CHAPTER 6

EVALUATION OF THE APPROACH

Some hypothetical data attached to the appendix are used in this chapter to test the models proposed in this methodological approach of the economic analysis of CHWs' performance in malaria control in Bénin. The evaluation of the approach to this study is comprised of three sections; the model of CHWs' performance analysis is tested in the first section, then both models of cost benefit analysis and cost effectiveness analysis are tested in the second section. The last section is devoted to the analysis of the relationship between the performance in one hand, and the costs, the benefits and the effectiveness in the other hand.

6.1 Performance of the CHWs in Malaria Control

Assuming one experimental commune A in the central region of Bénin with 20 villages and 60 CHWs. The number of malaria patients treated in 1995 by each CHW, and the set of independent quantitative and qualitative related to each CHW are in appendix 2.
The multiple linear regression model defined in section 4.4 is as follows:

$$y_i = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 + \beta_{10} x_{10} + \beta_{11} x_{11} + \beta_{12} x_{12a} + \beta_{13} x_{12b} + \beta_{14} x_{12c} + \beta_{15} x_{13} + \beta_{16} x_{14} + \beta_{17} x_{15} + \beta_{18} x_{16} + \beta_{19} x_{17} + e_i.$$

6.1.1 Analysis of multiple regression equation

When the "dummy" variables sex (x_{11}), employment (x_{13}), the support from the health services hierarchy (x_{16}) and the notion of private healing service before becoming CHW (x_{17}) are added to the quantitative independent variables in the regression equation, then run in TSP with Y dependent variable, the model of the regression function is:

$$\begin{array}{lllllllll} Y = 24.9 & + 0.9x_1 & + 1.4x_2 & + 3.8x_3 & + 0.04x_4 & - 3.5x_5 & + 7.7x_6 & + 6.3x_7 & + 34.2x_8 \\ (1.16) & (2.34^*) & (.90) & (1.02) & (.59) & (-2.72^*) & (.97) & (1.92) & (3.39^*) \end{array}$$

$$\begin{array}{llllll} + 1.7x_9 & + 1.1x_{10} & + 40.5x_{11} & - 19.9x_{13} & - 30.8x_{16} & - 25.3x_{17} \\ (.96) & (1.45) & (4.58^*) & (-2.11^*) & (-2.64^*) & (1.93) \end{array}$$

The figure in parenthesis under each independent variable and the constant is the value of t-statistic of each. Those with an asterix (*) are the t-statistic of the six independent variables which are significant at 5% level of significance (critical t-test at 5% and df=60 is 2.00). These variables are:

x_1, x_5, x_8, x_{11}, x_{13} and X_{16}.

The coefficient of multiple determination R^2 is 0.9586 and the adjusted R^2 is 0.9458. It means that 94.6% of the number of malaria patients treated in 1995 by the CHWs in the hypothetical experimental commune A can be explained by the independent quantitative variables, the sex, the employment, the support from the health services hierarchy and the notion of private healing service before becoming CHW.

F-statistic = 74.59, significant at 14, 46 degrees of freedom, with $p < 0.001$.

The regression coefficients are positive for nine quantitative variables (over 10) which are positively related to the number of patients treated. It means that when the value of those variables increases, the number of patients treated increases. Those variables are the followings:

- x1 the age of the CHW
- x2 the number of years of schooling
- x3 the number of years of experience as CHW
- x4 the annual amount of his/her household income
- x6 the value of informal gift he/she gets per year
- x7 the number of supervision he/she receives per year
- x8 the number of retraining since the beginning of the programme
- x9 the number of hours he/she is available a day
- x10 the amount of formal rewards he/she gets per year.

Only the number of dependents (x_5) is negatively related to the number of patients treated per year by the CHW. It means that when the number of dependents of the CHW increases, the number of patients decreases.

Among the qualitative variables, only the sex male ($x_{11} = 1$) is positively related to the number of patients treated per year as hypothesized in section 4.2. All the other qualitative variables are negatively related to the number of patients treated when their value is 1, unlike what was hypothesized in section 4.2. Those variables are:

- x13 represents his/her occupation
- x16 represents his/her support from the hierarchy
- x17 represents any private healing service before becoming CHW.

The combination of variables above is the only one with simultaneously the highest number of significant variables and the highest adjusted R^2 among all the alternatives tested.

6.1.2 Correlation analysis of independent variables

A correlation analysis was performed to identify the independent variables which are correlated with each other. The most significant correlation after thorough analysis is 76.6% between the number of years of experience as CHW (x3) and the number of retraining since the beginning of the programme (x8). So, only one of these two variables should be included in the model. Luckily, x3 was not significant, then x8 can be kept in the model.

6.1.3 Logit analysis

As the logit analysis presents a unique complement to multiple regression in its ability to utilize a binary dependent variable (see 4.5.3), only the logit model will be tested for the hypothetical data among the binary models discussed.

The logit model, based on the cumulative logistic probability function, is expressed in the form

$$P_i = \frac{e^{\alpha + \beta Y_i}}{1 + e^{\alpha + \beta Y_i}}$$

when $X15_i$ the attitude of the villagers towards the CHW, a dichotomous dummy variable, is considered as the dependent variable, and the number of patients treated Y_i is considered as the independent variable.

With the hypothetical data in appendix 3, after running the regression, we got

α = -1.5288
β = 0.0233

So the final logit model is:

$$P_i = \frac{e^{-1.5288 + 0.0233Y_i}}{1 + e^{-1.5288 + 0.0233Y_i}}$$

with t-statistic = -1.0829 for α
= 1.9393 for β,
significant at 5% level of significance (for β), with $p < 0.05$.

6.2 Cost and Outcomes Analysis of CHWs in Malaria Control

Assuming two experimental communes E_1 and E_2 in the southern region of Bénin. All the costs are identical in both communes except the formal rewards to CHWs in E_1, and no rewards to CHWs in E_2. The hypothetical control commune C_1 is neighbour to E_1, identical in all characteristics to E_1 except for the exposure to CHWs. All the costs of items are in **franc CFA**, the currency in use in Bénin and other 13 African countries.

6.2.1 Costing the inputs

1. <u>Information</u>

A. **Capital cost**

(1) Training of midwives trainers of CHWs (T1)

- number of midwives to be trained (n1=2)
- number of required training days (d1=20)
- required number of trainers (n2=1)
- perdiem per trainee (p1=1000)
- perdiem per trainer (p2=2000)
- average travel cost per trainee (t1=5000)
- administration cost per trainee (a1=1000)
- field visit cost per trainee (v1=1000)

(2) Training of CHWs (T2)
- number of CHWs per commune (n3=30)
- number of required training days (d2=10)
- required number of trainers (n4=1)
- perdiem per trainee (p3=0)
- perdiem per trainer (p4=0)
- average travel cost per trainee (t2=0)
- administration cost per trainee (a2=200)

(3) Villages assemblies per commune (V)
- average length (hour) per assembly (h1=2 hours)
- number of assemblies per village (as=3)
- average number of participants adults per assembly (n5=40)
- number of health personnel per assembly (n6=1)
- number of villages per commune (v1=10)

(4) Equipment of midwife per commune (E1)
- cost per motorcycle (m=350000)
- cost of other equipment per midwife (e1=50000)

(5) Equipment of CHWs (E2)
- number of CHWs trained (n3=30)
- cost of equipment per CHW (e2=5000)

B. **Operating cost**
(6) Salary of midwife per year (S)
- number of midwife per commune (n9=1)
- monthly salary per midwife (s1=50000)

(7) Retraining of CHWs (R)
- number of retraining per year (r=2)
- number of days per retraining (d2=5)
- number of CHWs per commune (n3=30)
- administration cost per retraining (a3=100)
- number of trainers per session (g5=1)
- average travel cost per trainee (t3=0)
- perdiem per trainee (p3=0)
- perdiem per trainer (p4=0)

(8) Supervision of CHWs (Sp)
- number of CHWs to be supervised per commune per month (n8=30)
- average time of supervision per CHWs (h2=2 hours)
- transport cost (gasoline + maintenance) per month (t4=5000)
- hourly salary of supervisor (wh=pm)

(9) Tools of management (M)
- yearly cost of all tools of management needed by the CHWs programme per commune (10000)

(10) Opportunity cost per CHW (Op)
- average time per day for CHWs' tasks (h3=4 hours)
- percentage of time for malaria control (x=60%)
- number of CHWs trained (n3=30)

(11) Financial incentives of CHWS in commune E1 (Fi)
- number of CHWs trained (n3=30)
- yearly amount of financial incentives (fi=360000)

2. Calculation

(1) Cost of training of two midwives trainers of CHWs (T1)

T1= (n1.d1.p1 + n2.d1.p2 + n1.t1 + n1.a1 + n1.v1)
= 2*20*1000 + 20*1*2000 + 2*5000 + 2*1000 + 2*1000
= 40000 + 40000 + 10000 + 2000 + 2000 = 94000 franc
The cost of training one midwife is then = 47000 franc.

(2) Cost for training of CHWs per commune (T2)
T2 = n3.d2.p3 + n4.d2.p4 + n3.t2 + n3.a2
= 30*10*0 + 10*1*0 + 30*0 + 30*200 = 6000

(3) Cost of villages assemblies per commune (V)
(only opportunity cost for participants, for the salary of health personnel covers that activity and should not be counted twice).

V = h1.as.n5.v1 * wage/hour + h1.as.n6.v1 * salary/hour
= 2*3*40*10*100 = 240000.

(4) Cost of equipment of midwife per commune (E1)
E1 = m + e1 = 350000 + 50000 = 400000.

(5) Cost of equipment of CHWs per commune (E2)
E2 = n3 * e2 = 30*5000 = 150000.

B. **Operating cost**

(6) Salary of midwife per commune per year (S)
S = s * 12 months = 50000 * 12 = 600000.

(7) Retraining of CHWs (R)
R = r.d2.n3.p3 + r.d2.n7.p4 + r.n3.t3 + r.n3.a3
= 2*5*30*0 + 2*5*30*0 + 2*30*0 + 2*30*100 = 6000.

(8) Supervision of CHWs per year (S)
S = n8.h2.wh + (t4 * 12 months)
= 30*2*0 + 5000*12 = 60000.

(9) Tools of management, M=10000

(10) Opportunity cost of CHWs per commune per year (Op)
$Op = n3.h3 * 365 * wage/hour$
$= 30*4*365*100 = 4380000.$

(11) Financial incentives for CHWS (Fi=360000)

ii. Value of the investment for the first 5 years

- Value of the investment in training the midwife, trainers of CHWs during the first five years of the programme ($T1_5$)
(Assuming lifetime = 30 years and interest rate is 10%, the annualization factor is a = 0.1061).
$T1_5 = 5 * 0.1061 * T1 = 5 * 0.1061 * 47000 = 24,934$

- Value of investment in training CHWs $T2_5$
Assuming lifetime = 5 years and interest rate = 10; a = 0.2638.
$T2_5 = 5 * 0.2638 * T2 = 5 * 0.2638 * 6000 = 7914$

- Value of investment in villages assemblies (V_5)
Assuming lifetime = 5 years and interest rate = 10; a = 0.2638.
$V_5 = 5 * 0.2638 * V = 5 * 0.2638 * 240000 = 316560$

- Value of investment in equipment of midwife ($E1_5$)
Assuming lifetime = 5 years and interest rate = 10; a = 0.2638.
$E1_5 = 5 * 0.2638 * E1 = 5 * 0.2638 * E1 = 527600$

- Value of investment in equipment of CHWs ($E2_5$)
Assuming lifetime = 5 years and interest rate = 10; a = 0.2638.
$E2_5 = 5 * 0.2638 * E2 = 5 * 0.2638 * 150000 = 197850$

iii. 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 (1), (2), (3), (4) and (5) as follows:
$TIC = T1_5 + T2_5 + V_5 + E1_5 + E2_5.$

$= 24934 + 7914 + 316560 + 527600 + 197850 =$ **1,074,858 franc.**

iv. Value of the operating cost for the first 5 years

Assuming that all the operating costs remain unchanged each year during the first five years.

(6) Salary of midwife per commune for 5 years (S_5)
$S_5 = 5 * 600000 = 3000000$

(7) Retraining of CHWs: $R_5 = 5 * 6000 = 30000.$

(8) Supervision of CHWs per year: $Sp_5 = 5 * 60000 = 300000.$

(9) Tools of management: M_5 = 5 * 10000 = 50000.

(10) Opportunity cost per CHW: Op_5 = 5 * 4380000 = 21,900,000.

(11) Financial incentives for CHWS: Fi_5 = 360000*5 = 1,800,000.
(for commune E_2, Fi_5 = 0.)

v. 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.

= 3000000 + 30000 + 300000+ 50000 + 21900000 + 1800000
= **27,080,000 franc** in commune E_1.
= **25,280,000 franc** in commune E_2.

vi. Calculation of Total Cost 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.
= 1074858 + 27,080,000 = 28,154,858 franc in commune E_1
= 1074858 + 25,280,000 = 26,354,858 franc in commune E_2.

Total cost for malaria control (TCMC) = (TC) * 0.6 (assuming malaria control as percentage of time of CHWs in simple disease control at the village level is 60%).

$TCMC_1$ = 28,154,858 * 0.6 = 16,892,915 franc in commune E_1
$TCMC_2$ = 26,354,858 * 0.6 = 15,812,915 franc in commune E_2.

6.2.2. Valuating the benefits

We assume the following population and number of malaria cases for the three hypothetical communes in study:
commune E_1 = 15000, number of malaria cases = 10000;
commune E_2 = 13000, number of malaria cases = 10000;
commune C_1 = 14000, number of malaria cases = 12000.

As the populations of the three communes are not the same, a correction factor is needed to adjust the number of cases of malaria so as to be able to compare them to each other. Let us assume that the population of the commune E_1 is the standard. If the other communes have the same population, their number of cases of malaria would be different. The correction factors are:

- for commune E_1: 10000/15000*15000)/10000 = 1;
- for commune E_2: 10000/13000*15000)/10000 = 1.15;

- for commune C_1: 12000/14000*15000)/12000 = 1.07;

1. Information

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

- ratio of cases of malaria in a year (r1),
$r1(E_1)$ = 10000/15000; $r1(E_2)$ = 10000/13000; $r1(C_1)$ = 12000/14000.

number of cases treated by CHWs (r2),
$r2(E_1)$ = 8000; $r2(E_2)$ = 6000; $r2(C_1)$ = 0.

number of cases treated in health centre (r3),
$r3(E_1)$ = 1000; $r3(E_2)$ = 2000; $r3(C_1)$ = 5000.

number of cases treated in district hospital (r4),
$r4(E_1)$ = 500; $r4(E_2)$ = 1000; $r4(C_1)$ = 2000.

treatment cost per case, drugs and others (t1),
treatment cost per case treated by CHWs (t2=200 franc),
treatment cost per case treated in health centre (t3=2000 franc),
treatment cost per case treated in district hospital (t4=7000 franc).

number of accompanying persons per case (n1=1),
other expenses (travel + food) per case (o=1000 franc),
number of days necessary to be accompanied (n2 = 3 days).

(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)
$r5(E_1)$ = 9000; $r5(E_2)$ = 8000; $r5(C_1)$ = 5000.

adult number of home malaria cases in a year (r6)
$r6(E_1)$ = 4000; $r6(E_2)$ = 3500; $r6(C_1)$ = 2000.

children number of home malaria cases in a year (r7)
$r7(E_1)$ = 5000; $r7(E_2)$ = 4500; $r7(C_1)$ = 3000.

length of home illness (l1 = 3 days)
$l1(E_1)$ = 2; $l1(E_2)$ = 3; $l1(C_1)$ = 5.

- number of hospitalized malaria cases (r8)
$r8(E_1)$ = 500; $r8(E_2)$ = 1000; $r8(C_1)$ = 2000.

adult number of hospitalized malaria cases in a year (r9)
$r9(E_1)$ = 200; $r9(E_2)$ = 400; $r9(C_1)$ = 800.

children number of hospitalized malaria cases in a year (r10)
$r10(E_1)$ = 300; $r10(E_2)$ = 600; $r10(C_1)$ = 1200.

length of hospital stay (l2)
$l2(E_1) = 3$; $l2(E_2) = 5$; $l1(C_1) = 7$.

- number of days of no work at all (w1)
$w1(E_1) = 2$; $l1(E_2) = 3$; $l1(C_1) = 5$.

- number of days of less work (w2)
$w2(E_1) = 2$; $w2(E_2) = 3$; $w2(C_1) = 5$.

- average daily wage or income of an adult (y=800 franc).

(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)
$r11(E_1) = 0$; $r11(E_2) = 100$; $r11(C_1) = 1000$.

- number of self treatment (r12)
$r12(E_1) = 200$; $r12(E_2) = 400$; $r12(C_1) = 2000$.

- number of non-medical treatment (r13)
$r13(E_1) = 300$; $r13(E_2) = 500$; $r13(C_1) = 2000$.

cost per self treatment (c1 = 1000 franc)
cost per non-medical treatment (c2 = 5000 franc).

2. <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),

Before comparing the cost between the communes, all the cost incurred by communes C_1 and E_2 will be adjusted respectively by correction factor 1.15 and 1.07.

total treatment cost by CHWs (ttcc)
ttcc = r2 * t2
- $ttcc(E_1)$ 8000*200 = 1,600,000
- $ttcc(E_2)$ 6000*200*1.15 = 1,380,000
- $ttcc(C_1)$ 0*200 * 1.07 = 0

cost of accompanying person(s) per case to health centre or district hospital (coap)
coap = (n1 * o) + (n1 * n2 * y)
 = 1*1000 + 1*3*800 = 1000 + 2400 = 3400 franc.

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

- ttch(E_1) = 1000*2000 + 3400*1000 = 2000000 + 3400000 = 5,400,000
- ttch(E_2) = (2000*2000 + 3400*2000)*1.15 = 5,382,000
- ttch(C_1) = (5000*2000 + 3400*5000)*1.07 = 28,890,000.

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

- ttcd(E_1) = 500*7000 + 3400* 500 = 3500000 + 1700000 = 5,200,000
- ttcd(E_2) =(1000*7000 + 3400*1000)*1.15 = 11,960,000
- ttcd(C_1) =(2000*7000 + 3400*2000)*1.07 = 22,560,000.

B1 = (ttch + ttcd)C_1 - (ttch + ttcd + ttcc)E_1
= (28,890,000 + 22,560,000) - (5,400,000 +5,200,000 + 1,600,000)

= **39,250,000 franc.**

B1' = (ttch + ttcd)C_1 - (ttch + ttcd + ttcc)E_2
= (28,890,000 + 22,560,000) - (5,382,000+11,960,000 + 1,380,000)
= **32,728,000 franc.**

(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 * 1/2w2))
+ 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.

- W(E_1) = 800f*(4000*2 + 4000*1/2*2 + 5000*2 + 2*200*3 + 3*200
300*3 + 300*1)
= 20,000,000 franc.

- W(E_2) = 800f*(3500*3 + 3500*1/2*3 + 4500*3 + 2*400*5 + 3*400
600*5 + 600*1)*1.15
= 35,006,000 franc.

- W(C_1) = 800f*(2000*5 + 2000*1/2*5 + 3000*5 + 2*800*7 + 3*800
1200*7 + 1200*1)*1.07
= 45,539,200 franc.

B2 = WC_1 - $W(E_1)$ = 45,539,200 - 20,000,000
= 25,539,200 franc.

B2'= WC_1 - $W(E_1)$ = 45,539,200 - 35,006,000
= 10,533,200 franc.

(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 = r11 * 12 * y).
- cont(E_1) = 0*3*800 = 0
- cont(E_2) =(100*5*800)*1.15 = 460,000
- cont(C_1) =(1000*7*800)*1.07 = 5,992,000.

cost of self treatment (cost = r12 * c1).
- cost(E_1) = 200*1000 = 200,000
- cost(E_2) =(400*1000)*1.15 = 460,000
- cost(C_1) =(2000*1000)*1.07 = 2,140,000.

cost of non-medical treatment (conm = r13 * c2).
- conm(E_1) = 300*5000 = 1,500,000
- conm(E_2) =(500*5000)*1.15 = 2,875,000
- conm(C_1) =(2000*5000)*1.07 = 10,700,000.

B3 = (cont + cost + conm)C_1 - (cont + cost + conm)E_1
= (5,992,000 + 2,140,000 + 10,700,000)-(0 + 200,000 + 1,500,000)
= 17,132,000 franc

B3' = (cont + cost + conm)C_1 - (cont + cost + conm)E_2
= (5,992,000+2,140,000+10,700,000)-(460,000+460,000+2,875,000)
= 15,037,000 franc.

b. <u>Value of Total Benefit</u>

- For commune E_1, **B = B1 + B2 + B3**

= 39,250,000 + 25,539,200 + 17,132,000 = 81,921,200 franc.

- For commune E_2, **B' = B1' + B2' + B3'**

= 32,728,000 + 10,533,200 + 15,037,000 = 58,298,200 franc.

Cost-benefit analysis

i) Benefit Cost ratio (B/C)

- For commune E_1
B/TCMC(E_1) = 81,921,200 /16,892,915 = 4.85

- For commune E_2,
B'/TCMC(E_2) = 58,298,200 /15,812,915 = 3.69.

This means that one unit spent on the programme yields more than four units of benefit for commune E_1; and one unit spent on the programme yields more than three units of benefit for commune E_2. Thus, the programme in both communes in worthwhile.

ii) Net Present Value (NVP = B-C)

- For commune E_1
B-TCMC(E_1) = NPV = 81,951,200 - 16,892,915 = 65,058,285 franc.

- For commune E_2,
B'-TCMC(E_2) = NPV = 58,298,200 - 15,812,915 = 42,485,285 franc.

The net present value (NPV) is highly greater than zero for both experimental communes. Thus, the programme in both communes is worthwhile.

The benefit cost ratio and the net present value in the experimental communes are higher where CHWs have formal financial rewards than where there is no financial rewards to CHWs. So the financial rewards to CHWs, though it increases the cost, has a positive consequence.

The difference in benefit cost ratio and net present value will be more commented in the next section.

6.2.2 Health effects analysis

Health effects are analyzed in terms of:

- Reduction of malaria specific morbidity in communes exposed to CHWs:
- Reduction of malaria specific mortality in communes exposed to CHWs:

1. Calculation

We assume a monthly epidemiological survey in households during one year in communes E_1, E_2 and C_1. At the end of the 12[th] month, the aggregate data of malaria morbidity and malaria mortality for the three hypothetical communes are as follows:

Total number of malaria cases

commune E_1 = $m(E_1)$= 10,000
commune E_2 = $m(E_2)$= 10,000
commune C_1 = $m(C_1)$= 12,000

Total number of deaths from malaria
commune E_1 = $M(E_1)$= 50
commune E_2 = $M(E_2)$= 80
commune C_1 = $M(C_1)$= 125.

Total population
commune E_1 = $P(E_1)$= 15000
commune E_2 = $P(E_2)$= 13000
commune C_1 = $P(C_1)$= 14000.

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 commune E_1 or in commune E_2, compared to commune C_1.

- Number of cases of malaria prevented

* in commune E_1:
Number cases prevented = $[m(C_1) * P(E_1) / P(C_1)] - m(E_1)$

= (12000*15000/14000)-10000 = 2857.

* in commune E_2:
Number cases prevented = $[m(C_1) * P(E_2) / P(C_1)] - m(E_2)$

= (12000*13000/14000)-10000 = 1143.

The effectiveness of malaria control by CHW at the village level regarding malaria specific mortality is equal to the Number of cases of malaria prevented in commune E_1 or in commune E_2, compared to commune C_1.

- Number of deaths from malaria averted

* in commune E_1:
Number deaths averted = $[M(C_1) * P(E_1) / P(C_1)] - M(E_1)$

= (125*15000/14000)-50 = 84.

* in commune E_2:
Number deaths averted = $[M(_1) * P(E_2) / P(C_1)] - M(E_2)$

= (125*13000/14000)-80 = 36.

2. Cost-effectiveness analysis

The cost and effectiveness analysis of the programme is calculated in natural unit. The equation for the estimation of effectiveness cost ratio is: C/E (Cost Effectiveness ratio).

(i) Regarding the morbidity,

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

(ii) Regarding the mortality,

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

For the cases of malaria prevented

* in commune E_1:

Cost effectiveness ratio = TCMC(E_1)/Number malaria cases prevented
= 16,892,915 / 2857 cases prevented
= 5,912 franc per case prevented.

* in commune E_2:

Cost effectiveness ratio = TCMC(E_2)/Number malaria cases prevented
= 15,812,915 / 1143 cases prevented
= 13,835 franc per case prevented.

For the deaths from malaria averted

* in commune E_1:

Cost effectiveness ratio = TCMC(E_1)/Number deaths averted
= 16,892,915 / 84 deaths averted
= 201,106 franc per death averted.

* in commune E_2:

Cost effectiveness ratio = TCMC(E_2)/Number deaths averted
= 15,812,915 / 36 deaths averted
= 439,248 franc per death averted.

The number of units of health effects (number of malaria cases prevented or number of deaths from malaria averted) in the experimental communes is higher where CHWs have formal financial rewards than where there is no financial rewards to CHWs. The cost per unit of effectiveness lower where CHWs have formal financial rewards than where there is no financial rewards to CHWs. So the financial rewards to CHWs, though it increases the cost, has positive consequences on the effectiveness.

6.3 Performance, Cost and Outcomes Analysis of the CHWs in Malaria Control

One of the important factors of performance of the CHWs in malaria control at the village level is the annual formal rewards they might get. It was shown in section 6.1 how that factor (x10) is positively related to the number of malaria patient treated. The value of its coefficient in the alternatives of multiple regression equations varies from 0.7 to 2.7 (see 6.1.1).

For the evaluation of the models, we assumed three communes:
- experimental commune E_1, with rewards to CHWs,
- experimental commune E_2, with no rewards to CHWs,
- control commune C_1 without CHWs.

The additional cost for malaria control at the village level by CHWs is TCMC(E_1) = 16,892,915 in commune E_1 and TCMC(E_2)=15,812,915 in commune E_2. The benefit cost ratio of both experimental communes compared to the control is respectively 4.85 for commune E_1 and 3.69 in commune E_2. If one compares those two benefit cost ratios, one concludes that when the programme spent more to give financial incentives to CHWs, it gains more than one unit of benefit.

Likewise, the cost effectiveness ratio showed an important difference, whether the CHWs get financial rewards or not. The cost effectiveness ratio is 5,912 franc per malaria case prevented in E_1, and 13,835 franc per malaria case prevented in commune E_2. Also, the cost effectiveness ratio is 201,106 franc per death from malaria averted in commune E_1, and 439,248 franc per death averted in commune E_2. If one compares those two types of cost effectiveness ratio, one can conclude that when the programme spent more to give financial incentives to CHWs, the gain is more than double of the amount of money spent to prevent each case of malaria and to avert each death from malaria.

So, the performance of the CHWs is intimately related to the benefits and effectiveness of their contribution in malaria control. The more the CHWs are performant, the more benefits and effectiveness their actions produce to the communities served. And to have the CHWs more performant, one must affect the factors of performance, such as financial rewards in this hypothetical example.