# CHAPTER 5

## MODELLING COST AND OUTCOMES ANALYSIS OF CHWs' PERFORMANCE

### 5.1 Introduction

The model will be developed on the basis of the analysis of the costs and the outcomes of CHWs programme at the village level in Benin. The model will be used as an instrument of economic analysis of the impact of CHWs' contribution to some basic diseases control at the village level, especially malaria control. This economic analysis includes the costing of inputs and the valuation of outcomes in the cost benefit analysis approach.

The chapter is comprised of three major sections dealing respectively with the costing of the inputs, the analysis and valuation of the outcomes and the cost benefit analysis of the contribution of CHWs' performance in malaria control at the village level in Bénin. At the end of this chapter, the unit of analysis and the population and sampling of inputs costing, analysis and valuation of outcomes and cost benefit analysis will be considered.

### 5.2 Design

The analysis of cost and outcomes of CHWs' contribution in malaria control at the village level will be an observational prospective cohort study for one year, with monthly repeated cross-sectional household survey[3] and health centres and district hospitals routine data collection[4]; as the CHWs already existed since 1990 and will not be assigned for the purpose of this study, which intends to measure some intermediate and final outcomes of this exposure of the experimental communes to CHWs. These outcomes will be compared to those of the neighbouring chosen villages without CHWs.

### 5.3 Costing the Inputs

#### 5.3.1 Costing principles

According to Hanson and Gilson, quoted in Begum (1995, 22), there are five main steps to be followed in costing:

- identify the resources used to produce the services being coasted;
- estimate the quantity of each input used;
- assign monetary values to each unit of input and calculate the total cost of the input;
- allocate the costs to activities in which they are used;

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3 To collect data for malaria specific morbidity and mortality in households

4 For counting the flow of simple malaria cases from villages to health centres/district hospitals, and the No. of severe cases of malaria at health centre/district hospitals and the total number of malaria in the whole commune or district.

- use measure of service output to calculate the average (unit) cost.

### 5.3.2 General considerations about costing inputs

Costing inputs for establishing CHWs programme at the village level should take into account the followings general considerations:

1. Activities

There are many activities related to the establishment or implementation of the CHWs programme for simple diseases control, especially malaria control at the village level. They are the followings:

i. Training of midwife for training CHWs

Health personnel were not trained in medical or nursing schools to the approach of community participation. So the midwives selected to train and supervise the CHWs were primarily trained to that approach; and also to training techniques by public health special trainers.

ii. Villages assemblies

Prior to the implementation of the CHWs programme, villages assemblies gathering elders, traditional practitioners, women and youth were held in all villages to explain to the communities the reasons behind and the possible advantages of such programme. Those assemblies also helped villagers to choose their CHWs among number of applicants.

iii. Training of CHWs

After being chosen by their communities, the CHWs were trained by the midwives to presumptive diagnosis and first aids of the three first diseases of their region; and also to recognize some obvious symptoms of risky pregnancies. Malaria was the first disease on which the CHWs were trained.

iv. Equipment

After that first round of training, the CHWs were provided with the equipment for the first aids they should provide to their future patients. The equipment of the trainers were motorcycle, training materials and others.

v. Supervision

The supervision started as soon as the CHWs were equipped, and continued after the retraining. Each CHWs is supervised by the health personnel once a month.

vi. Retraining

After few weeks, CHWs are trained on two other common diseases of their region. Their knowledge is reinforced on traditional birth attendance. especially the CHWs females who were taught more about the simple risk factors of pregnancies.

2. Types of costs

To analyze the structures of cost, the costs of inputs (internal costs) will be classified into cost borne by the Government (capital and recurrent costs), cost borne by the community financing as provider, and cost borne by CHWs.

**i. Cost borne by Government**

a.- Capital costs

- Training of CHWs trainers;
- Villages assemblies (communities mobilization);
- Training of CHWs;
- Equipment for CHWs;
- motorcycles and
- Other Equipment for midwives;
- material and supplies.

b.- Recurrent costs

- Salaries of midwives in charge of CHWs;
- Retraining of CHWs;

**ii. Cost borne by Community Financing (drug fund)**

- supervision of CHWs;
- tools of management;
- operation and maintenance of motorcycles ;

**iii. Cost borne by CHWs**

- opportunity cost for CHWs

3. Allocation of costs to activities in which they are used

All the resources for implementing CHWs programme at the village level are used to produce the overall services of CHWs: simple malaria, hookworm or intestinal parasites, simple respiratory infection, simple diarrhoea and simple wounds. The proportion of quantity of the input used for malaria control only is assumed to be equivalent to the proportion of time that malaria control represents in the services produced by the CHWs. For example, if the CHWs spends an average of 60 % of working time for malaria control, then malaria control uses 60% of the value of total input.

4. Computing capital costs

Capital cost is invested once at the beginning of the implementation of CHWs programme, and will not be provided each year; e.g. the equipment to CHWs or a motorcycle to health personnel for CHWs supervision is not provided each year. On the other hand, recurrent costs must be allocated each year; e.g. the salary of the health personnel must be provided in the budget of the health centre each year.

The distinction between recurrent and capital costs is based on life expectancy. Items which have a life expectancy of less than one year are recurrent, those with an expectancy of over one year are capital. The cost of a capital item is spread over its expected life. So the annualized cost of each capital item must be computed. According to Reynolds and Gaspari (1988, A12-A15), the steps include the following:

- identify all the capital cost items that occurred or are expected to occur for the implementation of the programme,
- determine the current value of each item,
- compute the annualized cost of each item (to do this. both the life expectancy of each item and the rate of interest must be determined),
- determine the proportion of item to be charged to the programme,
- sum the total.

Current value can be established in one of several ways. In this methodological study, three proposed methods will be explored

**i.** According to Carrin and Evlo (1995, 13-15), in order to calculate the future value of present capital cost, we need to determine the rate at which the wear and tear occur annually, i.e. the rate of depreciation or amortization, in order to know how much needs to be set aside annually to be able to ensure renewal. For this, we need to know for each investment cost of an asset the lifetime (n), the domestic rate of inflation (i) for asset purchased in local currency, the interest rate (r) at which the money saved annually is invested in the bank.

Let us assume that an item of equipment produced locally in Bénin is purchased for supervision in one experimental commune at $C_0$ franc CFA (the local currency), and has a lifetime of **n** years; if **i** is the inflation rate per year (assumed to be constant), the value of the item at the end of the $n^{th}$ year is:

$$C_n = C_0 * (1 + i)^n.$$

By the end of the $n^{th}$ year, an amount equivalent to $C_n$ has to be saved to renew the item. The programme must not wait until the end of the $n^{th}$ year before doing this, but should spread the amount $C_n$ (at the year n price) over the n years of the lifetime. So, each year j, the programme must save an amount $P_j$ whose total over the n years should add up to $C_n$ at the end of the $n^{th}$ year. Thus,

$$P_1 + P_2 + P_3 + \ldots + P_n = C_n$$

We know that the amount $P_1$ saved at the end of the first year is invested in the bank at an annual rate of interest r. It will thus worth:

$P_1\ (1 + r)^1$ at the end of the first year,
$P_1\ (1 + r)^2$ at the end of the second year and ...

$P_1\ (1 + r)^{n-1}$ at the end of the $n^{th}$ year.

If the future cost $C_n$ is to be distributed equally over the n years, the amount $P_j$ to save by the end of each year j will give $C_n/n$ at the end of the $n^{th}$ year (if it is invested in the bank at interest rate r per year. As the amount $P_n$ saved at the end of the last year will not have generated any interest, we will have thus:

$P_n = C_n/n$
$P_{n-1} = C_n/n(1+r)$
$P_{n-2} = C_n/n(1+r)^2 \ldots$
...
$P_2 = C_n/n(1+r)^{n-2}$
$P_1 = C_n/n(1+r)^{n-1}$.

So, each year j, till the $n^{th}$ year, the amount set aside annually for amortization of the item equipment is:

$$P_j = \frac{C_n}{n * (1 + r)^{n-j}}$$

If the equipment is imported, it is not the domestic rate of inflation, but the rate of depreciation (**d**) of the national currency against the currency of the country from which the equipment is imported, and the inflation rate (**i'**) in that country that determine the future value of the equipment in the national currency. At the end of the $n^{th}$ year, the value of the equipment in the national currency is:

$$C_n = C_0 * (1 + d)^n * (1 + i')^n.$$

**ii.** The method described above assumes that the depreciation rate (**d**) of the national currency against the currency of the country from which the equipment is imported remains constant during the lifetime, which is very unlikely to happen. To take into account the fluctuation of the depreciation, the value of the equipment in the national currency is:

$$C_n = C_0 * [\prod^n_{j=1}(1 + d_j)] * (1 + i')^n.$$

where: $d_j$ is the value of depreciation each year j and

$$\prod^n_{j=1}(1 + d_j) = (1+d_1)(1+d_2)(1+d_3)\ldots(1+d_n).$$

**iii.** The third method described by Reynolds and Gaspari (1988) states that the depreciation is not the only cost involved in calculating annualized costs. The undepreciated portion of the capital item represents an investment of resources that could have been used some other way. For example, if the cost of the motorcycle is 100,000 franc CFA with 5 years lifetime, the cost of the motorcycle only includes the 20,000 franc depreciation for the first year, but the loss of interest on the remaining 80,000 franc. If that money (100,00) could have been put in a savings account at 10% interest, it would have earned 100,000*0.1=10,000 franc. Thus, the total cost of the motorcycle is the depreciation plus the lost interest 20,000+10000 = 30,000.

There are two ways to compute the annualized cost of a capital item that includes depreciation and interest. The first is to use the following formula:

$$a(r,n) = \frac{[r(1+r)^n]}{[(1+r)^n - 1]} * CV$$

where: a = the annual cost,
r = the rate of interest,
n = the life expectancy of the item expressed in years,
CV = the current value of the capital item.

The second way is to use directly an "annualization table" such as the one shown in appendix 3, which shows annualization factors for capital items with different expected lifetimes at different rates of interest. This last method will be preferred and the annualization table will be used at 10% rate of interest for different lifetime of item equipment.

### 5.3.3 Costing of inputs activities

1. Information required for costing inputs activities and notations

The model to be built requires some key information for costing the 12 necessary items as shown in tables 5.1 and 5.2.

Table 5.1: Information for Costing Investment Cost

| Items to be coasted | Information needed for costing |
|---|---|
| 1. Training of midwife for training CHWs (T1) | - number of midwives to be trained (n1)<br>- number of required training days (d1)<br>- required number of trainers (n2)<br>- perdiem per trainee (p1)<br>- perdiem per trainer (p2)<br>- average travel cost per trainee (t1)<br>- administration cost per trainee (a1)<br>- field visit cost per trainee (f1) |
| 2. Training of CHWs (T2) | - number of CHWs per commune (n3)<br>- number of required training days (d2)<br>- required number of trainers (n4)<br>- perdiem per trainee (p3)<br>- perdiem per trainer (p4)<br>- average travel cost per trainee (t2)<br>- administration cost per trainee (a2) |
| 3. Villages assemblies per commune (V) | - average length (hour) per assembly (h1)<br>- number of assemblies per commune (as)<br>- average number of participants adults per assembly (n5)<br>- number of health personnel per assembly (n6) |
| 4. Equipment of midwife per commune (E1) | - cost per motorcycle (m)<br>- cost of other equipment per midwife (e1) |
| 5. Equipment of CHWs (E2) | - number of CHWs trained (n3)<br>- cost of equipment per CHW (e2) |

Table 5.2: Information for Costing Operating Cost

| Items to be coasted | Information needed for costing |
|---|---|
| 6. Salary of midwife per year (S) | - number of midwife per commune (n9)<br>- monthly salary per midwife (s1) |
| 7. Retraining of CHWs (R) | - number of retraining per year (r)<br>- number of days per retraining (d2)<br>- number of CHWs per commune (n3)<br>- administration cost per retraining (a3)<br>- number of trainers per session (n7)<br>- average travel cost per trainee (t3) |
| 8. Supervision of CHWs (S) | - number of CHWs to be supervised per commune per month (n8)<br>- average time of supervision per CHWs (h2)<br>- transport cost (gasoline + maintenance) per month (t4)<br>- hourly salary of supervisor (wh) |
| 9. Tools of management (M) | - yearly cost of all tools of management needed by the CHWs programme per commune (M) |
| 10. Opportunity cost per CHW (Op) | - average time per day for CHWs' tasks (h3)<br>- percentage of time for malaria control (x%)<br>- number of CHWs trained (n3) |
| 11. Financial incentives of CHWS (Fi) | - number of CHWs trained (n3)<br>- yearly amount of financial incentives (fi) |

2. Assumptions for costing

These are the necessary assumptions for costing the inputs in the model:

- All CHWs are economically active;
- CHWs are economically active 365 days;
- Percentage of loss in CHW trained is negligible, so that there is no need to train another CHW before the "lifetime[5]" of CHW;
- Garbage value of the motorcycle and other equipments after the lifetime is zero.

3. Calculations

Total cost for malaria control (TCMC) is:

$$TCMC = TC * x$$

5 "Lifetime" is used here to express the length of time after which there is a need to renew the mentioned activity

where:

TC = is the Total cost for the overall tasks of CHWs (TC) for the first five years of the implementation of the programme,

x = the percentage of time for malaria control.

Total cost for the overall tasks of CHWs (TC) for the first five years of the implementation of the programme is:

TC = TIC + TOC.

where: TIC = Total Investment Cost

TOC = Total Operating Cost

Total investment cost

The total investment cost (TIC) for the first five years of the implementation of the CHWs programme at the village level per commune is the summation of each of the value for the first five years of each of the investment in the programme:

$TIC = T1_5 + T2_5 + V_5 + E1_5 + E2_5$.

Where:

- $T1_5$ is the value of the investment in training the midwives, trainers of CHWs during the first five years of the programme,
- $T2_5$ is the value for 5 years of investment in training the CHWs for simple diseases control at village,
- $V_5$ is the value for 5 years of the investment in villages assemblies for communities mobilization,
- $E1_5$ is the value for five years of investment in equipment of midwife,
- $E2_5$ is the value for five years of investment in equipment of CHWs,

Total operating cost

The total operating cost is TOC, and its equation is the following:

$TOC = S_5 + R_5 + Sp_5 + M_5 + Op_5 + Fi_5$.

Where:

- $S_5$ is the salary of midwife per commune for 5 years,
- $R_5$ is the cost for retraining CHWs each year during 5 years,
- $Sp_5$ is the cost of supervision of CHWs per year during 5 years,
- $M_5$ is the cost of tools of management during 5 years,
- $Op_5$ is the opportunity cost for CHWs per commune for 5 years,
- $Fi_5$ is the cost of financial incentives to CHWS per commune for 5 years.

How are the costs calculated?

i. Value of the investment for the first 5 years

- Value of the investment in training the midwives, trainers of CHWs during the first five years of the programme ($T1_5$)

The midwife trained once for CHWs' training does not need to be trained before retirement. We assume that the lifetime of the investment in training the midwife is equal to the length of time she has to work. 30 years. Assuming that the interest rate is 10%, the annualization factor is *a = 0.1061* (see annualization table 3.1 in appendix).

The value for the first 5 years of the investment in training the midwife for CHWs training and supervision is:

$$T1_5 = 5 * 0.1061 * T1$$

- Value of investment in training CHWs ($T2_5$)

CHWs are expected to "work" for their community for 5 years. After the fifth year, they will be replaced by other volunteers. So, the investment in their training is assumed to have a lifetime of 5 years. If the interest rate is 10%, then the annualization factor is *a = 0.2638* (see annualization table 3.1 in appendix).

The value for 5 years of the training of CHWs for simple diseases control at the village level is calculated the same way as above and is:

$$T2_5 = 5 * 0.2638 * T2$$

- Value of investment in villages assemblies ($V_5$)

As the CHWs are to be renewed after the fifth year, other villages assemblies will be needed to choose the new ones. We can then assume that the lifetime of a village assembly is 5 years; if the interest rate is 10%, then the annualization factor is *a = 0.2638*.

The value for 5 years of the investment in villages assemblies for communities mobilization is calculated the same way as above, and is:

$$V_5 = 5 * 0.2638 * V$$

- Value of investment in equipment of midwife ($E1_5$)

The equipment of midwife is made of one motorcycle and some working material such as delivery instruments and others. All this equipment is expected to last five years. After this lifetime, it will be worthless to spend to maintain it, for the equipment will require much costly repairs and maintenance. So, all this equipment is planned to be renewed at the end of the fifth year. Assuming an interest rate = 10%, the annualization factor is *a = 0.2638* (see annualization table 3.1 in appendix).

The value for 5 years of the equipment of midwife for training and supervising the CHWs for simple diseases control at the village level is drawn from the annualization table 3.1 in appendix and is:

$$E1_5 = 5 * 0.2638 * E1$$

- Value of investment in equipment of CHWs ($E2_5$)
Assuming the lifetime of the equipment of CHWs is 5 years as explained above, and interest rate = 10%; then the annualization factor is *a = 0.2638*.

The value for 5 years of the equipment of CHWs for simple diseases control at the village level is calculated the same way as above and is:

$E2_5 = 5 * 0.2638 * E2$

ii. <u>Value of the operating cost for the first 5 years</u>

Assuming that all the operating costs remain constant (unchanged) each year during the first five years, the operating cost during 5 years for each of the items are:

- $S_5$ for the salary of midwife per commune for 5 years,
- $R_5$ for retraining CHWs per year per commune for 5 years,
- $Sp_5$ for supervision of CHWs per year per commune for 5 years,
- $M_5$ for tools of management per commune for 5 years,
- $Op_5$ for opportunity cost for CHW per commune for 5 years,
- $Fi_5$ for financial incentive to CHWS per commune for 5 years.

iii. <u>Cost of each of the 11 items</u>

A. Investment cost

1- Cost of training a midwife trainer of CHWs (T1)

T1 = (n1.d1.p1 + n2.d1.p2 + n1.t1 + n1.a1 + n1.f1)/6.

where: total perdiem for midwives = n1.d1.p1
total perdiem for trainers of midwives = n2.d1.p2
total travel cost for midwives = n1.t1
total administration cost for midwives training = n1.a1
total field visit cost for midwives training = n1.f1

2- Cost for training of CHWs per commune (T2)

T2 = n3.d2.p3 + n4.d2.p4 + n3.t2 + n3.a2

where: total perdiem for CHWs = n3.d2.p3
total perdiem for trainers of CHWs = n4.d2.p4
total travel cost for CHWs = n3.t2
total administration cost for CHWs training = n3.a2

3- Cost of villages assemblies per commune (V)

V = h1.as.n5.f1 * wage/hour + h1.as.n6.f1 * salary/hour

where: opportunity cost for participants to the assemblies = h1.as.n5.f1 * wage per hour

cost of health personnel = h1.as.n6.f1 * salary/hour

4- Cost of equipment of midwife per commune (E1)

$E1 = m + e1$

where: m = cost per motorcycle
e1 = cost of other equipment of midwife.

5- Cost of equipment of CHWs per commune (E2)
$E2 = n3.e2$

where: n3 = number of CHWs trained
e2 = cost of equipment per CHW

B. Operating cost

6- Salary of midwife per commune per year (S)
$S = s1.12$ months

where: s1 = monthly salary of midwife.

For this experimental phase, one midwife is committed per commune to take care exclusively of the CHWs programme in all the villages. But for the coming years, the CHWs programme will be integrated into the routine activities or tasks of the personnel of the health centre; so that the salary to be considered then will be the share of time devoted to CHWs in the daily task of the personnel. That alternative will be considered in the model to be built.

7- Retraining of CHWs (R)
$R = r.d2.n3.p3 + r.d2.n7.p4 + r.n3.t3 + r.n3.a3$

where: total perdiem for retrained = r.d2.n3.p3
total perdiem for re-trainers of CHWs = r.d2.n7.p4
total travel cost for retraining CHWs = r.n3.t3
total administration cost for CHWs retraining = r.n3.a3.

8- Supervision of CHWs per year (S)
$S = n8.h2.wh + (t4.12$ months)

where: manpower cost of midwife for supervision = n8.h2.wh
transport cost per year for supervision = t4.12 months.

9- Tools of management (M)
M = the yearly cost of all tools of management needed by the CHWs programme per commune

10- Opportunity cost of CHWs per commune per year (Op)
$Op = n3.h3.365$.daily wage

where number of CHWs per commune = n3
average time per day for CHWs' tasks = h3.

11- Financial incentives for CHWS (Fi)
$Fi = n3.fi$

where: number of CHWs per commune = n3
yearly amount of financial incentives = fi.

The financial incentives to CHWs is not yet official. It applies informally in some villages and communes. As it has been assumed earlier that financial incentives is an important factor affecting the number of patients treated by CHWs per year, the value of financial incentives will be added for costing inputs in the areas where it is applied; and this should be taken into account for further policy options by policy makers and health planners for the next planning of generalization of CHWs programme, if the latter shows any positive cost benefit.

Total cost of malaria control

The total cost for malaria control differs from one commune to another, due to the different numbers of CHWs per commune (see table 1.5 in appendix). The variation of costs is also due to the variation of different types of costs, especially whether the CHWs have financial incentives or not.

## 5.4 Outcomes Analysis

The outcomes analysis will be done by two types of comparisons:

- the first comparison is between two groups of communes, the first group with CHWs at the village level, the second group, neighbour to the first, identical in all characteristics except for the exposition of the villagers to the CHWs performance in malaria control;

- the second comparison will be performed between only experimental communes, the ones whose CHWs have any kind of formal reward, and the others whose CHWs have no rewards.

This will involve household survey and secondary data collection at health centres (see tools of data collection in section 5.8,).

The outcomes will be analyzed (i) in terms of benefits for the outcomes which can be converted into money terms, and (ii) in terms of effectiveness for the final outcomes (health effects) which will remain in natural units (eg. number of deaths prevented).

This section is comprised of five subsections, respectively:
- expected outcomes,
- expected benefits,
- cost benefit analysis model,
- expected health effects,
- cost effectiveness analysis model.

### 5.4.1 Expected outcomes

The outcomes expected from the contribution of the CHWs in malaria control at the village level are the followings:

i. the reduction of cost for treating simple malaria cases to villagers,

ii. the reduction of illness time by early diagnosis and prompt treatment of simple malaria cases,

iii. the increase in the number of malaria patients treated in the overall commune with CHWs, due to the reduction of non treatment, self treatment and other non-medical treatment,

iv. the reduction of malaria specific morbidity in villages and communes exposed to CHWs,

v. the reduction of malaria specific mortality in villages and communes exposed to CHWs,

Other expected outcomes in villages exposed to CHWs' performance in malaria control (but not easily measurable and or valuable) may be:

vi. the reduction of the flow of simple malaria cases from villages to health centres and district hospitals,

vii. the reduction of the number of severe cases of malaria at health centre and district hospital by early diagnosis and prompt treatment of simple cases by CHWs in villages.

### 5.4.2 Expected benefits

The first three outcomes will be valuated as the benefit of CHWs' performance in malaria control at the village level. They are the followings:

(1) the reduction of cost for treating simple malaria cases to villagers,

(2) the reduction of illness time by early diagnosis and prompt treatment of simple malaria cases,

(3) the increase in the number of malaria patients treated in the overall commune with CHWs, due to the reduction of non treatment, self treatment and other non-medical treatment,

This subsection of expected benefits is divided into five parts:
- valuation of expected benefits,
- information needed for valuation of benefits,
- assumptions for valuation of benefits,
- notations,
- calculation of the values of the benefits.

1. <u>Valuation of the expected benefits</u>

The value of total benefit includes the three following different types of benefit:

(1) reduced cost incurred by malaria patients treated in the overall commune with CHWs (benefit 1),

(2) value of reduced illness time for malaria patients in the overall commune with CHWs (benefit 2),

(3) value of additional number of malaria patients treated in the overall commune with CHWs, which includes,
    * value of prevented cases from non treatment,
    * value of prevented cases from self-treatment,
    * value of prevented cases from non medical treatment,
    (benefit 3).

2. <u>Information needed for valuation of benefits</u>

The model to be built requires some key information for valuation of the benefits. The population of the communes, as well as other specific information related to each type of benefit must be known above as follows:

**(1) Reduced cost incurred by malaria patients treated in the overall commune with CHWs** (benefit 1),

a. In villages without CHWs
- ratio of cases of malaria in a year over total population of the commune,
- number of cases treated in district hospital, health centre,
- treatment cost per case (drugs and others) in district hospital, health centre,
- number of accompanying persons per case,
- other expenses (travel + food) per case.

b. In villages with CHWs
- the information as above, plus:
- number of cases treated by CHWs,
- treatment cost per case (drugs and others) at CHWs.

**(2) Value of reduced illness time for malaria patients in the overall commune with CHWs** (benefit 2),

Malaria home illness patients are assumed to lose productive time equivalent to the duration or length of the illness, and hospitalized malaria patients lose productive time equivalent to the time spent in hospital. For children, it is assumed that one adult will be in attendance for the duration of the hospital stay. Usually, an adult caretaker remains with a hospitalized adult patient as well. According to Ettling and Shepard (1991, 217), in addition after the hospitalization, adult malaria patient is assumed to entail 3 days of work lost at home, while for child cases, the production loss is assumed to be 1 day of adult time spent in caring for the sick child at home.

Moreover, there are two periods in the illness time of an adult: a time during which the patient cannot perform his/her usual task as usual, assumed to be 50 % of day lost, and a time the patient cannot perform at all his/her usual task, that is 100% of day lost (Ettling and others, 1994, 77).

Thus, the information required to calculate the cost of illness time are:

number of home malaria cases per commune in one year,
number of adult home malaria cases in a year,
number of children home malaria cases in a year,
length of home illness per case;

number of hospitalized cases of malaria,
number of adult hospitalized malaria cases in a year,
number of children hospitalized malaria cases in a year,
length of hospital stay per case.

(3) **Value of additional number of malaria patients treated in the overall commune with CHWs** (benefit 3), which includes:
- * value of prevented cases from non treatment,
- * value of prevented cases from self-treatment,
- * value of prevented cases from non-medical treatment,

In villages, not all cases of malaria are treated. A study of the sources of care found that 5% of diseases at the village level are not at all treated for many reasons, including financial and geographical accessibility, beliefs, etc. (Alihonou, Hounye and others, 1994). Among those treated, the sources of treatment are various: self treatment with market drug, traditional medicine, friend/parent advice, exorcism, prayers etc. And it had been proved that all those sources of treatment are more expensive than CHWs who prescribe only essential drugs. So, the presence of CHWs in the villages of experimental communes would bring the service point close to the potential patients. Thus, self treatment, non treatment, and non medical sources of treatment because of inaccessibility of service are expected to be reduced. As a result, the number of patients treated in the overall communes with CHWs is expected to be higher than that of communes without CHWs.

The information needed to value the savings for additional number of patients treated are:

- number of no treatment over total number of malaria cases in the commune for one year,

- number of self treatment
  cost per self treatment,

- number of non-medical treatment,
  cost per non-medical treatment.

3. Assumptions for valuation of benefits

The followings are the necessary assumptions for valuating the benefits on the basis of the required information of the section above:

- All the changes in malaria morbidity and mortality of the villagers in experimental communes are due to the actions of CHWs.

- Self treatment and other non-medical treatment of malaria cases depend on health seeking behaviour of villagers.

- Only adults (> 15 years old) in households are assumed to be economically active, although it is known that some children under 15 can contribute to certain extent to the household income.

- All adults are economically active 365 days per year.

- In case of no treatment for malaria, illness time is assumed to be equivalent to the length of hospital stay.

4. Notation for valuation of outcomes

Commune with CHW = (CHW+) in subscript
Commune without CHW = (CHW-) in subscript
Total Benefit (B)
Benefit 1 = (B1)
Benefit 2 = (B2)
Benefit 3 = (B3).

**(1) Reduced cost incurred by malaria patients treated in the overall commune with CHWs** (B1):

ratio of cases of malaria in a year (r1),
number of cases treated by CHWs (r2),
number of cases treated in health centre (r3),
number of cases treated in district hospital (r4),

treatment cost per case, drugs and others (t1),
treatment cost per case treated by CHWs (t2),
treatment cost per case treated in health centre (t3),
treatment cost per case treated in district hospital (t4),

number of accompanying persons per case (n1),
other expenses (travel + food) per case (o),
number of days necessary to be accompanied (n2).

**(2) Value of reduced illness time for malaria patients in the overall commune with CHWs** (B2):

number of home malaria cases in a year (r5)

number of adult home malaria cases in a year (r6)
number of children home malaria cases in a year (r7)
length of home illness (l1)

number of hospitalized malaria cases (r8)
number of adult hospitalized for malaria in one year (r9)
number of children hospitalized for malaria in one year (r10)
length of hospital stay (l2)

number of days of no work at all (w1)
number of days of less work (w2)
average daily wage or income of an adult (y).

(3) **Value of additional number of malaria patients treated in the overall commune with CHWs** (B3), which includes:
  * value of prevented cases from non treatment,
  * value of prevented cases from self-treatment,
  * value of prevented cases from non-medical treatment,

number of no treatment (r11)
number of self treatment (r12)
cost per self treatment (c1)

number of non-medical treatment (r13)
cost per non-medical treatment (c2).

5. <u>Calculation</u>

a. <u>Value of each type of benefit</u>

(1) **Reduced cost incurred by malaria patients treated in the overall commune with CHWs (Benefit 1),**

total treatment cost by CHWs (ttcc)
ttcc = r2.t2

cost of accompanying person(s) (coap)
coap = (n1.o) + (n1.n2.y)

total treatment cost by health centre (ttch)
ttch = (r3.t3) + coap

total treatment cost by district hospital (ttcd)
ttcd = (r4.t4) + coap

$$B1 = (ttch + ttcd)_{CHW-} - (ttch + ttcd + ttcc)_{CHW+}$$

(2) **Value of reduced illness time for malaria patients in the overall commune with CHWs (Benefit 2),**

number of work days loss (w3) =
days lost for adult home illness in the household
(r6.w1) + (r6.1/2.w2) )

+ days lost for children home illness in the household
  r7.11

+ days lost for adult hospital illness in the household
  2r9.12 + r9.3 days

+ days lost for children hospital illness in the household
  r10.12 + r10.1 day.

Value of days of work loss (W); W = w3.y

$B2 = W_{CHW-} - W_{CHW+}$

**(3) Value of additional number of malaria patients treated in the overall commune with CHWs (Benefit 3)**, which includes,
* value of prevented cases from non treatment,
* value of prevented cases from self-treatment,
* value of prevented cases from non-medical treatment.

number of work days lost for non treatment of malaria (w4)
(assuming each case looses as long as length of hospital stay, 12)
w4 = r11.12

cost of non treatment (cont)
cont = r11.12.y

cost of self treatment (cost)
cost = r12.c1

cost of non-medical treatment (conm)
conm = r13.c2

$B3 = (cont + cost + conm)_{CHW-} - (cont + cost + conm)_{CHWs+}$

b. Value of Total Benefit

Total Benefit (B) of CHWs' performance impact in malaria control at the village level since the launching of the programme in experimental communes is the summation of all three benefits calculated above as follows:

$$B = B1 + B2 + B3$$

**5.4.3 Cost-benefit analysis model**

The cost benefit analysis will be performed to judge whether or not it is worth implementing such a programme. The behaviour of the benefit will be analyzed for the commune which cost includes the financial rewards to the CHWs. The cost in such communes would be higher The benefit in those communes is expected to be higher than in experimental communes with no financial rewards to CHWs.

The followings are a couple of assumptions that can strengthen this equation:

- costs of inputs and valuation of outcomes of CHWs' impact in malaria control should be done within a time frame to be defined for the long run ($\geq$ 5 years) to allow changes which cannot occur in short run (< 5 years);
- The costing of investment cost and the operating cost should consider the inflation rate.

The cost versus benefit of the present CHWs programme will be analyzed in two ways:

- benefit cost ratio of the CHWs project,
- net present value of the CHWs project.

1. The Benefit Cost Ratio

The equation for the estimation of benefit cost ratio is:

**B/C = Benefit Cost ratio**

The main equation is the estimation of benefit cost ratio on cost benefit analysis concept. The ratio should be greater or equal to one (B/C $\geq$ 1). The higher the ratio is, the better is the programme.

2. The Net Present Value

The cost benefit analysis can be done also by calculating the net present value with the following formula:

**B-C = Net Present Value**

The net present value (NPV) should be greater or equal to zero (B-C $\geq$ 0). The higher the NPV is, the better is the programme.

### 5.4.4 Expected health effects or effectiveness

This sub-section is divided into 4 parts:

- indicators for effectiveness analysis,
- assumption for analyzing the health effects,
- information needed for analyzing the health effects,
- calculation.

1. Indicators for effectiveness analysis

The following expected final outcomes or health effects will be analyzed as the effectiveness of CHWs' performance in malaria control at the village level in experimental communes:

(1) reduction of malaria specific morbidity in villages and communes exposed to CHWs,

(2) reduction of malaria specific mortality in villages and communes exposed to CHWs.

2. Assumption for analyzing the health effects

It is assumed that all the changes in malaria morbidity and mortality of the villagers in experimental communes are due to the actions of CHWs.

3. Information needed for analyzing the health effects

**(1) Reduction of malaria specific morbidity in communes exposed to CHWs:**

- population of experimental commune $P(E_t)$

- population of control commune $P(C_t)$

- number of malaria cases detected monthly during 12 months of follow up in the sample of households in experimental communes ($mE_1$, $mE_2$, $mE_3$, ..., $mE_{12}$), where $mE_i$ is the number of malaria cases in experimental commune for the $i^{th}$ month of the survey.

- number of malaria cases detected monthly during 12 months of follow up in the sample of households in control communes ($mC_1$, $mC_2$, $mC_3$, ..., $mC_{12}$), where $mC_i$ is the number of malaria cases in control commune for the $i^{th}$ month of the survey.

**(2) Reduction of malaria specific mortality in communes exposed to CHWs:**

- number of monthly deaths from malaria detected during 12 months of follow up in the sample of households in experimental communes ($ME_1$, $ME_2$, $ME_3$, ..., $ME_{12}$), where $ME_i$ is the number of deaths from malaria in experimental commune for the $i^{th}$ month of the survey.

- number of monthly deaths from malaria detected during 12 months of follow up in the sample of households in control communes ($MC_1$, $MC_2$, $MC_3$, ..., $MC_{12}$), where $MC_i$ is the number of deaths from malaria in control commune for the $i^{th}$ month of the survey.

4. Calculation

**(1) Number of malaria cases prevented**

- Number of malaria cases in experimental commune $m(E_t)$

$m(E_t) = \sum mE_i = mE_1 + mE_2 + mE_3 + \ldots + mE_{12}.$

- Number of malaria cases in control commune $(mC_t)$

$m(C_t) = \sum mC_i = mC_1 + mC_2 + mC_3 + \ldots + mC_{12}.$

$$\text{NUMBER CASES PREVENTED} = \left[\frac{m(C_t)}{P(C_t)} * P(E_t)\right] - m(E_t).$$

The effectiveness of malaria control by CHW at the village level regarding malaria specific morbidity is equal to the Number of cases of malaria prevented in experimental communes ($E_t$) compared to control communes ($C_t$).

**(2) Number of deaths from malaria avoided**

- Number of deaths from malaria in experimental commune $M(E_t)$

$$M(E_t) = \sum ME_i = ME_1 + ME_2 + ME_3 + \ldots + ME_{12}.$$

- Number of deaths from malaria in control commune $M(C_t)$

$$M(C_t) = \sum MC_i = MC_1 + MC_2 + MC_3 + \ldots + MC_{12}.$$

$$\text{NUMBER DEATHS AVERTED} = \left[\frac{M(C_t)}{P(C_t)} * P(E_t)\right] - M(E_t)$$

The effectiveness of malaria control by CHW at the village level regarding malaria specific mortality is equal to the Number of deaths from malaria averted in experimental communes ($E_t$) compared to control communes ($C_t$)

### 5.4.5 Cost-effectiveness analysis model

The cost and effectiveness equation for the cost effectiveness analysis is:

**C/E = Cost Effectiveness ratio**

The cost effectiveness analysis of the programme is calculated in natural unit as shown by the following equations:

**(i) Regarding malaria morbidity,**

$$\text{Cost effectiveness ratio} = \frac{\text{Total Cost}}{\text{Number cases prevented}}$$

**(ii) Regarding malaria mortality,**

$$\text{Cost effectiveness ratio} = \frac{\text{Total Cost}}{\text{Number deaths averted}}$$

The health effects will be analyzed specifically for the communes which cost includes the financial rewards to the CHWs. The cost in such communes would be higher. The number of units of health effects (number of malaria cases prevented and number of deaths from malaria averted) in those communes is expected to be higher than in experimental communes with no financial rewards to CHWs. Likewise, the cost per unit of effectiveness would be lower in experimental communes with financial rewards to the CHWs than in experimental communes with no financial rewards to CHWs.

## 5.5 Unit of Analysis of Cost and Outcomes Analysis

The unit of analysis for cost and outcomes analysis is the commune level which includes an average number of 8-12 villages (the health centre of the commune covers all the villages in the commune).

## 5.6 Population and Sampling

### 5.6.1 Household survey for outcomes data collection

The target population for the household survey is the whole population of the country. The study population is the population of the six districts involved in the CHWs programme: the members of the households of all the experimental communes (with CHWs), and also the households of neighbouring communes (without CHWs). The sample size for the experimental communes is **N**, calculated as follows:

$$N = \frac{Z^2_{\alpha} * p * q}{d^2}$$

where:
- N is the desired sample size;
- p is the variability of characteristic to be measured in the population; here, it is the maximum expected prevalence of malaria;
- q is the pessimatic value, and is obtained by 1 minus p;
- d is the maximum margin of error tolerated or degree of accuracy required;
- $Z_{\alpha}$ is the degree of confidence (odds ratio) which is required to be within the special range $\pm$ d. A value of Z = 2 or Z = 1.96 is often chosen since this provides a degree of confidence equal to odds of 19 to 1. This is technically termed a 95% confidence interval.

With:
p = 0.5 (50%); that value is chosen because there is no reasonable estimate; so to maximize the sample size, we chose 50%;
q = 1-p = 0.5; as there is no reasonable estimate of p, we used 50%, then q = 50%. This maximizes the expected variance (pq = 0.25) and ensures the sample size to be large enough for the purpose;
d = $\pm$ 1% = 0.01;
$Z_{\alpha}$ = 1.96;
N = 9604 people = <u>1685 households</u> (with 5.7 persons per household).

*** Sampling techniques:**

The 1685 households to be interviewed will be distributed in the overall six communes proportionally to the size of the population of each experimental commune. The head of household or any adult in the household can be interviewed. The number of households to be interviewed by commune is on table 5.3.

Multistage stratified sampling was performed in 1990 to select the experimental communes. There are six strata (each province is one stratum) in the country. There was a random choice of one district in each province, then a random choice of one experimental or pilot commune in each of the districts selected.

Table 5.3: Sample Size for Each Experimental Commune

| Experimental Communes | Population | Sample size of population | Sample size of households |
|---|---|---|---|
| 1. Agatogbo | 7,961 | 1,056 | 185 |
| 2. Djougou2 | 17,336 | 2,300 | 403 |
| 3. Hevie | 7,058 | 936 | 164 |
| 4. Paouignan | 18,075 | 2,398 | 421 |
| 5. Sori | 13,391 | 1,776 | 312 |
| 6. Takon | 8,582 | 1,138 | 200 |
| Total | 72,403 | 9,604 | 1,685 |

The control communes for each experimental commune, selected by purposive (non probability) sampling, are all the surrounding two or three communes in the same district, for their characteristics resemble those of the experimental commune with regard to the demographic characteristics, socio-economic conditions, culture, beliefs, religion, etc., except for the existence of CHWs. In Bénin, the district within the province is an homogenous social, cultural, economic and administrative unit.

### 5.6.2 Other data collection

Additional input and some benefit data will be collected at the health centres. Health centre records will be used and health personnel (nurses, assistant-nurses and midwives) involved in the CHWs programme will be interviewed. Also, the CHWs will be interviewed for evaluating their of opportunity cost. For all these, all the CHWs (126) in the experimental communes will be interviewed as explained earlier in section 4.3.8; the medical officers of the six districts (6 MD) are also might be included.

## 5.7 Tools for Data Collection

### 5.7.1 Cost data collection

Table 5.4 summarizes all the data to be collected for inputs activities costing.

Table 5.4: Costs Data Collection

| Information | Measurement | Type of data | Sources of data |
|---|---|---|---|
| 1. Training of midwife for training CHWs<br>- number of midwives to be trained<br>- number of required training days<br>- required number of trainers<br>- perdiem per trainee (Franc CFA)<br>- perdiem per trainer (Franc CFA)<br>- travel cost per trainee (Franc CFA)<br>- administration cost per trainee (Franc CFA)<br>- field visit cost per trainee (Franc CFA) | Interview | primary | HC personnel |
| 2. Training of CHWs<br>- number of CHWs per commune<br>- number of required training days<br>- required number of trainers<br>- perdiem per trainee<br>- perdiem per trainer<br>- average travel cost per trainee<br>- administration cost per trainee | Interview | primary | HC personnel<br>CHWs |
| 3. Villages assemblies per commune<br>- average length (hour) per assembly<br>- number of assemblies per commune<br>- number participants adults per assembly<br>- number of health personnel per assembly<br>- number of villages per commune | Interview | primary | HC personnel<br>CHWs |
| 4. Equipment of midwife per commune<br>- cost per motorcycle<br>- cost of other equipment per midwife | Calculation | secondary | DH record |
| 5. Cost of equipment of CHWs | Calculation | secondary | DH record |
| 6. Salary of midwife per year | Interview | primary | HC personnel |

| | | | |
|---|---|---|---|
| 7. Retraining of CHWs<br>- number of retraining per year<br>- number of days per retraining<br>- number of CHWs per commune<br>- administration cost per retraining<br>- number of trainers per session<br>- average travel cost per trainee | Calculation | secondary | HC record |
| 8. Supervision of CHWs<br>- average time of supervision per CHWs<br>- transport cost per month<br>- hourly salary of supervisor | Calculation | secondary | HC record |
| 9. Yearly cost of all tools of management needed by the CHWs programme per commune | Calculation | secondary | HC record |
| 10. Opportunity cost per CHW<br>- average time per day for CHWs' tasks<br>- percentage of time for malaria control | Interview | primary | CHWs |
| 11. Financial incentives of CHWS<br>- number of CHWs trained<br>- yearly amount of financial incentives | Interview | primary | CHWs<br>HC personnel |

### 5.7.2 Benefits data collection

The table 5.5 summarizes all the data to be collected for benefits data analysis. The comprehensive questionnaire for benefits data collection is in appendix 2

Table 5.5: Benefits Data Collection

| Variables (Benefits) | Unit | Measurement | Type of data | Sources of data |
|---|---|---|---|---|
| **1. Reduced cost incurred by malaria patients** treated in the overall commune with CHWs,<br>- Number of malaria cases per year<br>- number of cases treated in district hospitals, health centres and CHWs<br>- treatment cost per case in district hospitals, health centres and CHWs...<br>- number accompanied persons<br>- other expenses per case<br>- average daily rural wage in each province | Franc CFA | interview calculation | primary data | Household |
| **2.Value of reduced illness time**<br>- number of home malaria (adult, children)<br>- length of home illness<br>- number of hospitalized cases (adult, children)<br>-length of hospital stay | Franc CFA | interview calculation | primary data | households |
| **3. Value of additional patients treated**<br>- number of no treatment<br>- number of self treatment<br>- cost per self treatment,<br>- number of non-medical treatment,<br>- cost per non-medical treatment. | Franc CFA | interview calculation | primary data | households |

### 5.7.3 Health effects data collection

Table 5.6 summarizes all the data to be collected for effectiveness data analysis. The comprehensive questionnaire for effectiveness data collection is in appendix 2.

Table 5.6: Effectiveness Data Collection

| Variables (Effectiveness) | Unit | Measurement | Type of data | Sources of data |
|---|---|---|---|---|
| **1. Reduction of malaria specific morbidity in communes exposed to CHWs:** | Number | interview calculation | primary data | Household |
| - population of experimental communes<br>- population of control commune of each experimental commune | | | secondary data | Statistics institute |
| - number of malaria cases monthly during one year in the samples of households in experimental communes | | | secondary data | " |
| - number of malaria cases monthly during one year in the samples of households in control communes | | | primary data | Household |
| **2. Reduction of malaria specific mortality in communes exposed to CHWs:** | Number | interview calculation | primary data | Household |
| - number of monthly deaths from malaria during one year in the samples of households in experimental communes<br>- number of monthly deaths from malaria during one year in the samples of households in control communes | | | | |