THE ASSESSMENT OF ANNUAL DIRECT HEALTHCARE COSTS AMONG HEMODIALYSIS PATIENTS IN NORTHERN CYPRUS

HEMODİYALİZ HASTALARININ SAĞLIK BAKIM HARCAMALARININ DEĞERLENDİRİLMESİ: KUZEY KIBRIS ÖRNEĞİ

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Abstract: ***End-stage renal disease (ESRD) is a chronic condition that requires long-term management and exerts very high disease and cost burden on the governments. This study aimed to assess the direct costs of haemodialysis (HD) treatment, a type of renal replacement therapy, that has an important place in the management of ESRD. The study employed a retrospective approach using a cohort of HD patients and the costs of HD and catheter-related infection treatment were evaluated between the years of 2016 and 2020. HD treatment costs, HD laboratory and imaging costs, and catheter infection costs were determined in dollars ($). Average treatment costs and annual control costs for HD patients were determined as: $10391.14 in 2016; $8664.62 in 2017; $6140.65 in 2018; $4838.29 in 2019; $4081.89 in 2020. A statistical difference was found between the cost of outpatient and inpatient care of catheter-related infections and the year of diagnosis of ESRD in 2016 and 2018 respectively It is important to assess and determine the cost burden and related discrepancies in the cost coverage and resource management in the chronic disease care. This study emphasized the importance of developing targeted and updated policies and legislations for managing the cost of chronic disease care.***

Keywords: ***End-stage Renal Disease, Haemodialysis, Cost-burden, Catheter-related Infections.***

Öz: ***Son dönem böbrek yetmezliği (SDBY), uzun süreli tedavi gerektiren, toplum üzerinde yüksek hastalık ve maliyet yükü oluşturan kronik bir hastalıktır. Bu çalışmada SDBY yönetiminde önemli bir yere sahip olan bir renal replasman tedavisi türü hemodiyaliz (HD) tedavisinin doğrudan maliyetlerinin değerlendirilmesi amaçlanmıştır. Çalışmada HD tedavi maliyeti ve kateter ilişkili enfeksiyon maliyeti retrospektif bir yaklaşımla 2016-2020 yılları arasında değerlendirilmiştir. HD tedavi maliyetleri, HD laboratuvar ve görüntüleme maliyetleri, kateter enfeksiyonu maliyetleri dolar ($) cinsinden belirlendi. HD hastaları için ortalama tedavi maliyetleri ve yıllık kontrol maliyetleri 2016 yılında 10391,14$; 2017 yılında 8664,62$; 2018 yılında 6140,65$; 2019 yılında 4838,29$; 2020'de 4081,89$ olarak hesaplanmıştır. Kateter ilişkili enfeksiyonların ayaktan hasta bakım***

maliyeti, SDBY tanı yılı 2016 ve öncesi olan HD hastalarında istatistiksel fark yaratmıştır. SDBY tanı yılı 2018 ve öncesi olan HD hastalarında ise yatan hasta bakım maliyeti istatistiksel olarak fark oluşturmuştur. Bu çalışma kronik hastalıklara yönelik maliyet yükü ve kaynak yönetimi belirlenmesinin ve değerlendirilmesinin önemini göstermiş olup, kronik hastalıkların yönetim maliyetleri için hedefli politika ve yönetmeliklerin önemini vurgulamıştır.

Anahtar Kelimeler: ***Son Dönem Böbrek Yetmezliği, Hemodiyaliz, Maliyet Yükü, Kateter İlişkili Enfeksiyonlar.***

INTRODUCTION

Chronic Kidney Diseases (CKD), a crucial global clinical and public health issue, has rising incidence, prevalence, high expenditure, poorer quality life, and poor health outcomes (Luyckx et al., 2018; Francis et al., 2024). CKD often leads to impaired kidney function; resulting in chronic renal failure followed by end-stage renal failure. End-stage renal disease (ESRD) causes very important economic, social and medical problems. CKD is grouped into 5 stages of which Stage 1 to 3 progress majorly without symptoms, followed up by CKD Stage 4, where the function of kidneys is reduced to a level that requires renal replacement therapy. The final stage, Stage 5, is defined as ESRD,, at which toxins, fluids and electrolytes accumulate in the body because kidneys fail to function (Inker et al., 2014). ESRD is a serious health problem that requires renal replacement therapy (Akbari et al., 2015). The effect of ESRD on morbidity and mortality and its dependence on renal replacement therapy also negatively affect quality of life (Görgen et al., 2018). The epidemiology of ESRD on a global scale is affected by genetics, lifestyle, cultural structure, socio-economic and environmental factors. ESRD leads to significant economic and social burden on the populations (Thurlow et al., 2021; Kassa et al., 2020; Jha et al., 2023; Trivedi & Sodani, 2024).

The rate of people having renal replacement therapy (RRT), including haemodialysis (HD) is increasing in the World, as a result of the improving economy in the globe. For example, those having HD are increasing by about 7% per year (Kim et al., 2018). The cost of care provided to ESRD patients is therefore exerting an increasing burden on the population (Takemoto & Naganuma, 2019). HD and peritoneal dialysis (PD) are the types of renal replacement therapy. HD is performed by using an external machine that enables the circulation of blood through a membrane separating the body wastes from the blood; where in PD, a balanced electrolyte solution including an osmotically active agent is given into the abdomen of the patient using a small catheter inserted into the abdomen of the patient (Makhija et al., 2018). The ideal treatment for ESRD is transplantation (Tx); however, organ donation is very limited in most populations. Evidence suggests that approximately one year after Tx surgery, the patients experience better quality of life and a decrease in health care expenditure. Tx is also advantageous in terms of prolonging life of the Tx patients (Tingle et al., 2019; Vanholder et al., 2017).

Infections that occur during the treatment process of ESRD affect the patient negatively, resulting in a prolonged hospital stay and an increase in health costs (Lin et al., 2020; Lamarche et al., 2019). Catheter-related infections are more common in the ESRD patient group than in the normal population. Especially in ESRD patients, the risk of infection is higher. This is because CKD plays a role as a predisposing factor for infections; since CKD patients have suppressed immunity and use catheters that causes risk for infections (Sarnak & Jaber, 2000). Infection is one of the most common complications and is one of the main causes of mortality and morbidity in

patients with ESRD. It is among the leading causes of hospitalization. In particular, it can progress to sepsis in patients undergoing dialysis treatment. ESRD patients with immunosuppression are at risk for cancers and infections associated with immunodeficiency (Fisher et al., 2020; Hogan et al., 2017).

During dialysis treatment, central venous catheters (CVC) may cause complications in the patient. CVC-related complications that develop within the first 3 months after insertion of the catheter can be listed as bleeding, pneumothorax, thrombosis, and infection. CVC-associated infections are the most important complication and increase the length of stay in hospital, stay in intensive care unit, costs for treatment and mortality rates (Balikci et al., 2021; Ozmen et al., 2022). Infection risk in patients treated with HD are caused by immunodeficiency, disruption of the skin and mucous barrier, recurrent hospitalization, malnutrition and vascular interventions (Lamarche et al., 2019).

Lack of resources or inability to share risk adequacy of the healthcare infrastructure leads to poor quality healthcare provision. Allocating resources equally to the areas in most need, and identifying and correcting service gaps is very important in the policy development and implementation process of health systems (WHO 2015). In particular, more precise assessments of the economic benefits and cost changes associated with treatment programs provide better information to health policy-makers. Increasing prevalence and associated increasing cost of kidney disease care require an accurate understanding of the cost burdens of disease care to ensure effective, efficient and sustainable service delivery. It is firstly crucial to identify and improve gaps in patient care to inform the health needs of kidney patients. It is important to have an inclusive understanding of the healthcare systems and infrastructure of the health system (Bello et al., 2018).

There is lack of empirical studies that examine the health care costs and specifically the CKD treatment costs in Northern Cyprus. There are only the health statistics provided by the State Planning Organization, including the total health expenditures and their ratio to the state budget. For the year of 2019, the ratio of health expenditure to the state budget was %9.9, with about 11% in 2021 and about 9.8% in 2022 (State Planning Organization, 2023). Based on the international literature, it was reported that the annual global costs of hemodialysis range from $5000-$40,000 per patient (Bello *et. al.*, 2023). In the study conducted using data from 31 countries, including Turkey, the average annual cost of hemodialysis per patient was provided as $ 23,963 (Jha *et. al*., 2023).

There were limited studies in the literature that analysed the cost burden of HD patients; the present study was the first to evaluate the cost burden of HD patients treatment in Northern Cyprus. This study aimed to determine the annual treatment cost, control cost, and infection treatment cost of patients receiving HD treatment. The objectives of the study included: (i) an assessment of the cost burden of HD treatment; (ii) an assessment of the cost of catheter infections; and (iii) providing suggestions for improving the management of ESRD.

1. METHODOLOGY

The current quantitative study was designed as a multicentre, cohort study using a retrospective perspective. The data to be used in the study for the years from 2016 and 2020 were obtained from the files of the patients who were treated for ESRD in hospitals affiliated with the Ministry of Health of Northern Cyprus and from the hospital information system. The data used in the current study were released from the records on clinical, administrative, and financial data reported at the public hospitals of the Ministry of Health (Behlul & Ozdal, 2022).

Those who were diagnosed with ESRD in Northern Cyprus and were treated in hospitals in the HD unit affiliated with the Ministry of Health were included in the study. Visiting patients, patients living abroad, patients with acute renal failure, and soldiers were not included in the study as of 2020. The cost per person of each HD treatment will be calculated. This cost burden study will focus on the identification of per-patient direct medical costs. Indirect costs will be not included in the cost analysis.

In many studies where the cost of ESRD is calculated, the procedure/operation/treatment performed in the outpatient clinic/clinic, laboratory and radiology tests, drugs used and prescribed drugs in the hospital, complications occurring during or after the treatment/procedure/operation, and length of stay, the direct treatment costs variables used in the determination.

The HD treatment cost was calculated by taking the cost of each bicarbonate for each session. The Health Institutions Fee Schedule Regulation of TRNC was used to calculate the cost of the HD treatment costs, which includes each bicarbonate fee. Patients, on average, receive HD treatment three times in a week. The total cost of HD care per patient was calculated by including any inpatient and/or outpatient care received, plus the the costs of diagnostic tests carried out in biomedical laboratories and imaging.

The total catheter infection treatment costs included the cost of treatment provided as outpatient and inpatient care. When calculating the cost of treatment of catheter infections, costs of biochemical laboratory tests, imaging, medications used for infection management, and outpatient or inpatient treatment (hospital-bed care fees) were taken into account.

The Ethical approval for the methodology of the study was taken from the Ethics Committee of the European University of Lefke, with serial number of ÜEK/57/01/12/2021/02, 28.12.2020 and the Ethics Committee of Dr. Burhan Nalbantoglu State Hospital, with the serial number of 08/21, 25.02.2021.

1.1 Statistical Analysis

All costs were calculated for covering five-year period since 2016. HD treatment cost and HD treatment control cost were calculated over the average cost per patient between 2016 and 2020. The data were analysed by using the IBM Statistical Package for Social Sciences (SPSS) software version 28.0 (IBM Corp., Armonk, NY, USA) to determine the trends in the cost of renal replacement methods during

the study period. A significance value of $p < 0.05$ was accepted to determine statistically significant differences between the associations. Gender, the time of diagnosis, and the number of HD patients with catheter-related infections were studied using descriptive statistics. Treatment cost of patients with catheter infections, HD treatment cost, and HD treatment control costs were compared according to the time of diagnosis. The data did not meet the normal distribution conditions, based on Shapiro-Wilk and Kolmogorov-Smirnov based on the sample size (P<005 accepted as not being normally distributed. Therefore,the Mann-Whitney U test was used as non-parametric test when analysing the data.

HD treatment costs, HD laboratory and imaging costs, and catheter infection costs were determined in dollars ($) (1 USD=3.02 TL, inflation rate = 8.53% in 2016; 1 USD = 3.65 TL, inflation rate = 11.92% in 2017; 1 USD = 4,82, inflation rate = 20.30 in 2018; 1 USD = 5.68 TL, inflation rate = 11.84% in 2019; 1 USD= 7.01 TL, inflation rate = 14.60% in 2020; 1USD =8.87 TL, inflation rate = 36.08% in 2021) (TCMB, 2025).

2. RESULTS

The demographic characteristics of patients with HD, disease information and the costs from the perspective of the health system are included. The average age of females from 2017 to 2020 was 68.39±12.65 in 2016; 66.74±15.09 in 2017; 68.50±13.25 in 2018; 67.72±13.08 in 2018, 68.15±12.30 in 2019, and 65.75±13.82 in 2020. The information on the patients receiving HD between the years of 2016 and 2020 is given in Table 1. In all years the proportion of male patients receiving HD was higher compared to females 53.44% of 116 HD patients were male in 2016 and 65% of 263 patients were male in 2020. The proportion of the cases who were newly registered as HD patients and starting the HD treatment in the particular years from 2016 to 2020 ranged between 20.7% to 32.0%, with the lowest proportion in 2016 and the highest in 2018. The incidence of catheter infections between the years of 2016 and 2020 ranged from 15.5% to 38%, with the lowest rated in 2016 and the highest rates in 2020.

Table 1. Information on HD Treatment Receiving Patients from ESRD Patients between 2016-2020

	Years				
Variables	**2016**	**2017**	**2018**	**2019**	**2020**
	n (%)	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Gender					
Female	54 (46.55)	58 (41.13)	79 (39.2)	92 (35.8)	92 (35.0)
Male	62 (53.44)	83 (58.86)	118 (60.8)	165 (64.2)	171 (65.0)
Total	116 (100)	141(100)	197 (100)	257 (100)	263 (100)
The cases starting HD in the particular year					
Newly registered HD Patients	24 (20.7)	30 (21.3)	62 (32.0)	63 (24.5)	65 (24.7)
Previously registered HD	92 (79.3)	111 (78.7)	132 (68.0)	194 (75.5)	198 (75.3)

patients

Total	116 (100)	141(100)	194 (100)	257 (100)	263 (100)
Catheter infection					
Infected patient	18 (15.5)	35 (24.8)	46 (23.7)	64 (24.9)	100 (38.0)
None infected patient	98 (84.5)	106 (75.2)	148 (76.3)	193 (75.1)	163 (62.0)
Total	116 (100)	141 (100)	194 (100)	257 (100)	263 (100)

The annual average HD healthcare costs per HD patients towards HD treatment, control HD costs and catheter infections costs between the years of 2016 and 2020 are presented in Table 2. The annual average HD treatment cost of a HD patient was determined as being $10391.14 (9796.4-10970.4) and the annual average HD control cost was calculated $1290.07(1231.6-1341.6) in 2016. 18 HD patients were identified as having an infection at their catheter. The average cost of treatment provided as inpatient in patients receiving care for treating catheter infection was determined as $634.97(325.0-977.7), and the average cost of outpatient treatment was determined $162.43(61.8-296.3). In 2017, the annual average cost of treatment per patient was calculated as $8664.62(8205.5-9060.4), and the annual average cost of control per patient was $1057.06(1009.3-1099.9). In the same year, the average cost of treatment provided for 35 outpatients receiving catheter infection care was identified as $107.69(69.2-161.2), and the inpatient treatment cost was $391.49(179.6-642.0). In 2018, the annual average cost of treatment and control per patient for 197 HD patients was calculated as $6140.65(5771.7-6556.6), and $760.61(726.9-793.1) respectively. For 46 patients with catheter infection, the average cost of outpatient and inpatient treatment was determined as $94.43(57.7-135.5) and $227.91(138.1-345.7) respectively. In 2019, the annual average cost of treatment per patient and the average annual control cost per patient were determined $4838.29(4581.0-5097.4) and $620.74(594.1-645.4). In addition, catheter infection was identified in 64 patients receiving HD. The average outpatient and inpatient treatment costs of the patients were determined as $90.39(63.4-125.2), and $258.36(163.3-373.6) respectively. In 2020, the average annual cost of HD treatment per patient was $4080.89 and the HD control cost was $514.84. The inpatient catheter infection costs per person in the same year was $153.59 and it was $87.35 for outpatient care of catheter infections.

Table 2. Healthcare Costs towards Haemodialysis Treatment, Control Costs of Haemodialysis and Cost of Catheter Infections between 2016 and 2020

Variables	Years				
	2016	2017	2018	2019	2020
	Mean (Cl 95%)	Mean (Cl 95%)	Mean (Cl 95%)	Mean (Cl 95%)	Mean (Cl 95%)
HD treatment cost	$10391.14 (9796.4-10970.4)	$8664.62 (8205.5-9060.4)	$6140.65 (5771.7-6556.6)	$4838.29 (4581.0-5097.4)	$4081.89 (3881.6-4279.1)
Control cost of HD	$1290.07 (1231.6-1341.6)	$1057.06 (1009.3-1099.9)	$760.61 (726.9-793.1)	$620.74 (594.1-645.4)	$514.84 (495.7-535.8)
Cost of catheter infection					
Inpatient cost	$634.97 (325.0-977.7)	$391.49 (179.6-642.0)	$227.91 (138.1-345.7)	$258.36 (163.3-373.6)	$153.59 (111.1-204.1)
Outpatient cost	$162.43 (61.8-296.3)	$107.69 (69.2-161.2)	$94.43 (57.7-135.5)	$90.39 (63.4-125.2)	$87.35 (61.7-120.2)
Total cost	$797.49 (495.7-1128.6)	$499.18 (289.1-747.2)	$321.16 (227.7-431.0)	$349.58 (258.0-465.0)	$240.95 (186.5-301.9)

Comparative analysis of characteristics information and health costs of HD patients between 2016 and 2020 are presented in Table 3. When the treatment and annual control costs of haemodialysis patients were compared according to the time of diagnosis of HD; there was a statistically significant difference in the cost of HD treatment and the annual average control costs in all years from 2016 and 2020. Also, the HD Treatment cost was $27.98 in cases newly starting to HD in 2016 and $66.46 in cases who were previously under HD treatment ($p<0.05$). The control cost of HD was $35.21 in new starters of HD compared to $64.58 in cases who were already on HD ($p<0.05$).

Table 3. Comparative Analysis of the Time of Diagnosis of HD Patient and Cost Values ($) of 5 Different Time Periods (Between 2016 and 2020)

Characteristic	Year	Groups	Patient number	HD Treatment Cost	Control cost of HD
			n	**Mean Rank**	
The time of diagnosis of HD patient	2016	Cases on HD before 2016	92	$66.46	$64.58
		Newly registered HD Patients in 2016	24	$27.98	$35.21
		Total patients	116		
		p-value		***0.001***	***0.001***
		U		*371.50*	*545.00*
	2017	Cases on HD before 2017	111	$84.84	$83.37
		Newly registered HD Patients in 2017	30	$19.78	$25.22
		Total patients	141		
		p-value		**0.001**	**0.001**
		U		128.50	291.50
	2018	Cases on HD before 2018	132	$126.11	$125.48
		Newly registered HD Patients in 2018	62	$36.58	$37.94
		Total patients	194		
		p-value		***0.000***	***0.000***
		U		*7869.000*	*7785.000*
	2019	Cases on HD before 2019	194	$151.43	$149.87
		Newly registered HD Patients in 2019	63	$59.93	$64.72
		Total patients	257		
		p-value		***0.000***	***0.000***
		U		*10462.000*	*10160.000*
	2020	Cases on HD	198	$157.60	$156.41

	before 2020			
	Newly registered HD Patients in 2020	65	$54.03	$57.63
	Total patients	263		
	p-value		***0.000***	***0.000***
	U		11503.000	11269.000

U: Mann Whitney-U value; N: sample number

The inpatient and outpatient costs of catheter infection care in HD patients based on the time of registration on the HD between the years of 2016 and 2020 are presented in Table 4. The cost of catheter infection care was only significantly different in 2019 between the patients who newly started to HD treatment and who were already on the HD list. There was no significant difference in the other years between the patients who newly started HD care and those who were already on HD. The inpatient and outpatient catheter infection costs were also not significantly different between the new HD patients and patients who were already on HD, except in 2018. In 2018, the inpatient cost of catheter infections was significantly higher in patients who were on HD previously compared with the HD cases who started the HD in the specified year ($28.44 in cases newly receiving HD in 2018 compared to $20.87 in cases who were already on HD prior to 2018, p<0,05).

Table 4. Comparative Analysis of Characteristic Variables and Cost Values ($) of Different Time Periods

Characteristic variable	Groups	N	Inpatient	Outpatient	Total
			cost of catheter infection treatment		
			Mean Rank		
	Cases on HD prior to 2016	14	$8.29	$10.79	$8.50
	Newly registered HD Patients in 2016	4	$13.75	$5.00	$13.00
	Total patients	18			
	p value		0.066	***0.049***	0.137
	U		11.000	*10.000*	14.000
	Cases on HD prior to 2017	29	$17.33	$17.83	$17.21
	Newly registered HD Patients in 2017	6	$21.25	$18.83	$21.83
	Total patients	35			
	p value		0.344	0.825	0.314
The time of the diagnosis of HD	*U*		67.500	82.000	64.000
	Cases on HD prior to 2018	30	$20.87	$25.32	$22.27
	Newly registered	16	$28.44	$20.09	$25.81

HD Patients in 2018				
Total patients	46			
p value		***0.044***	0.204	0.393
U		*161.000*	294.000	203.000
Cases on HD prior to 2019	50	$33.79	$33.93	$35.52
Newly registered HD Patients in 2019	14	$27.89	$27.39	$21.71
Total patients	64			
p- value		0.239	0.243	***0.014***
U		414.500	421.500	*501.000*
Cases on HD prior to 2020	71	$50.82	$50.99	$52.08
Newly registered HD Patients in 2020	29	$49.72	$49.31	$46.64
Total Patients	100			
p- value		0.848	0.793	0.395
U		1052.000	1064.000	1141.000

U: Mann Whitney-U value; N: sample number

3. DISCUSSION

3.1 Main Findings

This study evaluated HD treatment cost, HD control cost, total cost of catheter infection of HD patients and outpatient and treatment of catheter infection provided as inpatient cost between 2016 and 2020 in Northern Cyprus. Each year, approximately 20% of kidney patients have just started RRT. The number of patients with catheter infections increased by approximately 20%, with also increase in number of ESRD patients between the years of 2016 and 2020. Average treatment costs and annual control costs for HD patients were determined as: $10391.14 in 2016; $8664.62 in 2017; $6140.65 in 2018; $4838.29 in 2019; and $4081.89 in 2020. It was determined that the average cost of inpatient treatment per patient due to catheter infection per year in HD patients was higher than the cost of outpatient treatment. When HD treatment cost and annual HD control cost were evaluated for each year between 2016 and 2020, it was determined that there was a statistically significant difference according to the year of diagnosis of HD. Outpatient treatment cost, inpatient treatment cost, and total catheter infection cost were calculated for catheter infection developing in HD patients included in the study for each year between 2016 and 2020. A statistical difference was also found between the cost of outpatient treatment of catheter-related infections and the year of diagnosis of HD in 2016. In 2018, a statistical difference was found between the cost of inpatient treatment of catheter-related infections and the year of diagnosis of HD.

3.2 Explanation of Study Findings and Comparison with Existing Literature

The types of RRT are using high-cost technology and they can complement each other according to the clinical condition of the patient. When the number of patients who have RRT and the cost findings evidence is examined, it can be observed that the economic structure, demographic structure, risk factors, genetic structure, and income level of the countries have an impact on the treatment costs. The number of individuals who lost their lives prematurely (before the age of 69) due to the lack of access to RRT care was shown as about 3 times greater than the number of those who have access to the treatment (Thurlow et al., 2021). Previous studies have shown that access to RRT is directly related to the income levels of the countries and the cost of HD treatment has different rates in various countries due to the characteristics of the cost components such as service, medicine, and materials used. Studies have reported that the prevalence of RRT in high-income countries is high, and the prevalence of RRT in middle- and low-income countries is low. The prevalence of HD was calculated as 68.69 in 100 000 population in Northern Cyprus in 2020, similar to the findings in the study conducted by Turkısh Society Nephrology in Turkey in the same year (70.92 in 100 000 population).

The current study assessed only the HD treatment costs per patient between 2016 and 2020 respectively ($10391.14 in 2016; $8664.62 in 2017; $6140.65 in 2018; $4838.29 in 2019; $4081.89 in 2020). The HD costs calculated in different studies from Iran, Turkey, Taiwan, Canada, and USA showed greater costs of HD compared to the costs calculated in this study for the years from 2016 to 2020, with $13477 in Iran (Moradpour et al., 2020), $14652 in Turkey (Yiğit & Erdem, 2015), $16643 in Taiwan (Chang et al., 2016), $43816 in Canada (Beaudry et al., 2018) and $72486 in USA (Axelrod et al., 2018). The reason for these lower and decreasing costs can be explained by the fact that the foreign currency is increasing and the Turkish Lira is losing value. However, these increasing changes in the currency and costs of the instruments and materials used in RRT are not reflected in to the legislations used for managing the cost of care provided in the public hospitals and healthcare institutions. This, therefore, leads to a gap in the cost of care that is reflected based on the legislation and the actual payment done by the Department of Health towards the costs of the materials and instruments required for RRT. This warrants the immediate regulations to be done on the legislation used in public hospitals, which is important in terms of cost-effective management of RRT services. The lessons learnt from other countries, not specifically on CKD management but generally on health services, emphasizes the importance of determining and evaluate the balance in financial models used in the healthcare systems, such as public insurance, private insurance and incentive mechanisms. It is also recommended to set up strategies to develop effective and efficient payment systems and pricing of health care services (Luca *et al*., 2019).

There is evidence from the studies that are based on the Canadian single-payer healthcare system. They reported that the annual in-center facility haemodialysis including all costs related to dialysis care were $64,214, with $43,816 costs towards home HD (Beaudry, et al., 2018; Surendra et al., 2018;

Ferguson et al., 2021). In another study examining the direct treatment costs, it was determined that per-patient cost of HD treatment was higher than per patient the cost of PD treatment, and the study findings of different countries support each other (Kim et al., 2017; Zhang, et al., 2020). In an Indian study using the perspective of annual reimbursement for HD, the total cost of one HD session in a public hospital was $64 (Bharati & Jha, 2020). This finding was higher than that in Northern Cyprus which costs $4.1.

The present study, in agreement with the results of previous studies, also found that HD treatment costs are higher compared to the cost of other types of RRT, for example PD and kidney transplantation (Mohnen et al., 2019; Wu et al., 2020; Ismail et al., 2019). In Northern Cyprus, HD treatment can be administered only in hospitals; therefore, there is no at-home HD treatment available, which explains the higher in-hospital cost for care (Wong et al., 2019). Previous studies have shown that the costs of HD treatment to the patient are higher than the expenditures and that more cost-effective strategies are necessary to prevent ESRD and provide alternative RRT methods, such as enhanced Tx (Kassa et al., 2020; Yang et al., 2021), PD for those eligible, and implementation of home-based dialysis (Wong et al., 2019; Oruc et al., 2021).

The present study reported that the prevalence of catheter infections in the HD patients raged from 15.8 to 38% between 2016 and 2020. There is also mixed evidence with low and high reporting of cathether infections in the similar studies. For example; whilst Nasiri et al., (2022) reported that 18% of 122 patients developed catheter-related infections, some studies are showing greater rates of catheter infections in HD patients, with for example 32 out of 50 patients (64%) (Alirezaei et al., 2019; Heidempergher et al., 2021); 101 in 329 patients (30.7%) developed catheter-related infections (30.7%) (Zhang et al., 2019) and 53 in 175 patients (30.3%) developed catheter infection (Karkout et al., 2021). Based on the findings between 2016 and 2020 and compared to the literature, it can be stated that the risk of catheter infections increased during the study period in the Northern Cyprus. This can be explained by the fact that the physical conditions in dialysis centres are inadequate for leaving adequate space between each patient when receiving HD. This can explain the greater risk of transmission of infections to other patients when the patients with catheter infections are treated in the hospital settings rising the rate of catheter infections in the HD patients. Restricted resources and inadequate management of catheter infection can therefore explain high rates of catheter infections in HD patients.

The catheter-related infections were more prevalent in those who previously started the HD treatment (they were not those who newly started to the HD in the particular year). The findings of the study also suggest that the prevalence of those having inpatient treatment due to catheter related infections was higher in those who were having HD treatment prior to the particular year. This, therefore, suggests that as the duration since the first HD treatment increases, the risk of comorbidities and the cost-burden of HD increases The cost of inpatient treatment for catheter infection in HD patients was found to be higher than the cost of outpatient treatment each year between 2016 and 2020 so the cost of catheter-related infections are important factors that increase the

burden of care for HD patients. This emphasizes the fact that the alternative interventions such as kidney transplantation to be used to reduce the burden and cost-burden of HD patients on the health systems (Catiwa, 2023; Guo et al., 2024).

3.3 Significance and Implications of the Study

The present study has helped providing crucial implications for managing RRT in ESRD patients. The direct HD costs were analysed to provide insight for allocating resources based on the demand of populations. The current study further provides information on the impact of infections, a major risk factor, on the rising RRT costs. Determining increased costs related to infection helps policymakers assign resources for RRT management and infection prevention.

The fact that the hospital information system used Ministry of Health affiliated hospitals and the data in the patient files cannot provide detailed information on the use of health services, especially on the cost of treatment, causes incomplete results. This reveals the importance of more active and accurate use of hospital information systems for future disease cost studies (using ICD codes, entering every transaction made to the patient through the system). In particular, it is very important to create accurate and objective information that will help health policy makers make evidence-based decisions.

3.4 Limitations of the Study

Although the study had important strengths, there are limitations of the study that provides implications for further research. For example, a limitation of the study is that it presents findings for four years before and during the first year of the Covid-19 pandemic and do not profile the trend in the healthcare costs towards HD after the pandemic. This suggests the requirement for further studies to assess the cost of HD care after the Covid-19 pandemic that is crucial for the allocation of resources and management of comorbidities associated with HD care. One of the other important limitation of the study is that there was no available data on indirect costs. Another limitation of the study is that the inflation led the Turkish lira to lose value with the rise in foreign currencies and the regulations did not reflect the rise in costs of care, medications and instruments used. This warrants immediate change in regulations, so the healthcare economy can be managed and organized more efficiently.

CONCLUSION

Within the scope of the study, the treatment costs, control costs, and infection treatment costs of patients diagnosed with ESRD and undergoing HD in the Northern Cyprus were calculated. For ESRD, which has a high cost in the society and requires long-term care, screening programs should be conducted to increase the awareness on CKD and to identify individuals at risk, and the sustainability of the CKD management and related RRT programs must be ensured. Determining the economic burden of such chronic diseases and the

effective evidence-based management of resources are considered to be important. This study also emphasized the immediate development of legislations to secure the regulation of costs of care in public hospitals, which is important in terms of cost-effective management of RRT service.

REFERENCES

Akbari, A., Clase, C. M., Acott, P., Battistella, M., Bello, A., Feltmate, P., & Welcher, E. S. (2015). "Canadian Society of Nephrology Commentary on the KDIGO Clinical Practice Guideline for CKD Evaluation and Management". *American Journal of Kidney Diseases*, *65*(2), 177-205.

Alirezaei, A., Massoudi, N., Zare, E., & Nouri, Y. (2019). "Catheter Related Blood Stream Infections; The Incidence and Risk Factors in Iranian Hemodialysis Patients". *Journal of Nephropharmacology*, *8*(2), e17-e17. doi: 10.15171/npj.2019.17.

Axelrod, D. A., Schnitzler, M. A., Xiao, H., Irish, W., Tuttle-Newhall, E., Chang, S. H., & Lentine, K. L. (2018). "An Economic Assessment of Contemporary Kidney Transplant Practice". *American Journal of Transplantation*, *18*(5), 1168-1176. https://doi.org/10.1111/ajt.14702.

Balikci, E., Yilmaz, B., Tahmasebifar, A., Baran, E. T., & Kara, E. (2021). "Surface Modification Strategies for Hemodialysis Catheters to Prevent Catheter-Related Infections: A Review". *Journal of Biomedical Materials Research Part B: Applied Biomaterials*, *109*(3), 314-327. https://doi.org/10.1002/jbm.b.34701

Beaudry, A., Ferguson, T. W., Rigatto, C., Tangri, N., Dumanski, S., & Komenda, P. (2018). "Cost of Dialysis Therapy by Modality in Manitoba". *Clinical Journal of the American Society of Nephrology: CJASN*, *13*(8), 1197. doi: 10.2215/CJN.10180917.

Behlul, S., & Artac Ozdal, M. (2022, November). "Risk of COVID-19 and Cost Burden in End-Stage Renal Disease Patients and Policy Implications for Managing Nephrology Services during the COVID-19 Pandemic". In *Healthcare*, 10(12), 235. MDPI. https://doi.org/10.3390/healthcare10122351.

Bello, A. K., Alrukhaimi, M., Ashuntantang, G. E., Bellorin-Font, E., Benghanem Gharbi, M., Braam, B., Feehally, J., Harris, D. C., Jha, V., Jindal, K., Johnson, D. W., Kalantar-Zadeh, K., Kazancioglu, R., Kerr, P. G., Lunney, M., Olanrewaju, T. O., Osman, M. A., Perl, J., Rashid, H. U., … Levin, A. (2018). "Global Overview of Health Systems Oversight and Financing for Kidney Care". In *Kidney International Supplements* (Vol. 8, Issue 2, pp. 41–51). Elsevier B.V. https://doi.org/10.1016/j.kisu.2017.10.008.

Bello AK, Okpechi IG, Levin A, Ye F, Saad S, Zaidi D., & Johnson DW (2023). "ISN–Global Kidney Health Atlas: A report by the International Society of Nephrology: An Assessment of Global Kidney Health Care Status focussing on Capacity, Availability, Accessibility, Affordability and Outcomes of Kidney Disease". *International Society of Nephrology*, Brussels, Belgium.

Bharati, J., & Jha, V. (2020). Global dialysis Perspective: India. *Kidney360*, *1*(10), 1143. doi: 10.34067/KID.0003982020.

Catiwa, J. (2023). *Haemodialysis Catheter-Related Infections in Australian and New Zealand Haemodialysis Services.*

Chang, Y. T., Hwang, J. S., Hung, S. Y., Tsai, M. S., Wu, J. L., Sung, J. M., & Wang, J. D. (2016). "Cost-effectiveness of Hemodialysis and Peritoneal Dialysis:

National Cohort Study with 14 Years Follow-up and matched for comorbidities and Propensity Score". *Scientific Reports*, *6*(1), 1-12. https://doi.org/10.1038/srep30266.

Euser, A. M., Zoccali, C., Jager, K. J., & Dekker, F. W. (2009). "Cohort Studies: Prospective Versus Retrospective". *Nephron Clinical Practice*, 113(3), c214-c217.

Ferguson, T. W., Whitlock, R. H., Bamforth, R. J., Beaudry, A., Darcel, J.,Di Nella, M., & Komenda, P. (2021). "Cost-utility of Dialysis in Canada: Hemodialysis, Peritoneal Dialysis, and Nondialysis Treatment of Kidney Failure". *Kidney medicine*, *3*(1), 20-30. https://doi.org/10.1016/j.xkme.2020.07.011.

Fisher, M., Golestaneh, L., Allon, M., Abreo, K., & Mokrzycki, M. H. (2020). "Prevention of Bloodstream Infections in Patients Undergoing Hemodialysis". In *Clinical Journal of the American Society of Nephrology*, 15(1), 132–151. https://doi.org/10.2215/CJN.06820619.

Francis, A., Harhay, M. N., Ong, A., Tummalapalli, S. L., Ortiz, A., Fogo, A. B., & Jha, V. (2024). "Chronic Kidney Disease and the Global Public Health Agenda: An International Consensus". *Nature Reviews Nephrology*, 1-13.

Görgen, Ö., Topbaş, E., & Bingöl, G. "Türkiye'de Hemşirelik Müfredat Programında Diyaliz Hemşireliğinin Yeri ve Önemi". *Nefroloji Hemşireliği Dergisi*, *13*(2), 62-70.

Guo, H., Zhang, L., He, H., & Wang, L. (2024). "Risk Factors for Catheter-Associated Bloodstream Infection in Hemodialysis Patients: A Meta-analysis". *Plos One*, *19*(3), e0299715.

Heidempergher, M., Sabiu, G., Orani, M. A., Tripepi, G., & Gallieni, M.(2021). "Targeting COVID-19 Prevention in Hemodialysis Facilities is Associated with a Drastic Reduction in Central Venous Catheter-related Infections". *Journal of Nephrology*, *34*(2), 345-353. https://doi.org/10.1007/s40620-020-00900-3.

Hogan, J., Pietrement, C., Sellier-Leclerc, A. L., Louillet, F., Salomon, R., Macher, M. A., & Couchoud, C. (2017). "Infection-related Hospitalizations after Kidney Transplantation in Children: Incidence, Risk Factors, and Cost." *Pediatric Nephrology*, *32*, 2331-2341. https://doi.org/10.1007/s00467-017-3737-x

Inker, L. A., Astor, B. C., Fox, C. H., Isakova, T., Lash, J. P., Peralta, C. A., & Feldman, H. I. (2014). "KDOQI US Commentary on the 2012 KDIGO Clinical Practice Guideline for the Evaluation and Management of CKD". *American Journal of Kidney Diseases*, *63*(5), 713-735.

Ismail, H., Manaf, M. R. A., Gafor, A. H. A., Zaher, Z. M. M., & Ibrahim, A. I. N. (2019). "Economic Burden of ESRD to the Malaysian Healthcare System." *Kidney International Reports*, 4(9), 1261-1270. https://doi.org/10.1016/j.ekir.2019.05.016.

Jha, V., Al-Ghamdi, S. M., Li, G., Wu, M. S., Stafylas, P., Retat, L.,& Garcia Sanchez, J. J. (2023). "Global Economic Burden Associated with Chronic Kidney Disease: A Pragmatic Review of Medical Costs for the Inside CKD Research Programme". *Advances in Therapy*, 40(10), 4405-4420.

Karkout, K., Ibrahim, A. A., Khoudeir, A., Karkout, R., Delgado, A. L., Saleem, A., & Chabaan, A. (2021). "The Rate of Catheter-related Bloodstream Infection in Renal Dialysis Patients Using Central Venous Catheters: A Retrospective Study". *Hamdan Medical Journal*, *14*(4), 179. DOI: 10.4103/hmj.hmj_22_21.

Kassa, D. A., Mekonnen, S., Kebede, A., & Haile, T. G. (2020). "Cost of Hemodialysis Treatment and Associated Factors among End-Stage Renal Disease Patients at the Tertiary Hospitals of Addis Ababa City and Amhara Region, Ethiopia". *Clinico Economics and Outcomes Research: CEOR*, *12*, 399.

Kim, J. H., Ho, S. H., Kim, H. J., & Lee, S. (2018). "The Economic Burden of Kidney Disorders in Korea". *Journal of Medical Economics*, *21*(3), 262–270. https://doi.org/10.1080/13696998.2017.1397523.

Lamarche, C., Iliuta, I. A., & Kitzler, T. (2019). "Infectious Disease Risk in Dialysis Patients: A Transdisciplinary Approach". In *Canadian Journal of Kidney Health and Disease*, 6. SAGE Publications Ltd. https://doi.org/10.1177/2054358119839080.

Lin, C.-H., Hung, P.-H., Liu, W.-S., Hu, H.-Y., Chung, C.-J., & Chen, T.-H. (2020). "Infections and Risk of End-stage Renal Disease in Patients with Nephrotic Syndrome: A Nationwide Population-based Case-control Study". *Annals of Translational Medicine*, *8*(5), 228–228. https://doi.org/10.21037/atm.2020.01.02.

Luca, L., & Paul, O. (2019). *Price Setting and Price Regulation in Health Care Lessons for Advancing Universal Health Coverage*. OECD Publishing.

Luyckx, V. A., Tonelli, M., & Stanifer, J. W. (2018). "The Global Burden of Kidney Disease and the Sustainable Development Goals". *Bulletin of the World Health Organization*, *96*(6), 414.

Makhija, D., Alscher, M. D., Becker, S., D'Alonzo, S., Mehrotra, R., Wong, L., McLeod, K., Danek, J., Gellens, M., Kudelka, T., Sloand, J. A., & Laplante, S. (2018). "Remote Monitoring of Automated Peritoneal Dialysis Patients: Assessing Clinical and Economic Value". *Telemedicine and E-Health*, *24*(4), 315–323. https://doi.org/10.1089/tmj.2017.0046.

Mohnen, S. M., van Oosten, M. J., Los, J., Leegte, M. J., Jager, K. J., Hemmelder, M. H., ... & de Wit, G. A. (2019). "Healthcare Costs of Patients on Different Renal Replacement Modalities–analysis of Dutch Health Insurance Claims Data". *PLoS One*, *14*(8), e0220800. https://doi.org/10.1371/journal.pone.0220800.

Moradpour, A., Hadian, M., & Tavakkoli, M. (2020). "Economic Evaluation of End Stage Renal Disease Treatments in Iran". *Clinical Epidemiology and Global Health*, *8*(1), 199-204. https://doi.org/10.1016/j.cegh.2019.07.001.

Nasiri, E., Rafiei, M. H., Mortazavi, Y., Tayebi, P., & Bariki, M. G. (2022). "Causes and Risk Factors of Hemodialysis Catheter Infection in Dialysis Patients: A Prospective Study". *Nephro-UrologyMonthly*, *14*(1). DOI:10.5812/numonthly.117820.

Oruc, A., Aktas, N., Dogan, I., Akgur, S., Ocakoglu, G., & Ersoy, A. (2022). "The Perspectives of Dialysis Patients about the Covid-19 Pandemic and Differences between the Modalities". *Therapeutic Apheresis and Dialysis*, *26*(1), 178-184. https://doi.org/10.1111/1744-9987.13697.

Sarnak, M. J., & Jaber, B. L. (2000). "Mortality Caused by Sepsis in Patients with End-stage Renal Disease Compared with the General Population". *Kidney International*, *58*(4), 1758-1764. https://doi.org/10.1111/j.1523-1755.2000.00337.x

Surendra, N. K., Rizal, A. M., Hooi, L. S., Bavanandan, S., Mohamad Nor, F. S., Shah Firdaus Khan, S., & Ong, L. M. (2018). "The Cost of Dialysis in Malaysia: Haemodialysis and Continuous Ambulatory Peritoneal Dialysis". *Malaysian Journal of Public Health Medicine*, *18*(2), 70-81.

State Planning Organization. (2023). *Macroeconomic and Sectoral Developments.* Presidency, Nicosia, TRNC.

Takemoto, Y., & Naganuma, T. (2019). "Economic Issues of Chronic Kidney Disease and End-Stage Renal Disease". *Contributions to Nephrology*, *198*, 87–93. https://doi.org/10.1159/000496533.

TCMB. TCMB Enflasyon Verileri 2016-2021. Available at: [TCMB - Tüketici Fiyatları] Thurlow, J. S., Joshi, M., Yan, G., Norris, K. C., Agodoa, L. Y., Yuan, C. M., & Nee, R. (2021). "Global Epidemiology of End-stage Kidney Disease and Disparities in Kidney Replacement Therapy". *American Journal of Nephrology*, *52*(2), 98-107. https://doi.org/10.1159/000514550.

Tingle, S. J., Figueiredo, R. S., Moir, J. A. G., Goodfellow, M., Talbot, D., & Wilson, C. H. (2019). "Machine Perfusion Preservation Versus Static Cold Storage for Deceased Donor Kidney Transplantation". In *Cochrane Database of Systematic Reviews*, 2019(3). John Wiley and Sons Ltd. https://doi.org/10.1002/14651858.CD011671.pub2.

Trivedi, N., & Sodani, P. R. (2024). "A Study on the Economic Evaluation of End-stage Renal Disease Treatment: Kidney Transplantation Versus Haemodialysis". *Journal of Health Management,* 26(2), 284-292.

Vanholder, R., Annemans, L., Brown, E., Gansevoort, R., Gout-Zwart, J. J., Lameire, N., Morton, R. L., Oberbauer, R., Postma, M. J., Tonelli, M., Biesen, W. van, & Zoccali, C. (2017). "Reducing the Costs of Chronic Kidney Disease while Delivering Quality Health Care: A Call To Action." In *Nature Reviews Nephrology*, 13(7), 393–409. Nature Publishing Group. https://doi.org/10.1038/nrneph.2017.63.

Wong, C. K., Chen, J., Fung, S. K., Mok, M. M., Cheng, Y. L., Kong, I., & Lam, C. L. (2019). "Direct and Indirect Costs of End-stage Renal Disease Patients in the First and Second Years after Initiation of Nocturnal Home Haemodialysis, Hospital Haemodialysis and Peritoneal Dialysis". *Nephrology Dialysis Transplantation*, *34*(9), 1565-1576. https://doi.org/10.1093/ndt/gfy395.

World Health Organization. (2015). *Health in 2015: From MDGs, Millennium Development Goals to SDGs, Sustainable Development Goals*. (Retrieved 7 January 2023).

Wu, H., Li, Q., Cai, Y., Zhang, J., Cui, W., & Zhou, Z. (2020). "Economic Burden and Cost-utility Analysis of Three Renal Replacement Therapies in ESRD Patients from Yunnan Province, China". *International Urology and Nephrology*, *52*(3), 573-579. https://doi.org/10.1007/s11255-020-02394-1

Yang, F., Liao, M., Wang, P., Yang, Z., & Liu, Y. (2021). "The Cost-effectiveness of Kidney Replacement Therapy Modalities: A Systematic Review of Full Economic Evaluations". *Applied Health Economics and Health Policy*, *19*(2), 163-180. https://doi.org/10.1007/s40258-020-00614-4.

Yigit, V., & Erdem, R. (2015). “Cost Effectiveness Analysis of Dialysis and Kidney Transplantation Treatment in Turkey”. *Mehmet Akif Ersoy University Journal of Social Sciences Institute, 7*(13), 211-236.

Zhang, H., Zhang, C., Zhu, S., Ye, H., & Zhang, D. (2020). “Direct Medical Costs of End-stage Kidney Disease and Renal Replacement Therapy: A Cohort Study in Guangzhou City, Southern China”. *BMC Health Services Research, 20*(1), 1-14. https://doi.org/10.1186/s12913-020-4960-x.