THE UTILITY OF HEALTH AND WEALTH FOR HIV PATIENTS ON ANTIRETROVIRAL THERAPY IN KENYA.

Abstract

Aims/ objectives: To determine the appropriate utility function that models the trade off between health and wealth for HIV/AIDS patients on Antiretroviral Therapy in Kenya.
Study design: Retrospective study.
Place and Duration of Study: Jomo Kenyatta University of Agriculture and Technology, between January 2019-April 2023
Methodology: The study involved a retrospective study of 2800 patients on Antiretroviral Therapy in Kenya from the period of 2005-2017. All the records are in terms of random patient id and in no way is the privacy and anonymity of patients is compromised. The inclusion criteria is patients who had complete information on the covariates used in the model over the follow up period. The logarithmic utility function, the negative exponential utility function and the power utility function are compared using the Akaike Information Criterion to determine which one best fits the empirical data to model the health and wealth trade off of patients on Antiretroviral Therapy in Kenya.
Results: Women constituted 66% of the sample. Only patients over the age of 18 years were included in the study. The mean age was 40.3. The health related quality of life values were calculated for each patient on Antiretroviral Therapy using the proxy utility function approach. The costs associated with receiving Antiretroviral Therapy treatment were obtained from simulating from a gamma distribution with ranges from existing published literature. The logarithmic utility function had the least AKaike Information Criterion.
Conclusion: The marginal utility of health increases with wealth for People living with HIV and the logarithmic utility function is suitable for modelling the shape of preferences for the trade off between health and wealth for HIV patients on Antiretroviral Therapy.

Keywords: Health; Utility; Wealth

1 Introduction

In low and middle income countries (LMICs), health policy makers, providers and development partners are setting up different healthcare initiatives in order to address the health challenges and needs of the population. These countries are setting up health care improvement systems in an attempt to achieve better health at a reduced cost for its population,(Ejughemre, 2013). Scarcity of resources has resulted to underfunded health systems in LMICs making access to decent health care services a challenge.

Governments and institutions are faced with the challenge of finding the right balance between prevention, treatment and care in order to achieve all technically feasible and potentially beneficial health care interventions, (Brazier et al., 2017). The Kenyan government is determined to improve the quality and access to healthcare in line with it’s Vision 2030 and Millenium Development Goals. For any given set of interventions for a disease, the challenge that arises is that resources are scarce. Choosing to allocate resources to one intervention brings about opportunity cost such that the prospects of allocating these resources to an alternative intervention is foregone,(Muennig and Bounthavong, 2016). This necessitates allocating these scarce resources to an intervention that yields optimal health and non health benefits to the population,(Peterson and Skolits, 2020).

HIV/AIDS has an effect on the survival of patients and their quality of life. Antiretroviral therapy (ART) is one of the treatments that people living with HIV (PLWHIV) are put on as a crucial HIV control measure. ART has been proven to extend patients’ survival years and reduce HIV morbidity by up to 85%,(Lara et al., 2008). This morbidity has an impact on a patients’ quality of life and is of increasing concern to decision makers. Chronic HIV infections have a negative public health impact thus adherence to ART treatment is vital. Nosyk et al. (2019) notes that in order to address the HIV epidemic, the goal should be to maximize on the quality adjusted life years(QALYs). However, ART therapy has been noted to be expensive and requires access to medical facilities and care.

Health and wealth are key factors that influence the well being of individuals,(Levy, 2012). PLWHIV are forced to make a trade off between health and wealth with regards to going for ART therapy a decision which has a social and economic effect. The costs associated with receiving ART treatment has contributed to non-adherence to continued ART use. In the Kenyan scenario, there is no empirical study on the utility of health and wealth for PLWHIV.

Utility theory is a theory that is postulated on the notion that individuals make decisions among competing alternatives based on the numerical representation of the perceived benefit of the alternatives, (Torrance, 1987). In health, utility is the benefit an individual perceives by receiving an intervention. Utility functions are used to analyse human behavior.

How the level of health is defined is key in the formulation of the utility function of health,(Levy, 2012).The health related quality of life(HRQoL) is a weight measuring the health of individuals as they receive treatment at different states. The utility weights lie between 0 and 1 signifying death and perfect health respectively,(Whitham et al., 2020). The time-trade off(Martin et al., 2000), Standard gamble (Bleichrodt and Johannesson, 1997), Visual analogue scale, EUROQoL-5D, Health Utility index and SF-6D are all approaches of calculating the HRQoL. In this study, the HRQoL of each patient has been calculated from the proxy utility function,(Deo and Grover, 2019). The HRQoL are used in the calculation of the QALYs to measure for impact of receiving a treatment to an individual,(Drummond et al., 2015).

Utility functions give the shape of preferences with regards to a particular intervention, (Viscusi, 1990). This research seeks to compare between the logarithmic function, the power function and the negative exponential utility function to determine which one shows the appropriate trade -off between wealth and health for PWLHIV on ART therapy. Previous studies have used the negative exponential utility function due to its analytical tractability of the function, but it has been criticized as having unrealistic properties (Markowitz et al., 1994). Other studies such as Merton and Samuelson (1974)advocate for the power utility function and Sinn (2003) advocate for the logarithmic utility function to model the preferences. Miyamoto (1999) formulated the standard linear, general multiplicative,

exponential multiplicative and power classes of QALY multiattribute utility models that are useful in health utility analyses.

This study aims at establishing the appropriate utility function for the wealth and health trade off to evaluate impact of health outcomes and health seeking behavior of patients receiving ART treatment in a setting of constrained resources. The objective of this study was to use the patient level utility values that change in health states and the associated costs to ascertain the best utility function.

2 Materials and Methods

2.1 Von Neumann-Morgenstern Utility Functions

Von Neumann-Morgenstern utility theory states that if an individual is faced with a choice of outcomes subject to various levels of probability, the optimal outcome is one that maximizes the expected value of the utility. The expected utility(EU) theory helps one to determine the health seeking behaviour of an individual based on their risk profiles. Under the EU framework, an individual is said to be risk averse if they prefer the expected value of a gamble to a gamble itself, with a concave curvature, risk seeking if they prefer a gamble to its expected value, with a convex curvature and risk neutral if always indifferent to a gamble and it's expected value with a linear curvature.

Let there be n discrete states of the world indexed by $j = 1; : : : ; n$ with each state having an associated health level Q_j and expenditure level C_j . The individual expected utility is given by the sum of the utilities in each health state weighted by the probability of p_j that that health state Q_j occurs, i.e:

$$EU = p_1U(Q_1;C_1) + p_2U(Q_2;C_2) + p_3U(Q_3;C_3) + : : : p_nU(Q_n;C_n) = \sum_{j=1}^{n} p_jU(Q_j;C_j) \quad (2.1)$$

where $Q_1;Q_2 : : : ;Q_n$ is the health at different health states/outcomes after receiving an intervention.
where $C_1;C_2 : : : ;C_n$ is the expenditure at different health states/outcomes while receiving an intervention.
where p_j is the probability of the utility at the different health states/outcomes.

Definition 2.1. Von Neumann-Morgenstern Axioms:

Peterson and Skolits (2020) show conditions that utility model must satisfy in order to be characterized within the expected utility theory.

_ Completeness
_ Transitivity
_ Independence
_ Continuity or archimedian axiom

Following the approach of Levy (2012) to develop the utility function of the health and wealth. Consider a general utility function of health state Q and expenditure C, i.e, $U(Q;C)$ where U is increasing or non-decreasing in both Q and C.

2.2 Logarithmic Utility function

The logarithmic utility function is defined by: $U(C) = \log(aC)$ implies that the utility of health and expenditure is given by:

$$U(Q;C) = Q{:}\log(aC) \quad (2.2)$$

where a is a scaling parameter in the economically relevant range aC _ 1. The utility function is

invariant to a positive linear transformation thus in the context of preferences over stochastic monetary alternatives, there is no difference between the utility function log(C) and log(aC) for any a > 0.
If we denote the maximal proportion of expenditure that an individual is willing to give up in order to be cured by x, we obtain:
Q:log(aC) = 1:log(aC(1 □ x)),
where Q:log(aC) is the utility without the treatment and 1:log(aC(1 □ x)) is the utility with the treatment-perfect health but only C(1 □ x) to consume. Thus we obtain:
$(aC)_Q$ = aC(1 □ x); x = 1 □
1
$(aC)_{1□Q}$ (2.3)

2.3 Power Utility Function

The power utility function is defined as: U(C) = $_{((C+A)1□\_)}$
$_{1□\_}$ with _ > 0.
This function reduces to the constant relative risk aversion (CRRA) case U(C) = $_{C1□\_}$
$_{1□\_}$ for A = 0.
The utility of health and expenditure is thus:
U(Q;C) = Q:
$(C + A)_{1□\_}$
1 □ _
(2.4)
This function is defined for C > □A, i.e. □A is the minimum consumption level required for existence.
The proportion of expenditure, x, that an individual with health Q and expenditure C is willing to incur for perfect health is given by the solution to:
Q:
$(C + A)_{1□\_}$
1 □ _
= 1:
$(C(1 □ x) + A)_{1□\_}$
1 □ _
(2.5)
which yields:
x = (1 +
A
Q
)(1 □ Q
^{1}
$_{(1□\_)}$) (2.6)
x decreases in Q and in perfect health (Q = 1), x = 0

2.4 Negative exponential utility function

The negative exponetial utility function is defined by U(C) = □$e_{□bC}$ is preferred because of it's analytic tractability properties. For U(C) _ 0, we must add a positive constant to this function. It hence becomes, U(C) = B □ $e_{□bC}$, with B > 0 and the relevant range of C is the range over which U(C) _ 0, i.e, C _ □$_{log(B)}$
$_b$.
Under this utility function the proportion ofx is given as the solution to:
Q:(B □ $e_{□bC}$) = 1:(B □ $e_{□bC(1□x)}$) (2.7)
which implies:
x =
1
bC
log(B(1 □ Q)e_{bC} + Q) (2.8)
In the relevant range B > $e_{□bC}$ x is decreasing in Q as expected.

2.5 Akaike Information Criterion

The Akaike Information Criterion (AIC), (Akaike, 1974) is used to determine which of the utility models best fits the empirical data.
AIC = □2:
L
n
+ 2:
k

n

(2.9)

where k is the number of free parameters in the model, the logarithmic utility function has 1 parameter while the negative exponential and power utility function each has 2 parameters, n is the number of observations, and L is the log likelihood function given by:

$$L = -\frac{n}{2}\left(1 + \ln(2\pi) + \ln\left(\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2\right)\right) \quad (2.10)$$

The model with the minimum AIC value assures a good balance of goodness of fit and complexity of the data.

The costs values are simulated from a gamma distribution based on published literature while the health utility values are calculated using the proxy utility approach. The simulated cost values are appropriate as they allow the testing of the predictions over a larger domain.

3 Results and Discussion

The simulations and model fitting to the data was done using R statistical package version 4.2.0. The main purpose of this study is to examine which between the logarithmic, power and negative exponential utility functions best describes individuals on ART therapy healthwealth trade-off choices. 2800 patients on ART over the period of 2005-2017 were sampled in the study.

Table 1 is a description of the socio-demographic characteristics of the patients on ART that were included in the study.

Table 1:Summary of the socio-demographics of the data

Variable	Description	Values/Code
Number of Participants	2800	
ID	Patient ID code	numbers
Sex	Female- 66.17% ;Male-33.83%	Female-0 ;Male-1
Age in (mean)	40.3 Years	
Marital Status	Married-60.1%;Single- 39.9%	Married-0;Single-1
Weight	Weight at each visit	numbers
Status	Dead or Alive%	Dead-1; Alive-0
Viral Load	Viral Load levels recorded	numbers
CD4 cell count	CD4 cell count recorded	numbers

The study comprised of 2800 patients on follow up ART treatment. Women comprised of 66.17% of the sample. The study included patients who were above 18 years of age with 60.1% being married. The weight of the patients at each visit was also recorded. The CD4 cell count and the Viral Load are the biomarkers of the patients that were measured to show disease progression.

3.1 Results of utility adjusted QALYs for patients on ART

Table 2 shows the results of the goodness of fit test of the logarithmic, negative exponential and power utility models to the empirical data. The second column gives the residual sum of squares for

each utility function, the third column provides the Akaike Information Criterion. The fourth column provides the ranking of the utility functions based on their goodness of fit as measured by the AIC.

Table 2: Results of the different utility functions

Utility function	Residual Sum of Squares	AIC	Rank of Utility Model
Logarithmic	2.15×10^{-3}	-23.3	1
Negative Exponential	3.12×10^{-3}	-19.2	2
Generalized power	1.07×10^{-2}	-13.2	3

The logarithmic utility function has the least AIC thus best fits the data of the trade off between health and wealth. The negative exponential utility function also fits quite okay.

4 CONCLUSIONS

a The marginal utility of health increases with wealth for PLWHIV on ART in Kenya.
b The logarithmic utility function is suitable for obtaining the trade off between wealth and health for PLWHIV in Kenya as it has the least AIC.
c The logarithmic utility function implies that optimal expenditure should be proportional to health for PLWHIV.

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Ethical Considerations

We used data with no personal identification for the analysis to maintain anonymity. We sort ethical approval from the JKUAT Institutional Scientific and Ethical Review Committee (ISERC) and the use of this data complies with the ethical guidelines defined for administrative and secondary data.

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