CHAPTER 2
LITERATURE REVIEW

2.1 The per unit costing method for CBA

There are three methods used to obtain the per unit costs incurred by the provider: (1) extrapolation from comparable services, (2) adjusted charges, and (3) activity-based costing. Extrapolation from comparable services is used when charges are not available and activity-based costing is too time-consuming. Adjusted charges are estimated by multiplying the billed charges by the cost-to-charge ratio. The cost: the costs per unit are estimates by absorption costing method. It is somewhat ambiguous and subject to interpretation, since they depend on numerous assumptions regarding overhead allocation, counting and averaging of quantities. Activity-based costing, the principle is that the values of the resources are estimated from direct observation and using prevailing wages, and then other common costs such as administration, utilities, and are applied as overheads. Costs per unit are more precise. For CBA, activity-based costing and adjusted charges are often combined with each other.

According to absorption costing method, there are five steps for estimating the costs per unit: (A) cost classification, (B) cost center identification and grouping, (C) determining total direct cost, (D) determining total cost, and (E) determining the per unit cost.

A. Cost classification

To estimate a health care program's costs, it is necessary to classify its components. Cost components can be broken down in several ways, depending upon the needs of the particular problem. Primary cost classification, classified by inputs, is comprised of capital and recurrent costs. Capital costs are the costs that last longer than 1 year, such as buildings, vehicles and equipment, where, to estimate the costs incurred in a year, original values will be depreciated annually throughout their lifetimes. Recurrent costs are the costs that are expended in the course of a year and are usually purchased regularly, such as personnel costs and medical supply costs. The secondary classification, classified by functions or activities, are direct and indirect costs.

B. Cost center identification and grouping

This is an aspect of a group arrangement of health service activities relating to financial data, to which direct and/or indirect costs will be assigned by distinguishing

various departments within an organization into two groups in accordance with revenue producing structure. These are (1) non-revenue-producing cost centers (NRPCCs), (2) revenue-producing cost centers (RPCCs) and (3) patient service cost centers (PSs).

1. Non-revenue producing cost centers

These are departments performing supportive duties, supporting the operational performance of patient-centered departments: RPCCs and PSs. Examples include department of administration, financial and accounting departments, department of operating supply, nutrition, and registration.

2. Revenue-producing cost centers

These are departments providing special services complementing patient treatment. Examples include departments of pharmacy, department of rehabilitative medicine, and department of radiology, operation. The charge fees for services provided by these cost centers are directly paid by the patient.

3. Patient service cost centers

These are departments directly responsible for the examination and treatment of patients. They are divided into out-patient services and in-patient services. For public hospital, the charge fees for services provided by these cost centers are not paid by the patient.

C. Determining total direct cost

The total direct cost (TDC) of each cost center is equal to the summation of labor costs, material costs and capital costs incurred directly by the services of those cost centers.

1. Labor cost (LC)

These are returns obtained by a performer in the form of a money value. For public health in Thailand, the LC usually includes salaries, wages, overtime, welfare such as medical treatment, children's school fees.

2. Material cost (MC)

These are the cost of material that is being used wastefully, over a period of time. These are represented by maintenance costs and various supply costs.

3. Capital cost (CC)

This is depreciation cost, according to a period of time, for assets that have an expected useful life of more than one year. Depreciation cost will usually be calculated annually.

There are several methods for the calculation of depreciation. However, the annual averaged method throughout the expected useful life of such an asset is the one most used. The method of calculation is as follows:

a) Calculation of annual economic depreciation cost

$$\text{Annual economic cost} = \frac{\text{Current value}}{\text{Annualization factor}}$$

b) Calculation of annual accounting depreciation cost

$$\text{Annual accounting cost} = \frac{\text{Current value}}{\text{Expected useful life}}$$

With either the economic method or the accounting method, the current value is calculated as follows:

$$C_{tn} = C_{t0} \times (1+r)^n$$

Where C_{tn} = Current value at year n

C_{t0} = Original value at year 0

r = Discount rate

n = $t_n - t_0$

The total direct cost (TDC) of each cost center is expressed by the following formula.

$$TDC = CC + LC + MC$$

D. Determining total cost

This means a process of the costs of absorbing cost centers: final cost centers where an average unit cost are measured, incorporating the costs allocated from transient cost centers: other cost centers that interrelated with each other. Average unit costs are not measured at these cost centers. This is done by one of four methods for cost allocation in compliance with cost allocation criteria, which are established from the relationships between each other. The four methods include (1) direct, (2) step-down, (3) double distribution, and (4) simultaneous equation methods.

1. Direct method

This is a direct allocation of costs from those of transient cost centers to all of the absorbing cost centers, regardless of the relationships between the transient cost centers. The advantages are that is easier and more appropriate for simple organization. A disadvantage is the inability to utilize the data obtained to estimate the efficiency of production, because it disregards the relationship between cost centers.

2. Step-down method

This method is an allocation of costs with an arrangement of orders of transient cost centers. Any transient cost centers that have larger costs will be allocated to other absorbing cost centers, according to their relationship. Upon completion of cost allocation, they will be abolished and will not be allocated from any other centers.

This method is more appropriate than direct method because it can specify the relationship of resource utilization.

3. Double distribution method

This method is an allocation and receipt of costs simultaneously, through several repeated allocations, until the costs of the transient cost center will be continuously decreased and collected at the absorbing cost center. Numerous repeated allocations will be made until the allocation amount using the step-down method will diminish times.

This method is advantageous because an actual relationship is acknowledged and effects the yield of an accurate indirect cost. However, one disadvantage is that the calculation is very sophisticated.

4. Simultaneous equation method

This method utilizes a linear equation to solve cost allocation and absorption simultaneously, by the assumption of a value which is the total value of costs allocated through transient cost centers continuously, until it reaches an equilibrium point. This is the point where there are no remaining costs at the transient cost center. Then, this value is used to calculate the cost that is received by absorbing cost centers, once again.

With this method the calculation is done by computer program. The result is the most accurate, but one disadvantage is that it cannot show how the costs of one cost center are allocated to other cost centers.

a) Routine service cost (RSC)

RSC is the health care costs that are incurred at patient service cost centers (PSs). RSCs are incurred even when no services are being provided, no patients are served or treated, are independent of disease conditions. As for public hospital, charge fee for service provided by PSs are not paid by the patients. The total direct costs (TDC) of the PSs, combined with indirect costs (IDC) allocated from NRPCCs comprise the total RSC.

The total RSC is expressed by the following formula.

Total RCS = TDC of PSs + IDC from NRPCCs

b) Medical care cost (MCC)

MCC is the health care costs that are incurred at revenue-producing cost centers (RPCCs). MCC is incurred when patients are diagnosed as having a specific decease, and depends upon the disease condition and the attending physician. Charge fee for services provided by RPCCs are directly chargeable to the patient. The total direct cost (TDC) of the RPCCs, combined with the indirect cost (IDC) allocated from NRPCCs comprises the total MCC.

The total MCC is expressed by the following formula.

$$\text{Total MCC} = \text{TDC of RPCCs} + \text{IDC from NRPCCs}$$

E. Determining the unit cost

1. Routine service cost (RSC)

The average RSC per OPD visit equals the total $RSC_{(OPD)}$ divided by the total number of OPD visits, and for the per IPD patient-day equals the total $RSC_{(IPD)}$ divided by the total number of IPD patient-days. These are expressed in the following formula:

$$\text{a) Average RSC per OPD visit} = \frac{\text{Total } RSC_{OPD}}{\text{Total No. of OPD visits}}$$

Unit of measurement: Baht per visit

$$\text{b) Average RSC per IPD patient-day} = \frac{\text{Total } RSC_{IPD}}{\text{Total No. of IPD patient-days}}$$

Unit of measurement: Baht per day

2. Medical care cost (MCC)

A. If the RPCCs' output are counted in term of DPD visits, and IPD patient days, the average MCC per OPD visit equals the total MCC divided by the total number of OPD visits, and the average MCC per IPD patient-day equals the total MCC divided by the total number of IPD patient-days. These are expressed in the following formula:

$$\text{a) Average MCC per OPD visit} = \frac{\text{Total MCC}}{\text{Total No. of OPD visits}}$$

Unit of measurement: Baht per visit

$$\text{b) Average MCC per IPD patient-day} = \frac{\text{Total MCC}}{\text{Total No. of IPD patient-days}}$$

Unit of measurement: Baht per day

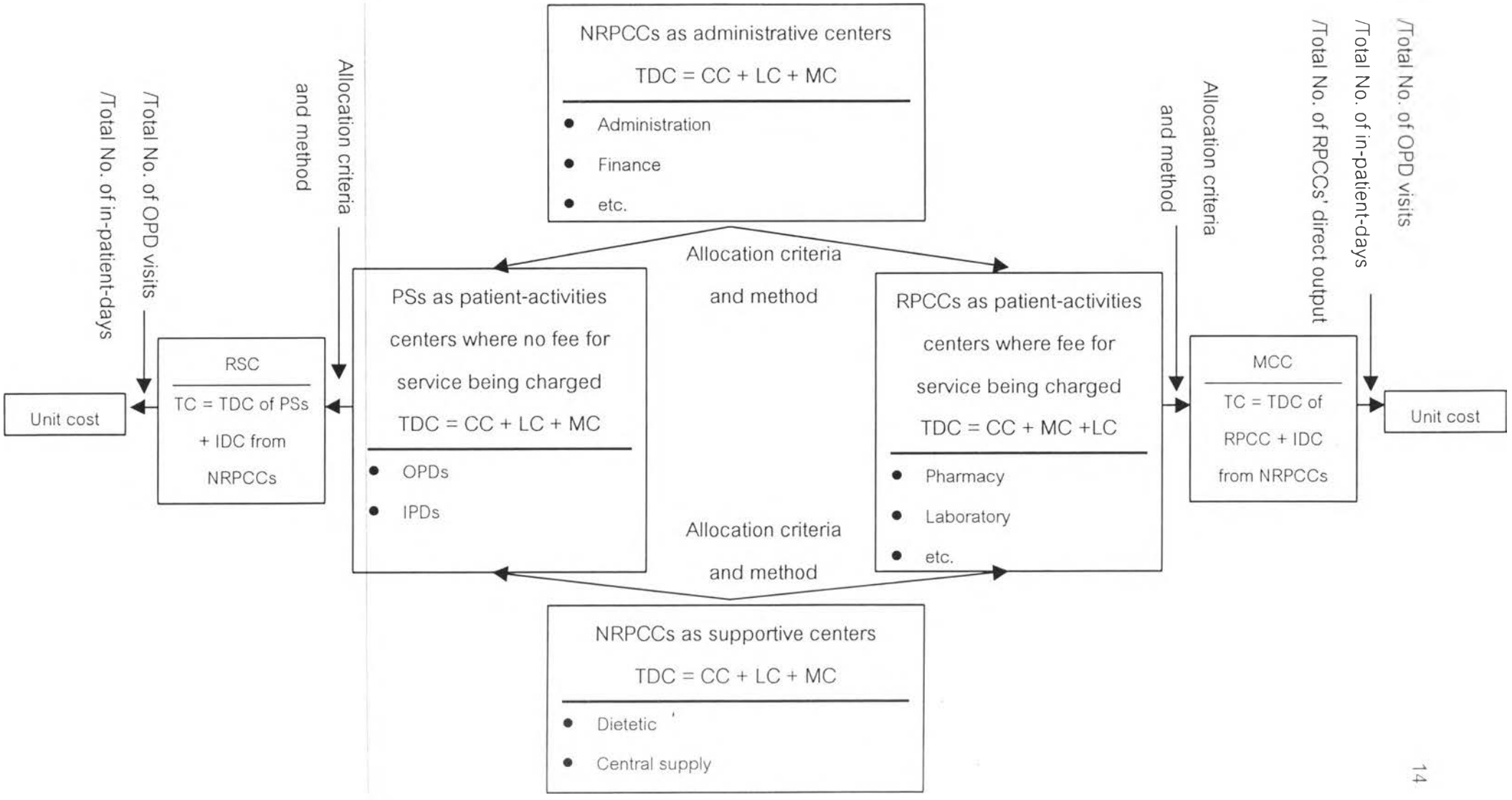
B. If the RPCCs' outputs are counted by the RPCCs' direct output. Example, at department of laboratory, the department's direct output is counted in term of laboratory test. The average MCC per laboratory test equals the total cost of the department: MCC_l divided by the total number of laboratory test. These are expressed in the following formula:

$$\text{a) Average } MCC_l \text{ per laboratory test} = \frac{\text{Total } MCC_l}{\text{Total No. of laboratory test}}$$

Unit of measurement: Baht per test

The estimation for RSC and MCC average unit cost is described in figure 2-1, attached.

Figure 2-1 Relationship between costs centers, and per unit cost estimation for routine service cost, and medical care cost.



Note:

CC	=	Capital cost
IDC	=	Indirect cost
IPDs	=	Inpatient departments
LC	=	Labor cost
MC	=	Material cost
MCC	=	Medical care cost
NRPCCs	=	Non-revenue producing cost centers
OPDs	=	Outpatient departments
PSs	=	Patient service cost centers
RPCCs	=	Revenue producing cost centers
RSC	=	Routine service cost
TDC	=	Total direct cost

2.2 Review of related literature

In conducting CBA, various value or form of relationship of the variables needed to calculate the effectiveness of regimens, and course of disease based on clinical trial, observational studies, or other aspects of studies are possibly have in literature, also, the costs: cost of the regimens, and treatment.

However, for leptospirosis prevention using a protective boot, up until now, there are no studies that identify an effectiveness of a protective boot directly, also, cost of the protective boot and treatment for leptospirosis infection. In this section, therefore, similar or applicable forms of cost analysis and effectiveness of a protective boot are reviewed as followings.

Tisayathikom and Thonimirt (2000) conducted an average unit cost analysis of health service provided at various levels: provincial, district, and sub-district. Its objective was to investigate the recurrent costs associated with each unit of health service provided, to achieve the most efficient use of scarce resources using absorption costing method, and counting organization output in term of out-patient visits, and in-patient days. For this study, the following health posts were purposively selected: 6 general/central hospitals: health post at provincial level, 13 community hospitals: health post at district level, and 160 health centers: health post at sub-district level. These health posts were located in 6 provinces:

Phayao, Pathum Thani, Yala, Yasothon, Nakhon Sawan, and Samut Sakhon. Cost data were collected during the year 2000. Recurrent costs were comprised of labor costs and material costs. Labor costs were comprised of monthly salary, monthly incentives for administrative positions, evening and night-shift payments, overtime, incentives for not practicing in a private hospital, and other civil servant benefits including child school fees, rent for use of house, child benefit allowances, medical fees for oneself and one's relatives. Material costs were comprised of utility, maintenance, fuel, housekeeping supplies, office supplies, medical supplies, laboratory supplies.

A. Hospitals

1. Cost centers:

a) Transient cost centers: non-revenue producing cost centers (NRPCCs) were comprised of following department: administration, maintenance, laundry, public relations, medical records and statistics, nurse administration, central supply, and dietetics.

b) Absorbing cost centers:

1) Revenue producing cost centers (RPCCs) were comprised of following department: laboratory, radiology, pharmacy, rehabilitative medicine labor room, operating room, and anesthesiology.

2) Patient service cost centers (PSs), were comprised of in-patient department (IPD) and out-patient department (OPD). IPD comprised of all wards. The IPD output was counted in term of in-patient days. OPD comprised of general out-patient, emergency, dental clinic, and hemodialysis unit. The OPD output was counted in term of OPD visits.

2. Determining total cost: a simultaneous equation allocating method was used to allocate common costs from NRPCCs to PSs, and RPCCs with following criteria.

Cost centers	Allocating basis
Administration	Number of PS cost center personnel
Maintenance	Number of maintenance services performed
Laundry	Kg of laundry

Cost centers	Allocating basis
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 PS cost center personnel
Central supply	Quantity of supplies disbursed
Dietetics	Number of patient-days

3. Results, at the central/general level, the per-outpatient RSC for general outpatient services ($RSC_{(H)OPD}$) was 131.69 Baht per visit (ranging from 64.11 – 287.79 Baht). The per-inpatient RSC for inpatient services ($RSC_{(H)IPD}$) was 794.41 Baht per day (ranging from 421.37 – 1,087.18 Baht). The per-outpatient MCC for general outpatient services ($MCC_{(H)OPD}$) was 94.76 Baht per visit (ranging from 35.64 – 143.35 Baht). The per-inpatient MCC for inpatient services ($MCC_{(H)IPD}$) was 549.47 Baht per day (ranging from 299.86 – 942.81 Baht).

B. Health centers

1. Cost centers:

a) Transients cost centers were comprised of administration, records and statistics.

b) Absorbing cost centers were comprised of OPD, maternal and child health, family planning and immunization services. Their outputs were counted in term of visit.

2. Determining total cost: a direct allocating method was used to allocate common costs from transients cost centers to absorbing cost centers based on the total direct cost of absorbing cost centers.

3. Result: the per OPD RSC service ($RSC_{(HC)CPD}$) was 38.33 Baht per visit (ranging from 26.62 – 60.77 Baht).

Estimating the cost and benefit in this study, the per unit cost incurred at health center is needed to estimate the per unit cost of the protective boot. The per unit cost incurred at central/general hospital is needed to estimate the per unit cost of treatment.

The Tisayathikom and Thonimirt (2000) study valued the cost at the same year as cost and benefit in this analysis is valued, also provided all the cost data needed: the per OPD RSC service at health center ($RSC_{(HC)OPD}$), the per OPD RSC for general outpatient services, and the per IPD RSC for inpatient services at central/general hospital ($RSC_{(H)OPD}$, $RSC_{(H)IPD}$). The per MCC, the output were measured by OPD visits/IPD patient-days as same

as RSC. OPD visits/IPD patient-days are not direct output of RPCCs, therefore the per unit is somewhat ambiguous. This cost benefit analysis is, therefore, employed only the per RSC from this study.

Tangkanakul et al (2000) conducted a retrospective matched case control study to investigate potential risk factors for leptospirosis infection in Nakhon Ratchasima during August 22nd – December 31st, 1998. Fifty-nine individuals with fever, headache, and myalgia including serologically confirmed using IgM ELISA (IgM +ve) comprised the cases. One hundred and ten neighborhood controls with any history of illness within 30 days before the interview were selected on the basis of age ($\pm$ 5 years), sex for each case. A standardized questionnaire was used to collect information on activities associated with water and animals (i.e. fishing, rice farming), environmental conditions of working field. The investigators also surveyed an environment of the cases and controls' house and work place. Epi info software was used to analyze univariate descriptive statistics and matched odds ratio. SAS software system was used to analyze multivariable, stepwise conditional logistic regression to determine independent risk factors.

An independently positive association between leptospirosis infection and factors contain four activities that they had done within two weeks prior to illness. These are walking through water, plowing in wet field more than 6 hours, fertilizing in wet field more than 6 hours, and pulling out rice sprout in wet field more than 6 hours.

Table 2-1 Univariate analysis of potential risk factors among case-control study participants.

Risk factors	Patients (n = 59) NO. (%)	Controls (n = 110) NO. (%)	OR (95% CI)
Rice activities without boots	24 (41)	26 (24)	7.1 (0.9, 56.8)
Plowing in wet field > 6 hours/day	17 (29)	9 (9)	6.3 (2.1, 19.2)*
Transplanting in wet field > 6 hours/day	22 (37)	16 (15)	3.5 (1.6, 7.9)*
Fertilizing in wet field > 6 Hours/day	33 (56)	26 (24)	4.4 (2.0, 9.5)*

Table 2-1 Continued.

Risk factors	Patients (n = 59) NO. (%)	Controls (n = 110) NO. (%)	OR (95% CI)
Pulling out sprouts in wet field > 6 hours/day	18 (31)	11 (10)	4.4 (1.7, 1.3)*
Walking through stagnant water	42 (71)	46 (42)	6.2 (2.3, 16.5)*
Cut wcund on feet and exposure through water and mud	14 (24)	10 (9)	2.6 (1.1, 6.2)*
Fish net casting without boot in static water	10 (17)	10 (9)	1.9 (0.6, 6.1)
Sowing rice seeds in wet field > 6 hours/day	7 (12)	12 (11)	1.4 (0.4, 2.9)
Keeping pet dog	18 (31)	52 (47)	0.4 (0.2, 0.9)
Fishing activities without boots	31 (53)	35 (32)	∞ (0.2, ∞)

Note: 1. * Significant.

2. OR = Odds ratio, CI = Confidence interval.

Source: Tangkanakul et al, Risk factors associated with leptospirosis in Northeastern Thailand, 1998. The American Journal of Tropical Medicine and Hygiene, Vol 63 (3, 4), 2000, (USA: The American Society of Tropical Medicine and Hygiene, 2000), 205.

Table 2-2 Multivariate analysis of potential risk factors among patient-control study participants.

Risk factors	Patients (n = 59)	Controls (n = 110)	OR (95%CI)	Water level[1]	Wound[1]
Plowing in wet field > 6 hours/day	17	9	3.5 (1.1, 11.6)	½ of shin	More
Fertilizing in wet field > 6 Hours/day	33	26	2.7 (1.1, 6.6)	½ of shin	Less
Pulling out sprouts in wet field > 6 hours/day	18	11	4.4 (1.7, 11.3)	¼ of shin	More
Walking through stagnant Water	42	46	4.8 (1.7, 13.7)	NA	NA

Note: 1. [1] Information was provided by Tangkanakul, Department of Communicable Disease Control, 2000.

2. OR = Odds ratio, CI = Confidence interval, NA = Data is not available.

Source: Tangkanakul et al, Risk factors associated with leptospirosis in Northeastern Thailand, 1998, The American Journal of Tropical Medicine and Hygiene, Vol 63 (3, 4), 2000, (USA: The American Society of Tropical Medicine and Hygiene, 2000), 206.

Based on this case control study, it is summarized that farmers infected with leptospirosis due to farming rice longer than 6 hours continuously without wearing of protective boot. If farmer wear protective boot, this risk will be reduced by 7.1 time if compared with not wearing.

Silawan et al (1999) carried a cross-sectional analytical study out of 450 stratified systematically randomly selected farmers of 60 villages of 30 sub-districts, 10 districts of Surin province during January – 28th February 1999. The study intended to examine about the farmers' protective behavior for themselves toward leptospirosis infection if their earning activities necessitate contracting with contaminated water by interviewed the selected samples for the information. The study found that the farmers almost did not wear a boot while working in rice filed.

Table 2-3 History of wearing a boot of farmers while working in rice field, by activities

Activities	N	Wearing a boot % (No.)	Never wearing a boot % (No.)
Plowing, Transplanting	415	2 (8)	98 (407)
Oversee after planted	260	20 (53)	80 (207)
Harvesting	367	53 (193)	47 (174)
Catching of fish	103	2 (2)	98 (101)

Note: There were excluded missing numbers.

Source: Silawan et al, A comparative study of recognition and observation of farmers toward leptospirosis between villages with and without leptospirosis infection, Burirum province, 1999. (Nakhon Ratchasima: Office of communicable disease control zone 5, 1999), preliminary report.

Based on this cross-sectional analytical study, it is summarized that more than 80% of rice farmers do not wear protective boot while operating a farm.

Tangkanakul et al (1998) examined a prevalence of asymptomatic infection among villagers who had contracted with leptospirosis according to their daily lifestyle at Nakhon Ratchasima province by examine sera of 143 villagers with disease-free during August 22nd – December 31st, 1998 . The study aimed to examine a prevalence of asymptomatic infection of villagers who contracted with leptospirosis according to their daily lifestyle. Asymptomatic infection was diagnosed if IgM leptospiral antibody titers, which were detected by Enzyme – Linked Immunosorbent Assays (ELISA), were $\geq$ 10 PanBio units. Result, 12 out of 143 cultured villagers (8.4%) have positive blood cultures asymptomatically.

Table 2-4 Prevalence of asymptomatic leptospirosis infection among high risk group.

No. of cultured villagers (cases)	No. of asymptomatic infection (cases)	Case rate (%)
143	12	8.4

Source: Tangkanakul et al, Prevalence of asymptomatic leptospirosis infection among high risk group. 1992. Journal of Health Science Vol. 9 No. 1 (January-March), 2000, (Bangkok: Health Technical Office, 2000) 58.

Based on this study, it is summarized that 8.4% of infection are asymptomatic infected.

Putikhanon et al (2000) conducted a clinical trial of ninja neoprene boot for accomplished its efficiency in 1,000 volunteered farmers at Najak and Houi Mai districts of Phrae province during May – December 2000. At a completion, the undertakers, Putikhanon et al reviewed the participants' weekly reports including interviewed 514 participants out of 1,000 participants, which were randomly selected for the data for the efficiency assessment. The result showed that most of participants (more than 90 %) complied with the neoprene protective boot. Twelve out of 1,000 participants (1.2%) were infected with leptospirosis. The neoprene protective boot's working lifetime was 1.55 months.

Table 2-5 Self-protective behavior of the participants toward leptospirosis infection by using the neoprene boot, by using frequency.

Using frequency	No. of participants	Percentage (%)
Always	474	92.2
Sometimes	39	7.6
Never	1	0.2
Sum	514	100

Source: Puthikanon et al, Study of efficiency of leptospirosis prevention boot. (Phitsanulok : Office of communicable disease control zone 9, 2001) 18.

Table 2-6 Leptospirosis infection when wearing the neoprene boot.

No. of Participants	No. of Cases (cases)	Cases rate (%)
1,000	12	1.2

Source: Puthikanon et al. Study of efficiency of leptospirosis prevention boot. (Phitsanulok : Office of communicable disease control zone 9, 2001) 27.

Table 2-7 The neoprene boot's working life time

Working life time (x) (months)	Frequency (f) (persons)	Percentage (%)	fx
1	337	65.6	337
2	105	20.4	210
3	36	7	108
4	36	7	108
Sum	514	100	799

$$\bar{x} = \frac{\sum fx}{\sum f} = \frac{799}{514} = 1.55 \text{ (S.D. = .8994)}$$

Source: Puthikanon et al, Study of efficiency of leptospirosis prevention boot. (Phitsanulok : Office of communicable disease control zone 9, 2001) 19.

Based on this study, it is summarized that 1.2% of farmer with ninja protective boot infected with leptospirosis. Ninja protective boot has 1.55 months of working lifetime. More than 90% of farmer comply with ninja protective boot.

Infection rate when with/without the protective boot; prevalence of symptomatic/asymptomatic infection all are the variables needed to calculate the number of case with/without the protective boot program, and then cost and benefit of the protective boot program.

There are no literatures that identify the infection rate when without the protective boot directly. Estimating infection rate with/without the protective boots, and course of the disease in this study, will employ concept of odds, infection rate with the protective boots and prevalence of asymptomatic from Putikhanon et al (2000) study, and Tangkanakul et al (2000, and 1998) study. Following are summary of the needed variables we have from the literature reviewed.

1. Most of rice farmers never wear any protective boot while operating a farm (Silawan et al, 1999).
2. Incremental risk (Odds ratio) without wearing of the protective boots while operating rice farm was 7.1 time if compare with wearing of the protective boot (Tangkanakul et al, 2000).
3. Ninja neoprene boot results 1.2% of the compliant infected with leptospirosis (Putikhanon et al, 2000).
4. The prevalence of asymptomatic infection was 8.4% (Tangkanakul et al, 1998).
5. Ninja neoprene boot's compliance by the farmer was 92.2%(Putikhanon et al, 2000)..
6. Ninja neoprene boot's working lifetime was 1.55 month (Putikhanon et al, 2000).
7. Routine service cost (RSC)

7.1 general/central hospital: the per out-patient RSC was 131.69 Baht per visit (ranging from 64.11-287.79 Baht), the per in-patient RSC was 794.41 Baht per day (ranging from 421.37-1,087 Baht) (Tisayathikom and Thonimirt, 2000).

7.2 health centers: the per out-patient RSC was 38.33 Baht (ranging from 26.62-60.77 Baht) (Tisayathikom and Thonimirt, 2000).