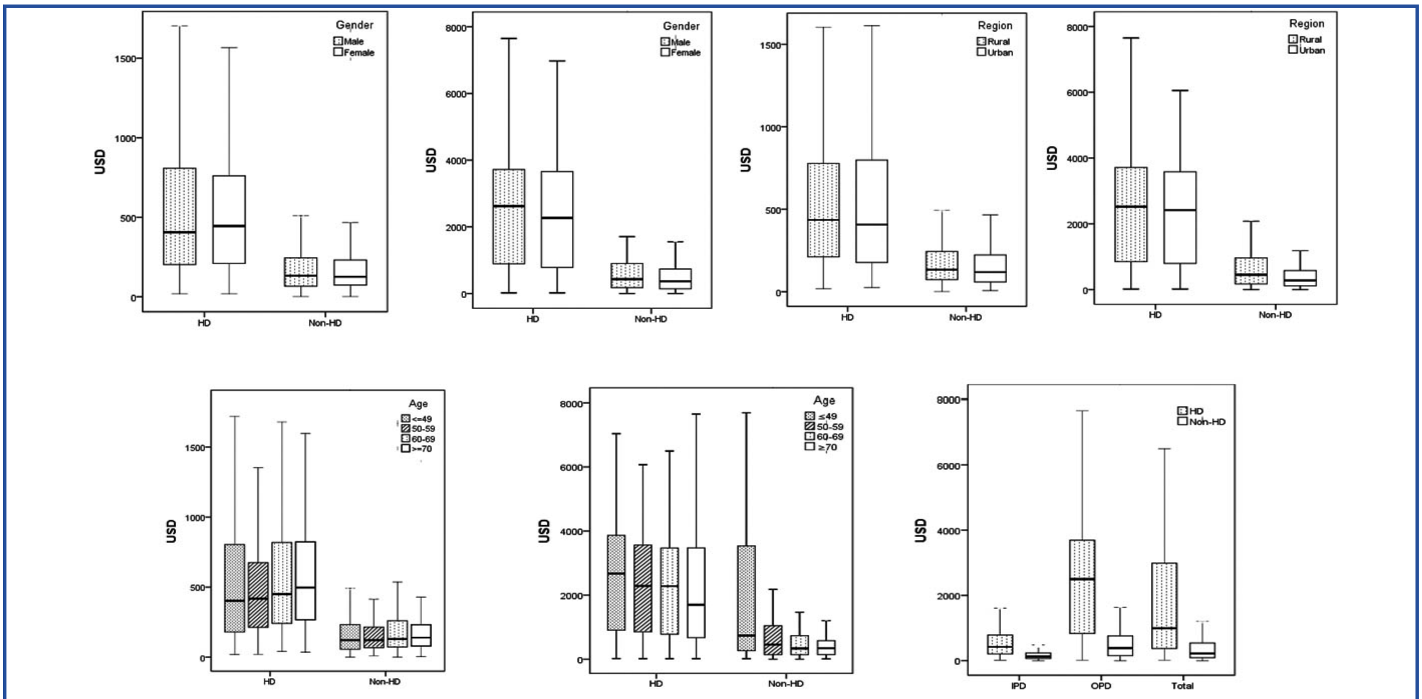
[Table/Fig-4]: The economic burden and direct medical cost by cost component per chronic kidney disease patient treated at the outpatient department, with and without haemodialysis {2018, USD, Arithmetic mean (bootstrap 95% CI)}.
Abbreviation: HD: Haemodialysis; Non-HD: Non-Haemodialysis; Labor tests: Laboratory tests; Ima Methods: Imaging Methods
Note: Others: Transportation, Blood, Fluid, Consumable Materials, Alternative Materials,…



[Table/Fig-5]: The proportion of direct medical costs by cost component and by cost of medicines (%).
Abbreviation: IPD: Inpatient Department; OPD: Outpatient Department; HD: Haemodialysis; Non-HD: Non-Haemodialysis

$272 estimate reported in another Indian study [29]. In the present study, CKD patients without HD in the ≤ 49-year-old age group had the highest direct medical cost of US $1,838; the lowest cost belonged to the ≥ 70-year-old age group. The research of Wyld M et al., carried out in Australia indicated the opposite result; the highest direct medical cost of treating CKD without HD was in the older group, whilst the youngest group had the lowest CKD treatment cost [30]. The cost of treating CKD without dialysis is twofold higher for rural residents compared to urban dwellers (US $1,176.5 and US $544.4, respectively). Ozieh MN et al., depicted a different result, in that city dwellers had a significantly higher direct medical expenditure [28]. The cost of treatment was also found to be higher in patients receiving reimbursement from insurance, which is consistent with research at a tertiary hospital in India [19]. The reason that higher costs are associated with insurance could be due to insured patients demanding the best possible treatment. For CKD stages 2 to 4, hospitalisation costs accounted for 47% and 71% of the total direct medical costs in the US [31] and in Germany [31], respectively. In our study, only 17.5% of the total direct medical cost was due to hospitalisation.

In our study, the cost components that imposed the most noticeable burden on direct medical costs were medicines and operations. Medication proportions contributing to the direct medical cost ranged from 23% to 47% for CKD treatment with and without HD at IPD as well as OPD. In comparison, the share of drug cost in the total direct cost in Italy was only 30% [17]. The costs of operations, mostly comprising HD service, made up over half of the total direct medical cost and is likely one of the factors leading to the higher costs for CKD patients with HD. In terms of medicines, the most expensive treatment, accounting for over 85%, was the injection of ESAs. The study by Ahlawat R et al., at the tertiary hospital in India also revealed ESAs to rank first in costly medications with a mean annual cost of treatment of US $1,397 [19]. ESAs are mostly used due to anaemia, which is one of the most prevalent complications of CKD patients.



[Table/Fig-6]: Box plots showing the direct medical cost attributed to chronic kidney disease by characteristic {2018, USD, Arithmetic mean (bootstrap 95% CI)}.

Characteristic	IPD				OPD			
	HD	P	Non-HD	P	HD	P	Non-HD	P
Age								
≤49	575.0 (520.5-632.5)	*	184.7 (148.9-229.3)	0.094	2543.0 (2428.1-2654.9)	*	1837.7 (1505.6-2175.7)	**
50-59	534.6 (480.3-595.1)		173.2 (146.4-202.2)		2296.7 (2148.8-2447.9)		1275.3 (1011.9-1543.6)	
60-69	694.5 (603.0-792.2)		236.7 (197.5-279.6)		2311.9 (2126.1-2493.3)		804.2 (662.4-952.5)	
≥70	715.6 (599.8-850.4)		198.1 (174.1-225.9)		2112.2 (1854.2-2375.6)		547.6 (459.8-646.8)	
Healthcare insurance (%)								
0	391.2 (317.1-477.5)	*	137.4 (107.5-175.3)	0.139	820.8 (366.8-1360.9)	**	85.4 (24.4-208.8)	**
80	579.2 (527.9-636.8)		214.7 (182.1-249.5)		1866.4 (1753.7-1982.6)		735.6 (621.7-857.9)	
95	597.7 (406.1-832.4)		231.2 (140.7-334.3)		2315.8 (1967.9-2677.0)		1783.3 (1160.1-2454.5)	
100	647.2 (594.8-703.0)		203.1 (181.4-227.6)		2710.6 (2610.8-2808.3)		1046.0 (915.3-1179.6)	
Gender								
Male	608.5 (555.2-667.8)	0.888	204.6 (177.7-233.8)	0.803	2469.5 (2352.9-2581.2)	0.094	1064.7 (898.9-1244.4)	0.132
Fem-ale	614.0 (565.4-667.6)		200.0 (178.7-224.1)		2335.8 (2224.8-2443.1)		901.2 (794.6-1012.9)	
Region								
Rural	605.8 (566.1-649.1)	0.626	209.8 (189.4-232.7)	0.112	2422.9 (2331.8-2508.6)	0.300	1176.5 (1046.7-1310.0)	**
Urb-an	632.4 (541.8-728.9)		179.9 (153.1-208.7)		2320.8 (2154.9-2486.8)		544.4 (454.6-644.1)	

[Table/Fig-7]: The pattern of direct medical costs involved in chronic kidney disease treatment {2018, USD, Arithmetic mean (bootstrap 95% CI)}.
Abbreviation: IPD: Inpatient Department; OPD: Outpatient Department; HD: Haemodialyis; Non-HD: Non-Haemodialysis; *: <0.05; **: <0.001

This study was not without its limitations. First, there was an absence of laboratory data (eGFR and albumin creatinine ratios) for identifying and staging CKD patients. Consequently, the study was unable to characterize the patients' CKD severity. Second, the study captured all costs incurred by patients with CKD. This may include costs attributable to other comorbidities as well as complications that are more prevalent among those with CKD, such as diabetes and hypertension. Third, because the CKD patient data was obtained using medical records, the direct non-medical and indirect costs were not included. The estimated economic burden is based only on direct medical costs. Finally, the study analysed patients who were treated at a general hospital. Therefore, these findings cannot be generalised for patients treated in private hospitals or in the nation as a whole.

CONCLUSION

This study found that the most expensive CKD treatment-related expenditures were operations and medications, particularly HD services and ESAs. Thus, a decrease in these two elements would reduce the economic burden caused by CKD treatment. This could be accomplished by increasing the number of dialysis facilities in public health centres as well as by calling for a full government subsidy for ESAs.

This study indicates that a considerable proportion of CKD patients face economic difficulties due to their disease. These findings should help policy makers understand the magnitude of the economic burden of CKD in Vietnam. The importance of dedicating resources to better evaluate the true cost of the disease and to provide interventions that effectively reduce the prevalence and progression of CKD and its related complications cannot be overstated. These findings have important policy implications for patients with early stages of CKD, as potential cost saving efforts may focus on reducing the economic burden of CKD treatment. This information could also be useful for evaluating the economic costs and benefits of various CKD interventions, including screening strategies.

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Conflicts of interest

No potential conflicts (financial, professional, or personal) is relevant to the manuscript.

Authors' contributions

TQV participated in study design, data collection, data analysis, and drafted the manuscript. PTLN participated in its data analysis and drafted the manuscript. HNH participated in its design and data collection. All authors read and approved the final manuscript.

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