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COST UTILITY ANALYSIS OF HEMODIALYSIS TREATMENT OFFERED TO PATIENTS OF END STAGE RENAL DISEASE

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Abstract

In 2017, about 1.7 million Cameroonians suffered from chronic kidney disease. This often progresses to end stage renal disease that cannot be treated but can be managed through hemodialysis interventions. This study aimed at calculating the average cost of hemodialysis, the utility gained from receiving hemodialysis, and the average cost utility ratio of hemodialysis treatment offered to patients of end stage renal disease. This study uses both primary and secondary data. Primary data was collected through observations and interviews of staff and patients while secondary data was gotten from patient files and mortality records (2019-2022) at the hemodialysis unit of the Bamenda regional hospital. A sample size of 56 hemodialysis patients was enrolled in to this study, 14 of whom were incident and 42 who were prevalent. The average cost of hemodialysis treatment per patient stood at 7232105.14 FCFA, 20330254.86 FCFA and 27562360 FCFA from the patient, provider and societal perspective respectively. In the societal perspective of cost, 26.24% was borne by the patient, while the provider represented by the government covers 73.76%. The study also revealed that hemodialysis treatment resulted to a 1.5 QALYs gain to the patient. The average cost-utility ratio of hemodialysis treatment was 4,821,403.427 FCFA/QALY gained, for the patient perspective. The average annual patient maintenance cost stood at 3,210,378 FCFA. This amount covered by the patient is still far higher than the minimum annual salary of Cameroon which stands at 502,500FCFA for a wage of 41,875FCFA per month. This study revealed that hemodialysis treatment could result in financial risk for patients. Hence there is need for the government and individuals, to invest more in preventive interventions like sensitization campaigns and regular screening.

Keywords: Cost Utility, Average Cost Utility Ratio, Hemodialysis Treatment

INTRODUCTION

Statistics from the Global Burden of Disease (GBD) 2017 study, Cockwell and Fisher (2020) estimated CKD global prevalence to be about 9.1%; a total of 700 million cases. Hence 700million CKD patients at risk of developing ESKD. According to Lv *et al* (2019), the prevalence of CKD as well as ESKD is continuously rising, due to the increasing prevalence of risk factors such as CKD, diabetes, hypertension, obesity and aging. The prevalence of CKD in Sub Saharan Africa was estimated to be about 61.3 million and the number of CKD deaths to be 101,660 (Lancet, 2020). This same study estimated the prevalence of CKD in Cameroon to be 1,741,850 in 2020. At its worst, kidney disease (KD) presents as ESKD, with glomerular filtration rate so low that the patient requires dialysis. ESKD can be managed through either of the following ways; Kidney Replacement therapies (KRT): could be either hemodialysis, peritoneal dialysis or kidney transplantation (Luyckx *et al,* 2021) and; Conservative kidney management: for ESKD patients not on dialysis (Castro, 2019).

ESKD can result in great financial losses. As reported by Luyckx *et al* (2021), most HICs allocate 2-3% of their annual health budget to kidney disease, though KD patients make up only less than 0.03% of the population. In 2010, 2.3 - 7.1 million ESKD patients, died without access to much needed dialysis (Luyckx *et al,* 2021). Likewise, Thurlow *et al* (2021), reports that only about 17-34% of patients in need of KRT in Asia, can obtain treatment. A much lower percentage is reported for Africa with only about 9-16% receiving treatment. Due to this shortage of KRT, patients living with CKD in LMICs are likely to die within months of the disease advancing to ESKD (Cockwell and Fisher, 2020). Similar results of high rates of discontinued dialysis treatment, high death rates amongst ESKD patients and low access to dialysis, were reported by Ashuntantang *et al* (2017), in a systematic analysis of studies on ESKD in Sub Saharan Africa. In low income countries (LICs), KRT is often paid for out of pocket. This leads to catastrophic health care expenditure (CHE), as monthly payments for essential ESKD medication, could use up more than 18 days' wages (Luycky *et al*, 2021). Obtaining treatment becomes even more difficult when jobs are lost because of constant travelling to get dialysis. Some patients because of cost, receive less than the recommended dose of dialysis, and some eventually drop out (Kaur *et al,* 2018; Akpan *et al,* 2020). Taking less than the recommended dose has been linked to increased hospitalization and mortality (Obialo et al, 2012; Tohme *et al*, 2017). It is worth noting that, legislative, sociocultural and infrastructural factors have hindered the use of kidney transplantation, as an alternative to dialysis, in most countries (Luycky *et al*, 2021). Despite the shortages experienced in LMICs, the global prevalence rate for dialysis has risen by 43% from 2003-2016, an indication of the inequity in access to KRT (Thurlow et al, 2021).

Hemodialysis is the only form of dialysis available to ESRD patients in Cameroon today. It was first offered at a price range of 60,000FCFA to 100,000 FCFA per session. Since 2002, the government has subsidized dialysis by 95% thus the price, has fallen to 5000 FCFA per dialysis session (Halle *et al,*2017) hence 40,000 FCFA a month for two sessions a week. In addition to the cost of hemodialysis sessions, patients incur other costs like transportation cost, home aides cost, intangible cost, opportunity cost and cost of basic needs like feeding and housing. The high cost coupled with the high unemployment rate means that most Cameroonians will not be able to afford hemodialysis. This probably explains the low adherence observed by Fouda *et al* (2017), which was more prevalent in those living outside the dialysis city center. ESKD has become a measure public health problem in Cameroon, due to the constant unavailability or shortage of hemodialysis. Due to this shortage, several patients have been forced to leave their resident regions to other regions, so as to obtain hemodialysis. This study therefore had as objectives to determine: the average cost of hemodialysis management of ESRD, the utility gained by patients on hemodialysis and the average cost utility ratio for hemodialysis treatment of ESRD. To effectively do this, it is important to review past studies.

LITERATURE REVIEW

Several studies have dwelled on this topic such as Mushi *et al* (2015), which conducted a systematic review of the cost of dialysis in low and middle income countries (LMICs). The study found the yearly cost of hemodialysis to range from Int$ 3,424 to Int$ 42,785 per patient while that for peritoneal dialysis (PD) ranged from Int$ 3,424 to Int$ 42,785 per patient. For most countries PD was found to be costlier than hemodialysis (HD). The authors explained that PD was costlier due to the large amount of supplies and consumables which needed to be imported, while the main contributor to HD costs which was personnel costs, were significantly lower than the importation costs incurred. Another study by Beaudry *et al* (2018) estimated costs using the perspective of the Canadian single healthcare payer system. The study revealed annual maintenance costs to be higher for in center HD ($64,214) than for home HD with NX ($43,816), with home HD with CM cost being $39,236 while the cost of PD stood at $38,658.. However, in center HD, had zero training costs while training costs for the other modalities in descending order were home HD with CM ($16,143), home HD with NX ($16,143) and PD ($7157). Makhele *et al* (2019) also carried out a study to investigate the costs of dialysis. It used the provider's perspective, a micro costing approach, and involved 46 patients. This study found the annual cost of dialysis per patient on HD (US$205, 681.40) to be greater than the annual cost per patient on PD (US$25, 282.00 per patient). Furthermore, the primary costs drivers for HD were fixed costs which included the cost and maintenance of the

hemodialysis machine, while that for PD were variable costs made up of consumables. Similarly, annual medication costs for PD stood at US $3,839.26 with the average prescription consisting of 9 medications. On the other hand, the average prescription for HD consisted of 7 drugs, and annual medication costs stood at US$742.33. These findings are in line with those of Mushi *et al* (2015) and Beaudry *et al* (2018) which revealed that consumables are the main cost driver for PD. This very high difference in HD and PD costs, may be explained by the exclusion of utility costs from PD costs, since PD is performed at home. Also personnel cost for PD is much lower for the same reason.

In Cameroon, Halle *et al* (2017) sort to determine the annual cost of maintenance hemodialysis. Prospective costs were collected over a period of 6 months, from a cohort of 154 patients at 4 different facilities. The study used the societal perspective, and revealed the total annual median costs to be US $13,581 of which 38% were out of pocket expenditures. According to this study, the main driver of cost was consumables, which accounted for 59.8% ($ 8120) of total cost. The study included indirect costs, which made up 6.6% ($ 902) of total costs. To conclude, there appears to be very few studies evaluating the cost utility of dialysis modalities in LMICs, in Africa and specifically in Cameroon.

This study therefore is aimed at filling these gaps by using a patient's perspective, while including indirect costs, and performing a cost utility analysis of hemodialysis.

METHODOLOGY

This study uses a descriptive research design where descriptive data such as the mean, was used to get the results of the length of life and quality of life, when calculating the QALYs gained. Similarly, average cost per patient was used to calculate the average cost utility ratio (ACUR). Data used for this study was collected at the hemodialysis center of the Bamenda Regional Hospital in 2022. Primary data on cost was collected through key informant interviews with doctors, nurses, lab technicians and pharmacists. Data on time use at the health facility was collected through observations and interviews with caretakers, nurses and lab technicians. Patient data such as quality of life, age, gender, employment status, dialysis initiation date, and number of comorbidities, was collected using questionnaires. Secondary data on mortality, was obtained from facility records. To ensure that data on the time the patients started dialysis was accurate and precise, the information provided was crosschecked with patient files. The EQ-5D-5L questionnaire, was used to collect quality of life data.

A convenient sampling technique was used to select the respondents. This method was most suitable given that most patients coming for dialysis are under stress, seeking the relief the treatment provides thus are not in the mood to answer any questions. Moreover, for most

patients, the 4-hour long process is tiring; even worse so, when complications such as blood clotting, hypotension and poor functioning of the access site occur during the procedure. Thus, it becomes difficult to interview some patients under such circumstances. Patients were required to consent to their involvement in the study, and signed the consent forms. At the time of the study, the Bamenda regional center provided dialysis for 65 patients. According to Krejcie and Morgan (1970), a study with a population size of 65 requires a sample size of 56 individuals. All patients who showed up for dialysis within the study period were approached for participation. However, those who did not consent were excluded from the study.

The sample was divided into 2 groups; the incident patients and prevalent patients. The incident group consisted of patients initiating HD, and patients who had been on HD for less than 3 months while the prevalent group consisted of patients who had been on dialysis for at least 3 months. Selecting patients who had been on dialysis for at least 3 months ensures that clinical stability has been attained as a result of the treatment (Lorenzo et al, 2010). Therefore, the incident group was used to capture the quality of life and life expectancy of patients not on hemodialysis while the prevalent group was used to capture the quality of life and life expectancy of patients on hemodialysis.

Modelling the Cost of Hemodialysis

Table 1: Costing tool

Phase	Component	Details (Breakdown)	Cost Estimate (Currency year)	Source/ Method to Obtain
Initiation phase	Material Cost	Pre-dialysis tests	Determined during the study	Cost at public facilities
		Vascular access		Cost at public facilities
		Sessions		Routine 5000FCFA per session for the patient and 95,000FCFA for the provider(95% subsidy)
	Personnel	Nephrologist	Determined during the study	Obtained through observation of personnel and interview of personnel
		Anesthetist		
		Nurse		
		Nephrologist		
	Other	Transport	Determined during the cost of the study	Obtained from patient interviews.
Maintenance Phase	Material Costs	Medication	Determined during the study	Treatment regimen determined by physician, cost determined using hospital prices.

Table 1...

	Dialysis sessions		Routine 5000FCFA per session for the patient and 95,000FCFA for the provider (95% subsidy)
	Laboratory tests		Cost at public facilities/Performing facility for PTH
	Consultation fees		Cost at the hemodialysis center
Personnel Costs	Nephrologist	Determined during the study	Obtained through observation of personnel and interview of personnel.
	Nurses		
	Lab technicians		
Other Costs	Indirect Costs	Salary lost in terms of time spent at hemodialysis center	Obtained using the minimum wage rate in Cameroon and observation of patients.
	Transportation Cost.	Determined during the study	Obtained through patient interviews

Modelling the QALYs gained

QALYs gained= $QAS_{\text{ESKD patients on dialysis}} - QAS_{\text{ESKD not on dialysis}}$

(adapted from Drummond et al, 2015)

$QAS_{\text{ESKD not on dialysis}}$ was obtained from patients about to initiate dialysis. Due to the small size of the population, incident cases were extended to include patients who have received dialysis for less than 3 months. This was done under the assumption that, these patients have not yet been stabilized by the hemodialysis treatment, hence have the same quality of life, as those still to initiate the treatment. $QAS_{\text{ESKD patients on dialysis}}$ was gotten from patients who had been on dialysis for 3 or more months. Dialysis increases patient life expectancy by an average of 34.11 months (Lee et al, 2009**).**

Table 2: Variables for the QALY Model

Variable	Meaning	Description
$QAS_{\text{ESKD patients on dialysis}}$	Quality adjusted survival for ESKD patients on dialysis	Quality of life × survival
$QALY_{\text{ESKD patients not on dialysis}}$	Quality adjusted survival for ESKD patients not on dialysis	Quality of life × survival

Modelling the Cost Utility Analysis for Hemodialysis

ACUR= CD/UG (adapted from Drummond et al, 2015)

Cost was captured as the cost over the average period of survival. Only dialysis related costs were included in cost calculations. Benefits were calculated in terms of the QALYs gained by patients as a result of the intervention.

Table 3: Description of variables in the Cost Utility Analysis of Hemodialysis

Variable	Meaning	Description
CD	Cost of Dialysis	Cost of dialysis over the average period of survival
UG	Utility gains in patient's health	QALYs gained by patients
ACUR	Average Cost Utility Ratio	Cost per QALY gained

RESULTS

Cost Analysis of Hemodialysis Treatment

Appendix 1 presents the cost of hemodialysis per patient. The initiation phase costs 691,026.56 FCFA, 394,000FCFA of which is paid by the patient, while the provider covers the rest. Monthly hemodialysis maintenance costs the patient 267531.5 FCFA in out of pocket expenditure and 20687.5FCFA in salary losses. The provider spends on average 783772.625FCFA per patient, each month.

HD patients are recommended to perform certain lab tests on a monthly basis. The results give the nephrologist details of the patient's blood composition. This enables the physician monitor the blood level of toxins and other compounds which are harmful to the patient's health. He also monitors other substances such as calcium, parathyroid hormone and hemoglobin. Based off of these results, the physician makes recommendations of diet, medication and blood transfusions, so as to prevent the onset of complications, which may result from either an excess or surplus of these compounds. More tests besides these are recommended for hemodialysis patients. However, not all are offered at the center. Amongst them is the PTH (parathyroid hormone) test, which is not offered at the Bamenda Regional Hospital, but can be done at the Nkwen Baptist Hospital. It is worth noting that, the already subsidized fee of 6,000 (instead of 24,000) for the baseline tests is unaffordable for some patients. Thus, adherence to recommendations for laboratory testing is not a hundred percent. HD patients need to constantly take these tests as information from these tests, enables the nephrologist to design interventions that prevent the occurrence of complications.

HD patients are expected to take 2 ampoules of vitamin B complex at each session. This is because the mode of preparation of their meals, leads to the loss of most nutrients, especially the B vitamins. The kidney is responsible for the production of erythropoietin, the hormone that controls for red blood cell formation. Since the kidney is damaged, ESRD patients cannot produce this hormone. Therefore, HD patients have to rely on artificial erythropoietin. This is taken alongside iron, which also aids RBC (hemoglobin) formation. The average patient is recommended 2 doses of erythropoietin; others are recommended more based on the results of their blood tests. Failure to adhere to this medication, could lead to anemia, with the patient needing a blood transfusion. Only 3 patients (4.62% of the population) at the center were on erythropoietin, of which, not all 3 were able to keep up with the recommended dose. This could explain why over 37.5% percent of the sample population is anemic. Furthermore, the impact of the non-adherence to this drug can be seen in the mortality records for ESRD patients, which reveals severe anemia as one of the causes of death. A cost effectiveness analysis of taking erythropoietin as opposed to receiving blood transfusions needs to be done.

Vitamin D, has been excluded from this analysis as the dose per patient varies, and is determined by the patient's tests results for that month. The kidney is responsible for the production of vitamin D, a function which is lost in ESRD patients. Vitamin D aids the absorption of Ca. Hence, its dose increases with a decrease in blood calcium levels. Vitamin D is also used to regulate blood levels of potassium and phosphorous. Adhering to vitamin D is needed, so as to prevent osteoporosis and injury, which can result from a shortage of Ca and bone weakness. Other medications such as blood pressure medications, medications for diabetes, were left out, as the intention of the study was to capture as much as possible, only costs directly related to hemodialysis. Furthermore vitamin B is needed because the dialysis process leads to a loss of Vitamin B. Although vitamin B is the cheapest medication included in the analysis, not all patients showing up for hemodialysis, have vitamin B. This non adherence exists despite the fact that a pack of 10 ampoules costs 2500FCFA, thus 500FCFA, for the 2 ampoules needed in a session. Perhaps the retail of ampoules of this medication at the dialysis center could improve adherence. Non adherence to both erythropoietin and vitamin B, is indicative of the fact that other factors besides cost, influence adherence. These factors need to be further investigated. The poor adherence to medication and recommendations of lab tests, could account for the low survival time and high mortality rate. More research needs to be done, to reveal medication and lab testing adherence amongst ESRD patients. As stated by (Lam and Fresco, 2015), an understanding of non- adherence and the factors contributing to it, could aid the designation of interventions that improve adherence, thus improving patient outcomes.

Utility Gained as a Result of Hemodialysis Treatment

A patient diagnosed of ESRD has 3 treatment options; hemodialysis, conservative management and kidney transplantation. If the patient chooses hemodialysis, he will have to stay on this treatment for the rest of his life. Thus HD, is simply a management of the condition, and not a cure, since the patient does not fully recover. In this study, the health gains from HD are calculated by comparing the quality adjusted survival of HD patients to that of ESRD patients who choose to not receive HD and our not on any other treatment. This method of calculating QALYs is used because an individual, irrespective of their age, will die within weeks of developing ESRD, if he is not on hemodialysis, conservative management and does not receive a kidney transplant.

$QALYs_{gained} = QAS_{\textbf{ESKD patient on HD}} - QAS_{\textbf{ESKD patientsnot on HD}}$

(adapted from Drummond et al, 2015)

$QAS_{\textbf{ESKD patient on HD}} = (QOL_{\textbf{ESKD patient on HD}})\ (Survival_{\textbf{ESKD patient on HD}})$

$QAS_{\textbf{ESKD patient not on HD}} = (QOL_{\textbf{ESKD patient not on HD}})\ (Survival_{\textbf{ESKD patient on HD}})$

Survival= Length of time the patient lives after ESKD diagnosis/ prescription of hemodialysis

$QOL_{\textbf{ESKD patient on HD}}$ = Average $QOL_{\textbf{ESKD prevalent group}}$ = 0.8

$QOL_{\textbf{ESKD patient not on HD}} = QOL_{\textbf{ESKD incident group}} = 0.7$

$Survival_{\textbf{ESKD patient on HD}}$ = (Average survival time of patients on HD) = 2.13 years.

$Survival_{\textbf{ESKD patient not on HD}} =$ 3 months (assumed to be 3 months).

As stated by Cockwell and Fisher (2020) ESRD patients without access to HD, die within months. It should be noted that at the time of this study, no other scientific study could be found that observed the survival of patients not on HD or an alternative treatment).

The quality of life (QOL) for ESRD patients on hemodialysis, was captured using the QOL of patients on HD for 3 months and more (prevalent group), as it takes 3 months for the patient to become clinically stable. Conversely, the QOL for ESRD patients not on HD was captured using the QOL of ESRD patients still to begin HD and those that have been on dialysis for less than 3 months. The addition of HD patients of less than 3 months to the incident group, was done based on the assumption that these patients had not yet achieved clinical stability and so have a QOL, comparable to ESRD patients who are still to begin HD.

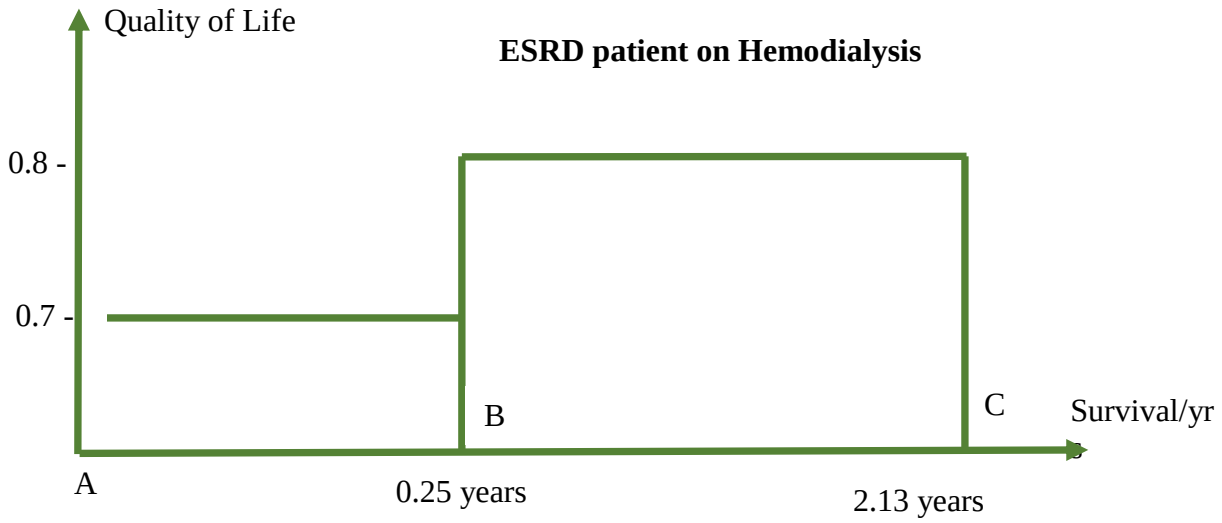

Figure 1: Quality of life and Survival of ESKD patients on Hemodialysis

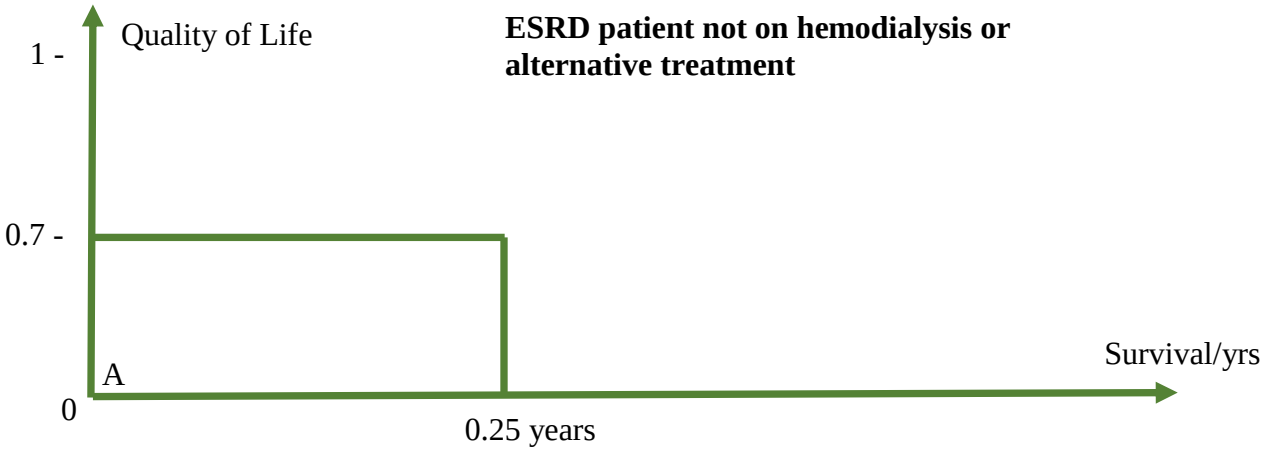

Figure 2: Quality of life and Survival of ESKD patients not on any treatment

The models above were developed as adaptations from Kobelt (2013). The quality of life of an HD patient changes over the course of life. For some, the invasive nature of the procedure may cause a fall in the quality of life, during the first months of treatment. For others, it gradually improves when treatment commences, since HD reliefs uremic symptoms. However, studies have shown that with extended time on hemodialysis, the patient's quality of life begins to decline. In the model above, the HD patient does not achieve clinical stability till after 3 months of hemodialysis. Thus as was assumed in the calculations for $QOL_{incident}$, his quality of life in the first three months of treatment, is same as his quality of life before he initiates dialysis. After the first 3 months, he achieves clinical stability and his QOL, improves to $QOL_{prevalent.}$ It is also assumed that in the period post 3

months to 2.13 years, his quality of life remains the same. For the patient who refuses treatment. It is assumed that his quality of life stays the same, and he dies after a month.

Hence, $QAS_{\boldsymbol{ESKD\ patient\ on\ HD}}$ = (0.7×0.25) + (0.8×1.88) QALYs = 1.68 QALYs

$QAS_{\boldsymbol{ESKD\ patient\ not\ on\ HD}}$ = (0.7×0.25) = 0.18 QALYs

$QALYs_{gained}$= (1.68-0.18) QALYs= 1.5 QALYs

Cost Utility Analysis

In the calculations for cost utility analysis, the cost used is equivalent to the cost that will be incurred over a period of 2.13 years, which is the life years gained as a result of being on dialysis. This is because unlike other diseases, which require a one-time treatment, hemodialysis is a maintenance treatment, which must be continued, if the patient is to stay alive. The patient must constantly receive treatment (2 sessions a week), to get rid of toxins in the blood. If the patient suddenly stops hemodialysis, and does not receive any alternative treatment, toxins and fluids accumulate in the body, and his health will deteriorate over time. This will eventually lead to death. As reported by (O'Connor et al, 2013) the median survival for patients who discontinued dialysis was 7.4 days, after admission into hospice care (end of life care). This study involved 1,947 patients, who discontinued dialysis. This is also evident in the mortality records of the HD center, which show abandoning treatment as a cause of death for HD patients.

a) Patient perspective

Annual maintenance costs = 3210378 FCFA

Maintenance cost over 2. 13 years= 6838105.14 FCFA

Total patient cost= Initiation + Maintenance= (394,000 + 6838105.14) FCFA

= 7232105.14 FCFA

QALYs gained= 1.5 QALYs

Average cost utility ratio= (7232105.14 FCFA/1.5) FCFA per QALY gained

=4,821,403.427 FCFA/QALY gained

Converting to dollars, at an exchange rate of 1USD=672.27FCFA (YAHOO finance on 23/01/2022)

=7,171.83 USD/QALY gained

Thus the patient must spend 4,821,403.427 FCFA to gain a year of full health

b) Provider perspective

Total provider cost= (Annual maintenance cost ×2.13) + Initiation cost

Total provider cost = (20033228.3+ 297026.56 FCFA)

= 20330254.86 FCFA

ACUR= (20330254.86/ 1,5) FCFA/QALY gained

=13,553,503.24 FCFA/QALY gained = 20,160.8033USD/QALY gained.

c) Societal perspective

Total cost of HD treatment= Patient cost+ Provider cost

= (7232105.14+20330254.86) FCFA

=27562360 FCFA

Average cost Utility of HD treatment = (27562360/1.5) FCFA/QALY

ACUR = 18,374,906.66 FCFA/QALY gained =27,332.63USD /QALY gained

Thus, it costs 18374906.66 FCFA, for a dialysis patient to gain a year of complete health.

The cost per QALY gain is very high and is not affordable to the average Cameroonian. This suggests that preventing ESRD, may be more suitable and more cost effective to both the provider and patient. Notably, during an interview with a patient, he suggested that diagnostic tests for kidney disease be made compulsory for the population He also said that he would have paid the sum of 100,000 FCFA for a lab test, if it would have led to an early discovery and treatment of his condition, instead of a treatment which has used up all of his life savings in less than 3 years.

CONCLUSION

The study revealed the average cost of hemodialysis per patient to be 7232105.14FCFA over a period of 2.13 years. Monthly recurrent cost for HD is 267531.5 FCFA thus 3210378 FCFA annually (excluding initiation cost). This is above the annual HD cost of 2,420,300 FCFA, reported by Halle et al. (2017). This difference could be explained by the fact that Halle et al (2017) in measuring patient costs, used actual patient expenditures, which due to financial constraints may be less than the cost of the standard treatment plan developed in this study. During the course of the study, non-adherence to sessions, medications and nutrition recommendations was observed. Patients showed up for hemodialysis without the ampoules of vitamin B recommended for each session. Less than 5% of the population, were on erythropoietin; with many patients citing its price as the reason for non-adherence. Similarly, some patients could barely keep up with the recommendation of 2 sessions a week.

The QALYs gained by ESRD patients undergoing dialysis is 1.5. The ACUR of HD treatment was found to be 18,374,906.66 FCFA/QALY gained (27,332.63USD/QALY gained) from the societal perspective, 13553503.24 FCA/QALY gained (20160.80 USD/QALY gained) from the provider perspective and 4821403.43 FCFA/QALY gained (7171.83 USD/QALY gained) from the patient's perspective. This is larger than the ACUR reported by most studies. Wong et al (2020), reveals a WTP threshold of 18609 - 20223 USD per QALY gained. This large difference could be explained in two ways. Firstly, Wong et al (2020), as other studies reviewed in this text, performed a comparative cost effectiveness analysis of different dialysis modalities while this study sought the cost effectiveness of HD care in relation to not receiving any other treatment. Secondly, HD care is most likely more expensive to provide in Cameroon, which imports all dialysis consumables. Furthermore, HMICs enjoy economies of scale which results from the bulk production of these consumables, however Cameroon does not. As seen in the literature reviewed, the main cost driver for HMICs is personnel costs not consumables. This is due to the high wage rate in these countries. Conversely, the wage rate for personnel in Cameroon is very low, most likely why the main driver for HD in Cameroon is session cost instead. Provider session costs which constitutes hemodialysis consumables is responsible for 99% of the total treatment cost. It should be noted that after the completion of this study, Cameroon began implementing a UHC policy that now charges 15, 000FCFA annually for hemodialysis sessions.

RECOMMENDATIONS

Given the high cost of hemodialysis and that, 57.57 % of the sample is unemployed, the study recommends that both the provider and patient invest in interventions that prevent the occurrence of ESRD and the need for hemodialysis. These could include awareness campaigns, screening campaigns and the patient regularly doing kidney function tests. Individuals should pick up lifestyle and dietary habits that prevent the onset of diabetes, a major risk factor for ESKD. Despite the subsidization of session fees to reduce patient costs, the patient still spends 140,000 francs each month on dialysis related drugs alone. As seen, drug costs accounts for 49.48% of total patient cost. A further subsidization of drug costs, in addition to the subsidization of laboratory and session costs, will improve adherence, and thus health outcomes.

Given the non adherence observed in the use of both vitamin B and erythropoetin, it is necessary to investigate what factors besides cost influence adherence, as drugs are a measure contributor to the cost of hemodialysis management of ESRD.

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APPENDICES

Appendix 1: Cost Analysis

Item		**Cost**
Initiation Costs		
i. **Material Costs**		
Pre-dialysis Tests		
Kidney function test	Urea	6,000
	Creatinine	
Hepatitis B		3,000
Hepatitis C		3,000
HIV/AIDS		1,000
Full Blood Count		6,000
Serum Na ions		3,000
Serum Ca ions		3,000
Serum P		3,000
Serum K ions		3,000
Abdominal Ultrasound		6,000
Total pre-dialysis test		**37,000**

Vascular Access Creation		
Central venous catheter (CVC)	Surgical procedure	70,000
	Materials	7,000
	Total CVC access cost	77,000
Arteriovenous Fistula (AVF)	Surgical Procedure	250,000
Total vascular access creation		**327,000**
Sessions		
Patient cost (5% Halle et al,2017)		
First session(2 hours)		5,000
Second session(3 hours)		5,000
Third session (4 hours)		5,000
Provider cost (95% Halle et al,2017)		
First session (2 hours)		95,000
Second session (2 hours)		95,000
Third session (4 hours)		95,000
Total session initiation cost		**300,000**
Total material cost		**663,000**
Personnel Costs		
Lab technician		985.63
Nurse		3,830.94
Nephrologist		3,920
Anesthetist		3,290
Total personnel costs		**12,026.56**
ii. **Other Costs**		
Transport for fistula access creation (to and fro patient and caregiver)		**15,000**
Total Initiation costs		**691,026.56**
Follow up Treatment (Per month Cost)		
a) Material Costs		
Post dialysis tests		
Full blood count		6,000
Serum Urea		3,000
Serum Creatinine		3,000

Serum Na ions	3,000		
Serum K ions	3,000		
Serum Ca ions	3,000		
Serum Phosphorous	3,000		
Total (offered at the regional hospital)	24,000	**18,000 covered by provider**	**Subsidized to 6,000**
Parathyroid hormone (offered at the Nkwen Baptist Hospital)	10,000		
Total costs of post dialysis tests	**34,000**		
Drugs			
16 ampules of vitamin B(2 per session)	4,000		
Erythropoietin (2×a week=8× a month)	120,000		
Iron injection (1× a week=4×a month)	16,000		
Total drug cost	**140,000**		
Sessions			
Patient cost for sessions (8)	40,000		
Provider cost for sessions (8)	760,000		
Total cost for sessions	**800,000**		
Nephrologist consultation	2,500		
Total material cost	**976,500**		
Personnel			
Nurses	2,563		
Lab personnel (post-dialysis tests only)	2,117.50		
Nephrologist (twice a month)	701		
Total personnel cost	**5,380.63**		
Other Costs			
Transport (patient and caregiver)	48,344		
Opportunity cost	20,687.50		
Water (140liters of water×8 session)	392		
Total	**69,423.50**		
Total monthly(recurrent) cost post initiation	**1,051,304.13**		
Annual maintenance costs(monthly×12)	**12,615,649.50**		
Initiation and 2.13 years of maintenance	**27,562,360.00**		

Appendix 2: Cost Analysis by Component

Patient Cost			
Type			
Initiation	**Item**	**Cost**	Total
Material	Predialysis test	37000	
	Vacular access creation	327000	
	Sessions	15000	
Others	Transport	15000	394000
Monthly Maintenance			
Material	Post dialysis test	16000	
	Drugs	140000	
	Sessions	40000	
	Nephrologist consultation	2500	
Others	Transport	48,344	
	Opportunity cost	20687.5	267531.5
Yearly maintenance =		3210378	
Maintenance for 2.13 years		**6838105.14**	
Total OPP for HD treatment=		**7232105.14**	
Provider Cost			
Type			
Initiation	**Item**	**Cost**	**Total**
Material	Sessions	285000	
Personnel	Personnel	12,026.56	297026.56
Monthly Maintenance			
Material	Postdialysis tests	18000	
	Sessions	760000	
Personnel	Personnel	5380.625	
Others	Water	392	783772.625
Yearly maintenance=		9405271.5	
Maintenance for 2.13 years=		**20033228.3**	
Total provider cost for HD treatment		**20330254.86**	
Total societal cost of HD Treatment=		**27562360**	

Patient Cost by component		**Patient Cost**	
Material Int	Mat	Tests	
379000	5452660	37000	
Material Main		408960	
198500	Others	445960	
Yearly Main	1779445.14	Sessions	
2382000		15000	

2.13 years		1022400	
5073660		1037400	
Others Int		Drugs	
15000		3578400	
		Transport	
Others Main		1,250,673	
69,032		Opportunity Cost	
Yearly Main		528772.5	
828,378		Consultation	
2.13 years		63,900.00	
1,764,445		Vascular access	
		327000	
Provider cost by component			
Material Int	Mat	**Personnel**	Sessions
285000	20170680	Nephrologist	19710600
Material Main		3,920	Post dialysistests
778000	Personnel	54,123	460080
Yearly Main	149555.335	58,043	Personnel
9336000		Nurse	149555.34
2.13 years	Others	3,830.94	Other
19885680	10019.52	65,498	10019.52
Personnel Int		**69,328**	
12026.56	**20330254.86**	Lab technici	
Personnel Main		985.63	
5380.625		17,907.98	
Yearly Main		**18,893.60**	
64567.5		Anesthetist	
2.13 years		3,290	
137528.775		**149,555.34**	