CHAPTER 3
RESEARCH METHODOLOGY

3.1 Conceptual framework

For estimating the costs of prevention and benefits, this study will first ascertain the expected number of cases when with and without the protective boot program. Secondly, it will examine the total costs of disease preventive efforts. These costs are comprised of the cost incurred in providing the protective boots and the treatment costs for cases despite their wearing the protective boots. Thirdly, the study will examine the treatment costs for cases when without the protective boots program. The net benefit is equal to the total cost when without the protective boot program minus the total cost when with the protective boot program. The net benefit can be calculated using the following equation, and described in the framework attached.

Formula: Net benefit = $TC_{(t)}(n^0) - TC_{(b)}$

Where $TC_{(t)}(n^0)$ = Total costs when without the protective boot program. These only are total costs of leptospirosis patients' treatment.

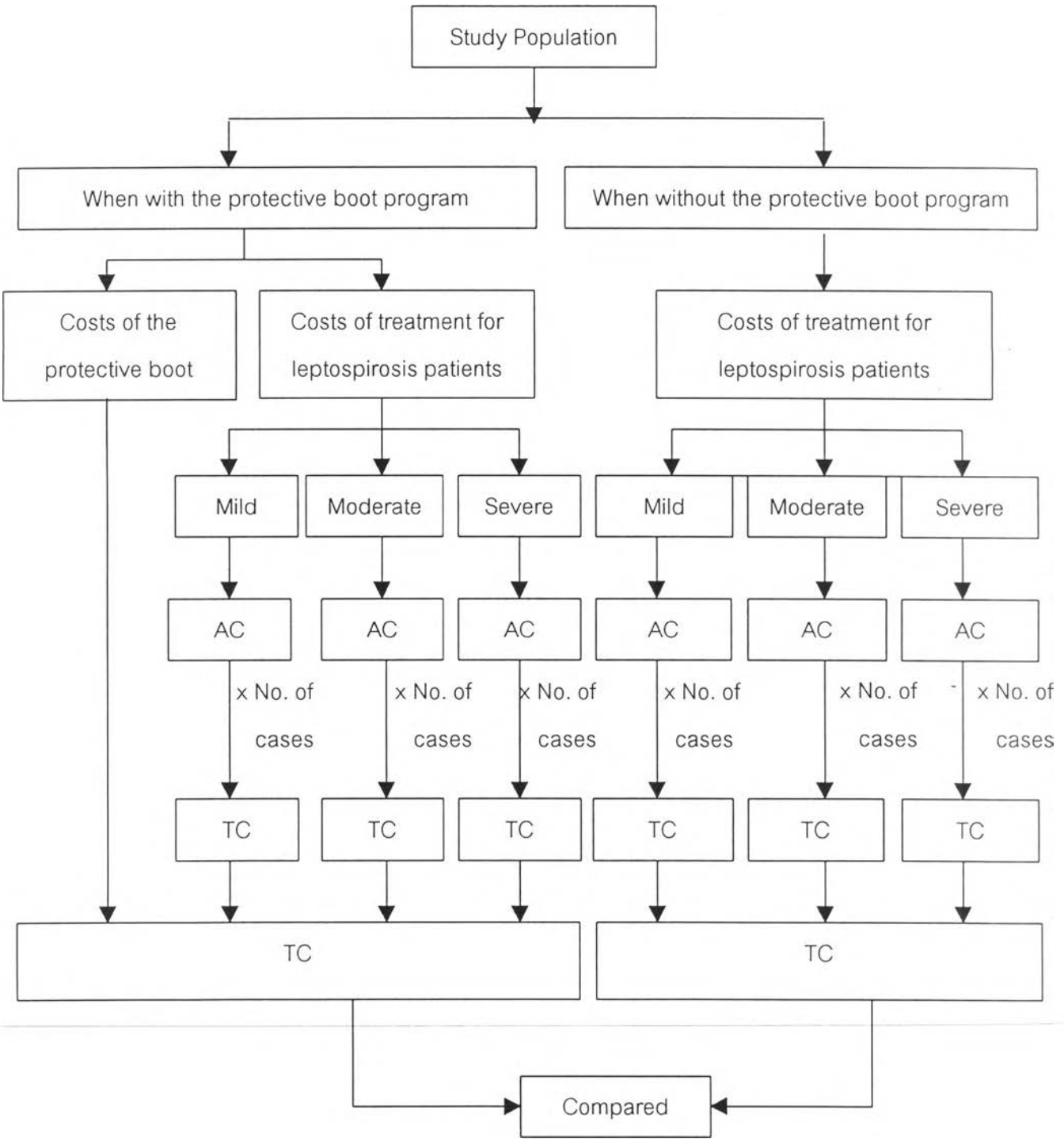
$TC_{(b)}$ = Total costs when with the protective boot program

= $TC_{(b)}(N) + TC_{(t)}(n)$

Where $TC_{(b)}(N)$ = Total costs of the protective boot program

$TC_{(t)}(n)$ = Total costs of leptospirosis patients' treatment when with the protective boot program

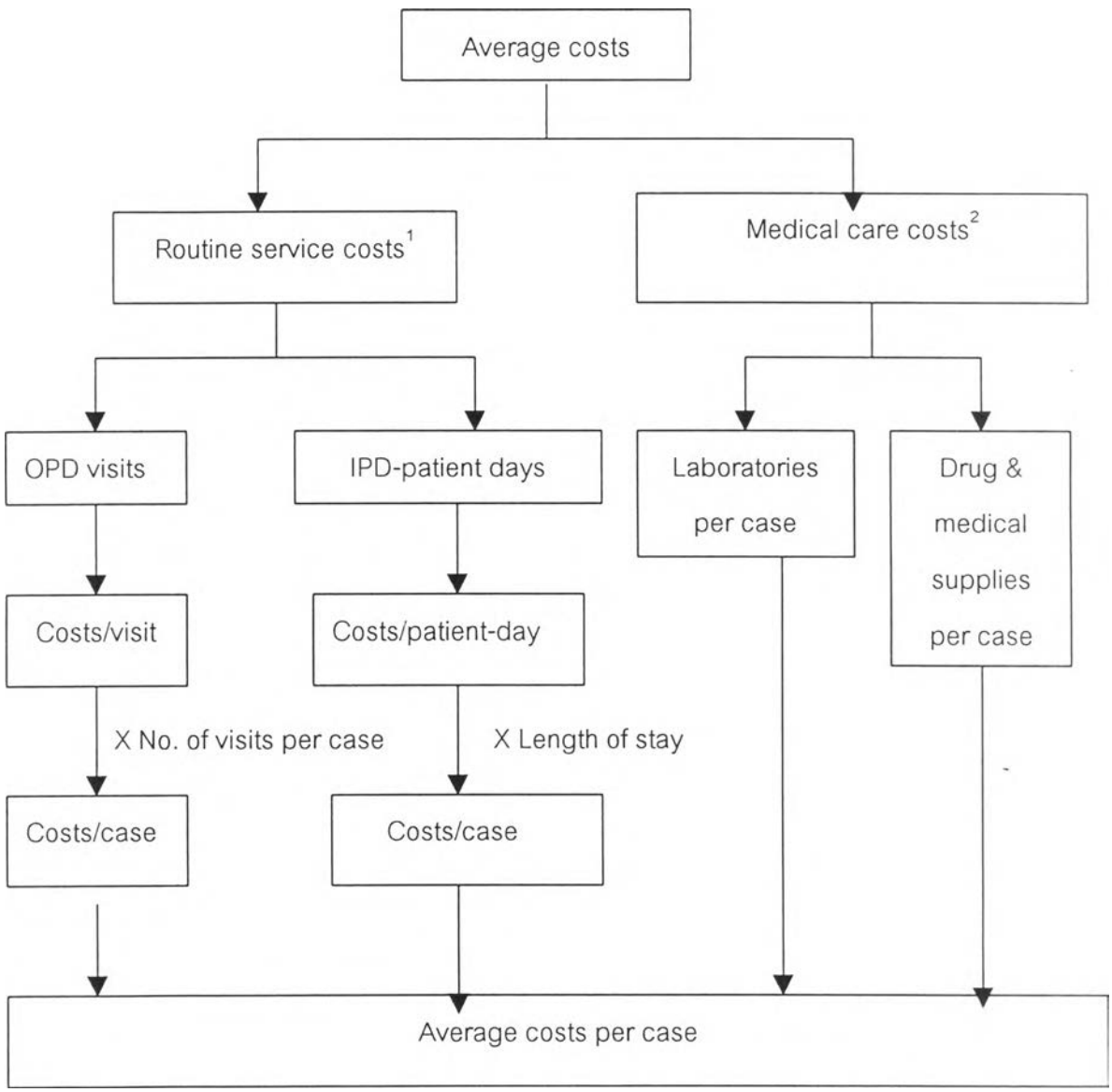
Figure 3-1 Conceptual framework for an estimation of the total costs: when with the protective boot program, and when without the protective boot program.



Note AC = Average costs

TC = Total costs

Figure 3-2 Conceptual framework for an estimation of the average treatment costs for leptospirosis patients, in provider perspective.



Note For this study

[1] Base on "Unit cost analysis of public health facilities in 6 provinces fiscal year 2000 under the social investment project (SIP)" Disyathikom and Thonimitri, 2000 of which labor and material are comprised.

[2] Based on retrospectively reviewed 30-leptospirosis patients' medical chart of Sa Kaeo Crown Prince Hospital, year 2000.

3.2 Study design

The study design is quantitative, estimating the costs and benefits of a leptospirosis preventive program using protective boots from the provider's perspective in the fiscal year 2000. For the following estimation, secondary data are derived from existing leptospirosis research, hospital unit cost analysis, and health reports. In addition, primary data are drawn from financial reports, patients' medical charts, and hospital medical price lists for this purpose.

1. Estimate the number of leptospirosis patients in associated with each infection conditions: when the farmers never wearing the protective boot while working in a rice field, and when the farmers wearing the protective boot while working in a rice field.

2. Estimate the number of leptospirosis patients in associated with each level of disease severity: mild, moderate, and severe when without the protective boot intervention program.

3. Estimate the number of leptospirosis patients in associated with each level of disease severity: mild, moderate, and severe when with the protective boot program.

4. Estimate the average costs per pair of the protective boots to be distributed to farmers and total costs of the protective program.

5. Estimate the average treatment costs per case in associated with each level of disease severity, and then total treatment costs in associated with conditions of infection.

6. Analyze the costs and benefit.

3.3. Study area

For identify the number of study population, Sa Kaeo Province was purposively selected to be study area, as the province was one of many affected by the disease in the year 2000.

3.4 Operational definitions

As used herein, related definitions are divided in to two parts: A. definition related to leptospirosis terms, and B. definitions related to economic terms. The following terms have the respective meanings set forth below.

A. Leptospirosis terms

1. "**Leptospirosis**" (ICD-10 : A27) is an acute infectious disease caused by leptospira interrogan. Transmission to the human body is primarily the result of direct blood exposure to contaminated water (through cuts or abrasions or softened skin). Transmission from person to person is rare. It is treatable with antibiotics if given within 4

days after the leptospirosis infection manifests itself. If not treated promptly, it can be fatal. It is also preventable by avoidance, if do not so one should wears protective clothing.

Its clinical criteria include acute febrile with headache, associated with at least one of the following symptom: muscle pain, prostration conjunctival suffusion, meningal irritation, an-oliguria and/or protinuria, jaundice, haemorrhages (from the intestines and lungs is notorious in some area), cardiac arrhythmia or failure, and having occupational activities or history of exposed to contaminated water or wet soil either with or without one of the following positive laboratory.

1. One of the following screening test: latex agglutination test (LA), dipstick test, lateral flow test, microcapsule agglutination test or
2. One of following confirmatory test: immunofluorescent antibody test (IFA), microscopic agglutination test (MAT), ELISA test for leptospirosis.

Note: We call the patient who meet only clinical criteria, without any positive laboratory test that suspected case, and the patient who meet clinical criteria with at least one positive laboratory test that confirmed case.

Its incubation period is 2-30 days; commonly, 10 days (Khukarat, 2001).

2. "Asymptomatic leptospirosis infection" means leptospirosis infections, which manifest no symptoms of leptospirosis illness for cure of which no treatment are required.

3. "Symptomatic leptospirosis infection" means leptospirosis infections, which manifest some of many symptoms of leptospirosis illness such as acute febrile with headache, muscle pain and so on for cure of which specific with or without concurrent treatment (depend on the disease's conditions) are required. This group of infection is classified by severity into 3 severe groups:

a) "Mild leptospirosis" means symptomatic leptospirosis infections for cure of which given treatment as OPD patient are required. Treatment specifically includes oral antibiotic for 7 days (doxycycline 100 mg twice a day or amoxycillin 500 mg four times a day). Concurrent treatment as indicate by the patient condition (Sirinavin and Chunsuthiwat, 2001).

b) "Moderate leptospirosis" means symptomatic leptospirosis infections for cure of which bed-rest in a hospital (IPD patient) are required. Treatment as indicated by the disease conditions. Whatsoever this group of patients is not too sever to irretrievable, usually because early diagnosis and treatment can be given at an earlier stage of the onset of illness.

c) "Severe leptospirosis" means symptomatic leptospirosis infections who are too severe to retrievable (death of patient), usually because early diagnosis and treatment cannot be given at an earlier stage of the onset of illness.

B. Economic terms

1. "Costs" is value of resource given up to achieve the protective boot program. They are consisted of the total cost of the protective boot program and the total treatment cost for leptospirosis infection even their wearing the protective boot. The costs are measured from provider perspective, in Thai Baht, in the year 2000.

2."Benefit" is the equivalent money of preventive cases measured by treatment costs from provider perspective, in Thai Baht, in the year 2000.

3. "Average Costs (AC)" means a measure of total costs associated with each unit of health improvement. The AC measures the value of all resource required for each unit of health improvement. This study, the AC comprised of routine service costs and medical care costs, which can be written in the following equation.

AC = RSC (OPD visits, IPD patient-days) + MCC (laboratories, drugs, medical supplies)

4. "Total costs (TC)" mean a measure of total costs associated with a given number of health improvement. The TC measures the aggregate resource required for such a given number of health improvement. It, therefore is a production of AC and the total number of targeted population multiplied together which can be written in the following equation.

$$TC(N) = AC(RSC, MCC) \times N$$

5. "Routine service costs (RSC)"

a) For treatment program, it means labor and operating supply costs which are incurred at patient service cost centers (PSs) of hospital: inpatient department (IPD), and outpatient department (OPD) resulted from the study of Tisayathikhom and Thonimirt (2000). In the year 2000, it was estimated at 131.69 Baht per OPD visit (ranging from 64.11 – 287.78 Baht per OPD visit), and was 794.41 Baht per IPD-patient day (ranging from 421.37 –1,087.18 Baht per IPD-patient day).

b) For the protective boot program, it means labor and operating supply cost which are incurred at OPD service of health centers resulted from the study of Tisayathikhom and Thonimirt (2000). In the year 2000, it was estimated at 38.33 Baht per OPD visit (ranging from 26.62 – 60.77 Baht per OPD visit)

6. "Medical care costs (MCC)"

a) For treatment program, it means the health care costs which are incurred at revenue producing cost centers (RPCCs) of Sa Kaeo Crown Prince Hospital: dept. of pharmaceutical, dept. of clinical pathology, dept. of radiological diagnosis. Their outputs' units of measurements are tablet, bottle, piece, ect for dept. of pharmaceutical, and test for dept. of clinical pathology, and radiological diagnosis. Charge fee for service of RPCCs is directly chargeable to patient. To having more precisely cost, this MCC will be estimated by adjusted charge costing method using 92.57% for laboratories, 97.13% for radiological diagnosis, (Suphanchaimart et al, 1997), and 115% for drugs and medical supplies (Yontrakul, 2000)

b) For preventive program, it means the average direct cost of protective boot with unit of measurement Baht per pair.

3.5 Study setting

A. Population

Refer to the 506-disease surveillance report, year 1999, which identified 6,080 leptospirosis cases. Of this 6,080 leptospirosis reported cases, they were composed of 5,102 rice farmers [83.91%], 372 labors [6.12%], 205 students [3.37%], and 401 others [6.60%] (Division of epidemiology, 2000).

Sa Kaeo Province was one province faced with leptospiroosis health problem in the year 2000. Purposively, the province was selected to be study area for cost and benefit analysis. The number of rice farmers of Sa Kaeo Province is defined as the number of the study population, because they are at highest risk growth.

Household survey data from Office of Sa Kaeo Provincial Agriculture (2000) revealed that in the year 2000, Sa Kaeo Province has 40,338 rice farmers' households; on average, each household has 4.53 household-dwellers; of these, 81.67% are rice farmers. Thus, there are 40,338 x 4.53 x (81.67/100) = 149,236 study population.

B. Interventions

Two alternative methods of dealing with farmers at risk of being infected with leptospirosis will be compared: (1) prevention using protective boots, and (2) doing nothing.

The protective boot program

The objective of the protective boot program is to encourage farmers to wear protective boots to prevent their feet from being damaged, especially with open wounds through which *Leptospira interrogans* may enter the body.

Various kinds of protective boots would be suitable for leptospirosis prevention. However, information about their effectiveness with farmers, such as how often the farmers wear the protective boots, the number of infected farmers there are even when they always wear protective boots, and the protective boots' working lifetime, is not evidently available, except for ninja neoprene boots. Thus, the effectiveness of the protective boots, as used in this study, is based on these neoprene boots.

Ninja neoprene boots have an average working lifetime of 1.55 months (S.D. = .8994). Farmer compliance was calculated at 92.2%, and it was estimated that 1.2% of the compliant farmers still become infected with the disease (Puthikannon, 2000).

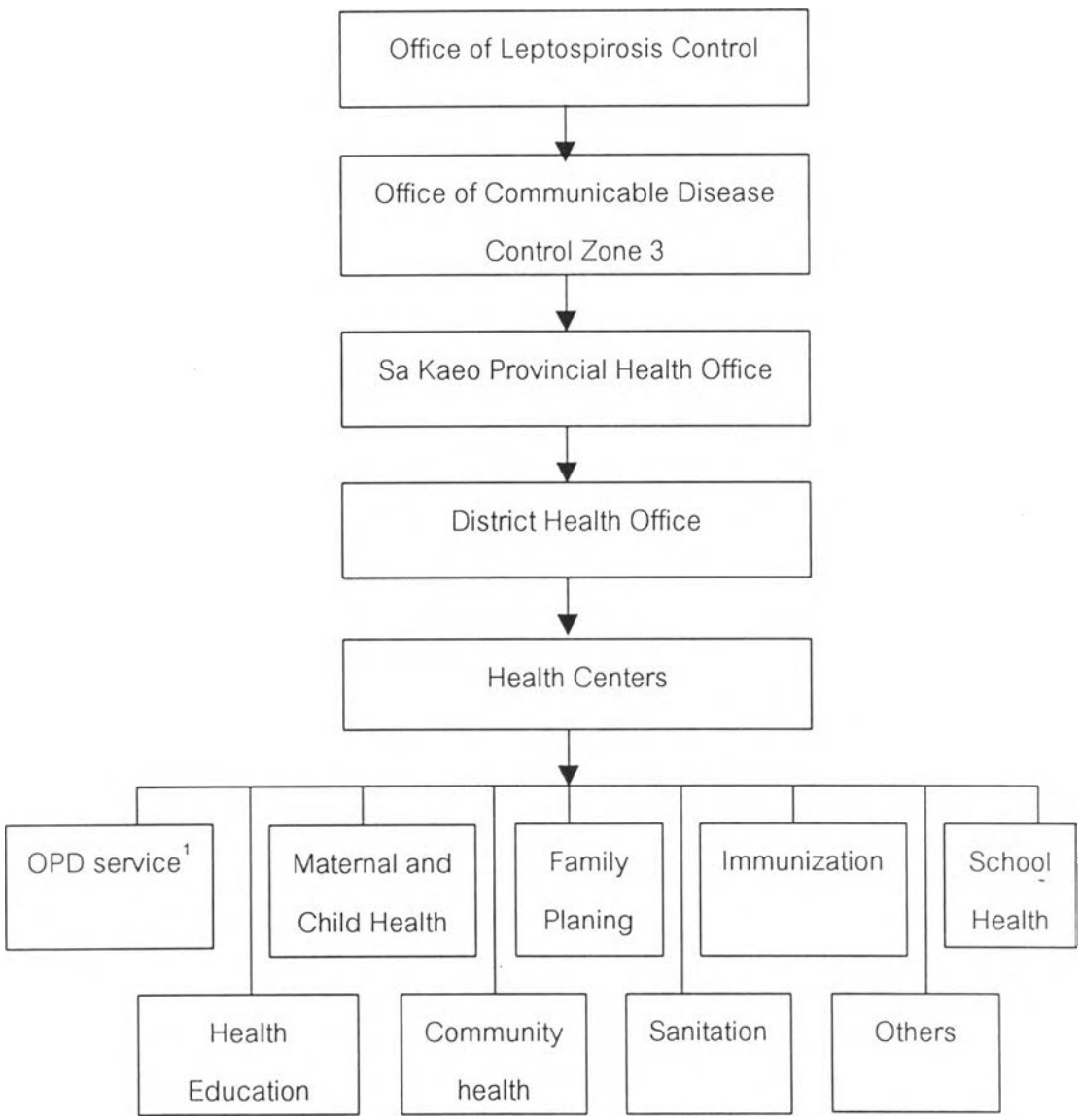
These neoprene boots require further efficiency improvement.

Figure 3-3 Farmers and their rice farming activities by which they are required to wear the protective boot to prevent their feet from any damages through which the organism are allowed to enter the body.

Figure 3-4 The ninja neoprene boot

The protective boots are given to all farmers with "free-of-charge", at health centers, the same service as the health centers' OPD service. Therefore, it is assumed that the routine service cost of the protective boot service and the OPD service of the health centers are identical, since both provided the same service at health centers. The protective boot program's organization is outlined in the diagram attached.

Figure 3-5 The protective boot program's organization.



Note: [1] For this study

1. Operating cost (labor & operating material cost): base on " Unit cost analysis of public health facilities in 6 provinces fiscal year 2000 under the social investment project (SIP)" Disyathikom and Thonimitri, 2000.
2. Medical care costs: base on financial report from Office of leptospirosis Control, 2000.

C. Time period

Time period is defined as rice-farming period during which every farmer is required to wear the protective boot against leptospiral infection while operating a farm. As used herein, rice-farming period rang from 140-150 days (Panichpatana, 2002).

D. Assumptions

Following are twelve assumptions, which are made in accordance with farmers' daily lifestyle, nature of disease and costs structure.

1. Each of the farmers has an equal risk of exposure as well as infection by which the farmers are required to wear the protective boot while they are working in a rice field.
2. Without the protective boot program, every farmer working in a rice field has never worn the protective boots. This assumption is supported by study of Silawan et al (1999). Please see table 2-7, page 41 for detail.
3. With the protective boot program, every farmer working in a rice field will always wears the protective boots. This assumption is supported by study of Puthikannon et al (2001). Please see table 2-10, page 46 for detail.
4. The outcome of disease in term of infection rate when with the protective boot program of Sa Kaeo Province is not different to that of Phrae Province, in the north of Thailand.
5. Odd ratio in associated with potential prevention of the protective boot of Sa Kaeo Province is not different to that of Nakhon Ratchasima Province, in the northeast of Thailand.
6. The outcome of disease in term of asymptomatic infection of Sa Kaeo Province is not different to that of Nakhon Ratchasima Province, in the northeast of Thailand.
7. The outcome of disease in term of infection rates, asymptomatic infection, mild infection, moderate infection, and severe infection when with the protective boot program and when without the protective boot program is not different to each other.
8. When with the protective boot program compared to when without the protective boot program, effects of other preventive and control intervention than the protective boot intervention are not difference to each other.

9. Routine service costs of Sa Kaeo Crown Prince Hospital and all health centers under authority of Sa Kaeo Provincial Health Office are not different to that of Phayao, Pathum Thani, Yala, Yasothon, Nakhon Sawan, and Samut Sakhon in the unit cost analysis of Tisayathikom and Thonimitr (2000).
10. Every protective boot has no side effects.
11. Every leptospirosis infection has no sequelae.
12. Cost to charge ratio of dept. of radiological diagnosis, and dept. of pathology of Sa Kaeo Crown Prince Hospital are not difference to that of Khon Kaen Hospital in the unit cost analysis of Suphanchaimart et al (1997).

3.6 Methodology and data for estimation

Hereinafter "h" represents leptospirosis patient group, where each "h" = 1,2,3 have the respective meaning below:

"1" denotes mild leptospirosis patient group,

"2" denotes moderate leptospirosis patient group, and

"3" denotes severe leptospirosis patient group.

A. Estimating the number of patient in associate with each infection conditions: with and without the protective boot program

1. Methodology

The number of leptospirosis patients revealed in the report system may possibly be under-reported because the disease's clinical manifestations lead to misdiagnosis by the physician. The finding by Ratanasang et al (1998) revealed that at least 6.89% of FUO (Fever of unknown origin) patients were possibly infected with leptospirosis. In addition, accurately establishing the number of infected persons who never wear protective boots is not evidently available while the other does. To estimate the number of patients associated with each infection condition, this study will; therefore, apply the concept of odds ratio. These numbers of patients are assumed to be the true number of leptospirosis patients.

The odds ratio (also called relative odds) is the ratio between the proportion of diseased persons with a history of not wearing protective boots and the proportion of diseased persons with a history of wearing protective boots in a case-control study. This type of epidemiological study is undertaken to identify the causes of disease and the potential for prevention when the disease being studied occurs infrequently (Gordis, 2000; Khuharat, 2001).

The odds ratio can be calculated using the following equation.

$$\text{Odds Ratio} = \frac{I_E+}{I_E-}$$

Where I_E+ = Percentage of leptospirosis infections when not wearing the protective boots while working in a rice field

I_E- = Percentage of leptospirosis infections when wearing the protective boots while working in a rice field

2. Data

a) Odds ratio, which was 7.1 is derived from the Tangkanahul et al (2000) study at Nakhon Ratchasima Province.

The Tangkanakul et al (200) study at Nakhon Ratchasrima Province was a case-control study to identify risk factors associated with leptospirosis infection in farmers. Fifty nine cases with serologically confirmation (diseased farmers) compared to randomly selected of one hundred and ten neighborhood controls (non-diseased farmers) on the basis of age (±5 years), and sex for each case were investigated for the factors. It was found that the cause of disease is that the farmers did not wear the protective boot while they were working in rice field with an incremental risk (OR) equals 7.1.

b) Infection rate when wearing the protective boot, which was 1.2%, is derived from the Phuthikhanon et al (2000) study at Phrae Province.

The Phuthikanon et al (2000) study at Phrae Province was an experimental study to identify effectiveness of the protective boot. A thousand of villagers volunteered to wear the protective boot while they were working in rice field during June–December 2000. At a completion, there were twelve out of a thousand villagers (1.2%) infected with leptospirosis.

Given the data, we have:

$$\text{Odds Ratio} = \frac{I_E+}{I_E-}$$

Where Odds Ratio = 7.1 (Tangkanakul et al, 2000)

I_E+ = An unknown percentage of leptospirosis infections when not wearing the protective boots while working in a rice field

I_E- = Percentage of leptospirosis infections when wearing the protective boots while working in a rice field, = 1.2% (Phuthikanon et al, 2000)

Solving the equation, we find $I_E+ = 7.1 \times 1.2\% = 8.5\%$

Table 3-1 Summary of costs variables, and their sources.

Cost variables	Unit of Measurement	Amount Per unit	Data sources
1. Infection rates when with, and without the protective boot program			
1.1 Potential for prevention of the protective boot (Odds ratio)		7.1	Secondarily, this data was derived from the study of Tangkanakul et al (2000), studied at Nakhon Ratchsima Province.
1.2 Infection rate when with the protective boot	%	1.2	Secondarily, this data was derived from the study of Phuthikanon et al (2000), studied at Phrae Province.
1.3 Prevalence of asymptomatic	%	8.4	Secondarily, this data was derived from the study of Tangkanakul et al (1998), studied at Nakhon Ratchsima Province.

Table 3-1 Continued

Cost variables	Unit of Measurement	Amount Per unit	Data sources
1.4 Percentage shares of mild, moderate, and severe case	%		Primarily, this data was derived from the annual epidemiological surveillance report, Sa Kaeo Provincial Health Office, year 2000.
A. Mild		9.22	
B. Moderate		87.94	
C. Severe		2.84	

Table 3-1 Continued

Cost variables	Unit of Measurement	Amount Per unit	Data sources
2. The protective boot program cost			
2.1 $RSC_{(b)}$	Baht per visit	38.33	Secondarily, this data was derived from the study of Tisayathikhom and Thonimit (2001) entitled "Unit cost analysis of public health facilities in 6 provinces, fiscal year 2000, under the social investment project (SIP)".
2.2 $MCC_{(b)}$	Baht per pair	132.24	Primarily, this data was drawn from a routinely financial report, Office of Leptospirosis Control, year 2000.
2.3 The protective boot working life time	Months	1.55	Secondarily, this data was derived from the study of Phuthikanon et al (2000), studied at Phrae Province.
2.4 Rice-farming period	Days (30 days for a month)	140-150	Secondarily, this data was derived from a technical document of Panichpatana (2002).

Table 3-1 Continued

Cost variables	Unit of measurement	Amount per unit	Data sources
3. Treatment cost			
3.1 $RSC_{(H)OPD}$	Baht per OPD visit	131.69	Secondarily, this data was derived from the study of Tisayathikhom and Thonimit (2000) entitled "Unit cost analysis of public health facilities in 6 provinces, fiscal year 2000, under the social investment project (SIP)".
3.2 $RSC_{(H)IPD}$	Baht per IPD patient-day	794.41	
3.3 $MCC_{(t)h}$	Baht per case		Primarily, this data was drawn from 30 purposively selected leptospirosis-infected patients hospitalized at Sa Kaeo Crown Prince Hospital, year 2000.
A. At 1st visit			
1. Mild		287.38 (n = 3)	
2. Moderate		3,722.38 (n = 25)	
3. Severe		1,356.74 (n = 2)	

Table 3-1 Continued

Cost variables	Unit of Measurement	Amount Per unit	Data sources
B. At 2nd visit			
1. Mild		259.90 (n=1)	
2. Moderate		402.67 (n=12)	
3. Severe		0.00	
3.4 $LOS_{(t)h}$	Patient-day per case		Primarily, this data was drawn from 30 purposively selected leptospirosis-infected patients hospitalized at Sa Kaeo Crown Prince Hospital, year 2000.
A. At 1st visit			
1. Mild		0.00	
2.Moderate		7.32 (n=25)	
3. Severe		2.00 (n=2)	
B. At 2nd visit: there is no IPD patient.			

Table 3-1 Continued

Cost variables	Unit of Measurement	Amount Per unit	Data sources
3.5 Second visit rate	%		Primarily, this data was drawn from 30 purposively selected leptospirosis-infected patients hospitalized at Sa Kaeo Crown Prince Hospital, year 2000.
1. Mild		33.00 (n=3)	
2.Moderate		48.00 (n=25)	

Note All costs are valued at year 2000.

B. Estimating the number of patient in associated with each patient groups and infection conditions

1. Methodology

a) The number of patient associated with each patient group when without the protective boot program, it is estimated as following equation.

$$n^0_h = N \times I_{E^+} \times P_s \times P_h$$

Where n^0_h = The number of patients in group h, when without the protective boot program

N = The number of farmers not wearing the protective boot while working in a rice field

I_{E^+} = Percentage of leptospirosis infection when not wearing the protective boots while working in a rice field

P_s = Percentage of symptomatic leptospirosis infection

P_h = Percentage of symptomatic leptospirosis infection of group h

h = Three groups of leptospirosis patient: 1 = mild case, 2 = moderate case, 3 = severe case

b) The number of patient associated with each patient group when with the protective boot program, it is estimated as following equation.

$$n_h = N \times I_{E^-} \times P_s \times P_h$$

Where n_h = The number of patients of group h, when with the protective boot program

N = The number of farmers wearing the protective boot while working in a rice field

I_{E^-} = Percentage of leptospirosis infection when wearing the protective boot while working in a rice field

P_s = Percentage of symptomatic leptospirosis infection

P_h = Percentage of symptomatic leptospirosis infection of group h

h = Three groups of leptospirosis patient: 1 = mild case, 2 = moderate case, 3 = severe case

2. Data

a) Percentage of symptomatic leptospirosis infection: P_S, It is estimated by taking 100% of leptospirosis infection: I_E^+, and I_E^- minuses the percentage of asymptomatic infection, which was derived from the Tangkanakul et al (1998) study and was estimated at 8.4%.

Tangkanakul et al (1998) study was a clinical study aiming to identify a prevalence of asymptomatic infection in high risk group. The study conducted at Nakhon Ratchasima Province. One hundred and forty-three villagers with disease-free during August 22nd – December 31st, 1998 and had contracted with leptospirosis according to their daily lifestyle were examine for serology. They were diagnosed as having leptospirosis asymptomatically if IgM leptospiral antibody were $\geq$ 10 PanBio units. Result, twelve of 143 cultured villagers (8.4%) have positive blood cultures.

Given the data, we; therefore, have a percentage of symptomatic infection = 100% – 8.4% = 91.6%.

b) Percentage of symptomatic infection in associated with each patient group: P_h; where h = 1 indicates mild leptospirosis patient group, 2 indicates moderate leptospirosis patient group, and 3 indicates severe leptospirosis patient group, the P_h is estimated by taking $P_S \times P_h$

The percentage of symptomatic infection in associated with each patient group were 9.22%, 87.94%, and 2.84% (n = 141) for mild, moderate, and severe case respectively. They are derived from annual epidemiological surveillance report, Sa Kaeo Provincial Health Office, 2000.

Given the data, we have:

a) The number of patient associated with each patient group when without the protective boot program.

$$n^0_h = N \times I_{E^+} \times P_s \times P_h$$

Where n^0_h = The number of patients in group h, when without the protective boot program

N = The number of farmers not wearing the protective boot while working in a rice field, = 149,236 rice farmers

I_{E^+} = Percentage of leptospirosis infection when not wearing the protective boots while working in a rice field, = 8.5%

P_s = Percentage of symptomatic leptospirosis infection, = 91.6 % of I_{E^+}

P_h = Percentage of symptomatic leptospirosis infection of group h; where h=1, P_1 = 9.22%; h=2, P_2 = 87.94%; h=3, P_3 = 2.84%,

h = Three groups of leptospirosis patient: 1 = mild case, 2 = moderate case, 3 = severe case

Solving the equation, we find

n^0_1 = 1,071 cases

n^0_2 = 10,219 cases

n^0_3 = 330 cases

Summation (n^0) = 11,620 cases

b) The number of patient associated with each patient group when with the protective boot program.

$$n_h = N \times I_{E^-} \times P_s \times P_h$$

Where n_h = The number of patients of group h, when with the protective boot program

N = The number of farmers wearing the protective boot while working in a rice field, = 149,236 rice farmers.

I_{E^-} = Percentage of leptospirosis infection when wearing the protective boot while working in a rice field, = 1.2% (Phuthikanon et al, 2000)

P_s = Percentage of symptomatic leptospirosis infection, = 91.6 % of I_{E^-}

P_h = Percentage of symptomatic leptospirosis infection of group h; where h=1, P_1 = 9.22%; h=2, P_2 = 87.94%; h=3, P_3 = 2.84%,

h = Three groups of leptospirosis patient: 1 = mild case, 2 = moderate case, 3 = severe case

Solving the equation, we find n_1 = 151 cases

n_2 = 1,442 cases

n_3 = 47 cases

Summation (n) = 1,640 cases

C. Estimating the total costs when with the protective boot program

When with the protective boot program, health provider incurs treatment costs treating a smaller number of leptospirosis patients (n) if compared to when without the protective boot program as well as the protective boot costs to prevent risk from infection to healthy individual (N). Total costs of the proposed leptospirosis program when with the protective boot program [$TC_{(b)}$] is; therefore, comprised of (a) total costs of the protective boot program itself [$TC_{(b)}(N)$] plus (b) total treatment costs of leptospirosis patients when with the protective boot program [$TC_{(t)}(n)$], and is estimated as a following equation.

$$TC_{(b)} = TC_{(b)}(N) + TC_{(t)}(n)$$

Where $TC_{(b)}$ = Total costs when with the protective boot program, unit of measurement: Baht

$TC_{(b)}(N)$ = Total costs of the protective boot program (a), unit of measurement: Baht

$TC_{(t)}(n)$ = Total treatment cost of leptospirosis patients when with the protective boot program (b), unit of measurement: Baht

(a) Estimating the total cost of the protective boot program.

1. Methodology

The total cost of the protective boot program, it is estimated as a following equation

$$TC_{(b)}(N) = N \times AQ_{(b)} \times AC_{(b)}$$

Where $TC_{(b)}(N)$ = Total cost of the protective boot program

N = Number of rice farmers of Sa Kaeo Province, = 149,236 rice farmers.

$AQ_{(b)}$ = Average number of the protective boots for each rice farmer, unit of measurement: pairs per person

$$AQ_{(b)} = \frac{\text{Rice farming period (=140-150 days)}}{\text{The protective boot's working life time (=1.55 months)}}$$

Therefore, $AQ_{(b)}$ = 3.01-3.22 pairs per person. As used herein, we employ 3 pairs per person.

$AC_{(b)}$ = Average costs for each pair of the protective boot to be distributed to rice farmers,
unit of measurement: Baht per pair

$$= RSC_{(b)} + MCC_{(b)}$$

Where $RSC_{(b)}$ = Routine service costs for each pair of the protective boot to be distributed to the farmers at health center.
It is estimated equal an OPD service being served by health center, and was 38.33 Baht each (Tisayatikom and Thonimirt, 2000)

$MCC_{(b)}$ = Direct cost the protective boot per pair, = 132.24 Baht per pair.

Therefore, $AC_{(b)}$ = 170.57 Baht per pairs.

2. Data

a) The protective boot working life time, which was 1.55 months is derived from the Phuthikhanon et al (2000) study the same study as the estimation of infection rate when with the protective boot program,

b) Routine service cost per OPD visit, at health centers, which was 38.33 Baht per OPD visit is derived from the Tisayatikom and Thonimirt (2000) study.

Tisayathikom and Thonimirt (2000) study is the unit cost analysis of the Ministry of Public Health, Office of Health Insurance. The study was conducted to investigate recurrent costs associated with each unit of health service provided at health centers, to achieve the most efficient use of scarce resource using absorption costing method and counting health centers' output in term of OPD visit. To do so, 160 health centers from Phayao, Pathun Thani, Yala, Yasothon, Nakhon Sawan, and Samut Sakhon were purposively selected. Cost data were collected during year 2000. A direct allocating method was used to allocate common cost. Total direct cost of absorbing cost centers was used as allocating basis.

c) The direct protective boot cost: $MCC_{(b)}$, which was 132.24 Bath per pair is derived from a retrospectively reviewed the financial report of Office of Leptospirosis Control, year 2000. It is estimated as follow.

$$MCC_{(b)} = \frac{\sum_{I=1}^{P} Pr_I Q_I}{\sum_{I=1}^{P} Q_I}$$

Where $MCC_{(b)}$ = Average direct cost for each pair of the protective boot to be availed at the health centers (Transportation is included)

Pr_IQ_I = Cost of each procurements
In total, it was 56,935,940.00 Bath in the year 2000

Q_I = Number of the protective boot in each procurement
In total, it was 430,531 boots in the year 2000

P = Number of the protective boot's procurements
in the year 2000

Therefore, $MCC_{(b)}$= 132.24 Baht per pair.

Given the data, we have $TC_{(b)}(N)$ = 76,365,553.56 Baht.

(b) Estimating the total treatment cost when with the protective boot program

1. Methodology

a) The total treatment cost when with the protective boot program is estimated as a following equation.

$$TC_{(t)}(n) = \sum_{h=1}^{3} AC_{(t)h} n_h$$

Where $TC_{(t)}(n)$ = Total treatment cost when with the protective boot program

$AC_{(t)h}$ = Average treatment costs for each of leptospirosis patients in group h,
unit of measurement: Baht per case

n_h = The number of leptospirosis patients of group h, when with the protective boot program.
where h=1, n=151; h=2, n=1,442; h=3,n=47 cases

h = Three groups of leptospirosis patient: 1 = mild cases, 2 = moderate cases, 3 = severe cases

b) The average treatment costs for each of leptospirosis patients in group h:

$AC_{(t)h}$, it is estimated as a following equation

$$AC_{(t)h} = RSC_{(t)h} + MCC_{(t)h}$$

Where $AC_{(t)h}$ = Average treatment costs for each of leptospirosis patients in group h, unit of measurement : Baht per case

$RSC_{(t)h}$ = Average routine service costs at provincial hospital for each of leptospirosis patients in group h, unit of measurement : Baht per case

$$= [RSC_{(H)OPD} \times V_{(t)h}] + [RSC_{(H)IPD} \times LOS_{(t)h}]$$

Where $RSC_{(H)OPD}$ = Routine service costs at provincial hospital per OPD visit. It equals 131.69 Baht per OPD visit (Tisayatikom and Thonimirt, 2000)

$V_{(t)h}$ = Number of OPD visits for each of leptospirosis patients in group h

As used herein,

at 1st visit, where $h = 1, V_{(t)} =$ 1 visit per case

$h = 2\ V_{(t)} =$ 1 visit per case

$h = 3, V_{(t)} =$ 1 visit per case

at 2nd visit, where $h = 1, V_{(t)} =$ 1 visit per case

$h = 2, V_{(t)} =$ 1 visit per case

$h = 3, V_{(t)} =$ 0 visit per case

$RSC_{(H)IPD}$ = Routine service costs at provincial hospital per IPD patient-day. It equals 794.41 Baht per day (Tisayatikom and Thonimirt, 2000).

$LOS_{(t)h}$ = Length of stay for each of leptospirosis patients in group h, unit of measurement: days for each case.

These data were drawn from 30 purposively selected leptospirosis patients hospitalized at Sa Kaeo Crown Prince Hospital in the year 2000. These were:

at 1st visit, where $h = 1, LOS_{(t)} = 0.00$ day per case (n=3)

$h = 2, LOS_{(t)} = 7.32$ days per case (n=25)

$h = 3, LOS_{(t)} = 2.00$ days per case (n=2)

at 2nd visit, there is no IPD patient.

(Please see appendix B for details)

$MCC_{(t)h}$ = Medical care cost for treatment for each leptospirosis patients in group h, unit of measurement: Baht for each case

These data were drawn from 30 purposively selected leptospirosis patients hospitalized at Sa Kaeo Crown Prince Hospital in the year 2000. These were:

at 1st visit, where $h = 1, MCC_{(t)} =$ 287.38 Baht per case (n=3)

$h = 2, MCC_{(t)} =$ 3,722.38 Baht per case (n=25)

$h = 3, MCC_{(t)} =$ 1,356.74 Baht per case (n=2)

at 2nd visit $h = 1, MCC_{(t)} =$ 259.90 Baht per case(n=1)

$h = 2, MCC_{(t)} =$ 402.67 Baht per case (n=12)

$h = 3, MCC_{(t)} =$ 0.00 Baht per case(n=0)

(Please see appendix B for details)

Therefore; at 1st visit, where $h = 1, AC_{(t)} =$ 419.07 Baht per case

$h = 2, AC_{(t)} =$ 9,669.15 Baht per case

$h = 3, AC_{(t)} =$ 3,077.24 Baht per case

at 2nd visit, where $h = 1, AC_{(t)} = 391.59$ Baht per case

$h = 2, AC_{(t)} = 534.36$ Baht per case

$h = 3, AC_{(t)} = 0.00$ Baht per case

2nd visit rate, where $h = 1$, 2nd visit rate = 33.00% (n =3)

$h = 2$, 2nd visit rate = 48.00% (n =25)

Given the data, we have $TC_{(t)}(n)$ = 14,540,181.24 Baht, and $TC_{(b)}$ = 90,905,734.80 Baht,

2. Data

a) Routine service costs; which were 131.69 Baht per OPD visit, and 794.41 Baht per IPD patient-day are derived from unit cost analysis of Tisayathikom and Thonimirt (2000) study the same study as the estimation of cost for the protective boot program.

The Tisayathikom and Thonimirt (2000) study is the unit cost analysis of the Ministry of Public Health, Office of Health Insurance. The study was conducted to investigate recurrent cost associated with each unit of health service provided at provincial hospital, to achieve the most efficient use of scarce resource using absorption costing method and counting the hospitals' output in term of OPD visit, and IPD patient day. To do so, 6 provincial hospitals at Phayao, Pathun Thani, Yala, Yasothon, Nakhon Sawan, and Samut Sakhon were purposively selected to be the study hospital. Cost data were collected during year 2000. Non-revenue producing cost centers: NRPCCs included administration, maintenance, laundry, public relations, medical records and statistic, nurse administration, central supply, and dietetics. Patient service cost centers: PSs included inpatient department and outpatient department. A simultaneous equation allocating method was used to allocate common cost. Following were allocating basis.

Cost centers	Allocating basis
Administration	Number of the PSs cost centers' personnel
Maintenance	Number of maintenance service
Laundry	Kg of laundry
Public relations	Number of OPD patients, IPD patients, year 2000
Medical records and statistics	Number of OPD patients, IPD patients, year 2000
Nurse administration	Number of the PSs cost centers' personnel
Central supply	Quantities of device disbursement
Dietetic	Number of patient-days

b) Medical care costs: $MCC_{(t)h}$, they are estimated though a retrospectively reviewed 30 patients' medical charts of Sa Kaeo Crown Prince Hospital. Costing is adjusted charge using 92.57% for laboratories, 97.13% for radiological diagnosis (Suphanchaimart et al, 1997), 115% for drugs and medical supplies (Yontrakul, 2000). The number of 30 of sample size is determined by following formula.

$$n = \frac{z^2 \times p \times q}{d^2}$$ (Kaewsonthi and Harding, 1992)

Where n = the desired sample size

z = the degree of confidence: at 95% of confidence interval, z = 1.96

p = the proportion of leptospirosis patient in the population, = 8.5 %

q = 1.0 – p = 91.5%

d = the degree of accuracy, 10%

An average medical care costs for treatment for each of leptospirosis patients and groups is expressed as a following equation.

$$MCC_{(t)h} = \frac{\sum_{i=1}^{r_h} C_L Q_{Lhi}}{r_h}$$

Where $MCC_{(t)h}$ = Average medical care costs for each of leptospirosis patients in group h, Baht per case

C_L = Cost of treatment L, per unit, Baht per unit

Q_{Lhi} = Number of treatment L, patient group h, patient I

h = Three groups of leptospirosis patient: 1 = mild case, 2 = moderate case, 3 = severe case

r_h = Number of leptospirosis samples, group h: h=1, r=3; h=2, r=25; h=3, r=2

results, at 1st visit, where

h = 1, $MCC_{(t)}$	=	287.38	Baht per case (n = 3)
h = 2, $MCC_{(t)}$	=	3,722.38	Baht per case (n = 25)
h = 3, $MCC_{(t)}$	=	1,356.74	Baht per case (n = 2)

at 2nd visit, where

h = 1, $MCC_{(t)}$	=	259.90	Baht per case (n = 1)
h = 2, $MCC_{(t)}$	=	402.67	Baht per case (n = 12)
h = 3, $MCC_{(t)}$	=	0.00	Baht per case (n = 0)

(Please see appendix B for details)

c) Length of stay for each of leptospirosis patient groups ($LOS_{(t)h}$) is derived though a retrospectively reviewed 30 patients' medical charts of Sa Kaeo Crown Prince Hospital in the same method as the estimation of $MCC_{(t)}$ and is estimated as a following equation.

$$LOS_{(t)h} = \frac{\sum_{i=1}^{r_h} LOS_{(t)hi}}{r_h}$$

Where $LOS_{(t)h}$ = Length of stay of leptospirosis patient group h, days per case

$LOS_{(t)hi}$ = Length of stay of leptospirosis patient group h, patient i, days

h = Three groups of leptospirosis patient: 1 = mild case, 2 = moderate case, 3 = severe case

r_h = Number of leptospirosis samples, group h: h = 1, r = 3; h = 2, r = 25; h = 3, r = 2

results, at 1st visit, where

h = 1, $LOS_{(t)}$	=	0.00	day per case (n = 3)
h = 2, $LOS_{(t)}$	=	7.32	days per case (n = 25)
h = 3, $LOS_{(t)}$	=	2.00	days per case (n = 2)

at 2nd visit, there is no IPD patient.

(Please see appendix B for details)

D. Estimating the total costs when without the protective boot program

1. Methodology

a) Total treatment when without the protective boot program: $TC_{(t)}(n^0)$. When without the protective boot program, health provider incurs only treatment costs treating a greater number of patient (n^0) if compared to when with the protective boot program. $TC_{(t)}(n^0)$ is estimated as a following equation.

$$TC_{(t)}(n^0) = \sum_{h=1}^{3} AC_{(t)h} n^0_h$$

Where $TC_{(t)}(n^0)$ = Total treatment costs of leptospirosis patient when without the protective boot program. Unit of measurement: Baht

$AC_{(t)h}$ = Average treatment costs for each of leptospirosis patients in group h. Unit of measurement: Baht per case

n^0_h = The number of leptospirosis patients in group h, when without the protective boot program,
unit of measurement: case.
where h=1, n^0=1,071; h=2, n^0=10,219; h=3, n^0=330 cases.

h = Three groups of leptospirosis patient: 1 = mild cases, 2 = moderate cases, 3 = severe cases.

b) The average treatment costs for each of leptospirosis patients in group h: $AC_{(t)h}$, both without the protective boot program, and with the protective boot program its methodology and data for estimation are the same (Please see pages 54-59 for details). The results were:

at 1st visit, where	h = 1, $AC_{(t)}$	=	419.07	Baht per case
	h = 2, $AC_{(t)}$	=	9,669.15	Baht per case
	h = 3, $AC_{(t)}$	=	3,077.24	Baht per case
at 2nd visit, where	h = 1, $AC_{(t)}$	=	391.59	Baht per case
	h = 2, $AC_{(t)}$	=	534.36	Baht per case
	h = 3, $AC_{(t)}$	=	0.00	Baht per case

2^{nd} visit rate, where $h = 1, 2^{nd}$ visit rate = 33.00% (n = 3)

$h = 1, 2^{nd}$ visit rate = 48.00% (n = 25)

Given the data, we have $TC_{(t)}(n^{0})$ = 103,032,627.39 Baht.

3.7 Sensitivity analysis

A. Unconditional service and the negligible cost burden for the farmers may cause the farmers take the provision of free protective boots for granted. These results in increased demand for the protective boots and increased costs for the program. If this is so, what would eventuate?

As used herein, we assume that the number of the protective boot per farmer increase from 3 pairs per person to 4 pairs per person. If this is so, how does the cost and benefit change?

B. In the year 2000, the protective boot market was monopolized, which possibly made price-fixing. In the future, the market would grow and there would be free competition, and as a result the price decreased. If this is so, what would eventuate?

As used herein, we assume that the price is deceased 50% from 170.57 Baht per pair. If this is so, how does the cost and benefit change?