THE ECONOMICS OF SCHISTOSOMIASIS INTERVENTIONS

A case study of the Mwea irrigation scheme in Kenya

TWO VOLUMES

VOLUME 1

The Study

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CONTAINS PULLOUTS

ABSTRACT

When decisions to intervene in different schistosomiasis severity states are taken in isolation, inefficiencies are unavoidable due to failure to take account of crucial synergy between community and facility level options. To date no studies have been conducted of the sequential nature of schistosomiasis intervention decision-making processes. The main aim of this thesis is to develop methodologies that could be used to compute the costs and benefits of alternative strategies for ameliorating the burden of illness from schistosomiasis, with a view to discovering the strategy that would produce the greatest excess of benefits over cost. In other words, the goal is to develop conceptual frameworks that could be used to map out the most efficient path of intervention options across a spectrum of schistosomiasis states - asymptomatic, mild, moderate, severe, very severe and comatose.

Cost effectiveness (CEDA) and cost benefit (CBDA) decision analyses models are developed and their operational feasibility is demonstrated. To test the operational feasibility of the two models, the following data were used: expected costs of both primary and facility level options; health state (outcome) utility values; health states (outcomes) willingness to pay values; expected life in years at each of the health states (outcomes); health states and subjective transition probabilities; population forecasts for Mwea Scheme; discount factors for each year; and a constant opportunity cost per QALY. To facilitate the collection of these data, quality of life (QoL), willingness to pay (WTP), Delphi technique (DT) and costing instruments were developed and used to collect primary data.

In the CBDA and CEDA models, (a) all the schistosomiasis intervention strategies passed the net-effectiveness (NE) and net present value (NPV) tests; (b) all strategies involving treatment at the community level were superior to non-treatment community strategies; (c) in both CEDA and CBDA (with WTP to avoid advancing to the next state) the mass population praziquantel chemotherapy (MPCPS) was found to be the optimal strategy, and the choice of optimal policy combinations was also fairly similar; (d) in the CBDA model (with WTP for return to normal) the selective population praziquantel chemotherapy (SPCPS) was the optimal strategy; (e) the use of different sets of probabilistic effectiveness judgements led to a switch of optimal strategy from SPCPS (when local expert subjective probabilities were used) to MPCPS (when international expert judgements were used); (f) the sensitivity analysis results were

mixed. The non-conclusive nature of the above results indicate that firm policy conclusions cannot be drawn on the basis of current epidemiological information, and more research is urgently required to establish both the validity and reliability of the QoL, WTP and DT procedures developed and operationalized in the thesis.

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ABBREVIATIONS

A - Very severe schistosomiasis state A

CBA - Cost Benefit Analysis

CBDA - Cost Benefit Decision Analysis

CEA - Cost Effectiveness Analysis

CEDA - Cost Effectiveness Decision Analysis

CMA - Cost Minimization Analysis

CORT - Cut-Off Relaxed Technique

CS - Category Scaling

CUA - Cost Utility Analysis

DA - Decision Analysis

DALYs - Disability Adjusted Life Years

DCs - Developed Countries

DE - Development Expenditure

DHL - Day of Healthy Life

DM - Drip Molluscicding Option

DM+DNY - Drip Molluscicding and do nothing completely at Y

DM+OCD - Drip Molluscicding at primary level and Oxamniquine Care at the Dispensary for health state S cases

DM+OCDH - Drip Molluscicding at primary level and Oxamniquine Care at the District Hospital for health state Z cases

DM+OCHC - Drip Molluscicding at primary level and Oxamniquine Care at the Health Centre for health state K cases

DM+PCD - Drip Molluscicding at primary level and Praziquantel Care at the Dispensary for health state S cases

DM+PCDH - Drip Molluscicding at primary level and Praziquantel Care at the District Hospital for health state Z cases

DM+PCHC - Drip Molluscicding at primary level and Praziquantel Care at the Health Centre for health state K cases

DM+PGHDM - Drip Molluscicding at the primary level and Provincial General Hospital Drug Management for state A cases

DM+PGHIUC - Drip Molluscicding at the primary level and Provincial General Hospital Intensive Unit Care for state R cases

DM+PGHSO - Drip Molluscicding at the primary level and Provincial General Hospital Surgical Operation for state A cases

DM+PGHSQ - Drip Molluscicding at the Primary Level and Provincial General Hospital Status Quo for state A cases

DM+PGHSQR - Drip Molluscicding at the primary level and Provincial General Hospital Status Quo for state R cases

DM+SQD - Drip Molluscicding at the primary level and Status Quo at the Dispensary for health state S cases

DM+SQDH - Drip Molluscicding at the primary level and Status Quo at the District Hospital for health state Z cases

DM+SQHC - Drip Molluscicding at the primary level and Status Quo at the Health Centre for health state K cases

DMS - Drip Molluscicding Strategy

DNC - Do Nothing Completely option

DNCA - Do Nothing Completely at very severe state A

DNCK - Do Nothing Completely at moderate state K

DNCP - Do Nothing Completely at Primary level

DNCR - Do Nothing Completely at coma state R

DNCS - Do Nothing Completely at mild state S

DNCSS - Do Nothing Completely Strategy

DNCZ - Do Nothing Completely at severe state Z

DSS - Do Something at state S

DSK - Do something at state K

DSZ - Do something at state Z

DSA - Do something at state A

DSR - Do something at state R

DT - Delphi Technique

DVBD - Division of Vector-Borne Diseases

EMV - Expected Monetary Value

EQoL - Expected Quality of Life

EQALYs - Expected Quality Adjusted Life Years

EP - Environmental Pollution

FFD - Fauna and Flora Destruction

FM - Focal Mollusciciding Option

FM+DNY - Focal Mollusciciding and do nothing completely at Y

FM+OCD - Focal Mollusciciding at primary level and Oxamniquine Care at the Dispensary for health state S cases

FM+OCDH - Focal Mollusciciding at primary level and Oxamniquine Care at the District Hospital for health state Z cases

FM+OCHC - Focal Mollusciciding at primary level and Oxamniquine Care at the Health Centre for health state K cases

FM+PCD - Focal Mollusciciding at primary level and Praziquantel Care at the Dispensary for health state S cases

FM+PCDH - Focal Mollusciciding at primary level and Praziquantel Care at the District Hospital for health state Z cases

FM+PCHC - Focal Mollusciciding at primary level and Praziquantel Care at the Health Centre for health state K cases

FM+PGHDM - Focal Mollusciciding at the primary level and Provincial General Hospital Drug Management for state A cases

FM+PGHIUC - Focal Mollusciciding at the primary level and Provincial General Hospital Intensive Unit for state R cases

FM+PGHSO - Focal Mollusciciding at the primary level and Provincial General Hospital Surgical Operation for state A cases

FM+PGHSQ - Focal Mollusciciding at the primary level and Provincial General Hospital Status Quo for state A cases

FM+PGHSQR - Focal Mollusciciding at the primary level and Provincial General Hospital Status Quo for state R cases

FMS - Focal Mollusciciding Strategy

FM+SQD - Focal Mollusciciding at the primary level and Status Quo at the Dispensary for health state S cases

FM+SQDH - Focal Mollusciciding at the primary level and Status Quo at the District Hospital for health state Z cases

FM+SQHC - Focal Mollusciciding at the primary level and Status Quo at the Health Centre for health state K cases

GBD - Global burden of disease

GoK - Government of Kenya

GPV - Gross Present Value

GPV(B) - Gross Present Value of Benefits

GPV(C) - Gross Present Value of Costs

HCT - Hospitalization Care Time

HHED - Household Health Education Option

HHED+DNY - Household Health Education and do nothing completely at Y

HHED+OCD - Household Health Education at primary level and Oxamniquine Care at the Dispensary for health state S cases

HHED+OCDH - Household Health Education at primary level and Oxamniquine Care at the District Hospital for health state Z cases

HHED+OCHC - Household Health Education at primary level and Oxamniquine Care at the Health Centre for health state K cases

HHED+PCD - Household Health Education at primary level and Praziquantel care at the Dispensary for health state S cases

HHED+PCDH - Household Health Education at primary level and Praziquantel Care at the District Hospital for health state Z cases

HHED+PCHC - Household Health Education at primary level and Praziquantel Care at the Health Centre for state K cases

HHED+PGHDM - Household Health Education at the primary level and Provincial General Hospital Drug Management for state A cases

HHED+PGHIUC - Household Health Education at the primary level and Provincial General Hospital Intensive Unit Care for state R cases

HHED+PGHSO - Household Health Education at the primary level and Provincial General Hospital Surgical Operation for state A cases

HHED+PGHSQ - Household Health Education at the primary level and Provincial General Hospital Status Quo for state A cases

HHED+PGHSQR - Household Health Education at the primary level and Provincial General Hospital Status Quo for state R cases

HHEDS - Household Health Education Strategy

HHED+SQD - Household Health Education at Primary level and Status Quo at the Dispensary for health state S cases

HHED+SQDH - Household Health Education at primary level and Status Quo at the District Hospital for health state Z cases

HHED+SQHC - Household Health Education at primary level and Status Quo at the Health Centre for health state K cases

HR - Household Resources

HPWS - Household Piped Water Supply Option

HPWS+DNY - Household Piped Water Supply and do nothing completely at Y

HPWS+OCD - Household Piped Water Supply at primary level and Oxamniquine Care at the Dispensary for health state S cases

HPWS+OCDH - Household Piped Water Supply at primary level and Oxamniquine Care at the District Hospital for health state Z cases

HPWS+OCHC - Household Piped Water Supply at primary level and Oxamniquine Care at the Health Centre for health state K cases

HPWS+PCD - Household Piped Water Supply at primary level and Praziquantel Care at the Dispensary for health state S cases

HPWS+PCDH - Household Piped Water Supply at primary level and Praziquantel Care at the District Hospital for health state Z cases

HPWS+PCHC - Household Piped Water Supply at primary level and Praziquantel Care at the Health Centre for health state K cases

HPWS+PGHDM - Household Piped Water Supply at the primary level and Provincial General Hospital Drug Management for state A cases

HPWS+PGHIUC - Household Piped Water Supply at the primary level and Provincial General Hospital Intensive Unit Care for state R cases

HPWS+PGHSO - Household Piped Water Supply at the primary level and Provincial General Hospital Surgical Operation for state A cases

HPWS+PGHSQ - Household Piped Water Supply at the primary level and Provincial General Hospital Status Quo policy for state A cases

HPWS+PGHSQR - Household Piped Water Supply at the primary level and Provincial General Hospital Status Quo for state R cases

HPWS+SQD - Household Piped Water Supply at primary level and status Quo at the Dispensary for health state S cases

HPWS+SQDH - Household Piped Water Supply at primary level and Status Quo at the District Hospital for health state Z cases

HPWS+SQHC - Household Piped Water Supply at primary level and Status Quo at the Health Centre for health state K cases

HPWSS - Household Piped Water Supply Strategy

HRS - Household Resources

K - Moderate schistosomiasis state K

KEMRI - Kenya Medical Research Institute

KNIB - Kenya National Irrigation Board

LEG- Life Expectancy Gains

MoH - Ministry of Health

MPCO - Mass Population Chemotherapy with Oxamniquine Option

MPCO+DNY - Mass Population Chemotherapy with Oxamniquine and do nothing completely at Y

MPCO+OCD - Mass Population Chemotherapy with Oxamniquine at primary level and Oxamniquine Care at the Dispensary for health state S cases

MPCO+OCDH - Mass Population Chemotherapy with Oxamniquine at primary level and Oxamniquine Care at the District Hospital for health state Z cases

MPCO+OCHC - Mass Population Chemotherapy with Oxamniquine at primary level and Oxamniquine Care at the Health Centre for health state K cases

MPCO+PCD - Mass Population Chemotherapy with Oxamniquine at primary level and Praziquantel Care at the Dispensary for health state S cases

MPCO+PCHC - Mass Population Chemotherapy with Oxamniquine at primary level and Praziquantel Care at the Health Centre for health state K cases

MPCO+PGHDM - Mass Population Chemotherapy with Oxamniquine at the primary level and Provincial General Hospital Drug Management for state A cases

MPCO+PGHIUC - Mass Population Chemotherapy with Oxamniquine at the primary level and Provincial General Hospital Intensive Unit Care for state R cases

MPCO+PGHSO - Mass Population Chemotherapy with Oxamniquine at the primary level and Provincial General Hospital Surgical Operation for state A cases

MPCO+PGHSQ - Mass Population Chemotherapy with Oxamniquine at the primary level and Provincial General Hospital Status Quo for state A cases

MPCO+PGHSQR - Mass Population Chemotherapy with Oxamniquine at the primary level and Provincial General Hospital Status Quo for state R cases

MPCOS - Mass Population Chemotherapy with Oxamniquine Strategy

MPCO+SQD - Mass Population Chemotherapy with Oxamniquine at the primary level and Status Quo at the Dispensary for health state S cases

MPCO+SQDH - Mass Population Chemotherapy with Oxamniquine at the primary level and Status Quo at the District Hospital for health state Z cases

MPCO+SQHC - Mass Population Chemotherapy with Oxamniquine at the primary level and Status Quo at the Health Centre for health state K cases

MPCP - Mass Population Chemotherapy with Praziquantel Option

MPCP+DNY - Mass Population Chemotherapy with Praziquantel and do nothing completely at Y

MPCP+OCD - Mass Population Chemotherapy with Praziquantel at primary level and Oxamniquine Care at the Dispensary for health state S cases

MPCP+OCDH - Mass Population Chemotherapy with Praziquantel at primary level and Oxamniquine Care at the District Hospital for health state Z cases

MPCP+OCHC - Mass Population Chemotherapy with Praziquantel at primary level and Oxamniquine Care at the Health Centre for health state K cases

MPCP+PCD - Mass Population Chemotherapy with Praziquantel at primary level and Praziquantel Care at the Dispensary for health state S cases

MPCO+PCDH - Mass Population Chemotherapy with Oxamniquine at primary level and Praziquantel Care at the District Hospital for health state Z cases

MPCP+PCDH - Mass Population Chemotherapy with Praziquantel at primary level and Praziquantel Care at the District Hospital for health state Z cases

MPCP+PCHC - Mass Population Chemotherapy with Praziquantel at primary level and Praziquantel Care at the Health Centre for health state K cases

MPCP+PGHDM - Mass Population Chemotherapy with Praziquantel at the primary level and Provincial General Hospital Drug Management for state

A cases

MPCP+PGHIUC - Mass Population Chemotherapy with Praziquantel at the primary level and Provincial General Hospital Intensive Unit Care for state R cases

MPCP+PGHSO - Mass Population Chemotherapy with Praziquantel at the primary level and Provincial General Hospital Surgical Operation for state A cases

MPCP+PGHSQ - Mass Population Chemotherapy with Praziquantel at the primary level and Provincial General Hospital Status Quo for state A cases

MPCP+PGHSQR - Mass Population chemotherapy with Praziquantel at the primary level and Provincial General Hospital Status Quo for state R cases

MPCPS - Mass Population Chemotherapy with Praziquantel Strategy

MPCP+SQD - Mass Population Chemotherapy with praziquantel at the primary level and status Quo at the Dispensary for health state S cases

MPCP+SQDH - Mass Population Chemotherapy with Praziquantel at the primary level and Status Quo at the District Hospital for health state Z cases

MPCP+SQHC - Mass Population Chemotherapy with Praziquantel at the primary level and Status Quo at the Health Centre for health state K cases

NGO - Non-Governmental Organization

NPV - Net Present Value

OCD - Oxamniquine Care at the Dispensary

OCDH - Oxamniquine Care at the District Hospital

OCHC - Oxamniquine Care at the Health Centre

OMA - Output Maximization Analysis

OPC - Out of Pocket Costs (Expenditures)

PCD - Praziquantel Care at the Dispensary

PCDH - Praziquantel Care at the District Hospital

PCHC - Praziquantel Care at the Health Centre

PGHDM - Provincial General Hospital Drug Management

PGHIUC - Provincial General Hospital Intensive Unit Care

PGHSO - Provincial General Hospital Surgical Operation

PGHSQ - Provincial General Hospital Status Quo

PGHSQR - Provincial General Hospital Status Quo for state R

PLCOT - Project Life Cut-Off Technique

QALYs - Quality Adjusted Life Years

RE - Recurrent Expenditures

R - Schistosomiasis coma state

RCET - Randomized Controlled Effectiveness Trial

S - Mild Schistosomiasis State S

SCP - Schistosomiasis Control Programme

SG - Standard Gamble

SPCO - Selective Population Chemotherapy with Praziquantel Option

SPCO+DNY - Selective Population Chemotherapy with Oxamniquine and do nothing completely at Y

SPCO+OCD - Selective Population Chemotherapy with Oxamniquine at primary level and Oxamniquine Care at the Dispensary for health state S cases

SPCO+OCDH - Selective Population Chemotherapy with Oxamniquine at primary level and Oxamniquine Care at the District Hospital for health state Z cases

SPCO+OCHC - Selective Population Chemotherapy with Oxamniquine at primary level and Oxamniquine Care at the Health Centre for health state K cases

SPCO+PC D - Selective Population Chemotherapy with Oxamniquine at primary level and Praziquantel Care at the Dispensary for health state S cases

SPCO+PCDH - Selective Population Chemotherapy with Oxamniquine at primary level and Praziquantel Care at the District Hospital for health state Z cases

SPCO+PGHIUC - Selective Population Chemotherapy with Oxamniquine at the primary level and Provincial General Hospital Intensive Unit Care for state R cases

SPCO+PGHDM - Selective Population Chemotherapy with Oxamniquine at the

primary level and Provincial General Hospital Drug Management for state A cases

SPCO+PGHSQR - Selective Population Chemotherapy with Oxamniquine at the primary level and Provincial General Hospital Status Quo for state R cases

SPCP+PGHIUC - Selective Population Chemotherapy with Praziquantel at the primary level and Provincial General Hospital Intensive Unit Care for state R cases

SPCO+PGHSO - Selective Population Chemotherapy with Oxamniquine at the primary level and Provincial General Hospital Surgical Operation for state A cases

SPCO+PGHSQ - Selective Population Chemotherapy with Oxamniquine at the primary level and Provincial General Hospital Status Quo for state A cases

SPCP+PGHSQR - Selective Population Chemotherapy with Praziquantel at the primary level and Provincial General Hospital Status Quo for state R cases

SPCOS - Selective Population Chemotherapy with Oxamniquine Strategy

SPCO+SQD - Selective Population Chemotherapy with Oxamniquine at the primary level and Status Quo at the Dispensary for health state S cases

SPCP+OCD - Selective Population Chemotherapy with Praziquantel at primary level and Oxamniquine Care at the Dispensary for health state S cases

SPCO+PCHC - Selective Population Chemotherapy with Oxamniquine at primary level and Praziquantel Care at the Health Centre for health state K cases

SPCO+SQDH - Selective Population Chemotherapy with Oxamniquine at the primary level and Status Quo at the District Hospital for health state Z cases

SPCO+SQHC - Selective Population Chemotherapy with Oxamniquine at the primary level and Status Quo at the Health Centre for health state K cases

SPCP - Selective Population Chemotherapy with Praziquantel Option

SPCP+DNY - Selective Population Chemotherapy with Praziquantel and do nothing completely at Y

SPCP+OCDH - Selective Population Chemotherapy with Praziquantel at primary level and Oxamniquine Care at the District Hospital for health state Z cases

SPCP+OCHC - Selective Population Chemotherapy with Praziquantel at primary level and Oxamniquine Care at the Health Centre for health state K cases

SPCP+PCD - Selective Population Chemotherapy with Praziquantel at primary level and Praziquantel Care at the Dispensary for health state S cases

SPCP+PCDH - Selective Population Chemotherapy with Praziquantel at primary level and Praziquantel Care at the District Hospital for health state Z cases

SPCP+PCHC - Selective Population Chemotherapy with Praziquantel at primary level and Praziquantel Care at the Health Centre for health state K cases

SPCP+PGHDM - Selective Population Chemotherapy with Praziquantel at the primary level and Provincial General Hospital Drug Management for state A cases

SPCP+PGHSO - Selective Population Chemotherapy with Praziquantel at the primary level and Provincial General Hospital Surgical Operation for state A cases

SPCP+PGHSQ - Selective Population Chemotherapy with Praziquantel at the primary level and Provincial General Hospital Status Quo for state A cases

SPCPS - Selective Population Chemotherapy with Praziquantel Strategy

SPCP+SQD - Selective Population Chemotherapy with Praziquantel at the primary level and Status Quo at the Dispensary for health state S cases

SPCP+SQDH - Selective Population Chemotherapy with Praziquantel at the primary level and Status Quo at the District Hospital for health state Z cases

SPCP+SQHC - Selective Population Chemotherapy with Praziquantel at the primary level and Status Quo at the Health Centre for health state K cases

SQ - Status Quo Option

SQD - Status Quo at the Dispensary

SQDH - Status Quo at the District Hospital

SQ+DNY - Status Quo at primary level and do nothing completely at Y

SQHC - Status Quo at the Health Centre

SQ+OCD - Status Quo at primary level and Oxamniquine Care at the Dispensary for health state S cases

SQ+OCHC - Status Quo at primary level and Oxamniquine Care at the Health Centre for health state K cases

SQ+PCD - Status Quo at primary level and Praziquantel Care at the Dispensary for health state S cases

SQ+OCDH - Status Quo at primary level and Oxamniquine Care at the District Hospital for health state Z cases

SQ+PCDH - Status Quo at primary level and Praziquantel Care at the District Hospital for health state Z cases

SQ+PCHC - Status Quo at primary level and Praziquantel Care at the Health Centre for health state K cases

SQ+PGHDM - Status Quo at the primary level and Provincial General Hospital Drug Management for state A cases

SQ+PGHIUC - Status Quo at the primary level and Provincial General Hospital Intensive Unit Care for state R cases

SQ+PGHSO - Status Quo at the primary level and Provincial General Hospital Surgical Operation for state A cases

SQ+PGHSQ - Status Quo at the primary level and Provincial General Hospital Status Quo for state A cases

SQ+PGHSQR - Status Quo at the primary level and Provincial General Hospital Status Quo for state R cases

SQ+SQD - Status Quo at primary level and Status Quo at the Dispensary for health state S cases

SQ+SQDH - Status Quo at primary level and Status Quo at the District Hospital for health state Z cases

SQ+SQHC - Status Quo at primary level and Status Quo at the Health Centre for health state K cases

SQS - Status Quo Strategy

TBOIS - Total Burden of Illness Studies

TC - Treatment Cost

TT - Travel Time

TTO - Time Trade-Off

VIPL - Vented Improved Pit Latrine Option

VIPL+DNY - Vented Improved Pit Latrine and do nothing completely at Y

VIPL+OCD - Vented Improved Pit Latrine at primary level and Oxamniquine Care at the Dispensary for health state S case

VIPL+OCDH - Vented Improved Pit Latrine at primary level and Oxamniquine Care at the District Hospital for health state Z case

VIPL+OCHC - Vented Improved Pit Latrine at primary level and Oxamniquine Care at the Health Centre for health state K case

VIPL+PCD - Vented Improved Pit Latrine at primary level and Praziquantel Care at the Dispensary for health state S cases

VIPL+PCDH - Vented Improved Pit Latrine at primary level and Praziquantel Care at the District Hospital for health state Z cases

VIPL+PCHC - Vented Improved Pit Latrine at primary level and Praziquantel care at the Health Centre for health state K cases

VIPL+PGHDM - Vented Improved Pit Latrine at the primary level and Provincial General Hospital Drug Management for state A cases

VIPL+PGHIUC - Vented Improved Pit Latrine at the primary level and Provincial General Hospital Intensive Unit Care for state R cases

VIPL+PGHSO - Vented Improved Pit Latrine at the primary level and Provincial General Hospital Surgical Operation for state A cases

VIPL+PGHSQ - Vented Improved Pit Latrine at the primary level and Provincial General Hospital Status Quo for state A cases

VIPL+PGHSQR - Vented Improved Pit Latrine at the primary level and Provincial General Hospital Status Quo for state R cases

VIPLS - Vented Improved Pit Latrine Strategy

VIPL+SQD - Vented Improved Pit Latrine at primary level and Status Quo at the Dispensary for health state S cases

VIPL+SQDH - Vented Improved Pit Latrine at primary level and Status Quo at the District Hospital for health state Z cases

VIPL+SQHC - Vented Improved Pit Latrine at primary level and Status Quo at

the Health Centre for health state K cases

WT - Waiting Time

WTP - Willingness to Pay

Y - Normal Health State

Z - Severe schistosomiasis state Z

PART I: INTRODUCTION

CHAPTER 1
INTRODUCTION:
PURPOSE AND SCOPE

1.1 Research Problem

1.1.1 *Background*

Schistosomiasis might be a social problem in areas where it is endemic, since it is alleged to have adverse effects on quantity and quality of lives of patients (actual and potential); retard growth in children; impose monetary and psychological costs on patients and their families; divert Ministry of Health (MoH) resources from competing uses; impair learning; and impair labour productivity. However, the Kenya Government has no clear policy for combatting the problem.

The agencies in charge of schistosomiasis control activities in Mwea Scheme (the main irrigated area where schistosomiasis is endemic in Kenya) are the Kenya National Irrigation Board (KNIB), the Division of Vector Borne Diseases (DVBD), the Kenya Medical Research Institute (KEMRI) and various Ministry of Health facilities (Dispensaries, the Health Centre, the District Hospital and the Provincial General Hospital). These agencies have implemented the current pattern of intervention without any economic appraisal. The KNIB is involved in environmental management, sanitation, molluscicide and sporadic treatments. The KEMRI has been involved in digging water bore holes (which are non-functional most of the time) and has conducted occasional small scale experimental chemotherapy exercises. The DVBD is responsible for haphazard screening of those patients who present themselves at the Kimbimbi Health Centre and occasional treatment of school children. The MOH facilities serve patients who present themselves for treatment. Due to lack of an overall schistosomiasis control policy, there is no co-ordination between the agencies.

Most of the "economic" studies reviewed in chapter 4 on schistosomiasis are accounting descriptive cost studies, hardly making a comparison of alternative options (Mills, 1985). Others are descriptive cost-outcome studies. There are a few cost-effectiveness studies of some modes of chemotherapy delivery (Rosenfield et al.,

1977;Prescott, 1987; Guyatt and Evans, 1992; Swiss Tropical Research Institute, 1993). All studies so far seem to have ignored the fact that schistosomiasis intervention decisions are of sequential nature and, by so doing, they may have misled decision making.

My argument is that, in an environment where decisions to intervene at different schistosomiasis severity states are taken in isolation, inefficiencies are inevitable. This is because the preventive action taken at the community level determines the distribution pattern of the Mwea population across various health states, and hence, the numbers of patients seeking care across the hierarchy of public and private health facilities.

The purpose of this thesis is to develop a decision theoretic framework which can be used to determine the optimal schistosomiasis intervention strategy. A strategy is defined as an intervention path involving community level preventive policy and intervention options for each of the five schistosomiasis health states (mild, moderate, severe, very severe and comatose).

1.1.2 *Methodological objectives*

The main research objectives of this thesis are to:

(a) Identify possible ways of ameliorating the schistosomiasis problem; develop rational criteria that can be used to reduce a long-list of interventions to a short, analytically tractable, list; demonstrate its use; develop strategies and generate policy combinations that reflect the synergy between primary and secondary interventions.

(b) Develop a cost-benefit decision analysis (CBDA) model for identifying the optimal schistosomiasis intervention strategy and then demonstrate its operational feasibility.

(c) Develop a cost-effectiveness decision analysis (CEDA) model for identifying the optimal schistosomiasis intervention strategy and then demonstrate its operational feasibility.

(d) Identify the types of data that would be needed to estimate both the CBDA and CEDA models.

(e) Develop an health related quality of life (QoL) measure and test its operational feasibility in a population survey.

(f) Develop an health outcome willingness to pay (WTP) measure and test its operational feasibility in a population survey.

(h) Develop an instrument for eliciting expert subjective probability judgements of the effectiveness of schistosomiasis interventions and test its operational feasibility.
(i) Develop a costing methodology and demonstrate its operational feasibility.
(j) Provide an analysis of the adequacy of the existing information base, especially epidemiological, QoL, WTP and costing data.
(k) Assess the adequacy of procedures for making policy recommendations.

1.2 Illustrative policy questions

As will be seen, there is sufficient uncertainty surrounding some of the crucial parameter values to make it hazardous to infer policy recommendations from the findings of the CBDA and CEDA models. The long-term aim remains, nevertheless, the collection of reliable and valid data that would enable policy-makers to address some of the key strategic issues in schistosomiasis control. Some of these questions are as follows:
(a) From the social perspective, is it worth continuing the status quo (SQS) schistosomiasis intervention strategy instead of either household piped water supply (HPWSS), household health education visits (HHEDS), household vented improved pit latrines (VIPLS), focal mollusciciding (FMS), drip mollusciciding (DMS), mass population chemotherapy with praziquantel (MPCPS), mass population chemotherapy with oxamniquine (MPCOS), selective population chemotherapy with praziquantel (SPCPS), or selective population chemotherapy with oxamniquine (SPCOS) strategies?
(b) Which of the ten schistosomiasis intervention strategies promises the highest net health benefit?
(c) From the social perspective, is it worth continuing the status quo (SQ) schistosomiasis primary option instead of either household piped water supply (HPWS), household health education visits (HHED), household vented improved pit latrines (VIPL), focal mollusciciding (FM), drip mollusciciding (DM), mass population chemotherapy with praziquantel (MPCP), mass population chemotherapy with oxamniquine (MPCO), selective population chemotherapy with praziquantel (SPCP), or selective population chemotherapy with oxamniquine (SPCO) options?
(d) Which of the ten schistosomiasis primary (or community level) interventions promises the highest net health benefit?

(e) From the social perspective, if the SQ (or HPWS, HHED, VIPL, FM, DM, MPCP, MPCO, SPCP, SPCO) is implemented at the community level, would it be more beneficial to provide either praziquantel care at the dispensary (PCD) or oxamniquine care at the dispensary (OCD), instead of status quo at the dispensary (SQD) policy for those suffering mild schistosomiasis?

(f) From the social perspective, if the SQ (or HPWS, HHED, VIPL, FM, DM, MPCP, MPCO, SPCP, SPCO) is implemented at the community level, would it be more beneficial to provide either praziquantel care at the health centre (PCHC) or oxamniquine care at the health centre (OCHC), instead of the health centre status quo (SQHC) policy for those suffering moderate schistosomiasis?

(g) From the social perspective, if the SQ (or HPWS, HHED, VIPL, FM, DM, MPCP, MPCO, SPCP, SPCO) is implemented at the community level, would it be more beneficial to provide either praziquantel care at the District Hospital (PCDH) or oxamniquine care at the District Hospital (OCDH), instead of status quo at the District Hospital (DHSQ) policy for those suffering severe schistosomiasis?

(h) From the social perspective, if the SQ (or HPWS, HHED, VIPL, FM, DM, MPCP, MPCO, SPCP, SPCO) is implemented at the community level, would it be more beneficial to provide either the Provincial General Hospital drug management (PGHDM) or the Provincial General Hospital surgical operation (PGHSO), instead of the provincial general hospital status quo (PGHSQ) policy for those suffering very severe schistosomiasis?

(i) From the social perspective, if the SQ (or HPWS, HHED, VIPL, FM, DM, MPCP, MPCO, SPCP, SPCO) is implemented at the community level, would it be more beneficial to provide either the Provincial General Hospital Intensive Unit care (PGHIUC) or the Provincial General Hospital status quo (PGHSQR) policy for the comatose schistosomiasis cases?

(j) Are primary interventions more cost-effective than secondary interventions?

(k) Are mass population chemotherapy options more cost-effective than selective population chemotherapy options?

(l) Is praziquantel more cost-effective than oxamniquine?

(m) Which strategies promise greater health benefits: treatment or non-treatment intervention strategies?

(n) Are the least costly strategies and policy combinations necessarily the most

beneficial?

1.3 Review of Epidemiology of Schistosomiasis

Most schistosomiasis intervention studies have used the before-after approach, whose major setback is the attribution of a proportion of the change in health indicator(s) to the intervention(s) under consideration as distinct from extraneous or confounding factors. The intervention studies needed for use in economic evaluations are randomized controlled effectiveness trials (RCETs), but none exists. The reviewed epidemiological studies on schistosomiasis do not use the measures of ultimate intervention outcomes (i.e. the improvement in quality and quantity of lives). The global morbidity indicators such as prevalence and incidence rates say nothing about the continuum of schistosomiasis disease severity stages. It may be more cost-effective to intervene at some severity stages than others. A partial objective of this thesis is to investigate whether that is the case. The above issues are discussed at length in chapter 4.

1.4 Review of Economic Literature

This section briefly reviews the economic literature of schistosomiasis under the following sub-topics: cost description analysis, cost-outcome analysis, cost effectiveness analysis, and total burden of illness. A fuller analysis is in chapter 3.

1.4.1 *Total burden of illness*

The objective of total burden of illness studies (TBOIS) is to estimate total economic losses from specific diseases. Such studies have numerous deficiencies: their methodologies omit important welfare effects such as disability, distress, and anxiety; they operate on the assumption that a perfect labour market exists (which may be untenable); they take into account only those people in the active labour force - omitting the self-employed, aged, handicapped, and children; they give no consideration to the impact of disease on persons' health status per se; they use expenditure data instead of opportunity costs; and, most fundamentally of all, since eradication of schistosomiasis

is an unattainable objective, the estimation of its potential benefits cannot inform the decisions that must, in reality, be taken. Although the TBOIS architects claim that their estimates constitute important inputs in the process of priority setting, it is difficult to perceive the usefulness of such estimates, since they provide neither total nor marginal estimates of the pay offs to specific (and practicable) policy options.

1.4.2 *Descriptive cost studies*

A key attribute of these studies is that they describe the cost (mostly accounting costs) of a single intervention. Examples of these studies are Highton et al. (1974), Choudhry (1974) and Choudhry (1975). Their main weaknesses are: failure to discount the flow of future programme costs; use of unadjusted market prices; use of accounting costs instead of the relevant economic/opportunity costs; calculation of "total costs" instead of marginal costs; ignorance of intervention consequences; failure to evaluate alternative interventions; omission of sensitivity analysis; and omission of important intervention cost components, such as community inputs.

1.4.3 *Cost-outcome studies*

There are many cost-outcome studies of schistosomiasis interventions (Jordan et al., 1978; Jobin, 1979; Jordan et al., 1982a; Jordan et al., 1982b; Prentice et al., 1981; etc.). They generally have the following drawbacks: they appraise only costs and outcome(s) of a single option; they omit many major cost components, e.g. costs met by patients and their families; they are based on historical accounting costs instead of opportunity costs; they measure outcomes using crude proxies, using such intermediate indicators as cases treated; they assume that all costs and consequences occur within a single year (ignoring the fact that virtually all schistosomiasis interventions have long time horizons); they use no sensitivity analysis; and they do not calculate incremental costs.

1.4.4 *Cost effectiveness studies*

Although the literature on the economics of schistosomiasis is littered with many studies bearing the tag "cost-effectiveness analysis" (CEA), very few are true CEA studies. By definition, economic evaluation involves a comparative analysis of alternative courses of action in terms of both their costs and benefits (Drummond et al., 1987). Any study which does not compare the costs and consequences of two or more alternative schistosomiasis intervention policies is not a cost-effectiveness study. Most of the studies that qualify to be CEA suffer virtually all the deficiencies mentioned in the preceding subsection.

1.5 Organization of the Rest of the Thesis

The thesis is divided into four parts. Part I is the introduction. Part II is a literature survey. Chapter 2 reviews the epidemiology of schistosomiasis. The first section provides a brief description of the geographical distribution of schistosomiasis. The second section describes the life cycle of the schistosome parasite, upon which the choice of intervention measures hinges. The third section delineates the four disease stages of *Schistosoma mansoni* (the only species of schistosome found in Mwea Scheme) and the morbidity corresponding to each phase of the schistosome life cycle. The fourth section reviews the schistosomiasis intervention literature. The chapter ends with a discussion of the social problems alleged to be caused by schistosomiasis. Chapter 3 is a review of the relevant economics literature. Section 1 summarizes the main economic evaluation methods, namely cost minimization analysis, outcome maximization analysis, cost effectiveness analysis, cost utility analysis and cost benefit analysis. Section 2 critically reviews cost description, cost-outcome, cost-effectiveness and total burden of illness studies on schistosomiasis disease. The chapter concludes with an overview of the decision analysis approach to be used in the thesis. Chapter 4 reviews the measurement of health. The chapter provides a chronological review of health indicators: mortality rates; clinical outcome measures (clinical judgement; laboratory tests; radiological tests); proximate measures (expressing health care resources as ratios of catchment population); intermediate output measures (throughput, global morbidity indices); health profiles (e.g. Independence in Activities of Daily Living, Seattle

Sickness Impact Profile, DUKE-UNC Health Profile, Nottingham Health Profile, Spitzer Quality of Life Index, Karnofsky Performance Index, and Rosser Kind scale). We need health status indexes for comparison, evaluation, allocation (social choices), monitoring, forecasting, compensation, incentives, budgeting and theorizing purposes. The Days of Healthy Life Index developed for measuring total impact of disease is critically reviewed. The Quality Adjusted Life Years Index is surveyed. The chapter concludes with a discussion of issues surrounding the QALY index.

Part III deals with the economic appraisal of schistosomiasis intervention strategies. It consists of four chapters. Chapter 5 develops policy options. Section 1 generates a long-list of primary interventions. Section 2 generates a long-list of secondary options. Section 3 discusses the criteria used in pruning the long lists of options to a manageable size. The chapter ends with brief discussions of strategies and policy combinations whose costs and benefits will have to be estimated. Chapter 6 develops decision theory for schistosomiasis interventions. It develops a conceptual framework within which potential schistosomiasis intervention benefits and costs can be identified, quantified, valued and compared. Section 1 develops the decision tree model. Section 2 develops a cost-effectiveness decision analysis model. Section 3 develops a cost-benefit decision analysis model. The chapter ends with an outline of data needs. Chapter 7 explains the methodology of benefit measurement. Section 1 discusses the quality of life instrument and its measurement. Section 2 discusses the willingness to pay instrument and its measurement. Section 3 discusses the Delphi expert technique and probability estimates. Sections 4 and 5 are preliminary analyses of expected quality adjusted life years and expected monetary values for various policy combinations. Chapter 8 explains the methodology of cost measurement. Section 1 is the primary interventions cost algorithm. Section 2 analyzes primary interventions cost results. Section 3 discusses the dispensary-, health centre-, district hospital- and provincial hospital-based schistosomiasis intervention cost algorithms and preliminary results.

Part IV reports the empirical results of the decision analysis. It consists of two chapters. Chapter 9 reports the decision analysis results from the cost-effectiveness and cost-benefit decision analysis models. The chapter compares the results from the two models and provides possible explanations for the differences. Chapter 10 evaluates the extent to which methodological objectives stated in this chapter have been achieved. In addition, the chapter attempts to draw methodological conclusions and to make

suggestions for future research.

PART II: LITERATURE SURVEY

CHAPTER 2
THE EPIDEMIOLOGY OF SCHISTOSOMIASIS

2.0 Introduction

This chapter provides a brief review of the general spatial distribution of schistosomiasis; the life cycle of the schistosome parasite; the morbidity caused by *Schistosoma mansoni*; describes the main schistosomiasis intervention studies and the social problems likely to be caused by schistosomiasis disease. The health states descriptions developed in chapter 7 are related to the clinical severity states reviewed in this chapter. Most of the studies reviewed were before-and-after intervention studies, with a few clinical drug efficacy studies. None of the epidemiological studies is appropriate for use in economic evaluation. The studies needed in economic evaluations are randomized controlled effectiveness trials (Mills, 1985 and Drummond, 1987); which are totally lacking.

2.1 Spatial Distribution of Schistosomiasis

Schistosomiasis or Bilharziasis [named after a German pathologist - Theodore Bilharz - who discovered schistosome eggs in 1852 while performing an autopsy in Cairo] is ranked by W.H.O. as second only to malaria in public health importance. The disease is widely spread throughout the tropical and semi-tropical climatic zone of the world where most of the developing countries are situated. There are now 76 countries in which schistosomiasis is endemic, with more than 600 million people at risk of infection and some 200 million infected. In Kenya the whole population of 24 million people is at risk of infection. Approximately 6 million people are already infected (W.H.O., 1989).

The disease spreads through contact with water contaminated by the schistosome parasite (cercariae) and is primarily acquired in childhood but reinfections (after cure) later in life are the rule. Thus, any socio-economic, cultural, and environmental factors which bring people in touch with schistosome infected waters propagate the disease (Farooq et al., 1966).

Three of the many species of schistosome are important causes of human infection: *Schistosoma mansoni*, which is responsible for intestinal schistosomiasis in Africa, the Eastern Mediterranean, parts of the Latin America and the Caribbean; *Schistosoma haematobium*, which is responsible for urinary schistosomiasis in Africa and the Middle East; and *Schistosoma japonicum*, which causes intestinal schistosomiasis in China, Japan, the Philippines and elsewhere in Asia (WHO, 1988; W.H.O., 1989). The former two types of schistosomiasis are common in Kenya. However, only *Schistosoma mansoni* is found in the Mwea irrigation scheme. The three different parasites (*Schistosoma Mansoni*, *Schistosoma Japonicum*, and *Schistosoma Haematobium*) are epidemiologically distinct, produce different clinical syndromes and are located in different anatomical areas of the body (Davis, 1986).

2.2 Life Cycle of Schistosome

All species of the schistosome have developmental stages in an intermediate host, the fresh water snail, from which free swimming cercariae worms are shed to penetrate the skin of the definitive human host when it comes into contact with water. After a successful penetration of the skin, the cercariae transform into schistosomula, which migrate through veins and lymph vessels to the lungs. From there they migrate to the liver, developing into young male and young female worms in the portal blood vessels. After 4-6 weeks, mating takes place and the worm pairs move to their final destination, which in urinary schistosomiasis is the vessels of the bladder and, in intestinal schistosomiasis, those of the intestines. Some eggs, produced by the female worm, work their way through the vessel walls and are shed in urine or faeces (mixed with blood), completing the cycle if they reach water, where free swimming larvae (miracidium), hatched from the eggs, can encounter the snail intermediate host. Many other eggs are retained in human tissues where they provoke inflammatory reaction. It is this reaction that is responsible for the disease. The mere presence in the blood stream of the adult schistosomes (which remain joined and continue to shed eggs for several years) does not give rise to any pathological response. However, the degree of morbidity and the intensity of infection are determined by the number of adult worms in the human host, as they shed eggs that may be deposited in organ tissue (W.H.O., 1989). One must distinguish between infection (the invasion of an individual by a disease causing

organism - the schistosome) and disease (the organic damage due to the invasion).

Epidemiologists seek to measure the intensity (via parasite egg counts) of infection and the severity (based on clinical symptoms) of disease. Intensity refers to the number of schistosome worms which have infected an individual. On the other hand, severity of disease refers to the extent of organic damage that has been produced by schistosome parasite invasion. Severity reflects the number of schistosome worms that the individual harbours, their stage of development and the duration of infection, as well as such aspects of general health status as nutrition, concurrent infections, age and sex (Rosenfield et al., 1984).

People infected by schistosomiasis can be categorized as symptomatic (those with manifest symptoms) and asymptomatic (those infected but without manifest symptoms). The former category can further be broken down along a clinical disease severity continuum: (a) mild infection, (b) moderate infection (manifested in heavy egg load), (c) severe disease, and (d) very severe disease (Farooq, 1963; Prescott, 1979). One can add normal health, comatose and death to the above stages to complete the continuum.

2.3 Morbidity Related to *Schistosoma Mansoni*

Schistosoma mansoni disease is mainly due to eggs deposited in host tissue by the adult female worms which induce inflammatory and fibrotic lesions in the following host organs: liver, spleen, intestines (small and large), lungs, heart, central nervous system and endocrine glands. Four disease stages corresponding to disparate parts of the schistosome life cycle in man can be delineated as follows:

(i) '*Kabure* Itch'

Cercarial invasion may induce a prickling sensation or itching of the skin after immersion in infected water. Visible skin reactions, ranging from a few minute petechiae (red or purple, flat, pin head spots that occur in the skin) to urticaria (a skin condition characterized by the development of itchy weals) or a puric papular eruption (skin rash caused by cercarial penetration) may be seen in non-immune subjects.

(ii) *Katayama* Syndrome

The main clinical manifestations of the acute infection include fever (with intermittent or remittent peaks in the evening), rigor, sweating, headache, general muscular pain, unproductive cough, abdominal pain, diarrhoea, urticaria, focal oedema, anorexia, lymphadenopathy and loss of weight. On physical examination, the liver is usually tender and enlarged, with or without a slightly enlarged and soft spleen (Davis, 1986; W.H.O., 1988).

Maturation of schistosome worms with migration to their preferred anatomical intravascular locations, followed by pairing and egg laying, produces a generalized hyper- allergic reaction responsible for acute phase symptoms. Farid et al. (1976) established that regardless of whether persons are visitors or native inhabitants, any initial contact with *Schistosoma mansoni* cercariae infested waters by non-immune persons can lead to acute disease, even if exposure is minimal and the infection is light. The incubation period of the Katayama Syndrome ranges from four to eighty seven days, but is generally between three and seven weeks. Generally, in a small proportion of the infections acute symptoms can start before egg deposition by the female worms (Hiatt et al., 1979). However, in most cases symptoms usually intensify when egg laying has started (Nash et al., 1982). Symptoms last for a few weeks to several months and gradually abate without therapeutic intervention (Nash et al., 1982). Among people living in endemic areas the acute phase may pass imperceptibly. During the acute phase of *Schistosoma mansoni* infection, death is exceptional (Nash et al., 1982).

(iii) The Intense egg laying phase

Intensive egg laying occurs and results in excretion of eggs in stools. The pathological sequelae of these worm activities are characterized by local tissue inflammatory reactions and granuloma formation around deposited eggs. The presenting clinical syndromes vary markedly in *Schistosoma mansoni* infections. Inhabitants of endemic areas may be symptom-free or have vague non-pathogenic abdominal complaints. Acute schistosomal dysentery is most uncommon but intermittent bouts of loose stools or diarrhoea may occur and blood is occasionally passed in stools. Diffuse abdominal pain or discomfort is frequent. Anorexia, nausea and weight loss may be

found singly or in combination (Davis, 1986).

There is disagreement as to whether egg production by *S.mansoni* is influenced by a density dependent factor, i.e., the number of eggs in faeces per worm pair decreases as the number of worm pairs in a person increase, as seen in some other intestinal helminth infections.

The Kato (i.e. cellophane thick faecal smear) technique (Jordan, 1985) has become a standard diagnostic tool, in epidemiological studies. It provides a direct measure of the number of eggs of the parasite in stools.

(iv) The Chronic Phase

The final, chronic stage, is marked by progressive fibrous tissue formation around pre-existing granulomata, and egg excretion in the excreta is often diminished by several orders of magnitude (Davis, 1986). As the clinical manifestations of the preceding stage subside, those infected can be symptom free and evolve to the chronic state (Nash et al., 1982). Most chronic infections are seen in asymptomatic inhabitants in endemic areas.

During the chronic phase the disease manifests itself in the following organs:

(a) Liver - causing hepatic schistosomiasis. Characterized by portal hypertension caused by changes that affect both the portal system and the hepatic artery. Pathological changes produce functional and obstructive changes in the portal system. Fibrous liver may lead to cancer. Damaged liver may lead to hepatic coma.

(b) Spleen - causing splenomegaly (spleen enlargement). Splenomegaly results from chronic passive congestion and hyperplasia of the reticula-endothelial system.

(c) Intestine - The main intestinal lesions due to *Schistosoma mansoni* infection are colonic polyposis and focal fibrosis and inflammation (Nash et al., 1982). In Cheever et al. (1978), *Schistosoma mansoni* infection is associated with colonic polyposis, which was the cause of death in 3 heavily infected subjects. Abdominal tumours have also been reported.

(d) Lung and heart - Shaw (1938) and Nash et al. (1982) have documented pulmonary hypertension and cor pulmonale induced by pulmonary arteritis as a result of *Schistosoma mansoni* egg deposition. Such pathological effects are due to collateral circulation in patients with liver fibrosis and portal hypertension which provides direct access of eggs to the lung (Sadigursky et al., 1976).

(e) Central nervous system - Schistosomes or their eggs may reach the central nervous system, and may cause inflammatory reactions and lesions. Central nervous system manifestations such as transverse myelitis or epileptiform seizures have been documented (WHO, 1988).

In conclusion, the basic pathological change in *S.mansoni* is the egg granuloma with inflammatory and fibrotic reactions. Intensity of the infection is a major factor which influences the clinical manifestations and severity of the disease but other factors, such as superimposed infections, malnutrition and genetic background, may also play a role. Most persons in endemic areas with light infections are asymptomatic. Intestinal disease is mainly seen in the large intestine. The infection finally causes liver fibrosis and portal hypertension. Its sequela, upper gastrointestinal bleeding from oesophageal varices, is the major cause of mortality from the disease. Hepatic coma may ensue. Deterioration of liver function and chronic hepatic failure can be expected. Egg deposits in the pulmonary vessels causing pulmonary hypertension and cor pulmonale, and deposits of *Schistosoma mansoni* immune complexes in the glomeruli inducing glomerulonephritis, are usually found in fibrotic liver disease. Assessment of morbidity is mainly based on clinical features, stool egg count and other laboratory findings. In recent years, ultrasound examination has revealed characteristic appearances of periportal fibrosis of the liver which can be differentiated from other hepatic diseases and this technique has its value in estimating the extent and degree of hepatic lesions. Chemotherapy with effective drugs (e.g. praziquantel and oxamniquine) against *Schistosoma mansoni* promotes reduction in transmission and reduces the incidence of serious disease without eradicating the infection in community. In endemic areas where chemotherapy is properly used, prevalence, intensity of the infection and the disease pattern have been changing considerably (W.H.O., 1988).

Human disease associated with *Schistosoma mansoni* infection evolves according to age at exposure, re-exposure and intensity of infection. In rural endemic areas the infection rates are usually higher in males than females (due to the economic activities men are involved in and their bathing habits). The intensity of *Schistosoma mansoni* infection increases during the first decades of life and thereafter decreases. Both peak prevalence in communities and the highest intensity of infection are usually seen in the 10-19 year age group (Mott, 1982; Sleigh et al., 1986; Sukwa et al., 1987). Several studies have shown that most persons with *Schistosoma mansoni* and *Schistosoma*

haematobium infection are symptom free (Cline et al., 1977; Hiatt et al., 1980; Pope et al., 1980; Prata, 1982) and severe clinical manifestations are seen in a relatively small proportion of patients with persistent or heavy infections (Arap Siongok et al., 1976; Costa et al., 1985; Mott, 1982). In the absence of the transmission mechanism (e.g. with total eradication of the snail vector), substantial egg output can be expected to persist for about 3 to 5 years (Warren et al., 1990), unless the victim is treated.

2.4 Review of Schistosomiasis Intervention Studies

2.4.1 *Schistosoma Mansoni treatment*

The primary objective of the use of chemotherapy in schistosomiasis control programmes is a reduction in human morbidity to levels below public health importance. According to W.H.O. (1983), that goal will be achieved when all remaining infections due to *Schistosoma mansoni* are below 100 eggs per gram of faeces. The current anti-schistosome drugs (i.e. praziquantel and oxamniquine - Table 2.1) after being administered to a large population have the following sequential effects:

(a) elimination and cure of the infection is obtained in a high proportion of the infected (see Tables 2.2 and 2.4 below); and in any event,

(b) the intensity of infection is reduced in those persons who remain infected (see table 2.4);

(c) after elimination of the infection or reduction of the intensity of the infection, the level of contamination by those remaining infected is dramatically reduced (Ouma et al., 1985) (see table 2.3);

(d) after this "chemotherapy shock" the risk of infection and transmission of schistosomiasis is lower. For instance, two years of chemotherapy campaign at Marquis Valley in St.Lucia reduced incidence from 18.1% to 4.1% (Jordan, 1977);

(e) and the risk of development of severe disease, associated with heavy infections, is lower (Mahmoud et al., 1983).

2.4.2 *Side effects of oxamniquine and praziquantel*

The frequency of side effects of oxamniquine and praziquantel is summarized in Table 2.6. Toleration of oxamniquine at all dosages is normally good. The only significant side effect is mild or moderate dizziness with or without drowsiness, reported by up to about 40% of patients, starting up to 3 hours after a dose and usually lasting for 3 to 6 hours (Foster, 1987). The following excerpt from Gryseels et. al. (1987b:pp.642-643) summarizes the effects of the two drugs:

For oxamniquine, dizziness and sleepiness were frequent and dose-related. In general, they appeared within one hour after administration; many of the people complained first of pronounced dizziness which forced them to lie down, and then fell asleep not unlike epileptics after a seizure. In fact, two people showed convulsions of arms and legs, lasting about 15 seconds, during this process; both were adults, one treated with 20 and the other 30 mg/kg. Neither had previous history of epilepsy. Nausea was another relatively frequent and dose-related complaint. In many cases, however, these side effects had subsided 24 hours after treatment. For praziquantel, diarrhoea and abdominal pain were most frequently reported (and observed): in most cases, a colicky pain developed 30 minutes to 1 hour after treatment, followed by the production of 2 or 3 loose stools. These side-effects subsided in general within 6 hours after treatment. Dizziness was also relatively frequently reported, though never with intensity observed after oxamniquine treatment. Urticaria appeared in 7 people treated with praziquantel, 5 at 30 mg/kg and 2 at 20 mg/kg.

2.4.3 *Preventive interventions*

There are five main schistosomiasis preventive interventions: mollusciciding (i.e. treatment of irrigation water with snail killing chemicals), clean water supply, sanitation, health education, and drainage system management. Virtually all the main interventions have more than one delivery mode (system) option. Each is meant to interfere with the life-cycle of the schistosomal parasite (the cercariae). The intermediate goal of interventions is to attenuate the risk of infection. The common expectation among epidemiologists is that reduction in transmission (indicated by incidence rate) would lead to reduction in the risks of morbidity and death. Of course the ultimate objective is to

enable people living in schistosomiasis endemic area to lead more healthy lives.

Very few epidemiological studies have been done to evaluate the effectiveness of the above interventions in meeting their objectives (intermediate and ultimate). Jordan (1977) reports a comparative evaluation of snail control, chemotherapy, and provision of water supplies in the control of *Schistosoma mansoni* in three valleys on the West Indian island of St. Lucia. In Cul-de-Sac Valley, 4 years of area-wide molluscicide of snails using 25% emulsifiable concentrate of niclosamide molluscicide reduced the incidence of new *Schistosoma mansoni* infection in children up to 10 years old from 22% (1970/71) to 4% (1974/75). Prevalence among a cohort of 1 to 14 year-olds was reduced from 45% to 34%, intensity of infection fell, and the infection rate in snails decreased from 3.9% to 1.1%.

In five villages on the southern side of Riche Fond Valley water was provided to individual households and three simple swimming pools and five laundry units were built. With education there was a 90% reduction in observed contact of the community with rivers and streams. All parameters of *Schistosoma mansoni* fell - incidence from 31% to 12%, prevalence among 1 to 14 year-old cohort from 47% to 42%, and the sentinel snail infection rate from 0.5% to 0.2%. In a nearby comparison area with a communal water supply *Schistosoma mansoni* prevalence increased.

In Marquis Valley hycanthone at a dose of 2.5 mg/kg body weight was offered to all those found infected with *Schistosoma mansoni* at annual surveys in 1973 and 1974; those found infected in 1975 were treated with oxamniquine. After two chemotherapy campaigns incidence fell from 18.8% to 4.1%; no infections were found in sentinel snails after the first treatment campaign. In summary, after 2 years of control in the three valleys, chemotherapy reduced incidence from 18.8% to 4%; snail control from 22% to 9.8%; and domestic water supplies, from 22.7% to 11.3%.

Jordan (1985) did a systematic study of the parasitological efficiency of chemotherapy, area-wide molluscicide, focal molluscicide, household water supply, water plus chemotherapy, communal water supply and sanitation, and do nothing option in St. Lucia. His findings are summarized in Table 2.7.

The effectiveness of do nothing option (in terms of reduction in the incidence of schistosomiasis) was substantially less than in any of the alternative options (save for the failed water with sanitation programme in Calypso north). The chemotherapy programme in Marquis valley resulted in the greatest fall in incidence, with an overall

decline of 87%. It also had the greatest reduction in both prevalence (88%) and the contamination potential (90%).

In the snail control schemes, area-wide molluscicide in Cul de Sac valley and focal molluscicide in Fond St. Jacques, overall reductions in incidence and prevalence were similar, but intensity was reduced more with area-wide control possibility due to the higher levels of infection in Cul de Sac at the commencement of the programme (Jordan, 1985:p.269). It seems that communal water supply combined with sanitation was completely ineffective. The author attributed the failure to the sporadic water supply, which adversely affected maintenance of latrines.

2.5 Schistosomiasis as a Social Problem

Schistosomiasis is mainly an infection of rural (plus some urban) and agricultural areas in tropical countries where there exist poverty, ignorance, poor housing, inaccessibility to safe water supplies, bad hygienic practices and few, if any, sanitary facilities (Davis, 1986). The farmer, wage-labourer, and fisherman face schistosomiasis as an occupational hazard. Housewives and children encounter the disease as part of their every day domestic activities. It is thus the poor - those who must come in contact with this disease as a result of daily life and need for survival - who are at greatest risk and at the same time are often the least informed about the means of transmission and control of the disease (Rosenfield et al., 1984).

Schistosomiasis disease is alleged to cause debility, morbidity and mortality (for example through the rupture of enlarged collateral blood vessels). Forsyth (1966) estimated that *S.haematobium* caused a mortality of 2 persons per 1,000 persons per year among a population of heavily infected men in North-West Tanzania. According to Walsh et al. (1979), the disease causes a loss of approximately 600 to 1,000 days of life per case and 500,000 to 1,000,000 deaths per year in Africa, Asia and Latin America. Roughly, 1,180,000 disability adjusted life years (DALYs) are lost per year in Sub-Saharan Africa (World Bank, 1993). Morbidity mainly emanates from functional impairment due to organic damage: motor deficit, brain damage, anaemia and psychological impairment.

Schistosomiasis, to be more specific, is said to be a social problem because it **may** cause:

(i) Malnutrition, whose consequences are:

(a) Protein energy malnutrition (PEM). PEM might be attributed to: worms of the small bowel impairing digestion and absorption of nutrients, loss of nutrients emanating from inflammation and toxic secretions, and systematic consequences of infection such as fever which may increase catabolic rate (Warren et al., 1991). The functional consequences of PEM may be substantial in many domains (e.g. mortality risk, mental development) (Warren et al., 1990).

(b) Growth Retardation (Forsyth, 1964; McGarvey et al., 1990). Stephenson (1987) traces three channels that lead from infection to growth faltering - anorexia, nutrient losses through malabsorption, and decreased nutrient utilization from impaired liver and spleen function.

(c) Anaemia. There is growing evidence that schistosomiasis disease causes anaemia (WHO, 1987; WHO, 1988; Stephenson, 1987).

(ii) Educational Impairment:

There has been limited and mixed evidence that heavy infection might impair learning (Kvalsvig, 1988; Pollitt, 1989). Such impairment may be occurring via:

(a) Intellectual impairment from brain damage (Rosenfield et al., 1984; WHO, 1988) reduces efficiency of education in imparting the general intellectual skills that are of far-reaching significance for economic development.

(b) Reduced school attendance (Morishita, 1980). Absenteeism from school may occur due to severe infection of school children. In addition, households may interrupt the schooling of their children in order to secure additional labour to replace that of an ill member. Education impairment in general reduces investment in human capital of children, with long-term negative implications on personal and societal economic well-being.

(iii) Labour productivity impairment, occurring in a number of ways:

(a) Debility causing a reduction in victim's earning capacity (Audibert, 1986). Chronic schistosomiasis disease may sharply reduce an individual's physical stamina (Warren et al., 1993), thus impairing activities of daily living. Anecdotal evidence suggest that heavy, but not light, infestation by *S.mansoni* has a negative effect on working capacity. In Egypt, where prevalence of *S.haematobium* and *S.mansoni* is high, the loss of labour output among infected people is estimated to be more than 35% (Farooq, 1967). A study of sugar cane estate workers in Tanzania demonstrated that those not infected with *S.mansoni* earned 11% more in bonuses that those infected (Fenwick and Figenschon, 1972). Collins et al. (1976) found a 10% difference in work performance between sugar cane cutters infected by *S.mansoni* and non-infected groups on a sugar plantation in Sudan. Study of an agricultural population in St.Lucia indicated that *S.mansoni* infection had a negative effect on productive potential, and daily earnings among the infected persons were reduced by 15% (Weisbrod et al., 1973; Weisbrod et al., 1977). Schistosomiasis is said to cause a productivity loss of US$ 818,703 per year in Kenyan national irrigation schemes (Choundry, 1990). Due to data and methodological limitations inherent in most of the studies cited above, their results cannot be said to be conclusive (Warren et al., 1993).

(b) Morbidity causing absenteeism from work. Ghana Health Assessment team (1981) estimated that about 1424 days of life per 1000 persons per year are lost (in Ghana) due to non-fatal disability caused by *S.haematobium* infection.

(c) Death resulting in loss of remaining days of productive life. In Ghana about 2944 days of life per 1000 per year are lost due to death from *S.haematobium* disease (Morrow, 1984).

(d) There is a growing concern that schistosomiasis might be retarding investment in land, especially in irrigation projects (World Bank, 1980). That is because farming in the third world countries is labour intensive (from cultivating, planting, and weeding to harvesting), and health impairment from schistosomiasis (and other diseases) may have adverse effects on overall agricultural productivity.

(iv) Direct (variable and fixed) costs on the MoH

Such costs are partly incurred in sustaining the schistosomiasis control activities and the process of screening and treating those infected.

(v) Costs on patients and their families

Such costs are mainly out-of-pocket expenses, household inputs into schistosomiasis interventions (curative and preventive), time lost from work or leisure, and psychological costs (Drummond, 1980; Drummond, 1987).

(vi) Finally, schistosomiasis may be a social problem due to its alleged adverse effects on the quality of life of patients and their families. In other words, the disease may affect not only the behaviour and well-being of sick persons but also of those who perceive themselves to be at risk from the disease and family members caring for the patient.

In short, schistosomiasis might be a social problem in endemic areas, since it is said to have adverse effect on the quality of life of patients (actual and potential); retard growth in children; cause death; impose monetary and psychological costs on patients and their families; divert MoH scarce resources from other uses; impair learning; and adversely affect labour and land productivity. However, although it is accepted that blood loss in intestinal schistosomiasis may result in anaemia and weakness, claims that schistosomiasis significantly affects learning ability, growth and physical fitness are more difficult to substantiate (WHO, 1993).

2.6 Summary

The chapter provides a brief review of the general spatial distribution of schistosomiasis, the life cycle of the schistosome parasite, the morbidity caused by *Schistosoma mansoni*, it also describes the main schistosomiasis intervention studies and the social problems thought to be associated with schistosomiasis. The main findings are: most of the epidemiology studies are before-and-after intervention studies which are inappropriate for use in economic evaluations, and relevant randomized controlled

effectiveness trials are totally lacking.

Table 2.1: W.H.O. Recommended treatment of schistosomiasis

Schistosome species	Drug of preference	Dosage per kg body weight
All species	Praziquantel-tablet 600mg	40mg, single dose
Schistosoma mansoni	Oxamniquine-capsule 250mg	15-60mg, single dose*

* The customary dose for adults is 15mg/kg; 20mg for children and doses up to 60mg/kg may be required in Central and East Africa or the Eastern Mediterranean Region.

Source: WHO, 1983.

Table 2.2: Summary of major trials with anti-schistosome drugs conducted in Zimbabwe

Drug	Regimen and route of drug administration	Schistosome species drug is effective against	Efficacy	Side effects	Source
Oxamniquine	Oral intake of 60mg/kg body weight given in equal doses over 2 days (twice daily)	*S.mansoni*	Cure rates of about 70%	Drug well tolerated and side effects are mild and transient. These include dizziness, headache, nausea and vomiting.	Axton et al. (1976); Clarke et al. (1976)
Praziquantel	Oral intake of 40mg/kg body weight given once or 20mg/kg body mass twice on a single day.	*S.haematobium* *S.Mansoni*	cure rate for *S.haematobium* range from 80 to 100% and for *S.mansoni* from 70 to 100%.	Drug is well tolerated and side effects are mild and transient. Side effects reported include epigastric pain, nausea, anorexia, diarrhoea, dizziness and headache.	Creasey et al. (1981); Taylor et al. (1988).

Source: Chandiwana et al. (1990)

Table 2.3: Population based chemotherapy programmes conducted in Zimbabwe

Control strategy	Study community (population)	precontrol infection status	Treatment regimen	Other control measures	Control Outcome	Source
Infected persons treated once at the first survey of a 3-year programme	Smallholder irrigation schemes (500 people of all ages)	prevalence of *Schistosoma haematobium* of 18% and that of *S.mansoni* of 3%	Single 40mg/kg body weight of praziquantel	Engineering and environmental controls measures	*S.haematobium* prevalence reduction of 52-82% and *S.mansoni* of 82-100%	Chandiwana et al. (1988)
Annual treatments targeted at infected school children for 3 years	Communal area (about 15,000 school children of 7-15 years of age)	Prevalence of *S. haematobium* of 62% and that of *S. mansoni* of 18% in school children.	Single 40mg/kg body mass of praziquantel	Improved sanitation, water supplies, health education and snail control.	*S. haematobium* prevalence 19% and that of *s. mansoni* 3% 6 months after first treatment.	Taylor (1986); Taylor (1988).

Source: Chandiwana et al. (1990)

Table 2.4: General efficacy of antischistosomicides of choice				
Drug	Dosage	Cure rate	Reduction in egg count among uncured	Duration of side effects
Oxamniquine	30-45 mg/kg (E.Africa)	60-85%	90%	6 hours
Praziquantel	60 mg/kg	80-95%	90-95%	48 hours

Source: Developed from WHO (1983)

Table 2.5: Effectiveness of selective chemotherapy with either oxamniquine or praziquantel

Country studied	Screening compliance	Pre-treatment prevalence	Treatment compliance	Dose (mg/kg)	Cure rate	Egg reduction in uncured	Author(s)
Egypt (Nile Delta)		50%		60°	89%		Saif and Gaber (1980)
Egypt (Nile)		>400epg		40°		91-99%	Strickland (1982)
Brazil	82%	83%	69%	30	80%	74%	Sleigh et al. (1981)
Brazil		32%			83%		Bina and Prata (1980)
Kenya: Machakos	>90%	99.6%	92%-98%	30°	83%	>90%	Butterworth et al. (1991)
Kenya: Machakos	-	97%	98%	30°	70%	98.8%	Butterworth et al. (1984)
Kenya: Machakos	99.6%	63%	100%	1.5^{H}	69%	81%	Sturrock et al. (1983)
Burundi: Rusizi	89%	46%	93%	40^{P}	85%	98%	Gryseels et al. (1987a)
Burundi: Rusizi	89%	46%	93%	40°	92%	98%	Gryseels et al. (1987b)
Burundi	>85%	42%	97%	40°	93%	87%	Gryseels and Nkulikyinka (1989)

* community study

* p - praziquantel, o - oxamniquine, H - hycanthone

Table 2.6: Frequency (%) of side effects after treatment with oxamniquine and praziquantel

	OXAMNIQUINE			PRAZIQUANTEL		
Dose	20mg	30mg	40mg	20mg	30mg	40mg
N	170	129	131	173	318	280
Diarrhoea	0.5	1.6	0.8	24.9	30.5	28.9
Abdominal pain	0.6	0	1.5	16.8	27.0	30.7
Nausea	4.7	8.5	16.7	1.2	1.9	1.4
Dizziness	32.0	46.5	53.4	5.8	7.2	10.0
Somnolence	20.0	27.9	34.4	0	1.9	2.1

N = number of subjects treated and interviewed
Source: Gryseels, et al. (1987b)

Table 2.7: Summary of parasitological results of different pilot control schemes in St. Lucia

AREA	Date	Change in incidence	Change in prevalence	Change in overall intensity	Change in contamination potential
Richefond (north): control	1970-75	-16	+20	-29	-42
Marquis Valley: chemotherapy	1973-76	-87	-88	-27	-90
Cul de Sac Valley: area-wide molluscicide	1971-75	-64	-46	-29	-58
Fond St. Jacques: Focal molluscicide	1976-80	-65	-46	-17	-53
Richefond (South): Household water supply	1970-75	-42	-32	-50	-68
Calypso (South): Water + therapy	1976-81	-45	-64	-24	-68
Calypso (North): communal water supply and sanitation	1977-80	+6	+35	0	+41

Source: Jordan, P. (1985:p.270)

CHAPTER 3
SCHISTOSOMIASIS ECONOMICS LITERATURE REVIEW

3.0 Introduction

Health care resources (land, buildings, vehicles, equipment, personnel time, community resources, and appropriate technology) are scarce, implying that any movement from the status quo involves opportunity costs elsewhere. For example, if more resources are allocated to a schistosomiasis control programme (SCP), fewer resources will remain to be allocated to other health producing activities and other services meant to improve human life generally (e.g. education, food production, housing, security, infrastructure, etc.). The meagre resources allocated to SCP alone are not adequate to implement and sustain all technically feasible interventions simultaneously. This fact has dawned upon both health policy-makers and those in the medical profession who hitherto advocated a multi-faceted approach to "eradicate" schistosomiasis. Such a realization is clearly indicated in the following quotation from World Health Forum:

"*Integrated (multiple-option) programmes to eradicate schistosomiasis have proved to be beyond the human and financial resources of most endemic countries and will not achieve their (eradication) objectives. Reduction in the prevalence and severity of disease....is a feasible objective based on sound epidemiological principles and is within the scope of every endemic country.*" (Mott, 1984:p.221)

Since the eradication objective will probably remain far beyond the production possibility frontier for Kenya, difficult choices have to be made. Such choices have to be preceded by priority setting (ranking of policies probably at the margin) based on considerations of both costs and benefits (plus, probably, equity). The MoH policy maker will have to manage schistosomiasis control resources in ways that maximize intervention benefits; that may entail redeploying existing resources, allocating limited new resources, or cutting back on the use of existing resources. Development of economic evaluation methodologies is a prerequisite to priority setting. The decision criteria of such methodologies (if adhered to) ensures that those policies that get priority are those producing greatest benefits per shilling spent.

This chapter reviews the methodological issues surrounding the economic studies

that have been done in the past on schistosomiasis. Section 3.1 reviews briefly the economic evaluation techniques. Section 3.2 surveys the methodological issues surrounding the past economic studies (cost description, cost-outcome, cost effectiveness and total burden of illness) on schistosomiasis.

3.1 Summary of Economic Evaluation Methods

Economic evaluation is the comparative analysis of alternative courses of action in terms of both their costs and consequences (Drummond et al., 1987). There are five types of economic evaluation:

(a) output maximization analysis;

(b) cost minimization analysis;

(c) cost effectiveness analysis;

(d) cost utility analysis; and

(e) cost benefit analysis.

3.1.1 *Cost minimization analysis (CMA)*

The CMA technique is built on the theory of economic cost. CMA is relevant where there is evidence that there are no differences in the outcomes expected from the schistosomiasis options under evaluation. So the evaluation problem reduces to a search for the least cost option. For instance, suppose that the MoH policy-makers' problem was to choose between focal hand-spraying and focal drip application of chemical molluscicide. Assuming that there was epidemiological evidence that the ultimate effectiveness (probably measured in terms of expected quality adjusted life years) of the two delivery systems was equal (or the difference was statistically insignificant), the evaluation problem would reduce to identification of the delivery option with the minimum cost.

In short, the CMA is appropriate where the question to be answered is: *Given that we must achieve a specific level of output, what is the least costly way of realizing it, given two (or more) equally effective options?* Implicit in the approach is the value judgement that, unless output is being produced with the least costly input combination, it is possible to improve the health status of at least one individual without reducing the

health status of others.

Drummond (1980) and Drummond et al. (1987) provides an exhaustive discussion of the CMA procedure.

A number of issues would arise in any attempt to apply CMA technique to schistosomiasis control problem in Kenya:

(a) measurement of marginal social opportunity cost of options;

(b) valuation of input requirements;

(c) absence of proof of equality in the ultimate effectiveness of options being appraised.

These issues are discussed in chapter 8.

3.1.2 *Outcome maximization analysis (OMA)*

This technique is built on the production theory of economics. It tackles the technical efficiency condition for economic efficiency, which requires that the health production process generate as much output as is technically possible from input combination in use. OMA is useful in identifying health care options with the highest amount of expected output with a given level of resource endowment. Where there is evidence that input requirements are equal across the options being appraised, OMA would be useful in identifying situations where it is possible to improve someone's health status without making anyone else health status any worse off simply by increasing the output being produced by the inputs already in use. Thus, OMA would be applicable if the problem facing an MoH decision maker was:

Given that the options under evaluation have equal cost, which option promises the highest level of output?

A number of issues would arise in any attempt to apply OMA technique to schistosomiasis control problem:

(a) definition of schistosomiasis policies outcome(s);

(b) measurement of the outcome(s), given that there are no randomized controlled effectiveness trials;

(c) absence of proof of equality in costs of options being appraised. The first two issues are tackled in chapter 4 and the last one in chapter 8.

3.1.3 *Cost effectiveness analysis (CEA)*

CEA invokes both the theory of production and the theory of economic cost. CEA compares two or more intervention policies, measuring the inputs in monetary terms and the outcomes in natural units such as years of life saved (Culyer et al., 1983). The technique is useful where the problem facing the policy-maker is as follows: Given that we are not sure what level of performance to aim at, or what level of resources will be at our disposal, and we have no way of valuing the benefits we produce, which options should be given priority?

Since the performance is measured in physical units only, "the focus of the analysis is limited to the pursuit of production efficiency, since the conditions for consumption efficiency (how outputs are valued by different individuals or groups) and product mix efficiency (how the outputs are valued relative to their opportunity costs) require utility based measures of outputs or equality between objective and subjective rates of substitution at the margin" (Birch and Gafni, 1991:p6). CEA seeks to identify ways of reallocating resources so as to move from a position inside the production possibilities frontier to a position on the production possibilities frontier.

CEA involves: spelling out of the viewpoint or perspective; definition of the research question; generation of competing options; identification of all relevant costs and effects (benefits) for each option; estimation of each options' streams of costs (explicitly valued) and effects (expressed in appropriate physical units); discounting of the estimated costs and effects; calculation of what the cost per unit of effect is for each option; ranking of the options using the cost-effectiveness ratio; and sensitivity analysis (Weinstein and Stason, 1977; Drummond, 1980; Culyer et al., 1983; Mills, 1985; Drummond et al., 1987).

The main setback in the application of CEA is the heterogeneous nature of the consequences of different schistosomiasis intervention policies. The curative options might not be compared directly with preventive options. Drummond et al. (1987:p74) suggest that "..in order to carry out a CEA, one or the other of the following conditions must hold:

(a) that there is one, unambiguous, objective of the intervention(s) and therefore a clear dimension along which effectiveness can be assessed; or

(b) that there are many objectives, but that the alternative interventions are thought to

achieve these to the same extent."

Birch and Gafni (1991:p9) posit that "...even where these conditions apply, if the alternative programmes under consideration have differing resource requirements, then the evaluation cannot be restricted to simply these two programmes with comparable outputs if it is to be used to pursue Pareto efficient solutions. On the contrary, the evaluation must also consider the opportunity cost (or benefits foregone) from reducing the size of other programmes in order to generate the additional resources required by the more expensive option, and in general these benefits will not be directly comparable to the benefits of the programmes under evaluation." So CEA is capable of merely identifying full effects of all options although it cannot produce a simple ratio which summarizes the effects.

In summary CEA is an inadequate means of promoting efficiency in the use of schistosomiasis intervention resources because the methodology: (1) gives no guide as to whether interventions should be implemented at all even though it is possible to rank order options to meet a specific objective (Mooney, 1977); (2) does not resolve the problem of option selection whenever different options yield more than one kind of beneficial effect with the mix of benefits differing between options (Jones-Lee, 1989); (3) inability to compare the benefits of an option with the opportunity cost. In short CEA cannot be used to address issues of exchange and product-mix efficiency.

3.1.4 *Cost utility analysis (CUA)*

CUA developed in response to the need to compare options producing heterogeneous health outcomes. It expresses outcomes in directly comparable units. CUA compares two or more interventions, measuring inputs in monetary terms and the outcomes in quality adjusted life years (Culyer et al., 1983). CUA incorporates simultaneously the gains in life expectancy and quality of life. The CUA procedure is exactly similar to that for CEA, except that effectiveness is expressed in terms of QALYs or some other suitable metric. CUA simultaneously satisfies the conditions for efficiency in production and efficiency in product mix. However, it does not tackle the issue of efficiency in exchange (Birch and Gafni, 1991). Another drawback of this method is that the field of utility analysis is relatively young and the methodology is still developing. Since QALYs are not monetized and hence made comparable with the

outcomes of other programmes, CUA does not address the issue of optimal intervention scale. The methodological issues surrounding QALY index are reviewed at length in chapter 4.

A number of issues would arise in any attempt to apply CUA technique to schistosomiasis control problem:

(a) measurement of the schistosomiasis interventions outcome(s), given that there are no randomized controlled effectiveness trials;

(b) construction of culturally acceptable quality of life measurement instrument; and

(c) administration of a quality of life instrument in a population where the majority of the people are illiterate.

The above issues are addressed in chapter 7. The CUA framework *per se* is not adequate to deal with the sequential research problems stated in chapter 1. As discussed in chapter 6, it is necessary to employ the CUA within a decision analysis framework. This thesis goes beyond the call of CUA; and makes an attempt to convert the expected QALYs into their monetary equivalents using a shadow willingness to pay value implied in the current schistosomiasis control decisions in Kenya.

3.1.5 *Cost benefit analysis (CBA)*

Cost benefit analysis is the technique employed in identifying, quantifying, and valuing in a common yard-stick (usually local currency) all the important costs and consequences to society of any change in resource allocation in the economy. Such a change may occur due to the introduction of a new disease intervention or from the expansion (or contraction) of an already existing policy.

The direct and indirect effects are assessed in each period at current values or prices. For direct resource allocation effects, inputs used in the intervention are evaluated at their social opportunity cost, i.e., at the true cost to society incurred by drawing resources from alternative uses. The value of outputs is the benefit to society from having the additional outputs. The value of indirect effects is the welfare change to society from the resource allocations induced elsewhere by the intervention. The evaluations are done for every relevant time period to yield a stream of net benefits, denoted by NB_t, in current values for each period t=0,....,T, where T is the last period that the intervention affects benefits and costs. Net benefits for each year are discounted

to their present values using a social discount rate and then aggregated to yield the net present value (NPV) of the intervention (Boadway and Bruce, 1984).

If the MoH policy-maker is faced with a single intervention option, the NPV rule demands that it should be accepted if the NPV is positive and rejected if it is negative. And be indifferent if NPV is equal to zero. In a scenario with more than one **strictly mutually exclusive** disease policy options, the general rule is to select the one promising the highest NPV. Where the MoH policy-maker has a fixed budget to invest in schistosomiasis control options (for example), he should rank all technologically feasible options in order of desirability and work down the list until the budget is exhausted. Pearce and Nash (1981) counsels that in such a situation one should rank the options by benefit-cost ratios.

3.1.5.1 *Techniques of Valuing Monetarily Health Outcomes*

There are three principal methods for putting monetary values to health outcomes:
(a) the 'human capital' approach;
(b) the 'implied values' approach; and
(c) the 'willingness to pay' (for risk reduction approach) (Mooney and Creese, 1991).

Human capital approach (HCA)

HCA considers benefits of investment in an intervention as consisting of production gained due to decrease in mortality, morbidity (loss of working time) and debility (loss of productive capacity at work). The production benefits are usually estimated using earnings data of the individuals whose health has improved. If the expected change in NPV of earnings associated with an intervention is greater than the cost of implementing the intervention in question, then the intervention is deemed worthwhile.

Mishan (1971) identified two variants or strands of HCA:
(a) Gross output approach - assumes that the objective function that society is trying to maximize through improved health is Gross National Product (GNP). Thus, the method calculates the economic worth of a person's health by discounting to the present the loss of person's potential future earnings. The underlying assumptions are: maximizing GNP

is an acceptable goal of economic policy; health care objectives are couched solely in terms of GNP; wages in developing countries are a precise indicator of productivity; if an individual is saved from death or ill-health at a particular moment in time, then thereafter he will continue to be a producer and earnings are a fairly accurate estimate of the value of this output. Most of the above assumptions are not plausible.

(b) Net output approach - involves estimation of net present value of the losses over time accruing to others only as a result of morbidity or/and premature death of a particular person(s). It assumes that what matters to a 'cold-blooded' society is simply the resulting loss or gain, to it following the death of one or more of its members. Death of any person whose net output is negative (or zero) confers no net benefit, and the cold-blooded society should rejoice when that happens. Such an approach would recommend that all persons who attain retirement age (irrespective of their ownership of property or contributions to national wealth during their active lives) be killed immediately, because the 'cold-blooded' society would better without them.

Merits of HCA

The approach has been widely used, partly due to its simplicity and also because the necessary data on mortality and earnings are readily available (Cook, 1978). Once the analyst is equipped with a set of mortality tables and individual earnings, it is a straight forward task to calculate the human capital benefits (Viscusi, 1978).

Demerits of HCA

The main drawbacks of HCA are, viz: it is not consistent with the basic rationale of the economic calculus used in cost-benefit analysis (the notion of a Pareto improvement); it ignores society *ex ante*, and concentrates wholly on society *ex post* (Mishan, 1971); people value prevention of death, morbidity and debility *per se* rather than because of their concern to preserve productive resources and maintain future levels of GNP (Jones-Lee, 1989); it ignores the existence of caring externality (Culyer, 1978), participation utility (Margolis, 1982) and religious externality; it measures livelihood rather than health per se (McGuire et al., 1988); it completely ignores potential beneficiaries preferences (Acton, 1973); if applied in developing countries it would

discriminate against women (majority of whom are full-time home makers), the retired, the children, the handicapped and the unemployed; it attaches greater weight to health benefits going to high income earners than the low earners which may be deemed an inequitable basis on which to set health priorities (Mooney and Creese, 1991); its underlying assumptions would never pass a test of realism in developing countries (Mills, 1985; Mooney and Creese, 1991); and although it has been alleged to produce precise estimates of economic costs of the health impacts, such precision is largely illusory to the extent that the analyst is not measuring the benefits of health risk reduction but rather a highly imperfect proxy (market value of a person as a productive asset). The above disadvantages have led many researchers and policy-makers to reject it as a basis for public policy.

The implicit value approach (IVA)

The IVA hinges on implicit values placed on life-saving and morbidity-saving by the past political processes. Its attributes are: politically designated person provides the values; the values are derived in whatever manner the person feels appropriate; the units and scale are whatever the person selects; the values of different persons do not have to be combined, if they do, the political sphere provides the combining rule (Acton, 1976).

Merit of IVA

IVA does not involve any change in the value system as the implied values would simply reflect those of the existing system (Mooney and Creese, 1991).

Demerits of IVA

Jones-Lee (1989), Mooney (1977) and Mishan (1971) identify the following disadvantages inherent in the IVA, viz: decisions to invest in certain projects are not determined by popular vote (especially in developing countries where dictatorship is a common phenomenon); investment decisions are not motivated primarily by the desire to advance general welfare, or any plausible criteria, but are rather the outcome of

political conflicts; implicit value attributable to loss of health by a particular public programme will differ widely from a value derived from another public programme; the idea of deriving quantitative values from the political process is clearly contrary to the idea of deriving them from an independent economic criterion; the requirements of consistency cannot be met by such implicit, arbitrary and erratic valuations of political outcomes; empirical evidence tend to confirm the *a priori* expectations that leaving the valuation of safety to informal judgement is likely to lead to inconsistency and consequent inefficiency in the allocation of scarce resources; and non-homogeneity of lives saved implies that one should not expect a single public sector value to emerge.

The willingness to pay approach

An effective schistosomiasis intervention will obviously improve Mwea scheme residents' welfare (satisfaction, utility or flourishing) by improving individuals' health status. To incorporate such welfare changes into CBA calculus, it is necessary to obtain a monetary representation of individual utility functions, defined as the amount of money required to attain various utility levels at a set of reference prices. This monetary representation is referred to as a money metric, and its value is obtained from the expenditure function (Boadway and Bruce, 1984). The two commonly used money metrics are the compensation variation (CV) and the equivalent variation (EV).

CV is the change in the individual's income that would restore the individual to his/her initial utility level (i.e. just compensate for the policy change). The CV of a move from mild schistosomiasis state (S) to normal health state (Y) is defined as the amount of income that could be taken away from an individual in a new state (Y) in order to leave him/her as well off as in the old state (S). Equivalently, it is the maximum amount of money the individual would be willing to give up in order to have the change occur (i.e. realize a health improvement from S to Y). If the individual is better off in (Y) than in (S), CV is positive; if worse off, it is negative. The society welfare change as a result of intervention is the sum of CVs for all potential beneficiaries. The sum of CVs may be positive or negative depending upon whether the change in schistosomiasis intervention policy has made the society's health better or worse off.

EV is a measure of the money transfer which, in absence of the contemplated

change in intervention policy, affords the individual an exactly equivalent change in his/her welfare (Mishan, 1971). Thus, EV is the amount of income (positive or negative) that must be given to an individual in the initial health state (S) to help him or her realize the utility of state (Y). Equivalently, it can be thought of as the minimum amount of income the consumer would be willing to accept in order to forego the move from mild state (S) to normal health state (Y). The EV will always be positive if $u_Y > u_S$ and negative if $u_Y < u_S$. The society welfare change as a result of intervention is the sum of EVs for all potential beneficiaries.

In short, the WTP approach (1) relies on the values of individuals through explicit statement of worth, (2) the units are dollars (or local currency), and (3) responses of individuals are aggregated by either a simple summing or a more complex weighting scheme if the decision maker feels it appropriate. An individual preference approach (based on WTP) does provide us with an assurance that society is made better off in some sense by the programmes that pass the criterion [potential pareto improvement] (Acton, 1976).

Merits of the WTP approach

The advantages of WTP approach are that it: values the relevant concept, i.e. reduction in the probability of statistical death (and morbidity) within some identifiable group of people none of whom expects to die (or fall ill) except eventually (Schelling, 1968); tackles the HCA and IVA deficiencies directly by explicitly incorporating consumer preferences (Acton, 1973); allows valuation of noneconomic aspects of the intervention, such as the intrinsic pleasure being alive or disease-free; is consistent with the potential Pareto improvement principle, and hence, consistent with cost-benefit analysis (Mishan, 1971); captures today's values; is specifiable and controllable (in the sense of allowing one to ask the precise question that interests policy makers); is sensitive (in the sense of allowing expressions of the need for change); direct (in the sense of looking at the stated preferences themselves and not their application to some specific decision problems); superficially simple (in the sense that you just ask people questions); and politically appealing (in the sense that peoples' views count) (Fishchoff and Cox, 1986).

Demerits of WTP approach

The WTP approach has five main setbacks: non-paternalistic assumption that a household has 'sovereignty' over how its welfare (equated with its own perceived satisfaction or utility) is to be measured is not an absolute rule (demerit and merit goods violate notions of non-paternalism); the underlying assumption that household's preferences are unchanging is debatable (Boadway and Bruce, 1984); to the extent that WTP is a function of income and wealth, it still relies on the current distribution of income; utility is the subjective satisfaction of the household and cannot be observed directly (it must be inferred from observable attributes of household consumption behaviour and the hypothesis of utility maximization); and the respondents may not reveal their true preferences. Deviation from the truth could come from either strategic response (deliberate misrepresentation of one's views so as to influence the results of the analysis) or social desirability effects (when respondents provide answers designed to make them look good to the interviewer) (Payne, 1952). Evidence suggests that strategic response exists more in theory than in practice (Brookshire et al., 1978).

3.1.5.2 *CBA methodological issues*

There are generally seven major methodological issues surrounding the application of CBA conceptual framework in the evaluation of health interventions. One, the measurement and valuation of intervention benefits (Williams et al. 1975; Mooney, 1977; Culyer, 1978; Mooney, 1986; Culyer, 1991d; and McGuire et al., 1988). Two, the controversial phenomena of valuation of statistical life initially highlighted in Schelling (1968). This is comprehensively reviewed in Mishan (1971), Acton (1975), Acton (1976), Mooney (1977) and Jones-Lee (1989). Third, the issue of derivation of a social welfare function from individual utility functions is adequately handled by Ng (1990), Boadway and Bruce (1984) and Deaton et al. (1980) among others. Harsanyi (1955) via some reasonable postulates proves that the social welfare function will be a weighted sum of individual utility functions. Four, the issue of equity in health sector is clearly discussed in Mooney (1987), Culyer (1991b), Culyer and Wagstaff (1991a), Culyer and Wagstaff (1991b), Culyer (1993), Wagstaff et al. (1991a), Wagstaff et al. (1991b), Wagstaff and Doorslaer (1993a, 1993b, 1993c). Five, the issues of uncertainty, time

preference and the nature of CBA decision rules have been well handled in Dasgupta and Pearce (1972), Sugden and Williams (1978) and Pearce and Nash (1981). Lastly, issues surrounding measurement and valuation of costs expounded in Drummond et al. (1987). Lee and Mills (1983), Mills (1985), Mills (1989), Brent (1990), Curry and Weiss (1993) discuss the above methodological issues within the context of the developing countries.

Special problems of applying CBA technique in developing countries

The cost of health professionals (and support staff) time, in-service training, drugs, materials, utilities (telephone, electricity and postage), maintenance (of vehicles, equipment and buildings), capital commodities (vehicles, equipment and buildings), community inputs (time, out-of-pocket expenses, other inputs), and the value of physical outputs (health gains and other outputs), all refer to resources that are committed to or produced by an intervention and that would have been used or produced in alternative intervention projects (i.e. the opportunity cost). Market prices would be 'right' from society's point of view only if the economy was run under perfect competition and there were no external effects. As such the market price would be equal to marginal costs or marginal social value would be equal to marginal social cost. In less developed countries (LDCs) commodity market prices may not reflect their social values for a number of reasons:

(a) Market prices usually rise at a much more rapid rate in LDCs than in developed countries (DCs) (Brent, 1990).

(b) Existence of taxes and subsidies. For example, a tax on imports raises their domestic price above the c.i.f. price, whilst a subsidy reduces it. On the other hand, an export tax will reduce the domestic price of an export below its f.o.b. price, whilst an export subsidy will increase it.

(c) Over valued official exchange rate, which does not reflect the value of extra foreign currency to the economy. The domestic currency is frequently overvalued and is maintained at its existing level by exchange controls, import quotas, tariffs, price controls, and other trade restrictions (Curry and Weiss, 1993; Brent, 1990; Pearce and Nash, 1981; Mishan, 1971).

(d) Wages in LDCs (especially within the public sector) are institutionally set and not

determined by market forces. In LDCs there may be significant differences between: public and private sector wages for equally qualified and experienced personnel; rural and urban wages for equally qualified and experienced personnel.

(e) The distribution of income is usually more unequal in LDCs than in DCs. Since market prices reflect person's ability to pay, as well as their willingness to pay, if there is remarkable inequality, consumer preferences are imperfectly reflected in market prices.

(f) Capital markets in LDCs are typically fragmented. As a result there may be major differences in interest rates charged in different sectors of the economy (the marginal social value of capital is not equal to marginal social cost of capital). Thus, one cannot rely on market interest rates to obtain a single rate for discounting purposes (Brent, 1990).

(g) Existence of a substantial sector of the economy based on subsistence farming, in which market prices for factors of production and outputs do not exist; this problem is resolved by imputing prices to unpriced gains and losses a specific intervention is expected to generate.

Given the above reasons the Kenyan market prices might not reflect the opportunity cost value of health producing resources, and thus financial profitability could be a misleading criteria for investment. "One solution is to test the international competitiveness of new (intervention) investments by conducting project analyses at international or world prices. If a project is analyzed at world prices, this would give an indication, first, of whether it could survive in the long term, and second, of whether its output could be obtained more cheaply from international sources. ....the alternative source of supply for many inputs and outputs is through international trade. The price at which to value a project input is its import price if it has to be imported, or its export price if greater domestic use would lead to a reduction in exports. Similarly, the price at which to value a project output would be its export price if it adds to exports, or its import price if local production leads to a saving in imports. ....use of the world prices to value project inputs and outputs amounts to applying the principle of trade opportunity cost. ....for imports, the border price (a price of traded commodity at the Kenyan border) will correspond to the amount of foreign currency needed to pay for the good at the border, the import cif price. For exports, the border price will correspond to the amount of foreign currency received at the border, the export fob price. However,

shadow prices are required at the project location (e.g. Mwea Scheme) rather than the border (Mombasa port) price itself, and hence it is necessary to calculate border parity prices, which include adjustments for the handling, transport and transfer payments between the project location and the border." (Curry and Weiss, 1993:pp.78-80).

The problem of divergence between domestic and world prices is tackled through shadow pricing (Mishan, 1971; Scott et al., 1976; Pearce and Nash, 1981; ODA, 1990; Brent, 1990). That problem is handled in this thesis by valuing resources at their 1992 constant market prices; and then converting them to shadow price values using a standard conversion factor (SCF). Brent (1990:158) defines SCF as the ratio which translates the domestic price for any non-tradable (often made non-tradable by protectionist policies) into its border price value, so that the good can be expressed in terms of its real domestic price equivalent." The SCF = OER/SER. It is important to note that the SCF is not equivalent to accounting ratios. Accounting ratios apply to specific individual commodities (e.g. personnel, materials, drugs, vehicles, equipment, and so on) or classes/categories of commodities (e.g. traded exports, traded imports, consumption, and non-traded commodities). The SCF on the other hand "..applies to any non-tradable, irrespective of whether it is a consumption or a production good (or a mix of the two)" (Brent, 1990:158).

In other words, SCF is a weighted average ratio of world to domestic prices for the main sectors of the whole economy (Curry and Weiss, 1993). It is an aggregate conversion factor used when detailed information is not available. The use of the SCF implies that the average ratio of world to domestic prices for the economy is a reasonable approximation to the ratio relevant for a particular good or type of expenditure (Curry and Weiss, 1993). SCF could be obtained from the following expression:

$SCF = (M + X)/(M + T_m - S_m) + (X - T_x + S_x)$.

where: M and X are the total value of imports and exports in a given year, converted into local currency at the official exchange rate; T_m and T_x are the total value of import and export taxes respectively; S_m and S_x are total trade subsidies on imports and exports respectively. The total value of imports at domestic prices will be their cif value (M) plus import taxes (T_m) minus import subsidies (S_m). The total value of exports at domestic prices will be their fob value (X) minus export taxes (T_x) plus export subsidies (S_x).

The main limitations of a SCF derived using the above formula are that: (a) it uses the existing average shares of goods in the foreign trade of the economy as weights (ideally it is marginal shares in additional expenditure that will be relevant); (b) it includes only traded goods in the comparison, although in practice the SCF is applied to convert non-traded items to world prices; (c) it omits the effect of trade controls, such as import quotas and licences, which where they are operative will add an additional scarcity margin to the domestic price of traded items; for economies with tight controls on trade use of this expression for the SCF can be quite misleading (Curry and Weiss, 1993); and (d) when a distribution has a number of extreme values, the average is a poor representation of the data (Table 3.0).

"The alternative and more satisfactory approach to the average conversion factor is to treat it as a genuine average. Where a set of CFs are available for different sectors of the economy the ACF will be given as a weighted average of the CFs for the main productive sectors, both traded and non-traded. Although still using existing shares in production or value added as weights, this approach overcomes the second and third objections to the other ACF formula. Both traded and non-traded sectors are covered, and if sectoral CFs for traded goods are derived from direct comparisons of world and domestic prices they will incorporate the price effects of trade restrictions" (Curry and Weiss, 1993:106).

The SCF used in this thesis is a weighted SCF derived by Scott et al. (1976). It obviates second and third weaknesses mentioned in Curry and Weiss (1993). Since the Kenyan accounting ratios for imports had extreme values, the use of the average would have been a poor representation of the data (Brent, 1990). Thus, the median was thought to be a better guide as to what is typical.

By using the median accounting ratios (or conversion factors) for all categories of goods and services (i.e. 0.8) as the standard conversion factor (SCF), this thesis obviates the limitations stated above. Brent (1990) and Scott et al. (1976) provides the details about procedures they used to calculate the conversion factors for Kenya. The median values in Table 3.0. can be viewed as reflecting 'effective rates of protection'. A value of 1 can be interpreted as no protection, less than 1 is positive protection, and greater than 1 is negative protection. According to the above authors, the close grouping of medians for different categories of goods and services around the median for all categories combined makes it sensible to adopt the short-cut procedure of taking a single

ratio for all of them (i.e. 0.8).

3.1.5.3 *CBA practical issues*

There are a number of practical issues that this thesis had to deal with:
(a) how to choose options to evaluate;
(b) development of schistosomiasis related health states;
(c) eliciting of health states willingness to pay values from a sample of largely illiterate farmers, teachers and health professionals;
(d) deciding whose willingness to pay values should count;
(e) Delphi expert panel assessment of schistosomiasis interventions probabilistic effectiveness; and
(f) since most of the interventions evaluated have not been implemented in Mwea irrigation scheme, there are no relevant expenditure data - which meant much of the cost had to be generated prospectively.

Chapter 5 presents the procedure employed to resolve the first issue. The issues (b) to (e) are tackled in chapter 7. The last problem is handled in chapter 8. The CBA framework *per se* is not adequate to deal with the sequential decision problem stated in chapter 1.

3.2 Schistosomiasis Economic Literature Review

This section reviews the economic literature of schistosomiasis under the following sub-topics: cost description, cost analysis, cost-minimization analysis, cost-effectiveness analysis and total burden (cost) of illness.

3.2.1 *Cost description studies*

This subsection reviews the studies that have attempted to describe costs of a single schistosomiasis intervention option. Highton et al. (1974) considered just one schistosomiasis intervention, i.e., snail control through molluscicide. The authors reported expenditure data on molluscicides, staff emoluments, mileage and subsistence costs for a single season planting season in 1971/72. No physical quantities of those

resources are reported. Thus, one can not tell how the resources consumed were quantified. Some major cost categories were omitted, viz. volunteer labour time, equipment (e.g., eclipse sprayers, head dispensers), buildings (storage facilities), administration, maintenance, wire mesh, and poles. Also there is no mention of how the costs were calculated. It is not clear whether the researchers used market prices or shadow prices and whether their cost figures are accounting costs or opportunity costs. Furthermore neither the issue of differential timing nor that of incremental cost was addressed. Instead the authors came-up with total costs and average costs which are of hardly any utility to the policy makers.

Choudhry (1974) provided a cost description of the snail control programme in Mwea irrigation scheme during the period 1967-74. The resources costed were personnel, transport, equipment, uniforms, and molluscicides. The man hours expended were used as a unit measure of personnel effort. There is no indication of the prices used to cost personnel time. It is not clear whether fuel and vehicle maintenance costs were included under transport. The author notes that "....running repairs are made on the spot and costing of spare parts is not included as this does not exceed a few shillings per sprayer per annum. .....it should be noted that complete eradication (of snails) has not yet been achieved ...the present control programme will be continued indefinitely" [pp.600-608]. Surely even though equipment maintenance cost appeared a minor item (intuitively), it is likely to be a major cost item over time (especially if the programme has to be continued indefinitely as the author postulates). Thus, there is no justification of ignoring that cost element on the basis of perceived magnitude. Moreover, the author used accounting costs instead of the relevant economic costs (i.e. opportunity cost). Also no attempt was made to discount the costs.

Choudhry (1975) described the costs of a five year molluscicide programme to prevent the snail incursion into the new Ahero pilot project of Kenya. The study had four cost items - molluscicides, personnel, transport, and equipment. The physical quantities of the former two items were presented. Otherwise the study has similar weaknesses as Highton et al. (1974).

Jobin (1973) was a cost-outcome description study with a fake title of "cost-benefit-analysis for application of molluscicides in the prevention of schistosomiasis". The study addressed the following question "in the case of molluscicides, is there a month or season when the cost-effectiveness ratio is unusually lower ?". It appears that

the aim was to identify the month during which molluscicide would achieve the greatest impact on snail population reduction. The study was done using two water reservoirs in north-east and Minas Gerais both in Brazil (the two reservoirs had the same capacity with a maximum of 9000 cubic metres). He concluded that the most effective time to apply molluscicides in the north east was November, before the dry season. The estimated cost per treatment (m^2) was NCr$ 4.22. And for Minas Gerais he found the best time of the year would be May or June with cost per treatment of NCr$ 52 and NCr$ 47.50 respectively. It is not clear how he arrived at the latter conclusion since cost of treatment is lowest in August, with NCr$ 38.50. The study assumed that the only inputs or resources required are chemicals and labour, which left out equipment, transport, and storage space. There is no indication of physical quantities used nor the prices used in arriving at the average costs. Amount of water treated is totally the wrong measure of effectiveness to use. At least one would have liked to see the link between reduction of snail population and reduction in prevalence or incidence of schistosomiasis (if not reduction in severity of the disease itself). No sensible government would embark on snail killing mission for the sake of it. This is not a cost-benefit analysis study and it is actually difficult to place it anywhere in the spectrum of economic evaluation studies.

Duke et al. (1976) described the resources consumed in an efficacy evaluation of molluscicide-chemotherapy option in control of *S.haematobium* at the Barombi Lake Foci in Cameroon. The resource inputs costed were wages, transport, spraying and laboratory equipment, schistosomicide (Ambilhar) and molluscicide (Frescon). The cost of supervisory qualified research staff was omitted (although reported to have been used). The authors rightly costed some material donated by Shell International Chemical Company (U.K.). The costs borne by the local community (travelling time, waiting time, transport fares) were omitted.

Werler (1986) described the total cost of well construction, as a means of supplying safe water in Mali. Unlike the other studies, Werler gave a fairly good description of the wells constructed and physical resources entailed. The community input although mentioned was never costed. Other resources were valued using both the local currency and American dollars.

The weaknesses in brief of above studies are (1) failure to pose efficiency questions (indicating the view point); (2) consideration of a single option and failure to

describe it adequately; (3) omission of important cost items and of course non consideration of outcomes; (4) absence of explicit statement of physical units used to measure some of the resources consumed in the programme; (5) lack of vivid indication of the resource prices used-market prices or shadow prices valuing resources used; (6) use of accounting costs instead of economic/opportunity costs; (7) calculation of total costs and average costs instead of marginal costs which are a more relevant aid in priority setting; (8) failure to discount flow of future programme costs; and (9) implicitly assuming a certain decision environment.

3.2.2 *Cost-outcome description studies*

The studies surveyed in this subsection describe both outcomes and costs of a single schistosomiasis intervention. Their major weakness is that none of the competing options is analyzed.

Table 3.1 provides a summary of the cost-outcome studies that have been done on schistosomiasis interventions in St.Lucia. The mollusciciding programmes were concentrated in Cul-de-sac valley, provision of improved water supplies in Riche Fond Valley and chemotherapy in Marquis valley. These studies used persons protected and case years prevented as measures (proxies) of effectiveness of various interventions under consideration.

The case years prevented were calculated by comparing cases that would occur without control with the number of cases that actually occurred over time while the particular control measure or measures were being applied. The difference was the case years of infection prevented. The general finding was that chemotherapy was the least cost strategy.

None of the following studies: Cook et al. (1977), Jobin (1979), Jordan et al. (1978)., Jordan et al. (1982a), Jordan et al. (1982b) and Prentice et al. (1981) made any attempt to consider competing alternatives. Therefore, since economic evaluation is about comparing costs and benefits of alternative interventions, and the above mentioned studies were on just a single option, none of them qualifies as economic analysis.

Cook et al. (1977) made an implicit assumption that treatment is synonymous with cure. That is, all those found infected and hence treated for schistosomiasis disease would automatically be cured and thus protected. However, since none of the existing

schistosomiasis drugs has a 100 percent cure rate, some of those treated would not be cured. This means that they will continue passing excreta with schistosomal eggs.

Jobin (1979), Jordan (1977), Jordan et al. (1978), and Prentice et al. (1981) operated on the assumption of an initial state of zero intervention to a scenario of complete eradication of snails, hence permanent protection. At least there must have been some form (may be unorganized) of intervention. Also complete protection can only be possible if schistosomiasis is eradicated, and that has not happened in any country so far. Which then means we can only talk about improvements in levels of protection.

Jordan et al. (1982a) do not provide an elucidation of how to disentangle the lagged effects of chemotherapy from those of household water supply. Another issue is that none of the studies really exemplifies whether protection under consideration is permanent or periodic.

None of the aforementioned studies measured effectiveness of the interventions in terms of the ultimate (relevant) outcome, i.e. impacts on the quality and quantity of lives of the beneficiaries. The latter is, of course, the key objective behind schistosomiasis policy options.

Another attribute of the St.Lucia studies is that by considering just direct costs of interventions to the provider, they lost sight of important tangible and intangible costs borne by the immediate beneficiaries and their families, e.g. out-of -pocket expenses (user charges and retail drug costs), time (travel time, waiting time, hospitalization time), extra costs for advanced screening, transport costs, anxiety costs, and negative secondary effects, *et cetera.* Of course most of such costs would not be incurred under molluscicide, for instance. But, as indicated in this thesis, they would form a major cost component under any chemotherapy option. Thus, their omission would most likely lead to gross under estimation of intervention costs, which could lead to wrong decisions (if the results are used to aid decision making process).

In addition, the reviewed studies did not discount costs and proxy consequences to their present values or annual equivalents. The benefits of molluscicide do not occur in the short-term because of the time lag between reduction in snail population and improvement in beneficiaries' quality of life due to reduced risk of schistosomiasis infection and / or reinfection. The costs are recurrent, meaning they occur throughout the project period. If the benefits are not discounted we are likely to fall into the "never

invest in molluscicide trap". On the other hand, biological control of snails is likely to have substantial capital cost during the first year and virtually no cost thereafter, when eventually launched fully in the field. However, the benefits from biological control methods are likely to accrue throughout the following decades after the competitor snails have established themselves. The same could be said to be true for costs and benefits of health education, household water supply and provision of lavatory facilities.

Furthermore, the analysts did not take into account the fact that various interventions may have some marked spillovers or externalities. For example the improvement in sanitation will not only curtail schistosomiasis infections but also other public health problems prevalent in developing countries. Also, provision of piped water in homesteads may make it feasible for households to develop kitchen gardens for growing vegetables and so on. What does this mean? It implies that total omission of positive neighbourhood effects may lead to marked underestimation of benefits from some interventions hence misleading decision makers. Although it might not be possible to quantify and value some of the spillovers, it's nevertheless important to identify them.

3.2.3 *Cost-effectiveness analyses*

These are studies that evaluate more than one schistosomiasis control option which have a common effect. The results of CEA may be expressed either as cost per unit of effect (e.g. cost per case year prevented) or effects per unit cost (e.g. days of healthy life per shilling spent).

Prescott (1987) developed a generalized framework for resource allocation in schistosomiasis chemotherapy, demonstrating that the optimal choice of chemotherapy regime depends critically on the level of budget constraint, the unit costs of screening and treatment, and rates of compliance with screening and chemotherapy. The solution for the model is generated assuming that the objective for schistosomiasis control is to maximize the proportion of cases cured (indicated by absence of schistosome eggs in urine or faeces samples). The implicit assumption in the above objective function is that patients who are treated but not cured have not been done any good. Intervention literature reviewed in chapter 2 of this thesis indicates clearly such an assumption is not plausible. There is evidence that treatment with either praziquantel or oxamniquine

normally leads to over 90% reduction in the intensity of infection (reduction schistosome egg load) among uncured cases (Foster, 1987).

A number of features emerge from the analysis of Prescott's model with illustrative parameter values (Table 3.2): (a) the optimal choice of chemotherapy regime tends to be very sensitive to behavioral and economic parameters (e.g. the level of the budget constraint); (b) the selected regimes tend to be more effective at the lower level budgets; (c) the selective regimes tend to be less effective than their mass counterparts because at any given budget level the fixed cost of screening has to be overcome before residual resources can be devoted to treating those who test positive; and (d) at higher budget levels the population-based regimes tend to be more effective because selected approaches quickly exhaust their inherently limited capacity to cure cases. Mass population chemotherapy coverage of the entire population is modified only by the compliance rate for treatment. However, impact of selective population chemotherapy is modified by three coverage-related parameters: screening compliance, sensitivity of the screening technique, and treatment compliance.

According to Prescott (1987) his analysis models the cost-effectiveness of interventions applied for one year. A control programme implemented continuously for several years consists of a sequence of discrete one-year interventions, so the same framework can be used to identify the optimal choice for each year within the period. The required extension would be a transmission model linking prevalence rates from one year to the next.

Korte et al. (1986) was a cost-effectiveness analysis of metrifonate and praziquantel selective mass chemotherapy. The former was a three dose regimen, while the latter was a one dose regimen. The assumptions were stated clearly. Effectiveness was measured in terms of persons cured (based on cure rates) and reduction in prevalence rate. Three cost items were taken into account, namely: medication (cost of drugs), screening, and transport. The costs borne by the participating community were omitted. Resources used were valued in Deutche Mark. The analysis shows that for metrifonate the cost per person cured came to DM 12.57 in setting I (80km) and DM 32.52 in setting II (250km). At the end of the intervention a prevalence of 4.2% was reached. If praziquantel was used, the cost per person cured would have been DM 8.36 in setting I and DM 11.47 in setting II. Prevalence at the end of the intervention would be 1.1%. The costs and benefits occurring beyond year zero were ignored. They did not

do marginal analysis and sensitivity analysis.

Polderman (1984) studied three mining villages (Tshamaka, Katoka and Makundu) of Miema region in Zaire, where bowel schistosomiasis is highly prevalent. The interventions evaluated were chemotherapy only in Tshamaka; chemotherapy and focal snail mollusciciding in Katoka; and chemotherapy and intense snail mollusciciding in Makundju. He notes that the "...degree of success of the control measures ought to be expressed....in terms of improvement in the clinical picture (decrease of hepatomegaly or splenomegaly) or of the improvement of the quality of life, e.g., as a reduction in the number and intensity of complaints." [p.1075]. In spite of that encouraging note, the author went ahead to use the 'traditional' schistosome egg count as sole proxy indicator of improvement in patients' health status as a result of schistosomiasis intervention. In schistosomiasis, the relationship between this and outcome is crucial - and is a key issue addressed later in this thesis.

The parasitological demonstration of schistosome eggs in stool or urine samples through egg counts is widely used for the initial diagnosis, although the method suffers from poor sensitivity. It is not the eggs that work their way through the human blood vessel walls and are shed in excreta that cause the disease. Instead many eggs are retained in the tissues, where they provoke an inflammatory reaction responsible for the disease. "The mere presence of the adult schistosome in the blood stream - where they remain joined and continue to shed eggs for several years - does not give rise to a pathological response.....the degree of morbidity and intensity of infection are determined by the number of adult worms in the human host and shedding eggs that may be deposited in the organ tissue "(WHO, 1989:p.55).

Three points are clear from this discussion:

(a) absence of schistosome eggs in excreta samples is not an absolute indicator of absence of schistosomiasis disease;

(b) a reduction in the number of schistosome eggs counted in urine or stool samples is not a good measure of reduction in disease severity. Even if a schistosomiasis patient is not treated, the egg count naturally subsides during the transition from acute stage into chronic stage (Davis, 1986). This makes it very difficult (if not impossible) to desegregate decreases in egg count as a result of intervention from the natural decrease that would have occurred anyway.

(c) Since egg count says nothing about schistosomiasis disease severity continuum, it

is an inadequate measure of expected health benefits from schistosomiasis interventions.

So the assumption that the observed reductions in egg count properly reflect reduced morbidity in the population and reduced disease in the individual is not realistic. That creates the need for development of direct measures of health status improvement as a result of schistosomiasis interventions.

Polderman made no attempt to identify the resource implications for each of the interventions. For chemotherapy intervention he assumed that the oxamniquine drug was the only resource used. Other resources like personnel time, supervision, transport, fuel, equipment, storage space, et cetera, were omitted. Costs falling on the consumers (e.g., time spent undergoing screening and treatment, travel time, and other resources that they may have contributed) were also excluded, despite the fact that the author intended to do the study from the infected populations' point of view. There is even no indication of how the per capita costs or average costs (which are of little utility to the policy makers) were arrived at. Polderman (1984) is a poor example of a cost-effectiveness study.

Rosenfield et al. (1977) developed a dynamic model for predicting the impact of water resource projects on transmission of schistosomiasis and verified it with data from 54 villages of Khuzestan Province, Iran (where *Schistosoma haematobium* is prevalent). The authors hypothesize that changes in prevalence of schistosomiasis in a population over time result from an imbalance in the opposing processes of infection and de-infection. They express the rate of change in prevalence in a population (dY/dt) as:

$$dY/dt = A(1-Y)-BY \quad \text{.....(1)}$$

$$Y_t = Ce^{-(A+B)t}+A/(A+B) \quad \text{.....(2)}$$

$$C = Y_t-A/(A+B) \quad \text{.....(3)}$$

$$Y_{t+\Delta t} = [(Y_t-A/(A+B)]e^{-(A+B)\Delta t}+A/(A+B) \quad \text{.....(4)}$$

$$A = \beta_0(H^{\beta 1} \times P^{\beta 2}) \quad \text{.....(5)}$$

$$\log_e A = \beta_0 + \beta_1 \log_e H + \beta_2 \log_e P \quad \text{.....(6)}$$

$$P = Y_t \times N \quad \text{.....(7)}$$

$$P = P(1-Q) \quad \text{.....(8)}$$

Where Y is the fraction of the population infected with schistosomiasis (i.e. prevalence); A is a rate coefficient for the process of infection; B is the de-infection coefficient rate; t is time; P is the number of persons infected; β_0, β_1, β_1 are regression coefficients; H represent metres of accessible snail habitat; Q is the chemotherapy treatment factor; and

N is the total population. Equation (1) assumes that after infected persons lose their infection, they develop no immunity to reinfection, and join the pool of susceptible individuals. 'A' is a function of metres of accessible snail habitats (an index of the likelihood of contact of uninfected individuals with infested water), and the size of the infected population (an important determinant of the level of miracidial contamination of snail habitats).

The authors made an attempt to use the transmission model described above to analyze the cost-effectiveness of molluscicide, chemotherapy, engineering (physical destruction of snail habitats using bulldozers and tractors), and a combination of the three options. The cost estimates were based on Bilharzia Control Programme (BCP) records of expenditures for labour, equipment, materials, and transportation. The authors used changes in prevalence rates and case-years of infection prevented as intervention effectiveness measures. The results obtained using changes in prevalence rate are presented in Table 3.4. Whilst the results obtained using case-years of infection prevented are given in Table 3.5. Their results indicated that the combined control programme led to a greater decrease in prevalence than any single measure. However, chemotherapy prevented more case-years of infection than combined control programme and other single options.

Rosenfield (1979) reported cost effectiveness analysis of schistosomiasis interventions in St.Lucia 1970-77. The author concluded that chemotherapy plus water supply, chemotherapy, water supply, and molluscicide cost $33.81, $8.95, $41.90 and $84.23 per case year prevented respectively.

Jordan (1977) did a cost-effectiveness analysis of three schistosomiasis interventions implemented in Cul-de-Sac, Riche Fond and Marquis valleys in 1973-74. Molluscicide, water supply and chemotherapy interventions cost $63.02, $68.13 and $14.99 per case year prevented respectively.

The Swiss Tropical Institute (1993) evaluates the cost and cost-effectiveness of three strategies for the control of *Schistosoma haematobium* by a single 40mg/kg dose of praziquantel chemotherapy - (a) annual mass treatment of school-children by a mobile team (MMT), (2) annual reagent strip testing of school children by teachers and referral to the dispensary for treatment (RST), and (3) passive testing and treatment at the dispensary level (PTT). The cost analysis was undertaken from the provider's point of

view, and effectiveness was assessed as the number of infected persons treated. RST was the least costly and PTT was the most expensive (Table 3.8). However, PTT was the most cost effective option since it minimized the cost per infected person treated. Praziquantel was found to account for the largest proportion of costs for both MMT (83.5%) and PTT (58.1%). This funding is consistent with the findings obtained in this thesis (chapter 8). This study's most amazing finding was that even if the cost of praziquantel were reduced by 100%, PTT remained the option of choice.

In summary, the major loopholes in the cost-effectiveness analyses reviewed in this subsection are: unclear viewpoint; omission of some costs; failure to employ ultimate outcome measures; omission of some key intervention benefits (such as averted costs); ignorance of differential timing of future intervention costs and consequences; lack of marginal analysis; and ignorance of equity implications.

3.2.4 *Total burden of illness*

A common approach adopted by most of the economic studies of schistosomiasis is based on total needs assessment and/or the related concept of cost of illness. Most researchers in this genre are convinced that the results of burden of illness studies are an indispensable basis for priority setting. They argue that the relative size of the burden of illness is an appropriate basis for priority setting.

Weisbrod and Helminiak (1977) studied the effects of parasitic diseases on agricultural productivity. They estimated four additive models using the ordinary least squares method to test four hypotheses. (i) Disease reduces weekly earnings (tested by regressing earnings per week on a number of disease and other personal characteristic variables). (ii) Disease causes workers to shift to physically less demanding jobs (was tested by regressing the ratio of days worked at "task" jobs to total days worked on a number of disease and other personal characteristics). (iii) Disease reduces productivity per day worked (was tested by regressing earnings per day from all types of work on independent variables). (iv) Disease reduces the amount of labour time supplied per week (was tested by regressing days worked per week on the independent variables). None of the disease variable coefficients was statistically significant. Thus, there was no evidence that schistosomiasis infection reduced weekly earnings. When the ratio of task to total days worked was regressed against schistosomiasis parasite egg count per

gram of stool, its coefficient was not statistically different from zero. Earnings per day was regressed against parasite presence, but its coefficient was statistically insignificant. In short, there was no conclusive evidence that schistosomiasis infection had significant adverse effects on individuals productivity or earnings.

Audibert (1986) attempted to assess the effect of health status on the productivity of non-wage-earning rice-growing peasants, in Mayo Danai, Cameroon. The author estimated a log-linearized production function of the following form:

$\ln(Yt)=Ó+ß_1\ln(X_1)+ß_2\ln(X_2)+ß_3\ln(X_3)+ß_4\ln(L)+....+ß_n\ln(n^{th})$

Where Y is output, K is experience, L is family size, L_f is labour force, L_A is adults, $S1_A$ is prevalence of malaria among adults, $S1_T$ is the prevalence of malaria among family members, $S2_A$ is prevalence of schistosomiasis among adults, $S2_T$ is the prevalence of schistosomiasis among family members, X_1 is the duration of transplanting, X_2 is the cultivated surface, X_3 is fertility, V_1 is millet output, V_2 is millet fields, and rainy season dummy variables. Except for L, the coefficients for all the other variables were statistically significant. Audiberts most important finding was that the coefficient for $S2_T$ variable (i.e. the prevalence of schistosomiasis among family members) was significant and had the expected negative sign. In other words, the finding supported the hypothesis that the health status of the manpower contributes in determining the level of output. She concluded that a 10% increase in the prevalence of schistosomiasis results in a 4.9% decrease in output, and thus, the marginal effect of schistosomiasis is not negligible.

Prescott (1979) critically reviewed conceptual frameworks of macro- and micro-economic studies done on schistosomiasis. Farooq (1963), Fenwick and Figenschou (1972), Wright (1972), Baldwin and Weisbrod (1974), Omer and El din Ahmed, N. (1974), Foster (1967), Weisbrod (1973), Weisbrod and Helminiak (1977) restricted their attention to schistosomiasis control as an investment in human capital formation which would augment productivity and incomes of the beneficiaries. Thus, many important elements of economic appraisal (evaluation) were not addressed, viz: valuation of intangible pure consumption benefits and future savings in treatment costs (averted costs); externalities, magnitudes of cost of programme inputs; and link between programme inputs and outputs. The models used in various macro-studies to derive the burden of illness (economic loss) estimates are of the following general form:

$K = N(\acute{O}Q)$

Where:

K = annual 'economic loss'

N = total number of individuals infected

Q = annual average labour output

Ó = an arbitrary percentage 'loss of working capacity' coefficient

Prescott (1979: p.10) argued that "---it is models of this type which have been the only source of the gains from schistosomiasis control, and the fact that these estimates have been adduced in favour of control renders their exposure to criticism especially important".

The model hinged on five basic assumptions. First, any degree of physical dysfunction necessarily entailed the same degree of reduced labour productivity. However, labour is heterogeneous and physical and psychic dysfunctions will be highly differentiated. The authors did not recognize that labour needs complementary inputs, such as, capital, land, intermediate inputs and technology to produce. Thus, if some of the complementary inputs are in short supply, improved health status does not automatically lead to increased labour productivity.

Second, the model assumed homogeneous morbidity experience among the infected population (that all infected individuals experienced identical degree of ill-health). This led to a general failure to distinguish between schistosome infection (as manifested in eggs passed in excreta - urine and stool - by the infected) and clinical severity of the disease. Table 3.6 below portrays this phenomenon.

Table 3.6: Differential gradient of schistosomiasis infection severity

Disease severity	Percentage of total infected cases
Asymptomatic	62
Mild	21.7
Moderate	14.8
Severe and very severe	1.5

Source: Farooq (1963)

In response to the four severity categories, Farooq (1963) used differential 'loss of working capacity' coefficients of 25%, 50%, 75% and 100% in his estimation of benefits

from schistosomiasis control in Philippines. Thus, although similar to other burden of illness studies in all other respects, Farooq (1963) took into account the differential gradient of schistosomiasis disease. Evidence in Table 3.6 indicates that relatively very few schistosomiasis cases are likely to advance to both severe and very severe disease stages.

The third assumption was that every infected individual is engaged in homogeneous productive activity. This assumption is not plausible since the majority of the beneficiaries (the children aged 5 to 19 years) are not yet in the active labour force. Such an assumption really leads to gross over estimation of expected benefits from schistosomiasis interventions.

The fourth assumption was that freedom from schistosomiasis infection implies perfect health. That postulate is necessary to facilitate the smooth transformation of the economic loss model into a gains from control model. Walsh et al. (1980) claimed that the prevalence in many developing countries of a plethora of parasitic infections in combination with poor nutritional intake creates a synergistic disease complex whose effects on labour performance may not be significantly diminished by the elimination of schistosomal infection alone. Thus, where multiple infections are common the assumption that schistosomiasis infected workers would otherwise be healthy will overstate the likely gains from control.

The fifth assumption was that of total eradication of schistosomiasis from a state of no control. Even if total eradication were technologically feasible (as it is) and economically feasible (which it is not), it is not realistic to assume a state of no control. The status quo would normally be a state where schistosomiasis patients seek care from the existing general health facilities after experiencing the symptoms.

All schistosomiasis cost-of-illness researchers used average product of labour as the output measure and an assumed arbitrary percentage 'loss of working capacity' coefficient as an indicator of loss in working capacity caused by infection. There are a number of conceptual problems underlying their derivation and usage of average product of labour. First, the measure of output employed as the standard of non-infected persons' output which infected workers presumably will attain after the elimination of their infections is itself dependent on the output levels achieved by infected workers. Second, of more importance to the managers of schistosomiasis control programmes would be what happens at the margins of the relevant policies. Third, the authors did not

appreciate that the relevant measure of economic loss is the opportunity cost of burden of illness. The term economic loss is employed by the authors of COI schistosomiasis studies to reflect the resource loss costs imposed on the economy by schistosomal infection, implying that the costs currently incurred would be averted and so accrue as measurable benefits in the future if schistosomiasis were eradicated. There is no point of wasting scarce research resources on the estimation of the unattainable benefits. Fourth, at best such studies are 'partial' cost of illness studies because they do not attempt to measure psychic cost of illness.

Prescott (1979) argued that "---efforts to determine the economic dimension of (schistosomiasis) disease continue to confront resistance from those who question the propriety of basing the decision whether to control disease on seemingly materialistic considerations such as its contribution to increased output, at the expense of 'humanitarian' considerations in terms of the suffering which averts it."[p.3]. The issue at hand is not just humanitarianism! It is that the output of health care industry is not labour productivity but improvements in quality and quantity of lives of beneficiaries. Any civilized society has a moral obligation to provide basic health care to all its citizens - children, housewives, retired, handicapped, capitalists, socialists, catholics / protestants, christians/muslims/hindus/heathen, employed/non-employed. Thus, those who advocate the "mechanistic" livelihood approach give economics (and those who practise it) an inhuman face which is wholly unwarranted by economic principles and methodology.

The flaws in conceptualization of analytical frameworks encountered in total cost of illness studies are not limited to studies conducted within the tropics. Such flaws are typical characteristics of all the studies in developed countries that have attempted to compute total burden of illness. Henke et al. (1986) was a more recent study that attempted to estimate total cost of illness in the Federal Republic of Germany in the year 1980. According to Drummond et al. (1986) more than 200 studies of this sort had been done to that date. Shiell et al. (1987) and Mooney and Creese (1991) provided extensive critiques of the total burden of illness studies.

Given that most of the studies reviewed above do not fulfil the Drummond et al. (1987) criteria of good economic evaluation studies, and that the five types of economic evaluations (output maximization analysis; cost minimization analysis; cost effectiveness analysis; cost utility analysis; and cost benefit analysis reviewed in section 3.1) might

not singly be robust enough to simultaneously deal with the sequential research problem stated in chapter 1; what can be done? The CBA and CUA decision criteria employed within a decision analysis theoretic framework provides an exit out of the dilemma.

3.3 Decision Analysis

Decision analysis (DA) is a philosophy, articulated by a set of logical axioms, a methodology and collection of systematic procedures based upon those axioms, for analyzing the complexities inherent in decision problems (Keeney, 1982). The major strength of DA framework is its ability to dissect a complex decision problem into its components, after which those components are reassembled in logical order with their meaning and import laid bare. The DA framework is built on a set of axioms formally developed by Von Neumann and Morgenstern (1947) and later restated by Marshak (1950), Savage (1954), Luce et al. (1957), Pratt et al. (1964) and Hey (1979). Keeney (1982) put the Neumann-Morgenstern axioms within DA context. Shoemaker (1982) and Bernasconi (1991) provides a comprehensive critical review of variants of the theory of expected utility.

The above axioms provide the rationale and theoretical basis of the "divide and conquer" approach of decision analysis (Howard, 1980 and Keeney, 1982). They directly lead to the five phase paradigm of decision analysis - preanalysis, structural analysis, uncertainty analysis, utility or value analysis, and optimal strategy evaluation (Keeney and Raiffa, 1976).

3.3.1 *Pre-analysis phase*

In this phase the decision environment is conceived. It involves (1) delineation of stakeholders and their objectives; (2) construction of an objectives hierarchy and development of measurable attributes for each of the lowest level objectives; and (3) generation of options and elimination of inadmissible options.

3.3.1.1 *Delineation of stakeholders'*

There are a number of possible stakeholders in schistosomiasis control activities, such as households living in Mwea scheme; the Ministry of Health (MoH) and Kenya National Irrigation Board (KNIB); households living in the neighbourhood of Mwea scheme; the Ministry of Finance; external donors (bilateral and multilateral); and politicians. However, in this thesis only the costs and benefits falling on the first two stakeholders would be considered (they will be most affected).

(i) Households living in Mwea scheme

This interest group consists of potential and actual schistosomiasis patients. Probably their motivations of participating in SCP are to realize health improvement; to have assurance from insurance against schistosomiasis (and other diseases); to attenuate medical expenses (e.g. travelling time, waiting time, user fees, drug costs, diagnosis fees, and miscellaneous expenses, such as purchase of food for patient); to reduce psychological costs, hence fuller enjoyment of leisure, increase in productivity, caring externality, utility from participation, and so on. Thus, the broad objective of this group might be to maximize welfare (happiness or utility) subject to the budget constraint.

(ii) The MOH and KNIB

The interest of the MoH and KNIB is either to maximize health production subject to their budget constraint (i.e. allocated resources) or to minimize expenditures subject to the desired level of health output.

3.3.1.2 *Hierarchy of objectives*

Figure 3.1 below presents a hierarchy of objectives for schistosomiasis intervention policies. The overall objective can either be to maximize social welfare, or maximize net social present value, or maximize expected value or utility. Whichever broad objective is adopted it is further desegregated into the second level, the third level, and the fourth level objectives. Each subsequent level substantiates the first broad objective.

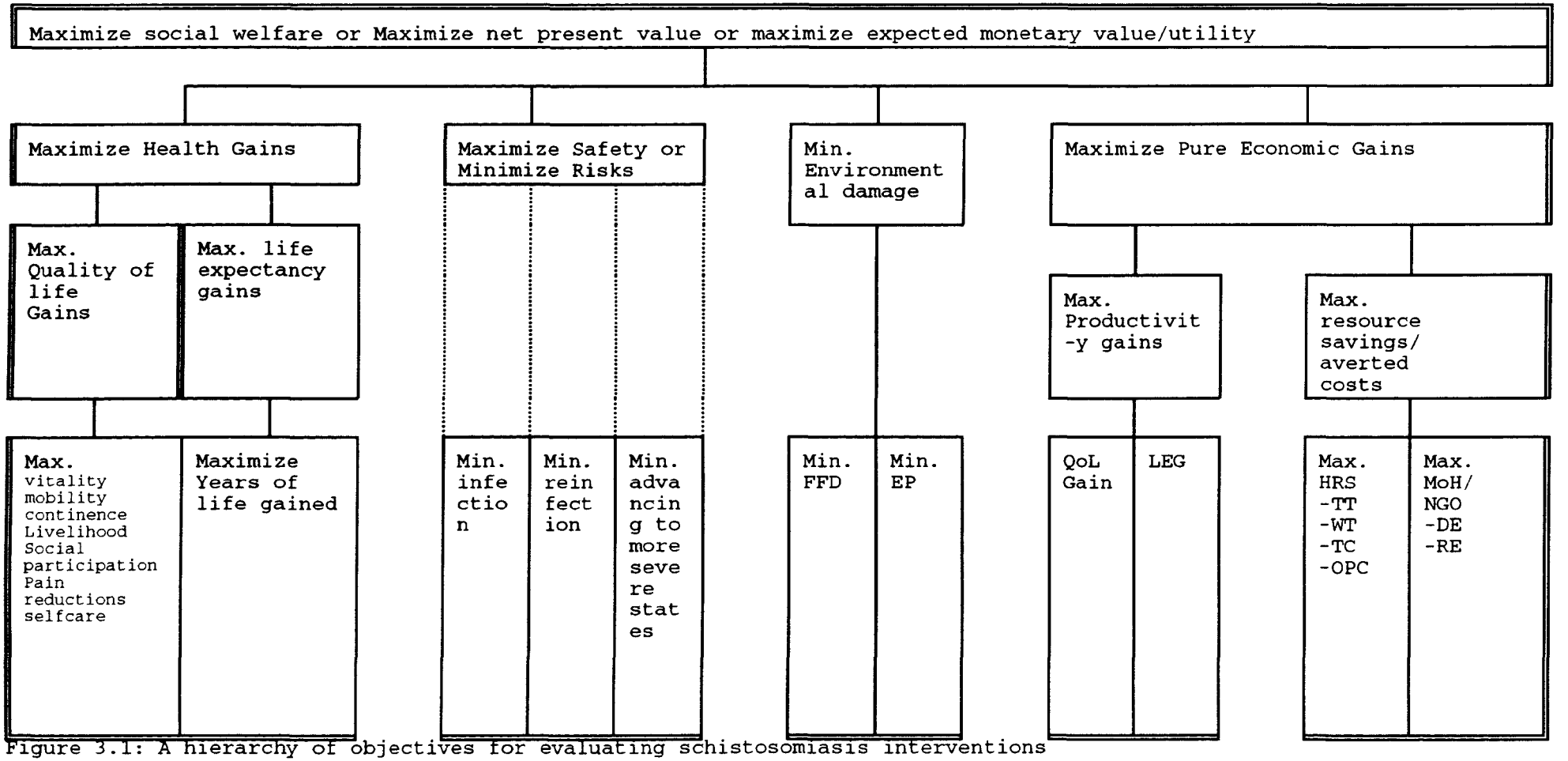


Figure 3.1: A hierarchy of objectives for evaluating schistosomiasis interventions

Specification of attributes

Having derived the hierarchy of objectives, it is important to associate an attribute to each of the lowest-level objectives that will indicate the degree to which alternative schistosomiasis intervention options meet that specific objective. The attribute provides a scale for measuring the degree to which its respective objective is met (Table 3.7).

3.3.1.3 *Development of options*

The process of schistosomiasis options identification and pruning is handled in chapter 5.

3.3.2 *Structural analysis phase*

In phase B the decision problem is structured into a decision tree portraying the sequential nature of decisions. This phase is explained in chapter 6.

3.3.3 *Uncertainty analysis phase*

In a typical decision making environment, it is impossible to predict with precision the costs and consequences of each schistosomiasis intervention policy. The implied risk and uncertainty could be attributed to a number of reasons. First, there is variation and uncertainty in diagnosis and treatment (Culyer, 1978). Second, effectiveness in terms of ultimate outcomes of virtually all schistosomiasis interventions is unknown or controversial. Third, most of the preventive schistosomiasis interventions have long time horizons, meaning that neither their costs nor their consequences are experienced immediately. The future costs of inputs entailed by such options will largely depend upon the performance of the whole economy. The perceived effects will depend on natural phenomena among other factors. Fourth, actions of some strong stakeholders, such as external donors and the local political system are uncertain. Lastly, the fact that schistosomiasis is not the only cause of risk of life and limb is bound to confound the assessment of options' effectiveness.

Phase C in decision analysis is concerned with the assessment of magnitude and

likelihood of impacts of schistosomiasis policies. In other words, that entails determination of possible consequences and the probabilities of each occurring under different interventions. That is formally done by identifying a probability distribution function $P_j(s)$ over the set of attributes for each schistosomiasis intervention option A_j. In the absence of frequency distribution data, the experts familiar with the disease interventions are asked to attach probabilities to every possible consequence at every chance node or health state without and with options being evaluated. The decision tree constructed earlier is again used as a probability data collection instrument. This phase is discussed further in chapters 6 and 7.

3.3.4 *Utility or value analysis phase*

This phase of eliciting utility or/and willingness to pay values for health state descriptions is discussed in chapter 7.

3.3.5 *Optimization analysis phase*

The task of this phase is to calculate expected values (both expected utilities and expected monetary values) for the optimal strategy. One of the approaches of obtaining the optimal strategy is through the dynamic programming algorithm of averaging out and folding back (Raiffa, 1968). The approach is also called backward induction (Hamburg, 1977; French, 1989). The optimal strategy tells the decision maker what he should do at the start of the decision tree and what options he should choose at every decision node.

Two sequential optimization decision analysis models - cost-benefit and cost-effectiveness - are developed in chapter 6 and estimated in chapter 9. The cost-benefit decision analysis (CBDA) model employs the net present value criterion. While the cost-effectiveness decision analysis (CEDA) model uses the net effectiveness criteria. The CBDA model determines "in advance" the marginal value of a QALY (through WTP approach) and then calculates the net benefits. Contrastingly, CEDA model calculates the "price" of a QALY and uses that price to convert expected QALYs from various strategies into their monetary equivalents. In short, CBDA values health benefits directly into their monetary equivalents using WTP; while, the CEDA model does so indirectly

using the "price" of QALYs implied in the current schistosomiasis control decisions.

3.4 Summary

Five economic evaluation techniques (OMA, CMA, CEA, CUA and CBA) have been reviewed in order to identify one which is most appropriate for answering the research questions posed in chapter 1. The economic literature on schistosomiasis has been reviewed under the following sub-topics: cost-description, cost-analysis, cost-minimization, cost-effectiveness and total burden (cost) of illness. The main findings are: most of the reviewed studies do not fulfil the Drummond et al. (1987) criteria of good economic evaluation studies; and no single one of the five types of economic evaluation is robust enough to deal simultaneously with the complex sequential research problem stated in chapter 1. The chapter concludes that the solution is to employ CBA and CUA decision criteria within a decision analysis theoretic framework.

Table 3.0: Conversion factors for goods and services in Kenya

Category	Median SCF	Standard deviation
Traded exports	1.00	0.25
Traded imports	0.86	0.25
Consumption	0.82	0.14
Non-traded	0.77	0.06
All combined*	0.80	0.21

Source: Brent (1990)

* SCF used in this thesis

Table 3.1: Cost-outcome descriptions of schistosomiasis interventions in St.Lucia

AUTHOR	AREA STUDIED	CONTROL METHODS DESCRIBED	RESULTS (1984 US$)
Cook et al. (1977)	Villages in Marquis valley, 1974-75	Chemotherapy	Annual cost per person protected: 1974: $2.65 1975: $1.45
Jobin (1979)	Cul-de-Sac Valley	Molluscicides	Annual cost per person protected: $11.14
Jordan et al. (1978)	7000 people in Cul-de-Sac Valley	Molluscicides	Annual cost per person protected: $5.76
Jordan et al. (1982a)	5 villages in Riche Fond valley, 1977-78	Household water supplies (after transmission was reduced by chemotherapy)	Annual cost per person protected: 1977-78: $8.05 1978-79: $9.72 1979-80: $12.35 1980-81: $12.61
Jordan et al. (1982b)	10 villages, Marquis valley	Chemotherapy until 1976	Annual cost per person protected: 1973: $2.91 1974: $1.60 1975: $1.42 1976: $1.45
Prentice et al. (1981)	5 communities with a total population of 1250, Soufriere River Valley, 1976-80	Monthly application of molluscicides (focal sites)	Annual cost per person protected: $3.75 Cost per case year prevented: $20.81

Table 3.2: Definition and illustrative values of model parameters		
Economic	Symbol	Value
Unit cost per treatment	C_t	2.5
Unit cost per screening test	C_s	0.50
Budget per capita (US$)	C(bar)/N	-
Behavioral		
Compliance rate for mass chemotherapy	$\grave{O}_m$	0.90
Compliance rate for screening	$\grave{O}_s$	0.75
Compliance rate for selective chemotherapy	$\grave{O}_c$	0.95
Epidemiological		
Total population	N	-
Eligible fraction	N_e/N	0.80
High prevalence fraction	N_h/N	0.40
Prevalence rate in N	p	0.45
Prevalence rate in N_e	P_e	0.50
Prevalence rate in N_h	p_h	0.70
Efficacy of chemotherapy	e	0.90
Sensitivity of screening test	s	0.90
Source: Prescott (1987)		

Table 3.3: Cost and effectiveness of schistosomiasis chemotherapy with no budget constraint (using illustrative parameter values)

Delivery Regime	Cost per capita (US$)	Proportion of total cases cured
Mass population	1.80	0.72
Selective population	0.94	0.51
Selected mass	0.90	0.50
Selected selective	0.60	0.36

Prescott (1987)

Table 3.4: Results of cost-effectiveness analyses				
Control measures	Level of prevalence after 7 years of control (1967-1973)	% change in prevalence after 7 years of control (1967-1973)	Projected level of prevalence 10 years after cessation of controls	Projected level of prevalence 22 years after cessation of controls
Analysis 1:	Control strategy comparison under same annual expenditures ending in 1973			
Molluscicíding	0.73	10.6% increase	0.80	
Engineering	0.69	4.5% increase	0.75	
Chemotherapy	0.60	9.1% decrease	0.80	
BCP combined controls	0.20	68.4% decrease	0.78	
Analysis 2:	Control strategy comparison under higher annual expenditures ending in 1973			
Molluscicíding	0.61	7.6% decrease	0.80	0.80
Engineering	0.42	36.4% decrease	0.66	0.77
Chemotherapy	0.005	99.2% decrease	0.80	0.80
Analysis 3:	Prolonged use of chemotherapy after hypothetical cessation of BCP			
Chemotherapy			0.68	

*Baseline (pre-control) prevalence = 0.64.
Source: Rosenfield, Smith and Wolman (1977)

Table 3.5: Case-years of infection prevented under analysis 1, using the same expenditure for each of four control options

Years	Estimated case years of infection with no control	Case-years of infection prevented		
		Combined controls	Chemotherapy	Engineering
1967-1973*	2,637	1,596	1,637	484
1967-1983**	6,537	2,666	2,143	1,353

* control application period
** Control application plus hypothetical cessation of controls

Source: Rosenfield, Smith and Wolman (1977)

Table 3.7: Attributes for measuring intervention objectives	
Objective	Measurable attribute
Maximize quality and length of life	X_1 = Change in Quality adjusted life years
Maximize productivity gains	X_2 = Income change in shillings
Maximize averted costs	X_3 = Change in resource use in Kenya Shillings
Minimize risk of infection	X_4 = Change in prevalence rate
Minimize risk of reinfection	X_5 = change in incidence rate
Minimize risk of advancing to more severe health states	X_6 = change in health state transition probabilities
Minimize environmental damage	X_7 = willingness to pay or accept payment for a simulated change in environment

Table 3.8: Comparison of the cost and cost-effectiveness of the three control options			
	Mass treatment by a mobile team (MMT)	Reagent strip testing by teachers (RST)	Passive testing and treatment at dispensaries (PTT)
Total cost (US$)	15,663	8,798	21,307
Number of infected persons treated	3,495	2,372	11,968
Cost per infected person treated (US$)	4.48	3.71	1.78
Cost per capita (US$)	0.084	0.047	0.114
Source: Swiss Tropical Institute (1993:30)			

CHAPTER 4
A REVIEW OF HEALTH MEASUREMENT

4.0 Introduction

Poor countries can ill-afford ineffective health care. An effective tropical disease intervention is one which produces a net improvement in beneficiaries' quality of life and/or life expectancy. This chapter provides a chronological review of most measures of health developed and used to date; with a view of choosing the most appropriate for use in evaluation of schistosomiasis interventions. The health index required in this thesis ought to: be capable of measuring schistosomiasis intervention policies' impact on both quality and quantity of life; have a QoL aspect defined in terms of cultural functional dimensions likely to be affected by the presence or absence of schistosomiasis interventions; have a QoL aspect that reflects the gradient or continuum of functional disability caused by different severity stages of the disease; be defined in non-medical terms for ease of application in a general population survey; and be suitable for administration by trained non-medical personnel. Owing to the lack of an appropriate index for use within a third world context, the chapter concludes that a functional health status index ought to be developed that applies most appropriately to schistosomiasis and the culture of Mwea Irrigation Scheme population. An attempt is made to develop and apply such an index in chapter 7.

4.1 Mortality Rates

In the past mortality rates have been used to describe changes in the well-being of populations (Anderson, 1983; Walsh and Warren, 1984, 1990). Three forms of mortality rates are in common use: the crude death rate; the infant mortality rate; and the case fatality rate (Anderson, 1983). The advantages of death rates are that they are determined objectively, are readily available in considerable detail for most countries, and are reasonably useful for intertemporal and interspatial comparisons (Fuchs, 1972).

If the objective function that society were trying to maximize was reduction in the number of deaths, then the death rate might be an appropriate indicator of population health status. However, mortality rates have the following drawbacks: (a) they consider

only the dead and ignore the living; (b) many important treatments or health care programmes might have negligible or no impact on mortality rates, but may improve the beneficiaries' quality of life considerably. For example, in the case of schistosomiasis where there is hardly any correlation between morbidity and mortality, death rate (as a single indicator) is too insensitive since it says nothing about changes in morbidity caused by intervention policies.

Schistosomiasis intervention is not just about preventing deaths or extending lives. The quality of life that one leads during the extended life span is important. Neither crude death rate, case fatality rate, infant mortality rate, nor life expectancy at birth come close enough to measuring the ultimate schistosomiasis intervention output, which is the change in individuals' health status as a consequence of intervention (since schistosomiasis is not a major cause of death in Kenya).

4.2 Clinical Outcome Measures

Clinical outcome measures are symptom oriented. They conceptualize health as the absence of general or specific symptoms. The clinical outcome assessment for schistosomiasis interventions is based on (a) clinical judgements of symptoms and medical history (e.g. haematemesis, haematuria, dysuria, itching, fever, "watering can" scrotum, etc.); (b) laboratory tests - parasitological egg count measure for schistosomiasis infestation - via kato and filtration techniques; (c) radiological tests e.g. for bladder calcification, ureter deformities, hydronephrosis, kidney-malfunction, urinary stones due to schistosomal infestation; and (d) electro-cardiography test for pulmonary hypertension (Forsyth et al., 1966; Forsyth, 1969; Davis, 1986).

In schistosomiasis there may be no correlation between the number of symptoms and severity of disease. In addition, absence of symptoms does not necessarily imply that the person is of normal health. For example, determination of health status through symptoms will omit most of the people with chronic schistosomiasis who are mostly asymptomatic. Also, since it is unusual for schistosome eggs to be excreted at the "*Kabure* itch" and the *Katayama* syndrome stages, the establishment of diagnosis may be difficult if clinicians depend on parasitological and laboratory tests (Davis, 1986). Yet the two stages have adverse effects on the role performance of the infected in society. It is necessary to determine the degree to which the symptoms limit functioning, the

duration of the symptoms and the value or preference associated with different types of dysfunction. Drummond (1989) and Kaplan et al. (1989) provides more detailed reviews of inadequacies of clinical measures.

4.3 Proximate Measures

Proximate measures are essentially indicators of health care resource provision. They express various health care inputs as ratios of catchment population(s), e.g. physicians per 100,000 persons, dentists per 100,000, hospital beds per 1000 persons, number of health centres per 1,000,000 persons and so on (Kenya Government, 1989). Such measures from an efficiency point of view deny us the opportunity of considering alternative modes of provision which involve different input proportions (Williams and Anderson, 1975).

4.4 Intermediate Output Measures

4.4.1 *Throughput measures*

Intermediate indicators are measures of throughput, workload or activity, e.g. cases treated, number of intense infections treated (as manifested in schistosome egg count), cases prevented, outpatient visits, hospital admissions, bed occupancy rates, surface area of vector habitat treated, number of lavatories constructed, number of health personnel home visits, discharges (often condition at discharge is not indicated), hospitalization days prevented, and so on. There is no evidence that such throughput indicators are correlated with the ultimate schistosomiasis intervention output. Although such measures abound in health policy literature and they may be valid social indicators for some purposes, they are not measures of output or of urgency of need or of effectiveness in meeting needs or of capacity to benefit (Williams and Anderson, 1975; Culyer, 1978, 1983; Drummond, 1989; Drummond, 1991).

If the objective function that a schistosomiasis control policy-maker wishes to maximize is health improvement, an appropriate measure of the schistosomiasis interventions' ultimate output is needed.

4.4.2 *Global morbidity indices*

Disease incidence and prevalence rates are classic examples of measures that ignore the health status of asymptomatic persons. These statistics of "ill health" cover a relatively small segment of the health status spectrum, since a large proportion of the population does not feature in the statistics except perhaps as denominators of incidence or prevalence ratios. At the individual level, too, dichotomizing health status into "sick" and "well" categories hardly tells the whole story, since there are degrees of sickness as well as degrees of "well-being" (Chen and Bryant, 1975). For example, schistosomiasis sickness normally varies in severity from asymptomatic, mild infection, moderate, severe, very severe, coma to death, and the numbers in each category are significant.

Neither incidence rate nor prevalence rate statistics tell us anything about severity and loss of functional ability among infected persons. If the objective of schistosomiasis control programmes is to reduce the rate of transmission (*per se*) of a specific disease, incidence rate becomes a relevant indicator. However, since the objective is to improve the health status of persons living in endemic areas neither of the two statistics is valid.

4.5 Health Profiles

Socio-medical indicators or health profiles are instruments, usually in the form of questionnaires, designed to gather information concerning physical, psychological and social states and may be self-administered, enumerator-administered or observer-rated. Generally, the hope has been that such indicators would be capable of measuring the health status of whole populations at a particular point in time; of providing reliable repeated measures over time; and of assessing the efficacy of medical and health care (Abel-Smith, 1976). Several attempts have been made to develop such self-assessed health status indicators, especially in North America and Great Britain, and to overcome the issues of definition, measurement, weighting, reliability, validity, sensitivity and applicability which are inherent in such endeavour.

Examples of such indicators are: the Index of Independence in Activities of Daily Living - constructed for evaluating treatment in relation to disabled groups, with items on individual patient functional independence or dependence in bathing, dressing, toileting, transfer, continence and feeding (Katz et al., 1963); the Cornell Medical Index

which is based on self-assessment and contains 95 yes-no questions referring to physiological disturbance, personal habits, frequency of illness, moods and feelings (Brodman et al., 1960); the McMaster Health Index Questionnaire, which contains items covering physical mobility, self-care, general well-being, social and occupational performance, family support and emotional functioning (Chambers et al., 1982); the Sickness Impact Profile, which contains 136 items referring to illness-related dysfunction in work, recreation, emotion, home life, sleep, mobility, social interaction and other areas (Bergner et al., 1981); the Nottingham Health Profile containing 38 items in the domains of physical mobility, pain, sleep, social isolation, emotional problems and energy, plus a second part on effect of health problems on daily life (Hunt et al., 1985); Spitzer's Quality of Life Index (Spitzer et al., 1981) and the Karnofsky Performance Index (Karnofsky and Burchenai, 1949).

4.5.1 *Index of independence in activities of daily living (ADL)*

The ADL is a scale whose grades reflect profiles of behavioral levels of six socio-biological functions, namely bathing, dressing, toileting, transfer, continence and feeding. Degree of independence in functional performance is summarized as grades A, B, C, D, E, F, or "Other", where A is the most independent grade relative to the scale and G the most dependent grade (Katz et al., 1966; Katz et al., 1968; Steinberg et al., 1963; Katz et al., 1967). The scale is meant for use by medical professionals. It has good validity and reliability and has been helpful in measuring the functional status of elderly institutionalized patients (Katz et al., 1976).

The ADL index permits one to distinguish only between "independent" and "dependent" (the intermediacy element is lost). Its application in a general population study of the effectiveness of schistosomiasis disease intervention(s) may be limited because: no attempt is made to obtain a unit measure; it omits some relevant health dimensions, such as pain, livelihood activities and socialization; ignores the fact that care which restores functionalism may also extend one's life (the quantity aspect); does not allow the determination of levels of health on a continuum: no dysfunction, mild dysfunction, moderate dysfunction, severe dysfunction, complete dysfunction and so on; and patients' views or perceptions or values are not taken into account.

4.5.2 *Seattle sickness impact profile (SIP)*

The SIP has 136 items grouped into 14 categories or areas of activity, viz. social interaction; ambulation or locomotion; sleep and rest; taking nutrition; usual daily work; household management; mobility and confinement; movement of the body; communication activity; leisure and recreation; intellectual functioning; interaction with family members; emotions, feelings, and sensations; and personal hygiene (Bergner et al., 1976a). The SIP questionnaire is administered by a trained enumerator who reads the instructions and each item. The respondent is asked to respond only to items which: (a) he is sure describe him on the interview day, and (b) are related to his health. Its categories cover a wide range of physical, social, and mental dysfunctions; and a single operation permits the aggregation of weights on a given item. However, no evaluation has been made of combinations of items, so weights assigned to such combinations cannot be predicted.

The SIP is not useful in economic evaluation of schistosomiasis intervention policies for a number of reasons, viz. it has no theoretical basis, and interpreting what it purports to measure is difficult; it measures the behavioral impacts of sickness in terms of dysfunction and does not assess levels of positive functioning; due to multiplicity of categories and items, the SIP is an insensitive measure of specific intervention health outcomes; it is long and too complicated; scoring and weighting for seriousness reflect the values of the agent (physician), and not the principal (actual or potential patients); and where answers are summed to a single score or index these could have been derived in different ways and involve the addition of scores from areas not logically connected, such as physical mobility and appetite.

4.5.3 *The Duke-UNC health profile (DUHP)*

The DUHP (Parkerson et al., 1981) consists of 74 items distributed among four dimensions as follows: symptom status, 28; physical function, 15; emotional function, 28; and social function, 5. DUHP architects argue that their instrument is suitable for studying the impact of primary health care since it is brief, easily interviewer-administered or self-administered, measures the major dimensions of health using a positive orientation, is sensitive to various levels of health, and has clinical content

validity while being neither disease nor organ specific.

The DUHP has two main limitations, viz. for the very sick patients, the utility of a self-reported health status instrument such as the DUHP is restricted; and no overall score was developed, and validity investigation was separate for each of the four health dimensions.

4.5.4 *The Nottingham health profile (NHP)*

The NHP is a self-administered questionnaire designed to measure perceived health and the extent to which health problems affect normal activities of daily life (Hunt, 1980). The instrument is made of two parts. Part I has 38 items (statements) in six dimensions: physical mobility, pain, sleep, emotional reactions, social isolation, and energy. Part II consists of seven items (statements) relating to those areas of daily life most affected by health, namely: paid employment, looking after the home, social life, sex life, home life, hobbies and interests, and holidays. The NHP has been tested for content and construct validity among groups of elderly people of differing clinical conditions (Hunt et al., 1981a), patients consulting their general practitioners (Hunt et al., 1981b), firemen (McKenna et al, 1980), mine rescue workers (McKenna et al., 1981), and patients undergoing minor surgery (Hunt et al., 1984).

The architects of the Nottingham profile identify the strengths of their profile as: suitability for use in a wide range of situations, from individual clinical reviews to large-scale population surveys; having a high degree of validity and reliability; easy and cheap to administer; taking only a short time to complete and highly acceptable to respondents; easy to score and compute.

The NHP has a number of weaknesses which even the architects acknowledge (Hunt et al., 1986); and which could undermine its usefulness in schistosomiasis intervention's economic evaluation. First, some individuals who are suffering discomfort may not be identified by the profile. Second, "normal" populations or those with mild and moderate schistosomiasis may affirm few statements in some sections. This makes it difficult to compare the scores or demonstrate change. Third, an improvement in health of "zero scores" cannot be shown by the profile, although in fact they may be feeling better than on the previous occasion when they answered the questions. Fourth, the scores in Part II are a combination of two functions: whether or not the respondent

has a health problem and if so, whether it is affecting the specified area. This should not be taken to mean that an area may not be affected even when the individual perceives no health problem. Also individuals who are having problems, say at work, may attribute them to ill health, whether or not this is the case. Fifth, part I involves six scores and part II a further seven. Analysis can, therefore, become cumbersome if large numbers of other variables need to be taken into account. The profile does not provide one global measure for a population, since combining scores in a single index was judged inappropriate. Sixth, the profile measures health by its absence, by focusing on negative aspects of health. This may deter people who do not have any of the stated problems from responding, especially to mailed questionnaires. Seventh, repeated measures on the very sick people might represent an intolerable burden and few clinicians would have time for the detailed analysis demanded.

4.5.5 *Spitzer quality of life (SQL) index*

The SQL index is a physician scored scale that evaluates the impact of disease on patients' quality of life along five dimensions: activity, daily living, health, support and outlook on life, all rated on a three-point scale from nought to two, giving a maximum score of ten (Spitzer et al., 1981).

The major limitations of the SQL index are: it equally weights all items in the index, which may not be realistic, there are not enough items within each key area to allow sufficient specificity of problems (Clark and Fallowfield, 1986), and it does not capture all the functional dimensions that would be affected by schistosomiasis disease.

4.5.6 *Karnofsky performance index (KPI)*

KPI is a performance scale with 11 categories: normal - no complaints; able to carry on normal activities - minor symptoms of disease; cares for self - unable to carry on normal activity or do active work; requires occasional assistance but able to care for most of his needs; requires considerable assistance and frequent medical care; disabled, requires special care and assistance; severely disabled - hospitalization indicated although death not imminent; very sick - hospitalization necessary - active support necessary; moribund; and dead (Karnofsky et al., 1949). The main weaknesses of KPI

are: its inter-rater agreement is less than 34 per cent (Hutchinson et al., 1979); the health professionals, upon whom the rating responsibility fell, often underestimate the dysfunction and impact of illness on patients' well-being; the KPI categories are vague and inexhaustive. For example, impacts on self-esteem, social participation, sexual life, anxiety and pain are not captured.

4.5.7 *Socio-medical health profiles drawbacks*

Generally, there are a number of issues surrounding the health profiles, namely:

(i) Cross-cultural transferability

Hunt (1986) cautions that, even within the same culture, there is much ambiguity and lack of consensus concerning the presence or absence of "health", "illness" and "disease". Cross-culturally such ambiguity is compounded by differences in the meaning systems of cultures, their values, expectations and their historical development. He further argues that the experience of illness is a cultural phenomenon which is reflected in beliefs about aetiology, manifestation of symptoms and illness behaviour, roles assigned to the relevant players, goals and methods of treatment and evaluation of the outcome. For example, among most ethnic groups in Kenya men (from boyhood) are discouraged from overtly manifesting some feelings, e.g. pain. Among such societies cases of pain will often be under-reported. In addition, sexual life is considered to be highly confidential, thus even if a disease may have impaired a person's sexual ability most people will not report it when asked. In most of the Kenyan sub-cultures stigma is attached to mental illness. For instance, young people are strictly advised never to marry in families with a history of mental illness. In such societies, most families with members suffering from mental problems will normally try to disguise them as much as possible.

In Kenyan rural areas questionnaires have to be administered by interviewers instead of being self-administered, due to high levels of illiteracy (especially among the adult population). Before socio-medical indicators can be transferred across cultures, they ought to be submitted to rigorous examination for conceptual, semantic and linguistic equivalence (Hunt, 1986).

(ii) Time dimension

Health profiles generally do not incorporate the duration of dysfunction. Many health care programmes may affect the probability of occurrence of future dysfunction rather than altering current functional status. For instance, with the exception of chemotherapy intervention, all other schistosomiasis interventions (clean water supply, sanitation, health education, molluscicide, and environmental management) do not have any effect on the current health status of the beneficiaries. The concept of health must consider both dysfunction and prognosis (probability of transition among health states over the course of time).

(iii) Quantity of life

Although the ultimate objective of health care is to improve health (life expectancy and quality of life), all health profiles discussed above ignore the impacts of disease on individuals' life expectancies.

(iv) Equal weighting of disparate dimensions

The psychometric or profile approaches fail to consider that health problems are not of equal concern: 1000 skin itches are not the same as a 1000 severe abdominal pains or 1000 urological pains (all three are symptoms of schistosomiasis).

(v) Non-unidimensional nature

Health profiles are multidimensional, unlike the decision-theory approaches whose aim is to provide an overall summary measure of health status that integrates subjective function states, preferences for those states, morbidity, and mortality (Kaplan et al., 1989).

Culyer (1991c) summarizes the weaknesses of social profiles, viz. criteria for selecting characteristics are unspecified; the scaling systems often imply only order but are subsequently used to construct a cardinal index; the possibility that combinations of characteristics may have higher or lower numbers than the sum of the separate scores

is often excluded; increasing marginal severity is rarely allowed; and criteria for selecting those making these value judgements are usually unspecified.

Due to the above mentioned issues, the health profiles in their current form are not suitable for use in the economic evaluation of schistosomiasis intervention policies.

4.6 Days of Healthy Life (DHL)

The DHL is an index that expresses the impact of a disease on a community in terms of the number of days lost through illness, disability and death (Ghana Health Assessment Team, 1981; Morrow, 1984; and Barnum, 1987). It is derived by combining data on the annual average ages at onset and death from the disease and the expectations of life at these ages, incidence rate, case fatality rate, extent and duration of disability and illness among those infected by the disease.

The DHL has an in-built ethical judgement that society is indifferent to one person being sick for 40 days or 40 people being sick for one day (so long as the totals are equal). That is doubtful.

The index takes neither medical professionals nor patients (actual or potential) health perceptions into account. It is also not defined in functional terms. Such an index would be very insensitive if used to evaluate changes in health status due to small changes in levels of intervention.

Finally, neither the reliability nor the validity of the DHL index has been established. In the light of the above weaknesses, the DHL index is not appropriate for use in schistosomiasis control decision-making process.

4.7 Disability Adjusted Life Years (DALYs)

DALY was first used as a measure of the global burden of disease (GBD) and then became a measure of health gain in relation to DALYs averted by an intervention. It combines (a) loss from premature death, which is defined as the difference between actual age at death and life expectancy at that age in a low-mortality population (82.5 years for females and 80 years for males), and (b) loss of healthy life resulting from disability (Jamison et al., 1993). DALY index is meant to quantify the full loss of healthy life. It is a product of lost life expectancy, disability value (by age and sex),

discount factor, and age group weights (i.e. an arbitrary value of a healthy year of life lived at each age). DALY entails the following procedure:

(a) Duration of life lost due to a death at each age

The number of years of life lost are defined as the difference between the actual age at death and the expectation of life at that age in a low-mortality population.

(b) Disability severity weights

Diseases were grouped into 6 classes of severity of disability and assigned weights ranging from zero, representing perfect health, to one, representing death. For example, class 2, which included most cases of leprosy and half the cases of pelvic inflammatory disease, was given a severity weight of 0.22, and class 4, which included 30% of cases of dementia and 50% of those of blindness, was assigned a severity weight of 0.6.

(c) Value of a healthy year of life lived at each age

DALY architects argue that most societies attach greater importance to a year of life lived by a young or middle-aged adult than to a year of life lived by a child or an elderly person. They modeled the relative value of a year of life at each age as an exponential function of the form Ka exp(-Ba), where 'a' is age and 'B' is equal to 0.04.

(d) Time preference

DALYs' architects used a discount rate of 3% per year which (they said) was entirely attributed to pure time preference. Such a low discount rate was adopted because "..higher discount rates would reduce the total burden of disease because future health damage from health losses in 1990 would count for less. More important, higher discount rates would also alter the relative importance of different diseases. Because the stream of life lost as a result of mortality is, on average, longer than that caused by disability, a higher discount rate raises the importance of disability compared with that of premature death" (World Bank, 1993,p.214). They deliberately ignored the fact that

any resources invested in the production of DALYs will obviously have an opportunity cost (i.e. probably interest income that would have been earned if the resources were saved or invested somewhere else). The reasons given for adopting a low discount rate are not convincing. There is no reason why length of life should be given more weight than the quality of life. There is evidence that individuals would be willing to trade-off length of life for quality life.

The rationale for lumping together different diseases with different - symptoms, prognosis, effects on victims lives (and indeed livelihood) and interventions is not clear, e.g. dementia and blindness; dementia and paralysis; leprosy and pelvic inflammations.

Although the reliability and validity of the DALY index and its measurements has yet to be demonstrated, it represents an important step towards the right direction (of measuring ultimate output of health care).

The next subsection review briefly the Quality Adjusted Life Year (QALY) index developed by Torrance and others in North America.

4.8 Quality Adjusted Life Years (QALYS)

The QALY index was developed by Williams (1985) and Torrance (1986). It is an arithmetic mean product of life expectancy and an adjustment for the quality of the remaining life years gained (Kind and Gudex, 1988). Thus, the QALY combines utility of health states with life expectancy to produce a single measure of output, which makes the measure in principle superior to disease specific scales and general health indices (and profiles). In the context of the measurement of output of schistosomiasis interventions, productivity is to be seen as the difference over a period of time between expected QALYs with a particular intervention and without it (Culyer, 1991d).

4.8.1 *Torrance QALYs*

Utility measurement involves identification of the health states for which utilities are needed, preparation of health state descriptions, choice of scale (QALY estimations require cardinal utilities), selection of subjects (which depends on the purpose and the viewpoint of the study), choice of appropriate utility measurement technique, and application of utility measurement instrument.

4.8.1.1 *Health states descriptions*

Each possible health outcome for the programme under evaluation and for the comparison programme must be defined as a health state for utility measurement. For example, this study required only seven states because there were only 7 distinct outcomes - normal health, mild, moderate, severe, very severe, coma and death states. According to Torrance et al. (1972) and Torrance (1986) health state descriptions should have the following attributes: be functionally oriented and comprehensive (include all relevant dimensions - physical, social and emotional), specify the age of onset for the state, the duration of the state, the exact prognosis for what follows the state, specify whether or not the state applies to the subject himself or to someone else, utility measurement should not be confounded by the subjects' economic wellbeing, and be of the same duration, same age of onset, and same prognosis (otherwise the results would be difficult to interpret).

4.8.1.2 *Utility scales*

There are three main types of scales:
(a) ordinal scales - involve ranking health states or outcomes in order of preference;
(b) interval scale - both the zero point and the size of measurement unit are arbitrary, but differences between scale values can be compared in a meaningful fashion;
(c) ratio scale - the zero point is clearly defined and only the unit of measurement is arbitrary - the ratios can be compared meaningfully. It is only the latter two scales that yield cardinal utilities required in QALY calculations.

4.8.1.3 *Utility measurement techniques*

There are three main alternative techniques used in measuring cardinal utilities, viz: Rating scale (RS), Standard Gamble (SG), and Time Trade Off (TTO) (Torrance, 1986; Drummond et al., 1987).

Rating Scale (RS)

In the RS approach the respondent is given a graduated visual analogue with the most preferred health state placed on one end (represented with a value of 1) and the least preferred at the other end (denoted by a value of 0). The respondent is then asked to choose the best (may be normal health) and worst (may be death) health states, and then map the two on the visual analogue scale. Lastly, he / she is requested to locate the remaining health states on the visual analogue scale relative to each other such that the distances between the locations have the interval scaling property. If death is judged to be the worst state and placed at the 0 end of the rating scale, the preference value for each of the other states is simply the scale value associated with its placement. If death is not judged to be the worst state but is placed at some intermediate point on the scale, say q, the preference values for the states are given by the formula (x-q)/(1-q), where x is the scale placement of the health state. More detailed discussion of this technique is provided in chapter 7.

The rating scale may be a useful measure of preferences under certainty. However, since medical interventions occur only in a world with uncertainty (Ben-Zion et al., 1983), the rating scale measures only quantity effect (and neglects gambling and time effect) (Gafni and Torrance, 1984). Mehrez and Gafni (1989) advice is that where such measures of outcome which assume a world with certainty are used, it may be appropriate to correct for uncertainty effects.

The rating scale is used in this study because of its ease of application in a population where the majority of the people are illiterate. Where health states' utility valuations and interventions' probabilistic effectiveness are elicited separately, the problem mentioned above may not arise.

Standard Gamble (SG)

The SG technique is the classical method of measuring cardinal preferences in an uncertain world. It is based directly on the Von Neumann-Morgenstern (1947) fundamental axioms of rational behaviour. Gafni and Torrance (1984) review and explore the application of the concepts of risk attitude and time preference to the field of health. Those authors present a mathematical model, both in a general form and in

an exponential form, which relates an individual's risk attitude to three effects, viz: a quantity effect, a gambling effect and a time preference effect. They illustrate that individual's risk attitude for time in a health state as measured by conventional lottery questions can be the result of any of the three effects acting singly or in combination. If two of the three effects are absent, the third can fully explain an individual's risk attitude (aversion, neutrality, or love). Thus, SG questions measure the overall risk aversion, which is made up of the sum of the separate contributions of the three effects.

The procedure of the SG technique used depends upon whether or not the chronic state is preferred to death.

(a) Chronic state preferred to death

Fig. 4.1 presents a standard gamble for a chronic state preferred to death. The respondent is given two options. Option 1 is intervention with two possible outcomes: either the patient is returned to normal health and lives for an additional **t** years (with probability P), or the patient dies immediately (with probability 1-P). Option 2 has the certain outcome of chronic state **K** for life (t years). For those who choose option 1, probability P is varied until the respondent is indifferent to the two options, at which point, the sought preference value for state K is simply P; i.e., Hk = P.

(b) Chronic state considered worse than death

Fig. 4.2 illustrates a standard gamble for a chronic state considered worse than death. Option 1 is intervention with two possible outcomes: either the patient is returned to normal health (with probability P), or the patient remains irreversibly in chronic state **k** (with probability 1-P). Option 2 is rapid progression to a certain death. The probability p is varied until the respondent is indifferent between the two options, at which point the preference value for state **k** is given by $H_k = -p/(1-p)$.

(c) Standard gamble for a temporary health state

As shown in fig. 4.3 the intermediate states **k** are measured relative to the best heath state (normal health) and the worst state (temporary state **j**). The probability p is

varied until the respondent is indifferent between the two options, at which point the preference value for state **k** is given by $H_k = p+(1-p)H_j$.

The major limitation of the SG technique for use in a survey project with many randomly selected interviewees from a general population is the complexity of lotteries and subjects' inability to conceptualize probabilities (Torrance, 1976). That would even be a greater setback in an environment where the majority of the respondents are illiterate. Rational choice (the "rock" upon which the SG approach is built) requires that the preference between options should not reverse with changes in frame. However, Tversky and Kahneman (1981) obtained systematic reversals of preference by variations in the framing acts, contingencies, or outcomes. Another investigation by Kahneman and Tversky (1979) demonstrated that low probabilities are commonly overweighed but intermediate and high probabilities are usually underweighted relative to certainty. Bernasconi (1991) provides a comprehensive review of the issues surrounding the standard gamble technique.

Time Trade Off Technique (TTO)

This technique was developed by Torrance et al. (1972) for estimating individuals' preference values for different health states. The essence of TTO technique is the sacrifice of life expectancy for better quality of life.

(a) Chronic state preferred to death

Fig. 4.4 illustrates time trade-off for a chronic state preferred to death. The respondent is offered two options - option 1: state i for t years (life expectancy of a patient with chronic condition i) followed by death; and option 2: healthy for time $x<t$ followed by death. Life expectancy x is varied until the respondent is indifferent between the two options, at which point the required preference value for state i is given by $H_i=x/t$.

(b) Chronic state considered worse than death

The respondent is offered two options - option 1: healthy for time x<t, followed by death; and option 2: immediate death. Life expectancy x is varied until the respondent is indifferent between the two options, at which point the required preference value for state i is given by $H_i=x/(x-t)$.

(c) Time trade-off for a temporary health state

As shown in fig. 4.6, the respondent is offered two options - option 1: temporary state i for time t (time duration specified for the temporary states), followed by normal health; and option 2: temporary state j for time x<t, followed by normal health. Time x is varied until the respondent is indifferent between the two alternatives, at which point the required preference value for state i is $h_i=1(1-h_j)x/t$.

Although compared to the standard gamble, the time trade-off is simpler to use, it may be difficult to apply in largely illiterate populations typical of developing countries.

4.9 *Rosser-Kind-Williams QALYS*

The Rosser-Kind-Williams (RKW) QALY approach is built on the Rosser and Kind (1978) index of severity of illness. The index measures severity along two dimensions - observed disability (loss of function and mobility) and subjective distress. Thus all other aspects of a patient's condition are thought to be subsumed within this framework. The index comprises 8 levels of disability and 4 levels of distress (which provides 32 combinations) (Table 4.1).

The RKW QALYs are derived through following steps:

(a) respondents are presented with six maker states and asked to rank them in order of perceived severity. Those maker states are: IC, IID, VC, VIB, VIIB, and VIID. They were selected from the 29 disability/distress states as representing the full range of ill health states.

(b) Respondents are given their first two cards (which they ranked as least ill states) and are asked "how many times more ill is a person in state two as compared with state

one?" The interviewees are advised to assume that the health state descriptions relate to a young to middle-aged adult; and all states have the same prognosis and could be cured if the patient is treated. If left untreated the patient's health status would remain static until some other condition supervenes (Rosser and Kind, 1978).

(c) The question posed in (b) is then repeated using successive pairs of maker states, viz. 2&3, 3&4, 4&5, 5&6.

(d) The marker states scores are derived by multiplying the value of each ratio by that for the succeeding ratio.

(e) The ranked marker states and their provisional scores provide a framework within which the remaining 23 states are ranked.

(f) Scores are transformed using the formula below, such that death receives a score of zero and IA (no disability-no distress) receives a score of one. Thus, such transformation yields QoL values.

$Vij = 1.0 - Vij/D$

Where Vij is the original score for the ith disability state/ jth distress state, and D is the score assigned to death.

(g) The future life years gains are discounted into their present values. If we are evaluating with and without a specific intervention scenario, the difference between total discounted QoL score for with intervention and without intervention constitutes QALYs gained.

Table 4.2 provides the transformed valuations for 29 health states. As the patient recovers there will generally be a gradual (or rapid) movement from the south-western corner (VIIID) to the north-western corner (IA) of the disability/distress matrix (league table). Gudex and Kind (1988) provide a detailed description of how the RKW approach QALY index is derived.

Donaldson et al. (1988) established that the dimensions of disability and distress, upon which the R-K-W QALY index is based, are too insensitive to changes in the health status of elderly people in long term care when compared to other measures (viz. Modified Crichton Royal Behavioral Rating Scale and Life Satisfaction Index) of quality of life which are frequently used in studies of older people. The concern of these authors is that insensitivity to the measure may lead to QALYs based-resource-allocations which discriminate against long-term care for the elderly and in favour of acute care. This criticism of RKW QALY approach may not necessarily apply to the Torrance strand of

QALYs.

Loomes and MacKenzie (1989) identify the neglect (or implicit neutrality assumption) of attitudes to risk and uncertainty as a major weakness in the RKW approach.

Sutherland et al. (1983) discovered that some states of health are thought to be worse than death, which indicates that death is not a natural low boundary in a continuum of health. This finding made the authors conclude that there is no rational "zero" reference point with which all other states can be compared, because for all health states thought to be worse than death it is possible to conceive of a modification in that state that will further lower its utility. In the absence of a rational zero reference point, it is possible only to construct interval or ordinal scales of health, but not a ratio scale.

There are a number of unresolved issues surrounding the QALY index, viz. Is the theoretical basis of QALYs (expected utility theory) sound or would Prospect and Regret theories be a better theoretical basis? Should QALYs be discounted? Are QALYs derived via disparate techniques consistent? Does a QALY measure what it is said to measure? Whose values are relevant? And many other issues discussed by Culyer, 1991c; Drummond, 1991; and Mooney and Olsen, 1991.

4.10.1 *QALY theoretical base*

QALYs are built on the expected utility theory (Neumann and Morgenstern, 1947), which assumes that the consumer is "...sufficiently able, willing and knowledgeable (in terms of choices, states of the world, final consequences, probabilities and utility assessment) to make the relevant choices.." (McGuire et al., 1988: p.37). That assumption is not plausible in the context of the health care commodity (Mooney, 1986; Culyer, 1991a; Mooney and Olsen, 1991).

Also underlying the EU theory is the assumption that the relevant utility bearing characteristics are consequences or outcomes of the final states, and not processes. That assumption has been criticized strongly by Kahneman and Tversky (1979); Loomes and Sugden (1982); and Mooney and Olsen (1991).

Loomes and Sugden (1982) argue that there is regret and rejoicing in a world of choice. In other words, satisfaction may be derived not only from the states of the world

arising (as hypothesized in EU theory) but also from the knowledge that one made a good choice (rejoicing/positive utility) or one made a bad choice (regret, negative utility). Culyer (1991d:p.96) counsels that "..research should be expanded to incorporate regret theory (and prospect theory) into health status and QALY measurement experiments in order to compare results systematically with other techniques".

There are some major features of prospect theory (Kahneman and Tversky, 1979; Tversky and Kahneman, 1981) that may be relevant to health status measurement:
(i) the framing of questions seems to matter, e.g. the same questions presented in different ways or with different emphasis can elicit differing responses from the same subjects;
(ii) outcomes are expressed as positive or negative deviations (gains or losses) from some neutral reference outcome, which is assigned a value of zero, meaning that it is changes from the reference point that are valued and not, as with the expected utility theory, the states per se (implying that U(S1 - S2) = U(S1) - U(S2), where S1 and S2 are two health states);
(iii) the value function (that associates a subjective value with any amount that may be gained or lost) is S-shaped, concave (such that each extra QALY gained adds less to the value than the preceding one) above the reference point and convex (so that each extra QALY lost causes a smaller change in value than the preceding one) below it; and
(iv) the response to losses is more extreme than the response to gains.

4.10.2 *QALY and equity*

The equity phenomena encompasses horizontal equity (which requires equal treatment of individuals who are equal in relevant respects) and vertical equity (which requires unequal treatment of individuals who are unequal in relevant respects) (Mooney, 1987; Culyer, 1991a; Culyer, 1991b). Culyer (1993) suggests that in the health domain, the relevant respects in which individuals or groups could be unequal are: the initial or presenting state of health; the need for health care; and the final health state (the state of health after receiving health care). Culyer concludes that equity in health care is ultimately concerned with the distribution of health, for which health care and health care expenditures are only instrumental.

It seems to be the general policy of the MoH, that since all residents of Mwea

irrigation scheme are at equal risk of schistosomiasis infection, there ought to be equality of access (irrespective of ability to pay) to primary or community level interventions (Kenya Government, 1989). There is no clear distribution policy regarding secondary health care services. However, it appears that when the schistosomiasis epidemiology experts were recommending the appropriate health facilities to treat patients suffering different severity states, they **may** have had the following equity concept in mind: 'patients suffering the same schistosomiasis state ought to be treated so that each receives the same expected increment of health'.

4.10.3 *Different results from different methods*

There is growing evidence that different QALY measurement techniques produce different results (Torrance, 1976; Llewellyn-Thomas et al., 1984; Read et al., 1984; Loomes and McKenzie, 1989). The SG method gave significantly higher values than the TTO and RS. Read et al. (1984) attributed the differences to: response spreading, i.e. the desire of respondents to space their intermediate outcomes over the entire 100-point scale, even if the "true" values were bunched at one end in RS; influence of attitude towards risk - unlike TTO and RS, SG method introduces risk explicitly; and different processes of evaluation.

The reason for relatively low RS values may be the choiceless context of the RS method as opposed to TTO and SG (Loomes and McKenzie, 1989; Mooney and Olsen, 1991). In RS, respondents are asked merely to assign relative values to the quality of inferior health states. The RS technique does not press for a "tragic choice" between a long life in an inferior health state and a short life in a normal health state (as is the case with TTO). Drummond (1987, 1991) suggests that it would be vital to investigate (through sensitivity analysis) the significance of differences in utilities derived via different techniques for resource allocation decisions.

4.10.4 *Risk issue*

The term 'risk' refers to situations where the range of possible values that a variable could take is known, and a probability of each value occurring can be estimated (O.D.A., 1988).

Culyer and Wagstaff (1993) delineate two types of risk relevant to QALY measurement: (a) risk associated with quality of life; (b) and the risk associated with length of life. The authors found that standard gamble based QALYs reflect both strands of risk. However, while the utility function underlying TTO-based QALYs captures attitudes towards the risk associated with health, it does not capture attitudes towards life years.

4.10.5 *Uncertainty issue*

Uncertainty refers to situations in which probabilities cannot be estimated for a variable to take any particular value (O.D.A., 1988). It is important that the attribute be reflected in decisions involving health status measurement where uncertainty or risk is present (Mooney and Creese, 1991).

Uncertainty may be caused by unavailability of data hence prompting the use of "guesstimates"; prior knowledge that estimates are imprecise; methodological controversies and value judgements made. In this thesis, uncertainty is dealt with through sensitivity analysis.

4.10.6 *Discounting health gains*

Since the value attached by beneficiaries of disease interventions to reductions in burden of illness at different times is not constant, QALYs (or any other benefits) ought to be discounted (Weinstein and Stason, 1977; Drummond, 1981; Mills, 1985; McGuire et al., 1986; Drummond et al., 1987; Williams, 1985; Culyer and Wagstaff, 1993; Mooney and Creese, 1991). There two main reasons for discounting QALYs at a positive rate. (i) Pure time preference, i.e. individuals generally prefer QALYs today to QALYs tomorrow and so expect to be compensated for any deferral. (ii) Resources invested in the production of QALYs have an opportunity cost - in that they could have been invested elsewhere to generate income. A few economists have argued that non-monetary health benefits should be discounted at a zero discount rate (Parsonage and Neuburger, 1992). However, there is no empirical evidence to support the latter argument (Cairns, 1992). There is no agreement on the use of a single discount rate; and thus, the common practice (in the Developed Countries) is to use a range of rates,

usually between 3% and 10%. Discount rates ranging from 3% to 20% have been used in Developing countries (Scott et al., 1976; Barnum, 1987; Brent, 1990; World Bank, 1993; Curry and Weiss, 1993).

4.10.7 *Do QALYs measure what they are said to measure?*

Gafni (1989) and Mehrez and Gafni (1989) claim that QALYs lead to the choice of a non preferred health intervention due to misrepresentation of the individual's preference. They propose the Healthy Years Equivalent (HYE), which they claim to derive directly from the individuals' utility function. Culyer and Wagstaff (1993) argue there is no evidence to date supporting the alleged tendency of QALYs to misrepresent preferences. They prove that HYEs are conceptually identical to QALYs derived from a time trade-off experiment and that the utility function underlying the former is just as restrictive as that underlying the latter. Therefore, HYE does not in any way exonerate itself from the QALY methodological problems discussed above.

4.10.8 *Whose values are relevant?*

According to Culyer (1991d:p.93) the answer "..may well depend upon the nature of the problem under consideration: politicians, civil servants, managers, representatives of the public, persons at risk of particular disease, patients, doctors, nurses..all may have some claims by virtue of identity, skill, or position of trust." Thus, the answer to the above question is determined by the perspective or viewpoint adopted in the study. For example, since the current study is conducted from a social perspective, it is necessary to elicit health state valuations from Mwea Scheme farmers, teachers (working and living in Mwea) and medical professionals (who treat patients from Mwea Scheme). The three groups of people and their families are exposed to varying degrees of the risk of schistosomiasis infection; and, hence stand to benefit from intervention strategies being evaluated, and this "at risk" criterion is used to determine the identity of those whose values are to be obtained.

4.11 Summary

Among the extant health measures reviewed in this chapter, only the QALY framework is capable of measuring disease interventions' impact on both quality and quantity of life. However, a more sensitive and specific functional health status index ought to be developed for schistosomiasis and the culture of Mwea Irrigation Scheme population. This would involve defining the QoL aspect of health in terms of cultural functional dimensions likely to be affected by the presence or absence of schistosomiasis interventions, and estimating the gradient or continuum of functional disability caused by different severity stages of the disease (in non-medical terms for ease of application in a general population survey and in a form suitable for administration by trained non-medical personnel). An attempt is made to develop and apply such an index in chapter 7.

Table 4.1: Rosser-Kind's classification of illness states

DISABILITY	DISTRESS
I. No disability	A. No distress
II. Slight social disability	B. Mild
III. Severe social disability and/or slight impairment of performance at work Able to do all household except very heavy tasks IV. Choice of work or performance at work very severely limited Housewives and old people able to do light housework only but able to go out shopping V. Unable to undertake any paid employment Unable to continue any education Old people confined to home except for escorted outings and short walks and unable to do shopping Housewives able only to perform a few simple tasks	C. Moderate
VI. Confined to chair or to wheelchair or able to move around in the house only with support from an assistant	D. Severe
VII. Confined to bed	
VIII. Unconscious	

Source: Rosser and Kind (1978)

Table 4.2: Transformed valuations for 29 health states

DISABILITY	DISTRESS			
	A	B	C	D
I	1.000	0.995	0.990	0.967
II	0.990	0.986	0.973	0.932
III	0.980	0.972	0.956	0.912
IV	0.964	0.956	0.942	0.870
V	0.964	0.935	0.900	0.700
VI	0.875	0.845	0.680	0.000
VII	0.677	0.564	0.000	-1.486
VIII	-1.028	-	-	-
FIXED POINTS: HEALTHY = 1 DEAD = 0				

Source: Gudex and Kind (1986)

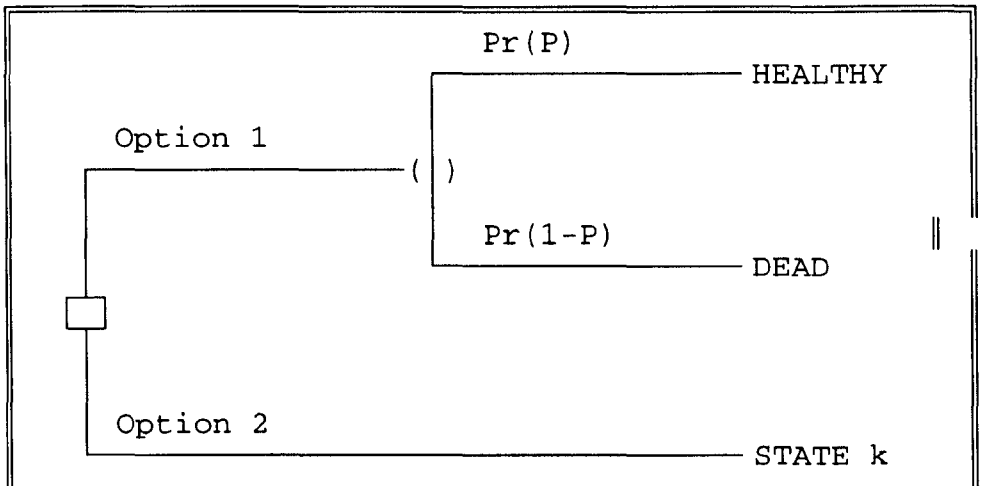


Fig. 4.1: Standard gamble for a chronic state preferred to death

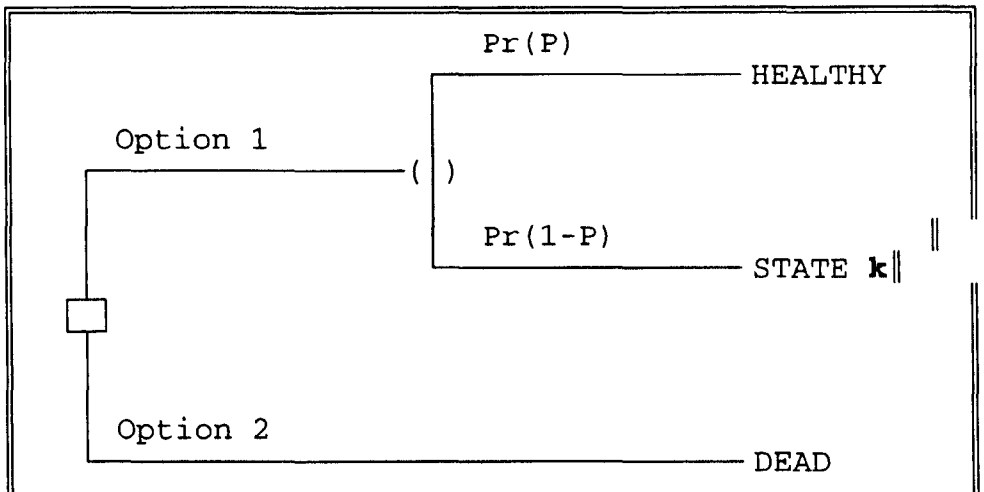


Fig. 4.2: Standard gamble for a chronic state considered worse than death

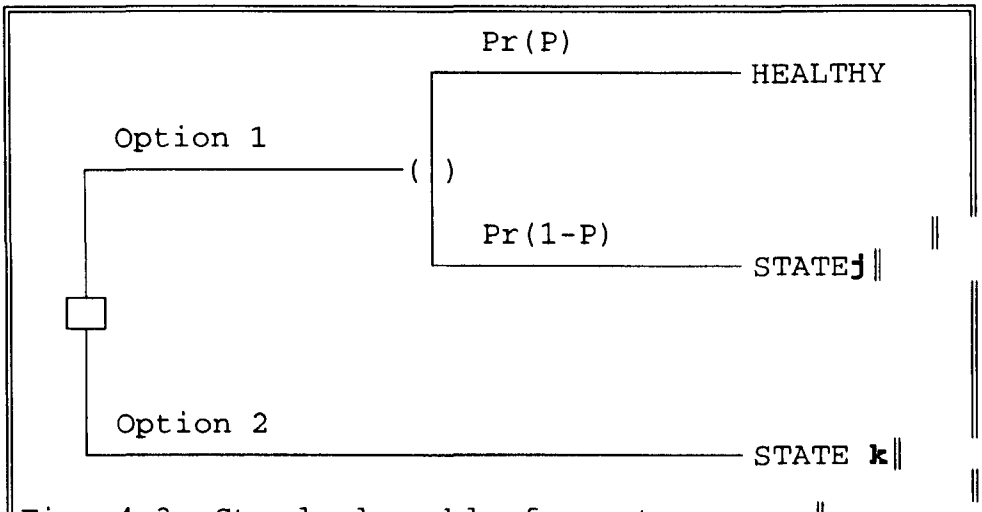


Fig. 4.3: Standard gamble for a temporary health state

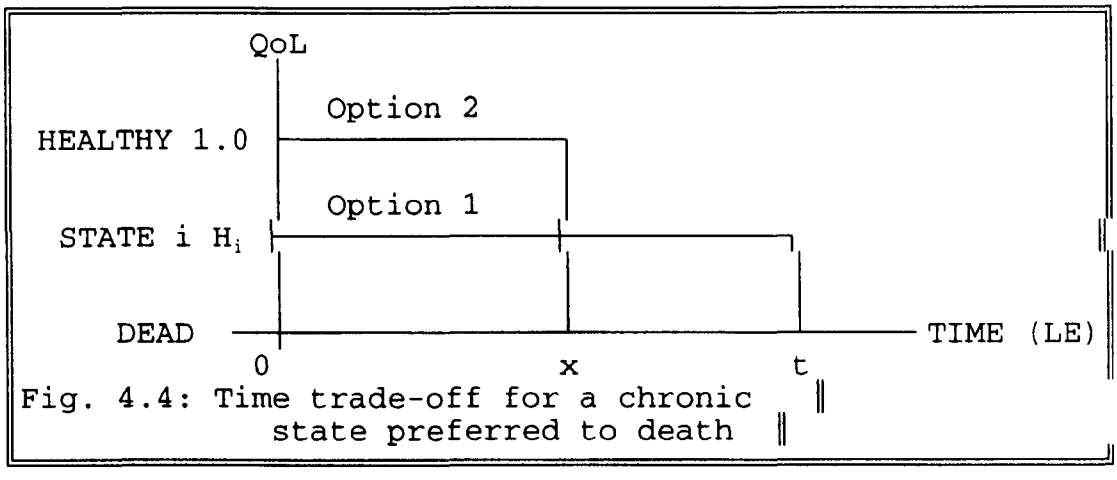


Fig. 4.4: Time trade-off for a chronic state preferred to death

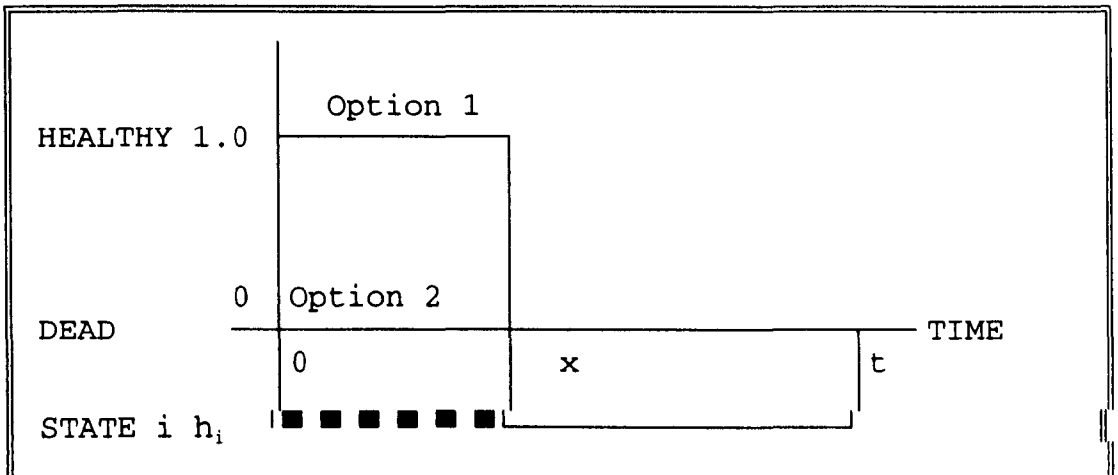


Fig. 4.5: Time trade-off for a chronic health state considered worse to than death

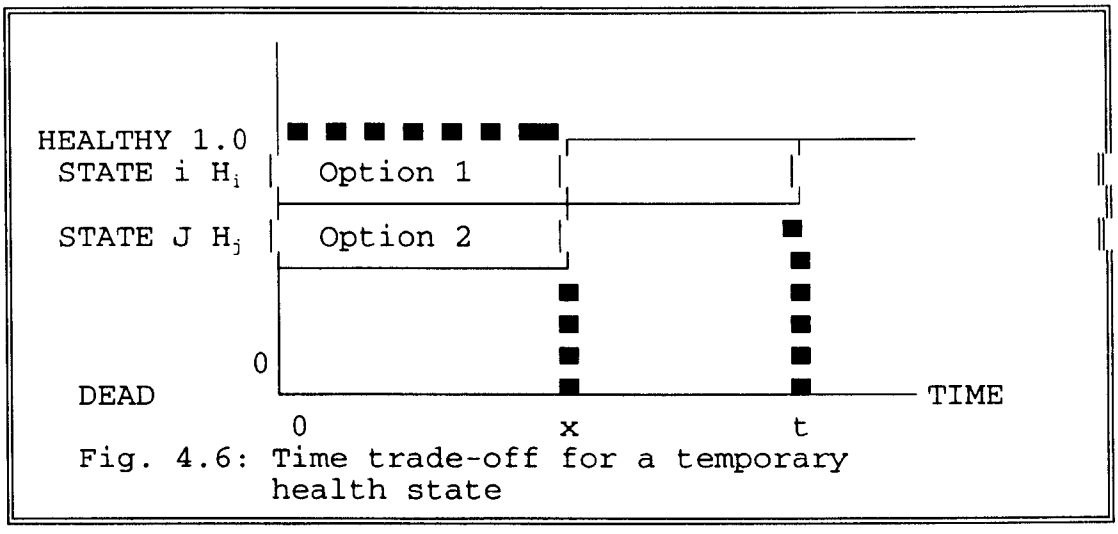


Fig. 4.6: Time trade-off for a temporary health state

PART III:
THE ECONOMIC APPRAISAL OF SCHISTOSOMIASIS STRATEGIES

CHAPTER 5
THE DEVELOPMENT OF SCHISTOSOMIASIS POLICY OPTIONS

5.0 Introduction

This chapter has five objectives. First, to identify all possible ways of ameliorating the schistosomiasis problem, without putting artificial constraints on what is deemed feasible. Second, to develop a rational criteria for eliminating impracticable options. Third, to apply the criteria to come up with a manageable number of primary and secondary options to be evaluated. Fourth, to develop policy strategies. Fifth, to generate policy combinations that reflect the synergism between primary and secondary interventions.

Section 5.1 presents a long-list of primary schistosomiasis interventions. Section 5.2 provides a long-list of secondary interventions. Section 5.3 explains the criteria used in pruning long-list of options to a manageable size. Section 5.4 develops the policy strategies and combinations whose costs and benefits would be inputs in the decision analysis models developed in chapter 6 and estimated in chapter 9.

5.1 Generation of Primary Interventions

Primary policies are defined as those aiming at attenuating the transmission of schistosomiasis. In other words, they are policies whose goal is to reduce the number of new infections and/or lead to early diagnosis and treatment of those found infected. Those are the policies that would determine the distribution patterns of Mwea population across the health states (i.e. normal, mild, moderate, severe, very severe and comatose states) discussed in chapter 7.

The primary options available to MoH decision makers involve doing nothing or doing something. If something is done that could be any of the following, singly or in combination: chemotherapy; provision of clean water; health education; sanitation; snail control; immunization; and status quo. The above **alternative** policies (if considered singly) have approximately 32 variant options (Table 5.1). If the 32 **alternative** primary options are combined 2 at a time, there would be 496 possible primary policy

combinations (i.e. 32!/2!(32-2)!). The possibility of combining primary policies is not explored in this thesis.

Table 5.1: A list of possible primary interventions

MAIN OPTION	VARIANT OPTIONS
1. CHEMOTHERAPY	1. Mass population chemotherapy with oxamniquine
	2. Selective population chemotherapy with oxamniquine
	3. Targeted mass chemotherapy with oxamniquine
	4. Targeted selective chemotherapy with oxamniquine
	5. Targeted-selective-targeted chemotherapy with oxamniquine
	6. Mass population chemotherapy with praziquantel
	7. Selective population chemotherapy with praziquantel
	8. Targeted mass chemotherapy with praziquantel
	9. Targeted selective chemotherapy with praziquantel
	10. Targeted-selective-targeted chemotherapy with praziquantel

Table 5.1 Continued	
2. SNAIL CONTROL	11. Area-wide molluscicidiing via hand spraying
	12. Area-wide molluscicidiing via aerial application
	13. Focal molluscicidiing via hand spraying
	14. Focal molluscicidiing via drip method
	15. Environmental management via canal weeding
	16. Environmental management via canal cementing
	17. Environmental management via periodical re-channelling of old canals and drains and refilling old ones
	18. Plant molluscicides
	19. Biological control

Table 5.1 Continued	
3. WATER SUPPLY	20. Household piped water supply
	21. Communal water taps and shower facilities
	22. Protected water wells
	23. Fetching water from canals
4. SANITATION	24. Household vented pit latrines
	25. Communal vented pit latrines
	26. Household water-flushed latrines
	27. Communal water-flushed latrines
5. IMMUNIZATION	28. Immunization
6. HEALTH EDUCATION	29. Health education via home visits
	30. Health education via public meetings
	31. Health education via school lectures
	32. Health education via health facilities outpatient departments
7. STATUS QUO	33. Status quo (current practise)

5.1.1 *Chemotherapy*

The objective of chemotherapy is to reduce human morbidity to levels below public health importance. According to WHO (1983) that goal will have been achieved when all remaining infections due to *S.mansoni* are below 100 eggs per gram of faeces.

There are currently two *S.mansoni* drugs available for use in large scale interventions. Oxamniquine is a single oral dose therapy which is effective only against intestinal schistosomiasis (*S.mansoni*). The second drug, praziquantel, has become the most widely used of the antischistosomal drugs. The latter is effective against all species

of schistosome, including mixed infections, as well as some other human trematodes (viz. opisthorchiasis, paragonimiasis, clonorchiasis) and cestodes.

One can delineate six alternative regimes of schistosomiasis chemotherapy according to the means of delivery, viz:

(a) Mass population chemotherapy: treatment is given to the entire population without prior diagnosis.

(b) Selective population chemotherapy: stool samples from the entire population are examined, and only persons excreting schistosome eggs are treated.

(c) Targeted mass chemotherapy: treatment is given to all persons in the target age group without screening. This is often given to children of school-going age who have peak prevalence, intensity and morbidity (WHO, 1989).

(d) Targeted selective chemotherapy: treatment is given only to those found infected (after screening) in the target age group.

(e) Targeted-selective-targeted chemotherapy: treatment is given only to persons passing high schistosome egg output. This regime, meant to reduce the intensity of infection, is still under experimentation (Prescott, 1987).

5.1.2 *Snail control*

Snail control is meant to break the schistosomiasis transmission cycle by preventing miracidia from developing into cercariae larva that eventually penetrate the human skin (when exposed to parasite infested waters). The intermediate objectives of the molluscicide operations are to eliminate or reduce infected snails and to contribute significantly to the reduction of transmission potential below levels that give rise to serious disease manifestations.

There are three broad methods of snail control, namely:

(a) chemical molluscicide;

(b) biological control; and

(c) environmental management.

5.1.2.1 *Chemical molluscicididing*

Niclosamide (BAYLUSCIDE) is the WHO (1973, 1989) recommended chemical molluscicide. It is the only chemical molluscicide currently available in the market.

One can delineate four alternative means of chemical molluscicididing according to the mode of delivery, viz:

(a) area-wide molluscicididing via hand spraying entails spraying the whole area infested with infected snails (for instance the whole irrigation scheme) using hand operated or automated pressure pump sprayers.

(b) Area-wide molluscicididing via aerial application involves spraying of the whole area infested with infected snails using a aeroplane.

(c) Focal molluscicididing via hand-spraying entails treating specific spots inhabited by vector snails using hand operated or automated pressure pump sprayers.

(d) Focal drip-method involves slow-release of molluscicide solution from automatic and semi-automatic dispensers.

5.1.2.2 *Plant molluscicide*

Of late, there has been growing interest in the study of compounds derived from plants with known molluscicidal activity (WHO, 1989). Toxicity studies are continuing on the most promising natural molluscicides extracted from Swartzia Madagascariensis shown to be efficacious against adult Balinus Globsus (WHO, 1989). However, their effectiveness in reducing snail populations in the field has not yet been demonstrated.

5.1.2.3 *Biological control*

This method involves the introduction of snail species that are not carriers or are poor carriers of the schistosomes harmful to man to displace species that harbour these parasites. Such snails can negatively affect target snails and associated trematodes by preying upon eggs, juveniles and adults of the target species, by competing for food or oviposition sites, by producing noxious secretions that interfere with growth and by serving as "decoys" or "sponges" of the miracidia of trematode parasites (WHO, 1988). However, there is need to be very cautious, since biological intervention is under

experimentation, and thus its effectiveness has not been established. In addition, the intervention might introduce a worse problem than that caused by the initial vector.

5.1.2.4 *Environmental management*

This is another method of controlling intermediate host snails: rendering the habitat unfavourable for their breeding by either cementing (Feachem et al., 1983), weeding, straightening or periodic re-channelling of old canal systems (Sandbach, 1977).

5.1.3 *Water supply*

This intervention entails the provision of clean water to the people at risk. The intermediate goal is to reduce the frequency of human contact with the schistosomal parasite (cercariae) contaminated water. Water can be supplied in a number of ways, viz. piped water supply to every household in the irrigation scheme; or at specific points for communal use (Jordan, 1985); construction of protected wells; and digging of bore-holes.

5.1.4 *Health education*

Health education is a programme aimed at imparting knowledge to the persons at risk concerning the life cycle of the schistosome parasite, symptoms of infection, and methods of avoiding infection and transmission of the disease. There are mainly four alternative media for health education in irrigation schemes, viz. public meetings; house to house visits; lectures in schools; and lectures by medical personnel to patients attending outpatient departments for preventive and curative health care.

5.1.5 *Sanitation*

Sanitation intervention involves the construction of hygienic toilets for human excreta disposal. Provision and use of lavatory facilities prevents excreta of those infected, which contain schistosome eggs, from coming into contact with the irrigation water. Under this intervention a decision-maker has four options: household vented

improved pit latrines; communal vented improved pit latrines; household water flushed lavatories; or communal water flushed lavatories.

The pit latrine is an on-site disposal system where excreta fall into an hole in the ground, and a new pit is dug when the hole is about two-thirds full. The pits are covered by squatting slabs. Ventilated improved pit (VIP) latrines in general are familiar to rural folk and will have higher usage/compliance. Since VIP latrines are fitted with a fly-screen, vent pipe odours are virtually eliminated. However, squatting slabs can easily become fouled and unhygienic. Fouled pit latrines become a focus of disease transmission and may make health matters worse than before the sanitation intervention (Feachem et al., 1983). Flies that visit a pit latrine to breed or feed may carry pathogens when they leave and thus promote transmission of other diseases. The use of a squatting plate hole removable cover and regular cleaning with disinfectants will obviously attenuate the above mentioned risk. VIP latrines fill up with time and so may be considered only a temporary measure.

Water flushed lavatories are permanent and could be more hygienic than pit latrines, if well maintained. However, they are unfamiliar to many rural people and may lead to low compliance in usage; they are not suited for communal use; and can be unhygienic when used by many people.

5.1.6 *Status quo*

The "status quo" primary policy means continuing current schistosomiasis control activities at the community level. Currently there are haphazardly implemented canal weeding, unhygienic household built latrines, sporadic drip-molluscicide, experimental water bore-holes (which are non-functional most of the time) and ad hoc experimental targeted-selective chemotherapy activities.

5.2 Generation of Secondary Options

Secondary interventions are defined as those aiming at influencing outcome (recovery, receding to preceding states, remaining in the state, advancing the next more severe states and dying in the state) probabilities for those suffering various stages of schistosomiasis disease. They encompass all possible treatment options available in

health facilities for the patients in various schistosomiasis states - mild, moderate, severe, very severe and comatose (Table 5.2).

On the advice of schistosomiasis epidemiologists, the consensus is that the most appropriate place to treat patients in:

(a) mild state is the dispensary;

(b) moderate state is the health centre;

(c) severe schistosomiasis is the district hospital;

(d) very severe state is the provincial general hospital inpatient department;

(e) and comatose state is the PGH intensive care unit.

Table 5.2: A list of possible secondary intervention options

Health state label	Secondary Options
MILD **S**	1. Status quo at the dispensary 2. Praziquantel care at the dispensary 3. Oxamniquine care at the dispensary
MODERATE **K**	4. Status quo at the health centre 5. Praziquantel care at the health centre 6. Oxamniquine care at the health centre
SEVERE **Z**	7. Status quo at the district hospital 8. Praziquantel care at the district hospital 9. Oxamniquine care at the district hospital
VERY SEVERE **A**	10. Provincial general hospital status quo 11. Provincial general hospital drug management 12. Provincial general hospital surgical operation
COMA **R**	13. Provincial general hospital status quo 14. Provincial General Hospital intensive unit care

5.2.1 *Mild health state options*

The patients in mild health state would be treated in the lowest level facility within the Kenya Government health care system hierarchy - the dispensaries. The dispensaries do not have laboratories.

There are three options for those suffering mild schistosomiasis state:

(a) Status quo at the dispensary (SQD)

This SQ entails continuing the current practice, which is characterized by rampant shortages of schistosomiasis treatment drugs (REACH, 1989; Forgey et al., 1990).

(b) Praziquantel care at the dispensary (PCD)

The PCD would entail diagnosis, followed by full dose of praziquantel. Under this option there would be no shortages of the relevant inputs.

(c) Oxamniquine care at the dispensary (OCD)

The OCD would entail diagnosis, followed by full dose of oxamniquine. Under this option there would be no shortages of the relevant inputs.

5.2.2 *Moderate health state options*

As mentioned in chapter 2, this is the stage where victims experience mass oviposition. The patients in moderate health state would be treated in the second lowest level facility within the hierarchy of the Kenya Government health care system - the health centre (HC). The HCs have laboratories where parasitological screening can be done.

There are three options for the moderate state cases:

(a) Status quo at the health centre (SQHC)

The SQHC entails continuing the current practice, which is characterized by chronic shortage of schistosomiasis treatment drugs (REACH, 1989; Forgey et al., 1990).

(b) Praziquantel care at the health centre (PCHC)

The PCHC would involve *Kato* screening of all patients visiting the Health Centre, and treatment with praziquantel of all those who test positive. Under this option there would be no shortage of inputs needed to treat the moderate schistosomiasis cases.

(c) Oxamniquine care at the health centre (OCHC)

The OCHC would involve *Kato* screening of all patients visiting the Health Centre, and

treatment with oxamniquine of all those who test positive. There would be no shortage of inputs needed to treat the moderate schistosomiasis cases under this option.

5.2.3 *Severe health state options*

As mentioned in chapter 2, this is the stage where human internal organs are infected. The patients in severe health state would be treated in the third lowest level facility within the hierarchy of the Kenya Government health care system - the district hospital (DH). The DHs have radiology departments where x-ray screening could be done.

There are three options for the severe state cases:

(a) Status quo at the District Hospital (SQDH)

The current practice at the district hospital outpatient department (DHOD) is characterized by chronic shortages of the recurrent diagnostic and therapy inputs needed in the treatment of severe schistosomiasis cases (REACH, 1989; Forgey et al., 1990).

(b) Praziquantel care at the District Hospital (PCDH)

The PCDH entails x-ray screening of all the patients presenting themselves to the DHOD from the Mwea Division and treatment of all those found suffering severe schistosomiasis with a full dose of praziquantel.

(c) Oxamniquine care at the District Hospital (OCDH)

The OCDH entails x-ray screening of all the patients presenting themselves to the DHOD from Mwea Division, followed by oxamniquine treatment to all those found manifesting severe schistosomiasis state.

5.2.4 *Very severe health state options*

As mentioned in chapter 2, this is the stage where the damage to human internal organs is irreversible (with the current state of technology in Kenya). The patients in severe health state would be treated in the second highest level facility within the hierarchy of the Kenya Government health care system - the Provincial General Hospital (PGH). The PGHs are 'supposed' to have adequately equipped and manned surgical departments.

There are three options for the very severe state cases:

(a) PGH status quo policy (PGHSQ).

Current practice at the PGH is characterized by shortages of diagnostic and therapeutic inputs needed in treatment of the very severe schistosomiasis cases (REACH, 1989).

(b) PGH drug management (PGHDM)

PGHDM would entail barium swallow x-ray for all the patients visiting the PGH from Mwea Division, followed by inpatient drug (vasopressin or sclerosant) treatment to reduce haematemesis (bleeding) and other relevant drugs to attenuate pain and anxiety.

(c) PGH surgical operation (PGHSO)

PGHSO would require investigation of oesophageal disorders by barium swallow and endoscopy of all the patients from Mwea Division, followed by balloon catheter treatment and surgical operation to lower the pressure in the blood supply to the liver.

5.2.5 *Comatose state options*

There are two options for patients in comatose:

(a) PGH status quo (PGHSQR)

The PGHSQR involves continuing the current practice of treating patients in comatose at the provincial general hospital inpatient department with minimal care.

(b) PGH intensive unit care (PGHIUC)

The PGHIUC would involve intensive bed care, and the use of a respirator, at the provincial general hospital.

5.3 Moving From the Long to a Short List of Options

Since the large number of options summarized in Tables 5.1 and 5.2 represent **roughly** the universe of options at disparate decision nodes in Figure 6.1, which options should be evaluated given that the available research resources are limited?

5.3.1 *Elimination criteria*

The criteria developed below are used in reducing the long list of options to a tractable number.

1. *Dominance*

If an option's expected cost is **obviously** greater than expected benefits, it is manifestly dominated by at least one other option and can be eliminated, because nothing is gained by using scarce research resources to prove the obvious.

2. *Representative option*

If one option is sufficiently similar to one or more of the other options, only one need be evaluated on the grounds that similar results will apply to those eliminated (should this representative option prove to be optimal, then it may be necessary to re-examine its close substitute).

3. *Gross uncertainty of option's effectiveness*

Schistosomiasis options that are currently experimental or subject to serious questioning as to their effectiveness can be eliminated (with such options, the technology in question may of course be an important target for future research).

4. *Binding constraint*

If an option is not feasible because of a truly binding constraint (such as political acceptability, environmental damage, or inputs needed are unavailable in local or international markets), then it can be eliminated (but the bindingness of a constraint needs to be subject to critical scrutiny).

5. *Cultural acceptability*

If an intervention is unlikely to be culturally acceptable to the patients (potential or actual), it may be eliminated on the grounds of limited expected compliance.

6. *Unethicality*

If an intervention is likely to create an environment conducive to the transmission of other diseases (health hazard) or discriminates between patients on the grounds of sex, age, or education, it is unethical, and can be eliminated.

5.3.2 *Application of the elimination criteria*

The environmental management options, viz. canal weeding; canal cementing; and re-channelling of canals, are eliminated on the basis of the gross uncertainty as to effectiveness criteria. There are hardly any intervention studies demonstrating the efficacy of environmental management (per se) in reducing snail population.

The area-wide chemical molluscicide options (either using pressure pumps or

aeroplane) are eliminated on the basis of the binding constraint criteria (specifically their expected damage on fauna). Since plant molluscicide and biological control are still experimental, both are eliminated on the basis of the gross uncertainty as to effectiveness criteria.

Since neither efficacy nor effectiveness of the protected water wells and bore-holes options has been established, both are eliminated by the gross uncertainty as to effectiveness criteria. Contrastingly, the effectiveness of household piped water supply has been demonstrated in St. Lucia (Jordan, 1985). The option of fetching water from the schistosome parasite contaminated irrigation water is both unethical and politically unacceptable. And its expected cost obviously exceed its expected benefits. Thus it is eliminated on the basis of both the binding constraint criteria, and dominance criteria. The communal water taps and shower facilities option would be culturally unacceptable to some sections of Mwea community, thus it is eliminated on the basis of cultural acceptability criteria.

Both the household water-flushed lavatories and the communal water-flushed lavatories would be culturally unacceptable to the Mwea community. Thus the two are eliminated on the cultural acceptability criteria. The efficacy and effectiveness of communal pit latrines option is uncertain, thus it is eliminated by the gross uncertainty as to effectiveness criteria.

The efficacy of health education via: schools, health facilities, and public administration meetings is uncertain. In addition, the three options discriminate against those not in school, the healthy, and women (and children) respectively. Thus the three are eliminated on the basis of the gross uncertainty as to effectiveness and unethicality criteria. In addition to their discriminatory characteristics, the three options will most likely have significantly lower participation rates than house to house health education visits.

Mass population chemotherapy with oxamniquine, mass population chemotherapy with praziquantel, selective population chemotherapy with oxamniquine and selective population chemotherapy with praziquantel are representative of the targeted mass chemotherapy with oxamniquine, targeted mass chemotherapy with praziquantel, targeted selective chemotherapy with oxamniquine and targeted selective chemotherapy with praziquantel options. Thus the latter four are eliminated by the representative option criteria.

The targeted-selective-targeted chemotherapy with oxamniquine and targeted-selective-targeted chemotherapy with praziquantel are experimental; thus both are eliminated by the gross uncertainty as to effectiveness criteria.

The status quo option is included to highlight its disadvantages and to make explicit the extra cost of gaining the extra benefit of doing something. Thus, the preceding elimination procedure reduced the long list of primary options in table 5.1 to the short list in Table 5.3. None of the possible secondary options could be eliminated, thus all of them would be evaluated (Table 5.3).

Table 5.3: A short list of primary and secondary schistosomiasis interventions

DECISION NODES CODES	HEALTH STATE LABELS	SELECTED SET OF OPTIONS
2 (PRIMARY OPTIONS)	COMMUNITY	1. Status Quo (SQ) 2. Household piped water supply (HPWS) 3. Household health education visits (HHED) 4. Drip Mollusciciding (DM) 5. Focal Mollusciciding (FM) 6. Household vented improved pit latrines (VIPL) 7. Mass population chemotherapy with praziquantel (MPCP) 8. Mass population chemotherapy with oxamniquine (MPCO) 9. Selective population chemotherapy with praziquantel (SPCP) 10. Selective population chemotherapy with oxamniquine (SPCO)
4 (SECONDARY OPTIONS)	MILD **S**	1. Status quo at the dispensary (SQD) 2. Praziquantel care at the dispensary (PCD) 3. Oxamniquine care at the dispensary (OCD)
6	MODERATE **K**	1. Status quo at the health centre (SQHC) 2. Praziquantel care at the health centre (PCHC) 3. Oxamniquine care at the health centre (OCHC)
8	SEVERE **Z**	1. Status quo at the district hospital (SQDH) 2. Praziquantel care at the district hospital (PCDH) 3. Oxamniquine care at the district hospital (OCDH)
10	VERY SEVERE **A**	1. Provincial general hospital status quo (PGHSQ) 2. Provincial general hospital IPD drug management (PGHDM) 3. Provincial general hospital IPD surgical operation (PGHSO)
12	COMA **R**	1. Provincial general hospital status quo (PGHSQC) 2. Provincial General Hospital intensive unit care (PGHIUC)

5.4 Policy Strategies and Policy Combinations

5.4.1 *Policy strategies*

In chapter 1, a strategy was defined as a comprehensive ameliorative course of action composed of one primary policy and all the short-listed secondary intervention options at each of the five schistosomiasis health states (mild, moderate, severe, very severe and comatose). Whatever policy is under taken at the community level determines the distribution pattern of Mwea Scheme population across various health states, hence numbers of patients (cases) seeking care across the hierarchy of Government and non-governmental organizations' health facilities. Thus it is wrong to evaluate the costs and benefits of primary and secondary interventions in isolation.

The number of strategies is equal to the number of primary options listed above. In short, the **strategies** evaluated were: Status quo (SQS); focal molluscicide (FMS); drip molluscicide (DMS); Household piped water supply (HWPSS); home health education visits (HHEDS); household vented improved pit latrine (VIPLS); mass population chemotherapy with praziquantel (MPCPS); mass population chemotherapy with oxamniquine (MPCOS); selective population chemotherapy with praziquantel (SPCPS); and selective population chemotherapy with oxamniquine (SPCOS). Each strategy is made up of policy combinations.

5.4.2 *Policy combinations*

A combination is a single secondary (facility level) intervention preceded by a single primary intervention at the community level. When a single primary policy is combined with options available to the mild, moderate, severe, very severe and comatose states cases, we get fourteen policy combinations. For example, combining the focal molluscicide (FM) policy with relevant secondary options yields one strategy consisting of the following combinations: FM+SQD, FM+PCD, FM+OCD, FM+SQHC, FM+PCHC, FM+OCHC, FM+SQDH, FM+PCDH, FM+OCDH, FM+PGHSQ, FM+PGHDM, FM+PGHSO, FM+PGHSQC, FM+PGHIUC. The positive sign (+) implies that effect of the primary intervention is reflected in the secondary option it is combined with (thus it **does not** imply two are combined in an additive manner). Thus,

there are 140 combinations (i.e. 14 secondary interventions times 10 primary options) for which expected cost, expected QALYs and expected monetary values need to be calculated to facilitate estimation of the cost-effectiveness and cost-benefit decision analysis models developed in chapter 8 (see Table 5.4 below). The abbreviation SQ+DNY means do the status quo at the community level and do nothing at all at the normal health state Y. Whereas, HWSP+OCD means implement household water supply at the primary level and give oxamniquine treatment at the dispensary to the mild schistosomiasis state (S) cases. The meanings of all the abbreviations are as defined in Table 5.3.

5.5 Summary

33 alternative primary options were identified. This number was reduced to 10 using the following criteria: dominance, representative option, gross uncertainty of option's effectiveness, binding constraint, cultural acceptability and unethicality. None of the 14 facility level interventions was eliminated. The chapter identified 10 schistosomiasis intervention strategies in 140 combinations for which expected cost, EQALYs and EMVs need to be calculated to facilitate estimation of the cost-effectiveness and cost-benefit decision analysis models developed in chapter 6.

Table 5.4: Health states intervention combinations	
Health States	Intervention Combinations
Y	SQ+DNY,HPWS+DNY, HHED+DNY, VIPL+DNY, DM+DNY, FM+DNY, MPCP+DNY, MPCO+DNY, SPCP+DNY, SPCO+DNY
S	SQ+SQD, SQ+PCD, SQ+OCD, HPWS+SQD, HPWS+PCD, HPWS+OCD, HHED+SQD, HHED+PCD, HHED+OCD, VIPL+SQD, VIPL+PCD, VIPL+OCD, DM+SQD, DM+PCD, DM+OCD, FM+SQD, FM+PCD, FM+OCD, MPCP+SQD, MPCP+PCD, MPCP+OCD, MPCO+SQD, MPCO+PCD, MPCO+OCD, SPCP+SQD, SPCP+PCD, SPCP+OCD, SPCO+SQD, SPCO+PCD, SPCO+OCD
K	SQ+SQHC, SQ+PCHC, SQ+OCHC, HPWS+SQHC, HPWS+PCHC, HPWS+OCHC, HHED+SQHC, HHED+PCHC, HHED+OCHC, VIPL+SQHC, VIPL+PCHC, VIPL+OCHC, DM+SQHC, DM+PCHC, DM+OCHC, FM+SQHC, FM+PCHC, FM+OCHC, MPCP+SQHC, MPCP+PCHC, MPCP+OCHC, MPCO+SQHC, MPCO+PCHC, MPCO+OCHC, SPCP+SQHC, SPCP+PCHC, SPCP+OCHC, SPCO+SQHC, SPCO+PCHC, SPCO+OCHC
Z	SQ+SQDH, SQ+PCDH, SQ+OCDH, HPWS+SQDH, HPWS+PCDH, HPWS+OCDH, HHED+SQDH, HHED+PCDH, HHED+OCDH, VIPL+SQDH, VIPL+PCDH, VIPL+OCDH, DM+SQDH, DM+PCDH, DM+OCDH, FM+SQDH, FM+PCDH, FM+OCDH, MPCP+SQDH, MPCP+PCDH, MPCP+OCDH, MPCO+SQDH, MPCO+PCDH, MPCO+OCDH, SPCP+SQDH, SPCP+PCDH, SPCP+OCDH, SPCO+SQDH, SPCO+PCDH, SPCO+OCDH
A	SQ+PGHSQ, SQ+PGHDM, SQ+PGHSO, HPWS+PGHSQ, HPWS+PGHDM, HPWS+PGHSO, HHED+PGHSQ, HHED+PGHDM, HHED+PGHSO, VIPL+PGHSQ, VIPL+PGHDM, VIPL+PGHSO, DM+PGHSQ, DM+PGHDM, DM+PGHSO, FM+PGHSQ, FM+PGHDM, FM+PGHSO, MPCP+PGHSQ, MPCP+PGHDM, MPCP+PGHSO, MPCO+PGHSQ, MPCO+PGHDM, MPCO+PGHSO, SPCP+PGHSQ, SPCP+PGHDM, SPCP+PGHSO, SPCO+PGHSQ, SPCO+PGHDM, SPCO+PGHSO
R	SQ+PGHSQR, SQ+PGHIUC, HPWS+PGHSQR, HPWS+PGHIUC, HHED+PGHSQR, HHED+PGHIUC, VIPL+PGHSQR, VIPL+PGHIUC, DM+PGHSQR, DM+PGHIUC, FM+PGHSQR, FM+PGHIUC, MPCP+PGHSQR, MPCP+PGHIUC, MPCO+PGHSQR, MPCO+PGHIUC, SPCP+PGHSQR, SPCP+PGHIUC, SPCO+PGHSQR, SPCO+PGHIUC

CHAPTER 6

APPLICATION OF DECISION ANALYSIS THEORY IN THE APPRAISAL OF SCHISTOSOMIASIS CONTROL

6.0 Introduction

This chapter structures the qualitative anatomy of a schistosomiasis decision maker's problem as the chronological arrangement of the choices under his control and those choices that are determined by chance (choices of nature). Section 6.1 develops the schistosomiasis decision tree model - which is the foundation of this thesis. Section 6.2 develops the cost-effectiveness decision analysis model. Section 6.3 develops the cost-benefit decision analysis model. The chapter concludes with a list of types of data needed to estimate the two models.

6.1 The Decision Tree Model

Figure 6.1 is a graphical representation of the alternative courses of action available to schistosomiasis decision makers and the alternative actions available to the nature (i.e. health outcomes), arranged in their natural sequence. Thus, it is a way of decomposing the complex decision problem into smaller problems which can be analyzed separately and then reconstituted to provide a solution to the larger and more complex problem. The tree is constructed in chronological order, the decisions and events being described by branches in the order in which they occur. The tree grows horizontally from left to right, with its trunk to the left of the sheet and branches to the right.

The decision tree (Fig. 6.1) has the following components:

(a) Square decision nodes which are controlled by the decision maker. There are 92 decision nodes in total, i.e. 9 secondary (facility) level decision nodes times 10 strategies plus 2 primary level decision nodes. The decision nodes marked 1 and 3 represent dichotomous decisions of either doing nothing (i.e. the current) or doing something; there are 52 such nodes. On the other hand, the decision nodes labelled 2 and 4 depict the choice and implementation of the option with the highest positive expected - net social benefits or net incremental effectiveness; there are 40 such nodes.

Starting from left, at the decision node 1, there are two options: either continue with current practice or do something else. If the decision is to do nothing, costs and benefits of such policy ought to be evaluated. Instead, if the decision is to do something, one ought to continue to decision node 2 where expected costs and benefits for each of the ten primary policies provided in Table 5.3 must be evaluated. And then select the option that promises highest expected net social benefits. As indicated on Table 6.1 below the decision maker has to keep on iterating till the last decision node. Each of the decision nodes n (n = 2, 4, 6, 8 and 10) represents a finite set of short-listed options **K**. Set **K** has **i** member options K_1, K_2,...,K_i. That is **K** = $\{K_i\}$, i=1,2,...,m.

Table 6.1: Sequential decision problems facing the schistosomiasis intervention decision makers

Decision Node	Decision problem at each node
1	1. Do something else or status quo?
2	2. Choose a primary health care option that yields highest positive expected net social benefits.
3	3. Do something else or status quo for cases in mild health state S?
4	4. Choose a secondary health care option that yields highest positive expected net social benefits.
5	5. Do something else or status quo for cases in moderate health state K?
6	6. Choose a secondary health care option that yields highest positive expected net social benefits.
7	7. Do something else or status quo for cases in severe health state Z?
8	8. Choose a secondary health care option that yields highest positive expected net social benefits.
9	9. Do something else or status quo for cases in health state A?
10	10. Choose a secondary health care option that yields highest positive expected net social benefits.
11	11. Choose either status quo or PGH intensive unit care, that promises the highest positive expected net social benefits for cases in health state R?

(b) Circular chance (random or probabilistic) nodes are beyond the control of decision makers. In other words, they represent "nature's choices". There are 160 chance nodes in total; i.e. 15 secondary level chance nodes (labelled B on figure 6.1) times 10 strategies being evaluated plus 10 primary (or community) level chance nodes (labelled A). The latter chance nodes represent the health states probabilities for Mwea population, given that specific K^{th} (K=1,2,..,10) policy is implemented independently/exclusively at the community level. Each of the branches emanating from chance node A has a probability (health state probability) attached to it. Each of the 160 chance nodes labelled B in figure 6.1 depicts an health state. For instance, Y is the normal state; S is the mild state; K is the moderate state; Z is the severe state; A is the very severe state; and Q is the absorbing dead state. At each chance node (health state) there is a finite set of uncertain outcomes **O**. The set **O** has 5 members o_1, o_2, o_3, o_4, and o_5. Where: o_1 is full recovery; o_2 is receding to the immediately preceding state; o_3 is remaining in that health state; o_4 is dying in the health state; and o_5 is advancing to the next more severe health state. In other words, O = $\{O_j\}$, j=o_1,o_2,o_3,o_4 and o_5. Those outcomes are depicted by the branches emanating from the chance nodes labelled B. It is necessary to qualify that if a person is currently in normal health state Y, he or she is faced with only three outcomes: O_3, O_4 and O_5. Another person who is in health state S, is faced with four outcomes: O_1, O_3, O_4 and O_5. The same could be said for a patient in health state R. However, anyone in states K, Z and A is confronted with all the five uncertain outcomes.

The listing of health states and outcomes is assumed to be exhaustive (i.e. includes all the possibilities) and mutually exclusive (implying any inhabitant of Mwea scheme can never be in more than one health state at any point in time or experience more than one outcome simultaneously).

The likelihood that an individual drawn at random from Mwea population will be in either health state Y, S, K, Z, A or R, depends upon the primary course of action taken collectively at the community level. On the other hand, the probability of a person who is already in any one of the health states experiencing j^{th} outcome will depend upon the effectiveness of the policy undertaken at the secondary level.

Since long-run frequencies are not available for estimating relevant health state and outcome probabilities either directly or with the aid of some model, this thesis will be based on subjective or personalistic probabilities (Raiffa, 1968). It has been proved

rigorously that, if the way those probabilities are assigned obey the standard laws and conventions of probability theory (Savage, 1954), those probabilities conform mathematically to a probability measure (Kolmogorov, 1933). The health state and outcome probabilities will be elicited from a Delphi Panel of schistosomiasis epidemiology experts (expounded in chapter 7).

6.2 The Cost-Effectiveness Decision Analysis Model

This Cost-Effectiveness decision model (MODEL 1 in the Disk labelled A) uses net incremental effectiveness as a criterion for selecting the optimal strategy (i.e. the optimal path of policy options from the community to provincial general hospital options). If an epidemiological cross-sectional survey were done in Mwea Scheme settlements at any point in time, the population would be distributed across the following health states: normal (Y), mild (S), moderate (K), severe (Z), very severe (A), and comatose (R); with some probability P_{ij} (i=1,2,..,m; j=1,2,..,m) associated with i^{th} health state and the j^{th} intervention combination policy. At each health state (represented by a chance node in Fig. 6.1) there is a finite set of uncertain outcomes O_k (k=1,2,..,r). The actual cost and effectiveness of various schistosomiasis interventions depend upon the true states of health. Since the true state is unknown for any individual, one can meaningfully speak of expected health outcomes, which in turn depend upon the probabilities of various true states of health.

Notation

A number of assumptions are made. First, that the schistosomiasis Delphi panel experts hold prior beliefs (P) about the distribution of Mwea population across the six health states, assuming j^{th} primary policy has been undertaken. That is $P = \{P_i\}$, $i=P_Y,P_S,P_K,P_Z,P_A$ and P_R. Where: P_Y is the probability that i^{th} individual is in normal state (Y); P_S is the probability that i^{th} individual is in mild state (S); P_K is the probability that i^{th} individual is in moderate state (K); P_Z is the probability that i^{th} individual is in severe state (Z); P_A is the probability that i^{th} individual is in v.severe state (A); and P_R is the probability that i^{th} individual is in comatose state (R).

Second, at each health state there is finite set of uncertain health outcomes O_k, $k=o_1,o_2,o_3,o_4$ and o_5. Where: o_1 is full recovery; o_2 is to recede to immediately preceding state; o_3 is to remain in that health state; o_4 is to die in the health state; and o_5 is to

advance to the next state. It is important to note that these outcomes are health states. For example, suppose that a patient is diagnosed to be in health state K at the beginning of the year; by the end of the year with or without intervention that patient may experience full recovery, which means going into state Y. Alternatively, the patient may recede to the immediately preceding state S; or remain in health state K; or die (Q) while in K; or advance to the next more severe state Z. For those in health state S, full recovery and receding to the immediately preceding state refers to the same state Y. While for those in state R, dying in the state and advancing to the next state both refer to death outcome Q.

Third, that the panel of experts hold prior beliefs (q) about the likelihoods of a person in i^{th} health state experiencing a specific outcome. That is $q = \{q_k\}$, $k=q_1,q_2,q_3,q_4,q_5$. Where: q_1 is the probability of full recovery; q_2 is the probability of receding to immediately preceding state; q_3 is the probability of remaining that health state; q_4 is the probability of dying in the health state; and q_5 is the probability of advancing to the next state.

Fourth, the panel of experts can estimate the remaining life expectancy (L) (to the nearest whole year) at each health state (assuming a five years base age and a general Kenyan life expectancy of 57 years) in absence of intervention policy. That is $L = \{L_k\}$, $k=L_1,L_2,L_3,L_4,L_5;L_6;L_7$. Where: L_1 is the remaining life for a person in state Y; L_2 is the remaining life for a person in state S; L_3 is the remaining life for a person in state K; L_4 is the remaining life for a person in state Z; L_5 is the remaining life for a person in state A; L_6 is the remaining life for a person in state R; and L_7 is the remaining life for a person in state Q (the latter is included for completeness).

Fifth, Mwea Division residents (farmers, teachers and health professionals) are the appropriate judges of their welfare, and their mean valuations (U) should count in the decision analysis. That is $U = \{U_k\}$, $k=U_Y,U_S,U_K;U_Z,U_A,U_R;U_Q$.

Where: U_Y is the average utility of health state Y; U_S is the average utility of health state S; U_K is the average utility of health state K; U_Z is the average utility of health state Z; U_A is the average utility of health state A; U_R is the average utility of health state R; and U_Q is the average utility of health state Q.

Sixth, by multiplying respective health states probabilities (P_{ij}) by the projected annual population, one derives the distribution (n) of Mwea population across health states. That is $n = \{n_k\}$, $k=n_Y,n_S,n_K;n_Z,n_A,n_R;n_Q$. Where: n_Y is the number of persons in

state Y under j^{th} policy combination for those in Y; n_S is the number of persons in state S under j^{th} policy combination for those in S; n_K = number of persons in state K under j^{th} policy combination for those in K; n_Z is the number of persons in state Z under j^{th} policy combination for those in Z; n_A is the number of persons in state A under j^{th} policy combination for those in A; n_R is the number of persons in state R under j^{th} policy combination for those in R; and n_Q is the number of persons in state Q under j^{th} policy combination for those in Q. Thus, the number of persons in a given health during any one year will depend upon the effectiveness of the intervention policy adopted at the primary/community level.

Seventh, employing reasonable criteria (developed in chapter 5) it was possible to delineate a manageable number of intervention combinations (Table 5.4) for patients suffering various schistosomiasis related health states:

Seventh, the rate of return on Kenya Government bonds reflects the social opportunity cost of capital; and thus all health benefits and costs should be discounted at a discount rate (**r**) equal to the real rate of return on bonds (i.e. 10%). It has also been empirically demonstrated that the social discount rate for Kenya is 10% (Scott et al., 1976; Brent, 1990). In other words, the present value of benefits (and costs) for year **t** will be a product of the relevant discount factor (DF_t) and expected benefits (and costs).

Eighth, the Delphi panel of experts will be able to propose a reasonable project life (T) for the schistosomiasis projects, i.e. beyond which the flow of costs and benefits would either cease or would be insignificant.

Ninth, the appropriate physical measure of intervention combination effectiveness is its expected quality adjusted life years index (EQALY). Where $EQALY_j$ is the sum of the values of each health outcome (O_k), with each outcome utility being multiplied by its probability of occurrence, the specific year under consideration (=1), discount factor and number of people who are likely to experience state K by the end of the year in question.

There are two alternative ways of calculating EQALYs within the decision analytic framework. The first one could be called project life cut-off technique (PLCOT). Under PLCOT, one would calculate each option's expected quality of life (EQoL) per year over the project life and sum those annual EQoL totals to get the grand total. For example, the expected quality adjusted life years of j^{th} intervention combination into state K would be calculated as follows using PLCOT:

$$T=15$$

$$\sum_{t=0} E(QALY)_{Kj} = q_1(U_Y)(DF_t)(n_k)+q_2(U_S)(DF_t)(n_k)+$$

$$q_3(U_K)(DF_t)(n_k)+q_4(U_Q)(DF_t)(n_k)+q_5(U_Z)(DF_t)(n_k).....(1)$$

Equation (2) is short form of equation (1):

$$\sum_{t=0}^{T=15} E(QoL)_{Kj} = \sum_{i=Y}^{I} EQoL_{Kj} .....(2)$$

Equations (1) and (2) assume that schistosomiasis disease and/or intervention does not have any effects on quantity of life. Thus, only quality of life is considered.

Equations (3) and (4) assume that schistosomiasis disease and/or intervention will affect only the year under consideration. That is why there are 'ones' in expression (3).

$$T=15$$

$$\sum_{t=0} E(QALY)_{Kj} = q_1(U_Y)(1)(DF_t)(n_k)+q_2(U_S)(1)(DF_t)(n_k)+ ...(3)$$

$$q_3(U_K)(1)(DF_t)(n_k)+q_4(U_Q)(1)(DF_t)(n_k)+q_5(U_Z)(1)(DF_t)(n_k)$$

Equation (3) is short form of equation (4):

$$\sum_{t=0}^{T=15} E(QALY)_{Kj} = \sum_{i=Y}^{I} EQALY_{Kj} .....(4)$$

Note that equations (1) and (2) are similar to equations (3) and (4), and all are based on following assumptions:

(a) The movement through health states Y to R has no effect on victim's life expectancy;

(b) survival is adequately taken care of by the probability of outcome Q (Death);

(c) individuals in either of the states Y, S, K, Z, A and R would lead normal life expectancies at the respective states; and

(d) health gains from intervention terminate with expiry of the assumed project life (i.e. end of year 15). In reality, the above assumptions are unlikely to hold. While individuals in health states Y, S and K may be expected to lead normal life expectancy with or without intervention, the same could not possibly be said for those in severe (Z), very severe (A) and coma (R) states. In addition, if an individual's health improves as a result

of intervention (or spontaneously) from state A to state Y (which is likely according to expert subjective outcome probabilities) by the end of year 15, that person would be expected to lead the remaining life expectancy of a person in Y (assuming the person is not re-infected). It is because of these problems that the second approach which may be called 'cut-off relaxed technique' (CORT) was adopted.

CORT requires calculation of EQALYs using the same approach as used in PLCOT for year 0 to 14, but then in year 15 one should use the remaining life expectancy instead of just the single year under consideration. The EQALYs for year 15 will have to be discounted at average discount factors (ADF) over the remaining life expectancies for the relevant outcomes. For example, let us assume that life expectancies (in years) of outcomes Y=57, S=57, K=57, Z=40 and Q=0. Assuming a base infection age to be 5 years, the remaining life expectancies (RLE) for health state K outcomes would be Y=37 (57-5-15), S=37 (57-5-15), K=37 (57-5-15), Z=20 (40-5-15), and Q=0. Thus, the CORT process would proceed in two steps to calculate EQALYs from j^{th} policy combination:

T=14

$$\sum_{t=0} E(QALY)_{Kj} = q_1(U_Y)(1)(DF_t)(n_k)+q_2(U_S)(1)(DF_t)(n_k)+ \quad \text{.....(5)}$$
$$q_3(U_K)(1)(DF_t)(n_k)+q_4(U_Q)(1)(DF_t)(n_k)+q_5(U_Z)(1)(DF_t)(n_k)$$

T=15

$$\sum_{t=15} E(QALY)_{Kj} = q_1(U_Y)(L_1)(DF_t)(n_k)+q_2(U_S)(L_2)(ADF_t)(n_k)+ \quad \text{.....(6)}$$
$$q_3(U_K)(L_3)(DF_t)(n_k)+q_4(U_Q)(L_7)(DF_t)(n_k)+q_5(U_Z)(L_4)(ADF_t).n_k$$

Equation (7) below is summary of the CORT:

$$\sum_{t=0}^{T=15} E(QALY)_{Kj} = \sum_{t=0}^{T=14} \sum_{i=Y} EQoL_K + \sum_{t=15}^{T=15} \sum_{i=Y} EQoL_K * RLE_{lt=15}$$

It is important to note that the expected QALYs for each combination ought to be calculated separately for each year over the assumed intervention's life (T years), and then summed.

The expected benefits to patients are defined as $EQALY_{ij}$; and expected cost as C_{ij}; where i denotes the health state and j denotes the policy combination being evaluated. The nursing officers treating health state S patients at the dispensaries will have thirty mutually exclusive policy combinations to choose from (see Table 5.4); obtained by multiplying the ten primary policies by three options available at the dispensaries for those suffering mild schistosomiasis. There will be an equal number of combinations for those in health states K, Z and A. However, there are only 20 combinations for those in state R; i.e. ten primary policies times two options at the Provincial General Hospital.

The following three policy combinations, SQ+SQHC, SQ+PCHC and SQ+OCHC, for those in state K will be used to illustrate how the cost-effectiveness analysis model works. Thus:

$QALY_{SQ+SQHC}$ = total QALYs expected from status quo policies at primary level and the Health Centre for those in state K

$QALY_{SQ+PCHC}$ = total QALYs expected from status quo policy at primary level and the praziquantel treatment at the Health Centre for those in state K

$QALY_{SQ+OCHC}$ = total QALYs expected from status quo policy at primary level and the oxamniquine treatment at the Health Centre for those in state K

Presumably, $QALY_{SQ+PCHC} > QALY_{SQ+SQHC}$ if SQ+PCHC combination is more effective than SQ+SQHC combination. Similarly, $QALY_{SQ+OCHC} > QALY_{SQ+SQHC}$ if SQ+OCHC combination is more effective than SQ+SQHC combination.

In parallel notation, the associated costs are:

$C_{SQ+SQHC}$ = total expected cost of status quo policies at primary level and the Health Centre for those in state K

$C_{SQ+PCHC}$ = total expected cost of status quo policy at primary level and the praziquantel treatment at the Health Centre for those in state K

$C_{SQ+OCHC}$ = total expected cost of status quo policy at primary level and the oxamniquine treatment at the Health Centre for those in state K

With partial differentials of the expected QALYS and costs of the SQ+PCHC and SQ+OCHC with respect to those of the status quo (SQ+SQHC), one can obtain the incremental QALYs and incremental costs. Thus:

$\partial QALY_1 = QALY_{SQ+PCHC} - QALY_{SQ+SQHC}$

$\partial QALY_2 = QALY_{SQ+OCHC} - QALY_{SQ+SQHC}$

$\partial C_1 = C_{SQ+PCHC} - C_{SQ+SQHC}$

$\partial C_2 = C_{SQ+OCHC} - C_{SQ+SQHC}$

Where: $\partial QALY_1$ and $\partial QALY_2$ depict QALY gains from SQ+PCHC and SQ+OCHC over SQ+SQHC; while ∂C_1 and ∂C_2 represent the change in cost by doing SQ+PCHC and SQ+OCHC over SQ+SQHC.

The Effectiveness-Cost Ratio (ECR) criteria demands that, if $\partial QALY_1/\partial C_1 > \partial QALY_2/\partial C_2$, SQ+PCHC option should be chosen (assuming there are only two combinations). If $\partial QALY_1/\partial C_1 = \partial QALY_2/\partial C_2$, the decision-maker would be expected to be indifferent. However, ECR criteria does not tell us whether the preferred combination is worth-doing. If one stopped here, the schistosomiasis decision-maker would be expected to place valuations on the QALYS and decide whether it is worth doing the policy recommended by ECR criteria. Surely, that does not make the decision-taking lives of schistosomiasis decision-makers easier. That problem could be overcome by calculating a "cut-off ratio", that reflects the opportunity cost, and would act as an external anchor or standard against which to judge the worthiness of new policies.

Cut-off effectiveness-cost ratio derivation

The cut-off ratios will be obtained by comparing the discounted costs and discounted QALYs of a "do-nothing-completely" (DNC) strategy with those of the status quo strategy (SQ). The DNC means terminating current practice (the status quo) at all levels. That is, at the primary level and at all the health facilities for all the potential and actual schistosomiasis patients (Y,S,K,Z,A,R). Thus, subsumed under the DNC strategy are a number of policy combinations: do nothing completely at primary level (DNCP); do nothing completely at primary level and at the dispensaries for health state S patients (DNCP+DNCS); do nothing completely at primary level and at the Health Centre for health state K patients (DNCP+DNCK); do nothing completely at primary level and at the District Hospital for health state Z patients (DNCP+DNCZ); do nothing completely at primary level and at the Provincial General Hospital for the health state A patients (DNCP+DNCA); and do nothing completely at the primary level and the Provincial General Hospital intensive care unit for health state R patients (DNCP+DNCR).

STEP 1: QALYS expected from DNC

The question addressed below is: suppose the society decided to terminate the current practice for schistosomiasis cases at all levels, what would be the benefits? Formulae (1a & 1b), (2a & 2b), (3a & 3b), (4a & 4b), (5a & 5b) and (6a & 6b) in Table 6.2 are mathematical expectations of QALYs anticipated at each health state, under the DNC strategy policy combinations. Summation of the total present values of QALYs expected from each of the 6 health states (expressions 1a & 1b, 2a & 2b, 3a & 3b, 4a & 4b, 5a & 5b and 6a & 6b), yields the total health benefits of the DNC strategy. That result is algebraically expressed in equation (7). In that equation, the subscript j refers to the present value of QALYs the i^{th} health state patients expect if j^{th} policy is undertaken for a period of 15 years.

Table 6.2: DNC strategy expected QALYs equations

$$\sum_{t=0}^{14} EQALY_{DNCP} = (q_1*U_Y*1*DF_t*n_Y)+(q_4*U_Q*1*DF_t*n_Y)+ (q_5*U_S*1*DF_t*n_Y) \quad \text{.....(1a)}$$

$$\sum_{t=15} EQALY_{DNCP} = (q_1*U_Y*L_1*ADF_t*n_Y)+(q_4*U_Q*L_7*ADF_t*n_Y)+ (q_5*U_S*L_2*ADF_t*n_Y) \quad \text{.....(1b)}$$

$$\sum_{t=0}^{14} EQALY_{DNCP+DNCS} = (q_1*U_Y*1*DF_t*n_S)+(q_3*U_S*1*DF_t*n_S)+ (q_4*U_Q*1*DF_t*n_S)+(q_5*U_K*1*DF_t*n_S) \quad \text{...(2a)}$$

$$\sum_{t=15} EQALY_{DNCP+DNCS} = (q_1*U_Y*L_1*ADF_t*n_S)+(q_3*U_S*L_2*ADF_t*n_S)+ (q_4*U_Q*L_7*ADF_t*n_S)+(q_5*U_K*L_3*ADF_t*n_S) \quad \text{..(2b)}$$

$$\sum_{t=0}^{14} EQALY_{DNCP+DNCK} = (q_1*U_Y*1*DF_t*n_k)+(q_2*U_S*1*DF_t*n_k)+ (q_3*U_K*1*DF_t*n_k)+(q_4*U_Q*1*DF_t*n_k)+(q_5*U_Z*1*DF_t*n_k) \quad \text{..(3a)}$$

$$\sum_{t=15} EQALY_{DNCP+DNCK} = (q_1*U_Y*L_1*ADF_t*n_k)+(q_2*U_S*L_2*ADF_t*n_k)+ (q_3*U_K*L_3*ADF_t*n_k)+(q_4*U_Q*L_7*ADF_t*n_k)+(q_5*U_Z*L_4*ADF_t*n_k) \quad \text{.....(3b)}$$

$$\sum_{t=0}^{14} EQALY_{DNCP+DNCZ} = (q_1*U_Y*1*DF_t*n_z)+(q_2*U_K*1*DF_t*n_z)+ (q_3*U_Z*1*DF_t*n_z)+(q_4*U_Q*1*DF_t*n_z)+(q_5*U_A*1*DF_t*n_z) \quad \text{...(4a)}$$

$$\sum_{t=15} EQALY_{DNCP+DNCZ} = (q_1*U_Y*L_1*ADF_t*n_z)+(q_2*U_K*L_3*ADF_t*n_z)+ (q_3*U_Z*L_4*ADF_t*n_z)+(q_4*U_Q*L_7*ADF_t*n_z)+(q_5*U_A*L_5*ADF_t*n_z) \quad \text{.....(4b)}$$

Table 6.2: Continued

$$\sum_{t=0}^{14} EQALY_{DNCP+DNCA} = (q_1*U_Y*1*DF_t*n_A)+(q_2*U_Z*1*DF_t*n_A)+ (q_3*U_A*1*DF_t*n_A)+(q_4*U_Q*1*DF_t*n_A)+(q_5*U_R*1*DF_t*n_A)..(5a)$$

$$\sum_{t=15} EQALY_{DNCP+DNCA} = (q_1*U_Y*L_1*ADF_t*n_A)+(q_2*U_Z*L_4*ADF_t*n_A) +(q_3*U_A*L_5*ADF_t*n_A)+(q_4*U_Q*L_7*ADF_t*n_A)+(q_5*U_R*L_6*ADF_t*n_A).....(5b)$$

$$\sum_{t=0}^{14} E(QALY)_{DNCP+DNCR}=(q_1*U_Y*1*DF_t*n_R)+(q_2*U_A*1*DF_t*n_R)+ (q_3(U_R*1*DF_t*n_R)+(q_4*U_Q*1*DF_t*n_R) .....(6a)$$

$$\sum_{t=15} E(QALY)_{DNCP+DNCR}=(q_1*U_Y*L_1*ADF_t*n_R)+(q_2*U_A*L_5*ADF_t*n_R) +(q_3(U_R*L_6*ADF_t*n_R)+(q_4*U_Q*L_7*ADF_t*n_R) .....(6b)$$

$$\sum_{i=1}^{6}\sum_{t=0}^{15} EQALY_{ij} .....(7)$$

$$\sum_{i=1}^{6}\sum_{t=0}^{15} C_j .....(8)$$

STEP 2: Expected cost of DNC strategy

The total cost of the DNC strategy is given by equation (8). In that equation, subscript j refers to the present value of cost that would be incurred if j^{th} policy is made available to patients in i^{th} health state, for a period of 15 years. However, the cost of DNC will be zero, since only anxiety cost will be incurred, which presumably will have been taken into account during the health states utility measurement. The notation C_{DNC} will be used for the total cost of DNC strategy.

STEP 3: Expected QALYs from status quo strategy (SQS)

The third step is to calculate the health benefits of the current practice across the health states. Subsumed under the SQ strategy are a number of policy combinations: do status quo at the primary level (SQ); do status quo at the primary level and at the dispensaries for health state S patients (SQ+SQD); do status quo at the primary level and at the Health Centre for health state K patients (SQ+SQHC); do status quo at the primary level and at the District Hospital for health state Z patients (SQ+SQDH); do status quo at the primary level and at the Provincial General Hospital for health state A patients (SQ+PGHSQ); and do status quo at the primary level and at the Provincial General Hospital for health state R patients (SQ+PGHSQ). The QALYs anticipated from the status quo strategy are given by the mathematical expressions (9a & 9b), (10a & 10b), (11a & 11b), (12a & 12b), (13a & 13b) and (14a & 14b) in Table 6.3. Summation of the expected QALYs across the 6 health states (expressions 9a & 9b, 10a & 10b, 11a & 11b, 12a & 12b, 13a & 13b and 14a & 14b), gives us the total health benefits of the status quo strategy (SQS). That result is be symbolically expressed in equation (15).

Table 6.3: SQS strategy EQALYs equations

$$\sum_{t=0}^{14} EQALY_{SQ} = (q_1*U_Y*1*DF_t*n_Y)+(q_4*U_Q*1*DF_t*n_Y)+ (q_5*U_S*1*DF_t*n_Y) \quad \text{.....(9a)}$$

$$\sum_{t=15}^{15} EQALY_{SQ} = (q_1*U_Y*L_1*ADF_t*n_Y)+(q_4*U_Q*L_7*ADF_t*n_Y)+ (q_5*U_S*L_2*ADF_t*n_Y) \quad \text{.....(9b)}$$

$$\sum_{t=0}^{14} EQALY_{SQ+SQD} = (q_1*U_Y*1*DF_t*n_S)+(q_3*U_S*1*DF_t*n_S)+ (q_4*U_Q*1*DF_t*n_S)+(q_5*U_K*1*DF_t*n_S) \quad \text{.....(10a)}$$

$$\sum_{t=15}^{15} EQALY_{SQ+SQD} = (q_1*U_Y*L_1*ADF_t*n_S)+(q_3*U_S*L_2*ADF_t*n_S)+ (q_4*U_Q*L_7*ADF_t*n_S)+(q_5*U_K*L_3*ADF_t*n_S) \quad \text{.....(10b)}$$

$$\sum_{t=0}^{14} EQALY_{SQ+SQHC} = (q_1*U_Y*1*DF_t*n_K)+(q_2*U_S*1*DF_t*n_K)+ (q_3*U_K*1*DF_t*n_K)+(q_4*U_Q*1*DF_t*n_K)+(q_5*U_Z*1*DF_t*n_K). \quad \text{(11a)}$$

$$\sum_{t=15}^{15} EQALY_{SQ+SQHC} = (q_1*U_Y*L_1*ADF_t*n_K)+(q_2*U_S*L_2*ADF_t*n_K)+ (q_3*U_K*L_3*ADF_t*n_K)+(q_4*U_Q*L_7*ADF_t*n_K)+(q_5*U_Z*L_4*ADF_t*n_K) \quad \text{....(11b)}$$

$$\sum_{t=0}^{14} EQALY_{SQ+SQDH} = (q_1*U_Y*1*DF_t*n_Z)+(q_2*U_K*1*DF_t*n_Z)+ (q_3*U_Z*1*DF_t*n_Z)+(q_4*U_Q*1*DF_t*n_Z)+(q_5*U_A*1*DF_t*n_Z) \quad \text{.....(12a)}$$

$$\sum_{t=15}^{15} EQALY_{SQ+SQDH} = (q_1*U_Y*L_1*ADF_t*n_Z)+(q_2*U_K*L_3*ADF_t*n_Z)+ (q_3*U_Z*L_4*ADF_t*n_Z)+(q_4*U_Q*L_7*ADF_t*n_Z)+(q_5*U_A*L_5*ADF_t*n_Z) \quad \text{.....(12b)}$$

Table 6.3: Continued

$$\sum_{t=0}^{14} EQALY_{SQ+PGHSQ} = (q_1*U_Y*1*DF_t*n_A)+(q_2*U_Z*1*DF_t*n_A)+ (q_3*U_A*1*DF_t*n_A)+(q_4*U_Q*1*DF_t*n_A)+(q_5*U_R*1*DF_t*n_A) \quad (13a)$$

$$\sum_{t=15} EQALY_{SQ+PGHSQ} = (q_1*U_Y*L_1*ADF_t*n_A)+(q_2*U_Z*L_4*ADF_t*n_A)+ (q_3*U_A*L_5*ADF_t*n_A)+(q_4*U_Q*L_7*ADF_t*n_A)+(q_5*U_R*L_6*ADF_t*n_A) \quad (13a)$$

$$\sum_{t=0}^{14} E(QALY)_{SQ+PGHSQ} = (q_1*U_Y*1*DF_t*n_R)+(q_2*U_A*1*DF_t*n_R)+ (q_3*U_R*1*DF_t*n_R)+(q_4*U_Q*1*DF_t*n_R) \quad (14a)$$

$$\sum_{t=15} E(QALY)_{SQ+PGHSQ} = (q_1*U_Y*L_1*ADF_t*n_R)+(q_2*U_A*L_5 *ADF_t*n_R)+(q_3*U_R*L_6*ADF_t*n_R)+(q_4*U_Q*L_7*ADF_t*n_R) \quad (14b)$$

$$\sum_{i=1}^{6} \sum_{t=0}^{15} EQALY_{ij} \quad (15)$$

$$\sum_{i=1}^{6} \sum_{t=0}^{15} C_{ij} \quad (16)$$

STEP 4: Calculate cost of the status quo strategy

This step answers following question: suppose the status quo strategy is allowed to continue for fifteen years from the end of 1992, how much would it cost in Kenya Shillings. A detailed costing methodology for status quo policy combinations for all health states is given in chapter 7. Each health state combinations' discounted cost were summed over the 15 years assumed intervention life. The process is summed up by equation (16). For simplicity, total cost of the status quo strategy will be represented by C_{SQ}.

STEP 5: Derivation of a Cut-off Effectiveness Cost Ratio

As mentioned earlier, ECR criteria does not tell us whether the preferred combination is worth doing. It was also mentioned that the problem could be overcome by calculating a "cut-off effectiveness cost ratio" (CECR). A CECR is the number of incremental QALYs gained per extra shilling being currently spent on the schistosomiasis control strategy (status quo). If the ECR of a new strategy is less than the CECR, it is not worth pursuing because Mwea community will lose QALYs. The decision rule becomes: adopt an alternative strategy as long as its incremental ECR exceeds the CECR. Thus, CECR acts as an external anchor or standard against which to judge the worthiness of new policies. ECR is obtained by subtracting expression (15) from (7) and dividing the result by the difference between (16) and (8). Thus:

$ECR = (EQALY_{SQ}-EQALY_{DNC})/(C_{SQ}-C_{DNC})$

$ECR = \partial QALY_{SQ}/\partial C_{SQ} = Ò$

Where Ò is the "cutoff" effectiveness-cost ratio. In other words, Ò is the ECR of the current practice; which is the least acceptable by Mwea society. This issue of "cut-off" ratio is explored at length in Phelps and Mushlin (1991) and Phelps et al. (1988).

As mentioned earlier, there are ten strategies, SQ (status quo) and alternative strategies (HPWS, HHED, VIPL, DM, FM, MPCP, MPCO, SPCP, SPCO). Each of the latter strategies will have to be compared with the former. The ECR criteria dictates that if an alternative strategy's (or a combination's) effectiveness cost ratio is greater than or equal to the cut-off ratio (Ò), the strategy (or combination) is worth implementing. That is:

$ECR_{HPWS} = (EQALY_{HPWS} - EQALY_{SQ})/(C_{HPWS} - C_{SQ}) >= Ò$

$ECR_{HHED} = (QALY_{HHED} - QALY_{SQ})/(C_{HHED} - C_{SQ}) >= Ò$

$ECR_{VIPL} = (QALY_{VIPL} - QALY_{SQ})/(C_{VIPL} - C_{SQ}) >= Ò$

$ECR_{DM} = (QALY_{DM} - QALY_{SQ})/(C_{DM} - C_{SQ}) >= Ò$

$ECR_{FM} = (QALY_{FM} - QALY_{SQ})/(C_{FM} - C_{SQ}) >= Ò$

$ECR_{MPCP} = (QALY_{MPCP} - QALY_{SQ})/(C_{MPCP} - C_{SQ}) >= Ò$

$ECR_{MPCO} = (QALY_{MPCO} - QALY_{SQ})/(C_{MPCO} - C_{SQ}) >= Ò$

$ECR_{SPCP} = (QALY_{SPCP} - QALY_{SQ})/(C_{SPCP} - C_{SQ}) >= Ò$

$ECR_{SPCO} = (QALY_{SPCO} - QALY_{SQ})/(C_{SPCO} - C_{SQ}) >= Ò$

And where there is more than one mutually exclusive alternative under evaluation, the strategy (or combination) with the highest ECR (among those whose ECRs are greater than the cut-off ratio Ò), should be implemented.

STEP 6: Conversion of expected QALYs into Kenyan Shillings

The inverse of the "cut-off" effectiveness cost ratio (1/Ò) yields the amount of money (in Kenya Shillings) that society is currently willing to pay to gain an additional QALY. In other words, price per QALY implied in the current practice for those living in schistosomiasis endemic Mwea Division. For example, this study established the value of Ò to be 0.0000487 incremental QALYs per shilling spent. That is the same as Ksh. 20,534 per extra QALY gained (i.e. 1/0.000487). Since the incremental cost per QALY (Ksh. 20534) has been derived from the current schistosomiasis control decisions, it is the shadow price the Kenyan society is currently paying per QALY gained by its members living in Mwea Irrigation Scheme.

The inverse of the "cut-off" effectiveness cost ratio (1/Ò) (i.e. the WTP implied in current decisions) will be used in the cost-effectiveness model to convert the expected QALYs into their monetary equivalents (see Appendix 2).

Therefore, since both the costs and effectiveness will finally be expressed in Kenya Shillings, the cost-effectiveness model will use the: **Net Effectiveness > 0**, as the criterion for identifying the combinations and strategies worth implementing. Since at every decision node in Figure 6.1, there may be more than one mutually exclusive policy combination meeting NE criterion, the one with the highest expected incremental effectiveness will be chosen. The justification for converting EQALYs into their

monetary equivalents using a shadow price per QALY derived from current schistosomiasis intervention decisions is presented in chapter 10.

6.3 The Cost-Benefit Decision Analysis Model

The steps described below will be followed when building the cost-benefit decision analysis model on the LOTUS 1-2-3 spreadsheet.

STEP 1: Build Figure 6.1 on the spreadsheet

The cost-benefit decision analysis model (MODEL 2 in the Disk labelled A) is similar to Figure 6.1. However, unlike the latter, the former has in-built formulae for performing the back-ward-induction or folding-back process of the tree. The approach used here follows that of Jones (1986) that involves building one main branch (depicting a single strategy) on spreadsheet and then copying it below as many times as the number of strategies under evaluation. A very important item of MODEL 2, is the Grand Master Table built on its right-hand side. The master table contains the total discounted expected monetary values and costs of all the ten strategies and outcome probabilities. Step 2 explains where the total expected monetary values in the Grand Master Table came from.

STEP 2: Calculate the expected monetary values (EMVs)

The EMV for each health state intervention combination is the sum of the monetary values of each outcome, with each outcome (O_i) probability of occurrence (q_i) being multiplied by its willingness to pay value (WTP_i), discount factor (DF_t) and the annual proportion of the Mwea population expected to be in the health state (n_i) in question at the end of each year, over the intervention combinations' life. The magnitudes of n_i are health state prevalence-or probability-dependent. They vary with the annual trends of health states prevalence over intervention policies' life span. The annual trend of health states prevalence is in turn dependent upon the effectiveness of the policy strategy in question. The other parameters: q_i, WTP_i and DF_t do not vary by strategy. The EMV for each policy combination was obtained by estimating the relevant

equation in Table 6.4. Where $\sum EMV_{ij}$ is the sum of monetary value of health benefits expected by patients in i^{th} health state assuming that the j^{th} policy combination is undertaken over a period of T years (T=15). For example, the EMVs for the 30 health state S policy combinations will be obtained by estimating equation (2) in Table 6.4 separately for each of the combinations. Any attempt to perform those calculations manually would be cumbersome and prone to error. To obviate this problem, sixteen master tables were generated, (a table for each year) each with data on all the ten strategies (160 combinations). The first column of the master table has the annual EMV formulae in Table 6.4 and four raw data columns with values of the parameters (q_i, WTP_i, DF_t and n_i) defined above. Since values of q_i, WTP_i and DF_t do not vary by strategy, they are common among all the strategies. Unlike q_i and WTP_i, the DF_t vary across each year of project life; and thus its column in the 16 annual master tables will be revised accordingly. The parameter n_i varies both across strategies and every year of the project life. The discounted EMVs are calculated annually and then summed over the project period (see equation 7 in Table 6.4). The total EMVs for each of the 10 strategies in 160 combinations are then entered in appropriate column in the Grand Master Table mentioned in step 1.

Table 6.4: Equations to be estimated to obtain the EMVs

$$\sum_{t=0}^{15} EMV_{Yj} = (q_1*WTP_Y*DF_t*n_Y)+(q_4*WTP_Q*DF_t*n_Y)+ (q_5*WTP_S*DF_t*n_Y) \quad \text{.....(1)}$$

$$\sum_{t=0}^{15} EMV_{Sj} = (q_1*WTP_Y*DF_t*n_S)+(q_3*WTP_S*DF_t*n_S)+ (q_4*WTP_Q*DF_t*n_S)+(q_5*WTP_K*DF_t*n_S) \quad \text{.....(2)}$$

$$\sum_{t=0}^{15} EMV_{Kj}=(q_1*WTP_Y*DF_t*n_K)+(q_2*WTP_S*DF_t*n_K)+(q_3*WTP_K*DF_t*n_K)+ (q_4*WPT_Q*DF_t*n_K)+(q_5*WTP_Z*DF_t*n_k) \quad \text{.....(3)}$$

$$\sum_{t=0}^{15} EMV_{Zj} = (q_1*WTP_Y*DF_t*n_Z)+(q_2*WTP_K*DF_t*n_Z)+ (q_3*WTP_Z*DF_t*n_Z)+(q_4*WTP_Q*DF_t*n_Z)+(q_5*WTP_A*DF_t*n_Z) \quad \text{...(4)}$$

$$\sum_{t=0}^{15} EMV_{Aj} = (q_1*WTP_Y*DF_t*n_A)+(q_2*WTP_Z*DF_t*n_A)+ (q_3*WTP_A*DF_t*n_A)+(q_4*WTP_Q*DF_t*n_A)+(q_5*WTP_R*DF_t*n_A) \quad \text{...(5)}$$

$$\sum_{t=0}^{15} EMV_{Rj} = (q_1*WTP_Y*DF_t*n_R)+(q_2*WTP_A*DF_t*n_R)+ (q_3*WTP_R*DF_t*n_R)+(q_4*WTP_Q*DF_t*n_R) \quad \text{.....(6)}$$

$$GPV(EMV)_{ij} = \sum_{t=0}^{T=15} \frac{EMV_t}{(1+r)^t} \quad \text{.....(7)}$$

$$GPV(C)_{ij} = \sum_{t=0}^{T=15} \frac{C_t}{(1+r)^t} \quad \text{.....(8)}$$

STEP 3: Calculate the cost of the combinations

This step answers the following question: suppose each of the admissible policy combinations for health states Y, S, K, Z, A and R is implemented independently and allowed to run for fifteen years from the end of 1992, how much will each cost in Kenya Shillings. A detailed costing methodology is given in chapter 8. The discounted cost for each combination is calculated annually and then summed over the 15 year period (i.e. the assumed project life). The gross present value of costs (C) to be incurred if j^{th} policy combination is implemented for the i^{th} health state patients over period T (where T = 15 years) is algebraically summarized in equation (8) of Table 6.4.

STEP 4: Decision rule

In this study, the numéraire will be the present (1992 - the base year) consumption. Thus, future benefits and costs will be converted to their present values using the 1992 interest rate on Government bonds as the social discount rate (assuming it is the discount rate at which the Kenyan society is willing to transform present into future consumption). The aggregation of each intervention combination's current values to present values using the social discount rate will yield their net present values (NPV).

(a) *Decision rule for combinations*

Subtracting expression (8) from (7) yields the net present value (or net social benefit) value (NPV) for j^{th} policy combination. Where j = 1,2,...,160. In other words, $NPV_j = GPV(EMV)_j - GPV(C)_j > 0$. Where $GPV(B)_j$ and $GPV(C)_j$ are the gross present values of benefits (EMV) and the gross present value of costs (C) for j^{th} policy combination.

The sign of NPV tells schistosomiasis control decision-makers whether or not Mwea society would be better off under the jth policy combination. The magnitude of the NPV indicates by how much society would be better off in terms of present consumption. The latter implies that, at each decision-node, policy combinations can be compared and ranked in terms of their expected contribution to social welfare. Since the alternative policy combinations at each decision node are mutually exclusive, the one

with the highest NPV ought to be implemented so as to maximize social welfare.

(b) *Decision rule for strategies*

Since a strategy is defined as a path of optimal policy combinations across the i^{th} health states, K^{th} strategy's NPV will be obtained by summing up the NPVs of the optimal policy combinations across the six health states. The optimal policy combinations will be selected automatically when the LOTUS 1-2-3 "IF" logical-expressions are built into the cost-benefit-decision model (MODEL 2 in Disk A). Such an expressions would look like: IF(A1>A2,A1,A2), when built in a cell where the choice between relevant policy combinations has to be made. The expression means that, if the NPV in cell A1 is greater than that in cell A2, the NPV in cell A1 must be selected and if otherwise the NPV in cell A2 should be selected.

A strategy is worth undertaking if the sum NPVs expected from its optimal policy combinations is greater than zero. That is:

$$NPV_j = \sum_{i=1}^{6} NPV > 0.$$

Where subscript j refers to the jth intervention strategy. The strategy that promises the highest positive net present value should be implemented.

6.4 Data Needs

The question addressed briefly in this section is: Having developed the cost-effectiveness and cost-benefit decision analysis models, what data sets are needed to facilitate their estimation?

6.4.1 *Benefits data*

Effectiveness data

The following information is needed in the calculations of expected QALY gains: average utility values for each of the 7 health states; outcome probability estimates;

annual health states probability estimates assuming each of the primary policies is undertaken singly over the relevant project period; overall schistosomiasis prevalence estimates for each year assuming each of the primary policies is undertaken singly over the relevant project period; annual population projections for Mwea Scheme over the project period; and an estimate of the social discount rate.

Monetary benefits data

The following information is needed in the calculations of expected monetary values: average willingness to pay values for each of the 7 health states; outcome probability estimates; annual health states probability estimates assuming each of the primary policies is undertaken singly over the relevant project period; overall schistosomiasis prevalence estimates for each year assuming each of the primary policies is undertaken singly over the relevant project period; annual population projections for Mwea Scheme over the project period; and an estimate of the social discount rate.

6.4.2 *Cost data*

Primary policies cost data

Fifteen years cost data for the following primary or community level interventions are needed, viz. DNC, SQ, HPWS, HHED, VIPL, DM, FM, MPCP, MPCO, SPCP and SPCO. Thus, physical quantities of various types of direct inputs (such as personnel time, in-service training, administrative services time; materials; drugs; travel and transport; utilities - electricity, telephone and postage; maintenance of vehicles, buildings and equipment; and capital - equipment, vehicles, buildings and land) and indirect inputs (such as patients and their families out-of-pocket expenditures on transport, time and materials) likely to be used in each of the options will have to be estimated. The shadow price per unit of each category of input will be needed.

The direct and indirect costs for each of the 160 policy combinations listed in Table 5.4 will have to be estimated for every year in the estimated project life. The cost in each case will be for the number of patients expected to use that specific secondary option assuming the primary policy it is combined with is already in place. Chapter 8 explains how the data identified above were collected and analyzed.

6.5 Summary

A sequential schistosomiasis decision tree model has been developed. The model has 9 main branches, each representing an intervention strategy. The steps required to build the CEDA and CBDA models on the LOTUS 1-2-3 spreadsheet have been set out. The EQALYs and EMVs formulae that would enable CEDA and CBDA models to perform the back-ward-induction or folding-back process of the tree have been developed. The analysis shows that the society is currently willing to pay Ksh. 20534 for an additional QALY gained. The following data sets would be needed to facilitate estimation of the two models: effectiveness data, monetary benefits data, primary options cost data and policy combinations cost data.

Figure 6.1: A decision tree model for schistosomiasis intervention strategies

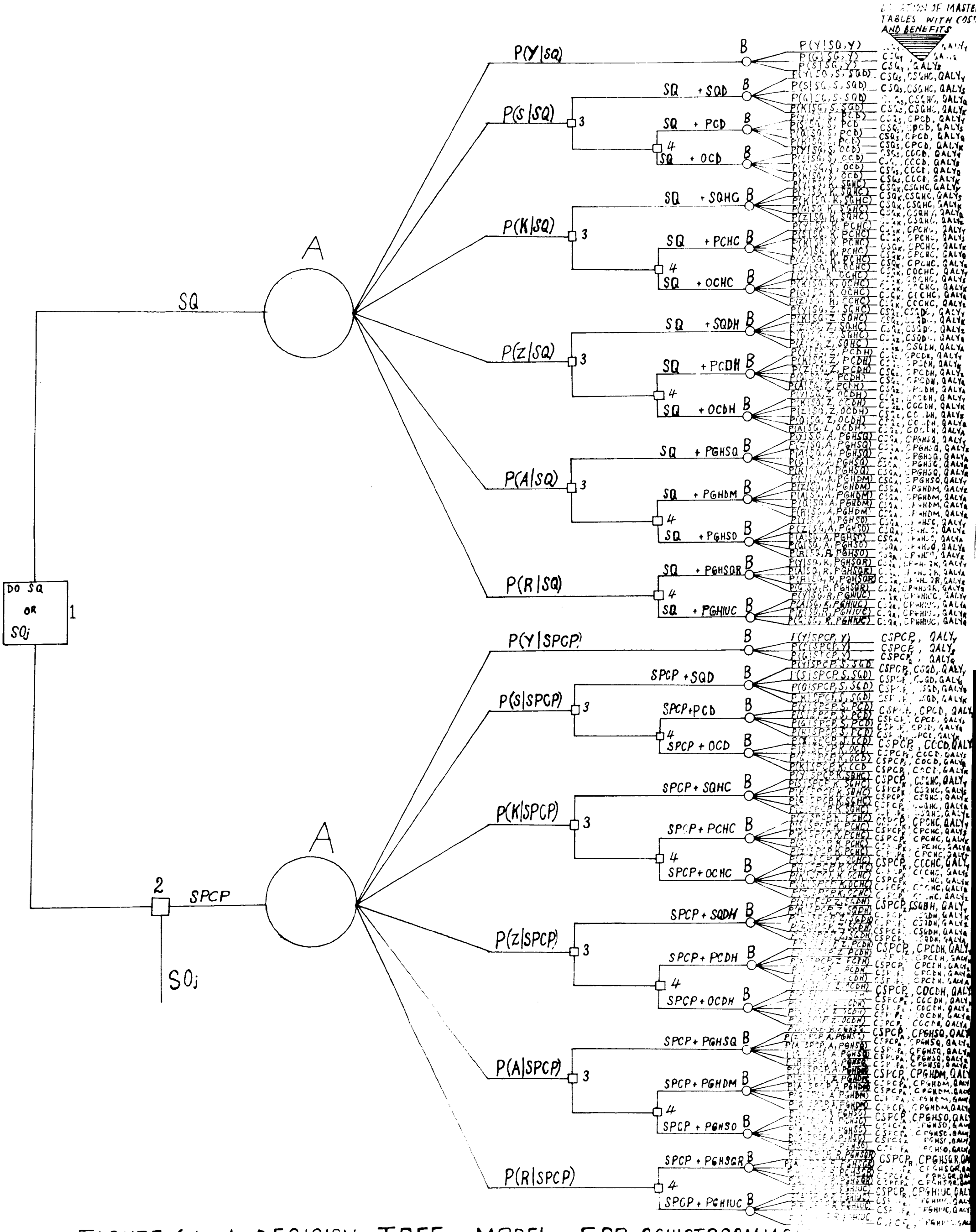


FIGURE 6.1: A DECISION TREE MODEL FOR SCHISTOSOMIASIS CONTROL STRATEGIES

Key for status quo strategy branch

HS_i - Health state i (i=K,Z,A,R)

COCD - cost of oxamniquine care at the dispensary

CPCD - cost of praziquantel care at the dispensary

OCD - Oxamniquine care at the dispensary

PCD - Praziquantel care at the dispensary

$QALY_Y$ - quality adjusted life years expected by those who experience outcome Y (normal health)

$QALY_S$ - quality adjusted life years expected by those who experience outcome S (mild state)

$QALY_K$ - quality adjusted life years expected by those who experience outcome K (moderate state)

$QALY_Z$ - quality adjusted life years expected by those who experience outcome Z (severe state)

$QALY_A$ - quality adjusted life years expected by those who experience outcome A (very severe state)

$QALY_R$ - quality adjusted life years expected by those who experience outcome R (coma state)

SO_j - Do some other jth primary option (j=HPWS, HHED, VIPL, DM, FM, MPCP, MPCO, SPCP, SPCO)

SQ - status quo at community level

CSQ_S - cost of status quo apportioned to state S

P(S|SQ) - probability of health state S occurring given that SQ community level option has been undertaken

P(Y|SQ,S,SQD) - probability of a patient in state S experiencing outcome Y given that SQ and SQD options have been adopted at the community level and dispensary respectively

P(S|SQ,S,SQD) - probability of a patient in state S experiencing outcome S given that SQ and SQD options have been adopted at the community level and dispensary respectively

P(K|SQ,S,SQD) - probability of a patient in state S experiencing outcome K given that SQ and SQD options have been adopted at the community level and dispensary

respectively

P(Q|SQ,S,SQD) - probability of a patient in state S experiencing outcome Q given that SQ and SQD options have been adopted at the community level and dispensary respectively

P(Y|SQ,S,PCD) - probability of a patient in state S experiencing outcome Y given that SQ and PCD options have been adopted at the community level and dispensary respectively

P(S|SQ,S,PCD) - probability of a patient in state S experiencing outcome S given that SQ and PCD options have been adopted at the community level and dispensary respectively

P(K|SQ,S,PCD) - probability of a patient in state S experiencing outcome K given that SQ and PCD options have been adopted at the community level and dispensary respectively

P(Q|SQ,S,PCD) - probability of a patient in state S experiencing outcome Q given that SQ and PCD options have been adopted at the community level and dispensary respectively

P(Y|SQ,S,OCD) - probability of a patient in state S experiencing outcome Y given that SQ and OCD options have been adopted at the community level and dispensary respectively

P(S|SQ,S,OCD) - probability of a patient in state S experiencing outcome S given that SQ and OCD options have been adopted at the community level and dispensary respectively

P(K|SQ,S,OCD) - probability of a patient in state S experiencing outcome K given that SQ and OCD options have been adopted at the community level and dispensary respectively

P(Q|SQ,S,OCD) - probability of a patient in state S experiencing outcome Q given that SQ and OCD options have been adopted at the community level and dispensary respectively

CSQ_K - Cost of SQ apportioned to state K

P(K|SQ) - probability of health state K occurring given that SQ community level option has been undertaken

P(Y|SQ,K,SQHC) - probability of a patient in state K experiencing outcome Y given that SQ and SQHC options have been adopted at the community level and health centre

respectively

P(S|SQ,K,SQHC) - probability of a patient in state K experiencing outcome S given that SQ and SQHC options have been adopted at the community level and health centre respectively

P(K|SQ,K,SQHC) - probability of a patient in state K experiencing outcome K given that SQ and SQHC options have been adopted at the community level and health centre respectively

P(Q|SQ,K,SQHC) - probability of a patient in state K experiencing outcome Q given that SQ and SQHC options have been adopted at the community level and health centre respectively

P(Z|SQ,K,SQHC) - probability of a patient in state K experiencing outcome Z given that SQ and SQHC options have been adopted at the community level and health centre respectively

P(Y|SQ,K,PCHC) - probability of a patient in state K experiencing outcome Y given that SQ and PCHC options have been adopted at the community level and health centre respectively

P(S|SQ,K,PCHC) - probability of a patient in state K experiencing outcome S given that SQ and PCHC options have been adopted at the community level and health centre respectively

P(K|SQ,K,PCHC) - probability of a patient in state K experiencing outcome K given that SQ and PCHC options have been adopted at the community level and health centre respectively

P(Q|SQ,K,PCHC) - probability of a patient in state K experiencing outcome Q given that SQ and PCHC options have been adopted at the community level and health centre respectively

P(Z|SQ,K,PCHC) - probability of a patient in state K experiencing outcome Z given that SQ and PCHC options have been adopted at the community level and health centre respectively

P(Y|SQ,K,OCHC) - probability of a patient in state K experiencing outcome Y given that SQ and OCHC options have been adopted at the community level and health centre respectively

P(S|SQ,K,OCHC) - probability of a patient in state K experiencing outcome S given that SQ and OCHC options have been adopted at the community level and health centre

respectively

P(K|SQ,K,OCHC) - probability of a patient in state K experiencing outcome K given that SQ and OCHC options have been adopted at the community level and health centre respectively

P(Q|SQ,K,OCHC) - probability of a patient in state K experiencing outcome Q given that SQ and OCHC options have been adopted at the community level and health centre respectively

P(Z|SQ,K,OCHC) - probability of a patient in state K experiencing outcome Z given that SQ and OCHC options have been adopted at the community level and health centre respectively

CSQ_Z - Cost of SQ apportioned to state Z

P(Z|SQ) - probability of health state Z occurring given that SQ community level option has been undertaken

P(Y|SQ,Z,SQDH) - probability of a patient in state Z experiencing outcome Y given that SQ and SQDH options have been adopted at the community level and district hospital respectively

P(K|SQ,Z,SQDH) - probability of a patient in state Z experiencing outcome K given that SQ and SQDH options have been adopted at the community level and district hospital respectively

P(Z|SQ,Z,SQHC) - probability of a patient in state Z experiencing outcome Z given that SQ and SQDH options have been adopted at the community level and district hospital respectively

P(Q|SQ,Z,SQHC) - probability of a patient in state Z experiencing outcome Q given that SQ and SQDH options have been adopted at the community level and district hospital respectively

P(A|SQ,Z,SQDH) - probability of a patient in state Z experiencing outcome A given that SQ and SQDH options have been adopted at the community level and district hospital respectively

P(Y|SQ,Z,PCDH) - probability of a patient in state Z experiencing outcome Y given that SQ and PCDH options have been adopted at the community level and district hospital respectively

P(K|SQ,Z,PCDH) - probability of a patient in state Z experiencing outcome K given that SQ and PCDH options have been adopted at the community level and district hospital

respectively

P(Z|SQ,Z,PCHC) - probability of a patient in state Z experiencing outcome Z given that SQ and PCDH options have been adopted at the community level and district hospital respectively

P(Q|SQ,Z,PCHC) - probability of a patient in state Z experiencing outcome Q given that SQ and PCDH options have been adopted at the community level and district hospital respectively

P(A|SQ,Z,PCDH) - probability of a patient in state Z experiencing outcome A given that SQ and PCDH options have been adopted at the community level and district hospital respectively

P(Y|SQ,Z,OCDH) - probability of a patient in state Z experiencing outcome Y given that SQ and OCDH options have been adopted at the community level and district hospital respectively

P(K|SQ,Z,OCDH) - probability of a patient in state Z experiencing outcome K given that SQ and OCDH options have been adopted at the community level and district hospital respectively

P(Z|SQ,Z,OCHC) - probability of a patient in state Z experiencing outcome Z given that SQ and OCDH options have been adopted at the community level and district hospital respectively

P(Q|SQ,Z,OCHC) - probability of a patient in state Z experiencing outcome Q given that SQ and OCDH options have been adopted at the community level and district hospital respectively

P(A|SQ,Z,OCDH) - probability of a patient in state Z experiencing outcome A given that SQ and OCDH options have been adopted at the community level and district hospital respectively

CSQ_A - Cost of SQ apportioned to state A

P(A|SQ) - probability of health state A occurring given that SQ community level option has been undertaken

P(Y|SQ,A,PGHSQ) - probability of a patient in state A experiencing outcome Y given that SQ and PGHSQ options have been adopted at the community level and provincial general hospital respectively

P(Z|SQ,A,PGHSQ) - probability of a patient in state A experiencing outcome Z given that SQ and PGHSQ options have been adopted at the community level and provincial

general hospital respectively

P(A|SQ,A,PGHSQ) - probability of a patient in state A experiencing outcome A given that SQ and PGHSQ options have been adopted at the community level and provincial general hospital respectively

P(Q|SQ,A,PGHSQ) - probability of a patient in state A experiencing outcome Q given that SQ and PGHSQ options have been adopted at the community level and provincial general hospital respectively

P(A|SQ,A,PGHSQ) - probability of a patient in state A experiencing outcome R given that SQ and PGHSQ options have been adopted at the community level and provincial general hospital respectively

P(Y|SQ,A,PGHSO) - probability of a patient in state A experiencing outcome Y given that SQ and PGHSO options have been adopted at the community level and provincial general hospital respectively

P(Z|SQ,A,PGHSO) - probability of a patient in state A experiencing outcome K given that SQ and PGHSO options have been adopted at the community level and provincial general hospital respectively

P(A|SQ,A,PGHSO) - probability of a patient in state A experiencing outcome A given that SQ and PGHSO options have been adopted at the community level and provincial general hospital respectively

P(Q|SQ,A,PGHSO) - probability of a patient in state A experiencing outcome Q given that SQ and PGHSO options have been adopted at the community level and provincial general hospital respectively

P(A|SQ,A,PGHSO) - probability of a patient in state A experiencing outcome R given that SQ and PGHSO options have been adopted at the community level and provincial general hospital respectively

P(Y|SQ,A,PGHDM) - probability of a patient in state A experiencing outcome Y given that SQ and PGHDM options have been adopted at the community level and provincial general hospital respectively

P(Z|SQ,A,PGHDM) - probability of a patient in state A experiencing outcome K given that SQ and PGHDM options have been adopted at the community level and provincial general hospital respectively

P(A|SQ,A,PGHDM) - probability of a patient in state A experiencing outcome A given that SQ and PGHDM options have been adopted at the community level and provincial

general hospital respectively

P(Q|SQ,A,PGHDM) - probability of a patient in state A experiencing outcome Q given that SQ and PGHDM options have been adopted at the community level and provincial general hospital respectively

P(A|SQ,A,PGHDM) - probability of a patient in state A experiencing outcome R given that SQ and PGHDM options have been adopted at the community level and provincial general hospital respectively

CSQ_R - Cost of SQ apportioned to state R

P(R|SQ) - probability of health state R occurring given that SQ community level option has been undertaken

P(Y|SQ,R,PGHSQR) - probability of a patient in state R experiencing outcome Y given that SQ and PGHSQR options have been adopted at the community level and provincial general hospital respectively

P(A|SQ,R,PGHSQR) - probability of a patient in state R experiencing outcome A given that SQ and PGHSQR options have been adopted at the community level and provincial general hospital respectively

P(R|SQ,R,PGHSQR) - probability of a patient in state R experiencing outcome R given that SQ and PGHSQR options have been adopted at the community level and provincial general hospital respectively

P(Q|SQ,R,PGHSQR) - probability of a patient in state R experiencing outcome Q given that SQ and PGHSQR options have been adopted at the community level and provincial general hospital respectively

Selective population chemotherapy with praziquantel Strategy Legend

SPCP - Selective population chemotherapy with praziquantel

$CSPCP_S$ - cost of SPCP apportioned to state S

P(S|SPCP) - probability of health state S occurring given that SPCP community level option has been undertaken

P(Y|SPCP,S,SQD) - probability of a patient in state S experiencing outcome Y given that SPCP and SQD options have been adopted at the community level and dispensary respectively

P(S|SPCP,S,SQD) - probability of a patient in state S experiencing outcome S given that

SPCP and SQD options have been adopted at the community level and dispensary respectively

P(K|SPCP,S,SQD) - probability of a patient in state S experiencing outcome K given that SPCP and SQD options have been adopted at the community level and dispensary respectively

P(Q|SPCP,S,SQD) - probability of a patient in state S experiencing outcome Q given that SPCP and SQD options have been adopted at the community level and dispensary respectively

P(Y|SPCP,S,PCD) - probability of a patient in state S experiencing outcome Y given that SPCP and PCD options have been adopted at the community level and dispensary respectively

P(S|SPCP,S,PCD) - probability of a patient in state S experiencing outcome S given that SPCP and PCD options have been adopted at the community level and dispensary respectively

P(K|SPCP,S,PCD) - probability of a patient in state S experiencing outcome K given that SPCP and PCD options have been adopted at the community level and dispensary respectively

P(Q|SPCP,S,PCD) - probability of a patient in state S experiencing outcome Q given that SPCP and PCD options have been adopted at the community level and dispensary respectively

P(Y|SPCP,S,OCD) - probability of a patient in state S experiencing outcome Y given that SPCP and OCD options have been adopted at the community level and dispensary respectively

P(S|SPCP,S,OCD) - probability of a patient in state S experiencing outcome S given that SPCP and OCD options have been adopted at the community level and dispensary respectively

P(K|SPCP,S,OCD) - probability of a patient in state S experiencing outcome K given that SPCP and OCD options have been adopted at the community level and dispensary respectively

P(Q|SPCP,S,OCD) - probability of a patient in state S experiencing outcome Q given that SPCP and OCD options have been adopted at the community level and dispensary respectively

$CSPCP_K$ - Cost of SPCP apportioned to state K

P(K|SPCP) - probability of health state K occurring given that SPCP community level option has been undertaken

P(Y|SPCP,K,SQHC) - probability of a patient in state K experiencing outcome Y given that SPCP and SQHC options have been adopted at the community level and health centre respectively

P(S|SPCP,K,SQHC) - probability of a patient in state K experiencing outcome S given that SPCP and SQHC options have been adopted at the community level and health centre respectively

P(K|SPCP,K,SQHC) - probability of a patient in state K experiencing outcome K given that SPCP and SQHC options have been adopted at the community level and health centre respectively

P(Q|SPCP,K,SQHC) - probability of a patient in state K experiencing outcome Q given that SPCP and SQHC options have been adopted at the community level and health centre respectively

P(Z|SPCP,K,SQHC) - probability of a patient in state K experiencing outcome Z given that SPCP and SQHC options have been adopted at the community level and health centre respectively

P(Y|SPCP,K,PCHC) - probability of a patient in state K experiencing outcome Y given that SPCP and PCHC options have been adopted at the community level and health centre respectively

P(S|HPWS,K,PCHC) - probability of a patient in state K experiencing outcome S given that SPCP and PCHC options have been adopted at the community level and health centre respectively

P(K|SPCP,K,PCHC) - probability of a patient in state K experiencing outcome K given that SPCP and PCHC options have been adopted at the community level and health centre respectively

P(Q|SPCP,K,PCHC) - probability of a patient in state K experiencing outcome Q given that SPCP and PCHC options have been adopted at the community level and health centre respectively

P(Z|SPCP,K,PCHC) - probability of a patient in state K experiencing outcome Z given that SPCP and PCHC options have been adopted at the community level and health centre respectively

P(Y|SPCP,K,OCHC) - probability of a patient in state K experiencing outcome Y given

that SPCP and OCHC options have been adopted at the community level and health centre respectively

P(S|SPCP,K,OCHC) - probability of a patient in state K experiencing outcome S given that SPCP and OCHC options have been adopted at the community level and health centre respectively

P(K|SPCP,K,OCHC) - probability of a patient in state K experiencing outcome K given that SPCP and OCHC options have been adopted at the community level and health centre respectively

P(Q|SPCP,K,OCHC) - probability of a patient in state K experiencing outcome Q given that SPCP and OCHC options have been adopted at the community level and health centre respectively

P(Z|SPCP,K,OCHC) - probability of a patient in state K experiencing outcome Z given that SPCP and OCHC options have been adopted at the community level and health centre respectively

$CSPCP_Z$ - Cost of SPCP apportioned to state Z

P(Z|SPCP) - probability of health state Z occurring given that SPCP community level option has been undertaken

P(Y|SPCP,Z,SQDH) - probability of a patient in state Z experiencing outcome Y given that SPCP and SQDH options have been adopted at the community level and district hospital respectively

P(K|SPCP,Z,SQDH) - probability of a patient in state Z experiencing outcome K given that SPCP and SQDH options have been adopted at the community level and district hospital respectively

P(Z|SPCP,Z,SQHC) - probability of a patient in state Z experiencing outcome Z given that SPCP and SQDH options have been adopted at the community level and district hospital respectively

P(Q|SPCP,Z,SQHC) - probability of a patient in state Z experiencing outcome Q given that SPCP and SQDH options have been adopted at the community level and district hospital respectively

P(A|SPCP,Z,SQDH) - probability of a patient in state Z experiencing outcome A given that SPCP and SQDH options have been adopted at the community level and district hospital respectively

P(Y|SPCP,Z,PCDH) - probability of a patient in state Z experiencing outcome Y given

that SPCP and PCDH options have been adopted at the community level and district hospital respectively

P(K|SPCP,Z,PCDH) - probability of a patient in state Z experiencing outcome K given that SPCP and PCDH options have been adopted at the community level and district hospital respectively

P(Z|SPCP,Z,PCHC) - probability of a patient in state Z experiencing outcome Z given that SPCP and PCDH options have been adopted at the community level and district hospital respectively

P(Q|SPCP,Z,PCHC) - probability of a patient in state Z experiencing outcome Q given that SPCP and PCDH options have been adopted at the community level and district hospital respectively

P(A|SPCP,Z,PCDH) - probability of a patient in state Z experiencing outcome A given that SPCP and PCDH options have been adopted at the community level and district hospital respectively

P(Y|SPCP,Z,OCDH) - probability of a patient in state Z experiencing outcome Y given that SPCP and OCDH options have been adopted at the community level and district hospital respectively

P(K|SPCP,Z,OCDH) - probability of a patient in state Z experiencing outcome K given that SPCP and OCDH options have been adopted at the community level and district hospital respectively

P(Z|SPCP,Z,OCHC) - probability of a patient in state Z experiencing outcome Z given that SPCP and OCDH options have been adopted at the community level and district hospital respectively

P(Q|SPCP,Z,OCHC) - probability of a patient in state Z experiencing outcome Q given that SPCP and OCDH options have been adopted at the community level and district hospital respectively

P(A|SPCP,Z,OCDH) - probability of a patient in state Z experiencing outcome A given that SPCP and OCDH options have been adopted at the community level and district hospital respectively

$CSPCP_A$ - Cost of SPCP apportioned to state A

P(A|SPCP) - probability of health state A occurring given that HPWS community level option has been undertaken

P(Y|SPCP,A,PGHSQ) - probability of a patient in state A experiencing outcome Y given

that SPCP and PGHSQ options have been adopted at the community level and provincial general hospital respectively

P(Z|SPCP,A,PGHSQ) - probability of a patient in state A experiencing outcome Z given that SPCP and PGHSQ options have been adopted at the community level and provincial general hospital respectively

P(A|SPCP,A,PGHSQ) - probability of a patient in state A experiencing outcome A given that SPCP and PGHSQ options have been adopted at the community level and provincial general hospital respectively

P(Q|SPCP,A,PGHSQ) - probability of a patient in state A experiencing outcome Q given that SPCP and PGHSQ options have been adopted at the community level and provincial general hospital respectively

P(A|SPCP,A,PGHSQ) - probability of a patient in state A experiencing outcome R given that SPCP and PGHSQ options have been adopted at the community level and provincial general hospital respectively

P(Y|SPCP,A,PGHSO) - probability of a patient in state A experiencing outcome Y given that SPCP and PGHSO options have been adopted at the community level and provincial general hospital respectively

P(Z|SPCP,A,PGHSO) - probability of a patient in state A experiencing outcome K given that SPCP and PGHSO options have been adopted at the community level and provincial general hospital respectively

P(A|SPCP,A,PGHSO) - probability of a patient in state A experiencing outcome A given that SPCP and PGHSO options have been adopted at the community level and provincial general hospital respectively

P(Q|SPCP,A,PGHSO) - probability of a patient in state A experiencing outcome Q given that SPCP and PGHSO options have been adopted at the community level and provincial general hospital respectively

P(A|SPCP,A,PGHSO) - probability of a patient in state A experiencing outcome R given that SPCP and PGHSO options have been adopted at the community level and provincial general hospital respectively

P(Y|SPCP,A,PGHDM) - probability of a patient in state A experiencing outcome Y given that SPCP and PGHDM options have been adopted at the community level and provincial general hospital respectively

P(Z|SPCP,A,PGHDM) - probability of a patient in state A experiencing outcome K

given that SPCP and PGHDM options have been adopted at the community level and provincial general hospital respectively

P(A|SPCP,A,PGHDM) - probability of a patient in state A experiencing outcome A given that SPCP and PGHDM options have been adopted at the community level and provincial general hospital respectively

P(Q|SPCP,A,PGHDM) - probability of a patient in state A experiencing outcome Q given that SPCP and PGHDM options have been adopted at the community level and provincial general hospital respectively

P(A|SPCP,A,PGHDM) - probability of a patient in state A experiencing outcome R given that SPCP and PGHDM options have been adopted at the community level and provincial general hospital respectively

$CSPCP_R$ - Cost of SPCP apportioned to state R

P(R|SPCP) - probability of health state R occurring given that SPCP community level option has been undertaken

P(Y|SPCP,R,PGHSQR) - probability of a patient in state R experiencing outcome Y given that SPCP and PGHSQR options have been adopted at the community level and provincial general hospital respectively

P(A|SPCP,R,PGHSQR) - probability of a patient in state R experiencing outcome A given that SPCP and PGHSQR options have been adopted at the community level and provincial general hospital respectively

P(R|SPCP,R,PGHSQR) - probability of a patient in state R experiencing outcome R given that SPCP and PGHSQR options have been adopted at the community level and provincial general hospital respectively

P(Q|SPCP,R,PGHSQR) - probability of a patient in state R experiencing outcome Q given that SPCP and PGHSQR options have been adopted at the community level and provincial general hospital respectively

jth Strategy Legend

j - j^{th} option at community level

Cj_S - cost of j^{th} option apportioned to state S

P(S|j) - probability of health state S occurring given that j^{th} community level option has been undertaken

P(Y|j,S,SQD) - probability of a patient in state S experiencing outcome Y given that j^{th} and SQD options have been adopted at the community level and dispensary respectively

P(S|j,S,SQD) - probability of a patient in state S experiencing outcome S given that j^{th} and SQD options have been adopted at the community level and dispensary respectively

P(K|j,S,SQD) - probability of a patient in state S experiencing outcome K given that j^{th} and SQD options have been adopted at the community level and dispensary respectively

P(Q|j,S,SQD) - probability of a patient in state S experiencing outcome Q given that j^{th} and SQD options have been adopted at the community level and dispensary respectively

P(Y|j,S,PCD) - probability of a patient in state S experiencing outcome Y given that j^{th} and PCD options have been adopted at the community level and dispensary respectively

P(S|j,S,PCD) - probability of a patient in state S experiencing outcome S given that j^{th} and PCD options have been adopted at the community level and dispensary respectively

P(K|j,S,PCD) - probability of a patient in state S experiencing outcome K given that j^{th} and PCD options have been adopted at the community level and dispensary respectively

P(Q|j,S,PCD) - probability of a patient in state S experiencing outcome Q given that j^{th} and PCD options have been adopted at the community level and dispensary respectively

P(Y|j,S,OCD) - probability of a patient in state S experiencing outcome Y given that j^{th} and OCD options have been adopted at the community level and dispensary respectively

P(S|j,S,OCD) - probability of a patient in state S experiencing outcome S given that j^{th} and OCD options have been adopted at the community level and dispensary respectively

P(K|j,S,OCD) - probability of a patient in state S experiencing outcome K given that j^{th} and OCD options have been adopted at the community level and dispensary respectively

P(Q|j,S,OCD) - probability of a patient in state S experiencing outcome Q given that j^{th} and OCD options have been adopted at the community level and dispensary respectively

Cj_K - Cost of j^{th} apportioned to state K

P(K|j) - probability of health state K occurring given that j^{th} community level option has been undertaken

P(Y|j,K,SQHC) - probability of a patient in state K experiencing outcome Y given that j^{th} and SQHC options have been adopted at the community level and health centre respectively

P(S|j,K,SQHC) - probability of a patient in state K experiencing outcome S given that j^{th} and SQHC options have been adopted at the community level and health centre respectively

P(K|j,K,SQHC) - probability of a patient in state K experiencing outcome K given that j^{th} and SQHC options have been adopted at the community level and health centre respectively

P(Q|j,K,SQHC) - probability of a patient in state K experiencing outcome Q given that j^{th} and SQHC options have been adopted at the community level and health centre respectively

P(Z|j,K,SQHC) - probability of a patient in state K experiencing outcome Z given that j^{th} and SQHC options have been adopted at the community level and health centre respectively

P(Y|j,K,PCHC) - probability of a patient in state K experiencing outcome Y given that j^{th} and PCHC options have been adopted at the community level and health centre respectively

P(S|j,K,PCHC) - probability of a patient in state K experiencing outcome S given that j^{th} and PCHC options have been adopted at the community level and health centre respectively

P(K|j,K,PCHC) - probability of a patient in state K experiencing outcome K given that j^{th} and PCHC options have been adopted at the community level and health centre respectively

P(Q|j,K,PCHC) - probability of a patient in state K experiencing outcome Q given that j^{th} and PCHC options have been adopted at the community level and health centre respectively

P(Z|j,K,PCHC) - probability of a patient in state K experiencing outcome Z given that j^{th} and PCHC options have been adopted at the community level and health centre respectively

P(Y|j,K,OCHC) - probability of a patient in state K experiencing outcome Y given that j^{th} and OCHC options have been adopted at the community level and health centre respectively

P(S|j,K,OCHC) - probability of a patient in state K experiencing outcome S given that j^{th} and OCHC options have been adopted at the community level and health centre respectively

P(K|j,K,OCHC) - probability of a patient in state K experiencing outcome K given that j^{th} and OCHC options have been adopted at the community level and health centre respectively

P(Q|j,K,OCHC) - probability of a patient in state K experiencing outcome Q given that j^{th} and OCHC options have been adopted at the community level and health centre respectively

P(Z|j,K,OCHC) - probability of a patient in state K experiencing outcome Z given that j^{th} and OCHC options have been adopted at the community level and health centre respectively

Cj_Z - Cost of j apportioned to state Z

P(Z|j) - probability of health state Z occurring given that j^{th} community level option has been undertaken

P(Y|j,Z,SQDH) - probability of a patient in state Z experiencing outcome Y given that j^{th} and SQDH options have been adopted at the community level and district hospital respectively

P(K|j,Z,SQDH) - probability of a patient in state Z experiencing outcome K given that j^{th} and SQDH options have been adopted at the community level and district hospital respectively

P(Z|j,Z,SQHC) - probability of a patient in state Z experiencing outcome Z given that j^{th} and SQDH options have been adopted at the community level and district hospital respectively

P(Q|j,Z,SQHC) - probability of a patient in state Z experiencing outcome Q given that j^{th} and SQDH options have been adopted at the community level and district hospital respectively

P(A|j,Z,SQDH) - probability of a patient in state Z experiencing outcome A given that j^{th} and SQDH options have been adopted at the community level and district hospital respectively

P(Y|j,Z,PCDH) - probability of a patient in state Z experiencing outcome Y given that j^{th} and PCDH options have been adopted at the community level and district hospital respectively

P(K|j,Z,PCDH) - probability of a patient in state Z experiencing outcome K given that j^{th} and PCDH options have been adopted at the community level and district hospital respectively

P(Z|j,Z,PCHC) - probability of a patient in state Z experiencing outcome Z given that j^{th} and PCDH options have been adopted at the community level and district hospital respectively

P(Q|j,Z,PCHC) - probability of a patient in state Z experiencing outcome Q given that j^{th} and PCDH options have been adopted at the community level and district hospital respectively

P(A|j,Z,PCDH) - probability of a patient in state Z experiencing outcome A given that j^{th} and PCDH options have been adopted at the community level and district hospital respectively

P(Y|j,Z,OCDH) - probability of a patient in state Z experiencing outcome Y given that j^{th} and OCDH options have been adopted at the community level and district hospital respectively

P(K|j,Z,OCDH) - probability of a patient in state Z experiencing outcome K given that j^{th} and OCDH options have been adopted at the community level and district hospital respectively

P(Z|j,Z,OCHC) - probability of a patient in state Z experiencing outcome Z given that j^{th} and OCDH options have been adopted at the community level and district hospital respectively

P(Q|j,Z,OCHC) - probability of a patient in state Z experiencing outcome Q given that j^{th} and OCDH options have been adopted at the community level and district hospital respectively

P(A|j,Z,OCDH) - probability of a patient in state Z experiencing outcome A given that j^{th} and OCDH options have been adopted at the community level and district hospital respectively

Cj_A - Cost of j apportioned to state A

P(A|j) - probability of health state A occurring given that j^{th} community level option has been undertaken

P(Y|j,A,PGHSQ) - probability of a patient in state A experiencing outcome Y given that j^{th} and PGHSQ options have been adopted at the community level and provincial general hospital respectively

P(Z|j,A,PGHSQ) - probability of a patient in state A experiencing outcome Z given that j^{th} and PGHSQ options have been adopted at the community level and provincial general hospital respectively

P(A|j,A,PGHSQ) - probability of a patient in state A experiencing outcome A given that j^{th} and PGHSQ options have been adopted at the community level and provincial general hospital respectively

P(Q|j,A,PGHSQ) - probability of a patient in state A experiencing outcome Q given that j^{th} and PGHSQ options have been adopted at the community level and provincial general hospital respectively

P(A|j,A,PGHSQ) - probability of a patient in state A experiencing outcome R given that j^{th} and PGHSQ options have been adopted at the community level and provincial general hospital respectively

P(Y|j,A,PGHSO) - probability of a patient in state A experiencing outcome Y given that j^{th} and PGHSO options have been adopted at the community level and provincial general hospital respectively

P(Z|j,A,PGHSO) - probability of a patient in state A experiencing outcome K given that j^{th} and PGHSO options have been adopted at the community level and provincial general hospital respectively

P(A|j,A,PGHSO) - probability of a patient in state A experiencing outcome A given that j^{th} and PGHSO options have been adopted at the community level and provincial general hospital respectively

P(Q|j,A,PGHSO) - probability of a patient in state A experiencing outcome Q given that j^{th} and PGHSO options have been adopted at the community level and provincial general hospital respectively

P(A|j,A,PGHSO) - probability of a patient in state A experiencing outcome R given that j^{th} and PGHSO options have been adopted at the community level and provincial general hospital respectively

P(Y|j,A,PGHDM) - probability of a patient in state A experiencing outcome Y given that j^{th} and PGHDM options have been adopted at the community level and provincial general hospital respectively

P(Z|j,A,PGHDM) - probability of a patient in state A experiencing outcome K given that j^{th} and PGHDM options have been adopted at the community level and provincial general hospital respectively

P(A|j,A,PGHDM) - probability of a patient in state A experiencing outcome A given that j^{th} and PGHDM options have been adopted at the community level and provincial general hospital respectively

P(Q|j,A,PGHDM) - probability of a patient in state A experiencing outcome Q given that j^{th} and PGHDM options have been adopted at the community level and provincial general hospital respectively

P(A|j,A,PGHDM) - probability of a patient in state A experiencing outcome R given that j^{th} and PGHDM options have been adopted at the community level and provincial general hospital respectively

Cj_R - Cost of j apportioned to state R

P(R|j) - probability of health state R occurring given that j^{th} community level option has been undertaken

P(Y|j,R,PGHSQR) - probability of a patient in state R experiencing outcome Y given that j^{th} and PGHSQR options have been adopted at the community level and provincial general hospital respectively

P(A|j,R,PGHSQR) - probability of a patient in state R experiencing outcome A given that j^{th} and PGHSQR options have been adopted at the community level and provincial general hospital respectively

P(R|j,R,PGHSQR) - probability of a patient in state R experiencing outcome R given that j^{th} and PGHSQR options have been adopted at the community level and provincial general hospital respectively

P(Q|j,R,PGHSQR) - probability of a patient in state R experiencing outcome Q given that j^{th} and PGHSQR options have been adopted at the community level and provincial general hospital respectively

CHAPTER 7
METHODOLOGIES OF SCHISTOSOMIASIS INTERVENTION BENEFITS MEASUREMENT AND DATA ANALYSIS

7.0 Introduction

This chapter describes the methodologies used in estimating schistosomiasis intervention benefits. Section 7.1 presents the quality of life measure and preliminary health states utility results. Section 7.2 presents the money metric measure of health state utilities and preliminary WTP results. Section 7.3 is the Delphi technique used in estimating impacts of schistosomiasis interventions, the remaining life expectancy at each health state, and preliminary probability results. Section 7.4 provides an analysis of quality adjusted life years expected from various policy combinations. Section 7.5 reports the expected monetary values of various policy combinations.

7.1 The Quality of Life Measure (QoL)

7.1.1 *Schistosomiasis severity stages*

As mentioned in chapter 4, the QoL index being developed here is for use in economic evaluation of schistosomiasis interventions, and it is important that the index reflects the gradient or continuum of functional disability caused by different severity states of the disease. A schistosomiasis epidemiologist delineated the seven main severity stages in S.mansoni and accompanying clinical symptoms: the "asymptomatic" stage, where the victim feels quite healthy (functionally normal); the "mild" stage characterized by cercarial dermatitis, mild fever and pulmonary symptoms (mild cough); the "moderate" stage characterized by gastro-intestinal symptoms, dysentery (plus increased frequency of stools), and microscopic haematuria; the "severe" stage characterized by hepatosplenomegaly, oesophageal varices (not bleeding) and ascites (mild to moderate); the "very severe" stage characterized by gross ascites, bleeding oesophageal varices and portal hypertension; the "comatose" stage; and finally the seventh, the absorbing stage of "death". The 6 non-absorbing severity states delineated above are likely to have different impacts on the victims' ability to perform their

expected roles in society.

7.1.2 *The concept of function / dysfunction*

It was said in chapter 4 that, the QoL measure should be defined in terms of cultural functional dimensions likely to be affected by schistosomiasis intervention policies. In the Mwea irrigation scheme each household member has specific roles that he or she is expected to play. Table 7.1 enumerates roles performed by children, men, and women in Mwea society. In such a society, people consider themselves to be well (healthy) if they are able to carry out their expected roles. To the extent that they cannot, they are in a state of dysfunction, or illness, or deviation from well-being. Thus, it is important that any health status index be able to measure the impacts (positive and negative effects) of disparate health interventions on beneficiaries' functional performance. The next task is to delineate, bearing in mind the information contained in table 1, those functional dimensions likely to be impaired by the disease.

7.1.3 *Relevant functional dimensions*

The choice of dimensions of functioning was determined by personal knowledge of the values in the Mwea community, informed by experience of index construction in Europe and North America. Six functional dimensions were identified - mobility, self care, livelihood, energy, pain, and social participation.

7.1.3.1 Physical functioning

(i) Mobility - mobility is defined here as an individual's ability to walk to school, work (farm), shopping centre, church, irrigation board offices, rice collecting centres and to move around the community in general.
(ii) Livelihood or work - defined as ability to perform one's "livelihood roles" in society, e.g., schooling, household tasks, farming activities, trading, and so on. This is a very important dimension especially in a society where most people are poor and there are no welfare benefits such as unemployment benefit, free health care, free education, disability benefit. Survival largely depends on their ability to work.

(iii) Energy - weariness, fatigue, loss (diminution) of vitality. Beside being a disutility in its own right, this attribute will affect both mobility and livelihood activities. For example, loss of energy due to schistosomiasis is a major cause of debility.

7.1.3.2 *Social functioning*

Social function is ability to perform self-care and to participate in community activities.

(i) Self-care includes ability to feed, bathe, dress, control bladder and bowels. This is the most basic form of role performance.

(ii) Social Participation refers to ability of an individual to take part in community social activities, such as church services, public meetings, clubs, peer play, self-help activities, beer drinking, and so on. This is a very important dimension because Kenya's rural communities are socially very active.

7.1.3.3 *Emotional functioning*

Torrance (1986) defines emotional well-being as being happy and relaxed most or all of the time, and having an average number of friends. In the rural Kenyan context, this concept of emotional functioning may be largely redundant for a number of reasons. First, the existence of extended families and hence typically of many caring persons reduces the prevalence of emotional or psychological problems. Second, the existence of well defined individual roles in society and households diminishes the competitive elements in society and, hence, their associated tensions, sense of failure, etc. For these reasons emotional function were represented in this study solely by pain. Men may under-report pain because most rural Kenyan societies despise men who show such feelings.

7.1.4 *Aggregate health state descriptions*

This subsection redefines clinical disease severity states into a finite number of function performance based health state descriptions. A schistosomiasis epidemiologist (from Kenya Medical Research Institute) was requested to explain briefly in layman's

language (and in terms of the five main functional dimensions) how patients suffering from each of the severity stages would explain their illness (or that of the next of kin) to the clinician. The process produced following seven health states in Table 7.2. The health state descriptions were then circulated among other local schistosomiasis experts, who concurred that the general health state descriptions closely reflected the functional disability attributable to each severity state.

To facilitate interpretation of results, the health states have been expressed as being of equal duration, same age of onset and same prognosis. Each health state is assumed to be temporary and to last for 3 years, after which the victim advances to a more severe state. The respondents were instructed to assume that the health state descriptions apply to themselves rather than third parties.

The use of the phrase "Your Normal State of Health" implies the concept of health is relative and not absolute. Normal health is defined in this study as complete ability to perform one's personal and societal normal functions or roles; in other words, unimpaired mobility, livelihood activities, self care, social participation, and absence of pain epitomise "normal health". The state of unconsciousness or coma has no significant distinction from death, except a non-zero transitional probability to a higher state (Fanshel and Bush, 1970). Death is a state of absolute dysfunction, and is "absorbing".

Translation of English to Kikuyu

The health state descriptions (in Table 7.2) were translated from English to Kikuyu by a medical researcher who was a native speaker of the Kikuyu language. The English and Kikuyu versions were then circulated to five other Kikuyus working in the Kenya Medical Research Institute and Kenyatta National Hospital. They suggested that the expression "You have bilharzia germs" should be incorporated explicitly into health states S, K, Z, A and R. The translated version was revised in light of their comments. In the field it was found that the dialect spoken by inhabitants of Mwea Division (Kirinyaga District) was slightly different. The descriptions had therefore to be revised yet again. Table 7.3 shows the revised Kikuyu health state descriptions used in the field translated back into English.

Two basic but important lessons were drawn from this experience: (i) anyone attempting to elicit health state utilities from an ethnically, culturally and linguistically diversified population, like that of Kenya (where there are more than thirty languages and an even greater number of dialects), is likely to encounter linguistic, semantic and conceptual difficulties; (ii) translation of health state descriptions written in English into the respondent population native or mother tongue should be done by a native speaker of not only the language but also the dialect spoken by the sample population.

Having defined and translated health states, the issue that follows is how to measure the preference of health states. The next sub-section describes the scale along which health state preferences were measured.

7.1.5 *Cardinal utility measurement*

Measurement is the assignment of numbers by a consistently applied rule to health states to represent the relative amounts or degrees of utility (quality of life) expected from them. Strength of preference as measured on a cardinal scale was needed to facilitate aggregation of utilities for use in economic evaluation or appraisal. Both interval and ratio scales yield cardinal values (or utilities). Most of the health indices developed so far have used interval scales (Torrance, 1986; Mehrez and Gafni, 1989). The aim of this study was to produce an index with interval scale properties. The size of the difference between pairs of health states has meaning and corresponds to distance between the corresponding pairs of amounts of the health state utilities (Torgerson, 1958). So, one would like to say $U^1-U^0=U^2-U^1$; meaning the gain in quality of life (QoL) attributable to movement from health state 0 to state 1 equals the gain in moving from state 1 to 2. Such a scale is analogous to Fahrenheit and Celsius scales in temperature measurement.

In order to define the scale, interval scaling requires assignment of two numbers arbitrarily (except that they must be consistent with the ordinal preference ranking). It has become customary to assign values of 0 and 1 to reference states 'dead' and 'healthy', respectively, and it is taken as self-evident that health is preferred to death.

A visual rice-sack scale (a modified form of the visual analogue scale developed in North America and Britain) graduated from 100 to 0 was used in measuring cardinal preferences for various health states [see figure 7.1]. With death judged to be the least

preferred (worst) state and mapped on 0 to the end of the rating scale, the preference values for other health states are the scale values corresponding to their location between 0 and 100.

7.1.5.1 *Mock measurement exercise*

A mock ranking and valuation exercise was used as a precursor to actual measurement of health state preference strength. This was meant to acquaint respondents with the ranking and scaling processes; and to test their ability to rank quantities. The respondents were presented with five pictures of rice sacks (objects familiar to all persons in cereal growing areas of Kenya): sack A was white; sack B was painted 1/4 red the rest being white; sack C was painted 1/2 blue the rest being white; sack D was painted 3/4 green the rest being white; sack E was painted fully in black.

First, respondents were told that the painted zone represented the quantity of rice and were requested to rank the sacks in increasing order of quantities of rice. Where a respondent's rankings were inconsistent with visual quantities of rice, the interviewers pointed the inconsistency out politely and then asked the respondent to revise the rankings. Second, the respondents were presented with a rice-sack visual analogue scale (RSVAS) numbered from 100 (representing a sack full of rice - most preferred) to zero (representing empty sack - least preferred rice quantity). They were asked to indicate on the RSAS where they would wish to place the most preferred and least preferred coloured rice sacks. Third, they were required to locate the remaining sack pictures on the same RSVAS relative to each other. The interviewer verified consistency by comparing the order in which the respondent ranked the rice sacks and the order in which he or she mapped them on the scale. Where inconsistency was identified, the respondent was asked to revise the valuations. Such inconsistencies were rare and were restricted to very old persons. Lastly, they were told that the exercise to follow would be quite similar but would involve bilharzia (schistosomiasis) health states rather than rice.

7.1.5.2 *Health state utility measurement*

The seven health states in Table 7.3 were printed on cards of different colours and labelled as follows: Y - green, S - pink, K - brown, Z - Yellow, A - blue, R - red, and Q - Black. The health state descriptions were read to the respondent in Mwea vernacular separately before giving the respondent the card. During the third reading (or more in some cases) the respondents were requested to arrange the health states described on the cards, beginning with least severe (most preferred) to most severe (least preferred). The interviewer recorded those rankings and used them later in verifying consistency.

The respondents were then asked to locate the best and the worst health states at 100 and 0 on the RSAS. Lastly, they were required to locate the remaining health states on the RSVAS relative to each other. The interviewers checked for inconsistencies by comparing respondents' earlier rankings with the order in which health states were mapped on the scale. Where inconsistencies were identified, the interviewer pointed out the problem and requested the respondents to revise the mapping appropriately.

Sample

A random sample of 417 households (about 10 per cent of the household population) was drawn from 10 randomly selected villages in Mwea-Tebere (i.e. 26 % of total villages). About 4 % of the household heads (they are the household decision-makers), who failed the consistency test during the mock ranking and valuation exercise and the health state ranking and valuation exercise, were removed from the sample, thus reducing the number of useful completed instruments to 400.

A random sample of 37 medical personnel (i.e. about 24 % of the population of medical doctors, nurses and public health officers) was drawn from the only public health centre in Mwea (the *Kimbimbi* health centre) and the District Hospital (the *Kerugoya* District).

A random sample of 92 teachers was drawn from a population of 225 teachers in Mwea primary and secondary schools. However, three respondents in secondary schools were uncooperative, thus reducing the sample size to 89 teachers.

Ten Kikuyu speakers, with a minimum of college education, were employed to administer the questionnaires. They were trained on the English and Kikuyu versions of

the questionnaire and in the ethics of interviewing for eight days. During this period they had several sessions of pre-testing amongst themselves, and pilot testing in some non-sampled villages. It took most of the non-literate respondents about three readings to grasp the health state descriptions. The actual household survey took approximately three weeks. One of the college graduates who administered the household questionnaire assisted the author in administering the English version of the questionnaire to the medical personnel and teachers. The interviews took approximately four weeks. The latter two samples were generally more inquisitive and critical than the household sample.

7.1.6 *The quality of life measure results*

7.1.6.1 *Descriptive statistics results*

Tables 7.4, 7.5, and 7.6 present the means, standard deviations, and variances of the health states utility valuations for medical professionals (u_p) , teachers (u_t), and farmers (u_h). Table 7.7 show similar statistics but for the three samples combined (justification is provided in chapter 10). Invariably, the utility valuations increase with the decrease in the perceived severity of health states. There is greater variation in the health state values elicited from the households than those of the medical professionals and the teachers. The effect of combining the three samples appears to be a general increase in the deviation of health state valuations from their means.

7.1.6.2 *Analysis of variance results*

A one-way analysis of variance (ANOVA) test was done to determine (for each health state) whether there was any significant difference in the average health state utilities obtained from the three samples. The null hypothesis H_0: $u_t = u_p = u_h$ was tested against the alternative hypothesis H_1:u_j not all equal. Since, the observed variance ratio (F_o) for health state S is less than the theoretical (critical) value F_c, at the 5 per cent level, the null hypothesis is accepted, i.e. the sample means for state S are not significantly different. However, the null hypotheses for other health states K, Z, A, and R should be rejected because their F_o's are greater than F_c's. Thus, we accept that there

is a significant difference in the average utilities for each of the latter four health states obtained from the three samples.

These differences raise the issue of whose values to incorporate in the economic evaluation. Average health states valuations for the combined samples (Table 7.7), were used in the quality adjusted life years calculations for two reasons. First, since the households of the farmers, teachers and health professionals living in Mwea Division stand to benefit directly (though probably unequally) from schistosomiasis intervention policies. It is common practice among teachers and health professionals working in Mwea Division to rent land from farmers (who are the legal allottees) for growing rice and horticultural crops to subsidize their monthly salaries, that exposes them and their families to schistosomiasis infection, although to a lesser degree than farmers. Second, because as mentioned in chapter 1, this study is done from a societal perspective, it was necessary to take the valuations of all the three main stakeholders into account. Justification is provided in chapter 10 for combining utility values from the three samples without standardization or normalization.

7.2 A Money Metric / Measure of Health State Utilities

Chapter 6 identified the need for measurement of health states monetary values for use in cost-benefit decision analysis model. This section discusses how the expressed willingness to pay approach explained in chapter 3 was used in eliciting WTP valuations for health states developed in the preceding section.

7.2.1 *Method*

7.2.1.1 *The Questionnaire*

The household questionnaire had questions on willingness to pay money: for a return to normal health from various health states; to prevent death of a yet unknown household member; to prevent death of one unknown person in the neighbourhood; and to remain in one's current health state. Questions 13 and 14 are reproduced verbatim in Table 7.9 to enable the readers understand the results. Otherwise, the full questionnaire is reproduced in Appendix 5.

7.2.1.2 *Hypotheses*

The following hypothesis were tested:

(i) Since the willingness to pay for each of the health states was collected from random samples of farmers (p), health professionals (p) and teachers (t), it was thought necessary to test whether there was any significant difference between means of the populations, u_h, u_t and u_p.

(ii) Jones-Lee (1989) postulates that expressed willingness to pay is dependent on an individual's net income, and whether the respondent takes into account the implied anxiety, loss of working or leisure time, medical expenses, children's absenteeism from school, and risk posed by one's health state to other people (negative externalities or neighbourhood effects). Thus, fourteen log-linear regressions of the following form were estimated using OLS method:

$$\ln (WTP_j) = \ln ß_0 + ß_1 \ln X + ß_2 D_1 + ß_3 D_2 + ß_4 D_3 + ß_5 D_4 + u$$

Where: $\ln(WTP_j)$ is natural logarithm of the j^{th} WTP dependent variable; and other variables are defined in Table 7.10. The ß's are the slope coefficient measuring the elasticity of WTP with respect to explanatory variables, i.e., the percentage change in WTP for a given small percentage change in explanatory variable.

The F test was done to determine the overall significance of each of the above multiple regressions (j). The null hypothesis tested were $H_0: ß_2=ß_3=ß_4=ß_5=0$ versus H_1: not all slope coefficients were simultaneously zero. Where the observed F_o exceeded critical F_c, the null hypothesis was rejected; otherwise it was accepted. The student-t test was done to determine significance of individual regression coefficients (H0: $ß_n = 0$ against H_1: $ß_n$ not equal to zero).

7.2.2 *Willingness to pay results*

7.2.2.1 *Descriptive statistics results*

Table 7.18 provides a summary of the personal characteristics of the respondents. Table 7.19 shows where farmers who reported to have suffered from schistosomiasis within four months preceding the survey sought health care. The evidence indicates that majority of the sick farmers sought care in private dispensaries. The descriptive statistics

in table 7.16 shows that majority of the respondents took into account medical care expenses, loss of working time, loss of earnings, children absence from school, anxiety caused to other household members, and risk posed to other persons by ones health state, when deciding the amounts of money they would be willing to pay. About 21.6%, 55.6%, 12.6%, and 8.1% of the respondents said they found the whole interview very difficult, not very difficult, very easy, and just easy respectively (Table 7.17). 88 % of the combined samples said they would be willing to take part in a similar exercise in future (Table 7.20).

Table 7.11 provides the average willingness to pay (WTP) values elicited from the farmers, teachers and medical professionals samples combined. Those are marginal WTP values, and not specific states willingness to pay valuations. The WTP values in Table 7.11 were transformed to health states WTP values in Table 7.12. The latter table shows that WTP decreases with perceived severity of health state. The WTP to avoid the risk of advancing to the next more severe state, generally seem to higher than WTP for a return to normal health. The values in the latter table were used in calculations of the expected monetary values.

7.2.2.2 *Analysis of variance results*

A one-way analysis of variance test was done to determine whether there was any significant difference between the average willingness to pay values of farmers (u_h), teachers (u_t) and medical professionals (u_p) populations. The test produced mixed results (Table 7.13). On one hand, the observed variance ratio F_o was greater than the critical F_c value, for the Y1, S1, K1, Z1, A1, R1, Q1, QN, Y2, S2 and R2 average willingness to pay values. So we reject the null hypotheses, i.e. we accept that the difference between the means is significant at the 5 per cent level. This evidence shows that the populations from which the samples were drawn do differ. On the other hand, because the observed F_o was less than critical F_c for K2, Z2 and A2 mean WTP values, we accept the null hypothesis, i.e. we accept that the sample means are not significantly different.

7.2.2.3 *Regression results*

Fourteen regressions were run to determine the main determinants of individuals' willingness to pay, either for a return to normal health or just to obviate the risk of advancing the next more severe state (Tables 7.14 and 7.15). Those regressions were also meant to explain the variations in WTP for each health state. The dependent variables were logarithms of Y1, S1, K1, Z1, A1, R1, Q1, QN, Y2, S2, K2, Z2, A2 and R2 (defined in Table 7.10). Step-wise regression analysis was done to determine the important independent variables. The parameters of age, sex, marital status, occupation, education, schistosomiasis episodes and risk posed to others - variables were statistically insignificant, and their inclusion in the multiple regression models reduced their explanatory power drastically. Multiple regression analysis was eventually done with following explanatory variables: MEDEX, ANXIETY, EARNING, WORKTIME and INCOME. The explanatory variables, MEDEX, ANXIETY, EARNING and WORKTIME, were dichotomous dummy variables; while INCOME was logarithm of household income (defined in Table 7.10). Each households' income was elicited via the following question: "How much income does your household earn from the following sources (listed in item 16 of Appendix 5) per month?" The expressed monthly income from different sources was summed up and then multiplied by 12 months to obtain annual households' income. The observed F_o ratios for all the regressions were greater than the theoretical F_c values (at the 95 per cent level of significance); indicating that the regressions were significant.

The INCOME variable coefficient is an elasticity; it indicates the degree of responsiveness of WTP to marginal changes in income. The INCOME coefficient was positive and highly significant in all the regressions. That evidence confirms that expressed willingness to pay is income dependent. The coefficients of the other explanatory variables were generally not statistically significant, indicating the medical expenses, anxiety cost, loss of earnings and the loss of worktime, implied in various health states descriptions had no effect on individuals expressed WTP values. The latter finding shows that there need for more research to identify the other (besides income) determinants of individuals' expressed willingness to pay.

7.3 The Delphi Technique

This section discusses the technique used in assessing effectiveness of schistosomiasis interventions and the results. The Delphi technique (DT) was used to elicit expert assessment of expected effectiveness of various schistosomiasis interventions in changing health state transition probabilities. DT is a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem (Listone and Turroff, 1975); while at the same time minimizing the undesirable aspects of group interaction such as specious persuasion, unwillingness to abandon publicly expressed opinions, and the bandwagon effect of majority opinion (Makridakis et al., 1978; Johnson et al., 1988). The structured communication entails: feedback of individual contributions of knowledge and information; assessment of the group judgement or view; opportunities for individuals to revise views; and some degree of anonymity for the individual responses.

The DT was chosen for several reasons: relevant effectiveness information was unavailable and would have been expensive to obtain; time and costs made frequent group expert meetings unfeasible; disagreements among individual panellists would have unpalatable effects, so anonymity had to be assured; and it permits a spread of opinion so that the uncertainties surrounding a situation can be reflected.

7.3.1 *The DT procedure*

Subjective evaluation of the schistosomiasis interventions effectiveness was done in two stages.

In stage 1, subjective probabilistic effectiveness of various intervention was elicited from two local schistosomiasis experts. Stage 2 involved replication of the elicitation procedure using an international schistosomiasis expert.

7.3.1.1 *Local experts intervention effectiveness evaluation procedure*

STEP I: The Delphi Questionnaire

The Delphi questionnaire (Appendix 6) was structured in a manner that made it possible to gather data on the following attributes:

(1) General data

Name, postal address, telephone number, and facsimile number of the respondent. This data was vital for correspondence purposes.

(2) Primary options effectiveness data

Only the population primary interventions implemented in Mwea scheme will affect the disease transmission. Their impacts would be reflected in the changes in both overall schistosomiasis prevalence and health states prevalence rates. The secondary interventions will only influence outcome probabilities.

(a) Impacts on the overall schistosomiasis prevalence

Judgements of overall schistosomiasis prevalence rates with various primary policies were elicited through the following question: "suppose each of the following primary schistosomiasis interventions: do nothing completely (DNC), status quo (SQ), household piped water supply (HPWS), household health education visits (HHED), household vented improved pit latrines (VIPL), drip molluscicide (DM), focal molluscicide (FM), mass population chemotherapy with praziquantel (MPCP), mass population chemotherapy with oxamniquine (MPCO), selective population chemotherapy with praziquantel (SPCP) and selective population chemotherapy with oxamniquine (SPCO), were implemented separately in Mwea Scheme (where the prevalence rate is currently 75%) at the beginning of the year and allowed to run for 15 years. Draw line graphs projecting the trend of overall schistosomiasis prevalence for each of the intervention policies over the 15 years period". Their projections are contained in

(b) Impacts on health states prevalence

Judgements of health states prevalence rates with various primary policies were elicited through the following question: "suppose each of the following primary schistosomiasis interventions: DNC, SQ, HPWS, VIPL, HHED, DM, FM, MPCP, MPCO, SPCP and SPCO, were implemented separately in Mwea Scheme (where the prevalence rate is currently 75 %) at the beginning of the year and allowed to run for 15 years. Suppose towards the end of each of the years 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, random samples of 100 persons are drawn from Mwea Scheme, what percentages would you expect to be in normal (Y), mild (S), moderate (K), severe (Z), very severe (A) and comatose (R) health states, with each of the primary policies mentioned above". Their health states probability estimates are contained in Appendix 1.

(c) Outcome or transition probabilities

The impacts of secondary interventions on probabilities for the five consequences mentioned in chapter 6 were elicited via the following question: "Suppose at the n^{th} chance node (on Fig. 6.1) you are given 100 persons randomly selected from Mwea Scheme, what percentage would you expect to: have spontaneous recovery, recede to the preceding health state, remain in n^{th} state, die in n^{th} state, and advance to the next state". The experts' outcome probability estimates and estimates of the remaining life expectancy at each health state are presented in Appendix 1.

Step II: Selection of panellists

Although it would have been ideal to have a Delphi panel of about 5 to 10 experts as Huber et al. (1972) recommends, only two local schistosomiasis epidemiologists were available and willing to participate in the Delphi exercise.

Step III: Consent and delivery of questionnaires

Telephone calls were made to potential panellists to organize appointments. The questionnaires were hand-delivered with an objective of clarifying the purpose of the exercise, seeking consent for participation, and agreeing on the date when completed questionnaires would be collected. The analyst went through the questionnaire with each of the panellists several times, until they were comfortable with the questionnaire and the decision tree. However, the DT did not work perfectly because the two researchers met and did the exercise together. So the DT anonymity feature was breached.

7.3.1.2 *International experts intervention effectiveness evaluation procedure*

Two anonymous U.K. schistosomiasis experts cast doubts on the validity of some of the probabilistic intervention effectiveness forecasts obtained from the local experts modified Delphi procedure. They had two major concerns. First, the local experts had forecast that if the status quo (SQ) community option is continued the schistosomiasis prevalence would rise from 75% in 1992 to 100% by the 10^{th} year of the project life (Table 1.1b in Appendix 2). They argued that since Mwea scheme had a very long history of schistosomiasis, it was likely that schistosomiasis reached a stable position 15 to 20 years ago. They then concluded that it was very unlikely that the existing level of prevalence would increase very much. The stability argument assumes that schistosomiasis transmission conditions, and hence infection vis-a-vis de-infection rates have attained an equilibrium. However, in the light of the remarkable expansion of the scheme and settlement of new tenants since independence (i.e. 1963), it is unlikely that the alleged equilibrium will be attained in the near future.

Second, the distribution of prevalence between different health states under the status quo assumed that by the end of the project life (year 15), 80% of the population would be in comatose state and 20% in the very severe state. The international experts argued that such an assumption was implausible because even in areas with very intense schistosomiasis transmission like the Nile Delta in Egypt and Recife in Brazil, such a level of very severe illness due to schistosomiasis has not been reported.

In view of the above concerns, it was recommended that re-analysis of the decision theoretic models should be done with a new set of schistosomiasis expert subjective

probabilities. Thus, the author was required to obtain the subjective judgements from different experts. At the time only one U.K. schistosomiasis expert was available and willing to subjectively evaluate the effectiveness of various interventions.

The Delphi questionnaire, local expert health states probability estimates and transition (outcome) probability estimates were sent by facsimile to the international expert. He provided a new set of transition probabilities and probabilistic effectiveness estimates for the status quo (SQ), mass population chemotherapy, and selective population chemotherapy. The international expert was of the opinion that oxamniquine and praziquantel would not have significantly different effectiveness. In other words, MPCP=MPCO and SPCO=SPCP. The expert did not have time to evaluate the effectiveness of the preventive options (DM/FM, HPWS, VIPL, HHED) and the do-nothing-completely (DNC) option. However, when the author went to collect the subjective probabilities he had a discussion about the effectiveness of preventive interventions with the expert, and during the discussion the expert implied the following relationship: DM=FM>HPWS>VIPL>HHED>SQ>DNC. Given that no other international expert was available and willing at the time to provide subjective judgements on the effectiveness of preventive interventions, the author was advised to evaluate their effectiveness guided by insights gained from his discussion with the international expert and schistosomiasis intervention literature, and counter-check them with some anonymous U.K. schistosomiasis experts. The author's estimates together with those made by the international expert were sent by facsimile to a friend who then passed them to the anonymous experts. After studying them carefully, they agreed that the new estimates were close to reality. Appendix 2 contains the revised epidemiological data used in the decision analysis.

The differences between local and international expert opinion about the effectiveness of various schistosomiasis interventions highlights: the importance of including a full-range of expert opinion in such exercises; uncertainty surrounding both the ultimate effectiveness of schistosomiasis interventions, and impacts of schistosomiasis on victims function performance; and hence need for use of decision analysis techniques to guide policy-makers. The lack of consensus also illuminates the urgency for randomized controlled effectiveness trials tailored in a manner that would enable them to produce "hard" epidemiological data needed in decision analysis. The methodological issues and differences in the expert estimates are discussed more fully

in chapter 10.

Practical problems

Two problems came-up in the course of the exercise:
(i) Whereas the analyst had made it clear that the probabilities at each chance node should add up to one, some of their evaluations were not adding to one. Thus, the analyst explained politely the mistake and they revised their estimates.
(ii) After a few options had been evaluated, the analyst realized that the experts did not compare (collate) evaluations of the status quo with their assessments of the alternative interventions. The issue was discussed and the experts repeated the exercise.

Lessons from the effectiveness evaluation exercise

A number of basic but important lessons were learnt: (i) an effectiveness evaluation exercise is time consuming and mentally exhausting, and can be effectively done only by committed medical research scientists (commitment in terms of willingness to learn how DT works and to participate in subjective probability elicitation process); (ii) epidemiologists have major problems and reluctance in providing probabilistic effectiveness judgements; (iii) analysts should not assume that epidemiological experts understand probability laws and conventions; (iv) a decision tree diagram can be a good visual aid when assessing health state and outcome probabilities; (v) questions expressed in terms of prevalence and percentages are easier for the medical experts to conceptualize than probabilities; and (vi) the effectiveness assessment exercise requires close guidance and monitoring by the study designer. However, the latter should be done sensitively to avoid resentment and non-compliance.

Epidemiological judgements elicited in this section are an input in the intervention options QALY, EMV and cost calculations.

7.4 Discounted Quality Adjusted Life Years

This section 7.4 analyzes the discounted quality adjusted life years expected from various policy combinations. Expected QALYs from the various options are given in

Appendices 2(A), 2(B), 2(C) and 2(D). Those estimates will be a crucial input in the cost-effectiveness decision analysis model.

The behaviour of expected QALY gains from various policy combinations follows closely the behaviour of specific health states' prevalence over respective primary policies life. The greatest numbers of QALYs would be realized from intervention policies geared at less severe states, such as normal, mild, and moderate. There seems to be an inverse relationship between health states severity and the QALY benefits from intervention. This evidence creates a strong case for reallocation of health producing resources from the more expensive hospital-based care to community-based care.

7.5 Expected Monetary Values Results

Appendix 3 provides discounted monetary value of benefits expected from various policies. Those EMVs are a major input into the cost-benefit decision analysis model. The flow of EMVs from various interventions follows closely their impacts on health states prevalence (or probabilities). The greatest benefits would be reaped from primary level interventions; and options targeted at less severe states. The benefits from intervention decrease rapidly as one approaches very severe schistosomiasis state. This further boosts the case for a shift of resources from secondary and tertiary care to primary care.

7.6 Summary

The QoL, WTP and Delphi methodologies used in estimating schistosomiasis intervention benefits have been described. Preliminary results using those measures have also been presented. The two benefit measures were used to facilitate a comparison of the CEDA and CBDA models. The main results are: less severe health states command higher WTP and utility values; the greatest number of EQALYs and EMVs would be realized from intervention policies geared at less severe states; there seems to be an inverse relationship between health states severity and the QALY and EMV benefits from intervention; and the policy combinations of treatment strategies promise greater amounts of health benefits than non-treatment strategies. This thesis succeeded in only developing QoL, WTP and DT instruments and demonstrating their operational

feasibility. Thus, there is need for more research to establish their validity and reliability.

Table 7.1: Role play in Kenya's rural societies	
Category	Roles / functions
CHILDREN (4-15 years)	-self-care - feeding, bathing, dressing, going to toilet -peer play -attending school -baby-sitting -fetching fuel-wood, water -sent to buy or borrow basic consumable e.g. salt, sugar -looking after livestock -assisting parents in farming
WOMEN	-self-care -household work - cooking, washing utensil, clothes, baby-caring, hewing fuel-wood, fetching water -helping in farming when free -selling farm produce -participating in women group activities
MEN	-self-care -Farming- planting, weeding, harvesting or/and livestock herding -participating in self-help community activities -leisure time- social beer drinking; playing draft (maune); relaxing in local shopping centre

Table 7.2: Schistosomiasis related state descriptions
STATE Y: Your normal state of health.
STATE S: Your normal mobility, livelihood activities, self-care, social participation and energy except for: -occasional mild bladder or/and stomach pain -you will proceed to the next more severe state, in 3 years, without intervention.
STATE K: Your normal mobility, self-care, and social participation, except for: -frequent moderate bladder or/and stomach pains -slight reduction in energy causing moderate reduction in capacity for livelihood activities, but no absence from livelihood activities - work, schooling, etc. -you will proceed to the next more severe state in 3 years, without intervention.
STATE Z: -no difficulty with self-care -slightly impaired mobility, can only walk for more than 1 mile with difficulty -persistent moderate bladder or / and stomach pains -moderate reduction in energy causing frequent absence from livelihood activities - school, work -frequent absence from social community activities - church, peer get-together meetings, public "baraza", etc. -you will proceed to the next more severe state in 3 years, without intervention.
STATE A: -severely impaired mobility, bed-ridden most of the time -moderate lack of control of urination and defecation -severe reduction in energy causing total absence from livelihood activities - work, school -total absence from social activities - church, public 'baraza', peer get-together meetings, etc. -severe body pain -you will proceed to the next more severe state in 3 years, without health intervention.
STATE R: Unconscious (in coma) -you will proceed to the next more severe state in 3 years, without health intervention.
STATE Q: Death

Table 7.3: English translation of kikuyu version of health states
STATE Y: Your normal state of health.
STATE S: You have bilharzia germs, but your mobility, livelihood activities, self-care, social participation and energy are normal, except for occasional mild bladder and stomach pain. - you will proceed to the next more severe state, in 3 years, without intervention.
STATE K: You have bilharzia germs, but your mobility, self-care, and social participation are normal, except for: -frequent moderate bladder and stomach pains -slight reduction in energy causing moderate reduction in capacity for livelihood activities, but no absence from livelihood activities - work, schooling, etc. -you will proceed to the next more severe state in 3 years, without intervention.
STATE Z: You have bilharzia germs, but you have no difficulty with self-care, except for: -slightly impaired mobility, can only walk for more than 1 mile with difficulty -persistent moderate bladder and stomach pains -moderate reduction in energy causing frequent absence from livelihood activities - school, work -frequent absence from social community activities - church, peer get-together meetings, public "baraza", etc. -you will proceed to the next more severe state in 3 years, without intervention.
STATE A: Due to bilharzia germs, you have: -severely impaired mobility, bed-ridden most of the time -moderate lack of control of urination and defecation -severe reduction in energy causing total absence from livelihood activities - work, school -total absence from social activities - church, public 'baraza', peer get-together meetings, etc. -severe body pain -you will proceed to the next more severe state in 3 years, without health intervention.
STATE R: You are unconscious because of bilharzia germs - you will proceed to the next more severe state in 3 years, without health intervention.
STATE Q: Death

Table 7.4: Medical professionals' health state utilities			
HEALTH STATES	MEAN	STANDARD DEVIATION	VARIANCE
Y	1	0	0
S	0.85	0.08	0.01
K	0.68	0.12	0.01
Z	0.52	0.14	0.02
A	0.32	0.14	0.02
R	0.13	0.08	0.01
Q	0	0	0
Sample Size	37		

Table 7.5: Teachers' health state utilities			
HEALTH STATES	MEAN	STANDARD DEVIATION	VARIANCE
Y	1	0	0
S	0.81	0.09	0.08
K	0.63	0.1	0.01
Z	0.46	0.11	0.01
A	0.28	0.1	0.01
R	0.12	0.07	0.01
Q	0	0	0
Sample Size	89		

Table 7.6: Household health state utilities			
HEALTH STATES	MEAN	STANDARD DEVIATION	VARIANCE
Y	1	0	0
S	0.81	0.18	0.03
K	0.66	0.17	0.03
Z	0.5	0.17	0.03
A	0.34	0.17	0.03
R	0.19	0.19	0.04
Q	0	0	0
Sample Size	400		

Table 7.7: Summary statistics all samples			
HEALTH STATES	MEAN	STANDARD DEVIATION	VARIANCE
Y	1	0	0
S	0.81	0.35	0.12
K	0.65	0.39	0.16
Z	0.49	0.38	0.15
A	0.33	0.38	0.15
R	0.17	0.36	0.13
Q	0	0	0
Sample Size	526		

Table 7.8: Analysis of variance of health states utilities

Health state	F_o	F_c ($F_{0.05}$)	Comparison of the observed and critical F	Decision (accept or reject: $Ho=u_1=u_2=u_3$
S	1.17	3.00	$F_o<F_c$	Accept
K	247	3.00	$F_o>F_c$	Reject
Z	1006	3.00	$F_o>F_c$	Reject
A	2345	3.00	$F_o>F_c$	Reject
R	3231	3.00	$F_o>F_c$	Reject

Table 7.9: Willingness to pay question

(13) Let us refer again to the health states described on our cards (A, Q, Z, Y, K, R and S); rank the cards again in order of preference, starting with most preferred to the least preferred. A person can only be in one health state at time.

13(a) Suppose you are in health state described on card____, how much money (or rice) would you be willing to pay for treatment that would return you to your best health state?

13(b) Suppose you are not yet infected by bilharzia, how much money (or rice) would you be willing to pay per year to prevent infection?_____Ksh. or _____Kgs. of rice

13(c) Suppose you knew for certain that a member of your household would die during the coming year from schistosomiasis infection; what is the maximum amount of money or rice would be willing pay to prevent his or her death?

_____Ksh. or _____Kgs. of rice

13(d) Suppose you knew for certain that one unknown person in your neighbourhood would die during the coming year from schistosomiasis infection: What is the maximum amount of money or rice would you be willing and able to pay to save his or her life?_____Ksh. or _____Kgs. of rice

(14) Suppose there was no intervention which would enable you to return to your normal health state (unless if you are already in normal health state Y). Assume that the available interventions can only prevent you from proceeding to the next more severe health state.

14(a) If you are currently experiencing health state described on card_____, how much money or rice would you be willing to pay to insure yourself from proceeding to the next more severe state_____?

14(b) When deciding on the amounts of money or rice you would be willing to pay did you take any of the following factors into consideration? (Yes/No)

(i) Medical expenses (user fees, drug costs, and transport costs)? Yes/No (ii) Loss of working/ leisure time? Yes/No (iii) Loss of earnings/ productivity? Yes/No

(iv) Children's absenteeism from school? Yes/No

(v) Anxiety caused by health state to you and others in your household? Yes/No

(vi) Risk posed by your state to other people? Yes/No

Table 7.10: Variable descriptions	
Dependent variables	Variable descriptions
Y1	Logarithm of willingness to pay to remain in normal state (Y)
S1	Logarithm of willingness to pay for return to Y from mild state
K1	Logarithm of willingness to pay to return to Y from moderate state (K)
Z1	Logarithm of willingness to pay to return to Y from severe state (Z)
A1	Logarithm of willingness to pay to return to Y from very severe state (A)
R1	Logarithm of willingness to pay to return to Y from comatose state (R)
Q1	Logarithm of willingness to pay to prevent own death
QN	Logarithm of willingness to pay to prevent other's death
Y2	Logarithm of willingness to pay to remain in normal state (Y)
S2	Logarithm of willingness to pay for remain in mild state (S)
K2	Logarithm of willingness to pay to remain in moderate state (K)
Z2	Logarithm of willingness to pay to remain in severe state (Z)
A2	Logarithm of willingness to pay to remain in very severe state (A)
R2	Logarithm of willingness to pay to remain in comatose state (R)

Table 7.10 Continued	
Explanatory variables	Variable descriptions
INCOME	Logarithm of household income
ANXIETY	ANXIETY = 1 if the respondent considered anxiety cost implications; 0 otherwise
MEDEX	MEDEX = 1 if the respondent considered medical expense implications; 0 otherwise
EARNING	EARNING = 1 if the respondent considered the implied earnings loss; 0 otherwise
RISKOT	RISKOT = 1 if the respondent considered the risk to others; 0 otherwise
ABSENT	ABSENT = 1 if the respondent considered the implied child's absenteism from school due to schistosomiasis infection; 0 otherwise
WORKTIME	WORKTIME = 1 if the respondent considered the implied loss of work time; 0 otherwise
CONSTANT	Intercept term

Table 7.11: Combined samples willingness to pay		
Health States	Willingness to pay in Ksh. for:	
	Return to Normal	Avoiding risk of advancing
Normal (Y)	0	15417
Mild (S)	395	14638
Moderate (K)	749	16725
Severe (Z)	1636	19461
Very severe (A)	7795	24457
Comatose (R)	20518	37285
Own death (Q)	27877**	0
Others death (QN)	1363**	0
Note: ** means WTP to avoid death WTP values in this table are marginal values		

Table 7.12: Health states willingness to pay

Health States	Willingness to pay in Ksh. for:	
	Return to Normal*	Avoiding risk of advancing**
Normal (Y)	27877	127983
Mild (S)	27482	112566
Moderate (K)	27128	97928
Severe (Z)	26241	81203
Very severe (A)	20082	61742
Comatose (R)	7359	37285
Death (Q)	0	0

Note:
* The values in this column are specific states WTP, with the questions framed in terms of going back to normal
** The values in this column are specific states WTP, with the questions framed in terms of avoiding advancing to next state

Table 7.13: One-way analysis of variance test for health states willingness to pay values from the three samples

Health States	F_o (observed)	F_c (critical)	Comparison	Decision
Y1	7.9	3	Fo>Fc	Reject
S1	39.9	3	Fo>Fc	Reject
K1	61.3	3	Fo>Fc	Reject
Z1	37.7	3	Fo>Fc	Reject
A1	11.1	3	Fo>Fc	Reject
R1	9.4	3	Fo>Fc	Reject
Q1	11.3	3	Fo>Fc	Reject
QN	30.6	3	Fo>Fc	Reject
Y2	5.7	3	Fo>Fc	Reject
S2	3.3	3	Fo>Fc	Reject
K2	2.9	3	Fo<Fc	Accept
Z2	2.9	3	Fo<Fc	Accept
A2	2.9	3	Fo<Fc	Accept
R2	4.1	3	Fo>Fc	Reject

Table 7.14: Regression results of WTP for return to normal health

Dependent variable	Degrees of freedom		Observed F_o	Explanatory variables	parameters (ß's)	t-ratio
	v_1	v_2				
Y1d	5	446	8.6	INCOME	0.214	3.76
				MEDEX	-0.500	-1.64
				ANXIETY	-0.143	-1.12
				EARNING	-0.108	-0.42
				WORKTIME	-0.456	-1.848
				(Constant)	4.871	9.831
S1	5	447	7.8	INCOME	0.204	4.428
				MEDEX	-0.012	-0.052
				ANXIETY	0.007	0.068
				EARNING	-0.338	-1.676
				WORKTIME	-0.179	-0.900
				(Constant)	3.90	9.576
K1	5	445	11.66	INCOME	0.249	5.376
				MEDEX	-0.123	-0.518
				ANXIETY	0.009	0.087
				EARNING	-0.424	-2.087
				WORKTIME	-0.188	-0.939
				(Constant)	4.318	10.532

Table 7.14: Continued

Z1	5	446	13.70	INCOME MEDEX ANXIETY EARNING WORKTIME (Constant)	0.307 -0.064 0.009 -0.549 -0.155 4.353	6.064 -0.245 0.079 -2.452 -0.700 9.807
A1	5	444	18.78	INCOME MEDEX ANXIETY EARNING WORKTIME (Constant)	0.394 0.068 -0.042 -0.656 -0.163 4.17	7.308 0.248 -0.347 -2.769 -0.699 8.841
R1	5	434	17.66	INCOME MEDEX ANXIETY EARNING WORKTIME (Constant)	0.486 0.118 -0.113 -0.475 -0.243 3.820	7.595 0.360 -0.789 -1.684 -0.876 6.783
Q1	5	447	26.69	INCOME MEDEX ANXIETY EARNING WORKTIME (Constant)	0.615 0.361 -0.166 -0.593 -0.440 2.905	9.236 1.036 -1.091 -1.968 -1.499 4.920
QN	5	443	4.784	INCOME MEDEX ANXIETY EARNING WORKTIME (Constant)	0.220 0.188 0.042 -0.098 -0.441 3.984	3.633 0.594 0.302 -0.358 -1.655 7.567

Table 7.15: Regression results to avoid advancing to the next state

Health State	Degrees of freedom		Observed F_o	Explanatory Variable	Parameters	t-Ratio
	v_1	v_2				
Y2	5	444	14	INCOME MEDEX ANXIETY EARNING WORKTIME (Constant)	0.369 -0.273 -0.002 -0.052 -0.559 2.939	6.392 -0.934 -0.018 -0.205 -2.254 5.849
S2	5	445	17.22	INCOME MEDEX ANXIETY EARNING WORKTIME (Constant)	0.405 -0.081 -0.051 -0.241 -0.396 3.018	7.364 -0.287 -0.415 -0.992 -1.638 6.273
K2	5	446	19.18	INCOME MEDEX ANXIETY EARNING WORKTIME (Constant)	0.436 -0.066 -0.055 -0.312 -0.225 3.10	8.169 -0.242 -0.457 -1.325 -0.969 6.637

Table 7.15: Continued

Z2	5	444	19.42	INCOME MEDEX ANXIETY EARNING WORKTIME (Constant)	0.433 0.107 -0.051 -0.340 -0.341 3.406	7.941 0.385 -0.412 -1.411 -1.426 7.143
A2	5	443	19.67	INCOME MEDEX ANXIETY EARNING WORKTIME (Constant)	0.458 0.123 -0.129 -0.253 -0.289 3.413	8.236 0.435 -1.032 -1.036 -1.206 7.023
R2	5	422	20.53	INCOME MEDEX ANXIETY EARNING WORKTIME (Constant)	0.507 0.221 -0.193 -0.444 -0.253 3.451	8.177 0.727 -1.432 -1.647 -0.878 6.462

Table 7.16: Factors that respondents took into account when deciding their WTP								
VARIABLE LABELS	Teachers (N=89)		Medics (N=37)		Farmers		Combined samples	
	YES (%)	NO (%)	YES (%)	NO (%)	YES (%)	NO (%)	YES (%)	NO (%)
MEDEX	87.6	11.2	97.3	2.7	90.9	8.2	91.1	8.3
WORKTIME	58.4	40.4	75.7	24.3	89.0	10.1	83.4	16.1
EARNING	61.8	37.1	86.5	13.5	89.0	10.1	84.7	15.3
ABSENT	55.1	43.8	48.6	51.4	89.9	9.1	81.7	18.3
ANXIETY	73.0	25.8	81.1	18.9	87.5	11.3	85.0	15.0
RISKOT	70.8	28.1	83.8	16.2	77.7	21.3	77.3	22.7

Table 7.17: Answers to the question - how did you find the whole interview?				
How did you find the whole interview?	Teachers (N=89)	Medics (N=37)	Farmers (417)	Combined samples (N=528)
	(%)	(%)	(%)	(%)
Very difficult	16.9	10.8	23.5	21.6
Not very difficult	65.2	62.2	52.8	55.6
Very easy	5.6	0.0	15.1	12.6
Just easy	10.1	24.3	6.2	8.1
Missing	2.2	2.7	2.8	2.0

Table 7.18: Personal characteristics of the samples

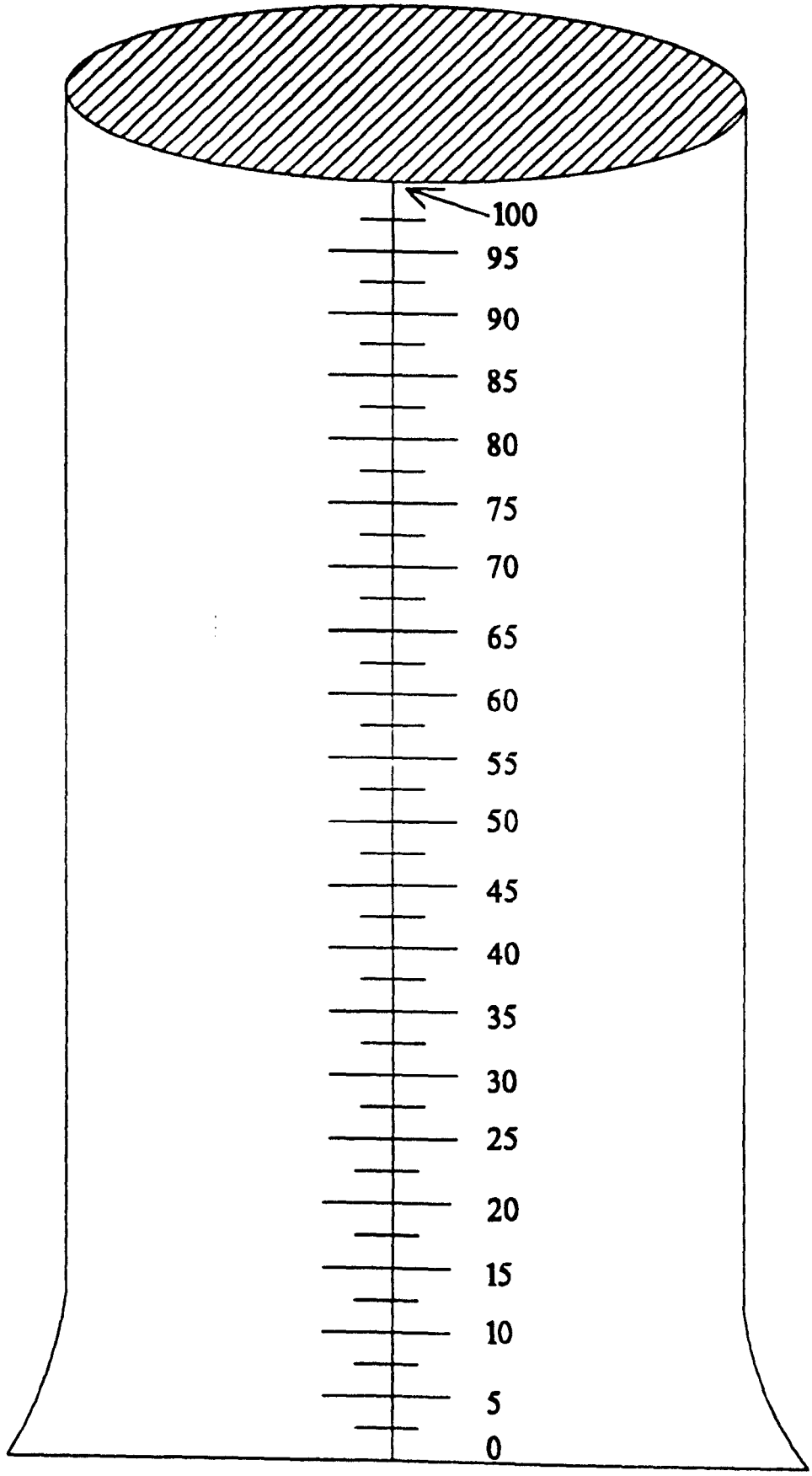
Characteristic	Teachers (N=89)	Medics (N=37)	Farmers (N=417)	Combined samples (N=528)
Sex	F=36%; M=64%	F=32.4%; M=67.4%	F=14.9%;M=84.7%	80.4%
Age (years)	32 (s=8)	34 (s=7)	47 (s=14)	44 (s=3)
Mean household size	3 (s=2)	3 (s=2)	6 (s=3)	5
Mean income (Ksh.)	4619 (s=3684)	5463 (s=4178)	780 (s=922)	1,734 (s=2655)
Travel time to health facility		79.7% travel for 0.5 hours and less		
Waiting time for care		90.8% wait for 1 hour and less		
Schistosomiasis experience in the household	10.1%	0%	30.5%	25.1%

Table 7.19: Source of health care among farmers who reported to have suffered from schistosomiasis (within four months preceding the survey)	
Government hospital	0.2%
Government health centre	3.8%
Government dispensary	0.7%
Private hospital	2.2%
Private dispensary/clinic	17.5%
Mission hospital	4.6%
Chemist/pharmaceutical shop	0.2%
Herbalist	0.2%

Table 7.20: Respondents answers to the question - would you be willing to take part in a similar exercise in future?

Response	NO (%)	YES (%)	MISSING (%)
Teachers (N=89)	13.5	84.3	2.2
Medics (N=37)	18.9	78.4	2.7
Farmers (N=417)	7.9	89.2	2.9
Combined samples (N=528)	9.6	88.0	2.4

FIGURE 71: THE RICE-SACK ANALOGUE SCALE



CHAPTER 8
SCHISTOSOMIASIS INTERVENTIONS COST METHODOLOGY AND DATA ANALYSIS

8.0 Introduction

This chapter explains in detail the methodology used to estimate the costs of various primary and secondary intervention options. Section 8.1 presents the primary interventions' costing methodology. Section 8.2 is a preliminary analysis of primary options' cost data. Section 8.3 puts forward policy combinations' costing methodologies. Section 8.4 is a preliminary analysis of the policy combinations' cost data.

8.1 Costing Methodology for Primary Interventions

This subsection reports the general methodology used in calculating the cost of the ten primary options (SQ, FM, DM, HPWS, HHED, VIPL, MPCP, MPCO, SPCP, SPCO) generated in chapter 5, and the results. Since the cost analysis results would be an input in the prospective cost-effectiveness and cost-benefit decision analyses models (meant to help policy makers and program managers select a future course of action), what is needed are the estimates of what the costs of the alternatives are likely to be. Thus, apart from the cost of SQ (which is based on 1992 expenditure data), the estimates of quantities of inputs that would be needed under alternative options (over the next 15 years) were estimated prospectively using the questionnaires in Appendix 7. The estimated input quantities were then valued in constant Kenya Shillings (Ksh) at 1992 market prices; and then multiplied by a standard conversion factor to convert them to opportunity costs.

For every primary policy, present values of the following cost components were needed: personnel time; in-service training; administration; travel and transport; materials; drugs; utilities (electricity, telephone and postal services); maintenance of vehicles, buildings and equipment; capital cost; and community resource inputs. The specific assumptions made when estimating quantities and value of inputs needed in specific primary options are presented in Appendix 11. Otherwise, this subsection presents the general formulas used in estimating the cost of each input over the assumed

15 year project life.

8.1.1 *Labour cost*

The estimated skilled and semi-skilled labour time was valued at 1992 average civil service monthly salaries for the relevant categories of staff. The unskilled casual labour time was valued at the prevailing wage rate in the local labour market. The labour opportunity costs were estimated using the following expression:

$$\sum_{t=0}^{t=15} \sum_{i=1}^{i=n} PC_j = [((Q_i * T_i * W_i) + FB_i) * SCF * df] * S_i$$

Where: $\sum\sum PC_j$ is the present value of the j^{th} option's personnel cost; Q_i is the number of ith category of personnel required in a specific policy; T_i is the time in months each person in the ith cadre expects to spend on the policy being appraised; W_i is the monthly salary or wage of the i^{th} cadre; FB_i is the value of the fringe benefits i^{th} cadre of staff is entitled; SCF is the standard conversion factor; df is the discount factor; and S is the proportion of i^{th} cadre's cost that should be apportioned to the policy under evaluation.

8.1.2 *In-service training cost*

The unit cost per training day for the relevant courses were obtained from AMREF (1992). The in-service training opportunity cost under various schistosomiasis primary policies were derived using the expression provided below:

$$\sum_{t=0}^{t=15} \sum_{i=1}^{i=n} ITC_j = Q_i * DAY_i * AC_i * SCF * S_i * df$$

Where: $\sum\sum ITC_j$ is the present value of the j^{th} option's in-service training cost; Q_i is the number of persons expected to take i^{th} course; DAY_i is the length of i^{th} course in days; AC_i is the average cost per trainee per day; SCF is the standard conversion factor; df is the discount factor; and S is the proportion of the i^{th} course cost that should be apportioned to the policy under evaluation.

8.1.3 *Travel cost*

The MoH per diem rates for the relevant categories of personnel were used. Each policy's expected opportunity cost of travel was calculated using the following expression:

$$\sum_{t=0}^{t=15} \sum_{i=1}^{i=n} TPD_j = Q_i * ND_i * PD_i * SCF * S_i * df$$

Where: $\sum\sum TPD_j$ is the present value of the j^{th} options per diem cost; Q_i is the number of the i^{th} personnel expected to spend at least a night outside one's working station on the j^{th} policy's business; ND_i is the number of days a person in i^{th} cadre of staff is expected to spend outside his/her working station; PD_i is the per diem rate for the i^{th} cadre of staff; SCF is the standard conversion factor; df is the discount factor; and S is the proportion of i^{th} cadre travel cost that should be apportioned to the j^{th} policy.

8.1.4 *Transport cost*

The transport cost includes the cost of fuel, engine oil and insurance. The cost per kilometre estimates for the relevant vehicles was obtained from the Kenya Automobile Association (1992). The opportunity cost of transport for each option was obtained using the following formula:

$$\sum_{t=0}^{t=15} \sum_{i=1}^{i=n} TRC_j = NV_i * KM_i * C_i * SCF * S_i * df$$

Where: $\sum\sum TRC_j$ is the present value of the j^{th} option's transport cost; NV_i is the number of vehicles with i^{th} engine capacity expected to be used in the j^{th} policy per year; KM_i is the number of kilometres i^{th} vehicle is expected to be used for per year; C_i is the i^{th} vehicle's operating cost per kilometre; SCF is the standard conversion factor; df is the discount factor; and S is the proportion of i^{th} type of vehicle transport cost that should be apportioned to the j^{th} policy.

8.1.5 *Materials cost*

This component includes the cost of all inputs whose useful life is less than a year. All the materials are valued at 1992 constant market prices; and then converted to opportunity costs using a standard conversion factor. The expression given below was used to calculate the cost of materials:

$$\sum_{t=0}^{t=15} \sum_{i=1}^{i=n} TMC_j = Q_i * P_i * SCF * S_i * df$$

Where: $\sum\sum TMC_j$ is the present value of the j^{th} option's materials cost; Q_i is the quantity of the i^{th} type of material; P_i is the price per unit of the i^{th} type of material; SCF is the standard conversion factor; df is the discount factor; and S is the proportion of the i^{th} type of material cost that should be apportioned to the j^{th} policy.

8.1.6 *Utilities cost*

This component includes the cost of electricity, telephone and postal services. The Ministry of Energy and Ministry of Transport and Telecommunications engineers estimated the quantities of utilities various schistosomiasis policies would consume per year. Since those services are produced and sold by public corporations (Kenya Power and Lighting, and Kenya Posts and Telecommunications), the 1992 charges were used in the valuation. The expected opportunity cost of utilities under various policies were estimated using the following formula:

$$\sum_{t=0}^{t=15} \sum_{i=1}^{i=n} TUC_j = Q_i * P_i * SCF * Df * S_i$$

Where: $\sum\sum TMC_j$ is the present value of the j^{th} option's utilities cost; Q_i is the quantity of the i^{th} type of utility; P_i is the price per unit of the i^{th} type of utility; SCF is the standard conversion factor; df is the discount factor; and S is the proportion of the i^{th} type of material cost that should be apportioned to the j^{th} policy.

8.1.7 *Maintenance cost*

The Ministry of Public Works (1992) standard maintenance norms for various types of buildings and equipment were used in calculations of maintenance cost. The maintenance norms developed by KAA (1992) were used in estimating cost of maintaining motor vehicles. The opportunity cost of preventive and rehabilitative maintenance of vehicles, equipment and buildings to be used in j^{th} policy was estimated as follows:

$$\sum_{t=0}^{t=15} \sum_{i=1}^{i=n} TCM_j = Q_i * C_i * SCF * Df * MN_i * S_i$$

Where: $\sum\sum TMC_j$ is the present value of the j^{th} option's maintenance cost; Q_i is the number of the i^{th} type of commodity; C_i is the cost of replacing each unit of the i^{th} type of commodity; MN_i is the maintenance norm for the i^{th} type of commodity; SCF is the standard conversion factor; df is the discount factor; and S_{ij} is the proportion of maintenance cost of the i^{th} type of commodity that should be apportioned to the j^{th} policy.

8.1.8 *Capital cost*

The capital items considered were buildings, vehicles and equipment. Both the basic equipment and buildings expected to be used under primary policy options were valued at 1992 local constant market prices. The market values of vehicles, buildings, and equipment were converted into opportunity costs using a standard conversion factor (SCF).

$$\sum_{t=0}^{t=15} \sum_{i=1}^{i=n} TCC_j = Q_i * C_i * SCF * AF_i * S_{ij}$$

Where: $\sum\sum TCC_j$ is the present value of the j^{th} option's capital commodities cost; Q_i is the number of the i^{th} type of commodity; C_i is the cost of replacing each unit of the i^{th} type of commodity; AF_i is the annuity factor for the i^{th} type of commodity; and S_{ij} is the

proportion of the annual equivalent cost of the i^{th} type of commodity that should be apportioned to the j^{th} policy.

8.1.9 *Community input under preventive policies*

There is no community input in the HPWS, FM and DM policies. The community would be expected to invest their time and cleaning materials into the VIPL policy. However, the only community input into the HHED policy would be time.

The majority of Mwea Scheme households do not participate in the labour market, thus estimation of the opportunity cost of their time is not straight forward. This situation is complicated by the fact that patients in very severe and comatose schistosomiasis states would be too ill to participate in a labour market, in which case the opportunity cost of their time would be zero. In spite of the foregoing, a meaningful shadow price of community time can be computed. If it is assumed that households place a positive value on their leisure time, it can further be assumed that members of these households would not take a job at a prevailing wage rate in a local labour market unless that wage rate compensates them for the loss in utility that they incur when they withdraw their time from leisure to wage activities. Therefore, a prevailing wage rate in a labour market can reasonably be assumed to be a shadow price of the households' time. The expected time investment by children (aged over 5 years) was valued at the market wage rate, in the hope that it may partly capture disinvestment in future labour force incurred by society due to absence of children from school. The children are more productive than adults in most rice field activities. In spite of the above argument, all market values of community inputs were converted to opportunity costs using a standard conversion factor (SCF). The present value of time the community would be expected to invest in jth policy was estimated as follows:

$$\sum_{t=0}^{t=15} TTC_j = DAY * WR * Df * SCF * S_{tj}$$

Where: TTC_j is the present value of the j^{th} option's community time cost; DAY is the number of days invested in the j^{th} policy; WR is the daily wage rate; Df is the discount factor; and S_{tj} is the proportion of the community time cost in t^{th} year that should be apportioned to the j^{th} policy.

Since the number of latrines would remain constant over the assumed project period, the time (and other resources) invested by the community in VIPL policy would remain fairly constant. The cost of community time under the HHED policy is dependent on the annual population growth rate.

8.1.10 *Drugs needs under primary chemotherapy policies*

The anti-schistosome drugs needed under both SPCP and SPCO were estimated using the algorithm in Table 8.2, population projections in Table 8.4 and parameter values in Table 8.5. The variable descriptions are presented in Table 8.1. The drug costs of SPCP and SPCO in subsequent years could be estimated either by repeating steps 1 to 12 for as many times as the assumed project life or by performing step 13. The quantity of drugs needed in SPCP and SPCO would be dependent on both changes in the annual prevalence of schistosomiasis and population growth rate.

Although the above algorithm may seem to be cumbersome, in reality it is not. Once the assumptions and formulae have been built into a Lotus 1-2-3, Symphony or Quattro Pro spreadsheet, the calculations are done in a matter of seconds. Once any of the parameters (in Table 8.5) is changed, the spreadsheet recalculates the estimates in a few seconds. In that case there may be no need of employing the short-cut suggested in step 13 of Table 8.2.

The algorithm in Table 8.2 was also used in estimating drug needs under MPCP and MPCO policies with slight modification. Under the latter policies steps 2, 3 and 4 would not be necessary. The number eligible for treatment (i.e. STEP 5) was obtained using the following expression: $NT_t = N_t - (N_t * GAF_t)$. Otherwise, all the other steps apply without any change.

The estimates of anti-schistosome drug needs under mass population chemotherapy (MPC) regimes are independent of the annual behaviour of schistosomiasis prevalence rate; they are dependent on annual population growth rate. The MPC regimes drug cost projections for the n^{th} year were made using the formula given below instead of that given in step 13: $PDCOST_{t=n} = [PDCOST_{t-1} + (PDCOST_{t-1} \times PG_{t=n})] * df_t$.

Estimates of drugs needed in treating negative side-effects of anti-schistosome drugs were estimated using the algorithm in Table 8.3.

8.1.11 *Community resource inputs under chemotherapy options*

Community resource inputs into SPCP and SPCO were estimated using the algorithm in Table 8.6 and parameter values in Table 8.8. Those parameter values were obtained from both the household survey and REACH (1989). The variable descriptions are given in Table 8.7.

The SPCP and SPCO policies involve three phases: specimen screening, treatment of positives and treatment of those who suffer negative side-effects. Specimen screening phase entails: screening information dispatch; specimen extraction and packaging; and delivery of specimens by household heads to the collecting centres. Therapy phase involves: therapy information (dissemination of screening results, date and venue of treatment) dispatch and treatment.

The community's time investment (CTIME) into selective population chemotherapy policies were valued, for each year, using the following formula:

$$CTIME_{t=n} = (V5 + V6 + V9 + V12 + V15i + V15j + V18 + V19 + V21 + V22 + V24 + V25 + V27 + V28) * WAGE * SCF$$

Where WAGE is the casual wage rate and SCF is the standard conversion factor. It is important to note that the magnitudes of V27 and V28 would be greater under the SPCO than SPCP policy, because the proportion of patients expected to suffer side effects is greater under the latter. Even children's time input was valued at the market wage rate (and then converted to opportunity cost using a SCF), with the hope that part of their future disinvestment may be captured.

The community time input into MPCP and MPCO policies would occur during therapy information dispatch, travel, waiting/queuing, treatment, externality monitoring and externality treatment. The algorithm developed in Table 8.6 was also used in estimating expected community inputs into MPCP and MPCO. However, only the therapy, externality monitoring and treatment phases procedures were relevant to MPCP and MPCO policies.

8.2 Cost Analysis of Primary options

For every primary policy and intervention policy combination, present values were calculated of personnel time; in-service training; travel and transport; materials; drugs; administration; utilities; maintenance of vehicles, equipment and buildings; community resource inputs; and capital cost (vehicles, equipment and buildings). Itemized cost data can be obtained from the author. Otherwise exhibits of the itemized and detailed data are in Appendix 8. Table 8.9 summarizes the flows of cost over various primary options. Table 8.9(B) presents the cost-effectiveness analysis results of primary options. The total cost relationships of the nine primary options could be expressed as follows: DM<SQ<HHED<SPCP<SPCO<HPWS<MPCP<MPCO<VIPL. Thus, drip molluscicide (DM) is the least costly community level option. SPCP is the least costly option among the community treatment options. The mass population chemotherapy options are almost three times more expensive than selective population chemotherapy options. The MPCP and MPCO are equally effective, and the two dominate all the other options in terms of expected total QALYs. The SPCP and SPCO are also equally effective. The selective population chemotherapy with praziquantel (SPCP) is the most cost-effective primary option, i.e. ignoring the synergy between community intervention(s) and facility level options. As will be seen in chapter 9, ignorance of the synergistic relationship between community and facility-based options, can easily mislead decision-making.

The status quo policy at the primary level is the least costly option but also least beneficial. A policy-maker (agent) who wrongly bases his decisions on the cost of interventions per se, would hastily vote for the status quo, and by so doing condemn his principals to continued unnecessary suffering.

Appendix 9 portrays the behaviour of various cost components of the primary interventions over their lives. The single most costly item, throughout the project lives of drip molluscicide, focal molluscicide and the status quo, was personnel. Personnel also dominates during the first year of household water supply option, but it decreases drastically thereafter (from 34.5% in year zero to 6.1% during the subsequent years) because the installation phase of this policy is labour-intensive and, once installed, maintenance labour cost is negligible. For health education policy, personnel and community inputs (especially time) are the most costly components. This is mainly because the policy requires much community involvement. For the VIPL latrine option,

the drug (disinfectant component) dominates the other cost components throughout its life. In the Mwea scheme, where a single latrine has to be shared by large families, large quantities of disinfectants are required to prevent them from becoming focal transmission points for other diseases caused by unhygienic conditions. The drug component constitutes over 75% of the annual cost of the mass population chemotherapy regimes (MPCP and MPCO), throughout their lives because mass population regimes involve treatment of the whole population without screening. Thus, this component increases as the population grows. However, in the selective population regimes (SPCP and SPCO), where treatment is preceded by screening, the drug cost component decreases as prevalence of schistosomiasis decreases. The materials cost component remained dominant from year one till the end of selective population chemotherapy regimes lives. The latter finding could be attributed to the fact that the whole population has to be screened throughout the SPCP and SPCO lives.

8.3 Costing Algorithms and Results for Secondary Interventions

8.3.1 *Dispensary treatment options for mild state (S) cases*

The number of patients presenting themselves at the dispensary every year suffering mild schistosomiasis state S, depends on the effectiveness of the primary intervention under taken within Mwea community level. Cost estimates at the dispensary level, were based on the assumption that all patients manifesting mild schistosomiasis state (S) would present themselves at the dispensary for treatment. The plausibility and implications of the latter assumption are discussed in chapter 10.

8.3.1.1 *Labour cost*

The personnel needs estimations were based on the assumptions in Appendix 12. The algorithm developed in subsection 8.1.1 was employed in estimating expected labour cost under various dispensary combinations. The calculations were based on numbers of different categories of personnel that are needed in a dispensary operating at full capacity. The estimated labour time was valued at the median MoH salaries and fringe benefits the relevant categories of personnel are entitled to. The ratios of expected

numbers of the mild schistosomiasis cases to the total number of cases expected at the dispensary annually (Table 8.10), were used as the basis of apportioning total dispensary personnel cost to the relevant policy combinations. That ratio would vary with primary intervention policy undertaken. The personnel cost component behaviour would be dependent on annual changes in the mild health state (S) prevalence rate and population growth rate.

8.3.1.2 *In-service training cost*

The calculation of in-service training cost under dispensary policy combinations were done using the algorithm in subsection 8.1.2.; but based on the assumptions in appendix 12.

8.3.1.3 *Material costs*

The types and quantities of materials needed in a dispensary in a year were estimated with the help of a nurse in charge of one dispensary (Appendix 12). The ratios of expected numbers of the mild schistosomiasis cases to the total number of cases expected at the dispensary annually (Table 8.10), were used as the basis for apportioning material cost to various policy combinations. Once the formula developed in subsection 8.1.5 was built on Lotus 1-2-3 spreadsheet, the material cost in every subsequent year was obtained by keying in the appropriate ratio (S_j).

8.3.1.4 *Drug cost*

The formula developed in subsection 8.1.10, with minor modifications, was used to estimate the costs of drugs that are likely to be used in various mild state policy combinations. The calculations are based on the assumptions in Appendix 12 and the parameter values in Table 8.5. Steps 2 and 4 are irrelevant, since parasitological facilities are not available in dispensaries. The only changes were made in steps 3 and 5. In step 3, $NSS_{jt} = N_t \quad x \quad SP_{tj}$. Where: NSS_{tj} is the number of patients expected to experience mild state S in year t (t=0,1,...,15), assuming the j^{th} primary policy is in place; SP_{tj} is the year t health state prevalence, assuming the j^{th} primary policy is already

in place. The health state prevalence rates used in step 3 are contained in Appendix 1. In step 5, NSS_{jt} replaces NID_t in the step 5 equation. Otherwise, the other steps were followed without any changes.

8.3.1.5 *Community inputs cost*

The expected community resource inputs into mild schistosomiasis state policy combinations were estimated using the algorithm developed in Table 8.12 and parameters in Table 8.13. The variable descriptions are in Table 8.11.

8.3.1.6 *Transport and travel costs*

The dispensaries do not have on site transport means; they share the vehicle and motor cycle allocated to the health centre. The ratio of dispensary cases to the total number of health centre and dispensary cases were used to prorate the travel and transportation cost for the dispensary (Appendix 12). Then the dispensary travel cost and transport costs were apportioned to schistosomiasis policy combinations using the relevant ratios (Table 8.10).

Transport Cost

The state S policy combinations transportation costs were estimated using the formula developed in section 8.1.4. However, the expression on the right-hand side was multiplied by a constant proportion of dispensary share (i.e. 40%).

Travel cost

The formula developed in subsection 8.1.3 were used in estimating the costs of travel under various policy combinations. However, the expression on the right-hand side was multiplied by a constant proportion of dispensary share (i.e. 40%).

8.3.1.7 *Maintenance cost*

The costs of maintaining equipment, vehicles and buildings to be used in mild schistosomiasis policies were based on the assumptions in Appendix 12. Thus, the expected maintenance cost for each of the j^{th} policy combinations were obtained using the algorithm in subsection 8.1.7 and apportioning ratios in Table 8.10.

8.3.1.8 *Capital cost*

The annual equivalent cost of dispensary building, equipment and vehicles (a 4WD vehicle and a motor cycle) were calculated using the algorithm developed in subsection 8.1.8. and the assumptions in Appendix 12. The annual dispensary capital cost were then apportioned to respective policy combinations using ratios in Table 8.10.

8.3.2 *Cost analysis of mild Schistosomiasis state (S) policy combinations*

For every health state S dispensary-based policy combination, present values of the following cost components were calculated: personnel time; in-service training; travel and transport; materials; drugs; administration; utilities; maintenance of vehicles, equipment and buildings; community resource inputs; and capital cost (vehicles, equipment and buildings). Itemized cost data can be obtained from the author. Otherwise exhibits of the itemized and detailed data are in Appendix 8. Appendix 4(A) summarizes flows of opportunity cost over various policy combinations. The cost figures in Appendix 4(A) alone (without reference to policy combinations effectiveness) are of no value to schistosomiasis control policy makers. Thus, the average cost per EQALY and incremental cost per EQALY were also calculated (see Appendix 4F). The findings in Appendix 4(F) lend support for the hypothesis that when decisions to intervene at different schistosomiasis severity states are taken in isolation, inefficiencies are inevitable. For instance, a casual look at both average costs per EQALY and incremental cost per EQALY would falsely lead to the choice of the status quo (SQ+SQD) as the most cost-effective policy combination for mild schistosomiasis state patients. The cost estimates in Appendix 4(A) are a major input into the cost-effectiveness and cost-benefit decision analysis models.

8.3.3 *Health Centre treatment options for moderate state K cases*

The schistosomiasis epidemiologists thought that the appropriate place to treat patients suffering moderate schistosomiasis state (K) would be health centre (HC). The HC, unlike the dispensary, has a laboratory where parasitological screening could be done. The cost estimates for the HC status quo combinations are based on 1992 actual expenditure. However, the cost estimates for alternative combinations were derived prospectively. The estimates for the latter were based on an ideal health centre operating at full capacity (without any shortages). An optimally operating HC ought to treat about 36000 patients per year (Forgey et al., 1990).

8.3.3.1 *Labour costs*

The HC based moderate schistosomiasis policy combination's labour time cost was estimated using the algorithm developed in subsection 8.1.1. Those estimates were based on the assumptions in Appendix 13; and apportioning factors in Table 8.14.

8.3.3.2 *In-service training costs*

The in-service training cost of moderate schistosomiasis state policy combination's was obtained using the algorithm in subsection 8.1.2. The assumptions made in that subsection are applicable to this subsection, except that different apportioning factors were used (Table 8.14).

8.3.3.3 *Materials costs*

The cost of materials needed in moderate schistosomiasis policy combination's was estimated using the algorithm in subsection 8.1.5. Those estimates were based on the assumptions in Appendix 13; and apportioning factors in Table 8.14. The cost of materials likely to be shared with other disease programmes, were apportioned using the proportion of schistosomiasis cases to the total number of health centre patients.

8.3.3.4 *Drug costs*

The expected cost of drugs that would be needed in moderate schistosomiasis state policy combination's was estimated using the algorithm in subsection 8.1.10 and with modifications mentioned in subsection 8.3.1.4.

8.3.2.5 *Travel and transport costs*

The travel and transport costs of the moderate schistosomiasis states policy combination's was estimated using the algorithm in subsections 8.1.3 and 8.1.4; and the assumptions in Appendix 13. About 60% of the combined dispensary and health centre cost were apportioned to health centre. The total health centre annual travel and transport cost was apportioned to various policy combinations using the relevant apportioning factors in Table 8.14.

8.3.2.6 *Capital costs*

The expected cost of capital commodities needed in moderate schistosomiasis state policy combination's was estimated using the algorithm in sub-section 8.1.8; and assumptions in Appendix 13. Whereas the equipment and buildings are used solely for health centre activities, transport facilities are used on 60% of the time for health centre activities. The annual equivalent cost of buildings, equipment and transport facilities were apportioned to schistosomiasis policy combinations using the apportioning factors in Table 8.14.

8.3.2.7 *Maintenance costs*

The annual cost of maintenance for the moderate schistosomiasis state policy combination's was estimated using the algorithm in sub-section 8.1.7; and the assumptions in Appendix 13. The buildings, equipment, and transport facilities maintenance cost were apportioned to the schistosomiasis intervention policies using allocation factors in Table 8.14.

8.3.2.8 *Community inputs cost*

The expected cost of community input into moderate schistosomiasis policy combination's was estimated using the algorithm in subsection 8.3.1.5 and parameters values in Table 8.15.

8.3.4 *Cost analysis of moderate schistosomiasis (K) policy combinations*

For every health state K health centre-based policy combination, present values of the following cost components were calculated: personnel time; in-service training; travel and transport; materials; drugs; administration; utilities; maintenance of vehicles, equipment and buildings; community resource inputs; and capital cost (vehicles, equipment and buildings). Itemized cost data can be obtained from the author. Otherwise exhibits of the itemized and detailed data are in Appendix 8. Appendix 4(B) provides summarized flows of opportunity cost over various policy combinations. The preliminary CEA results are presented in Appendix 4(G). The SQ+SQHC had both least average cost per EQALY and incremental cost per EQALY. However, as argued in section 8.3.2, it would be misleading to recommend continuation of the status quo without taking into account choices at other health states.

The cost figures in Appendix 4(B) are a major input into the cost-effectiveness and cost-benefit decision analysis models.

8.3.5 *District Hospital options for severe state cases*

The cost estimations in this section are based on the assumption that all severe schistosomiasis cases will seek treatment at the Kerugoya District Hospital Outpatient Department (OPD). It is the nearest hospital from Mwea Irrigation Scheme. A district hospital OPD operating at full capacity (without input shortages) is capable of treating 107391 curative outpatient cases per year (REACH, 1989). The cost of each strategy's policy combinations was based upon the expected number of severe schistosomiasis cases. That number was obtained by multiplying each year's Mwea scheme population projection by the respective strategy's severe schistosomiasis state probability.

8.3.5.1 *Personnel cost*

The entire District Hospital annual personnel cost was estimated using the algorithm in subsection 8.1.1 and assumptions in Appendix 14. That cost estimate was then apportioned to the outpatient department (OPD) using the percentage of floor space it occupies (which is 13.8%). The OPD personnel cost was then apportioned to specific severe state policy combinations using relevant apportioning factors in Table 8.16.

8.3.5.2 *In-service training costs*

The annual in-service training District Hospital cost was estimated using the algorithm in subsection 8.1.2; and the assumptions in Appendix 14. The share of OPD in-service training cost was derived using OPD hospital space (13.8%). The OPD share of in-service training cost was then apportioned to specific severe schistosomiasis disease policy combinations using the proportion of severe schistosomiasis cases to the annual total number of OPD cases (Table 8.16).

8.3.5.3 *Materials costs*

The District Hospital OPD based severe schistosomiasis policy combinations expected cost of materials and supplies was estimated using the algorithm in subsection 8.1.5; and the assumptions in Appendix 14. The cost of materials likely to be shared with other disease programmes, was apportioned using the proportion of expected schistosomiasis cases to the total number of hospital curative OPD cases (Table 8.16).

8.3.5.4 *Drug costs*

The expected cost of drugs needed under severe schistosomiasis policy combinations was estimated using the algorithm in subsection 8.1.10 and modifications mentioned in subsection 8.3.1.4.

8.3.5.5 *Travel and transport costs*

The District Hospital cost of travel and transport was estimated using the algorithm in subsections 8.1.3 and 8.1.4, and the assumptions in Appendix 14. About 49% of the travel and transport costs was apportioned to OPD. The OPD travel and transport cost was then apportioned to severe schistosomiasis policy combinations using apportioning factors in Table 8.16.

8.3.5.6 *Capital costs*

The annual equivalent cost of vehicles, equipment and buildings were estimated using the algorithm in subsection 8.1.8 and the assumptions in Appendix 14. The annual capital cost was apportioned to OPD using the percentage of floor space it occupies. The schistosomiasis policy combinations capital cost was prorated using the allocation factors in Table 8.16.

8.3.5.7 *Maintenance costs*

The annual maintenance cost entailed under severe schistosomiasis policy combinations was estimated using the algorithm in subsection 8.3.1.7, the assumptions in Appendix 14 and the allocation factors in Table 8.16.

8.3.5.8 *Community inputs cost*

The cost of expected community input into severe schistosomiasis policy combinations was estimated using the algorithm developed in subsection 8.3.5.5 and parameter values in Table 8.17.

8.3.6 *Cost analysis of severe state policy combinations*

For every policy combination, present values of the following cost components were calculated: personnel time; in-service training; travel and transport; materials; drugs; administration; utilities; maintenance of vehicles, equipment and buildings;

community resource inputs; and capital cost (vehicles, equipment and buildings). Itemized cost data can be obtained from the author. Otherwise exhibits of the itemized and detailed data are in Appendix 8. Appendix 4(C) summarizes flows of cost over various policy combinations available to severe schistosomiasis cases. The preliminary CEA results are presented in Appendix 4(H). HHED+SQDH had the least average cost per EQALY. The caution in subsection 8.3.4 applies here too. The cost figures in Appendix 4(C) are a major input into the cost-effectiveness and cost-benefit decision analysis models.

8.3.7 *PGH-based options for very severe schistosomiasis cases*

This section explains the methodology used to estimate expected cost of the very Severe Schistosomiasis state policy combinations. As discussed in chapter 5 all very severe state cases would be treated at the Provincial General Hospital (PGH).

8.3.7.1 *Labour costs*

The expected cost of personnel entailed under very severe schistosomiasis policy combinations were estimated using the algorithm in subsection 8.1.1, allocation factors in Table 8.18 and the assumptions in Appendix 15.

8.3.7.2 *In-service training costs*

The PGH-based policies in-service training cost was estimated using the algorithm in section 8.1.2 and assumptions in Appendix 15. The share of inpatient department was prorated using the percentage of total floor space occupied the department (i.e. 86.2%). IPD in-service training cost was then apportioned to specific palliative drug management policy combinations using the proportion of severe schistosomiasis cases to the annual total number of IPD cases (Table 8.18).

On the other hand, IPD in-service training cost was apportioned to surgical division using the proportion of surgical cases to total number of IPD cases (i.e. 27.1%). The surgical department in-service training cost was then apportioned to the specific very severe state surgical operation policy combinations using the proportion of very

severe schistosomiasis patients to the annual total number of surgical department cases (Table 8.18).

8.3.7.3 *Materials and supplies costs*

The PGH IPD based very severe schistosomiasis policy combinations' expected cost of materials and supplies was estimated using the algorithm in subsection 8.3.7.3.

8.3.7.4 *Travel and transport costs*

The PGH cost of travel and transport was estimated using the algorithm developed in subsections 8.1.3, 8.1.4, and the assumptions in Appendix 15. Since the transport facilities are used 51% of the time on IPD matters, 51% of the PGH travel and transport cost was apportioned to IPD.

IPD travel and transport cost was then apportioned to specific very severe state drug management policy combinations using the proportion of severe schistosomiasis cases to the annual total number of IPD cases (Table 8.18).

About 27.1% of the Nyeri PGH IPD cases are surgical cases (interactive interview with Nyeri PGH superintendent, Dr. Shariff, 1992). That percentage was used to prorate the travel and transport cost of the surgical department. The surgical department travel and transport cost were then apportioned to specific very severe state surgical operation policy combinations using the proportion of very severe schistosomiasis patients to the annual total number of surgical department cases (Table 8.18).

8.3.7.5 *Drug costs*

The PGHs do not have drugs and dressings 31% of the year (Forgey et al., 1990). The 1992 expenditure on drugs and dressings was inflated by 31% to cater for shortages in the course of the year. About 63% of total drug expenditure was prorated to the inpatient departments (Forgey et al., 1990).

The cost of drugs needed in specific schistosomiasis policy combinations were prorated using the proportion of admissions due to very severe schistosomiasis disease infection to the total number of inpatient department admissions (Table 8.18).

8.3.7.6 *Capital costs*

The PGH annual equivalent cost of vehicles, buildings and equipment was estimated using the algorithm in subsection 8.1.8 and the assumptions in Appendix 15. Equipment and buildings are used 86.2% of the time for IPD activities (Forgey et al., 1990); thus, 86.2% of the cost was apportioned to IPD. The transport facilities are used 51% of the time for IPD activities; thus, 51% the cost of vehicles and motor cycles was apportioned to IPD. The annual capital cost of buildings, equipment and transport facilities was apportioned to the very severe state policy combinations using the allocation factors contained in Appendix 15.

8.3.7.7 *Maintenance costs*

The PGH annual cost of maintenance was estimated using the algorithm developed in subsection 8.1.7 and the assumptions in Appendix 15. Equipment and buildings maintenance cost was then apportioned to the IPD using the percentage of floor space occupied it occupies (i.e. 86.2%). IPD cost were subsequently allotted to the schistosomiasis policies using the ratios of expected very severe schistosomiasis inpatients at the PGH to the total number of annual admissions at the PGH (Table 8.18).

The maintenance cost of vehicles and motor cycles were prorated to the IPD on the basis of the time transport facilities would be used for IPD purposes (i.e. 51% of the time). IPD cost was then apportioned to very severe schistosomiasis policies using allocation factors in Table 8.18.

8.3.7.8 *Community resources*

The expected community input into very severe state policy combinations was estimated using the algorithm in Table 8.20, parameter values in Table 8.21 and the assumptions in Appendix 15.

8.3.8 *Cost analysis of very severe state policy combinations*

For every policy combination, present values of the following cost components were calculated: personnel time; in-service training; travel and transport; materials; drugs; administration; utilities; maintenance of vehicles, equipment and buildings; community resource inputs; and capital cost (vehicles, equipment and buildings). Itemized cost data can be obtained from the author. Otherwise exhibits of the itemized and detailed data are in Appendix 8. Appendix 4(D) summarizes flows of opportunity cost over various policy combinations. The preliminary CEA results are presented in Appendix 4(I). HPWS+PGHSO had the least average cost per EQALY. However, DM+PGHSO had the least incremental cost per EQALY. As mentioned earlier, it would be misleading to base decisions on these preliminary findings, without regard for choices made at other severity states. The cost figures in Appendix 4(D) are a major input into the cost-effectiveness and cost-benefit decision analysis models.

8.3.9 *Discussion of Parameter Values*

8.3.10.1 *The parameter values used in calculating community level treatment options drug needs*

This sub-section attempts to justify the use of various parameter values contained in Table 8.5 of chapter 8. The annual population growth rate (PG_t) of 4% was the forecast for Kirinyaga District in 1989 population census (Kenya Government, 1989). As the coverage of family planning programme service increases, the population growth rate may be expected to stabilize at 4%.

According to 1989 Kirinyaga District population census about 50% of the population is within the 0-15 year age bracket (Kenya Government, 1989). There was no reason to suppose that the population age structure would change over the intervention project life.

The assumed screening compliance rate (S_c) of 90% is fairly consistent with published schistosomiasis chemotherapy epidemiology studies (Sturrock et al., 1983; Muthami et al., 1986; Gryseels et al., 1987b; Gryseels et al., 1987a; and Butterworth et al., 1991). If the existing framework of community health workers and local

administrators is used in a consciously coordinated manner there may be no reason to suppose that even a higher compliance rate cannot be achieved.

The gross adjustment factor (GAF_t) components (i.e. L_m, AGE, A_H, E_m, N_c and O_T) were adopted from a chemotherapy study conducted in Mwea Irrigation Scheme in 1986 (Muthami et al., 1986). The percentage of the infected population expected to suffer the very severe and comatose states (AR_t) will be dependent on effectiveness of the intervention strategy under consideration.

The parameter values of KG1 (the average weight of those aged <= 15 years), KG2 (the average weight of those aged > 15 years), and W (% of capsules or tablets expected to be spoilt or wasted or lost) were adopted from WHO (1989b).

The oxamniquine and praziquantel dosages (D_o and D_p) used in this thesis are the standard dosages used in Kenya (Foster, 1987; Butterworth, 1991).

It was assumed that about 10% and 20% of the patients treated with praziquantel ($PEX\%_t$) and oxamniquine ($OEX\%_t$) would suffer negative side effects. According to Foster (1987) the only significant side effect of oxamniquine is mild or moderate dizziness with or without drowsiness, reported by up to about 40% of patients. In Gryseels et al. (1987b), 46.5% and 10% of the patients treated with oxamniquine and praziquantel were reported to have suffered dizziness. The latter authors went further to qualify that although dizziness was the most frequently reported side effect under praziquantel, it was never with the intensity observed after oxamniquine treatment. It was after an extensive review of the relevant literature and consultation with practising schistosomiasis epidemiologists/clinicians that a decision was made to use the parameter values stated above.

It was assumed that side effects would subside within a day (24 hours) after treatment. This assumption is consistent with empirical evidence (Gryseels et al., 1987b). However, the existing literature on the above issue is not conclusive (Foster, 1987).

In Muthami (1986) study in Mwea irrigation scheme had a treatment refusal rate (N_c) of 4.2% (i.e. a treatment compliance rate of 95.8%). That parameter value was used in chemotherapy options cost estimates. The above treatment non-compliance rate was close to compliance rates reported by other epidemiological studies done in Kenya (Sturrock et al., 1983; Butterworth et al., 1984). For example, Butterworth et al. (1985) reported compliance rates ranging from 92 to 98%. Similarly high levels of compliance have been reported in studies carried out in other countries where schistosomiasis is

endemic (Sleigh et al., 1981; Gryseels et al., 1987b).

It is assumed that all patients manifesting different schistosomiasis states will be detected by community health workers and referred to the appropriate health facilities for treatment. There are three assumptions implicit in the above assumption: a perfectly accurate system for detecting, differentiating patients suffering different severity states, 100% compliance with the referral advise, and 100% treatment compliance. The extent to which the first assumption would be realized depends on future development of techniques for identifying patients suffering different states. In principle 100% referral advise compliance and 100% treatment compliance could be achieved (may be at no incremental cost or at a minimal additional cost). Obviously, where compliance is a problem, the effectiveness of treatment options may fall below their ideal level of efficiency. Although the above assumptions may seem implausible, they are nevertheless "good" efficiency goals (or targets) to strive for. One could argue further that efficiency (and hence economic evaluation) is concerned with identification and implementation of optimal interventions.

A relevant question is: What would be the effects of high compliance rates assumed above on expected cost and benefits estimates? Since those assumptions apply equally to all policy combinations (facility-based options) under consideration, they are unlikely to affect the rankings of options. That ought to be the case if those assumptions lead to proportionate over-estimate of interventions effectiveness and costs. Thus, it might be like changing benefits and costs by a scalar (the magnitudes of net benefits would obviously change but the ranking are likely to remain invariant).

8.3.10.2 *The parameter values used in calculating community level treatment options drug needs*

This sub-section attempts to justify the use of various parameter values contained in Table 8.8 of chapter 8. The Mwea Scheme is made up of 38 villages (with a total of 4223 households); each administered by a village head nominated by village elders and the sub-location sub-chief. The village head acts as a 'liaison officer' between residents of his village, the local government administrative machinery, and various government ministries offices situated in the Mwea Division. A lot of power rests on those village heads. The chemotherapy compliance or non-compliance of the villagers they represent

depends largely on their good-will. In addition, since one of their daily roles is that of dispatching information, it was thought that they would be best placed to dispatch general information related to schistosomiasis chemotherapy activities.

It was assumed that each screening information dispatcher will spend on average 1 hour per household (V1). It is important that the information dispatcher takes time to explain the: purpose of the screening process, importance of all household members to participate, importance of supervising especially young children specimen extraction and packaging processes to avoid specimens getting mixed up, groups of medical personnel who will be conducting the exercise (from MoH), nearest specimen delivery centre, and dates within which specimens have to be delivered. The dispatchers will have to warn the household heads not to listen to any possible negative rumours concerning the exercise, explain that the intervention programme is sponsored by the government, and then reassure them that screening will automatically be followed by treatment of all those found infected.

It was assumed that since much of the explaining will have been done during the screening-information-dispatch phase, dispatchers would take on average 30 minutes per household to dispatch information related to therapy phase (V14).

Since the public transport system within the scheme is very poor, most of the people normally walk on foot to local health facilities, rice collecting centres, and local shopping centres. Thus, it was assumed that each household head delivering household specimens to collecting centres will spend on average 1 hour on a return journey to the nearest collecting centre on foot (V11). Patients would spend an equal amount of time on a return journey to a treatment centre (V16). It was assumed that the treating team would make conscious effort to plan treatment appointments so as to minimize patients waiting time (V20 = 30 minutes).

It was assumed that the treatment process (i.e. a short interview followed by dispensing of drugs) would take on average 10 minutes per patient (V23); each patient would be detained for 30 minutes to monitor side effects of schistosomal drugs (V26); 6 hours would be spent on externality treatment and clinical monitoring of those suffering side effects (V31). According to Foster (1987) treatment side effects would be reported within 3 hours after a chemotherapy dose and would normally last for 3 to 6 hours. The assumed detention time may be a conservative estimate, but its impact on expected cost estimate might be counteracted by the long duration assumed for

externality treatment and monitoring.

The parameter values used in calculating facility level options community inputs have been justified in the Appendix 11. Most of those parameter values were obtained from the past health services delivery studies conducted in Kenya (REACH, 1988; REACH, 1989; Forgey et al., 1990; MoH, 1992).

8.4 Summary

The procedures developed and used to estimate the opportunity costs of various primary options and policy combinations have been explained. The main preliminary findings are: the drip mollusciciding (DM) option at the primary level is the least costly option but also least beneficial; vented improved pit latrines (VIPL) is the most expensive option; mass population chemotherapy options (MPCP and MPCO) are more expensive and more effective that selective population chemotherapy options; the drug component constitutes over 75% of the annual cost of the mass population chemotherapy options (MPCP and MPCO); and community input in SPCP and SPCO constitutes about 10% of their annual costs; and cost per EQALY increases with increase in severity of health states. Reliance on these results must be tempered, however, because their accuracy depends on the accuracy of the subjective probabilistic effectiveness.

Table 8.1: Drug needs algorithm parameter label descriptions

N_t = Total population in year t
PG_t = Year t population growth rate
Sc = Screening compliance rate
NS_t = Number to participate in year t screening
P_t = Year t overall schistosomiasis prevalence rate
∂P_t = Year t change in prevalence rate
S_R = Kato test sensitivity
GAF_t = Gross adjustment factor in year t
L_M = % of the population lactating babies
AGE = % of the population below 2 years
A_H = % absent from home during treatment
E_M = % of mothers expecting babies
N_C = % of the population that would not comply with therapy
AR_t = % in severe and comatose states
OT = % on other treatments
$GAF = L_M + AGE + A_H + E_M + N_C + AR_t + OT$
AGE1 = % of the infected in aged <= 15 years
AGE2 = % of the infected in aged > 15 years
KG1 = Average weight of those aged <= 15 years
KG2 = Average weight of those aged > 15 years
D_P = Praziquantel dose per kilogramme of body weight
D_O = Oxamniquine dose per kilogramme of body weight
M_P = milligramme per praziquantel tablet
M_O = milligramme per oxamniquine capsule
W = % of capsules or tablets to be spoilt or wasted or lost
$DRUG_t$ = Quantity of drugs needed in year t
NI_t = Number infected in year t
$NAGE1_t$ = Number of those infected aged <= 15 years in year t
$NAGE2_t$ = Number of those infected aged > 15 years in year t
NIDt = Number of those infected to be detected in the test
$NIDE_t$ = Number of positives eligible for treatment
$NAGEKG1_t$ = Total body weight of those aged <= 15 years
$NAGEKG2_t$ = Total body weight of those aged > 15 years
$NAGEKG_t$ = Grand total body weight in year t
$DRUGP_t$ = Total praziquantel drug needs in year t
$DRUGO_t$ = Total oxamniquine drug needs in year t
$ADRUGP_t$ = $DRUGP_t$ adjusted for wastage and loss in year t
$ADRUGO_t$ = $DRUGO_t$ adjusted for wastage and loss in year t

Table 8.1 Continued

P_P = Price of praziquantel
P_O = price of oxamniquine
P_C = price of chlorpheniramine
SCF = standard conversion factor
$PDCOST_t$ = Cost of praziquantel needs in year t
$ODCOST_t$ = Cost of oxamniquine needs in year t
PEX_t = Number of patient under SPCP to suffer side-effects
OEX_t = Number of patient under SPCO to suffer side-effects
$PEX\%_t$ = % of patient under SPCP to suffer side-effects
$OEX\%_t$ = % of patient under SPCO to suffer side-effects
AGE3 = % of patients aged 2 years >= AGE3 <= 5 years
AGE4 = % of patient aged above 5 years
CMG = milligramme per chlorpheniramine tablet
DOSE3= recommended dose for those aged 2 year>=AGE3<=5years
Times3 = No. of doses per day for those aged 2 year >=AGE3 <=5 years
DOSE4= recommended dose for those aged > 5 years
Times4 = No. of doses per day for those aged > 5years
DAYS = Number of days externality treatment needed
$PEXD1_t$ = Number of externality drugs needed by those aged 2 year >=AGE3 <=5 years
$OEXD1_t$ = Number of externality drugs needed by those aged 2 year >=AGE3 <=5 years under SPCP
$PEXD2_t$ = Number of externality drugs for the > 5 years
$OEXD2_t$ = Number of externality drugs for the > 5 years
$PEXD_t$ = Grand total of externality drugs needed in SPCP
$OEXD_t$ = Grand total of externality drugs needed in SPCO
APEXDt = Adjusted externality drug needs under SPCP
AOEXDt = Adjusted externality drug needs under SPCO
EXPCOSTt = Cost of externality drug needs under SPCP in year t
EXOCOSTt = Cost of externality drug needs under SPCO in year t
$NAGEKG_t$ = Grand total body weight

Table 8.2: Schistosomiasis drug needs algorithm

STEP 1: Population of Mwea Scheme

$N_t = N_{t-1} + (N_{t-1} \times PG_t)$

STEP 2: Number of N_t to participate in screening

$NS_t = N_t \times S_C$

STEP 3: Number of NS_t infected

$NI_t = NS_t \times P_t$

STEP 4: Number of NI_t to be detected by the test

$NID_t = NI_t \times S_R$

STEP 5: Number of NID_t eligible for treatment

$NIDE_t = NID_t - (NID_t \times GAF_t)$

STEP 6: Number of $NIDE_t$ <= 15 years

$NAGE1_t = NIDE_t \times AGE1$

STEP 7: Number of $NIDE_t$ > 15 years

$NAGE2_t = NIDE_t \times AGE2$

STEP 8: Total body weight in $NAGE1_t$

$NAGEKG1_t = NAGE1_t \times KG1$

STEP 9: Total body weight in $NAGE2_t$

$NAGEKG2_t = NAGE2_t \times KG2$

STEP 10: Grand total body weight

$NAGEKG_t = NAGEKG1_t + NAGEKG2_t$

STEP 11(a): Praziquantel drug needs in year t

$DRUGP_t = NAGEKG_t \times (D_P / M_P)$

STEP 11(b): $DRUGP_t$ adjusted for wastage, spoilage and loss

$ADRUGP_t = DRUGP_t + (DRUGP_t \times W)$

STEP 12(a): Oxamniquine drug needs in year t

$DRUGO_t = NAGEKG_t \times (D_O / M_O)$

STEP 12(b): $DRUGO_t$ adjusted for wastage, spoilage and loss

$ADRUGP_t = DRUGO_t + (DRUGO_t \times W)$

STEP 13: Cost of praziquantel needs in year t

$PDCOST_t = (ADRUGP_t + P_P) * SCF$

STEP 14: Cost of oxamniquine needs in year t

$ODCOST_t = (ADRUGO_t + P_O) * SCF$

STEP 13: Projection of $PDCOST_t$ and $ODCOST_t$ over t=1,..,n

$PDCOST_{t+n} = PDCOST_{t-1} + (PDCOST_{t-1} \times PG_{t+n}) - (PDCOST_{t-1} + (PDCOST_{t-1} \times PG_{t+n})) \times \partial P_{t+n}$

Where $PDCOST_{t-1}$ is the preceding years drug needs; PG_{t+n} is the n^{th} year population growth rate; and ∂P_{t+n} is the n^{th} year change in schistosomiasis prevalence with i^{th} SPC regime.

Table 8.3: Externality drug needs algorithm

Chlorpheniramine Tablet needs under SPCP
STEP 1: Total number of patients likely to suffer side-effects
PEX_t = $NIDE_t$ x PEX%
STEP 2: Tablets needed by 2 years >= PEX_t <= 5 years
$PEXD1_t$ = PEX_t x AGE3 x (CMG/DOSE3) x TIMES3
STEP 3: Tablets needed by patients above 5 years
$PEXD2_t$ = PEX_t x AGE4 x (CMG/DISE4) x TIMES3
STEP 4: Grand total quantity of externality drugs
$PEXD_t$ = $PEXD1_t$ + $PEXD2_t$
STEP 5: Adjusted $PEXD_t$
$APEXD_t$ = $PEXD_t$ + ($PEXD_t$ x W)
STEP 6: $APEXD_t$ x P_C x SCF
Chlorpheniramine Tablet needs under SPCO
STEP 1: Total number of patients likely to suffer side-effects
OEX_t = $NIDE_t$ x OEX%
STEP 2: Tablets needed by 2 years >= PEX_t <= 5 years
$OEXD1_t$ = OEX_t x AGE3 x (CMG/DOSE3) x TIMES3
STEP 3: Tablets needed by patients above 5 years
$OEXD2_t$ = OEX_t x AGE4 x (CMG/DISE4) x TIMES3
STEP 4: Grand total quantity of externality drugs
$OEXD_t$ = $OEXD1_t$ + $OEXD2_t$
STEP 5: Adjusted $PEXD_t$
$AOEXD_t$ = $OEXD_t$ + ($OEXD_t$ x W)
STEP 6: $AOEXD_t$ x P_C x SCF

Table 8.4: The Mwea scheme annual population projections (n_t) used in chemotherapy policies cost estimates

Year	Number of people
1992	29561
1993	30743
1994	31973
1995	33252
1996	34582
1997	35965
1998	37404
1999	38900
2000	40456
2001	42074
2002	43757
2003	45507
2004	47327
2005	49220
2006	51189
2007	53237

Table 8.5: The parameter values used in the drug needs calculations

Labels	Parameter values
PG_t	4% per annum
S_C	90%
P_t	In appendix 1
GAF_t	L_m=2.9%; AGE=4.9%; A_H=12.5%; E_M=1.3%; N_C=4.2%; OT=0.044%; AR_t=variable
AGE1	50%
AGE2	50%
KG1	30kg
KG2	52 kg
D_P	40mg
D_O	30mg
M_P	600mg
M_O	250mg
W	10%
P_P	KSH. 142.26
P_O	KSH. 84.5
P_C	KSH. 0.5
PEX%	10%
OEX%	20%
AGE3	20%
AGE4	80%
CMG	4mg
DOSE3	2mg
TIMES3	3
DOSE4	4mg
TIMES4	4
DAYS	1

Table 8.6: Community input quantity estimation algorithm

Screening Phase:
Information dispatch time
V5 = [(V1 x V2 x V3) / V4]
Specimen packaging time
V6 = (V7 x V8) / V4
Specimen delivery time
V9 = (V10 x V11) / V4
Therapy information dispatch time
V12 = [(V13 x V2 x V14) / V4]
Adult patients treatment time
V15i = [(V16 x V17 x AGE2) / V4]
Young patients treatment time
V15j = [(V16 x V17 x AGE1) / V4] x 2
The above expression is multiplied by 2 because of the assumption that all children (<=15 years) would be accompanied by one adult to the treatment centres.
Adult Cases Waiting / queuing time
V18 = (V17 x V20 x AGE2) / V4
Young Cases Waiting / queuing time
V19 = [(V17 x V20 x AGE1) / V4] x 2
Adult cases treatment time
V21 = (V17 x V23 x AGE2) / V4
Children cases treatment time
V22 = [(V17 x V23 x AGE1) / V4] x 2
Adult Cases Externality Monitoring Time
V24 = (V17 x V26 x AGE2) / V4
Young Cases Externality Monitoring Time
V25 = [(V17 x V26 x AGE1) / V4] x 2
Externality Treatment Time Under SPCP
Adult patients
V27 = (V17 x V29 x V31 x AGE2) / V4
Young patients and accompanying adults
V28 = [(V17 x V29 x V31 x AGE1) / V4] x 2
Externality Treatment Time Under SPCO
Adult patients
V27 = (V17 x V30 x V31 x AGE2) / V4
Young patients and accompanying adults
V28 = [(V17 x V30 x V31 x AGE1) / V4] x 2

Table 8.7: Community resource algorithm variable descriptions

V1 = number of information dispatchers (village heads)
V2 = Hours spent in each household by a dispatcher
V3 = Number of households in Mwea Scheme
V4 = Hours per working day
V5 = Total number of days spent by households on information dispatch
V6 = Total number of community days spent on specimen extraction and packaging
V7 = Hours spent per person on extraction and packaging
V8 = Total number of individuals to participate in screening phase (equals NS_t)
V9 = Total number of community days spent on specimen delivery
V10 = Total number of household heads to deliver specimens to the collecting centres
V11 = Hours spent by a single household head on a return journey to specimen collecting centre on foot
V12 = Total number of days invested by community in therapy phase information dispatch
V13 = Number of dispatchers under therapy phase
V14 = Hours spent by each household head with a dispatcher
V15i = Total number of days invested by adult patients on travel to and from treatment centres
V15j = Total number of days invested by young patients (<=15 years) and accompanying adults on travel to and from treatment centres
V16 = Hours spent per patient on a return journey to a treatment centre
V17 = Total number of individuals participating in therapy phase (which would be equal to $NIDE_t$)
V18 = Total number of days spent by infected adults queuing for treatment
V19 = Total number of days spent by infected children and accompanying adults queuing for treatment
V20 = Number of queuing hours per patient

Table 8.7 Continued

V21 = Total number of days spent by adult patients on treatment
V22 = Total number of days spent by infected children and accompanying adults on treatment/consultation
V23 = Time in hours each patient would spend with a clinician
V24 = Total number of days spent by adult patients on externality monitoring
V25 = Total number of days spent by infected children and accompanying adults on externality monitoring
V26 = Hours each patient would be detained to monitor side effects
V27 = Total number of days spent by adult patients on externality care
V28 = Total number of days spent by infected children and accompanying adults on externality care
V29 = PEX% under SPCP
V30 = OEX% under SPCO
V31 = Hours spent per patient on treatment and monitoring of those suffering side effects

Table 8.8: The parameters use in estimating community input into selective population chemotherapy regimes

Label	Parameters
V1	38 village heads
V2	1 hour
V3	4223 households
V4	8 hours
V7	0.17 hours
V8	NS_t
V10	4223 household heads
V11	1 hour
V13	38 village heads
V14	0.5 hours
V16	1 hour
V17	$NIDE_t$
V20	0.5 hours
V23	0.17 hours
V26	0.5 hours
V29	10%
V30	20%
V31	6 hours

Table 8.9a: The total discounted cost of ten primary schistosomiasis interventions (in Ksh.)

YEAR	MPCO	MPCP	SPCO	SPCP	DM	FM	HPWS	HHED	VIPL	SQ
0	10,855,814	10,222,865	7,631,278	7,367,660	864,335	1,295,545	10,031,613	1,894,982	42,468,886	1,176,496
1	9,734,826	8,920,097	4,509,798	3,622,253	840,266	1,259,276	4,018,642	1,686,820	29,566,773	1,085,292
2	9,025,490	8,097,718	3,724,076	3,035,155	815,587	1,222,090	4,023,539	1,567,026	27,132,009	1,002,767
3	8,405,129	7,428,494	3,160,165	2,533,296	790,775	1,184,704	4,032,343	1,457,183	24,899,437	928,109
4	7,815,360	6,954,500	2,810,489	2,211,759	766,031	1,147,421	4,044,707	1,356,257	22,849,168	860,414
5	7,330,111	6,506,453	2,263,652	1,921,371	742,938	1,112,611	4,060,410	1,263,524	20,966,972	798,960
6	6,722,735	6,022,066	2,041,717	1,659,462	720,242	1,078,398	4,079,283	1,178,407	19,241,377	743,127
7	6,153,115	5,567,297	1,639,640	1,469,336	698,046	1,044,936	4,101,042	1,100,117	17,656,899	692,266
8	5,818,017	5,264,199	1,593,022	1,429,231	676,459	1,012,388	4,125,455	1,028,010	16,200,794	645,828
9	5,518,602	4,992,973	1,468,036	1,394,565	655,729	981,126	4,152,448	975,696	14,866,674	603,414
10	5,202,440	4,707,364	1,407,799	1,336,310	635,820	951,098	4,181,741	900,751	13,640,805	564,528
11	4,920,558	4,452,366	1,338,643	1,270,802	616,975	922,666	4,213,309	844,750	12,519,454	528,875
12	4,652,978	4,210,322	1,273,062	1,208,657	599,027	895,582	4,246,831	793,026	11,487,981	496,013
13	4,401,529	3,982,897	1,211,491	1,150,352	582,240	870,243	4,282,341	745,591	10,545,512	465,737
14	4,161,906	3,766,159	1,152,901	1,094,846	566,332	846,222	4,319,478	701,624	9,676,589	437,651
15	3,937,000	3,562,731	1,097,945	1,042,790	551,618	823,995	4,358,349	661,310	8,883,402	411,631
Total cost (Ksh)	104,655,610	94,658,500	38,323,714	33,747,846	11,122,422	16,648,300	72,271,530	18,155,072	302,602,731	11,441,109

Table 8.9b: A summary of cost-effectiveness of primary schistosomiasis interventions (in Ksh.)

YEAR	MPCO	MPCP	SPCO	SPCP	DM	FM	HPWS	HHED	VIPL	SQ
Cost per capita	162	147	59	52	17	26	112	28	469	18
AC per EQALY	292	264	118	104	41	61	373	104	1,601	83
Incremental per QALY*	422	377	143	119	-2	39	1,082	184	5,626	-

* (Cost of alternative option minus cost of SQ divided by EQALY from the alternative option minus EQALY from SQ)
** Note that this table represents only a partial cost-effectiveness analysis, because the cost and benefits beyond community level are ignored. This evidence supports the argument that, in an environment where decisions to intervene at different schistosomiasis severity states are taken in isolation (ignoring synergism between primary and secondary options), inefficiencies are inevitable. *** Incremental cost of the MPCPS (optimal strategy) was Ksh. -392 per EQALY

Table 8.10: Mild schistosomiasis state policies shared cost allocation basis

Year	SQ/DSS	HPWS/DSS	HHED/DSS	VIPL/DSS	DM/DSS	FM/DSS	MPCO/DSS	SPCO/DSS	MPCP/DSS	SPCP/DSS
0	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.27
1	0.29	0.28	0.28	0.28	0.27	0.27	0.06	0.14	0.06	0.14
2	0.31	0.28	0.29	0.28	0.27	0.27	0.07	0.15	0.07	0.15
3	0.33	0.29	0.30	0.29	0.26	0.26	0.07	0.15	0.07	0.15
4	0.35	0.29	0.32	0.29	0.26	0.26	0.07	0.16	0.07	0.16
5	0.37	0.30	0.33	0.30	0.25	0.25	0.07	0.16	0.07	0.16
6	0.39	0.31	0.34	0.31	0.25	0.25	0.08	0.16	0.08	0.16
7	0.41	0.31	0.36	0.31	0.24	0.24	0.08	0.15	0.08	0.15
8	0.44	0.32	0.37	0.32	0.24	0.24	0.08	0.15	0.08	0.15
9	0.46	0.32	0.39	0.32	0.23	0.23	0.09	0.14	0.09	0.14
10	0.49	0.33	0.40	0.33	0.22	0.22	0.09	0.14	0.09	0.14
11	0.52	0.33	0.42	0.33	0.21	0.21	0.09	0.14	0.09	0.14
12	0.55	0.34	0.43	0.34	0.20	0.20	0.10	0.15	0.10	0.15
13	0.58	0.34	0.45	0.34	0.18	0.18	0.10	0.15	0.10	0.15
14	0.62	0.35	0.47	0.35	0.17	0.17	0.11	0.16	0.11	0.16
15	0.65	0.35	0.49	0.35	0.16	0.16	0.11	0.17	0.11	0.17

Table 8.11: Community input algorithm parameter definitions

X_1 = the percentage of patients living within 5.1 KM, who would walk to the dispensary
X_2 = time taken by those to walk (return)
X_3 = the percentage of patients living beyond 5.1 KM, who would take a bus to the dispensary
X_4 = return journey time for those to travel by bus
X_5 = adults return bus fare
X_6 = children return bus fare
X_7 = percentage of patients to be accompanied by adults
X_8 = the number of mild, moderate, severe, very severe and comatose of patients expected to visit the dispensary, health centre, district hospital, provincial general hospital (PGH) inpatient department and PGH intensive care unit respectively
X_{9A} = total number of days the adult patients to walk are expected to spend on travel
X_{9Y} = total number of days the young patients and accompanying adults to walk are expected to spend on travel
X_{9AB} = total number of days the adult patients to travel by bus are expected to spend on travel
X_{9YB} = total number of days the young patients and accompanying adults to travel by bus are expected to spend on travel
$TTCOST_t$ = the value in Kenya Shillings of the total time the community is expected to spend on travel
X_{10} = total amount of money spent on travel
X_{11} = patients aged <= 15 years
X_{12} = patients aged > 15 years
X_{13} = length of a working day
X_{14} = total amount of money the adult patients are expected to spend on bus fare
X_{15} = total amount of money the young patients and accompanying adults are expected to spend on travel
$FARE_{t=n}$ = the total amount of money the community is expected to spend on bus fare
X_{16} = total days adult patients are expected to spend waiting for treatment
X_{17} = total days spent by youth and accompanying adults waiting for treatment
X_{18} = percentage of patients expected to wait for <= 1 hour
X_{19} = percentage of patients expected to wait for > 2 hours
$WTCOST_t$ = the money value of the total time the community is expected to spend waiting or queuing for treatment
X_{20} = time spent by each patient with clinician (or nurse)
X_{21} = total number of days adults patients are expected to spend with clinicians
X_{22} = total number of days young patients and accompanying adults are expected to spend with clinicians
$TRTCOST_t$ = the money value of total time the community is expected to spend on treatment time
X_{23} = total number of days spent by adult cases on externality monitoring

X_{24} = total number of days spent by young patients and accompanying adults on externality monitoring
X_{25} = hours spent per patient on monitoring side effects
X_{26} = percentage of patients expected to suffer side effects under praziquantel treatment combinations
X_{27} = percentage of patients expected to suffer side effects under oxamniquine treatment combinations
X_{28} = time spent per patient on externality care
X_{29} = total days spent by adult patients on praziquantel drug caused side effects treatment
X_{30} = total days spent by young patients and accompanying adults on praziquantel drug caused side effects treatment
X_{31} = total days spent by adult patients on oxamniquine drug caused side effects treatment
X_{32} = total days spent by young patients and accompanying adults on oxamniquine drug caused side effects treatment
X_{33} = casual wage rate (Ksh.)
X_{34} = total user fees paid by the community
X_{35} = user fee per person per visit
X_{36} = percentage of schistosomiasis patients eligible to pay user fees (i.e. those aged over 5 years)
X_{37} = total laboratory fees paid by the community
X_{38} = fees per test or x-ray in Kenya Shillings
X_{39} = number of tests or x-rays per patient
X_{40} = percentage eligible to pay laboratory or x-ray fees
X_{41} = total amount of money the community would be expected to pay in official mortuary fees
X_{42} = total amount of money the community expects to pay in mortuary
X_{43} = conditional probability of dying in a specific health state
X_{44} = official mortuary fees per dead body in Kenya Shillings
X_{45} = unofficial (bribery) mortuary fees per body in Shillings
X_{46} = Total number of cases to undergo screening in the dispensary in year t (t=0,..,15)
X_{47} = Average time it is expected to take to screen a single case

Table 8.12: An algorithm for community input into health state S - dispensary based policies

Travel Time

Adult patients walking time

$X_{9A} = (X_8 * X_1 * X_2 * X_{12}) / X_{13}$

Young patients and accompanying adults walking time

$X_{9Y} = [(X_8 * X_1 * X_2 * X_{11}) / X_{13}] * 2$

Adult patients travel time by bus

$X_{9AB} = (X_8 * X_3 * X_4 * X_{12}) / X_{13}$

Young patients and accompanying adults travel time by bus

$X_{9YB} = [(X_8 * X_3 * X_4 * X_{11}) / X_{13}] * 2$

Total Value of travel time

$TTCOST_{t=n} = (X_{9A} + X_{9Y} + X_{9AB} + X_{9YB}) * X_{33}$

Bus Fare

Adult patients bus fare

$X_{14} = (X_8 * X_3 * X_5 * X_{12})$

Young patients and accompanying adults bus fare

$X_{15} = (X_8 * X_3 * X_6 * X_{11}) + (X_8 * X_3 * X_5 * X_{11})$

Total Bus Fare

$FARE_{t=n} = X_{14} + X_{15}$

Waiting Time

Adult cases waiting time

$X_{16} = [(X_8 * X_{18} * 1 \text{ hour} * X_{12}) + (X_8 * X_{19} * 2 \text{ hours} * X_{12})] / X_{13}$

Young cases and accompanying adults waiting time

$X_{17} = [(X_8 * X_{18} * 1 \text{ hour} * X_{11}) + (X_8 * X_{19} * 2 \text{ hours} * X_{11})] / X_{13}$

Table 8.12 continued

Total Value of Waiting Time

$WTCOST_t = (X_{16} + X_{17}) * X_{33}$

Total Value of Treatment Time

$TRTCOST_{t=n} = (X_{21} + X_{22}) * X_{33}$

Treatment Time

Adult cases treatment time

$X_{21} = (X_8 * X_{20} * X_{12}) / X_{13}$

Young cases and accompanying adults treatment time

$X_{22} = ((X_8 * X_{20} * X_{11}) / X_{13}) * 2$

Externality monitoring time under praziquantel policies

Adult patients monitoring time

$X_{23} = (X_8 * X_{12} * X_{25}) / X_{13}$

Young cases and accompanying adults monitoring time

$X_{24} = [(X_8 * X_{11} * X_{25}) / X_{13}] * 2$

Total value of externality monitoring time

$XMONCOST_{t=n} = (X_{23} + X_{24}) * X_{33}$

Externality treatment time under praziquantel policies

Adult patients treatment time

$X_{29} = (X_8 * X_{26} * X_{12} * X_{28}) / X_{13}$

Young cases and accompanying adults treatment time

$X_{30} = [(X_8 * X_{26} * X_{11} * X_{28}) / X_{13}] * 2$

Total value of externality treatment time

$XTTCOST_{t=n} = (X_{29} + X_{30}) * X_{33}$

Table 8.12 Continued

Externality treatment time under oxamniquine policies
Adult patients treatment time
$X_{31} = (X_8 * X_{27} * X_{12} * X_{28}) / X_{13}$
Young cases and accompanying adults treatment time
$X_{32} = [(X_8 * X_{27} * X_{11} * X_{28}) / X_{13}] * 2$
Total value of externality treatment time
$XTTCOST_{t=n} = (X_{31} + X_{32}) * X_{33}$
Total Expected Community Expenditure on User Fees
$X_{34} = X_{35} * X_8 * X_{36}$
Total Community Expenditure on Laboratory or X-ray Fees
$X_{37} = X_8 * X_{38} * X_{39} * X_{40}$
Total community Expenditure on Mortuary Fees
Official Mortuary Fees
$X_{41} = X_8 * X_{43} * X_{44}$
Bribery Mortuary Fees
$X_{42} = X_8 * X_{43} * X_{45}$
Time invested in screening phase
$X_{48} = (X_{46} * X_{47}) / X_{13}$
Total Value of Screening Time
$SCOST = X_{48} * X_{33} * SCF$

Table 8.13: Parameters used in estimations of community input into mild state policy combinations

Label	Parameter values
X_1	82%
X_2	1.1 hours
X_3	18%
X_4	0.33 hours
X_5	Ksh. 20
X_6	Ksh. 10
X_7	50%
X_8	$N_t * SP_{jt}$
X_{11}	50%
X_{12}	50%
X_{13}	8 hours
X_{18}	63%
X_{19}	37%
X_{20}	0.33 hours
X_{25}	0.5 hours

Table 8.13 Continued

X_{26}	10%
X_{27}	20%
X_{28}	0.42 hours
X_{33}	Ksh. 40
X_{35}	Ksh. 0
X_{36}	0%
X_{38}	Ksh. 0
X_{39}	1
X_{40}	80%
X_{43}	$P(Q\|S) = 0$
X_{44}	Not applicable
X_{45}	Not applicable

Table 8.14 : Moderate schistosomiasis state policies shared cost allocation basis

Year	SQ/DSK	HPWS/DSK	HHED/DSK	VIPL/DSK	DM/DSK	FM/DSK	MPCO/DSK	SPCO/DSK	MPCP/DSK	SPCP/DSK
0	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
1	0.19	0.18	0.19	0.19	0.18	0.18	0.04	0.09	0.04	0.09
2	0.20	0.19	0.20	0.20	0.18	0.18	0.04	0.10	0.04	0.10
3	0.22	0.19	0.20	0.20	0.18	0.18	0.05	0.10	0.05	0.10
4	0.23	0.20	0.21	0.21	0.17	0.17	0.05	0.11	0.05	0.11
5	0.24	0.20	0.22	0.22	0.17	0.17	0.05	0.10	0.05	0.10
6	0.26	0.20	0.23	0.23	0.17	0.17	0.05	0.10	0.05	0.10
7	0.28	0.21	0.24	0.24	0.16	0.16	0.05	0.10	0.05	0.10
8	0.29	0.21	0.25	0.25	0.16	0.16	0.06	0.10	0.06	0.10
9	0.31	0.22	0.26	0.26	0.15	0.15	0.06	0.09	0.06	0.09
10	0.33	0.22	0.27	0.27	0.15	0.15	0.06	0.09	0.06	0.09
11	0.35	0.22	0.28	0.28	0.14	0.14	0.06	0.09	0.06	0.09
12	0.37	0.23	0.29	0.29	0.13	0.13	0.07	0.10	0.07	0.10
13	0.39	0.23	0.30	0.30	0.12	0.12	0.07	0.10	0.07	0.10
14	0.41	0.23	0.31	0.31	0.11	0.11	0.07	0.11	0.07	0.11
15	0.44	0.24	0.33	0.33	0.10	0.10	0.07	0.11	0.07	0.11

Table 8.15: Parameters used in estimations of community input into moderate policies

Label	Parameters
X_1	66%
X_2	1.1 hours
X_3	34%
X_4	0.33 hours
X_5	Ksh. 20
X_6	Ksh. 10
X_7	50%
X_8	$N_t * SP_{jt}$
X_{11}	50%
X_{12}	50%
X_{13}	8 hours
X_{18}	63%
X_{19}	37%
X_{20}	0.33 hours
X_{25}	0.5 hours
X_{26}	10%
X_{27}	20%
X_{28}	0.42 hours
X_{33}	Ksh. 40
X_{35}	Ksh. 0
X_{36}	0%
X_{38}	Ksh.10
X_{39}	1
X_{40}	80%
X_{43}	P(Q|K) = 0
X_{46}	36,000+(36,000*PG_t)
X_{47}	0.17 hours

Table 8.16: Severe schistosomiasis state policies shared cost allocation basis										
Year	SQ/DSZ	HPWS/DSZ	HHED/DSZ	VIPL/DSZ	DM/DSZ	FM/DSZ	MPCO/DSZ	SPCO/DSZ	MPCP/DSZ	SPCP/DSZ
0	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
1	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
2	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
3	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
4	0.03	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01
5	0.03	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.01	0.01
6	0.03	0.03	0.03	0.03	0.02	0.02	0.00	0.01	0.00	0.00
7	0.03	0.03	0.03	0.03	0.02	0.02	0.00	0.00	0.00	0.00
8	0.03	0.03	0.03	0.03	0.02	0.02	0.00	0.00	0.00	0.00
9	0.03	0.03	0.03	0.03	0.02	0.02	0.00	0.00	0.00	0.00
10	0.03	0.03	0.03	0.03	0.02	0.02	0.00	0.00	0.00	0.00
11	0.03	0.03	0.03	0.03	0.02	0.02	0.00	0.00	0.00	0.00
12	0.04	0.04	0.04	0.04	0.01	0.01	0.00	0.00	0.00	0.00
13	0.04	0.04	0.04	0.04	0.01	0.01	0.00	0.00	0.00	0.00
14	0.04	0.04	0.04	0.04	0.01	0.01	0.00	0.00	0.00	0.00
15	0.04	0.04	0.04	0.04	0.01	0.01	0.00	0.00	0.00	0.00

Table 8.17: Parameters used in estimations of community input into severe policy combinations	
Label	Parameter values
X_1	0%
X_2	0
X_3	100%
X_4	2 hours
X_5	Ksh. 60
X_6	Ksh. 30
X_7	50%
X_8	$N_t * SP_{jt}$
X_{11}	50%
X_{12}	50%
X_{13}	8 hours
X_{18}	63%
X_{19}	37%
X_{20}	1 hours
X_{25}	1 hours
X_{26}	10%
X_{27}	20%
X_{28}	0.42 hours
X_{33}	Ksh. 40
X_{35}	Ksh.20
X_{36}	80%
X_{38}	Ksh.100

Table 8.17: Continued	
X_{39}	1
X_{40}	80%
X_{43}	P(Q|Z) =
X_{44}	Ksh. 300
X_{45}	Ksh. 150
X_{46}	$OPDcases_{t0}$ from MD = 35439 $CASES_{t-1}+(CASES_{t-1} * PG_t)$
X_{47}	0.17 hours

Table 8.18: Very severe schistosomiasis state policies shared cost allocation basis

Year	SQ/DSA	HPWS/DSA	HHED/DSA	VIPL/DSA	DM/DSA	FM/DSA	MPCO/DSA	SPCO/DSA	MPCP/DSA	SPCP/DSA
0	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
1	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03	0.03
2	0.05	0.05	0.05	0.05	0.05	0.05	0.02	0.02	0.02	0.02
3	0.05	0.05	0.05	0.05	0.05	0.05	0.01	0.01	0.01	0.01
4	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00
5	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00
6	0.05	0.05	0.05	0.05	0.05	0.05	0.00	0.00	0.00	0.00
7	0.06	0.06	0.06	0.06	0.05	0.05	0.00	0.00	0.00	0.00
8	0.06	0.06	0.06	0.06	0.05	0.05	0.00	0.00	0.00	0.00
9	0.06	0.06	0.06	0.06	0.05	0.05	0.00	0.00	0.00	0.00
10	0.06	0.06	0.06	0.06	0.05	0.05	0.00	0.00	0.00	0.00
11	0.07	0.07	0.07	0.07	0.05	0.05	0.00	0.00	0.00	0.00
12	0.07	0.07	0.07	0.07	0.06	0.06	0.00	0.00	0.00	0.00
13	0.07	0.07	0.07	0.07	0.06	0.06	0.00	0.00	0.00	0.00
14	0.07	0.07	0.07	0.07	0.06	0.06	0.00	0.00	0.00	0.00
15	0.08	0.08	0.08	0.08	0.06	0.06	0.00	0.00	0.00	0.00

Table 8.19: Parameter definitions

A_1 = Number of Mwea population to suffer very severe state each year with policy combination j_{th} in place
A_2 = percentage of A_1 to seek care at Nyeri PGH
A_3 = percentage of A_1 to travel by bus
A_4 = percentage of A_1 to travel by hired car
A_5 = return journey time by bus
A_6 = return journey time by car hire
A_7 = Number of adults to accompany each patient
A_8 = Number of visitors per patient per day
A_9 = Average length of hospital stay
A_{10} = percentage of patients to die each year [=P(Q|A)] under the PGHDM policy combinations
$A1_{0i}$ = percentage of patients to die each year [=P(Q|A)] under the PGHSO policy combinations
A_{11} = Average number of or relatives and friends to accompany each dead body home
A_{12} = percentage of the dead to be transported home by hired cars
A_{13} = hours to be spent by each of the 6 relatives or /and friends overseeing the washing, treatment and dressing of the departed members body
A_{14} = Return fare by bus
A_{15} = Return fare by car hire
A_{16} = total number of days spent by patients on one-way travel
A_{17} = length of working day
A_{18} = total numbers of days to be spent by adults to accompany patients during the first day (admission day)
A_{19} = total number of days to be spent visiting hospitalized patients
A_{20} = total number of days to be spent with patients

Table 8.19: Continued

A_{21} = average number of hours to be spent by each visitor with each patient
A_{22} = total days to be spent those discharged home alive on travel, under PGHDM policy combinations
A_{23} = total days to be spent by the relative accompanying those discharged home alive on travel, under PGHDM policy combinations
A_{24} = percentage of patients to be discharged alive under PGHDM (1-P(Q|A)
A_{25} total number of days spent by relatives supervising body washing and dressing under PGHDM policy combinations
A_{26} = total number of days spent by relatives to collect the body and transport it home under PGHDM
A_{27} = total days to be spent by those who would be discharged alive travelling home under PGHSO
A_{28} = total days to be spent by the relatives accompanying those discharged home alive under PGHSO
A_{29} = total number of days spent by relatives supervising body washing and dressing under PGHSO
A_{30} = total number of days spent by relatives to collect the body and transport it home under PGHSO
A_{31} = percentage of patients expected to be discharged alive under PGHSO
A_{32} = total number of admissions in general at the Nyeri PGH A_{33} = Kirinyaga District share of the PGH admissions
A_{34} = Mwea share of patients admitted at the PGH from Kirinyaga district
A_{35} = percentage of PGH patients aged <= 15 years
A_{36} = percentage of PGH patients aged > 15 years
A_{37} = admission process and x-ray time per patient
A_{38} = total number days to be spent undergoing X-ray and on admission process
A_{39} = total fare by bus to be incurred by all patients to the PGH
A_{40} = total fare to be incurred by the patients to use car hire

Table 8.19 Continued

A_{41} = total amount of money to be spent on bus fare by accompanying adults
A_{42} = Total expenditure on bus fare by visitors
A_{43} = total fare to be spent by patients discharged home alive, under PGHDM
A_{44} = total fare of adults accompanying survivors home under PGHDM
A_{45} = total cost of transporting the dead home under PGHDM
A_{46} = total fare to be spent by patients discharged home alive, under PGHSO
A_{47} = total fare of adults accompanying survivors home under PGHSO
A_{48} = total cost of transporting the dead home under PGHSO
A_{49} = total expected expenditure on bus fare for patient discharged alive
A_{50} =total expected expenditure on bus fare for relatives to accompany patients discharged alive, home
A_{51} = Total expected community expenditure on user fees
A_{52} = User fees per patient day
A_{53} = Percentage of schistosomiasis cases eligible to pay user fees
A_{54} = total expected community expenditure on X-rays
A_{55} = fees per X-ray film
A_{56} = average number of X-rays per person
A_{57} = number eligible to pay x-ray fees
A_{58} = total amount of money the community is expected to spend on mortuary fees under PGHDM policy combinations
A_{59} = total amount of money the community expects to pay in terms of mortuary bribes
A_{60} = Official mortuary fees per dead body
A_{61} = average bribe in Kenya Shillings per body

Table 8.20: Community input into very severe state PGH-based policies algorithm

Travel time

(a) Patients One-way

$X_{16}=[(A_1 * A_2 * A_3 * A_5)/2)+((A_1 * A_2 * A_4 * A_6)/2]/A_{17}$

The terms in brackets are divided by 2, since patients would not be returning home the same day

(b) Accompanying adults return

$X_{18}=[(A_1 * A_2 * A_3 * A_5 * A_7)+((A_1*A_2*A_4*A_6*A_7)]/A_{17}$

(c) Visitors travel time

$A_{19} = (A_1 * A_2 * A_8 * A_9 * A_5) / A_{17}$

(d) Visitor time with patients

$A_{20} = (A_1 * A_2 * A_8 * A_9 * A_{21}) / A_{17}$

PGHDM policy combinations

(e) Alive discharges home journey under PGHDM

$A_{22} = [(A_1 * A_2 * A_7 * A_{24} * A_5) / A_{17}] / 2$

(f) Relatives accompanying those discharged home alive

$A_{23} = [(A_1 * A_2 * A_7 * A_5 * A_{24}) / A_{17}]$

(g) Relatives and friends overseeing preparation of bodies under PGHDM policy combinations

$A_{25} = [(A_1 * A_2 * A_{10} * A_{11} * A_{13}) / A_{17}]$

(h) Relatives and friends taking the bodies home under PGHDM

$A_{26} = [(A_1 * A_2 * A_{10} * A_{11} * A_6) / A_{17}]$

Table 8.20: Continued

PGHSO policy combinations

(i) Alive discharges home journey under PGHSO

$A_{27} = [(A_1 * A_2 * A_7 * A_{31} * A_5) / A_{17}] / 2$

(j) Relatives accompanying those discharged home alive under PGHSO

$A_{28} = [(A_1 * A_2 * A_7 * A_5 * A_{31}) / A_{17}]$

(k) Relatives and friends overseeing preparation of bodies under PGHSO policy combinations

$A_{29} = [(A_1 * A_2 * A_{10i} * A_{11} * A_{13}) / A_{17}]$

(l) Relatives and friends taking the bodies home under PGHSO

$A_{30} = [(A_1 * A_2 * A_{10i} * A_{11} * A_6) / A_{17}]$

Admission and x-ray time

(a) Patients time

$A_{38} = (A_{32} * A_{33} * A_{34} * A_{37}) / A_{17}$

All patients from Mwea Division, presenting themselves at the PGH, have to undergo barium swallow x-ray

(b) Accompanying adults time

$A_{38} = (A_{32} * A_{33} * A_{34} * A_{37} * A_7) / A_{17}$

MONEY EXPECTED TO BE SPENT ON TRANSPORT

PGHDM Policy Combinations

(a) Patients bus one-way fare

$A_{39}=[(A_1 * A_2 * A_3 * A_{35} * A_{14}) / 2$
$+((A_1 * A_2 * A_3 * A_{36} * A_{14i}) / 2$

(b) Car hire return fare

$A_{40}= (A_1 * A_2 * A_4 * A_{15})$

The car hire charges are the same for adults and children. Remember also car hire charges do not vary with the number of passengers, thus avoid double counting.

(c) Accompanying adults return bus fare

$A_{41}=[(A_1 * A_2 * A_3 * A_7 * A_{17})$

(d) Visitors bus fare

$A_{42}=[(A_1 * A_2 * A_8 * A_9 * A_{14})$

Table 8.20: Continued

(e) patients hospital to home fare

$A_{43}=[(A_1 * A_2 * A_{24} * A_{35} * A_{14}) / 2$
$+((A_1 * A_2 * A_{24} * A_{36} * A_{14i}) / 2$

(f) Accompanying adults return fare

$A_{44}= (A_1 * A_2 * A_{24} * A_{35} * A_{14})+(A_1 * A_2 * A_{24} * A_{36} * A_{14i})$

PGHSO Policy Combinations

(a) Patients bus one-way fare

$A_{45}=[(A_1 * A_2 * A_3 * A_{35} * A_{14}) / 2$
$+((A_1 * A_2 * A_3 * A_{36} * A_{14i}) / 2$

(b) Car hire return fare

$A_{46}= (A_1 * A_2 * A_4 * A_{15})$

The car hire charges are the same for adults and children. Remember also car hire charges do not vary with the number of passengers, thus avoid double counting.

(c) Accompanying adults return bus fare PGHSO

$A_{47}=[(A_1 * A_2 * A_3 * A_7 * A_{17})$

(d) Visitors bus fare

$A_{48}=[(A_1 * A_2 * A_8 * A_9 * A_{14})$

(e) patients hospital to home fare under PGHSO

$A_{49}=[(A_1 * A_2 * A_{31} * A_{35} * A_{14}) / 2$
$+((A_1 * A_2 * A_{31} * A_{36} * A_{14i}) / 2$

(f) Accompanying adults return fare under PGHSO

$A_{50}= (A_1 * A_2 * A_{31} * A_{35} * A_{14})+(A_1 * A_2 * A_{31} * A_{36} * A_{14i})$

Total Expected Community Expenditure on User Fees

$A_{51} = A_1 * A_2 * A_{52} * A_{53}$

Total Community Expenditure on Laboratory or X-ray Fees

$A_{54} = A_1 * A_2 * A_{55} * A_{56} * A_{57}$

Total community Expenditure on Mortuary Fees

Official Mortuary Fees under PGHDM

$A_{58} = A_1 * A_2 * A_{10} * A_{60}$

Bribery Mortuary Fees under PGHDM

$A_{59} = A_1 * A_2 * A_{10} * A_{61}$

Official Mortuary Fees under PGHSO

$A_{62} = A_1 * A_2 * A_{10i} * A_{60}$

Bribery Mortuary Fees under PGHSO

$A_{63} = A_1 * A_2 * A_{10i} * A_{61}$

Table 8.21: Parameters used in estimations of community input into very severe policy combinations

Label	Parameters
A_1	$= N_i * PA_{ij}$
A_2	100%
A_3	80%
A_4	20%
A_5	3 hours
A_6	1.5 hours
A_7	1
A_8	1
A_9	13
A_{10}	90%
A_{11}	6
A_{12}	100%
A_{13}	2 hours
A_{14} A_{14i}	Ksh. 100 Ksh. 50
A_{15}	Ksh. 2000

Table 8.21: Continued	
A_{17}	8 days
A_{21}	0.5 hours
A_{24}	10%
A_{10i}	85%
A_{31}	15%
A_{32}	$A32_{t0} = 27366$ $A32_{t=N} = A32_{t-1}+(A32_{t-1}*PG_t)$
A_{33}	25%
A_{34}	33%
A_{35}	50%
A_{36}	50%
A_{37}	2 hours
A_{52}	Ksh. 20
A_{53}	80%
A_{55}	Ksh. 100

PART IV:
COST EFFECTIVENESS AND COST BENEFIT DECISION ANALYSES MODELS EMPIRICAL RESULTS AND CONCLUSIONS

CHAPTER 9
DECISION ANALYSIS RESULTS

9.0 Introduction

A strategy was defined (section 5.4.2) as consisting of a single primary intervention combined with all secondary options available to the mild, moderate, severe, very severe and comatose cases. A policy combination was defined as a single secondary intervention preceded by a single primary intervention. Thus, the word combination is used in this thesis to show the synergistic relationship between primary policies and secondary policies. The cost-benefit or cost-effectiveness behaviour of secondary options depends on the effectiveness of the underlying primary policy.

Cost-benefit and cost-effectiveness decision analysis models were estimated to determine whether they would yield similar results. In other words, whether they would nominate the same path of efficient options across all the health states.

As explained in earlier chapters, the purpose of this thesis was to develop decision theoretic framework(s) which could be used to determine the optimal schistosomiasis intervention strategy. This chapter reports the results obtained when both CBDA and CEDA models were run with the international expert's subjective probability forecasts. The two sequential decision models (discussed in chapter 6) were estimated - using the cost effectiveness and cost benefit analyses criteria to help identify an efficient path of options across all the health states. Results from the two models are presented and discussed in sections 9.1.0 and 9.2.0. Section 9.3.0 is a comparison of the results from the two models.

9.1 Results of Cost Effectiveness Decision Analysis ModeL

9.1.1 *Net effectiveness results*

The cost effectiveness decision analysis model (MODEL 1 in DISK A) evaluated nine schistosomiasis intervention **strategies**; namely, the status quo (SQS), household piped water supply (HPWSS), household health education visits (HHEDS), vented improved pit latrines (VIPLS), drip molluscicide (DMS), mass population chemotherapy with praziquantel (MPCPS), mass population chemotherapy with oxamniquine (MPCOS), selective population chemotherapy with praziquantel (SPCPS), and selective population chemotherapy with oxamniquine (SPCOS). Each strategy has a primary or community level policy plus various health facilities treatment options available to the patients suffering different schistosomiasis states.

The CEDA model used the net effectiveness decision criteria discussed in chapter 6. Net effectiveness (NE) values for the nine strategies are positive (Table 9.1); thus each of the nine is worth implementing. The strategies with treatment at the community and secondary levels are more effective than those with non-treatment policies at the community level. The selective MPCPS had the highest net effectiveness value. Contrastingly, when the same model was run with local experts subjective probabilities, SPCPS turned out to be the optimal strategy. Thus, estimation of the decision analysis models with an international expert's subjective probabilities led to a switch in the choice of optimal strategy from SPCPS to MPCPS.

Appendix 10(A) summarizes the sensitivity analysis results to changes in EQALYs and opportunity cost. Analysis of the impacts of systematic changes in EQALYs and the opportunity cost on the choice of optimal strategy was done; holding the expected cost constant. The sensitivity results were mixed. When the expected QALYS and opportunity cost were varied 'across-the-board' by over 80%, choice of the MPCPS as the optimal strategy remained invariant. However, the choice of MPCPS as the optimal strategy was found to be extremely sensitive to minor variations (1% change) in its effectiveness with the effectiveness of other strategies held constant.

9.1.2 *Results of policy combinations net effectiveness*

The **optimal strategy's** policy combinations' net effectiveness values are given in Table 9.2. It is important to note that all the health state options under the optimal strategy will have been preceded by MPCP treatment at the primary level.

(a) Mild Schistosomiasis state

It will be recalled (subsection 5.2.1) that there are three sub-options: status quo at the dispensary (MPCP+SQD); praziquantel care at the dispensary (MPCP+PCD); and oxamniquine care at the dispensary (MPCP+OCD). All the three options were worthwhile doing since they had positive NE. The NE relationships were as follows: $NE_{MPCP+PCD}>NE_{MPCP+OCD}>NE_{MPCP+SQD}$. The NE criteria requires that the MPCP+PCD treatment should be given to mild schistosomiasis patients, because it would yield the greatest net benefit.

(b) Moderate schistosomiasis state (K)

It will be recalled (subsection 5.2.2) that there are three sub-options: status quo at the Health Centre (MPCP+SQHC); praziquantel care at the Health Centre (MPCP+PCHC); and oxamniquine care at the Health Centre (MPCP+OCHC). The three options' NE values were positive. The NE relationships were as follows: $NE_{MPCP+PCHC}>NE_{MPCP+OCHC}>NE_{MPCP+SQHC}$. Net incremental effectiveness criteria dictates that the MPCP+PCHC treatment should be given to moderate schistosomiasis patients, since it would yield the highest expected net benefit.

(c) Severe schistosomiasis state (Z)

The three options are: status quo at the District Hospital (MPCP+SQDH); praziquantel care at the District Hospital (MPCP+PCDH); and oxamniquine care at the District Hospital (MPCP+OCDH). The three options are worthwhile doing, having positive NE values. The three rank as follows: $NE_{MPCP+SQDH}>NE_{MPCP+PCDH}>NE_{MPCP+OCDH}$. Since MPCP+SQDH dominates the other two, the status quo therapy at the District Hospital outpatient department should be continued for severe schistosomiasis cases.

(d) Very severe schistosomiasis state (A)

The three options are: Provincial General Hospital status quo (MPCP+PGHSQ); Provincial General Hospital inpatient department palliative drug management (MPCP+PGHDM); and Provincial General Hospital surgical operation (MPCP+PGHSO). The analysis shows that MPCP+PGHSQ is not worth doing, since its NE value is

negative. However, the two alternative options are worthwhile doing, since they have positive NE values. The three rank as follows: $NE_{MPCP+PGHSO}>NE_{MPCP+PGHDM}>NE_{MPCP+PGHSQ}$. Since MPCP+PGHSO dominates the other two, the very severe schistosomiasis cases should be given surgical operation at the Provincial General Hospital Surgical Department. Unlike the local experts, the international expert was of the opinion that coma state is irrelevant in schistosomiasis, thus there was no justification for estimating costs and effectiveness of comatose treatment options.

9.2 Results of Cost Benefit Decision Analysis Model

The cost-benefit decision analysis (CBDA) model was first estimated with health states WTP values for return to normal health, and then with WTP values to avoid advancing to the following more severe state (Table 7.12 and MODEL 2 and 3 in Disk A). The CBDA model was run with the two sets of data to determine whether there would be any change in the choice of optimal path of interventions. The CBDA model employed the expected net present value decision criterion (discussed in chapter 6) which requires that only those strategies or policy combinations with positive net present values (NPVs) should be accepted for implementation. Where there is more than one mutually exclusive strategy or option, that with the highest NPV should be implemented. By implication, any current practice found to be having a negative net present value should be terminated.

9.2.1 *NPV results of strategies*

Models 2 and 3 (in DISK A) are full cost-benefit decision analysis models. Tables 9.3 and 9.5 provides the expected NPVs (from the two models) of the nine strategies listed in preceding section. The magnitude of the NPV indicates by how much Mwea community will be better off in terms of present consumption. The two models produced different results. The CBDA model was first estimated using WTP for return to normal. All the strategies passed the NPV decision criteria (i.e. NPV >= 0) (Table 9.3). The expected net improvement in health related welfare from the nine strategies can be expressed as follows:

$NPV_{SPCPS}>NPV_{SPCOS}>NPV_{MPCPS}>NPV_{MPCOS}>NPV_{DMS}>NPV_{HHEDS}>NPV_{HPWSS}>NPV_{SQS}>N$

PV_{VIPLS}. Assuming that the nine strategies are mutually exclusive, SPCPS should be undertaken since it dominates.

The CBDA model was then estimated using WTP to avoid advancing to the next state. All the strategies passed the NPV decision criteria (i.e. NPV >= 0) (Table 9.5). The expected net improvement in health related welfare from the nine strategies can be expressed as follows:

$NPV_{MPCPS}>NPV_{MPCOS}>NPV_{SPCPS}>NPV_{SPCOS}>NPV_{DMS}>NPV_{HHEDS}>NPV_{SQS}>NPV_{HPWSS}>N$ PV_{VIPLS}. Assuming that the nine strategies are mutually exclusive, MPCPS should be undertaken since it dominates.

The sensitivity analysis results were mixed (Appendix 10(B)). The choice of the optimal strategy was invariant to 'across-the-board' changes in the expected monetary values; with expected cost held constant. However, the choice of the optimal strategy was found to be extremely sensitive to minor variations (1% change) in its effectiveness with the effectiveness of other strategies held constant.

9.2.2 *NPV results of policy combinations (with WTP for return to normal)*

Table 9.4 provides the NPVs of the efficient secondary (facility level) options within the optimal strategy (SPCPS). It is important to remember that all health state options under consideration below are to be preceded by SPCP primary policy. Thus, they are combinations.

(a) Mild Schistosomiasis State

SPCP+SQD, SPCP+PCD and SPCP+OCD, are the three mutually exclusive options at the Dispensary for patients in mild schistosomiasis. Their NPVs were found to be positive. NPVs of the three can be arranged as follows:

$NPV_{SPCP+PCD}>NPV_{SPCP+OCD}>NPV_{SPCP+SQD}$. NPV rule demands that the praziquantel care (SPCP+PCHC) should be given at the dispensary to those suffering mild disease.

(b) Moderate Schistosomiasis State

SPCP+SQHC, SPCP+PCHC and SPCP+OCHC, are the three mutually exclusive options available at the Health Centre to those in moderate schistosomiasis state. Their NPVs were positive; and could be expressed as follows:$NPV_{SPCP+SQHC}>NPV_{SPCP+PCHC}>NPV_{SPCP+OCHC}$. Since SPCP+SQHC had the highest NPV, the status quo should be continued at the health centre for patients presenting

themselves with moderate schistosomiasis.

(c) Severe Schistosomiasis State

SPCP+SQDH, SPCP+PCDH and SPCP+OCDH, are the three mutually exclusive policies available at the District Hospital for severe schistosomiasis cases. Their NPVs were positive; and could be expressed as follows: $NPV_{SPCP+SQDH}>NPV_{SPCP+PCDH}>NPV_{SPCP+OCDH}$. According to the NPV rule, status quo treatment (SPCP+SQDH) should be continued at the District Hospital Out Patient Department for severe schistosomiasis cases.

(d) Very Severe Schistosomiasis State

SPCP+PGHSQ, SPCP+PGHDM and SPCP+PGHSO, are the three mutually exclusive interventions available at the Provincial General Hospital for the very severe schistosomiasis cases. The NPVs of the three were positive in Model 2. Their NPVs could be expressed as follows: $NPV_{SPCP+PGHSO}>NPV_{SPCP+PGHDM}>NPV_{SPCP+PGHSQ}$. Thus, SPCP+PGHSO should be given at the Provincial General Hospital Surgical Department to very severe schistosomiasis cases.

9.2.3 *NPV results of policy combinations (with WTP to avoid advancing to the next state)*

Table 9.6 provides the NPVs of the efficient secondary (facility level) options within the optimal strategy (MPCPS). It is important to remember that all health state options under consideration below are to be preceded by MPCP primary policy. Thus, they are combinations.

(a) Mild Schistosomiasis State

MPCP+SQD, MPCP+PCD and MPCP+OCD, are the three mutually exclusive options at the Dispensary for patients in mild schistosomiasis. Their NPVs were found to be positive. NPVs of the three can be arranged as follows: $NPV_{MPCP+PCD}>NPV_{MPCP+OCD}>NPV_{MPCP+SQD}$. NPV rule demands that the praziquantel care (MPCP+PCHC) should be given at the dispensary to those suffering mild disease.

(b) Moderate Schistosomiasis State

MPCP+SQHC, MPCP+PCHC and MPCP+OCHC, are the three mutually exclusive options available at the Health Centre to those in moderate schistosomiasis state. Their NPVs were positive; and could be expressed as follows:

$NPV_{MPCP+PCHC}>NPV_{MPCP+OCHC}>NPV_{MPCP+SQHC}$. Since MPCP+PCHC had the highest NPV, the praziquantel care (MPCP+PCHC) should be given at the health centre to patients presenting themselves with moderate schistosomiasis.

(c) Severe Schistosomiasis State

MPCP+SQDH, MPCP+PCDH and MPCP+OCDH, are the three mutually exclusive policies available at the District Hospital for severe schistosomiasis cases. Their NPVs were positive; and could be expressed as follows:
$NPV_{MPCP+PCDH}>NPV_{MPCP+OCDH}>NPV_{MPCP+SQDH}$. According to the NPV rule, the praziquantel care (MPCP+PCDH) should be provided at the District Hospital Out Patient Department to severe schistosomiasis cases.

(d) Very Severe Schistosomiasis State

MPCP+PGHSQ, MPCP+PGHDM and MPCP+PGHSO, are the three mutually exclusive interventions available at the Provincial General Hospital for the very severe schistosomiasis cases. The NPVs of the three were positive in Model 3. Their NPVs could be expressed as follows: $NPV_{MPCP+PGHSO}>NPV_{MPCP+PGHDM}>NPV_{MPCP+PGHSQ}$. Thus, MPCP+PGHSO should be given at the Provincial General Hospital Surgical Department to very severe schistosomiasis cases.

9.3 A Comparison of the Cost-Effectiveness and Cost-Benefit Decision Analysis Models Results

In the CBDA and CEDA models, (a) all the schistosomiasis intervention strategies passed the NE and NPV tests; (b) all strategies which involve treatment at the community level were superior than those with non-treatment community level policies; (c) in both CEDA and CBDA (with WTP to avoid advancing to the next state) the mass population chemotherapy with praziquantel (MPCPS) was found to be the optimal strategy, and their choice of optimal policy combinations was also fairly similar; (d) in CBDA model (with WTP for return to normal) the selective population praziquantel chemotherapy (SPCPS) was found to be the optimal strategy; (e) the sensitivity analysis results were mixed. The non-conclusive nature of the above results indicate that no firm policy conclusions can be drawn from the results of this thesis; and more research is urgently required to establish both validity and reliability of the QoL, WTP and DT procedures developed and operationalized in this thesis.

9.4 Summary

Two decision theoretic models (CBDA and CEDA) were developed and their operational feasibility demonstrated. The chapter also demonstrated that the choice of the optimal strategy and associated policy combinations is very sensitive to adoption of different sets of subjective probabilities. The results obtained in this thesis should **strictly be considered as illustrative**, until their validity and reliability (plus the validity and reliability of associated measurement instruments) has been ascertained.

Table 9.1: Net Effectiveness of schistosomiasis intervention strategies (estimated using international experts' subjective probabilities)			
STRATEGIES	NE (IN KSH.)	INTERNATIONAL EXPERT RANKINGS	LOCAL EXPERTS RANKINGS
SQS	7,503,007,748	7	9
HPWSS	7,422,946,574	8	6
HHEDS	7,670,324,590	6	7
VIPLS	7,149,375,151	9	8
DMS	8,055,543,102	5	5
MPCPS	8,542,640,008	1	2
MPCOS	8,504,777,076	2	4
SPCPS	8,498,721,476	3	1
SPCOS	8,477,514,465	4	3

Table 9.2: Net effectiveness of secondary options under the optimal schistosomiasis intervention strategy - MPCPS (estimated using international experts' subjective probabilities)

Health State	Secondary Options	Net Effectiveness	Value of EQALYs	Cost (Ksh)
Y	MPCP+Y	7,258,800,552	7,353,459,052	94,658,500
S	MPCP+SQD	514,773,956	524,360,101	9,586,145
	MPCP+PCD	627,322,953	642,598,163	15,275,210
	MPCP+OCD	626,725,412	642,598,163	15,872,751
K	MPCP+SQHC	440,359,275	452,499,740	12,140,465
	MPCP+PCHC	560,821,385	595,688,497	34,867,112
	MPCP+OCHC	560,359,308	595,688,497	35,329,189
Z	MPCP+SQDH	90,492,536	104,410,691	13,918,155
	MPCP+PCDH	81,359,599	116,688,788	35,329,189
	MPCP+OCDH	70,798,659	116,688,788	45,890,129
A	MPCP+PGHSQ	-1,140,630	20,878,303	22,018,933
	MPCP+PGHDM	4,839,813	27,415,280	22,575,467
	MPCP+PGHSO	5,202,582	27,415,280	22,212,697

Table 9.3: NPVs of schistosomiasis control strategies (using WTP for return to normal and international experts' subjective probabilities)

STRATEGIES	NPV (in Ksh.)	International Experts Rankings	Local Experts rankings
SQS	8,324,380,236	8	9
HPWSS	8,375,488,234	7	6
HHEDS	8,500,085,157	6	8
VIPLS	7,988,015,854	9	7
DMS	8,588,939,685	5	5
MPCPS	8,667,425,726	3	2
MPCOS	8,639,684,126	4	4
SPCPS	8,717,362,966	1	1
SPCOS	8,698,501,705	2	3

Table 9.4: NPVs of the optimal strategy secondary options (with WTP for return to normal health and international experts' subjective probabilities)

HEALTH STATE	OPTION	NPV (Ksh.)	GPV(EMV)	GPV(COST)
Y	SPCP+DNY	6,446,718,825	6,480,466,671	33,747,846
S	SPCP+SQD	992,966,424	1,000,804,271	7,837,846
	SPCP+PCD	1,001,163,738	1,014,886,056	13,722,318
	SPCP+OCD	1,000,545,221	1,014,886,056	14,340,835
K	SPCP+SQHC	980,368,446	990,412,219	10,043,772
	SPCP+PCHC	975,786,810	1,009,283,195	33,496,384
	SPCP+OCHC	975,311,180	1,009,283,195	33,972,015
Z	SPCP+SQDH	239,553,241	253,467,386	13,914,145
	SPCP+PCDH	209,644,030	259,003,606	49,359,576
	SPCP+OCDH	209,469,787	259,003,606	49,533,819
A	SPCP+PGHSQ	39,222,012	60,702,982	21,480,970
	SPCP+PGHDM	49,197,979	71,231,335	22,033,356
	SPCP+PGHSO	49,558,715	71,231,335	21,672,620

Table 9.5: NPVs of schistosomiasis control strategies (using WTP to avoid advancing to the next state and international experts' subjective probabilities)

STRATEGIES	NPV (in Ksh.)	International Experts Rankings	Local Experts Rankings
SQS	37,086,774,956	7	9
HPWSS	37,029,826,200	8	6
HHEDS	37,289,211,617	6	8
VIPLS	36,772,160,029	9	7
DMS	37,920,885,418	5	5
MPCPS	39,401,022,882	1	2
MPCOS	39,361,156,039	2	4
SPCPS	39,112,276,182	3	1
SPCOS	39,090,120,892	4	3

Table 9.6: NPVs of the optimal strategy secondary options (with WTP to avoid advancing to next state and international experts' subjective probabilities)

HEALTH STATE	OPTION	NPV (Ksh.)	GPV(EMV)	GPV(COST)
Y	MPCP+DNY	32,145,129,067	32,239,787,567	94,658,500
S	MPCP+SQD	2,823,211,606	2,832,797,752	9,586,145
	MPCP+PCD	3,201,049,890	3,216,325,100	15,275,210
	MPCP+OCD	3,200,452,349	3,216,325,100	15,872,751
K	MPCP+SQHC	2,575,320,865	2,587,461,329	12,140,465
	MPCP+PCHC	3,028,438,587	3,063,305,700	34,867,112
	MPCP+OCHC	3,027,976,511	3,063,305,700	35,329,189
Z	MPCP+SQDH	782,719,535	796,637,690	13,918,155
	MPCP+PCDH	822,069,993	857,399,182	35,329,189
	MPCP+OCDH	811,509,053	857,399,182	45,890,129
A	MPCP+PGHSQ	164,782,634	186,801,567	22,018,933
	MPCP+PGHDM	203,972,577	226,548,043	22,575,467
	MPCP+PGHSO	204,335,346	226,548,043	22,212,697

CHAPTER 10
DISCUSSION, CONCLUSIONS AND SUGGESTIONS FOR FURTHER RESEARCH

The main aim of this thesis has been to discover whether an ambitious decision theoretic algorithm is capable of application in a developing country context. With appropriate modifications to the methods that have been developed in the developed world, we hope to have shown that they are indeed feasible. In this chapter we review the methods and make some comments on the course that future research in this field might take.

10.1 The QoL Measure

Schistosomiasis is not a major killer disease (WHO, 1993), but it is thought to affect adversely victims' quality of life. Thus, any effective interventions into the disease are likely to have more impact on individuals' QoL than on their remaining life expectancy. That is true especially for patients in mild and moderate schistosomiasis states which are thought to have insignificant effect on victims life expectancy. However, any intervention that increases the probability of receding (going back) to either normal, mild or moderate states from either severe or very severe states, will not only improve the quality of life but also extend the beneficiaries' life expectancy. Thus, it is important to measure both quality of life and life expectancy gains expected from various schistosomiasis interventions. This realization created the need for a quality of life instrument that could be used in a population survey of a typical third world socio-economic-cultural environment.

Ideally, it would have been best to conduct a preliminary survey among the Mwea population to establish the relevance or irrelevance of particular concepts of ill health and functioning among Mwea community. Such an exploration would probably have entailed (i) interactive interviews with samples of women, children and men (ii) the development of long questionnaire(s), similar to questionnaires used in health profile surveys (iii) pilot testing followed by an actual survey among probably school children, people in different occupations and probably religions (iv) grouping together of different items under "representative" dimensions (v) development of brief health states

descriptions reflecting the "representative" dimensions; innovation (or invention where possible) of a measurement technique (and visual aids) (vi) pilot testing of the instrument for relevance and feasibility (vii) a mock ranking and valuation exercise to determine the potential respondents ability to perform the actual health state valuation exercise (viii) actual survey(s) to test for reliability and validity, and so on. Such an endeavour would require substantive resources (technical man-days, research assistants man-days, copy typist man-days, questionnaire printing expenses, computer time, transport, rapport creation expenses, and so on).

Due to research resource constraints, a second best option was chosen. The choice of dimensions of functioning was determined by personal knowledge[1] of the values in the Mwea community, informed by clinical experience of a Kenyan epidemiologist and experience of index construction in Europe and North America. Six functional dimensions were identified - mobility, self care, livelihood, energy, pain, and social participation. The health states descriptions were developed in close consultation with an experienced schistosomiasis epidemiologist. During the survey, personal **informal** interactive interviews with Mwea residents and clinicians supported the hypothesis that the dimensions included in the instrument reflected societal perception of ill health and of functioning. However, this is an issue that urgently needs more systematic and detailed field investigation and analysis.

This study used random sample data from Kirinyaga District (specifically Mwea irrigation scheme) in Kenya to test the following null hypotheses:
(i) it is not possible to elicit intelligible outcome utilities from a third world population which is predominantly illiterate; and
(ii) there is no significant difference between average health states utilities from the three samples (farmers, teachers and health professionals).

Anyone attempting to elicit outcome utilities from an ethnically, culturally and linguistically diversified population, like that of Kenya (and majority of sub-Saharan countries), is likely to encounter linguistic, semantic and conceptual difficulties. Inspite of these obstacles, this study proves that it is possible to elicit reasonable outcome utilities from a third world population which is predominantly illiterate. The pragmatic way to proceed is not to **adopt** but **adapt** measurement methods invented in developed countries to the socio-economic and cultural scenarios found in third world countries. A mock ranking and valuation exercise was used to acquaint respondents with the

ranking and scaling processes. In addition, a Rice-Sack-Visual-Analogue-Scale was used when scaling (a rice sack is an object familiar to all persons in cereal growing areas of Kenya). The health states dimensions were also defined in terms that Mwea respondents could relate to. Establishing both validity and reliability of the QoL instrument (and its estimates) was beyond the scope of this thesis. Tan-Torres (1991) examined the validity, reliability and feasibility of the three methods (Rating Scale, Time Trade-Off and Standard Gamble) of eliciting health states utilities from patients with paucibacillary leprosy in the Philippines. Contrary to the studies done in DCs she found that rating scale performed better than time trade-off and standard gamble. She then concluded that, despite its theoretical limitations, the rating scale performed well in terms of validity, reliability and feasibility.

The overall response rate of 99% compares with the response rate of 100% reported by Tan-Torres (1991) in Philippines. The possible explanations for high response rate are (i) deliberate effort was made to cultivate a rapport with chiefs, sub-chiefs and village heads - who even before the research team was constituted spread a favourable message among sample villages and asked villagers to feel free to help with the survey (ii) greater degree of caring externality among Mwea household (in virtually all rural areas in Kenya people always have time for others and often they are not in a hurry) (iii) expected utility of participation may be greater than the perceived opportunity cost of their time (iv) use of interviewers who not only spoke respondents language but were known to respondents (v) whenever the interviewers did not find the head of the household at home, they left a message with other members of the household indicating the time they would be back to interview him or her (vi) the researcher invested many days training interviewers on QoL instrument, interview techniques, and the ethics of face-to-face interviews (vii) the hope that the results may be useful in reducing burden of schistosomiasis related illness. The latter could also be seen as a disadvantage, if it led to strategic bias, but there was no evidence to suggest that happened. Majority of the people in Mwea (like most other rural areas in Kenya) do not have household telephones and post office boxes. They often use addresses of local government offices, churches, primary schools, health facilities, and so on. In addition, due to low literacy levels face-to-face interview is the only feasible mode of collecting survey data. Personal interviews suffers least from non-response probably because it is difficult to refuse someone face-to-face (Amstrong, 1978).

About 97% of the responses of those who responded were useable in generating health state utilities. This finding is consistent with previous research (Sackett and Torrance, 1978). This indicates, *ceteris paribus*, that it may be possible to incorporate the values of the general public into decision-making about schistosomiasis health interventions.

Descriptive statistics results indicated that the less severe health states commanded higher utility valuations. This finding is consistent with previous research (Tan-Torres, 1991; Nord, 1991; Torrance, 1987; Williams, 1985; Kaplan, 1989; Llewellyn-Thomas, et al., 1984; Read, et al., 1984; Sintonen, 1981; Sackett and Torrance, 1978; Rosser and Kind, 1978). Generally, the ANOVA results show that there is a significant difference in the average utilities for health states K, Z, A and R from the three samples (farmers, teachers and health professionals). In other words, the populations from which the samples were drawn do differ.

10.1.1 *Limitations of the QoL instrument and use of its valuations*

Combining health state utilities from different samples

The same QoL instrument was administered separately but under the same conditions as three samples drawn from populations of farmers, teachers and health professionals. Their valuations for each health state were combined into a single distribution without standardizing or weighting of health state utilities. That was done in spite of the fact that the ANOVA test indicated there was significant difference between the means and standard deviations of the valuations of the three groups. One may argue that unitary weighting (which is essentially the same as not weighting), biases the choice of intervention options towards the group(s) with higher preference values. However, no standardization or normalization was carried out for a number of reasons: (i) Having assumed that the health states preferences were elicited under the same conditions with exactly the same instrument, the researcher followed the advice of Ghiselli, Campbell and Zedeck (1981:p.70), which says that:

If there is reason to suppose that the various samples were drawn in a truly random fashion, then it can be held that differences in the distributions of scores are merely by

chance variations. Therefore we should be justified in throwing all scores into a common distribution (without weighting or normalizing)." In short, differences in means and standard deviations of health states utilities for the three groups are attributed to chance. (ii) Even if one had an adequate reason to believe that differences in group means and standard deviations cannot be accounted for on the basis of sampling error, but due to probably differences in conditions or in measuring devices; and standardized valuations from each group and then combined the standard scores from each group, one would be introducing another error. This is because: *"different forms of an instrument never do quite measure the same properties, different conditions of testing introduce different factors that affect performance, and variations in sampling are always with us. Consequently, it is a matter of judgement, or perhaps faith, whether the errors introduced by this procedure (standardization or normalization) are greater or lesser than those that are eliminated"* (Ghiselli, Campbell and Zedeck, 1981:p.70). (iii) Since the researcher did not know whether the differences between groups (samples) were due to systematic difference in the measuring instrument, sampling error, real differences in the health states preferences or other yet unknown difference(s) inherent among the groups, one is bound to be wary of attempting any transformation (or weighting) of the valuations.

Even if one decided to use the average (or median) health states valuations for the three groups separately in the economic evaluations, which would amount to running the cost-benefit decision analysis and cost-effectiveness analysis models three times, eventually some one will have to deal with the issue of which economic evaluation results should decision-makers use (if the results are used to guide decision-making).

Given that the choice of the optimal strategy seems to be invariant to 'across-the-board' variations in the EQALYs or even expected cost, use of different valuations may not alter the rankings, but just the magnitudes of EQALYs (which is obvious). Nevertheless, it may be interesting in future to re-run the two decision analysis models with valuations from the three samples separately to see whether the strategy rankings would be sensitive to changes in outcome utilities (and willingness to pay values).

Scenario construction biases

The information used in constructing health states descriptions was obtained through a review of epidemiological and clinical literature of schistosomiasis, by interviewing one schistosomiasis epidemiologist/clinician, and personal knowledge of Mwea population. A number of issues may be raised with the scenario construction approach used in this thesis: (i) since the epidemiological literature on impacts of schistosomiasis disease on both function performance and mortality is not conclusive (WHO, 1993), it may not be a strong or even appropriate basis for construction of health state descriptions; (ii) consultation of a single epidemiologist is greatly unrepresentative - the use of a sizeable Delphi panel of experts would have been better; (iii) it may also be argued that although the analyst was born and brought up in a typical peasant farming culture, his perception of function/dysfunction may be different from that of Mwea population due to the fact the schistosomiasis is almost non-existent in the analysts' home district and due to linguistic differences (and probably other yet unknown differences); (iv) although emotional dimension was thought to be irrelevant, probably, it should have been included in the states; (v) actual schistosomiasis patients may be better placed to provide information on the functional impact of the disease (since they have first-hand experience); (vi) the ideal would have been to obtain health states construction information from representative sample(s) of the general population and probably government and private sector employees working within Mwea; (vii) the decision process of what functional dimensions to include or exclude is highly subjective, and it is possible that different people may come-up with different dimensions; and (viii) there is no way of ensuring (with certainty) that the number of health states included represent adequately the full spectrum of experiences of the victims of schistosomiasis disease. The above, yet unresolved issues, signal the need for systematic research in future on the health states scenario construction processes.

Interval scale anchor points bias

The health states preference values were obtained through rating scale, using a Rice-Sack-Visual-Analogue-Scale. The rice-sack scale may be criticized for not allowing for values less than zero and greater than one. It has been argued that if an individual's

negative values are not incorporated into the analysis, the final average utility value, and therefore EQALY, would be biased upward (Smith and Dobson, 1993). This is yet another issue that could do with more research in future.

Interview subject selection bias

The interview procedure assumed that household heads were the right people to interview. In Mwea community (like in most other Kenyan communities) the male is normally the head of the family. In such a patriarchal community, household decisions heavily influence individual behaviour since resources allocated to each individual and the individuals' obligations are a result of the decisions taken by the head of the household (at times in consultation with other members of the household) (Mills, 1985). As a result of either bereavement, divorce, or separation, the wife may assume the role of the household head (if there is no son who is old enough to assume that role). Normally, household members would be extremely reluctant to participate in any interviews, unless the household head gives his approval. That may sound archaic, chauvinistic and draconian especially to people in Developed Countries, but that is the culture of the Mwea people. And any researcher who adopts a missionary zeal of changing existing cultural outlook of people in such a community, is likely to be met with remarkable hostility. In short, it is advisable for a researcher to keep his or her beliefs and principles to oneself and just to play along. Because of the above reasons, it seemed obvious, that the household heads were the right people to interview.

Labelling bias

The interview procedure assumed that community members were acquainted with the term 'Bilharzia'. It could be argued that there may be a large gap between what health professionals understand to be 'Bilharzia' and think the community perceives to be 'Bilharzia', and what the community itself understands to be 'Bilharzia.' For example, the symptoms of severe and very severe 'Bilharzia', may not be seen as a phenomenon relating to 'Bilharzia'. The inclusion of the term 'Bilharzia' into each of the health states descriptions could be justified in a number of ways: (i) since the health states were developed specifically to evaluate impacts of the disease on victims quality

of life with and without interventions, it was necessary to state explicitly that they were states caused by 'Bilharzia' (ii) due to the very reason that the symptoms of severe and very severe 'Bilharzia', may not be seen as phenomena relating to the disease made it necessary to state clearly that the states should be assumed to apply specifically to 'Bilharzia' and (iii) the fact that there are other helminths and non-helminthic diseases prevalent in Mwea that may lead to the same or similar health conditions contained in various scenarios, improves the case for including the word 'Bilharzia' in the states.

Notwithstanding the above attempt to justify the inclusion of the disease name in health states descriptions, the literature remains divided on this issue, with some researchers reporting that resultant valuations systematically vary with differences in the framing and labelling of variables (Sutherland, et al., 1983; Kahneman and Tversky, 1982; McNeil, et al., 1982; Hershey, et al., 1982; Sackett and Torrance, 1978) while others report that they do not (Gerard, 1991 and Gerard et al., 1993). This lack of consensus creates a strong case for further research in framing and labelling effects on preference valuations.

Comparison with other studies

There may be no basis for collating health states utility estimates obtained from this study with studies done elsewhere, for a number of reasons:

(i) there is no standard method of constructing health states descriptions, the wording, length, content, the perspective from which scenarios are written, method of administration (self-administered vs. interviewer-administered), visual-scales, sampling framework, generic vs. disease-specific and sample size vary from study to study;

(ii) cultural dynamics - attitudes, perceptions of function vis-a-vis dysfunction, nature of livelihood activities (mental, manual or mechanical);

(iii) this was the first study to have attempted quantifying schistosomiasis-related health state preferences;

(iv) lack of consensus on the impact of framing (first, second and third person) and labelling (use of disease names) on health states valuations obtained (Smith and Dobson, 1993);

(v) and scarcity of information on the bias that may result from methods used to generate the information upon which health states descriptions are based. Such biases

may emanate from scenario related information sources (e.g. quality of epidemiological/clinical literature, experience of clinicians interviewed and/or perceptions of potential and actual patients interviewed); the dimensions of the diseases to be included or ignored; and the number of health states needed to represent adequately the full spectrum of experiences within a health condition (Smith and Dobson, 1993).

Until a number of studies have been done using the same (in all or most respects) quality of life instrument, elicitation procedures, and similar populations (in terms of social, cultural and economic characteristics), there would be no justifiable basis for making comparisons in health states preference values obtained from different studies. And even then, if the studies are not done simultaneously, only directional comparisons (Y >= S >= K >= A >= Q or Y <= S <= K <= A <= Q) may be justifiable, since the preferences will most probably vary over time.

Validity and Reliability of QoL

The purpose of developing a quality of life instrument was to gather illustrative data for testing the decision theoretic models. Thus, establishing validity and reliability of the instrument was beyond the scope of this particular study. However, it may be worthwhile to discuss in passing the different types of validity and reliability that one may be concerned about in finding out what an instrument does measure, and how accurately it does it.

Validity

Validity in the context of quality of life measurement refers to the extent to which a quality of life instrument measures what it purports to measure. Ideally, this requires one to correlate estimates obtained with external criterion measurements. Unfortunately, it is impossible to find any one criterion that will be an unambiguous indicator of quality of life; this is mainly because health states have no analogous products sold on market.

Instead of asking the old validity question, *To what extent does this instrument measure what it purports to measure?*, probably we should ask, *Just what is it that this*

instrument does measure? (Taylor and Walsh, 1979). In the context of the latter pragmatic (operational) validity question Drummond et al. (1987:p.117) explains that utility values are valid if: *the subjects are appropriate (a statistically representative sample size); the health state descriptions are adequate to properly describe the states and are neutral in their influence on the measurement; the measurement questions are framed in a balanced or neutral way; and the measurement technique itself is reliable and valid.*

Five main types of validity may be relevant to instruments developed in this thesis: criterion, construct, content, interpretive and face validity.

Criterion-related validity is concerned with exploring the relationship between instrument estimates and actual behaviour in specific situations (i.e. actual valuation of health outcomes or health states for instance). Estimates are empirically checked against some criterion (external anchor or standard).

Criterion validity has two strands: concurrent and predictive validity. Concurrent validity involves validating estimates from an instrument with current behaviour (or criterion). Predictive validity requires a correlation of instrument estimates with some future behaviour or criterion.

Construct validity is concerned with the association between instrument estimates and the theoretical prediction. It is best demonstrated by an accumulation of supportive evidence, from different sources over some period of time, of what the instrument measures. "*..in demonstrating construct validity one must show that a test meets theoretical expectations and is associated with variables with which it should be reasonably correlated...(and) it is not related to other variables with which it should not be reasonably correlated*" (Taylor and Walsh, 1979: p.31).

Content validity is concerned with whether or not a QoL instrument encompasses all relevant functional dimensions that it purports to incorporate. This is a highly subjective type of validity (Taylor and Walsh, 1979). For example, while one researcher may think that his or her instrument encompasses all the relevant functional dimensions likely to be affected by presence or absence of a specific disease condition (or intervention), it is possible that another person or a group of persons might come up with different dimensions (and hence health state descriptions) all together. For instance, while the Kenyan schistosomiasis experts agreed that schistosomiasis disease could be broken down into asymptomatic (normal), mild, moderate, severe, very severe state,

comatose and dead states; the external expert was of the opinion that comatose state was not relevant.

Face validity pertains to the appropriateness, the relevance, and the attractiveness of the instrument items to respondents or people providing health states (outcomes) preference values. This more or less refers to the acceptability of the instrument within the sample in which it is administered. If the respondents find health states and/or the method used to elicit health state utilities culturally unacceptable, ethically unacceptable, confusing or difficult to comprehend, the instrument may be thought to lack in face validity. The compliance rate may be a good reflection of the face validity. If the compliance rate is very "low", lack of face validity may be one of the explanations. The survey reported in this thesis had very high response rate (99%) and percentage of useful responses (97%), which may be an indication the QoL instrument had face validity. When asked how they found the whole interview, 21.6%, 12.6%, 8.1% and 55.6% of the respondents answered respectively, very difficult, very easy, just easy and not very difficult. 88% said they would be willing to take part in a similar exercise in future. Answers to such questions could be argued to be indicative of face validity.

Interpretive validity is concerned with whether an instrument was interpreted accurately and meaningfully to the subjects or respondents who provided valuations. The use of a mock ranking exercise as a precursor to actual valuation exercise, Rice-Sack-Visual-Analogue-Scale, health states descriptions written in respondents mother-tongue, well-trained interviewers from the locality and repeated reading of health states descriptions to the respondents may have enhanced interpretive validity of the instrument. However, it remains a matter of subjective judgement.

Reliability

Reliability is about how consistently an instrument measures individual preferences for health states or outcomes. Test-retest reliability requires administration of the same instrument to a specific sample of respondents twice, with a short interval (probably a week or two weeks) between the sessions. The more alike the two valuations (for each state) for each respondent are, the more reliable, the instrument is in measuring non-random health states preferences. The reliability of rating scales, as measured by the product moment correlation coefficient ranges from 0.86 to 0.94 (Drummond, et. al.,

1987). No attempt was made in this thesis to establish the reliability of the QoL instrument.

The issues raised in chapter 4 relating to QALY index apply to health status index developed in this thesis. Although those issues were beyond the scope of the current study, they nevertheless require systematic and exhaustive research in the near future.

10.1.2 *Questions that need addressing in future QoL studies*

Similar, but more comprehensive studies need to be done to shed light on the following issues:

(a) Do health state descriptions wholly encapsulate the impact of the health condition and/or intervention on quality of life (in terms of physical, livelihood, psychological and social effects)?

(b) How does one strike a balance between the length and contents of an health state description? This is important to obviate cognitive overload and superficiality (due to insufficient detail to characterize the disease state adequately).

(c) Does the perspective (use of first, second or third person) from which health states descriptions are presented affect magnitudes of the expressed cardinal preferences?

(d) Whose valuations should be elicited in LDCs where literacy rates are relatively low?

(e) Are the expected benefits (probably in terms of expected efficiency improvements) of information on households health states utility valuations greater than the expected cost of acquiring the information?

(f) Are the QoL instrument and its measurement valid and reliable?

Most of the questions raised above and in chapter 4 have been raised before by other researchers in developed countries context. The recap was meant to illuminate fragility of this study and others done in the past.

It is important to caution readers that the instrument developed in this thesis **should** be considered only as the beginning of what is likely to be highly controversial, greatly contested, arduous road to development and validation of measures of quality of life in developing countries. The only consolation to all those venturing into this area is that there is a dire need for a measure or measures of ultimate health care output (that is the only palpably uncontroversial phenomena in the realm of measurement of health care output).

10.2 The Willingness to Pay Measure

Health states WTP valuations were elicited simultaneously with utilities to test the following null hypotheses:

(i) it is not possible to elicit intelligible WTP values from a third world population which is predominantly illiterate;

(ii) there is no significant difference between average WTP values from the three samples (farmers, teachers and health professionals); and

(iii) the expressed WTP is not dependent on households income and other considerations (such as implied anxiety, loss of working or leisure time, medical expenses, children's absenteeism from school, and risk posed by one's health state to other people determinants of WTP.

This study demonstrates that it is possible to elicit coherent WTP values from a third world population which is predominantly illiterate. As mentioned earlier, the pragmatic approach is not to **adopt** but to **adapt** instruments and measurement methods built in developed countries to socio-economic and cultural scenarios found in third world countries.

The study had a higher response rate (99%) than normally reported in WTP studies conducted in developed countries (60%-95%) (Gyldmark, 1993; Johannesson et al., 1993 Johannesson, 1992; Johannesson et al., 1991; Appel et al., 1990; Thompson, 1986). The high response rate could be attributed to reasons given in the preceding section.

Descriptive statistics results indicated that the less severe health states commanded higher WTP valuations. This finding is consistent with previous research and with intuition (Rushby, 1991; Thompson et al., 1984; Thompson, 1986).

Generally, the ANOVA results show that the average WTP values of farmers, teachers and health professionals are statistically different. In other words, the populations from which the samples were drawn do differ. The cost-benefit decision analysis models were estimated using the average health states WTP values from the three samples combined with no weighting or standardization. Given that the average health states WTP values from the three samples were statistically different, the wisdom of combining them (and hence implied shilling democracy) may be questioned. The justification for using combined valuations given in the preceding section equally applies to this section too.

The regression results show that expressed WTP is dependent on households income. This finding is consistent with previous research (Gyldmark, 1993; Appel et al., 1990; Jones-Lee, 1989; Thompson, 1984). This confirms that even in the hypothetical situation, one's WTP may be limited by one's ability to pay. This raises concerns of bias and differences based on socio-economic status. It appears that wealthy individuals have a disproportionate impact on the WTP, and hence influence on the choice of optimal intervention strategy. As mentioned earlier, this is a limitation inherent in the contingent valuation approach. If the mode of financing the optimal strategy is either Exchequer funds or health insurance based on common rating, use of the averages may be of little (if any) distribution consequence. It might also be argued that any distribution concerns might be better handled by direct use of taxes and subsidies.

Since the main goal of this study was to test feasibility of a population survey-based method of eliciting health outcome WTP valuations, following important issues were not addressed: validity and reliability of WTP instrument and of responses, replicability, considerations individuals took into account when deciding magnitudes of WTP, understanding and processing information in the hypothetical scenarios, and strategic behaviour in responding.

Johannesson et al. (1993:p.106) delineates three ways to test the validity of the contingent valuation approach. (a) Compare the results of the CV method with those of indirect methods of measuring WTP, such as hedonic prices, the travel cost method and waiting/queuing time. They immediately qualify that in the realm of health care indirect methods are not applicable and thus comparisons are ruled out. (b) Carry out simulated market experiments in which hypothetical payments are compared with actual payments; it is difficult to carry out such a study in practice. (c) Assess whether the hypothesized theoretical relationships are supported by the data (e.g. the relationship between WTP and subjective risk reduction and income). Acton (1976:p.67) reasons that "a rigorous test of validity might be to survey a group of people and then come back and actually market the goods that had been described or raise their taxes in accordance with responses. Some people may refuse to act in accordance with their previous responses because of intervening factors which may be difficult to control against and which the respondent cannot even articulate." Acton concludes that it is not clear whether the validity of WTP valuations can ever be firmly established. It could be suggested, in addition, that directional (and not magnitude) comparisons of the strength of preferences

or dispreferences for various health outcomes (states) obtained from QoL instrument and WTP instruments may be used as indictors of validity and reliability. For instance, if the implied order of outcome preferences elicited via QoL and WTP instruments is similar {u(Y)>u(S)>u(K)>u(Z)>u(A)>u(R)>u(Q)}, that could contentiously be used as **a rough** indicator of both validity and reliability. The limitations mentioned in preceding section apply to the WTP instrument developed in this thesis.

10.2.1 *Questions that need addressing in future WTP studies*

Similar, but more comprehensive studies need to done in future to shed light on the following issues:

(a) Whose valuations should count in LDCs where literacy rates are relatively low?

(b) Are findings from WTP surveys likely to help health care decision-makers in LDCs in priority setting?

(c) Are the expected benefits (probably measured in terms of expected efficiency improvements) of information on households WTP greater than the expected cost of acquiring the information?

(d) Does contingent valuation technique give valid and reliable estimates?

(e) How do hypothetical answers to expressed WTP questions compare with actual money transactions (especially for treatment of different health states)?

(f) What are the potential sources of bias in WTP studies done in LDCs (incentives to misrepresent responses, implied value cues, scenario mispecification, sample design and execution biases, and inference bias); how can those problems be detected and be solved or even avoided?

(g) Do WTP values for the same: health states (outcomes), level of risk, or treatment change over project life? If yes, do they vary systematically or unsystematically (randomly)? And what factors are likely to explain temporal variance?

(h) How should the WTP data collection instruments be framed?

(i) Is it necessary (and feasible) for WTP studies in LDCs to fulfil Gafni (1991) and Morrison and Gyldmark (1992) criteria for good WTP studies? Is there any need of framing questions in terms of insurance while financing cultures or systems in probably most LDCs are non-insurance? Is there any practical sense of framing WTP questions for use in LDCs in probabilistic terms?

(j) Can individuals in LDCs understand probabilities? Are there any culturally acceptable ways of presenting probabilistic decision problems to LDCs general populations?
(k) Might it be more practical to decompose the decision problem for the respondents in order to get valuations about the parts (such that the analyst may then synthesize these parts to get an overall expected value)?
(k) Are probabilities taken at face value or weighted by some prior briefs?
(l) How much information about the good being valued can be given to respondents without causing 'cognitive overload'?
(m) How can altruism be incorporated in a valid way in economic evaluations?

The questions raised above reflect the tentativeness of both WTP instruments and estimates from this study and others done in the past. In short, since the validity and reliability of the WTP assessments were not established, the WTP findings generated in this thesis cannot be generalized. Further empirical work is clearly needed to at least address the validity and reliability of contingent valuation approach and its measurement.

10.3 The Probability Judgements

Evaluating the schistosomiasis decision theoretic framework developed in this thesis required each intervention's effectiveness data expressed in terms of changes in health state probabilities (prevalence) and transition / outcome probabilities. Ideally, that information can only be generated by randomized controlled effectiveness trials. Economic evaluators faced by such a problem have to resort to second (or even third) best potential sources. One (and probably the only) solution is to resort to judgemental forecasts (otherwise referred to as technological or qualitative methods). Technological forecasting techniques are not simply an extrapolation of past data patterns, as are many of their counterparts, nor do they assume constancy of the past pattern into the future. Even though history plays an important role in these methods of forecasting, technological forecasting techniques require imagination combined with individual talent, knowledge, and foresight in order to effectively predict long-run changes (in intervention effectiveness) (Markidakis and Wheelwright, 1978).

The set of technological forecasting techniques consists of personal interview, telephone interview, mail questionnaire, traditional meeting, structured meeting, group depth interview, role playing (game theory), opinion polls or surveys, jury of expert

opinion, and the Delphi (Granger, 1980; Markidakis and Wheelwright, 1978; Amstrong, 1978; Johnson and King, 1988).

This thesis attempted to use the Delphi technique to circumvent problems associated other methods mentioned above. First, subjective probabilistic effectiveness assessments were obtained from two local schistosomiasis experts. Later, an international expert provided his subjective judgements, after two anonymous U.K. schistosomiasis experts cast doubts on some of the effectiveness forecasts made by the local experts. The magnitudes of both transition (outcome) and health states probabilities obtained from the two sources were largely different.

The differences between local and international expert opinion about the effectiveness of various schistosomiasis interventions highlights: the importance of including full-range of expert opinion in such exercises; uncertainty surrounding ultimate effectiveness of schistosomiasis interventions; impacts of schistosomiasis on victims function performance; and hence need for decision analysis techniques to guide policy-makers. The lack of consensus also illuminates the urgency for randomized controlled effectiveness trials tailored in a manner that would enable them to produce "hard" epidemiological data needed in decision analysis.

10.3.1 *Limitations of the Delphi Technique (and other Technological Forecasting Techniques)*

(a) It is extremely hard to determine accuracy of estimates obtained via technological forecasting techniques, it can take many years before one knows whether or not the forecast proves to be accurate (Granger, 1980; Markidakis and Wheelwright, 1978; Granger, 1967).

(b) Using the same method with different experts does not produce the same forecasts, and sometimes the divergence in opinions among experts is so extensive that it is hard to imagine that any substantial confidence could be placed in the results (Johnson and King, 1988; Markidakis and WheelWright, 1978: p.494). This problem is clearly manifested in this thesis.

(c) Following a technological forecasting technique gives no assurance that the goal of better forecasts will be achieved (Markidakis and Wheelwright, 1978).

(d) Generally these subjective judgement assessment approaches do not include much

detail as the actual steps individual experts follow in their thought processes. Rather, the focus is on obtaining predictions in certain formats so that they can then be integrated with other planning and decision-making processes.

(e) The Delphi technique, like any other forecasting approach, could be criticized for its often low level of reliability, its over sensitivity of results to ambiguity in the questionnaire, and the difficulty in assessing the degree of expertise incorporated in its forecast.

(f) In dealing with subjective judgements it quickly becomes apparent that a wide range of values can be given for a single event or outcome. This range represents: increased uncertainty because there are no relevant historical patterns readily available for extrapolation, and differences in psychological weighting of past experience.

(g) Bias may be introduced into the data collection process by the group facilitator misunderstanding the gist of a participant's statement (Smith and Dobson, 1993).

(h) Predictions of experts reflect not only what they think will happen but also what they hope will happen. That is called optimism bias (Amstrong, 1978).

(i) Presence of a type of anchoring called conservatism. It refers to the assumption that the future will look like the past; there will be no abrupt changes. Conservatism leads to under prediction of the magnitude of expected change (Amstrong, 1978).

10.3.2 *Limitations specific to the DT used in this thesis*

The approach used in this thesis can only be described as an approximation of the Delphi technique for a number of reasons. First, an ideal Delphi technique would have required many professionals (at least 5) with expertise in each of the interventions being evaluated. In this study, only two local experts and one external expert with expertise mainly in chemotherapy of schistosomiasis were available and reluctantly willing to provide subjective judgments. The experts were even more reluctant (and understandably so) to evaluate the effectiveness of the interventions in which they felt they had little expertise. They agreed to provide forecasts on condition that they are used to test and explore the methodology, and **not to draw** binding policy conclusions. Given the large penumbra of uncertainty surrounding epidemiology of schistosomiasis and unproven effectiveness of most of the schistosomiasis interventions (especially preventive), one can not only appreciate the reluctance of experts who provided subjective probabilities,

but also admire their imagination, intuition, judgement, expertise and courage. Probably, it is only by involving epidemiologists in such evaluations, can students of economics (and may be practising economists) and epidemiologists be sure about the specific information needed in economic evaluations. Until that is made clear, economists will always stand accused of ambiguity, and the long-awaited randomized controlled effectiveness trials data would not be forthcoming. And common sense would seem to suggest that epidemiologists need to be encouraged to provide their subjective judgements, not to be criticized for having made such judgements explicit. In any case, practising health professionals implicitly make such judgements every day in their practice. The only problem is that until such judgements are put on paper, it is virtually impossible for them to be subjected to constructive critical analysis or even debate.

Second, Delphi technique obtains opinions through a mail survey. In this study, telephone calls were made to potential panellists to organize appointments, and then questionnaires were hand-delivered to each expert who was willing and available to participate. One may argue that those who were available and willing to participate were not necessarily the best experts. Such a criticism may not be valid for two reasons: (a) the two experts did their PhD's on epidemiology of Schistosomiasis and were actively involved in research, and (b) out of more than 100 studies reviewed by Amstrong (1978) on the value of experts in predictions only a few suggested that expertise improved accuracy of forecasts, and even then the gains were insignificant.

Third, the Delphi technique anonymity and controlled feedback features were breached because the two local experts met and did the exercise together. It is difficult to tell whether that had any undesired effect on their probability estimates.

Fourth, the analyst had to intervene on several occasions to ensure coherence in subjective probabilities provided by both local and international experts. This is because often they forgot to collate alternative interventions effectiveness valuations with their prior assessments of the status quo. Thus, it is not clear to whether such interference by the analyst may have biased experts judgement. And if it did, in what direction and by what magnitude.

Fifth, since the international expert did not have time to provide subjective probabilities for household piped water supply, health education, vented pit latrines and mollusciciding, the analyst was required to make his own probabilistic judgements guided by the discussion he had with the international expert and indicative

epidemiological intervention studies done in St. Lucia, Kenya, Zimbabwe, Brazil among other countries. Those forecasts (as explained in chapter 7) were counter-checked with two anonymous U.K. schistosomiasis experts who concurred that the estimates were a close representation of epidemiological expectations.

Sixth, the Delphi technique instrument developed and used in this thesis and its measurements have not been validated (and it is only the test of time that can validate the forecasts). Also, due to resource constraints it was not possible to determine stability of the subjective probabilities via a test-retest reliability test.

Seventh, the estimates of the change in prevalence for each of the different policy options assumes the technically efficient application of primary and secondary options. It could be argued that in practice magnitudes of benefits expected from interventions like HPWS, SPCP, SPCO, MPCP, MPCO, HHED, VIPL and facility level interventions will vary with the rate of compliance of the population. This thesis assumed compliance rates of 90% and 100% for community level treatment and preventive options respectively. If in practice the compliance rates of the former options happen to be lower than the assumed, that may lead to a proportionate decrease in both expected costs and benefits, and a simultaneous increase in both expected costs and benefits of the facility level options they are combined with. The effect of such a high level of compliance (which may not be achieved in practice) would be to overestimate the benefits from preventive interventions, and at the same time underestimate both costs and benefits from the relevant facility level options they are combined with. The effect on facility level options would be to overestimate both expected costs and benefits; if that occurs in a proportionate manner (which is likely to be the case), the use of a lower compliance rate would lead to a proportionate decrease in both benefits and costs, without altering rankings of options. With the counteracting changes in both expected costs and benefits, there may be no change in strategy rankings (save for the obvious changes in magnitudes of net benefits).

Eight, the finding that even committed medical research scientists have a lot of problems in providing subjective probabilistic effectiveness data, mainly because they often do not think in the ways required by economic evaluation, casts further doubts on the validity of the judgements obtained.

Lastly, different experts gave remarkably different forecasts. The fact that the two sets of estimates do not correspond, may make someone too apprehensive of adopting

any of the set of estimates. One could even argue that due to the great divergence, some other approach, or data source, may need to be explored. A counter-argument would be that the author resorted to subjective probabilities because relevant objective probabilities were not available (and are unlikely to be available in the near future). Nevertheless, the subjective probabilities generated and used in this thesis should be assessed in the light of the general short-comings of DT and other problems specific to the study.

10.3.3 *Questions that need addressing in future DT studies*

There are several issues that need to be addressed in future:

(a) Is there a real need for subjective health states and outcome probabilities in economic evaluation and hence decision-making?

(b) Are there conceptually better and feasible approaches that can be used to generate the relevant intervention effectiveness data, urgently needed in guiding decision-making?

(c) Given that technological forecasting techniques have been widely and fruitfully used in industry and commerce (among other areas) in developed countries, can the Kenya health policy makers do worse (than the status quo) by using analyses based on data from such techniques, where relevant historical data are lacking?

(d) How should the questions for eliciting subjective probabilities be framed?

(e) Besides using a decision tree, are there other better visual aids that could facilitate elicitation of probabilities?

(f) Is there any statistically significant relationship between an individual panellist level of expertise and accuracy of one's forecast?

(g) Is there any statistically significant relationship between the size of a panel and accuracy of one's forecast?

(h) Is there any way of evaluating performance of technological forecasting techniques without having to wait for the long-run?

(i) Is the use of an international panel of experts likely to lead to more accurate forecasts? Would the formation and running of such a panel be cost-effective?

(j) How do forecasts from technological forecasting techniques compare with real (hard) data where they exist?

(k) Is the increased involvement of epidemiologists (and others in related areas) likely

to trigger an increase in probabilistic randomized controlled effectiveness trials to test subjective probabilities?

This section succeeded in: (a) identifying relevant types of effectiveness data needed in decision analysis of Schistosomiasis interventions, (b) developing an instrument which can be used to obtain subjective probabilistic intervention effectiveness, (c) demonstrating its operational feasibility and replicability, and (d) obstacles that need to be overcome within a developing country context were highlighted.

10.4 The Costing Methodology

Using the questionnaires in Appendix 7, an attempt was made to generate prospective cost data of various strategies. The costing process involved identification, quantification and valuation of direct inputs (health professionals time, in-service training, administration, drugs, materials, utilities (telephone, electricity and postage), maintenance (of equipment, vehicles and buildings), capital commodities (vehicles, equipment and buildings), and community inputs (time, money and materials) into various strategies. The quantified inputs were valued in 1992 constant market prices. The costs were discounted at a social discount rate (SDR) of 10%, a rate calculated and used in other economic evaluation studies done in Kenya (Curry and Weiss, 1993; Brent, 1990; McArthur, 1978; and Scott et al., 1976). Coincidentally, the social discount rate was equal to the then rate of return on government security bonds. A standard conversion factor (discussed in chapter 3), derived and used by the above mentioned authors, was used in this thesis to revalue interventions resources from their constant market price values to their shadow price values. Hence: **Shadow price = SCF x market price value.**

The purpose of shadow pricing is to arrive at better disease control intervention investment decisions and to improve the effectiveness of such investments. As Curry and Weiss (1993) argues, shadow pricing methods are surrounded by following (yet unresolved) issues: Is the value system upon which economic analysis of disease interventions is based on universally applicable in all types of economies? Given the static nature of most economic analysis applications and the difficulties of including dynamic effects, is it worth investing scarce research resources in shadow pricing?

Lastly, given the World Bank/IMF sponsored economic adjustment programmes taking place in many developing countries (Kenya included), is there any need for economic analysis of health care programmes today?

10.4.1 *The value system built-in economic analysis*

World prices represent the terms on which an economy can participate in foreign trade, and are therefore relevant when planning (health care) investments that either use or produce traded goods (Curry and Weiss, 1993: p.274). Where local transportation and distribution costs are incurred moving goods to and from the border, there will be a divergence between economic value of an health care investment and cif or fob prices.

The contingent valuation approach upon which CBA is based derives from the existing distribution of income. If the existing income distribution is skewed, the expressed WTP may need to be adjusted by consumption weights for stakeholders affected by the contemplated programme. Curry and Weiss (1993:p.275) cautions there would be a "difficulty in obtaining acceptability for a set of consumption weights and (another related problem is) the fact that in practice this form of project analysis has not often been applied". This thesis did not attempt any weighting of willingness to pay values for the reasons discussed earlier in this chapter.

In addition, given that health care output (expected health gains) is not-tradeable and hence not subject to international competition then world prices may not be an appropriate for valuing outputs of health care.

10.4.2 *Dynamic effects*

There may be dynamic effects emanating from learning and technical change, leading to reductions in unit costs or improvements in quality of care over time. "The problem is in predicting if and when such changes will occur. If dynamic effects are not allowed for, this procedure will allocate investment only to activities that are currently competitive internationally, and will ignore the long-run dimension of changing efficiency over time" (Curry and Weiss, 1993:p.277).

10.4.3 *Developing countries economic adjustment programmes versus economic evaluation*

Shadow pricing techniques were developed and perfected in 1960s to evaluate investment projects in developing countries where there was marked government interference with the invisible hand of market mechanism in terms of price and trade controls, credit controls, public investment and artificial restrictions over activities of private sector (Curry and Weiss, 1993). Given that as a result of economic adjustment programme public sector role has been reduced, domestic market prices decontrolled, credit controls lifted, trade liberalized, and the gap between the official exchange rate and market exchange rate has been reduced drastically in a country like Kenya, is there any need for economic analysis of health care programmes?

In an attempt to address the above issue Curry and Weiss (1993:p.278) argues that: *If market prices reflect opportunity cost, conversion factors will tend towards unity and returns at market prices will hardly differ from returns at shadow prices. ... However, equality between market-determined prices for these factors (foreign exchange, labour and capital) and their opportunity costs to the economy will only obtain where an economy has no taxes and subsidies, and is perfectly competitive in the sense of having complete mobility and full employment of resources, and full information on their opportunity costs.* Since the equality between the market prices and opportunity costs is unlikely to have been realized in Kenya, shadow pricing will continue to have an important role in evaluation of health care programmes.

This thesis did not explore the impacts of changes in prices and exchange rate on the choice of the optimal schistosomiasis intervention strategy. The author concurs with Curry and Weiss (1993), that it is necessary in future to compute a standard set of national parameters (such as conversion factors) for use in economic evaluation to ensure analytic consistency.

10.5 The cost-effectiveness decision analysis (CEDA) model

This thesis attempted to develop a cost-effectiveness decision analysis (CEDA) model for determining the optimal path of interventions across various schistosomiasis states. To test the operational efficiency of CEDA model following data was needed:

expected costs of both primary and facility level options; health states (outcomes) utility values; expected life in years at each of the health states (outcomes); health states and transition subjective probabilities; population forecasts for Mwea Scheme; discount factors for each year; and a constant opportunity cost per QALY.

The CEDA model converts QALYs expected from various strategies into Kenyan Shillings using a shadow price per QALY implied in the current practice for those living in schistosomiasis endemic Mwea Division. Having expressed both the cost and benefits in Kenya Shillings, the model uses: Net Effectiveness > 0, as the criterion for identifying the combinations and strategies worth implementing. Since there are more than one mutually exclusive policy combination meeting NE criterion, the one with the highest expected NE is chosen.

The CEDA model was estimated first using local experts subjective probabilities and the results obtained are briefly discussed in this paragraph. NE values for the nine strategies (SQS, HPWSS, HHEDS, VIPL, DMS, MPCPS, MPCOS, SPCOS and SPCPS) were positive; implying each is worth implementing. However, the SPCPS was the optimal option since it had the highest net effectiveness value. All the three sub-options (SPCP+SQD, SPCP+PCD, SPCP+OCD) for those in mild schistosomiasis state passed the NE criteria. However, SPCP+PCD was found to be the optimal option among the three. The three sub-options (SPCP+SQHC, SPCP+PCHC, SPCP+OCHC) available to moderate schistosomiasis sate passed the NE criteria. However, SPCP+PCHC was found to be the optimal option among the three. None of the options available to severe, very severe and coma state patients passed the NE criteria. If the validity and reliability of the estimates obtained from QoL and DT instruments had already be established (which was not done), the implication of the latter finding would have been to recommend termination of even current interventions into the three states. However, currently the above findings and implications are at best illustrative.

The CEDA model was then estimated with external experts' subjective probabilities and the results obtained are briefly discussed in this paragraph. NE values for the nine strategies (SQS, HPWSS, HHEDS, VIPL, DMS, MPCPS, MPCOS, SPCOS and SPCPS) were positive; implying each is worth implementing. However, the MPCPS was the optimal option since it had the highest net effectiveness value. All the three sub-options (MPCP+SQD, MPCP+PCD, MPCP+OCD) for those in mild schistosomiasis sate passed the NE criteria. However, MPCP+PCD was found to be the optimal option

among the three. The three sub-options (MPCP+SQHC, MPCP+PCHC, MPCP+OCHC) available to moderate schistosomiasis sate passed the NE criteria. However, MPCP+PCHC was found to be the optimal option among the three.

The three sub-options (MPCP+SQDH, MPCP+PCDH, MPCP+OCDH) available to severe schistosomiasis sate passed the NE criteria. However, MPCP+PCDH was found to be the optimal option among the three. Among the three sub-options (MPCP+PGHSQ, MPCP+PGHDM, MPCP+PGHSO) available to very severe schistosomiasis state, only MPCP+PGHSQ did not pass the NE criteria. MPCP+PGHSO proved to be the optimal option among the three. Since the external expert decided that coma state was non-existent in schistosomiasis, there was no basis for estimating costs and effectiveness of coma state. The finding from the CEDA model (estimated with external experts judgements) that MPCP is the optimal community level intervention is consistent with previous research (Prescott, 1987).

10.5.1 *Potential for controversy*

Conversion of EQALYs into Kenya Shillings

Some readers may find the idea of an analytical framework that converts EQALYs into local currency equivalent repulsive. However, criticisms ought probably to be done with following reasons for the innovation in mind: (a) By expressing EQALYs and costs values in the same unit of measurement in which budgets are defined, CEDA provides information which could be used to aid the allocation of health care resources to a specific intervention without knowledge of the relative values of all other available interventions. In other words, it provides answer to a question like: Is an intervention X worth undertaking? The NE criteria indicates that if NE>0, then the intervention is worth undertaking. One could rightly argue that such an innovation blurs the distinction between CBDA and CEDA model.

(b) In a country like Kenya where EQALY concept is yet a foreign and unfamiliar phenomenon, it is important that the expected QALY gains and costs be converted into a numeraire which minor and major decision makers are used to (and that is the Kenya Shilling). The decision-makers who might be interested to know where monetary values came from could be taken one step back to EQALYs. That could easily be done by

dividing monetary value of EQALYs by the implicit shadow price per QALY (i.e. opportunity cost of a QALY).

(c) Conversion of QALYs into their monetary equivalents increases scope for not only intra-sectoral but also inter-sectoral comparisons. For example, benefits expected from health interventions can be compared with net benefits expected from housing, education, environmental improvement, and so on.

(d) A less important reason for converting EQALYs into their monetary equivalents was to test the hypothesis that cost-effectiveness and cost-benefit analysis would nominate the same intervention strategy (Phelps and Mushlin, 1991).

Use of an incremental price derived from past decisions

Having calculated incremental cost effectiveness ratios for various primary and facility level options (policy combinations), the analyst had to face-up-to the question - what is an acceptable cost-effectiveness ratio? In other words, the issue was whether the options under consideration were cost-effective (i.e., whether additional EQALYs are worth additional expected cost)? It is wrong to recommend adoption of the strategy or option with the lowest cost-effectiveness ratio for two reasons. "(1) Unless there is a clear-cut base-line strategy against which all others are to be compared, the cost effectiveness ratio of each strategy is not uniquely defined. (2) There is no theoretical justification for asserting that the strategy with the lowest cost-effectiveness ratio (i.e., the one that yields the greatest benefit per dollar spent) is the most desirable one" Doubilet et al. (1986:255). Those authors explain that unavoidable and inherently difficult value judgements must be made to select one strategy over its alternatives. They argue further that whether a strategy or an option is cost-effective (worth pursuing) depends on the amount of money society is willing to pay for each additional EQALY. There is growing consensus among economists that the CEA calculus entails derivation of society's cut-off level (or ratio) of permissible cost per QALY (Weinstein and Stason, 1977; Doubilet et al., 1986; Phelps and Mushlin, 1988; Phelps and Mushlin, 1991; Birch and Gafni, 1991). Inspite of the above mentioned consensus, there is no agreement on the appropriate magnitude of the cut-off effectiveness ratio and on the way it should be derived. A possible source is to derive the price or value that decision-makers' currently attach to an additional QALY gained (Sugden and Williams, 1978; McGuire et al.,

1991).

The shadow price (opportunity cost of resources currently being used in control of schistosomiasis) per QALY is an inverse of the "cut-off" effectiveness-cost ratio (ECR). As explained in chapter 6, the cut-off ECR ratio was obtained by dividing the difference in QALYs expected from SQS and DNCS by the difference in their efficiency costs. Since the shadow price (opportunity cost) per QALY was derived from values implied in the existing political system, it could be argued that it suffers most of the demerits attributed to the implicit value approach reviewed in chapter 3. However, the above statement probably ought to be viewed in the light of the following considerations:

(a) The implied incremental price (or cost) per extra QALY is used in this study merely as a conversion factor. The implied cost per QALY was converted into its shadow price equivalent using a standard conversion factor.

(b) According to Mooney (1977:73), "if the decision-maker (politician) was unclear what the implications (of his resource allocation decisions) were but made some guess, then even if his guess were wrong it is that guess on which he made his decision - and it is valid to use this for obtaining the implied value".

(c) Given that there is no agreement on the appropriate cutoff ratio, it was necessary to do sensitivity analysis on the implied price per QALY derived and employed in this thesis. As explained in chapter 9, the strategy rankings were invariant to more than 50% variations in the shadow price.

In short, whether the implied incremental opportunity cost per QALY used to convert EQALYs into their monetary equivalents suffers the weaknesses of the socially implied values approach reviewed in chapter 3 remains a matter of subjective judgement. And we should not forget that no procedure exists at the moment of deriving the cut-off ratio that is free from ethical issues (Doubilet et al., 1986; Phelps and Mushlin, 1988).

Multiple primary interventions

This study assumes that primary options (like secondary options) are mutually exclusive. While the assumption is definitely plausible for the latter, in reality it may not hold for the former. However, that problem in principle could easily be dealt with in the CEDA model, by evaluating a combination of two or more primary options as a

single option. For example, if MPCP was combined with DM, we would have MPCP/DM primary option plus associated secondary options (MPCP/DM+SQD, MPCP/DM+PCD, MPCP/DM+OCD, and so on). The author of this thesis attempted to elicit subjective probabilistic effectiveness of combinations of primary options, but experts found combinations extremely difficult to evaluate. The possible reason is that while their costs could be just summed up, the same could not be done to their effectiveness (mainly because it's not linear).

Validity and Reliability

Given that validity and reliability of the quality of life and the Delphi instruments was not established, the reliability and validity of results from the cost-effectiveness model remains grossly uncertain. A pertinent question is: what are the implications of not establishing the validity of the QoL and DT instruments? (a) Since the validity and reliability of the QoL and DT assessments was not established, the findings generated in this thesis cannot be generalized, and hence there is no basis for making binding (save for illustrative) policy recommendations. (b) It follows that the EQALYs estimated in this thesis are very tentative and they **should not** be used to aid decision making, until such a time that the instruments employed have been validated. (c) Current ideas about what the relevant QoL dimensions are, as well as what the instrument measures will most likely change as new evidence becomes available. (d) Research is urgently required to establish the validity and reliability of the QoL and DT instruments developed and field-tested in this thesis. (e) The disadvantages of effectiveness assessments from a Delphi panel must be weighed against the advantages that can be achieved through use of subjective probabilities. The fact remains that in many instances these technological methods are the only systematic approaches available. (f) More empirical work need to be done on the contributions to accuracy of the three key aspects of Delphi (i.e., experts, iterative procedure, and feedback).

10.6 The Schistosomiasis Cost-Benefit Decision Analysis (CBDA) model

This thesis attempted to develop a CBDA model for determining the optimal path of interventions across various schistosomiasis states. To test the operational efficiency

of CBDA model following data was needed: expected costs of both primary and facility level options; health states (outcomes) WTP values; health states and transition subjective probabilities; population forecasts for Mwea Scheme; and discount factors for each year.

Unlike the CEDA model, CBDA model values directly the cost and benefits in Kenya Shillings. The model uses: NPV>0, as the criterion for identifying the combinations and strategies worth implementing. Since there are more than one mutually exclusive strategies and policy combinations meeting NE criterion, the one with the highest expected NPV is automatically chosen.

The CBDA model was estimated first using local experts subjective probabilities and **WTP for return to normal**. NPVs for the nine strategies (SQS, HPWSS, HHEDS, VIPL, DMS, MPCPS, MPCOS, SPCOS and SPCPS) were positive; implying each is worth implementing. However, the SPCPS was the optimal strategy since it had the highest NPV. SPCP+PCD proved to be the optimal option for those in mild schistosomiasis. SPCP+PCHC was the optimal option for moderate schistosomiasis cases. SPCP+PCDH was the optimal option for severe state cases. None of the options available to the very severe and coma state[2] patients passed the NPV criteria. If the validity and reliability of the estimates obtained from WTP and DT instruments had already be established (which was not done), the implication of the latter finding would have been to recommend termination of even current interventions into the three states. However, currently the above findings and implications are at best illustrative.

The CBDA model was estimated for the second time using local experts subjective probabilities and **WTP to avoid advancing to the next state**. NPVs for the nine strategies (SQS, HPWSS, HHEDS, VIPL, DMS, MPCPS, MPCOS, SPCOS and SPCPS) were positive; implying each is worth implementing. However, the SPCPS was the optimal strategy since it had the highest NPV. SPCP+PCD proved to be the optimal option for those in mild schistosomiasis. SPCP+PCHC was the optimal option for moderate schistosomiasis cases. SPCP+PCDH was the optimal option for severe state cases. SPCP+PGHSO was the optimal option for very severe state cases. None of the options available to the comatose state patients passed the NPV criteria. Thus, except for the very severe state, the findings from CBDA estimated with WTP for return to normal and WTP to avoid advancing to the next state were fairly similar. Implying that the way WTP questions are framed may affect magnitudes of health states WTP, but not

necessarily the order in which options are ranked.

The CBDA model was estimated for the third time using international experts subjective probabilities and WTP for return to normal. NPVs for the nine strategies (SQS, HPWSS, HHEDS, VIPLS, DMS, MPCPS, MPCOS, SPCOS and SPCPS) were positive; implying each is worth implementing. However, the SPCPS was the optimal strategy since it had the highest NPV. SPCP+PCD proved to be the optimal option for those in mild schistosomiasis. SPCP+SQHC was the optimal option for moderate schistosomiasis cases. SPCP+SQDH was the optimal option for severe state cases. SPCP+PGHSO was the optimal option for very severe state cases. The cost-benefit analysis of the options available to the coma state patients was excluded since the external expert thought there is no coma state in schistosomiasis.

The CBDA model was run for the fourth time using local experts subjective probabilities and WTP to avoid advancing to the next state. NPVs for the nine strategies (SQS, HPWSS, HHEDS, VIPLS, DMS, MPCPS, MPCOS, SPCOS and SPCPS) were positive; implying each is worth implementing. However, the MPCPS was the optimal strategy since it had the highest NPV. MPCP+PCD proved to be the optimal option for those in mild schistosomiasis. MPCP+PCHC was the optimal option for moderate schistosomiasis cases. MPCP+PCDH was the optimal option for severe state cases. MPCP+PGHSO was the optimal option for very severe state cases. The coma state was excluded for the same reason as above. The use of subjective probabilities from a different expert led to a switch of the optimal strategy from SPCPS to MPCPS.

10.7 Conclusion

The proven operational feasibility of CEDA and CBDA models indicates that decision analysis conceptual framework provides an essential adjunct to either cost-effectiveness or cost-benefit analysis. It also provides a cohesive framework for dealing with both uncertainty and complex value judgements, as well as the complex sequencing of decisions based on the current level of information and long-range probabilistic effectiveness forecasts.

The finding that the use of subjective probabilities from different experts alters the ranking of intervention strategies both in CEDA and CBDA models does not in any way diminish the importance of either DT or subjective probabilities or reduce the need to

incorporate them into intervention strategy choice decisions. Instead, it indicates there is need for research into the mental processes which individual experts use when evaluating the subjective probabilistic effectiveness of various disease interventions. By understanding these processes better experimental methods via which a true consensus may be reached might be improved. Further, the dependence of studies such as this upon subjective judgements is itself something that could be alleviated by research into the substantive epidemiology of schistosomiasis. This too is a priority for future research in the field.

The choice of SPCPS (using local expert judgements) and MPCPS (using external expert judgements) as the optimal strategies in both CEDA and CBDA models was invariant to changes in expected effectiveness and expected monetary values across-the-board. However, the choice of SPCPS and MPCPS as the optimal strategies proved to be very sensitive when their effectiveness was varied holding the effectiveness of the other strategies constant. Such ultra-sensitivity could be attributed to the closeness of various strategies probabilistic effectiveness values (as assessed by experts).

In summary the above findings imply that the use of a different set of subjective probabilities may not only lead to a change in the order in which intervention strategies are ranked but also to a change in both the net benefits and ranking of the associated policy combinations. There is no basis for drawing any policy conclusions, and any policies implied in this thesis are strictly illustrative. There is a need for a consensus among the schistosomiasis intervention(s) experts. In addition, a change is necessary in the way RCETs are currently conducted to enable them produce the relevant epidemiological information needed in economic evaluations. Clearly, there is a need to replicate the methodologies developed and used in this thesis with a view of determining their reliability and validity.

Finally, readers are cautioned that the main purpose of this thesis **was not** to produce a policy document for adoption or implementation by the Ministry of Health. Instead its purpose was to develop decision analytic frameworks which could be used to determine the optimal path of interventions across various schistosomiasis states, when reliable and valid empirical data become available. To meet the requirements for data needed to test operational feasibility of CBDA and CEDA models, four instruments (QoL, WTP, DT and cost questionnaires) were developed and used to collect primary data. It is hoped that the methods, which we have developed and demonstrated here to

be feasible, will be subject to more widespread testing and further refinement.

Footnote

1. The author was born and brought-up in typical peasant farming culture. In Kenya, the Ameru (authors tribe) and Kikuyu (survey tribe) are regarded as close cousins. There are a lot of similarities in crops grown (although rice is not grown in Meru), farming technology (use of the hoe), family organization (with father as the household-head), division of labour within the household, food, general socializing habits, religious beliefs, history, and to a lesser degree the language. Among the Ameru, individuals (and society) consider themselves to be healthy if they are able to carry out their expected roles. To the extent that they cannot, they are sick.

2. Although coma state is excluded from the detailed discussion of the model in chapter 7 and 8 on the advice of the international expert, the model has also been run to reflect the judgements of local experts. In this form the coma state is included.

REFERENCES

Abel-Smith, B. (1976), *Value for money in health services*, London: Heineman.

Acton, J.P. (1973), *Evaluating public programmes to save lives: the case of heart attacks*, Research Report R-73-021, Santa Monica, California Rand Corporation.

Acton, J.P. (1976), Measuring the monetary value of life saving programmes, *Law and contemporary problems*, 40:46-72

Adreano R. and Helminiak T. (1988), Economics, health and tropical disease: a review, In: Herrin A.N. and Rosenfield P. (eds.) *Economics, Health and Tropical Diseases*, Manila, University of the Philippines, School of Economics, pp.19-72.

Akehurst, R.L. and Buxton, M.J. (1985), *Options Appraisal in the NHS: a guide to better decision-making*, Nuffield, Nuffield Provincial Hospitals Trust.

AMREF (1992), Cost quotations for short-term courses in planning and management of health services, Nairobi, African Medical Research Foundation, unpublished document.

Amstrong, J.S. (1978), *Long-range forecasting: from crystal ball to computer*, New York, John Willey and Sons.

Anderson, M. (1983), *An introduction to epidemiology*, London, Macmillan.

Anderson, R.M. and May, R.M. (1982), Population dynamics of human helminth infections: control by chemotherapy, *Nature*, 297, 557-563.

Anderson, R.M. and Medley, G.F. (1986), Community control of helminth infections of man by mass and selective chemotherapy, *Parasitology*, 90, 629-660.

Appel, L.J., Steinberg, E.P., Powe, N.R., Anderson, G.F., Dwyer, S.A. and Faden, R.R. (1990), Risk reduction from osmolality contrast media, *Medical Care*, 28, 324-337.

Audibert, M. (1986), Agricultural non-wage production and health status, *Journal of Development Economics*, 24, 275-291.

Axton, J. and Garnett, P.A. (1976), A trial of oral oxamniquine in the treatment of schistosome infection in children, *Southern Africa Medical Journal*, 50, 1051-1053.

Baldwin, R.E. and Weisbrod, B.A. (1974), Disease and labour productivity,

Economic Development and Cultural Change, 22, 414-435.

Barnum, H. (1987), Evaluating health days of life gained from health projects, *Social Science and Medicine*, 24, 10, 833-841.

Ben-Zion, U. and Gafni, A. (1983), Evaluation of public investment in health care: is the risk irrelevant, *Journal of health economics*, 2, 161-165.

Bergner, M. et al., (1976), The sickness impact profile: conceptual formulation and methodology for the development of a health status measure, *International Journal of Health Services*, 6, 3, 393-415.

Bergner, M., Bobbit, R.A., Pollard, W.E., Martin, D.P., and Gilson, B.S. (1976), The Sickness Impact Profile: Validation of a health status measure, *Medical Care*, 1, 57-67.

Bergner, M., Bobbit, R.A., Kressel, S., Pollard, W.E., Gilson, B.S., and Morris, J.R. (1978), The Sickness Impact Profile: Conceptual formulation and methodology for the development of a health status measure, *International Journal of Health Services*, 6, 3, 393-415.

Bergner, M., Bobbit, R.A., Carter, W.B., and Gilson, B.S. (1981), The Sickness Impact Profile: Development and Final revision of a health status measure, *Medical Care*, 8, 787-805.

Bernasconi, M. (1991), Non-conventional decision analysis: theories, evidence and implications, D.Phil. thesis, University of York.

Bina, J.C. and Prata, A. (1980), Oxamniquine in the treatment of schistosomiasis in a population in an area with low endemicity, *Revista do Instituto de Medicine Tropical de Sao Paulo*, 22, 94-97.

Birch, S. and Donaldson, C. (1987), Applications of cost-benefit analysis to health care, *Journal of Health Economics*, 6, 211-225.

Birch, S. and Gafni, A. (1991), Cost effectiveness/Utility analyses: Economic approaches to pursuing non-economic goals?, Centre for Health Economics and Policy Analysis, McMaster University, Discussion Paper.

Boadway, R.W. and Bruce, N. (1984), *Welfare economics*, Cambridge, Basil Blackwell.

Brent, R.J. (1990), *Project appraisal for developing countries*, London: Harvester Wheatsheaf.

Brinkmann, U.K., Werler, C., Traore, M. and Korte, R. (1988), The cost of

schistosomiasis control in a Sahelian country, *Trop. Med. Parasit.*, 39, 175-181.

Brookshire, D.S., Thayer, M.A., Schultze, W.D. and d'Arge (1982), Valuing public goods: A comparison of survey and hedonic approaches, *American Economic Review*, 72, 165-177.

Brodman, K., Erdman, A.J. and Wolff, H.G. (1960), *Cornnel medial index-health questionnaire manual*, New York, Cornnel University Medical College.

Bundy, D.A.P. (1990), Control of intestinal nematode infections by chemotherapy: mass treatment versus diagnostic screening, Royal Society of Tropical Medicine and Hygiene Meeting at Manson House, 18 January 1990, *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 84, 622-625.

Butterworth, A.E., Dalton, P.R., Dunne, D.W., Mugambi, M., Ouma, J.H., Richardson, B.A., Arap Siongok, T.K., and Sturrock, R.F. (1984), Immunity after treatment of human *Schistosomiasis mansoni*. I. Study design, pretreatment observations and the results of treatment, *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 78, 108-123.

Butterworth, A.E., Dalton, P.R., Dunne, D.W., Mugambi, M., Ouma, J.H., Prentice, M.A., Richardson, B.A., Sturrock, R.F. (1985), Immunity after treatment of human *Schistosomiasis mansoni*. II. Identification of resistant individuals and analysis of their immune responses, *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 79, 393-407.

Butterworth, A.E., Sturrock, R.F., Ouma, J.H., Mbugua, G.G., Fulford, A.J.C., Kariuki, H.C. and Koech, D. (1991), Comparison of different chemotherapy strategies against *Schistosoma mansoni* in Machakos District, Kenya: effects of human infection and morbidity, *Parasitology*, 103, 339-355.

Cairns, J. (1992), Discounting and health benefits, *Health Economics*, 1, 76-79.

Carr-Hill, R.A. (1992), A second Opinion: Health related quality of life measurement - Euro style, *Health Policy*, 20, 321-328.

Carrin, G. (1984), Economic evaluation of health care interventions: a review of alternative methods, *Social Science and Medicine*, 19, 10, 1015-1030.

Carter, W.B., Bobbit, R.A., Bergner, M., and Gilson, B.S. (1976), Validation of an interval scaling: The Sickness Impact Profile, *Health Services Research*,

11, 516-528.

Chambers, L.W., MacDonald, L.A., Tugmell, P., Buchanan, W.W. and Kraag, G. (1982), The McMaster Health Index Questionnaire as a measure quality of life for patients with rheumatoid disease, *Journal of Rheumatism*, 9, 780-784.

Chambers, L.W., Sackett, D.L., Goldsmith, C.H., Macpherson, A.S. and McAuley, R.G. (1976), Development and application of an index of social function, *Health Services Research*, 11, 430-41.

Chandiwana, S.K. (1988), Antischistosomal treatment and measurement of incidence in schistosomiasis in a community of high transmission, *Trop. Geogr. Med.*, 40, 314-317.

Chandiwana, K.C. and Taylor, P. (1990), The rational use of antischistosomal drugs in schistosomiasis control, *Social Science and Medicine*, 30, 10, 1131-1138.

Chen, M.M. and Bryant, B.E. (1975), The measurement of health - a critical and selective overview, *International Journal of Epidemiology*, 4, 4, 257-264.

Chen, M.M., Bush, J.W. and Patrick, D.L. (1975), Social indicators for health planning and policy analysis, *Policy Sciences*, 6, 71.

Cheever, A.W. (1978), Schistosomiasis and neoplasia, *Journal of the National Cancer Institute*, 61, 13-18.

Cheever, A.W., Kamel, I.A., Elwi, A.M., Mosimann, J.E., Danner, R. and Sippel, J.E. (1978), *Schistosoma mansoni* and *S. haematobium* infections in Egypt: extrahepatic pathology, *American Journal of Tropical Medicine and Hygiene*, 27, 55-75.

Choudhry, A.W. (1974), Seven years of snail control on Mwea Irrigation Scheme Settlement, Kenya: results and costs, *East African Medical Journal*, 51, 600.

Choudhry, A.W. (1975), The results of five years of snail control at Ahero Pilot scheme, Kenya, *East African Medical Journal*, 52, 10, 573-577.

Choundry, A.W. (1990), Economic aspects of schistosomiasis in irrigated areas in Kenya, In: WHO (ed.), *Water resources development and vector-borne diseases in Kenya*, Geneva: World Health Organization, 74-78.

Clark, A.W. and Fallowfield, L.J. (1986), Quality of life measurements inpatients with malignant disease: a review, *JRSM*, 79, 165.

Clarke, V. de V. and Blair, D.M. (1976), Trials with ambihar (Ciba 32644-BA) in

the treatment of Bilharziasis in Rhodesia, *Southern Africa Medical Journal*, 50, 1867-1871.

Cline, B.L., Ryzmo, W.T., Hiatt, R.A., Knight, W.B., Berrios-Duran, L.A. (1977), Morbidity from *Schistosoma mansoni* in Puerto Rican community: a population-based study, *American Journal of Tropical Medicine and Hygiene*, 26, 109-117.

Cohen, J.E., Some potential economics benefits of eliminating mortality attrubuted to schistosomiasis in Zanzibar, *Social Science and Medicine*, 8, 383-393.

Collins, K.J., Brotherwood, R.J., Davies, C.T.M., Dore, C., Hackett, A.J., Imms, F.J., Musgrove, J., Weiner, J.S., Amin, M.A., El-Karim, M., Ismail, H.M., Omver, A.H.S. and Sukkar, M.Y. (1976), Physiological performance and work capacity of sudanese cane cutters with *Schistosome mansoni* infection, *American Journal of Tropical Medicine and Hygiene*, 25, 410-421.

Cook, P.J. (1978), The value of human life in the demand for safety: comment, *American Economic Review*, 68, 710-711.

Cook, J.A, Jordan, P. and Bartholomew, R.K. (1977), Control of *Schistosome mansoni* transmission by chemotherapy in St. Lucia, *The American Journal of Tropical Medicine and Hygiene*, 26, 5, 887-893.

Costa, M.F.F.L.E, Rocha, R.S., Magalhaes, M.H.A. and Katz, N. (1985), A clinico-epidemiological survey of *Schistosomiasis mansoni* in a hyperendemic area in Minas Gerais State (Comercinho, Brazil). I. Differences in the manifectastions of schistosomiasis in the town centre and in the environs, *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 79, 539-545.

Creasey, A.M., et al. (1981), Field trial of praziquantel in the treatment of schistosomiasis in Zimbabwe, Annual Report, Ministry of Health.

Culyer, 1980, *The Political Economy of Social Policy*, Oxford, Martin Robertson.

Culyer, A.J. (ed.)(1983), *Health Indicators: an International Study of the European Science Foundation*, London, Martin Robertson.

Culyer, A.J., Maynard, A. and Posnett, J.W. (1990), *Competition in health care: reforming the NHS*, London, Mc Millan Press.

Culyer, A.J. (1991a), *Equity in health care policy*. Ontario, University of Toronto.

Culyer, A.J. (1991b), *Health, expenditures and equity*. Discussion Paper 83, York,

Centre for Health Economics, University of York.

Culyer, A.J. (1991c). Conflicts between equity concepts and efficiency in health: a diagrammatic approach, *Osaka Economic Papers*, 40, 141-154.

Culyer, A.J. (1991c). The normative economics of health care finance and provision, In A. McGuire, P. Fen and K. Mayhew, (eds.), *Providing Health Care: the Economics Systems of Finance and Delivery*, Oxford, Oxford University Press, 65-98.

Culyer, A.J. and Wagstaff, A. (1991a), *Need, Equity and Social Justice.* Discussion Paper 90, York: Centre for Health Economics, University of York.

Culyer, A.J. and Wagstaff, A. (1991b), *Need, Equity, and Equality in Health and Health Care*, Discussion paper 95, Centre for Health Economics, University of York.

Culyer, A.J. (1992), The morality of efficiency in health care - some uncomfortable implications, *Health Economics*, 1, 7-18.

Culyer, A.J. (1993), Health, Health Expenditures and Equity, In E. Van Doorslaer, A. Wagstaff and Rutten, F. (eds.), *Equity in Finance and Delivery of Health Care: An International Perspective*, Oxford, Oxford University Press.

Culyer, A.J. and Wagstaff, A. (1993), *QALYs versus HYEs*, Department of Economics, University of York, Working Paper.

Curry, S. and Weiss, J. (1993), *Project analysis in developing countries*, London: The MacMillan Press Ltd.

Dalkey, N.C. (1975). *'Toward a theory of group estimation'*. In Listone and Turrof (ed) London: Addison Wesley.

Dasgupta, P.A. and Pearce, D.W. (1972), *Cost-Benefit Analysis: theory and practice*, New York, Bernews and Noble.

Davis, A. (1986), Recent advances in schistosomiasis, *Quarterly Journal of Medicine*, 226, 95-110.

Deaton, A., and Muellbauer, J.(1984), *Economics and consumer behaviour*, Cambridge, Cambridge University Press.

Doherty, N. (1976), *Insurance pricing and loss prevention*, Westmead, Saxon House.

Donaldson, C., Atkinson, A., Bond, J. and Wright, K. (1988), Should QALYs be

programme specific?, *Journal of Health Economics*, 7, 239-57.

Donaldson, C. and Wright, K. (1989), Programme-specific QALYs: a reply, *Journal of Health Economics*, 8, 489-91.

Donaldson, C. (1990), Paying for publicly provided goods: a possible measure of benefit? *Journal of Health Economics*, **9**(1), 103-18.

Doubilet, P., Weinstein, M.C. and McNeil, B.J. (1986), Use and misuse of the term "cost effective" in medicine, *The New England Journal of Medicine*, 314(4), 253-255.

Drummond, M.F. (1980), *Principles of economic appraisal in health care*, Oxford, Oxford University press.

Drummond, M.F. (1981), Studies in economic appraisal: Vol.1, Oxford, Oxford University press.

Drummond, M.F., Ludbrook, A., Lowson, K. and Steele, A. (1986), Studies in economic appraisal in health care: Vol.2, Oxford, Oxford University press.

Drummond, M.F. (1987), Resource allocation decisions in health care: a role for quality of life assessments, *Journal of Chronic Diseases*, **40**, 605-16.

Drummond, M.F., Stoddart, G.L., and Torrance, G.W. (1987), *Methods for the of Economic Evaluation of Health Care Programmes*, Oxford, Oxford University Press.

Drummond M.F. (1989), Output Measurement for resource allocation decision in health care, *Oxford Review of Economic Policy*, 5, 59-74.

Drummond, M.F. (1987), 'Resource allocation decisions in health care: a role for quality of life assessments', *Journal of Chronic Diseases*, 40, 6, 605-16.

Drummond M.F. (1987), Economic analysis and medical research. In: A. Williams, *Health and Economics*, London, MacMillan Press.

Drummond, M.F. and Mills, A. (1989), Developing economics expertise for the evaluation of primary health care, *Public Administration and Development*, 9, 83-96.

Drummond, M.F. (1991), Output Measurement for Resource Allocation Decisions in Health Care, In A. McGuire, P. Fen and K. Mayhew, (eds.), *Providing Health Care: the Economics Systems of Finance and Delivery*. Oxford, Oxford University Press, 99-119.

Duke, B.O.L. and Moore, P.J. (1976), The use of molluscicide in conjunction with

chemotherapy to control *Schistosomma haematobium* at the Barombi Lake foci in Cameroon, III. Conclusions and cost, *Tropenmed. Parasit.*, 27, 505-508.

El Karim, M.A., Collins, K.J., Brotherhood, J.R., Dore, C., Weiner, J.S., Sukker, M.Y., Omer, A.H., Amin, M.A. (1980), Quantitative egg excretion and work capacity in a Gezira population infected with *Schistosoma mansoni*, *American Journal of Tropical Medicine and Hygiene*, 29, 1, 54-61.

EuroQoL Group, (1990), A new facility for the measurement of health related quality of life, Health Policy, *Health Policy*, 16, 199-208.

EuroQoL, (1992), A reply and reminder, *Health Policy*, 20, 329-332.

Fanshel, S. and Bush, J.W. (1970), A health-status index and its applications to health services-outcomes, *Operations Research*, 18, 1021-1066.

Farid, Z., Miner, F.W., Higashi, G.I. and Hassan, A. (1976), Reversibility of lesions in schistosomiasis: a brief review, *Journal of Tropical Medicine and Hygiene*, 9, 164-166.

Farooq M. (1963), A possible approach to the evaluation of the economic burden imposed on a community by schistosomiasis, *WHO Bulletin*, 323-331.

Farooq, M. (1966), The epidemiology of *Schistosoma haematobium* and *S. mansoni* infections in the Egypt - 49 Project Area. 2. Prevalence of Bilharziasis in relation to personal attributes and habits, *Bulletin of the World Health Orgainization*, 35, 293-318.

Farooq, M. (1967), Progress in Bilharziasis control, The situation in Egypt, *WHO Chronicals*, 21, 175.

Feachen, R.G., Bradley, D.J., Garelick, H., Mara, D.D. (eds.) (1983). *Sanitation and Disease: Health aspects of excreta and waste water management*, Chichester, John Wiley and Sons.

Feeney, D.H. and Torrance, G.W. (1989), Incorporating utility-based quality-of-life assessment measures in clinical trials: two examples, *Medical Care*, Supplement, 27, 3, 190-204.

Feldstein, P.J. (1973), *Financing dental care: an economic analysis*, London, Lexington Books.

Feldstein, P.J. (1981), *Hospital costs and health insurance*, London: Havard University Press.

Fenwick, A. (1972), The costs and a cost-benefit analysis of an *S.mansoni* control programme on an irrigated sugar estate in northern Tanzania, *Bulletin of World Health Organization*, 47, 573-578.

Fenwick, A. and Figenschou, B.M. (1972), The effect of *Schistosome mansoni* infection on the productivity of cane cutters on sugar estate in Tanzania, *Bulletin of World Health Organization*, 47, 567-572.

de Ferranti, D. (1985), Paying for Health Services in Developing Countries: an overview, World Bank staff working paper No. 721.

de Finetti (1962), Does it make sense to speak of 'Good Probability Appraisers'?, In I.J. Good (ed.), *The Scientist Speculates: An anthropology of Partly Baked Ideas*, London, Heinemann, pp. 357-364.

de Finetti (1965), Methods for discriminating partial knowledge concerning a test item, *The British Journal of Mathematical and Statistical Psychology*, 18: 87-123.

Fishchoff, B. and Cox, L.A. (1986), Conceptual framework for regulatory benefits assessment, In: *Benefits Assessment: the state of the art*, Bentkover, J.D., Covella, V.T. and Mumpower, J. (eds), Boston, D. Reidel Publishing Company.

Forgey, L., Manundu, M., Muchiri, Ikiara, G.K., J., Nganda, B., et al. (1990), *Primary Health Care Financing Gap in Kenya*, Nairobi, Unpublished MOH report.

Forsyth, D.M. and Bradley, D.J. (1964), Irreversible damage by *Schistosome haematobium* in school children, *The Lancet*, pp.169-173.

Forsyth, D.M. and Bradley, D.J. (1966), The consequences of bilharziasis: medical and public health importance in North-West Tanzania, *Bulletin of the World Health Organization*, 34, 715-735.

Forsyth, D.M. (1969), A longitudinal study of endemic urinary schistosomiasis in a small East African community, *Bulletin of World Health Organization*, 40:771-783.

Foster, R. (1977), Schistosomiasis on an irrigated estate in East Africa. III. Effects of asymptomatic infection on health and industrial efficiency, *Journal of Tropical Medicine and Hygiene*, 70, 185-195.

Foster, R. (1987), A review of clinical experience with oxamniquine, *Transactions*

of the Royal Society of Tropical Medicine and Hygiene, 81, 55-59.

Fox-Rushby, J. (1993), Appraising the use of contigent valuation: a note in response, *Economic Evaluation*, 2, 361-362.

French, S. (1989), *Readings in Decision Analysis*, New York, Chapman and Hall.

Friedman L.S. (1985), *Micro-economic policy analysis*, New York, McGrow-Hill.

Fuchs, V.R. (ed.) (1972), *Essays in the economics of health and medical care*, New York, National Bureau of Economic Research.

Fuchs, V.R. (1983), *Who shall live?*, New york, Basic Books.

Gafni, A. and Torrance, G.W. (1984), Risk attitude and time preference in health, *Management science*, 30, 440-451.

Gafni, A. (1989), The quality of QALYs (quality-adjusted-life-years): do QALYs measure what they at least intend to measure?, *Health Policy*, 13, 81-83.

Gafni, A. (1991), Willingness-to-pay as a measure of benefits: relevant questions to ask in the context of a public decision making about health care programmes, *Medical Care*, 29, 1246-52.

Gerald, K., Dobson, M. and Hall, J. (1993), Framing and labelling effects in health descriptions: quality of life years for treatment of breast cancer, *Journal of Clinical Epidemiology*, 46, 77-84.

Gerald, K. (1991) *A review of cost utility studies: assessing their policy making relevance*, Discussion Paper 11/91, Health Economics Research Unit, Aberdeen University, 1991.

Ghana Health Assessment Project Team (1981), A quantitative method of assessing the health impact of different diseases in less developed countries, *International Journal of Epidemiology*, 10, 73-80.

Ghiselli, E.E., Campbell, J.K. and Zedeck S. (1981), *Measure theory for the behavioral sciences*, San Francisco, W.H. Freeman and Company.

Granger, C.W.J. (1980), *Forecasting in business and economics*, London, Academic Press

Granger, C.W.J. (1967), *Investigating the future: statistical forecasting problem*, Nottingham, Hawthornes of Nottingham.

Grogono, A.W., and Woodgate, D.J. (1971), Index for measuring health, *Lancet*, 1024-1026.

Gryseels, B. and Polderman, A.M. (1987a), The morbidity of *Schistosomiasis*

mansoni in Miema (Zaire), *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 81, 202-209.

Gryseels, B., Nkulikyinka, L. and Coosemans, M.H. (1987b), Field trials of praziquantel and oxamniquine for the treatment of *Schistosomiasis mansoni* in Burundi, *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 81, 641-644.

Gryseels, B. (1988), The morbidity of *Schistosomiasis mansoni* in the Rusizi Plain (Burundi), *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 82, 582-587.

Gryseels, B. and Nkulikyinka, L. (1989), Two-year follow-up of *Schistosomiasis mansoni* infection and morbidity after treatment with different regimens of oxamniquine and praziquantel, *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 83, 219-228.

Gryseels, B. and Polderman, A.M. (1991), Morbidity due to *Schistosomiasis mansoni*, and its control in Sub-Saharan Africa, *Parasitology Today*, 7, 244-248.

Gudex, C. (1986), *QALYs and their use by the health service*, Discussion Paper 20, Centre for Health Economics, University of York.

Guilford J.D. (1954), *Psychometric Models*, New York, McGraw-Hill.

Guyatt, H.L., Bundy, D.A.P. and Evans, D. (1992), A population dynamic approach to the cost effectiveness analysis of community based anthelmintic treatment: effects of treatment frequency, Unpublished Research Paper, London, Imperial College of Science, Technology and Medicine.

Guyatt, H.L. and Evans, D. (1992), Economic considerations for helminth control, *Parasitology Today*, 8(12), 397-401.

Gyldmark, M. and Morrison, G.C. (1993), Re-appraising the use of contigent valuation: a reply, *Economic Evaluation*, 2, 363-365.

Gyldmark, M. (1993), Preferences for health care services in Denmark - an investigation through contigent valuation, Discussion Paper presented at the 14th Meeting of the Nordic Health Economist Group, Tromso, August 18-20, 1993.

Hamburg, M. (1977), *Statistical analysis for decision making*, New York, Harcourt Brace Javanovich.

Harsanyi, J.C. (1955), Cardinal Welfare, Individualistic Ethics, and Interpersonal Comparisons of utility, *Journal of Political Economy*, 63, 309-321.

Henderson, J. (1984), Appraising options, Series of Options Appraisal Papers No. 2., Health Economics Unit, University of Aberdeen.

Henderson, J. (1986), Benefits and costs of community and long-stay health services in the Borders, Series of options appraisal papers No. 10, Health Economics Unit, University of Aberdeen.

Henke, K.D. and Behrens, C.S. (1985), The economic cost of illness in the Federal Republic of Germany in the year 1980, *Health Policy*, 6, 119-143.

Hershey, J.C., Kunreuther, H.C. and Shoemaker, P.J.H. (1982), Sources of bias in assessment procedures for utility functions, *Management Science*, 28, 936-54.

Hey, J.D. (1979), *Uncertainty in microeconomics*, Oxford, Martin Robertson.

Hiatt, R. and Gabre-Medhin, M. (1977), Morbidity from *Schistosome mansoni* infections: an epidemiology study based on quantitative analysis of egg excretion in Ethiopia children, *American Journal of Tropical Medicine and Hygiene*, 26, 473-81.

Hiatt R.A., Sotomayor Z.R., Sanchez G., Zambrana M., Knight W.B. (1979), Factors in the pathogenesis of acute *Schistosomiasis mansoni*, *Journal of Infectious Diseases*, 139, 659-666.

Hiatt, R.A., Cline, B.L., Ruiz-Tiben, E., Knight, W.B. and Berrios-Duran, L.A. (1980), The Bocqueron Project after five years: a prospective community-based study of infection with *Schistosoma mansoni* in Puerto Rico, *American Journal of Tropical Medicine and Hygiene*, 29, 1228-1240.

Highton, R.B. and Choudhry, A.W. (1974), The cost evaluation of molluscicide operation on five irrigation schemes in Kenya, *The East African Medical Journal*, 51, 2, 180-193.

Hogarth, R.M. and Reder, M.W. (1986), *Rational Choice: the contrast between economics and psychology*, Chicago, University of Chicago Press.

Howard, R.A. 1980, An assessment of decision analysis, *Operations Research*, 28, 4-27.

Huber, G.P. and Andre, D. (1972), Guidelines for combining the judgements of individual members in decision conferences, *Academy of Management*

Journal, 15, 161-174.

Hunt, S.M., McEwan, J. and McKenna, S.P. (1981a), A quantitative approach to perceived health status: a validation study, *Journal of epidemiology and community health*, 34, 281-286.

Hunt, S.M., McEwan, J. and McKenna, S.P. (1981b), Notingham Health Profile: subjective health status and medical consultations, *Social science and medicine*, 15A, 221-229.

Hunt, S.M., McEwan, J. and McKenna, S.P. (1984), Subjective health assessments and the perceived outcome of minor surgery, *Journal of Psychosomatic Research*, 28, 105-114.

Hunt, S.M., McEwan, J. and McKenna, S.P. (1985), Measuring health status: a new tool for clinicians and epidemiologists, *Journal of the Royal College of General Practitioners*, 185-188.

Hunt, S.M., McEwan, J. and McKenna, S.P. (1986), *Measuring Health Status*, London, Croom Helm.

Hunt, S.M. (1986), Cross-cultural issues in the use of socio-medical indicators, *Health Policy*, 6, 149-158.

Hutchinson, T.A., Boyd, N.F., Feinstein, A.R., Gonda, A., Hollemby, D. and Rowatt, B. (1979), Scientific problems in clinical scales, as demonstrated in the Karnofsky index of performance status, *Journal of Chronic Diseases*, 32, 661-666.

Jamison, D.T., Mosley, W.H., Meacham, A.R., Bobadilla, J-L, (eds.) (1993), *Disease control priorities in developing countries*, New York, Oxford University Press.

Jobin, W.R. (1973), *Cost/benefit analysis for application of molluscicides in the prevention of schistosomiasis*, Geneva: World Health Organization.

Jobin, W.R. (1979), Snail control, *American Journal of Tropical Medicine and Hygiene*, 28, 142-154.

Johannesson, M. and Jonsson, B. (1991a), Economic evaluation in health care: is there a role for cost-benefit analysis, *Health Policy*, 17, 1-23.

Johannesson, M. Johannesson, M. and Jonsson, B. (1991b), Cost effectiveness analysis of hypertension treatment: a review of methodological issues, *Health Policy*, 19, 55-78.

Johannesson, M., Jonsson, B. and Borgquist, L. (1991c), Willingness to pay for antihypertensive therapy: results of a Swedish pilot study, *Journal of Health Economics*, 10, 461-474.

Johannesson, M. (1992), Economic evaluation of lipid lowering - A feasibility test of the contigent valuation approach, *Health Policy*, 20, 309-320.

Johannesson, M. (1993), The contigent valuation method - Appraising the appraisers, *Health Economics*, 2, 357-359.

Johannesson, M., Johansson, P.O., Kristrom, B. and Gredtham, U.G. (1993a), Willingnes to pay for antihypertensive therapy: further results, *Journal of Health Economics*, 12, 95-108.

Johannesson, M., Johansson, P.O., Kristrom, B., Borgquist, L. and Jonsson, B. (1993b), Willingness to pay for lipid lowering: a health production function approach, *Applied Economics*, 25, 1023-1031.

Johnson, D. and King, M. (1988), *Basic forecasting techniques*, London, Butterworths.

Jones-Lee, M.W. (1976), *The value of life: An economic analysis*, London, Martin Robertson.

Jones-Lee, M.W. (1989), *The economics of safety and physical risk*, Oxford, Basil Blackwell.

Jones, J.M. (1986), Decision analysis using spreadsheets, *European Journal of Operational Research*, 26, 385-400.

Jordan, P., Woodstock, L., Unrau, G.O. and Cook, J.A. (1975), Control of *Schistosomiasis mansoni* transmission by provision of domestic water supplies, *Bulletin of World Health Organization*, 52, pp.9-20.

Jordan, P. (1977), *Schistosomiasis-research to control*, American Journal of Tropical Medicine and Hygiene, 26, 877-86.

Jordan, P. and Webbe, G. (1982a), *Schistosomiasis, epidemiology, treatment and control*, London, William Heinemann Medical Books.

Jordan, P., Christie, J.D. and Unrau, G.O. (1982), Evaluation of chemotherapy in the control of *Schistosome mansoni* in Marquis valley, Saint Lucia, I. Results in humans, *American Journal of Tropical Medicine and Hygiene*, 31, 103-110.

Jordan, P. (1985), *Schistosomiasis: the St. Lucia Project*, Cambridge, Cambridge

University Press.

Jordan, P., Barnish, G., Bartholomew, R.K., Grist, E. and Christie, J.D. (1978), Evaluation of an experimental molluscicide programme to control *Schistosoma mansoni* transmission in St. Lucia, *Bulletin of the World Health Organization*, 56, 139-146.

Kahneman, D. and Tversky, A. (1979), Prospect theory: an analysis of decision under risk, *Econometrica*, 47, 2, 263-291.

Kahneman, D. and Tversky, A. (1981), The psychology of preferences, *Science American*, 160-73.

Kahneman, D. and Tversky, A. (1982), The psychology of preference, *Scientific America*, 266, 160-173.

Kahneman, D. and Tversky, A. (1984), Choices, values and frames, *America Psychologist*, 39, 341-350.

Kaplan, R.W., Bush, J.W., and Berry, C.C. (1976). Health Status: Types of validity and the index of well-being. *Health Services Research.* 11, 478-507.

Kaplan, R.M., Bush, J.W. and Berry, C.C. (1979), Health Status Index: Category Status Index: Category Rating versus Magnitude estimation for measuring levels of well-being, *Medical Care* 17, 501-525.

Kaplan, R.M., Anderson, J.P., Wu, A.W, Mathews, C., Kozin, F. and Orenstein, D. (1989), The quality of well-being scale: applications in AIDS, cystic fibrosis and arthritis, *Medical Care*, 27, S27-S43.

Karnofsky, D.A., Abelmann, W.H. et al. (1948), The use of nitrogen mustards in the palliative treatment of carcinoma, Cancer, November, 634-656.

Karnofsky, D.A. and Burchenal, J.H. (1949), 'The clinical evaluation of chemotherapeutic agents in cancer', in C.M. MacLeod (ed.), *Evaluation of Chemotherapeutic Agents*, New York, Columbia University Press.

Katz, S., Ford, A.B., Moskowitz, R.W., Jacobson, B.A. and Jaffe, M.W. (1963), The index of ADL: a standardized measure of biological and physiological indicators, *Journal of Gerontology*, 29, 555-563.

Katz, S., Amasa, B.F., Roland, W.M., Beverly, A.J. and Marjorie, W.J. (1963), Studies of illness in the aged, The Index of ADL: A Standardized Measure of Biological and Psychological Function, *JAMA*, 185, 914-919.

Katz, S. and Akpom, C.A. (1976), A measure of primary sociobiology functions,

International Journal of Health Services, 6, 493-507.

Katz, S., Ford, A.B., Chinn, A.B. and Newill, V.A. (1966), Prognosis after strokes: II. Long-term course of 159 patients with stroke. *Medicine*, 45, 2-246.

Katz, S., Heiple, K.G., Downs, T.D., Ford, A.B., and Scott, C.P. (1967), Long-term course of 147 patients fracture of the hip, *Surg., Gynaecol., Obstet.*, 124, 1219-1230.

Keeney, R.L. and Raiffa, H. (1976), *Decisions with multiple objectives: Preferences and value trade-offs*, Wiley, New York.

Keeney, R.L. (1982), Decision analysis: an overview, Operations Research, 5, 803-838.

Kenya Government (1989). *Development Plan 1989-1993*, Nairobi: Government Printer.

Kenya Government (1989), *Population census statistics*, Nairobi: Kenya Government.

Kenya Government (1991), *Kirinyaga District Development Plan*, Nairobi: Kenya Government.

Kind, P. (1988), The design and construction of quality of life measures, Discussion Paper 43, Centre for Health Economics, University of York.

Kind, P. and Rosser, R. (1988), The quantification of health, *European Journal of social psychology*, 18, 63-77.

Kind, P., Rosser, R. and Williams, A. (1982), Valuation of quality of life: some psychometric evidence, in: M.W. Jones-Lee, M.W. (ed.), *The value of life and safety: proceedings of a conference held by the Geneva Association*, Amsterdam, North Holland, pp. 150-170.

Kimani, S.K. (1990), A review of the current health promotional activities in irrigation schemes under the National Irrigation Board, In: WHO (ed.), *Water resources development and vector-borne diseases in Kenya*, Geneva: World Health Organization, 62-65.

Kirigia, J.M. (1988), The economics of prepaid health services: a case study of the Meru Central Coffee Farmers Co-operative Union, Unpublished M.A. Dissertation, University of Nairobi.

Kirigia, J.M., Fleuret, P. and Byrne, D. (1989), A simulation of the impacts of health care user fees: Meru District Study, UNICEF/USAID report.

Kirigia, J.M. (1991), The economics of prepaid health services: a case study of the *Maendeleo ya Wanawake* Organization, unpublished Diploma dissertation, Tromso University.

Kloetzel, K., Chieffi, P.P. and de Signeira, J.G.V. (1990), Repeated mass treatment of *Schistosomiasis mansoni*: experience in hyperendemic areas of Brazil. 3. Techniques for assessment and surveillance, *Lancet*, 84, 74-79.

KNIB (1992), *Mwea Irrigation Settlement: Location and history*, Nairobi: Kenya National Irrigation Board.

Kolmogorov A.N. (1950). *Foundations of the theory of probability* (edited by Morrison N.), New York, Chelsea, 1950.

Korte R., Schmidt-Ehry B., Kielmann A.A. and Brinkmann (1986). Cost and effectiveness of different approaches to schistosomiasis control in Africa. *Trop. Med. Parasit.*, 37, 149-152.

Kvalsvig, J.D. (1988), The effects of parasitic infection on cognitive performance, *Parasitology Today*, 4, 206-208.

Lee, K. and Mills, A. (eds.) (1983), *The economics of health in developing countries*, Oxford, Oxford University Press.

Listone H.A. and Turrof M. (eds.) (1975). *The Delphi Method: techniques and applications*. London, Addison-Wesley.

Llwelyn-Thomas, H., Sutherland, H.J. et al. (1982), The measurement of patients' values in medicine, *Medical Decision Making*, 2, 449-462.

Llwelyn-Thomas, H., Sutherland, H.J. et al. (1984), Describing health states, *Medical Care*, 22, 543.

Loomes, G. and Sugden, R. (1982), Regret theory: an alternative theory of rational choice under uncertainty, *Economic Journal*, 92, 805-824.

Loomes, G. and McKenzie, L. (1989), The use of QALYs in health care decision making, *Social Science and Medicine*, 28, 4, 299-308.

Luce R.D. and Raiffa H. (1957). *Games and Decisions*. New York, John Wiley.

MacArthur, J.D. (1978), Appraising the distributional aspects of rural development projects: a Kenya case study, *World Development*, **6** (2), 167-193.

Machina, M.J. (1982), Expected utility analysis without the independence axiom, *Econometrica*, 50, 277-323.

Mahmoud, A.A.F., Siongok, T.A., Ouma, J., Houser, H.B. and Warren, K.S.

(1983), Effect of targeted mass treatment on intensity of infection and morbidity in *Schistosomiasis mansoni*, *Lancet*, i, 849-51.

Mahmoud, A. (1966), Blood loss caused by helminthic infections, *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 60: 766-767.

Manning, W.G., Newhouse, J.P., Duan, N., et al., (1987), Health Insurance and the Demand for Medical Care: Evidence from a Randomized Experiment, *The American Economic Review*, Vol. 77 No. 3.

Margolis, H. (1982), *Selfishness, altruism and rationality*, Cambridge, Cambridge University Press.

Markidakis, S. and Wheelwright, S.C. (1978), *Forecasting: methods and applications*, New York, John Wiley and Sons.

Marshack, J.(1950), Rational behaviour, uncertain prospects, and measurable utility, *Econometrica*, **18**, 111-141.

McGarvey, S.T., Daniel, B.T., Tso, M., Wu, G., Zhong, S., Olveda, R., Wiest, P.M. and Olds, G.R. (1990), Child growth and *Schistosomiasis japonica* in the Philippines and China, American Society for clinical investigation, meeting, Washington D.C.

McGravey, S.T., Wu, G., Zhang, S., Wang, Y., Peters, P., Olds, R.G. and Wiest, P. (1993), Child growth, nutritional status, and *Schistosomiasis Japonica* in Jiangxi, People's Republic of China, *American Journal of Tropical Medicine and Hygiene*, 48(4), 547-553.

McGuire, A., Henderson, J. and Mooney, G. (1988), *The economics of health care*, London: Routledge and Kegan Paul.

McKenna, S.P., Hunt, S.M. and McEwan, J.2 (1980), Looking at health from the consumers point of view, *Occupational Health*, 32, 350-355.

McKenna, S.P., Hunt, S.M. and McEwan, J. (1981), Absence from work and perceived health among mine rescue workers, *Journal of the society of occupational medicine*, 31, 151-157.

McNeil, B.J., Weichselbam, R. and Pauker, S.G. (1981), Speech and survival: trade-offs between quality and quantity of life in laryngeal cancer, *New England Journal of Social Medicine*, 305, 17, 982-987.

McNeil, B.J., Pauker, S.G., Sox, H.C. and Tversky, A. (1982), On elicitation of preferences for alternative therapies, *New England Journal of Medicine*, 306,

1259-1262.

Mehrez, A. and Gafni, A. (1989), Quality adjusted life years, utility theory, and healthy-years equivalents, *Medical Decision Making*, 9, 142-149.

Mehrez, A. and Gafni, A. (1985), A note on an application of the trade-off method in evaluating a utility function, *Managerial Decision Economics*, 6, 191-3.

Mills, A. (1985), Survey and examples of economic evaluation of health programmes in developing countries, *World Health Statistics Quarterly*, 38, 402-431.

Mills, A. (1985), Economic evaluation of health programmes in developing countries, *World Health Statistics Quarterly*, 38, 4, 368-382.

Mills, A. (1989), The application of cost-effectiveness analysis to disease control programmes in developing countries, with special reference to malaria control in Nepal, Unpublished Ph.D. thesis, University of London.

Mills, A. (1990), The economics of hospitals in developing countries. Part I: expenditure patterns, *Health Policy and Planning*, 5, 2, 107-117.

Mills, A. and Lee, K. (eds.) (1993), *Health Economics Research in Developing Countries*, Oxford, Oxford University Press.

Mishan, E.J.(1971), *Cost-Benefit Analysis*, London, Unwin Hyman.

MoH (1989), Ministry of Health Staffing Norms, Unpublished Kenya Government Document.

MoH (1992), Ministry of Health Equipment Valuations, Unpublished Kenya Government Document.

MoH (1992), *Health Care Financing Programme Report*, Nairobi: Kenya Government.

Mone, H., et al (1986). *Journal of Parasitology*. 72:410-416.

Mooney, G.H. (1977), *The valuation of human life*, London, Macmillan.

———— , Russel, E.M. and Weir, R.D.(1980), *Choices for health care*, London, MacMillan.

———— (1986), *Economics, Medicine and Health Care*, Brighton, Wheatsheaf.

———— (1987), What does equity in health mean? *World Health Statistics Quarterly*, *40*, 296-303.

———— and McGuire, A.(1987), Distributive justice with special reference to geographic inequality and health care, in A. Williams (ed.), *Health and*

Economics, London: MacMillan.

———— (1988), *QALYs: some qualifications*, paper presented at the Nordic HESG, Oslo, September.

———— and Crease, A.(1990), Cost and cost effectiveness analysis of health intervention, Washington: World Bank.

———— and Olsen, J.A. (1991). QALYs: Where Next?, In A. McGuire, P. Fen and K. Mayhew, (eds.), *Providing Health Care: the Economics Systems of Finance and Delivery*. Oxford: Oxford University Press, 120-140.

Morishita, K. (1980). Japanese literature concerning influence of parasites, especially of soil-transmitted helminths upon psychosomatic condition in maternity and childhood. In: *Collected Papers on the Control of Soil-transmitted Helminthiasis*. Tokyo: Asian Parasite Control Organization. pp.377-379.

MoPW (1992), Equipment and Buildings Maintenance Norms, Unpublished Kenya Government Document.

Morrison, G.C. and Gyldmark, M. (1992), Appraising the use of contigent valuation, *Health Economics*, 1, 233-243.

Morrow, R., Smith, P. and Nimo, K. (1981), A quantitative method of assessing the health impact of different diseases in less developed countries, *International Journal of Epidemiology*, 10, 73-80.

Morrow, R.H. (1984), The application of a quantitive approach to the assessment of the relative importance of vector and soil transmitted diseases in Ghana, *Social Science and Medicine*, 19, 1039-1049.

Mott, K.E. (1982), Control of schistosomiasis: morbidity reduction and chemotherapy. *Acta Leidensia*, 49, 101-111.

Mott, K.E. (1984), Schistosomiasis: a primary health care approach, World Health Forum, 5: 221-225.

Muthami, L.N., Katsivo, M.N., Kinoti, S.N., et al. (1992), Patterns of *Schistosomiasis mansoni* infection after intervention in Mwea irrigation scheme in Kenya, Unpublished Research Report, Nairobi, Kenya Medical Research Institute.

Mwabu, G.M. (1986), The effect of ownership of health care systems on distribution and quality of health services, *Eastern Africa Economic Review*,

2, 1, 77-84.

Mwabu, G.M., Wang'ombe, J.K. and Kimani, V.N. (1991), Health service reforms and health care demand in Kenya, Paper presented at the 4th Annual Meeting of the IHPP in Nyon, Switzerland.

Nash, T.E. (1982), Diagnostic serological responses: schistosome infections in humans: Perspectives and recent findings, *Annals of internal medicine*, 97, 749-50.

Nash, T.E., Cheever, A.W., Ottesen, E.A. and Cook, J.A. (1982), Schistosome infections in humans: perspectives and recent findings, *Annals of internal medicine*, 97, 740-754.

National Irrigation Board (1991), Annual Report, Nairobi: Kenya National Irrigation Board Unpublished Report.

Ng, Y.K. (1990), *Welfare Economics*, London, Macmillan.

Ng Y. (1990), A Social *welfare and economic policy*, New York, Harvester Wheatsheaf.

Nord, E. (1992), Methods for quality adjustment of life years, *Social Science and Medicine*, 34, 559-569.

Nord, E., EuroQoL (1991), Health related quality of life measurement. Valuations of health states by the general public in Norway, *Health Policy*, 18, 25-36.

Nord, E., (1991), The validity of a visual analogue scale in determining social utility weights for health states, *International Journal of Health Planning and Management*, 6, 232-242.

Nord-Larsen, M. (1983), What kind of health measure for what kind of purpose?, In: A.J. Culyer (ed.), *Health Indicators: an International Study of the European Science Foundation*, London: Martin Robertson, pp. 101-109.

Omer, A.H.S. and El Din Ahmed (1974), Assessment of physical performance and lung function in *Schistosome mansoni* infection. *East African Medical Journal*, 51, 217-222.

Ouma, J.H. (1987), Transmission of *Schistosome mansoni* in an endemic area in Kenya with special reference to the role of human defecation behaviour and sanitary practices, Ph.D. Thesis, University of Liverpool.

Ouma, J.H., Wijars, D.J.B. and Siongok, T.K. (1985), The effect of targeted mass treatment on the prevalence of *Schistosomiasis mansoni* and the intensity of

infection in Machakos, Kenya, *Annals of Tropical Medicine and Parasitology*, 79, 431-8.

Overseas Development Administration (1988), *Appraisal of projects in developing countries: a guide for economists*, London, Her Majesty's stationery office.

Osoro, C.M. (1990), A projection of smallholder irrigation in Kenya by the year 2000, In: WHO (ed.), *Water resources development and vector-borne diseases in Kenya*, Geneva: World Health Organization, 14-16.

Parkerson, G.R., Gehlback, S.H., Wagner, E.H., et al., (1981), The Duke-UNC health profile: an adult health status instrument for primary care, *Medical Care*, 19, 806-828.

Payne, S.L. (1952), The art of asking questions, Princeton, Princeton University Press.

Pearce, D.W. and Nash, C.A. (1981). *The social appraisal of projects*, London, MacMillan.

Phelps, C.E. and Mushlin, A.I. (1988), Focusing technology assessment using medical decision theory, *Medical Decision Making*, 8, 279-289.

Phelps, C.E. and Mushlin, A.I. (1991), On the (Near) equivalence of cost-effectiveness and cost-benefit analysis, *International Journal of Technology Assessment in Health* Care, 7(1), 12-21.

Personage, M. and Neuburger, H. (1992), Discounting and health benefits, Health Economics, 1, 71-76.

Pollard, W.E., Bobbit, R.A., Bergner, M., Diane, P.M., and Gilson, B.S. (1976), The Sickness Impact Profile: Reliability of a Health Status Measure, *Medical Care*, 2, 146-155.

Pollitt, E. et al. (1989), Iron deficiency and educational achievement in Thailand, *American Journal of Clinical Medicine*, 5, 89-101.

Polderman, A.M. and Manshande, H.P. (1981), Failure of targeted mass treatment to control schistosomiasis, *Lancet*, i, 27-28.

Polderman, A.M. (1984), Cost-effectiveness of different ways of controlling intestinal schistosomiasis: a case study, *Social Science and Medicine*, 19, 1073-1080.

Pope, R.T, Cline, B.L. and El Alamy, M.A. (1980), Evaluation of schistosomal morbidity in subjects with high intensity of infections in Qalyub, Egypt,

American Journal of Tropical Medicine and Hygiene, 29, 416-425.

Prata, A. (1978), Clinical experience with oxamniquine, *Advances in pharmacology and therapeutics*, 10, 27-40.

Pratt, J.W., Raiffa, H. and Schlaifer, R.O. (1964), The foundations of decision under uncertainty: an elementary exposition, *Journal of American Statistics Association*, 59, 353-375.

Prentice, M.A. and Barnish, G. (1981), Snail infections following chemotherapy of *Schistosome mansoni* in St. Lucia, West Indies, *Transactions of the Royal Society of Tropical Medicine and Hygiene.*

Prescott, N.M. (1979), Schistosomiasis and development, *World Development*, 7(1), 1-14.

Prescott, N. (1987), The economics of schistosomiasis chemotherapy. *Parasitology Today*, 3, 21-24.

Prescott N. (1989), Economic analysis of schistosomiasis control projects, In: Service, M.W. (ed), *Demography and vector borne diseases*. Florida, CRC Press, PP.155-163.

Prescott, N.M. (1993), Cost effectiveness analysis of chemotherapy regimes of schistosomiasis control, In A. Mills and K. Lee (ed.), *Health Economics Research in Developing Countries*, Oxford, Oxford University Press.

REACH (1988), Nairobi area health services delivery study, Nairobi: Ministry of Health Consultancy Report.

REACH (1989), Nakuru provincial and district hospital health services delivery study, Nairobi: Ministry of Health Consultancy Report.

Read, J.L, Quinn, R.J., Berwick, D.M. et al. (1984), Preferences for health outcomes. Comparison of assessment methods, *Medical Decision Making*, 4, 315-329.

Raiffa H. (1968), *Decision Analysis*, Reading Massachussets, Addison-Wesley.

Richardson, J., Hall, J., and Salkeld, G. (1989), 'Cost utility analysis: the compatibility of measurement technicians and the measurement of utility through time', paper presented to the 11th Annual Conference of the Australian Health Economists' Group, ANU, 7-8 september.

Richardson, J., Robert S. and Williams A. (1978). *The principles of cost-benefit analysis*, Oxford, Oxford University Press.

Ron, A., Abel-Smith, B. and Tamburi, G. (1990), *Health Insurance in Developing Countries*, Geneva, International Labour Office.

Rosenfield, P.L., Smith, R.A. and Wolman, M.G. (1977), Development and verification of a schistosomiasis transmission model, *American Journal of Tropical Medicine and Hygiene*, **26**(3), 505-516.

Rosenfield, P.L., Golladay, F. and Dividson, R.K. (1984), The economics of parasitic diseases: research priorities, *Social Science and medicine*, 10, 1117-1126.

Rosser, R. and Watts, V. (1972), The measurement of hospital output, *International Journal of Epidemiology*, 1, 361-368.

Rosser, R. and Kind, P. (1978), A scale of valuations of states of illness: Is there a social consensus?, *International Journal of Epidemiology*, 7, 347-358.

Rushby, J.A. (1991), Willingness to pay as a method for valuing health related quality of life, Paper presented at the U.K. HESG July.

Sackett, D.L. and Torrance, G.W. (1978), The utility of different health states as perceived by the general public, *Journal of Chronic Diseases*, 31, 697-704.

Sadigursky, M., Andrade, Z.A., Danner, R., Cheever, A.W., Kamel, I.A., and ELwi, A.M. (1976), Absence of schistosomal glomerulopathy in Schistosoma haematobium infection in man, *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 70, 322-323.

Saif, M. and Gaber, A. (1980), Clinical development of oxamniquine in Egypt, *Revista do Instituto de Medicina Tropical de Sao Paulo*, 22, 18-27.

Sandbach, F.R. (1975), Preventing schistosomiasis: a critical assessment of present policy, *Social science and Medicine*, 9, 517-527.

Savage L.J. (1954). *The Foundations of Statistics*. New York, Wiley.

Schelling, T.C. (1968), *The life you save may be your own*, in S.B. Chase (ed.), Problems in public expenditure analysis, Washington, The Brookings Institution.

Scott, M.F.G., MacArthur, J. and Newberry, D.M.G. (1976), *Project appraisal in practice: The Little-Mirrlees method applied in Kenya*, London: Heinemann.

Shaw, A.F.B. and Ghareeb, A.A (1938), The pathogenesis of pulmonary schistosomiasis in Egypt with special refrence to Ayerza's disease, *Journal of Pathology and Bacteriology, 46, 401-424.*

Shiell, A., Gerald, K. and Donaldson, C. (1987), 'Cost of illness studies: an aid to decision-making?', *Health Policy*, 8, 317-323.

Shoemaker, P.J.H. (1982), The expected utility model: its variants, purposes, evidence and limitations, *Journal of economic literature*, 20, 529-563.

Sintonen, H. (1981), An approach to measuring and valuing health states, *Social Science and Medicine*, 15c, 55-65.

Siongok, T.K.A., Mahmoud, A.A.F., Ouma, J.H., Warren, K.S., Muller, A.S., Handa, A.K. and Houser, H.B. (1976), Morbidity in *Schistosomiasis mansoni* in relation to intensity of infection: study of a community in Machakos, Kenya, *American Journal of Tropical Medicine and Hygiene*, 25, 273-84.

Sleigh, A.C., Mott, K.E., T.M., E.A., Hoff, R., Maguire, J.H. and Franca-Silva, J.T. (1981), A three year follow-up chemotherapy with oxamniquine in a Brazilian community with endemic *Schistosomiasis mansoni*, *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 75, 234-238.

Sleigh, A.C., Hoff, R., Mott, K.E., Maguire, J.H. and Da Franca Silva, J.T. (1986), Mansoni's schistosomiasis in Brazil: 11-year evaluation of successful disease control with oxamniquine, *Lancet*, i, 635-7.

Smith, R. and Dobson, M. (1993), Measuring utility values for QALYs: two methodological issues, *Health Economics*, 2, 349-355.

Southgate, B.A. (1992), Where are we now? Schistosomiasis. *Health Policy and Planning*, **7**(1), 86-89.

Spitzer, W.O., Dobson, A.J., Hall, J., et. al., (1981), Measuring the quality of life of cancer patients: a concise QL-index for use by physicians, *Journal of Chronic Diseases*, 34, 585-97.

Splitzer, W.O., Dobson, A.J. and Hall, J. (1981). 'Measuring The quality of life of cancer patients, *Journal of Chronic Disease*, 34:595-7.

Steiberg, F.U., and Frost, M. (1963), Rehabilitation of geriatric patients in general hospital: A follow up study of 43 cases, *Geriatrics*, 18, 158-164.

Stephenson, L.S. (ed.) (1987), *The impact of helminth infections on human nutrition: schistosome and soil transmitted helminths*, London: Taylor and Francis.

Stevens, S.S. (1966), A metric for social consensus, *Science*, 151, 530-541.

Strickland, G.T., Merritt, W., El-Sahly, A. and Abdel-Wahab, F. (1982), Clinical

characteristics and response to therapy in Egyptian children heavily infected with *Schistosoma mansoni*, *Journal of Infectious Diseases*, 146, 20-29.

Sturrock, R.F., Kimani, R., Butterworth, A.E., Cottrell, B.J., Seitz, H.M., Arap Siongok, T.K., and Houba, V. (1983), Observations on possible immunity to reinfection among Kenyan school children after treatment for *Schistosoma mansoni*, *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 77, 363-371.

Sturrock, R.F., Bensted-Smith, R., Butterworth, A.E., Dalton, P.R., Kariuki, H.C., Koech, D., Mugambi, M., Ouma, J.H. and Arap Siongok, T.K. (1987), Immunity after treatment of human *Schistosomiasis mansoni*. III. Long-term effects of treatment and retreatment, *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 81, 303-314.

Sugden, R. and Williams, A. (1978), *The principles of cost-benefit analysis*, Oxford, Oxford University Press.

Sukwa, T.Y., Bulsara, M.K. and Wurapa, F.K. (1986), The relationship between morbidity and intensity of *Schistosoma mansoni* infection in a rural Zambian community, *International Journal of Epidemiology*, 15, 248-251.

Sukwa, T.Y., Bulsara, M.K. and Wurapa, F.K. (1987), Reduction in prevalence, intensity of infection and morbidity due to *Schistosoma mansoni* infection in community following treatment with praziquantel, *Journal of Tropical Medicine and Hygiene*, 90, 205-211.

Sukwa, T.Y., Boatin, B.A. and Wurapa, F.K. (1988), A three year follow-up of chemotherapy with praziquantel in rural Zambian community endemic for *Schistosomiasis mansoni*, *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 82, 258-260.

Sutherland, H.J., Dunn, V. and Norman, F.B. (1983), Measurement of values for states of health with linear analogue scales, Medical Decision Making, 3, 4, 477-487.

Swiss Tropical Institute (1993), *Swiss Tropical Institute Research Report: 1991-1993*, Geneva, Swiss Tropical Institute.

Tan-Torres, T. L. (1991), Comparison of different methods of eliciting utilities for outcome states in leprosy, Report to TDR, Geneva, WHO.

Tylor, L.E. and Walsh, W.B. (1979), *Tests and Measurements*, Ney Jersey,

Prentice-Hall.

Taylor, P., et al. (1988), Efficacy of low doses of praziquantel for *Schistosome mansoni* and *S. haematobium*, *Journal of Tropical Medicine and Hygiene*, 91, 15-17.

Taylor, P. (1986), A proposed evaluation of a primary health care approach to control schistosomiasis in Zimbabwe, *Tropical Medicine Parasitology*, 37, 160-163.

Thompson, M.S., Read, J.L. and Liang, M. (1984), Feasibility of willingness-to-pay measurement in chronic arthritis, *Medical Decision Making*, 4, 2, 195-215.

Thompson, M.S. (1986), Willingness to pay and accept risk to cure chronic disease, *American Journal of Public Health*, 76-392-396.

Torgerson, W.S.(1958), *Theory and methods of scaling*, New York: John Wiley and Sons.

Torrance, G.W., Thomas, W.H., and Sackett, D.L.(1972), A utility maximization model for evaluation of health care programmes, *Health Services Research*, 7, 2, 118-33.

Torrance, G.W. (1976), Social preferences for health states, an empirical evaluation of the three measurement techniques, *Socio-Economic Planning Science*, 10, 129-36.

———— (1982), Application of multi-attribute theory to measure social preferences for health states, *Operations Research*, **30**, 6, 1043-69.

———— (1986), Measurement of health state utilities for economic appraisal, *Journal of Health Economics*, **5**, 1-30.

————(1985), Measurement of health state utilities for economic appraisal - a review, *Journal of Health Economics*, 5, 1-30.

———— (1987), Utility approach to measuring health-related quality of life, *Journal of Chronic Diseases*, 40, 593-600.

Tversky, A. and Kahneman, D. (1981), The framing of decisions and psychology of choice, *Science*, 211, 453-8.

Uhde, A. (1983), The need for health indicators, In: A.J. Culyer (ed.), *Health Indicators: an International Study of the European Science Foundation*, London, Martin Robertson, pp. 110-116.

UNIDO (1986). *A guide to practical project appraisal: social cost benefit analysis in developing countries*, United Nations Industrial Development Organization, Vienna.

Van Doorslaer, E. and Wagstaff, A. (1993), Equity in the finance of health care: methods and findings, In: Van Doorslaer, E., Wagstaff, A. and Rutten, R. (eds.), *Equity in the finance and delivery of health care*, Oxford, Oxford University Press.

Varian H.R. (1984). *Microeconomic analysis*, New York, Norton and company.

Viscusi (1978), Labour market valuations of life and limb: empirical evidence and policy implications, *Public Policy*, 26, 359-386.

Von Neumann, J. and Morgenstern, O. (1947). *Theory of games and economic behaviour*, Princeton, Princeton University Press.

Wagstaff, A., Paci, P. and Van Doorslaer, E. (1991a), On the measurement of inequities in health, *Social Science and Medicine*, 33, 545-57.

Wagstaff, A., Van Doorslaer, E. and Paci, P. (1991b), On the measurement of horizontal equity in the delivery of health care, *Journal of Health economics*, 10, 169-206.

Wagstaff, A. and Van Doorslaer, E. (1993a), Equity in the finance and delivery of health care: concepts and definitions, In: Van Doorslaer, E., Wagstaff, A. and Rutten, R. (eds.), *Equity in the finance and delivery of health care*, Oxford, Oxford University Press.

Wagstaff, A. and Van Doorslaer, E. (1993b), Equity in the delivery of health care: methods and findings, In: Van Doorslaer, E., Wagstaff, A. and Rutten, R. (eds.), *Equity in the finance and delivery of health care*, Oxford, Oxford University Press.

Wang'ombe, J.K. (1984), Economic evaluation in primary health care: The case study of Western Kenya community-based health care project, *Social Science and Medicine*, 18, 375-385.

Walsh, J. and Warren, K. (1979), An interim strategy for disease control in developing countries, *New England Journal of Medicine*, 301, 967-973.

Walsh, J. and Warren, K. (1984), Selective primary health care: An interim strategy for disease control in developing countries, *New England Journal of Medicine*, 301, 967-974.

Walsh, J. (1990), Estimating the burden of illness in the tropics, In: *Tropical and Geographical Medicine*, K.S., Warren and A.A.F. Mahmoud (eds.), New York: McGraw-Hill, pp. 185-196.

Warren K.S., Bundy D.A.P., Anderson, R.M., et al. (1990). Helminth infections, In D.T. Jamison and W.H. Mosley (eds.), Washington, World Bank Health Priorities Review, chapter 15.

Warren, K.S. and Mahmoud, A.A.F. (1990), *Tropical and Geographical Medicine*, New York: McGraw-Hill.

Warren, K.S., Bundy, D.A.P., Anderson, R.M., Davis, A.R., Henderson, D.A., Jamison, D.T., Prescott, N., and Senft, A. (1993), Helminth infections, In: Jamison, D.T., Mosley, W.H., Meacham, A.R., Bobadilla, J-L, (eds.) (1993), *Disease control priorities in developing countries*, New York, Oxford University Press.

Wiemer, C. (1988), A framework for assessing productivity loss from schistosomiasis, *The Journal of Human Resources*, 3, 320-341.

Weinstein, M.C. and Stason, W.B. (1977), Foundations of cost-effectiveness analysis for health and medical practices, *New England Journal of Medicine*, 296, 716-721.

Weisbrod, B.A. (1961), *Economics of public health: measuring the economic impact of diseases*, Philadelphia, University of Pennylvania Press.

Weisbrod, B.A., Andreano, R.L., Baldwin, R.E., Epstein, E.H. and Kelley, A. (1973), *Disease and economic development: the impact of parasitic diseases in St. Lucia*, University of Winsconsin Press.

Weisbrod, B.A. and Helminiak, T.W. (1977), Parasitic diseases and agricultural labour productivity, *Economic Development and Cultural Change*, 25(3), 505-522.

Werler, C. (1986), Cost of implementing water supply in a schistosomiasis control programme in Mali, *Tropical Medicine Parasitology*, 37, 189-190.

WHO (1973), *Schistosomiasis control*, Technical Report Series No. 515, Geneva, World Health Organization.

WHO (1974), Health education: a review of WHO programmes, *WHO Chronicals*, 28, 401.

WHO (1983), *The role of chemotherapy in schistosomiasis control*,

WHO/SCHISTO/83.70, Geneva, World Health Organization.

WHO (1984), *Report of an informal consultation on research on the biological control of snail intermediate hosts*, Geneva, WHO publication.

WHO (1985), *The control of schistosomiasis, Report of a WHO Expert Committee*, World Health Organization Technical Report Series, 728, 1-113, Geneva, World Health Organization.

WHO (1987), *Progress in assessment of morbidity due to Schistosoma haematobium infection: A review of recent literature*, WHO/SCHISTO/88.91, Geneva, World Health Organization.

WHO (1988), *Progress in assessment of morbidity due to Schistosoma mansoni: a review of recent literature*, WHO/SCHISTO/88.97, Geneva, World Health Organization.

WHO (1989a), *Tropical Diseases*, Ninth Programme report/TDR, Geneva, World Health Organization.

WHO (1989b), *An estimate of global needs for praziquantel within schistosomiasis control programmes*. Geneva, WHO publication.

WHO (1990), *Water resources development and vector-borne diseases in Kenya*, Geneva, World Health Organization.

WHO (1993), *Tropical disease research*, Geneva, World Health Organization.

Williams, A. (1985). "Economics of coronary artery bypass grafting." *British Medical Journal*, 291, 326-329.

Williams, A. (1989), Comment on 'Should QALYs be programme specific?', *Journal of Health Economics*, 8, 485-7.

Williams, A. and Anderson, R. (1975), *Efficiency in the social services*, Oxford, Basil Blackwell.

Wilmott, S. (ed) (1987), Report of an independent evaluation mission on the National Bilharzia Control Programme in Egypt, 1985. Ministry of Public Health, Arab Republic of Egypt, *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 81, 1-87.

World Bank (1980), *Poverty and Human development*. Oxford, Oxford University Press.

World Bank (1982), *World Development Report: Development and the environment*, Oxford, Oxford University Press.

World Bank (1993), *World development report: Investment in health*, Oxford, Oxford University Press.

Wright, H. (1972), A consideration of the economic impact of schistosomiasis, *Bulletin of World Health Organization*, 197, 47, 559-566.