

COST ANALYSIS OF ANATOMICAL PATHOLOGY LABORATORY

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จุฬาลงกรณ์มหาวิทยาลัย

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การวิเคราะห์ต้นทุนทางห้องปฏิบัติการทางพยาธิวิทยากายวิภาค



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GENE (ราคา 9,983.78 บาท) และของรัฐได้แก่ Kidney biopsy with direct  
immunofluorescence (ราคา 845.39 บาท) ส่วนต้นทุนต่อหน่วยที่ต่ำสุดได้แก่ การตรวจ Pap  
smear ซึ่งเอกชนราคา 217 และของรัฐราคา 106.76 บาท ต้นทุนต่อหน่วยของห้องปฏิบัติการเอกชน  
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PATTANATIP SAKSRIBUNDEE: COST ANALYSIS OF ANATOMICAL PATHOLOGY LABORATORY. ADVISOR: ASSOC. PROF. SIRIPEN SUPAKANKUNTI, Ph.D., CO-ADVISOR: PROF. PIROM KAMOLRATANAKUL, M.D., 96 pp.

This study is a retrospective analysis of cost and unit cost in private and public anatomical pathology laboratory using direct cost allocation. Unit cost of pathology tests of private laboratory was compared to the company's price and the comptroller general's department (CGD)'s price. Unit cost of public laboratory was compared to the CGD's price lists. Sensitivity analysis and Break-Even analysis were also performed.

The results of the study showed the total direct cost in private and public pathology laboratory were 131 and 12 million bahts, the material costs were 63 and 2 million bahts, the labor costs were 65 and 7 million bahts and the capital costs were 2.5 and 2.3 million bahts, respectively. The highest cost 9,983.78 baht was HER2 Gene in private and the kidney with direct immunofluorescence 845.39 baht was the highest cost of public laboratory. The lowest cost was Pap smear 217 baht in private and 106.76 baht in public. The profit of the tests in private laboratory were positive when compare to the company's price except for C4d and special stains. The profit of the tests in public laboratory comparing with the CGD's prices were negative for small, medium and large biopsy.

In conclusion, cost analysis is useful to private and public side and laboratory medicine like anatomical pathology should perform their own cost analysis in order to manage and improve the quality and efficiency of laboratory tests and cost reduction. The direct cost allocation method is suitable for private while for public laboratory should consider the other cost allocation methods. The CGD's price listed needs to be revised in order to reflect the real cost of pathology examination.

Field of Study: Health Economics and      Student's Signature .....

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## CHAPTER 1 INTRODUCTION

### 1.1 Background and significance of problem

One important section of laboratory medicine is pathology laboratory. Technological advances in the pathology sector are improving hospital services. The development of state of the art machines that can cut some test times from hours to minutes has obvious benefits for the clinicians and physicians depending on results. Pathology play a significant role in both non-communicable and communicable diseases. ("The center for international economics (The CIE)," 2016). It is safe to say that the hospital cannot function without pathology laboratory. The two main parts of pathology are clinical pathology and anatomical pathology.

Anatomical pathology is a branch of pathology that has been playing the important role to improve quality and efficiency of health care service. It is a core of diagnosis part in modern hospitals which handle examination of all kinds of tissues removed from the patients in order to make a specific diagnosis.

Anatomical pathology is divided into surgical pathology and cytology. Surgical pathology is the study of tissues and cytology is the study of cells. Importantly, fluid and tissues that surgeons take from human body need to send to pathology laboratory for investigation. For example, punch biopsy of skin, needle biopsy of lung, breast mastectomy and lower limb amputation. Tissue that need the pathology diagnosis is



involved the abnormal look, lesion cannot be identified by naked eyes, need specific treatment and highly suggestive of malignancy.

Surgical pathology is a vital pole in cancer treatment. It is a key role of diagnosis part of cancer in hospital setting and health care system. It helps to specify the definite type and the stage of cancer (Connolly et al., 2003)

The following graphs present the incidence of most common cancer between male and female in Thailand in the year 2016.

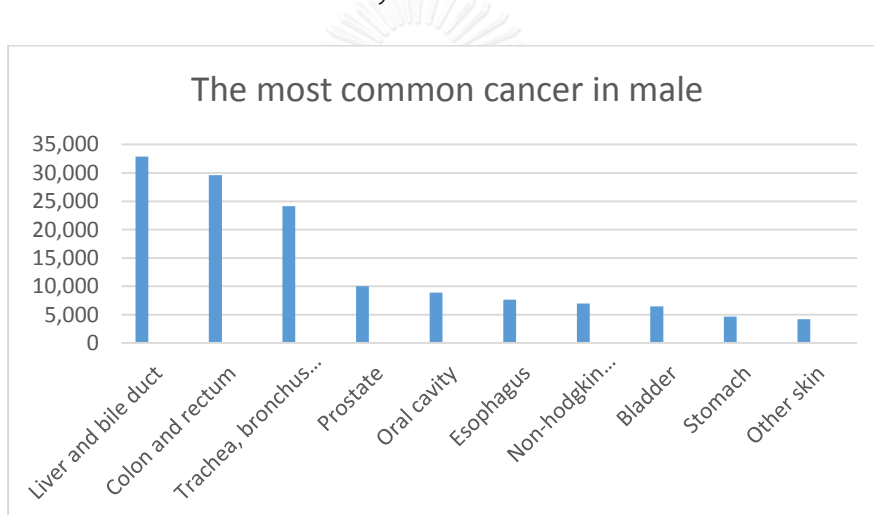


Figure 1 The most common cancer in male

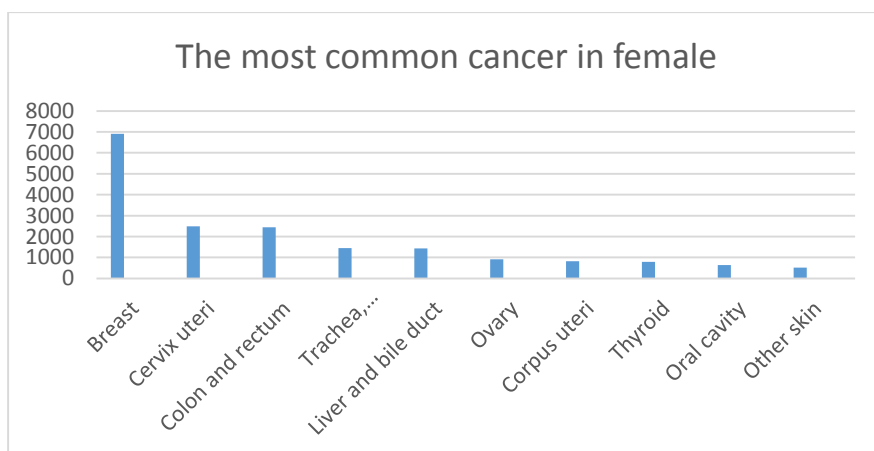


Figure 2 The most common cancer in female

Source: [http://www.nci.go.th/th/cancer\\_record/cancer\\_rec1.html](http://www.nci.go.th/th/cancer_record/cancer_rec1.html)

Number of new cancer cases of the most common type of cancer in male and female is about 150,000 cases. Necessarily, pathology results remain a gold standard for cancer diagnosis. This data can be implied that more than 150,000 cases that need surgical pathology test to find whether tumor is benign or malignancy.

From exploratory of the pathology laboratory, all the services of pathology are provided in teaching hospitals, in some private hospitals and private laboratories. The first private laboratory was founded by pathologist from Teaching hospital in order to serve the need of pathology diagnosis from public hospital after official working hours.

Comparing to other medical specialist, pathologists are grouped into a rare specialist in Thailand. Similar to other medical specialist, most of pathologists are practicing in teaching hospital and since pathologists are scanty, majority of them also work part-time for private laboratories.

The type of laboratory depends on expertise of physician transcend specialty to this branch of medicine looking into disease tissue under microorganisms. No automatic machine can replace the hard-work. Service of this kind is normally found in large hospital or medical school. Consequently, most of pathologists working in private laboratories are appear to be part time.

Moreover, the significant need for pathology services are included efficiency, quality, and turnaround time. These factors affect the changes of pathology laboratory in all laboratory activities and interfere the work schedule which lead to difficulty management. Most of the works in surgical pathology laboratory are done by labor

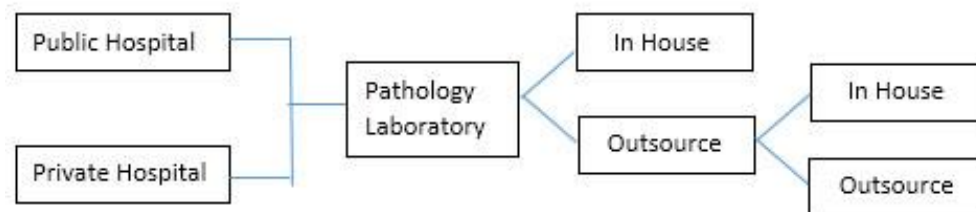
force more than automate machine (Muirhead, Aoun, Powell, Juncker, & Mollerup, 2010). In addition, all material, equipment and machines in pathology laboratory are costly. Then, it is difficult to run the pathology laboratory with constraint of workforces and budgets.

In Thailand, most of public pathology laboratory use the CGD's price list for pathology examination. Some use the price list from ministry of public health in order to charge from hospitals and patients depend on schemes.

Thus, knowing the cost of the tests performing in anatomical pathology laboratory are essential for laboratory management to provide the maximum quality and service in the most economical manner and improve the quality and efficiency in pathology laboratory. For this reason, a cost analysis in laboratory is need to determine the component cost of laboratory tests.

Furthermore, there is no a formally study of the cost and unit cost analysis of pathology laboratory in Thailand. Along this lines, this study aim to analysis the cost of pathology laboratory and the unit cost of pathology laboratory tests.

## 1.2 Pathology Service in Thailand



*Figure 3 Public and private providers of anatomical pathology.*

Surgical pathology service providing most in Teaching hospital, Regional hospital and in some general hospitals. The teaching hospitals have a capacity to generate many specific tests and most of subspecialist are in Teaching hospital. In general hospital and regional hospital some of services perform in house and some are sent to outside laboratory. The test performing outside are the tests that not available in in-house and requested send by clinicians. There are 219 anatomical pathology laboratories in public sectors and 607 pathologists practicing in laboratories. ("Royal college of pathologists of Thailand," 2017)

Laboratories in teaching hospital provides full services and some laboratories in regional hospital are doing service for referrals or provide only cytology service. Number of public hospital providing surgical pathology compile from the internet based of hospital website and annual report is describe in the table below.

*Table 1: Type of public hospital providing pathology laboratory*

Type of Hospital	Anatomical Pathology Laboratory
Teaching Hospital	10
Regional Hospital	28
General Hospital	5
Community Hospital	N/A

Source: <http://apgroup.iop.or.th/> and annual report of hospitals from 2013 to 2016.

Private hospitals also have their own pathology laboratory but smaller than Teaching hospital. Private hospitals that can perform surgical laboratory are considered to be a big hospital. In the same meaning of public hospital, laboratory tests that cannot function in house will be sent to perform outside.

Most of private pathology laboratory received laboratory tests from public hospital, private hospital and private clinics. Some general tests like small biopsy and pap smears can be performed in laboratory and some complexity test such as immunohistochemistry and in situ hybridization will send to process outside. Moreover, some laboratories only provide referral service for pathology test. The table below shows the market share of private laboratories in Thailand in 2015. The data of revenue is available for seven private laboratories from the website of Department of business development.

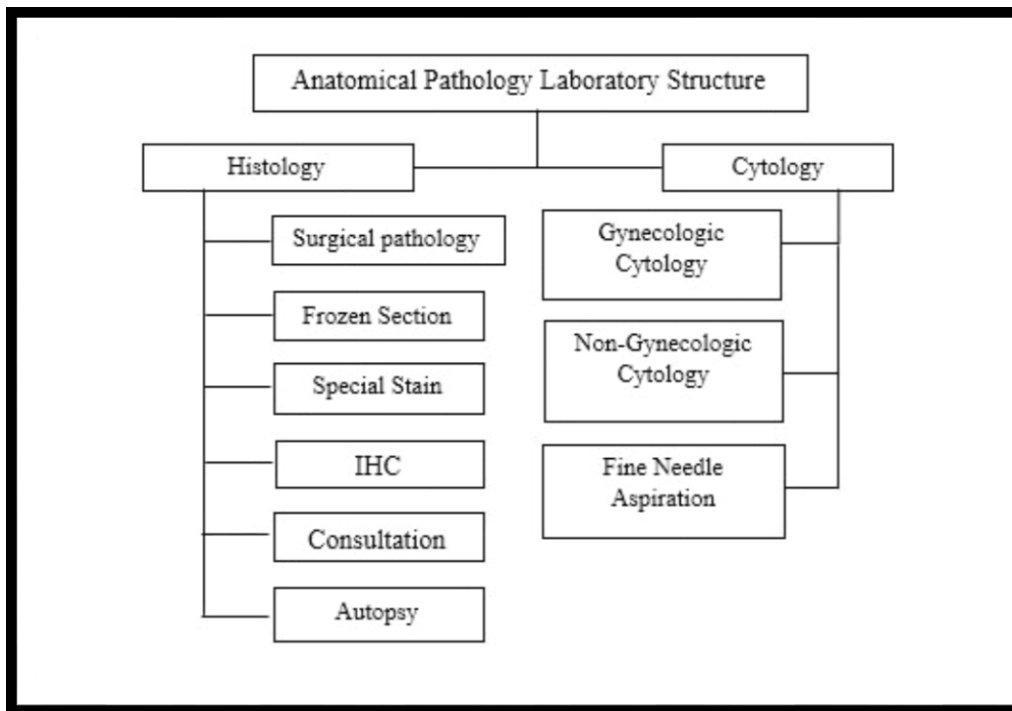
Table 2: Market share of private pathology laboratory in Thailand in 2015.

Company	Revenues (Baht)	Market Share
Professional Laboratory Management Corp.	458,785,715.21	37.96
Bangkok B.R.I.A. Laboratory	277,731,340.99	22.98
Bangkok Pathology Laboratory	258,211,746.53	21.36
N Health Pathology Laboratory	113,782,526.00	9.41
Bangkok Cytogenetics Center	44,690,729.37	3.70
Pathology Diagnostic Center	18,749,439.78	1.55
Innotech Laboratory	16,464,845.73	1.36
HE pathology laboratory	15,571,954.38	1.29
RuamPath Pathology Laboratory	4,628,094.94	0.38

Source: <http://datawarehouse.dbd.go.th/bdw/search/search1.html>. Industry report

2015. Data collection from revenue report of the laboratory services.

Activities in Anatomical Pathology Laboratory.



*Figure 4:Activity in anatomical pathology laboratory*

The figure above showing the activities of anatomical laboratory. Pathology laboratory mostly consists of histology and cytology. Some laboratory in Teaching hospital or private laboratory will provide molecular pathology test such as ALK GENE FISH or HER2 GENE DISH.

### 1.3 Research Questions

1. What are the costs of pathology laboratory of private and public laboratories in 2016 ?
2. What are the unit costs of surgical pathology and cytology tests of private and public laboratories in 2016?
3. What are the cost of generating H&E slides, special histochemical and immunohistochemical slides of private laboratory in 2016?

### 1.4 Objective

To analyze the cost of anatomical pathology laboratory and the unit cost of the tests performing in anatomical pathology laboratory.

### 1.5 Specific Objectives

1. To determine the cost component of generate routine histopathology of private laboratory in 2016.
2. To determine the cost component of generate routine cytopathology of private laboratory in 2016.
3. To analyze the unit cost of pathology laboratory tests including histology and cytology.
4. To analyze the cost of generating H&E slides, special histochemical, immunohistochemical and HER2 GENE slides of private laboratory in 2016.



5. To compare the unit cost of pathology examination of private laboratory with the company's price list and the CGD price lists.
6. To compare the unit cost of pathology examination of public laboratory with the CGD price lists.

#### 1.6 Benefits of the study

Information of cost component of histology and cytology tests will help for laboratory manager to manage the expenditure of each activity. Unit cost of pathology examination of each test and cost that spent for generating slides will be useful for the laboratory in order to control the cost of materials in each examination. Comparison of unit cost of surgical pathology tests with the CGD's price will be help to consider to revise the price of pathology tests.

#### 1.7 Definitions

1. Pathology in this study refers to anatomical pathology.
2. Histology is the study of disease from human living tissues. Surgical pathology examination in this study are unlisted small biopsy (less than 2 cm.), unlisted medium biopsy (2-5 cm.) and (5- 10 cm), unlisted large specimen (over 15 cm.), kidney biopsy with direct immunofluorescence, appendix and gallbladder.
3. Histopathology is the routine process of pathological examination of human living tissue.

4. Frozen Section is the process of fresh tissue processing and interpreting in Pathology laboratory.

5. Special stain in this study included PAS, GMS, AFB, Mucin, Masson trichome, Giemsa and Alcian blue.

6. Immunohistochemistry (IHC) in this study is consists of ER, PR, HER2, Ki-67, p53, CKHMW, CK7, CK20 and ALKD5F3.

7. HER2 GENE test is a molecular pathology test.

8. Cytology is the study of human living fluid and it is divided into Gynecologic cytopathology which is pap smear test and Non-gynecologic cytopathology which mean fluid cytology test.

9. The CGD's price is stand for the comptroller government department's price.

10. HE or H&E is stand for hemotoxylin and eosin which is the standard staining of histopathology.

11. HE slide is the slide that performed from tissue in paraffin blocks. Slide can be sectioned from paraffin block until there is no tissue left in the paraffin blocks. The first slide that section from paraffin block is called HE slide original.

12. HE recut or recut is the slide performed after the original slide, usually perform for further investigation.

13. Deeper cut slide is also performed after HE slide original, usually perform to investigate more on the tissue sample.

14. Cassette is the container of tissue in surgical pathology tests. After the surgical specimen is examined by naked eyes. A small piece of specimen was cut and put into cassette.

15. Formalin fixed tissue is the specimen in containers fixing with formaldehyde. Surgical specimens are received with specimen in formalin.

16. Unstained slide is a slide that not stained with HE, special stains, immunohistochemical stains.

17. P&L is stand for profit and loss.

18. Labor cost (LC) in this study was salary, overtime, benefit of personnel.

19. Material cost (MC) in this study was materials, reagents, utilities, communication expense, rental expense in the laboratory,

20. Capital cost (CC) in this study was cost of instrument, and other renovate laboratory that cost is last longer than one year.

## CHAPTER 2

### LITERATURE REVIEWS

#### 2.1 Surgical pathology

Surgical pathology is a branch of pathology that study human-living tissue to diagnose specific disease under the microscope. Surgical pathology was developed by many clinical specialists and the first surgeon who created surgical pathology was believed to be William S. Halsted, an American surgeon and the first American surgical pathologist was Joseph Colt Bloodgood at Hopkins.

The study of surgical specimens can help to explain success and failure of therapy. Surgical pathologist are generally work in the laboratory which distant from direct contact with the patients. The process is started when clinician obtain the tissue from living patients with many kinds of medical procedure. These tissue can be small, medium, large or very large biopsy, size arrange from 1 mm. to amputation. The specimen will put in container with formalin and send to surgical pathology laboratory after that pathologist will examine the specimen with naked eyes which called gross examining follow by embedding and the technique that use for century called hematoxylin-eosin (H&E) staining. A surgical pathologist will use the H&E slide to define the disease and lesion.

Before the final pathology report, the result is not based on evidence of tissue alone. Pathologists use clinical diagnosis from clinician and other imaging results. There

are several limitations on histologic diagnosis including pathologist's experience, well-obtained tissue, size of specimen, difficulty in sectioning process, contaminated in H&E staining, incomplete communication between clinician and pathologist even incomplete of pathological requisition form. These will make diagnosis difficult or impossible. (Rosai, 2011). The results of pathological examination on surgical pathology are more accurate than cytology. Because the examination of the tissue is more detailed and comprehensive than the examination of the cell.

## 2.2 Routine histology technique

The Routine technique for histology are fixation in formalin, embedding in paraffin, and staining with hematoxylin and eosin or H&E (Henriques, 1981), H&E is commonly used in routine staining of tissues specimens in the histopathology laboratory to reveal the underlying tissue structures and conditions.

## 2.3 Special stain

The term "special stains" has long been used to refer to a large number of alternative staining techniques that are used when the H&E does not provide all the information the pathologist or researcher needs. (Henriques, 1981)

## 2.4 Immunohistochemical stains

Immunohistochemistry (IHC) is an important part in many histopathology laboratories. Immunohistochemical techniques detect antigens in tissue sections by means of immunological and chemical reactions. The utilization of monoclonal and polyclonal antibodies for the detection of specific antigens in tissue sections. Immunohistochemistry (IHC) is widely used for diagnosis of cancers and diagnosis of diseases (Duraiyan, Govindarajan, Kaliyappan, & Palanisamy, 2012).

## 2.5 Cytopathology

Cytopathology is a study of human fluid. It is divided into gynecologic cytopathology and non-gynecologic cytopathology. The first technique of cytopathology was pap smear and still remain in pathology laboratory. Later, the technique of fine needle aspiration was developed and was found to be a powerful diagnostic technique. However, it still has a limitation because it induces artifacts of various types in tissues and it can lead to misinterpretation. (Rosai, 2011)

## 2.6 Definition and classification of cost

Cost by an economist's point of view was described and it can be defined in the following paragraphs.

The definition of that cost is divided into accounting cost and economic cost. Accounting cost is explicit and it is the amount of money and expense that be paid.

Economics cost is the resource use both in monetary and non-monetary include negative consequence, it is implicit and add it into a cost such as opportunity cost. Then economics cost is higher than accounting cost. Moreover, cost and expense is not the same and there are several criteria to group the type of cost (Kaewsonthi & Kamolratanakul, 1991).

- 1) Cost by cost bearer: There are 2 types of cost bearer, one is internal cost the other is external cost. Internal cost is cost that occur in several levels of organization. External cost is cost that occur to clients or patients.
- 2) Cost by activity: There are two types of cost by activity. One is direct cost and the other is indirect cost. For example, in healthcare program as vaccination, direct cost of internal cost is cost of vaccine, cost of medical officer and indirect cost is cost of marketing on the other hand, direct cost of external cost is cost of transportation fee for client or patients and indirect cost is cost of transportation fee for their relatives who come with them.
- 3) Cost by expenditures: There are 2 types of cost by expenditures. One is explicit cost or tangible cost and the other one is implicit cost or intangible cost.
- 4) Cost by medical cost and non-medical cost. This type of costs will be helpful when group into classification as cost as described above. The name of them are obvious to explain. Medical cost is cost of medicine and the

other relevant such as doctors, nurses. Non-medical cost is cost of food, transportation and administration.

In addition, characteristic of cost can be group into 4 categories.

- 1) Fixed cost: This cost is not changed by the amount of products. For example cost of building.
- 2) Semi fixed cost: This cost is not directly relevant to the products but it can alters by the amount of products being produce. For instance, salary, fee.
- 3) Variable cost: This cost is vary by the amount of product.
- 4) Total cost: It is sum of the fixed cost, semi fixed cost and variable cost.

Cost in healthcare and healthcare program can be classified into different group. Cost must be relevant to the situation, not overlap and cover all possibilities. (Creese & Parker, 1994)

1. Classification by input. This is a useful and widely suitable. Inputs are grouped by considering similar characteristics. This classification has a lot of valuation such as

- 1) It involves a manageable number of classifies to be applied to health program or healthcare activities.
- 2) It differentiates two significant classifies of resources for example recurrent cost and capital cost.
- 3) It centers on operating costs of investment in capital (vehicle, building etc,) by making theses unto distinct classification.



Capital cost is cost of ( vehicle, equipment, building, instruments ) that last longer than one year.

Recurrent cost is cost of (personnel, supplies, utilities, maintenance etc.) that are used up in the course of a year and usually purchased regularly.

2. Some possible secondary classification. This is divided into 4 sub-secondary classification.

2.1 Classification by functions or activities. For example health program for maternal and child vaccination. This is to identify the different functional component in health activities.

2.2 Classification by level. For instance, national level, local level or international level. Which level that resources are used.

2.3 Classification by source. Source or contributor (hospital, national government, donors etc.)

2.4 Classification by currency. It is important to know what currency use because of the exchange rate will use to justify. If the result of that study is compare with program in other countries.

2.7 Method of cost allocation.

In the guideline for cost analysis of hospital by ministry of public health, Thailand 2011. There are 3 methods of cost allocation use to allocate the cost center from indirect cost center ("Ministry of Public Health, Thailand," 2011).

1. Direct Allocation Method is the allocation of subservient activities to the activities that directly produce the output. There will be no allocation between supportive activities.

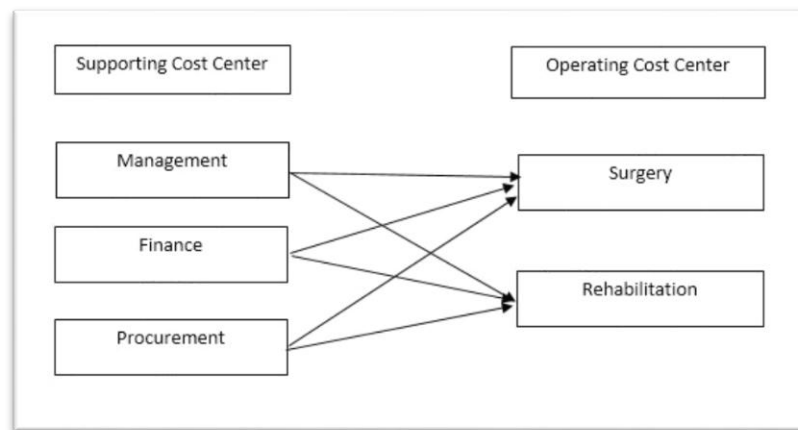


Figure 5: Direct Allocation

2. Step Allocation Method is the allocation of all activities by assigning the allocation sequence of what activities are allocated first.

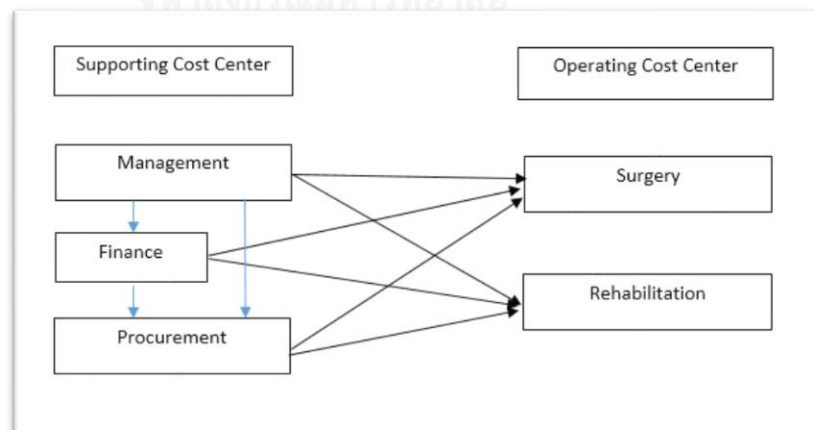


Figure 6: Step down Allocation

3. Reciprocal Allocation Method is the allocation of all activities. This allocation is the most accurate allocation. Because of the fact that the support cost centers are using the operating cost center. And the operating cost centers are using the support cost centers, so the first two allocations are allocated to the results. Rationing may be misleading, but back-to-the-way allocations are relatively difficult, especially in the case of large numbers of activities.

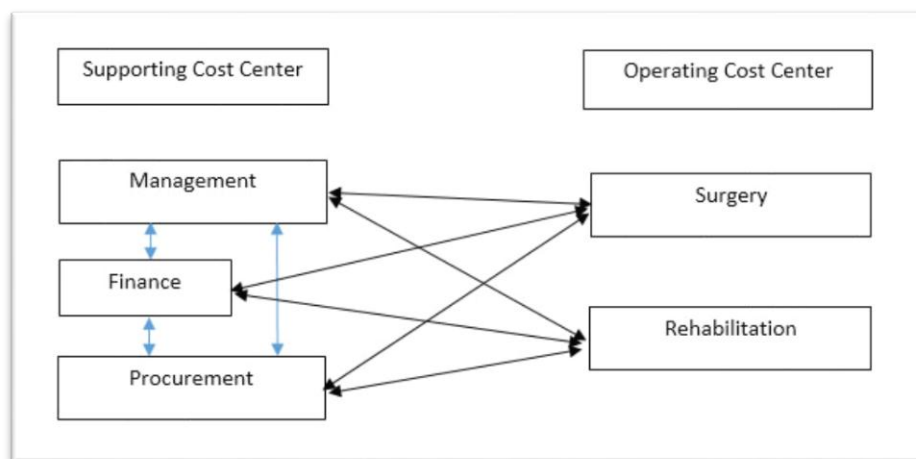


Figure 7: Reciprocal (simultaneous) allocation

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## 2.8 Direct cost allocation method

Direct cost allocation is not the same as direct costs. Direct costing as is used is the method of allocating cost to a product. Direct allocation has a real merit for management decisions. The basic of it is the separation of costs into their fixed and variable costs. Direct costing makes it easier to get information, easily manageable in cost control (Richardson, 1966).

## 2.9 Related Research

The study of cost analysis of clinical laboratory test at King Chulalongkorn Memorial Hospital was found that the laboratory is a revenue producing cost center in hospital. The expenditure of the laboratory was 32,094,960.24 baht and the income was 97,393,244.40 baht. Data collection in laboratory will help to improve laboratory efficiency. Consequently, all laboratories should perform their own cost analysis (Charuruks, Chamnanpai, & Seublinvog, 2004)

The study of unit cost analysis of Bannagsata hospital, Yala province in 2010 and the unit cost of the service of laboratory medicine including clinical and pathological laboratory was 351.23 baht per service. The total direct cost were 5,614,776.57, the total indirect cost were 585,859.44 baht. The full cost of laboratories were 6,200,645.15 baht. It was 7.28% of the total cost of the hospital. The total tests were 17,654. The labor cost, material cost and capital costs were 1,127,724.12 baht, 4,393,345.05 baht and 93,697.40 baht, respectively. The revenue of the laboratory was 4,991,490 baht. The ratio of cost and revenue was 1.24 (Bumrungchu, 2011).

The study of unit Cost of Service in Bangkhla Hospital, Chachoengsao Province was retrospective study of descriptive research, analyze total direct cost of each cost center and analyze the indirect cost by simultaneous equation method. The study showed that laboratory which is the revenue producing cost center has the highest total direct cost, represent 26.35% of all direct cost and the total direct cost was

1,372,619.57 baht. There is no study about unit cost of laboratory services (Sookratamornkul, 2010).

The study of unit Cost Analysis of Puainoi Hospital, Khon Kaen Province in provider perception. The study design was prospective study of the expenditure between 1<sup>st</sup> of June to 31th of August in 2010. Analyze the direct cost of each cost center and indirect cost from support cost center and calculate the unit cost of patient services. The study found that cost component of laboratory were labor cost 148,785.00 baht, material cost 24,954.76 baht and capital cost 68,195.50 baht. The percentage of each are 2.89, 0.97 and 3.61, respectively (Saybuathong, 2011).

The study of cost and unit cost analysis of Thoen hospital in Lampang province during 1997 fiscal year. There were three cost center, NRPCC, RPCC and PS. The study was found the proportion of labor cost: material cost: capital cost, 54: 30: 16. The result was included the unit cost outpatient, inpatient case in hospital. There is no study of unit cost of laboratory (Sridaeng, 1998).

There was a study of unit cost of pathology examinations in Department of Pathology, Ankara University, Turkey. The study used the activity-Based Costing to calculate the unit cost of histopathological examination. Data collections of labor cost, material cost and capital cost and forty-four examinations were selected during September 2010. The study found that all cost of each pathology examination were higher than the prices. The highest cost was 401.19 TL (3871.82 baht) prostate, radical

resection and the lowest cost was 15.95TL (153.53 baht) Appendix. (Ergun, Agirbas, & Kuzu, 2013)

Most of the laboratory that performed cost analysis are clinical laboratory. Some are study of unit cost of service of laboratory. So far there is no a formal study of cost in anatomical laboratory in Thailand.

The direct allocation method is used world wild to calculate the direct cost. This method concern only about the cost allocation of support cost center directly to the functional cost center. Support cost center will not allocate their cost to each other. Direct method is a useful tool to calculate only direct cost of the cost center then it was used in this study to calculate the cost of laboratory in 2016 and unit cost costs of pathology examinations. Because of all cost in the laboratory are directly to the products which are laboratory tests.

## CHAPTER 3

### METHODOLOGY

#### 3.1 Cost analysis

##### 3.1.1 *Scope of the study*

1. The cost analysis of this study cover only direct cost of anatomical pathology laboratories in private laboratory and public laboratory.

2. The units of the measurement in private laboratory were the expenditure from January 1, to December 31 of 2016 while in the public laboratory were the expenditure in fiscal year of 2015. The CPI was used to convert the expenditure in 2015 to be 2016.

3. The tests of private laboratory in this study were surgical pathology, frozen section special stain, immunohistochemistry, HER2 GENE, pap smear and fluid cytology.

4. The surgical pathology tests of private laboratory were unlisted small biopsy (less than 2 cm and 2-5 cm), unlisted medium biopsy ( 5 – 10 cm and 10-15 cm), unlisted large specimen (over 15 cm) and kidney biopsy with direct immunofluorescence.

5. The tests of public laboratory were unlisted small biopsy, medium biopsy, large biopsy, frozen section, kidney biopsy with direct immunofluorescence, pap smear , fluid cytology, and immunohistochemistry for ER, PR and HER2.

6. The unit costs of pathological examinations in private were compared to the company's price lists and the CGD's price lists.

7. The unit costs of pathological examinations in public were compare to the CGD's price lists.

### *3.1.2 Characteristic of Private Laboratory*

The private laboratory provide anatomical pathology service to more than four hundred clients including private hospitals, public hospitals and private clinics. There are 3 fulltime pathologists, 25 partime pathologists, 22 fulltime laboratory staffs and 4 partime laboratory staffs with 8.00 – 20.00 hr. everyday service.

### *3.1.3 Characteristic of Public Laboratory*

The public laboratory is in a teaching hospital which have a capacity of more than 850 beds and more than 3,000 hospital officers. The anatomical laboratory is one unit and provide service within the hospital. There are about 29 employees working in the laboratory. There are seven pathologists, twenty-two laboratory staffs. Laboratory working time is 8.00 – 17.00 hr., Monday to Friday.



## 3.2 Conceptual Framework

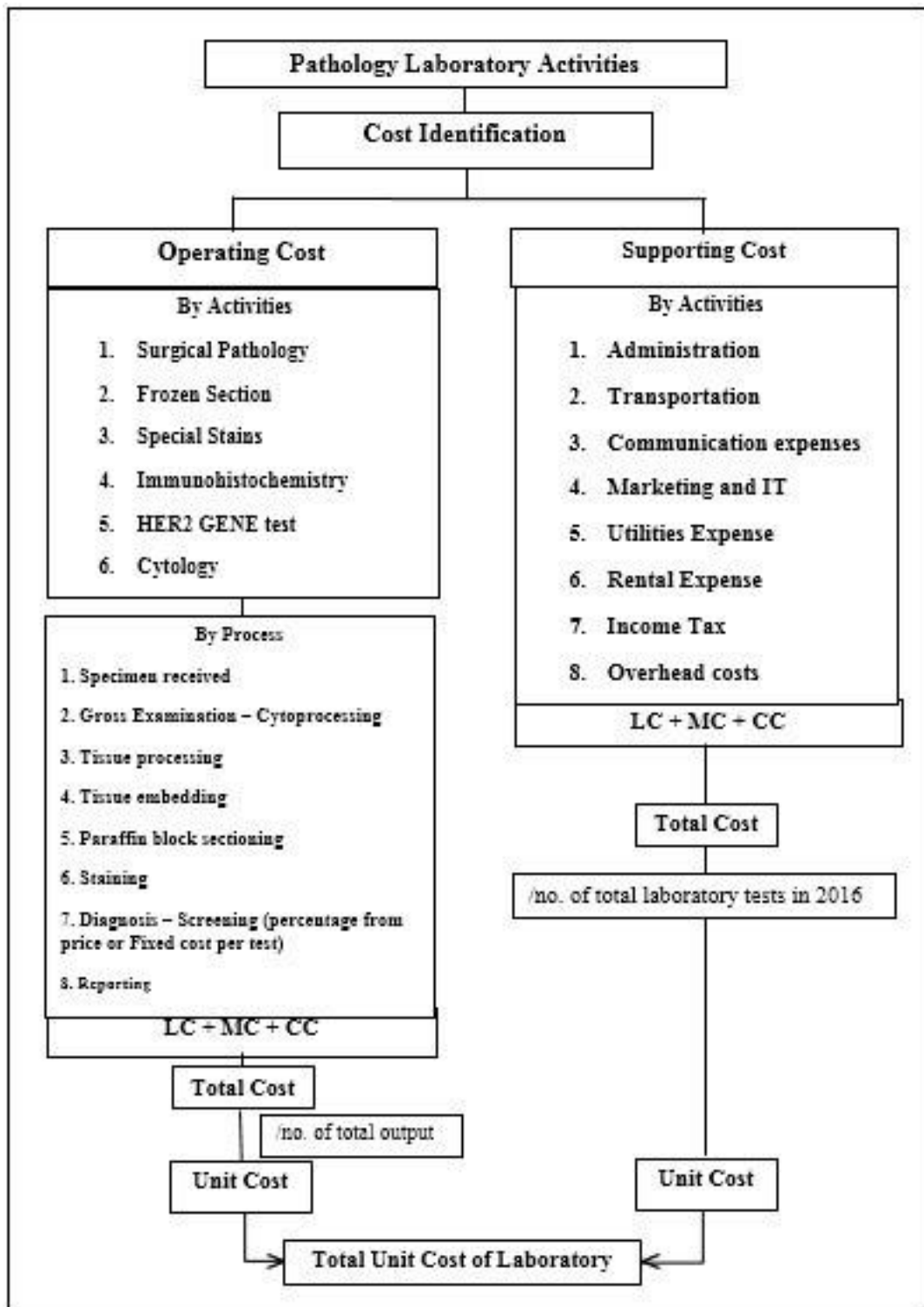


Figure 8: Conceptual framework

### 3.3 Study Design, scope and data collection

*Table 3: Source of data collection*

Description	Data source
Full cost of laboratory	Pathology Department (summary P&L of 2016)
Details of labor cost	People soft program
Details of Material cost	Pathology laboratory stock consumption (excel data 2016)
Details of capital cost	Pathology laboratory assets (file record 2016)

A retrospective study were used to analyze the expenditure of private and public laboratory. Cross sectional data on number of laboratory tests will be derived from secondary data and number of slides will derived from primary data. The total costs of labor costs, material costs and capital costs were obtained from profit and loss (P&L) of the department. The details of labor costs in personnel were derived from salary/OT/Benefits from people soft program. The details of material costs were obtained from laboratory stock consumption and the details of capital costs were obtained from laboratory assets.

Data on public laboratory was obtained from a study of hospital costing in 2015. Consumer price index was used to adjust the interest rate in 2015 to be 2016.

### 3.4 Identifying Cost

#### 3.4.1 *Operating cost*

Operating costs are costs in process of producing product which are pathological examination tests of histology and cytology specimens. There are including labor cost, material cost and capital cost that directly in each process and activities. For example, salary, OT and bonus of lab technicians, supervisor and histotechnologists.

#### 3.4.2 *Supporting cost*

These costs also consists of labor costs, material costs and capital costs and they are describe as follows. Labor costs are salary, OT and bonus of director, assistant directors, administrative officers and salary of full time pathologists. Material costs are consists of cost of material used in laboratory that not directly to activities, cost of other expenses such as transportation, utilities expense, marketing and IT, income tax and overhead costs. Capital costs are costs in management office such as computers, tables, desks and cost of offices renovate.

#### 3.4.3 *Capital cost*

Capital cost is the cost of resources that last longer than a year which purchased in one year but use in several year. The study was used the life span according to the method the company. The useful life for capital cost in the laboratory

was calculated as 1) Cost of machine use in laboratory has the life span of 7 years. 2) Cost of computer use in laboratory and administrative office has the life span of 3 years. 3) Cost of renovate laboratory has a useful life of 8 years. The Double declining method was used to calculate the depreciation of capital cost. Depreciation of building in private laboratory was replaced by laboratory rental expenses.

#### *3.4.4 Labor Cost*

Labor cost is recurrent cost in the laboratory and consists of cost of administrative officer, lab technicians, lab admins, histotechnologists, cytotechnologists, pathologists, supervisors, assistant director and director. Cost of full time pathologists was calculate as supporting costs because of it was consider to be fixed cost of laboratory that has to be paid for pathologists for honorary which there will be additional cost of diagnosis case and cost of partime pathologists were added to tests by using 30% of the prices except for pap smear, frozen section and kidney biopsy with direct immunofluorescence that cost of doctor fee are fixed not vary with the prices.

#### *3.4.5 Material Cost*

Example of the material costs in the laboratory are cost of chemical reagents, glass slides, forceps and gloves and material costs in the administrative office are papers, envelopes and other stationary.

#### *3.4.6 Direct cost in operating cost*

Direct cost in this study consists of direct cost of labor, material and capital.

Direct cost of labor is cost of laboratory staff that doing the test such as histotechnologists and cytotechnologists.

Direct material costs are cost of material that use directly to the tests such as absolute, alcohol, reagents, xylene, glass slide and cover slide.

Direct cost of capital is cost of equipment and instrument that use directly to the tests such as cryostats, grossing machines, microtomes and microscopes.

#### *3.4.7 Indirect Cost in operating cost.*

Indirect cost in this study consists of direct cost of labor, material and capital.

Indirect cost of labor is cost of supervisor who manage the activity in histology and cytology.

Indirect material costs are cost of material that not use directly to the test such as mask, glove, tissue hand towels, gauze and cap.

Indirect costs of capital are cost of instrument and equipment that not use directly to the tests such as refrigerators and calibration.

### 3.5 Method for calculation

Cost of Pathology laboratory = Operating cost + Supporting cost

All costs in the laboratory are direct to internal pathology laboratory test, including labor cost, capital cost and material costs are calculate using direct method. The cost of outsource and other expenses such as electricity, water supply, laundry, food, and cost from academy are also calculated for total cost of the laboratory.

The capital cost in laboratory such as grossing machine, immunohistochemical staining machine and the refrigerators was calculated by using the double declining straight line method of depreciation. Estimate average annual costs of each item by simple is equal to the current value of the equipment divide by the life span of the capital. The company use this method to calculate the depreciation of capital cost.

Double declining straight line method.

$$D = \text{Net book value} \times (2/N)$$

Where  $D$  = depreciation charge

$N$  = useful life in years.

Since net book value = Initial cost – accumulated depreciation

### 3.6 Unit cost analysis

*Table 4: Source of data collection for unit cost*

Description	Data source
Pathology tests in 2016	Laboratory count tests program
Number of HE slides	Laboratory recording of HE slides
Number of special stain slides	Book recording of special stains ordered in 2016
Immunohistochemistry, HER2 GENE	Program Immunochemistry/HER2 gene tests ( slide recorded )
Number of cassette	Laboratory tracking data

The data of number of laboratory tests was obtained from laboratory count test program. The data of number of HE slides were derived from the HE slide's record which include HE recut, Deeper cut and all slide HE performed. The number of special stained slides were obtained from Book ordered special stains and the number of Immunohistochemistry and HER2 GENE tests were obtained from the IHC performed program. Number of cassettes used were obtained from laboratory material supplied records.

### 3.7 Unit Cost calculation

Calculate unit cost of each pathology test by activity.

There are seven activities in the anatomical pathology laboratory. 1) Surgical pathology 2) Frozen section 3) Special stains 4) Immunohistochemistry 5) HER2 GENE

test 6) Cytology-Gyne (pap smear) 7) Cytology-Non Gyne (Fluid cytology). In the seven activities, each activity has the step of process and it determines as follows.

### 3.7.1 Surgical pathology

*Table 5: Surgical pathology specimen processing and calculate unit cost of surgical pathology*

Activities	Allocation criteria
1.Specimen received	Number of histology tests received
2.Gross Examination	Number of cassette
3.Tissue processing	Number of cassette
4.Tissue embedding	Number of cassette
5.Paraffin block sectioning	Number of unstained slide
6.HE staining	Number of slide stained by HE technique
7.Diagnosis and report	Percentage from price Number of laboratory tests report

- 1) Specimen received. This step all histology specimen will be checked and refer to the next steps. Tests that send to process outside laboratory were also pass this step and calculate to be the cost of specimen received.

$$\text{Cost of specimen received} = LC + MC + CC / \text{Number of tests received.}$$

- 2) Gross Examination. After the specimens were checked in the first step. Surgical specimens were referred to examine by naked eyes or macroscopic



examination by histotechnologists or pathologists. They cut the specimens into small pieces and put it in a cassette block.

Cost of gross examination =  $LC + MC + CC / \text{Number of tissue cassette.}$

- 3) Tissue processing. The cassette blocks from the step above was put into the process call tissue processing which spent 12 hrs for this process.

Cost of tissue processing =  $LC + MC + CC / \text{Number of tissue cassette.}$

- 4) Tissue embedding. In this process, a tissue in cassette from the process above will be transfer to embed machine and lab technician will put in by considering the type of specimens.

Cost of tissue embedding =  $LC + MC + CC / \text{Number of tissue embedded cassette.}$

- 5) Paraffin blocks section. After the tissue was put with the correct position on the paraffin blocks. It was cut by lab technician with the machine called microtome and turn it into an unstained slides.

Cost of paraffin blocks sectioning =  $LC + MC + CC / \text{Number of unstained slide.}$

- 6) Staining. This process, all unstained slides were stained by HE process for routine histopathology specimens.

Cost of staining =  $LC + MC + CC / \text{Number of HE stained slides.}$

- 7) Diagnosis and reporting. After the HE slides are done. They were brought to pathologists to interpret and report. The copy of report was released by administrative officers.

Unit cost of surgical pathology test are calculated with considering cost of pathologist who interpret the H&E slide, cost of histotechnologists or pathologists who examine the surgical pathology specimens, cost of technician, cost of material providing for the tests including cost of administration and the other indirect cost.

Unit cost of surgical pathology examination per test

Unit cost = (Sum of Cost of each process x ( number of cassettes and slides )  
+ (Supporting cost/Number of laboratory tests)

Unit cost of generate HE slides = (Cost of step 1 to 6) + (Supporting costs)

### 3.7.2 Frozen section

- 1) Calculate unit cost of frozen section. The steps of frozen section are classified as follows.

Table 6: Frozen section calculation

Activities	Allocation criteria
Specimen received	Number of histology tests received
Gross Examination	Fixed cost from test
Tissue sectioning	Number of unstained slide
HE staining	Number of slide stained by HE technique
Diagnosis and report	Fixed cost from test Number of laboratory tests report

1. Specimen received. This step are also calculated as the same as surgical pathology. All costs are similar.

2. Gross Examination. Fresh tissue was examined by pathologists who responsible for the frozen section case. Pathologist will get paid by fixed cost for frozen section and it is included in the step of diagnosis. The other processes will calculated similar to surgical pathology specimens. Because of the fresh tissue will be put in the cassettes and process with the next step as surgical specimen till they were reported.

3. Sectioning. Fresh tissue was used to cut in the cryostat machine by lab technician and put into slides which different from the formalin fixed specimens.

4.HE staining. Manual staining by lab technician were used to stained the HE slides for this process.

Cost of Frozen HE slides = LC+MC+CC / Number of Frozen section HE slides

5.Diagnosis and reporting. This process also calculate the same as the surgical specimens.

### 3.7.3 Calculate unit cost of special stain

Table 7: Special stain calculation

Activities	Allocation criteria
Paraffin block sectioning	Number of unstained slide
Special staining	Number of slide stained by special stain technique
Diagnosis and report	Percentage from price Number of laboratory tests report

1.Paraffin blocks sectioning. This process calculate the same as the surgical pathology specimens.

2.Special staining. In the special staining process, unstained slides will be stained by different reagent depend on what type of stain, Example PAS, GMS and Masson Trichome.

Cost of special stain = LC +MC+ CC/ Number of slide stains

3.Diagnosis and reporting. This process calculate the same as the surgical pathology specimens.

### 3.7.4 Calculate unit cost of Immunohistochemistry and HER2 GENE tests

Table 8: Immunohistochemistry and HER2 GENE calculation

Activities	Allocation criteria
Paraffin block sectioning	Number of unstained slide
Immunohistochemistry/HER2 GENE staining	Number of slide stained by immunohistochemistry / HER2 GENE technique
Diagnosis and report	Percentage from price Number of laboratory tests report

1.Paraffin blocks sectioning. This process calculate the same as the surgical pathology specimens.

2.IHC staining, unstained slides will be stained by different reagent depend on what type of stain, Example ER, PR and HER2

3.Diagnosis and reporting. This process calculate the same as the surgical pathology specimens.

### 3.7.5 Cytology

Table 9: Cytology calculation

Activities	Allocation criteria
Specimen received	Number of cytology tests received
Cyto-processing	Number of cytology tests
Screening	Fixed cost per screening tests
Diagnosis and report	Fixed cost from test/ Percentage from price Number of laboratory tests report

1. Specimen received. All cytology specimens will be received in this step.

Cost of cytology specimen received =  $LC+MC+CC$  / Number of cytology tests

2. Cytology processing

Cost of processing =  $LC+MC+CC$  / Number of cytology tests

3. Screening. Cytotechnologists will screening slides before send to pathologists.

Cost of each test screening for cytotechnologist will add to calculate per test.

4. Diagnosis and report. This process calculate the same as the surgical pathology specimens. All cytology reports will be released by administrative officers.

Unit cost of cytology for gynecologic test are calculated with considering cost of pathologists who diagnosis the test, cost of cytotechnologist who screening the slide, cost of lab technician who process the cytology specimen, cost of material and indirect costs items.

### *3.7.6 Unit cost calculation of public laboratory*

In the unit cost of pathology examination of public laboratory. Unit cost of surgical pathology specimens were calculate by considering unit costs of each items that calculate from private and estimate in the cost of public, total labor cost, material cost and capital cost were obtained from the previous study of hospital costing in 2015.

Adjusted the price by using consumer index price. The base year is 2015.

Unit cost of surgical pathology =  $(LC+MC+CC)$  / Number of HE slides

Unit costs of gynecology =  $(LC+MC+CC)/$  Number of pap smear slides

Unit costs of fluid cytology non-gyne =  $(LC+MC+CC)/$  Number of fluid cytology slides

Calculate cost of depreciation by divided number of all slides spent.

### 3.8 Sensitivity Analysis

The sensitivity analyses are analyzed by changing one parameter. This study uses the changing in labor cost, material cost and prices. The objective of sensitivity analysis is the prediction of uncertainty.(Supakankunti, 2016)

The percentage of labor cost increase and decrease was calculate base on private laboratory. Every year the price of each test is consider to increase in 10% of the base price of previous year and it effect to the labor cost because when price of laboratory test increase the labor cost of pathologist will also increase.

The percentage of material cost increase and decrease was calculate by consider to the usage of material such as slide and cassette in surgical pathology because of the same test, same price such as colon biopsy sometime use one cassette, one slide and sometime use more than one cassette and one slide. The material price such as cassette and slide increase around 10% in each year.

Table 10: Sensitivity analysis

Situation	Labor cost	Material cost	Price	Profit
1	Labor cost increase 10%	Material cost increase 10%	Price increase 10%	
2	Labor cost decrease 10%	Material cost decrease 10%	Price decrease 10%	
3	Labor cost increase 20%	Material cost increase 15%	Price increase 25%	
4	Labor cost decrease 20%	Material cost decrease 15%	Price decrease 25%	

### 3.9 Break-Even analysis

The break-even analysis is a tool for a firm or company to consider how many unit of a product will produce. Or to identify the start up cost which will help to know the sales revenue need to pay ongoing business expense. The analysis give the point where total cost is equal to total revenue. At this point there is no loss or profit for company (Supakankunti, 2017).

$$\text{Break-Event point} = \text{Total cost} - \text{Total revenue} = 0$$

$$\text{Total cost} = \text{Fixed cost} + \text{Variable cost}$$



## CHAPTER 4 RESULTS

This part is divided into part of cost analysis of private laboratory and part of cost analysis of public laboratory.

### 4.1 Private Laboratory

#### 4.1.1 Full cost of private laboratory

Cost of anatomical laboratory were consists of operating cost and supporting cost.

The operating cost are consist of cost of labor 12,658,508.84, cost of material 49,795,988.28 cost of capital 1,147,321 and Doctor Fee 35,869,618.03 baht. The material costs were divided to 38,730,740.48 baht for in-house solution and 11,065,247.80 baht for out-lab solution.

The supporting cost are consists of labor cost 17,007,450.88, material cost 13,541,478.75 and capital cost 1,370,908.92 baht.

Total Costs of Pathology laboratory in 2016 were 131,391,274.70 baht. Total labor cost was 65,535,577.75 baht. The total material cost was 63,337,467.03 baht and the total capital cost was 2,518,229.92 baht.

Total laboratory tests in 2016 were 190,528 tests. Histology 87,957 tests. Cytology 10,2571 test. Number of cassettes used were 98,822 cassettes. Number of

slide HE were 159,277 slides. Number of Slide IHC performed in-house were 3,465 slides. Number of slide special stains 4,424 slides. Number of slide Immunofluorescences were 12,209 slides.

*Table 11: Supporting Cost of pathology laboratory.*

<b>Supporting Cost</b>	Total Cost	Total cost per test (Total test 190528 tests)
Administration (Salary, OT, Bonus)	17,007,450.88	89.26
Transportation	370,227.66	1.94
Communication expenses	207496.3	1.089
Advertising and Marketing	48346	0.25
Utilities Expense	2,329,383.81	12.23
Rental Expense (Laboratory space)	4,426,638.49	22.23
Income Tax	5,150,681.24	27.03
Cost of medicine	288,619.47	1.51
Laundry Service	21,060.00	0.11
Depreciation (IT software, other equipment's)	1,370,908.92	7.2
Other expenses	188,914.30	0.99
Maintenance	417362.9	2.1905

From the above, all costs can be classified into labor cost, material cost and capital cost. Labor costs of supporting was 89.26 per test. Material cost of supporting cost was 47.34 baht and capital cost was 7.2 baht per test.

#### 4.1.2 Cost component of routine histopathology

Cost component of generate routine histopathology can be classified by the activities to produce the HE slides which are specimen received, gross examination, tissue processing

Table 12: Cost component of generate routine histopathology test of private laboratory in 2016.

Activities	LC (baht) Amount (%)* (%)**	MC (Baht) Amount (%)* (%)**	CC (Baht) Amount (%)* (%)**	TC (Baht) Amount (%)* (%)**
1.Specimen received	2.67 -95.36 -2.01	0.05 -1.79 -0.09	0.08 -2.86 -0.62	2.8 -100 -1.37
2.Gross Examination	5.42 -76.12 -4.08	0.97 -13.62 -1.65	0.73 -10.25 -5.62	7.12 -100 -3.48
3.Tissue Processing	2.67 -41.52 -2.01	2.48 -38.57 -4.23	1.28 -19.91 -13.24	6.43 -100 -3.15
4.Tissue Embedding	4.41 -47.69 -3.32	0.91 -12.93 -1.55	1.72 -24.43 -4.93	7.04 -100 -3.44
5.Paraffin blocks sectioning	4.44 -55.02 -3.34	2.99 -37.05 -5.1	0.64 -7.93 -6.77	8.07 -100 -3.95
6.HE staining	4.44 -57.29 -3.34	2.43 -31.35 -4.15	0.88 -11.35 -1.46	7.75 -100 -3.79
7.Reporting	13.41 -94.24 -10.1	0.63 -4.43 -1.07	0.19 -1.34 -1.79	14.23 -100 -6.96

	6.03	0.82	0.27	7.12
8.Indirect cost	-84.69	-11.52	-3.79	-100
	-4.54	-1.4	-2.08	-3.48
9.Supporting Cost	89.26	47.34	7.2	143.8
	-62.07	-32.92	-5.01	-100
	-67.24	-80.76	-55.43	-70.37
Total	132.75	58.62	12.99	204.26
	-64.96	-28.68	-6.36	-100
	-100	-100	-100	-100

Source: Author's calculation

Amount (%)\* Percentage of cost component in each activity

(%)\*\* Percentage of cost component among 9 activities

From the table above. Labor cost is the highest cost in all activities. The highest labor cost is 5.42 per cassette in gross examination. Supporting cost was the highest cost component in labor cost, material cost and capital.

#### 4.1.3 Cost component of routine cytopathology

Cytology processes were different from histology. Each step was performed with the same person through screening slides except for diagnosis and report.

*Table 13: Cost component of generate routine cytopathology of private laboratory in 2016.*

Activities	LC Amount % (%)	MC Amount % (%)	CC Amount % (%)	TC Amount % (%)
1.Specimen received	2.01 (100) (1.52)	0 (0) (0)	0 (0) (0)	2.01 (100) (0.75)
2.Cyto-processing	2.01 (2.46) (1.52)	79.78 (97.54) (62.05)	0 (0) (0)	81.78 (100) (30.52)
3.Screening	19.74 (100) (14.96)	0 (0) (0)	0 (0) (0)	19.74 (100) (7.37)
4.Reporting	13.41 (94.24) (10.16)	0.63 (4.43) (0.49)	0.19 (1.34) (2.55)	14.23 (100) (5.31)
5.Indirect Cost	5.56 (86.47) (4.21)	0.82 (12.75) (0.64)	0.05 (0.78) (0.67)	6.43 (100) (2.40)
6.Supporting Cost	89.26 (62.07) (67.63)	47.34 (32.92) (36.82)	7.2 (5.01) (96.77)	143.8 (100) (53.66)
Total	131.99 (49.25) (100)	128.57 (47.97) (100)	7.44 (2.78) (100)	268.00 (100) (100)

Source: Author's calculation

Amount (%)\* Percentage of cost component in each activity

(%)\*\* Percentage of cost component among 6 activities

Supporting cost was the highest cost component in labor cost, material cost and capital.

#### 4.1.4 Unit cost of histology and cytology tests of private laboratory in 2016

##### 1) Unit cost of surgical pathology

Unit cost of each pathology examination are consists of cost of specimen received, cost of gross examination, cost of tissue processing, cost of tissue embedding, cost of paraffin block sectioning, cost of HE staining, cost of diagnosis or doctor fee, cost of reporting and management costs. Costs are vary with input on slides and cassettes.

*Table 14: Unit cost of surgical pathology tests*

Test Lists	Labor Cost (%)	Material Cost (%)	Capital Cost (%)	Total Cost (%)
Unlisted small biopsy (1 slide)	357.75 (83.61)	55.13 (12.88)	14.99 (3.50)	427.87 (100)
Unlisted small biopsy (2 slides)	379.13 (81.96)	68.45 (14.80)	14.99 (3.24)	462.57 (100)
Unlisted small biopsy (4 slides)	421.89 (80.50)	87.23 (16.64)	14.99 (2.86)	524.11 (100)
Unlisted medium biopsy (6 slides)	464.65 (79.12)	107.64 (18.33)	14.99 (2.55)	587.28 (100)
Unlisted large specimen (15 slides)	972.07 (82.82)	186.7 (15.91)	14.99 (1.28)	1173.76 (100)
Unlisted very large specimen (30 slides)	1712.77 (82.72)	342.88 (16.56)	14.99 (0.72)	2070.64 (100)
Appendix (2 slides)	379.13 (81.96)	68.45 (14.80)	14.99 (3.24)	462.57 (100)

Gallbladder (2 slides)	379.13 (81.96)	68.45 (14.80)	14.99 (3.24)	462.57 (100)
Kidney Biopsy with direct Immunofluorecent	1991.83 (91.39)	177.82 (8.16)	9.77 (0.45)	2179.42 (100)
Frozen Section	1649.13 (92.86)	116.95 (6.59)	9.77 (0.55)	1775.85 (100)

Source: Author's calculation

The highest percentage of every test above are labor cost. The labor cost and material cost vary by the input to the test. Labor cost and Material cost are increase with the large specimen.

## 2) Unit cost of special stain

*Table 15: Unit cost of special stain*

Special stain	Labor Cost	Material Cost	Capital Cost	Total Cost
PAS	195.81	50.20	7.48	253.49
AFB	195.81	50.70	7.48	253.99
GMS	195.81	52.33	7.48	255.62
Giemsa	195.81	49.21	7.48	252.5
Masson Trichome	195.81	100.86	7.48	304.15
Alcian Blue	195.81	57.33	7.48	260.62
Mucin	195.81	58.24	7.48	261.53
Special Stains(ALL)	195.81	117.84	7.48	321.13

Source: Author's calculation

## 3) Unit cost of Immunohistochemistry

*Table 16: Unit cost of immunohistochemistry.*

Test	Labor Cost	Doctor Fee	Material Cost	Capital Cost	Total Cost
ER	120.81	450	424.51	7.48	1002.8
PR	120.81	450	453.42	7.48	1031.71
HER2	120.81	450	532.84	7.48	1111.13
Ki67	120.81	450	461.67	7.48	1039.96
P53	120.81	450	746.07	7.48	1324.36
CKHMW	120.81	450	402.23	7.48	980.52
ALKD5F3	120.81	750	1043.53	7.48	1921.82
C4D	120.81	450	1689.03	7.48	2267.32
CK20	120.81	450	486.06	7.48	1064.35
CK7	120.81	450	486.06	7.48	1064.35

Source: Author's calculation

## 4) Unit cost of HER2 GENE test

*Table 17: Unit cost of HER2 GENE DISH test*

TEST	LC	MC	CC	Total cost
HER2 GENE	3120.81	6832.83	7.48	9961.12

Source: Author's calculation



## 5) Unit cost of cytology

Table 18: Unit cost of cytology test.

Cytology test	LC	MC	CC	TC per test
Pap smear	143.59	65.97	7.44	217
Surepath	143.59	278.61	7.44	429.64
ThinPrep	143.59	392.56	7.44	543.59
Other tests	143.59	66.55	7.44	217.58
Fluid cytology for non-gyne	473.85	439.56	7.44	920.85

Source: Author's calculation

## 4.1.5 Unit cost of generating slides (HE, special stains, immunohistochemistry, HER2 GENE)

Table 19: Unit cost of generate slides for HE, Special stain, immunohistochemistry and HER2 GENE DISH.

Stained Slides	Labor Cost	Material Cost	Capital Cost	Total Cost
H&E from Formalin Fixed tissue	119.34	57.99	12.8	190.13
HE from Paraffin Block	104.17	53.58	8.99	166.74
HE from Unstained Slide	99.73	50.59	8.35	158.67
PAS	120.81	50.20	7.48	178.49
AFB	120.81	50.70	7.48	178.99
GMS	120.81	52.33	7.48	180.62
Giemsa	120.81	49.21	7.48	177.5
Masson Trichome	120.81	100.86	7.48	229.15
Alcian Blue	120.81	57.33	7.48	185.62
Mucin	120.81	58.24	7.48	186.53

ER	120.81	424.51	7.48	552.8
PR	120.81	453.42	7.48	581.71
HER2	120.81	532.84	7.48	661.13
Ki67	120.81	461.67	7.48	589.96
P53	120.81	746.07	7.48	874.36
CKHMW	120.81	402.23	7.48	530.52
ALKD5F3	120.81	1043.53	7.48	1171.82
C4D	120.81	1689.03	7.48	1817.32
CK20	120.81	486.06	7.48	614.35
CK7	120.81	486.06	7.48	614.35
HER2 GENE	120.81	6832.83	7.48	6961.12

Source: Author's calculation

#### 4.1.6 Unit cost of private laboratory compare to prices

Table 20: Comparison the unit cost of surgical pathology examination with the company price and the CGD's price list

Test Lists	TC	Company Price	P&L	CGD price	P&L
Unlisted small biopsy less than 2 cm. (1 slide)	427.87	750	322.13	290	-137.87
Unlisted small biopsy less than 2 cm (2 slides)	462.57	750	287.43	290	-172.57
Unlisted small biopsy 2-5 cm. (4 slides)	524.11	750	225.89	290	-234.11
Unlisted medium biopsy 5-10 cm (6 slides)	587.28	750	162.72	600	12.72
Unlisted medium 10-15 cm. (15 slides)	1173.76	1800	626.24	600	-573.76
Unlisted very large specimen more than 15 cm. (30 slides)	2070.64	3200	1129.36	1200	-870.64
Appendix (2 slides)	462.57	750	287.43	290	-172.57
Gallbladder (2 slides)	462.57	750	287.43	290	-172.57

Kidney Biopsy with direct Immunofluorescent	2179.42	6000	3820.58	2820	640.58
Frozen Section	1775.85	4500	2724.15	1395	-380.85

Source: Author's calculation

*Table 21: Comparison unit cost of special stain with the company's price and the CGD's price.*

Special stain	Total Cost	Company's Price	P&L	CGD's price	P&L
PAS	253.49	250	-3.49	75	-178.49
AFB	253.99	250	-3.99	75	-178.99
GMS	255.62	250	-5.62	75	-180.62
Giemsa	252.5	250	-2.5	75	-177.5
Masson Trichome	304.15	250	-54.15	75	-229.15
Alcian Blue	260.62	250	-10.62	75	-185.62
Mucin	261.53	250	-11.53	75	-186.53
Special Stains(ALL)	321.13	250	-71.13	75	-246.13

Source: Author's calculation

Table 22: Comparison unit cost of immunohistochemistry with the the company's price and the CGD's price lists.

Test	Total Cost	Company's Price	P&L	CGD's Price	P&L
ER	1002.8	1500	497.2	685	-317.8
PR	1031.71	1500	468.29	685	-346.71
HER2	1111.13	1500	388.87	890	-221.13
Ki67	1039.96	1500	460.04	470	-569.96
P53	1324.36	1500	175.64	470	-854.36
CKHMW	980.52	1500	519.48	-	-
ALKD5F3	1921.82	3000	1078.18	-	-
C4D	2267.32	1500	-767.32	2400	132.68
CK20	1064.35	1500	435.65	420	-644.35
CK7	1064.35	1500	435.65	410	-654.35

Source: Author's calculation

The CGD' price show negative sign except for the immunohistochemistry for C4D

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Table 23: Comparison of HER2 gene test with the company's price and the CGD's price.

TEST	Total cost	Company's Price	Profit	CGD's Price	Profit
HER2 GENE	9961.12	13000	3038.88	12000	2038.88

Source: Author's calculation

Table 24: Comparison unit cost of cytology tests for the company's price and CGD's price.

Cytology test	TC	Company's Price	P&L	CGD's Price	P&L
Pap smear	217	250	33	120	-97
Surepath	429.64	550	120.36	-	-
ThinPrep	543.59	650	106.41	-	-
Other tests	217.58	450	232.42	-	-
Fluid cytology for non-gyne	770.59	1250	329.15	600	-170.59

Source: Author's calculation

\*Cost of Doctor fee for Fluid cytology for non-gyne is 30% from Price

\*Cost of doctor fee for all gyne cytology is 30 baht per test

#### 4.1.7 Sensitivity Analysis (Private Laboratory)

The analysis of sensitivity is shown in the table below.

*Table 25: Sensitivity analysis of pathological examination of unlisted small specimen to unlisted very large specimen compare to the company's price.*

Total cost	427.87		587.28		1173.76		2070.64	
Setting	Unlisted small	Profit	Unlisted medium	Profit	Unlisted medium	Profit	Unlisted large	Profit
<b>Base Line labor cost</b>	<b>357.75</b>	<b>322.13</b>	<b>464.65</b>	<b>162.72</b>	<b>972.07</b>	<b>626.24</b>	<b>1712.77</b>	<b>1129.36</b>
LC increase 10%	380.25	299.63	487.15	442.15	1026.07	572.24	1808.77	1033.36
LC decrease 10%	335.25	344.63	442.15	487.15	918.07	680.24	1616.77	1225.36
LC increase 20%	402.75	277.13	509.65	419.65	1080.07	518.24	1904.77	937.36
DF decrease 20%	312.75	367.13	419.65	509.65	864.07	734.24	1520.77	1321.36
<b>Base Line</b>	<b>55.13</b>	<b>322.13</b>	<b>107.64</b>	<b>162.72</b>	<b>186.7</b>	<b>626.24</b>	<b>342.88</b>	<b>1129.36</b>
Material cost increase 10%	60.643	327.643	118.404	151.956	205.37	607.57	377.16	1095.08
Material cost decrease 10%	49.617	316.617	96.876	173.484	168.03	644.91	308.6	1163.64
Material cost increase 15%	63.4	313.86	123.786	146.574	214.7	598.24	394.31	1077.93
Material cost decrease 15%	46.86	330.4	91.494	178.866	158.7	654.24	325.73	1180.79
<b>Base Line</b>	<b>750</b>	<b>322.13</b>	<b>750</b>	<b>162.72</b>	<b>1800</b>	<b>626.24</b>	<b>3200</b>	<b>1129.36</b>
Price increase 10%	825	397.13	825	237.72	1980	806.24	3520	1449.36
Price decrease 10%	675	675	675	87.72	1620	446.24	2880	809.36
Price increase 25%	937.5	509.63	937.5	350.22	2250	1076.24	4000	1929.36
Price decrease 25%	562.5	134.63	562.5	<b>-24.78</b>	1350	176.24	2400	329.36

Source: Author's calculation

When price decrease by 25%. Profit is negative on unlisted medium specimen and it shows the lower profit than other scenarios.

## 4.2 Public laboratory

### 4.2.1 Full cost of public laboratory

The total direct cost of public laboratory was 12,374,841.66 baht. The material costs were 2,145,510.74 baht. The labor costs were 7,858,516.88 baht and the capital costs were 2,370,814.04 baht.

The total number of laboratory tests was 24044 tests. The total slides including HE, immunohistochemical stains, pap smear were 45952 slides. The number of histology tests was 15159 tests ( 7598 cases) . The number of cytology was 8848 tests, pap smear 7966 tests and fluid cytology 882 tests.

### 4.2.2 Unit cost of public laboratory compare to the CGD's price

Table 26: The unit costs of pathology examinations compare to the CGD's price.

	Labor cost	Material cost	Capital cost	Total cost	CGD Price	Profit
Unlisted small specimen	322.65	46.37	12.6	381.62	290	-91.62
Unlisted medium specimen	644.34	95.18	12.6	752.12	600	-152.12
Unlisted large specimen	1112.43	156.19	12.6	1281.22	1200	-81.22
Frozen	337.31	23.82	12.6	373.73	1395	1021.27
kidney with direct IF	459.18	373.61	12.6	845.39	2820	1974.61
Pap smear	84.40	9.76	12.6	106.76	120	13.24
Fluid cytology	128.77	76.88	12.6	218.25	600	381.75
ER	54.27	119.58	12.6	186.45	685	498.55
PR	54.27	140.33	12.6	207.2	685	477.8
HER2	54.27	302.62	12.6	369.49	890	520.51

Source: Author's calculation

#### 4.2.3 Sensitivity Analysis (public laboratory)

The analysis of sensitivity of public laboratory is shown in the table below.

Table 27: Sensitivity analysis of pathological examination of unlisted small specimen to unlisted large specimen of public laboratory.

Total cost	381.62		752.12		1281.22	
Setting	Unlisted small	Profit	Unlisted medium	Profit	Unlisted Large	Profit
<b>Base Line labor cost</b>	<b>322.65</b>	<b>-91.62</b>	<b>644.34</b>	<b>-152.12</b>	<b>1112.43</b>	<b>-81.22</b>
LC increase 10%	354.915	-123.885	708.77	-216.55	1123.673	-92.463
LC decrease 10%	287.1585	-59.355	579.91	-87.78	1101.187	-69.977
LC increase 20%	387.18	-156.15	773.208	-280.988	1334.916	-303.706
LC decrease 20%	258.12	-27.09	515.472	-23.252	889.944	141.266
<b>Base Line</b>	<b>46.37</b>	<b>-91.62</b>	<b>95.18</b>	<b>-152.2</b>	<b>156.19</b>	<b>-81.22</b>
Material cost increase 10%	51.007	-96.257	104.7	-161.64	174.86	-99.89
Material cost decrease 10%	41.733	-86.983	85.66	-142.6	137.52	-62.55
Material cost increase 15%	53.32	-98.57	114.22	-171.16	184.19	-109.22
Material cost decrease 15%	39.42	-84.67	76.14	-133.08	-133.08	-53.22
<b>Base Line</b>	<b>290</b>	<b>-91.62</b>	<b>600</b>	<b>-152.12</b>	<b>1200</b>	<b>-81.22</b>
Price increase 10%	319	-62.62	825	72.88	1320	38.78
Price decrease 10%	261	-120.62	675	-77.12	1080	-201.22
Price increase 25%	362.5	-19.12	937.5	185.38	1500	218.78
Price decrease 25%	232	-149.62	562.5	-189.62	900	-381.22

Source: Author's calculation

The profit show positive sign when price increase by 10% and 25% on Unlisted medium and large specimens. The rests are showing negative sign.



#### 4.3 Break-Even Analysis (Private Laboratory)

Break-even analysis was performed from private laboratory tests in 2016.

Number of unlisted small biopsy test in 2016 was 6144 tests. Figure 9 to figure 11 were unlisted small biopsy and analyzed comparing when the increasing number of slides in the test.

##### 4.3.1 Unlisted small biopsy (1 slide)

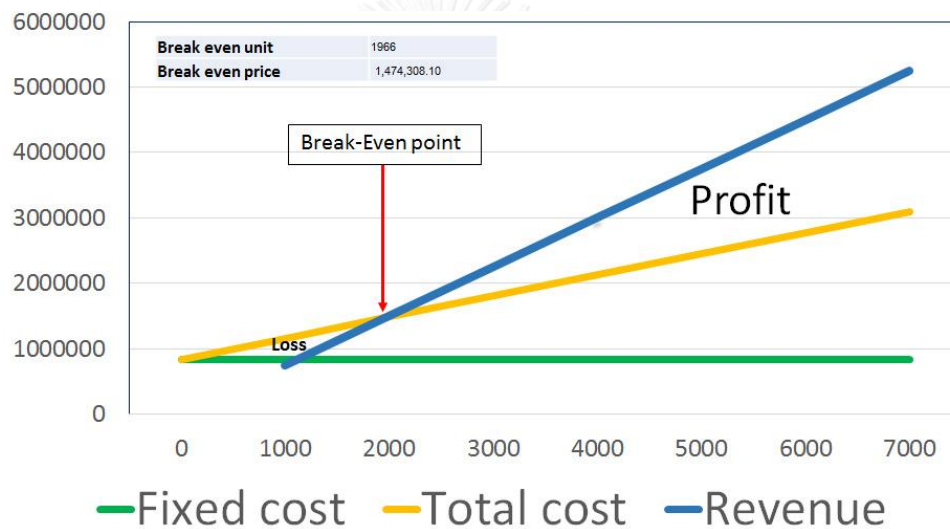


Figure 9: Unlisted small biopsy (1 slide)

Break-even point of this test when using 1 slide per test was 1966 units. Unit price is 750 baht.

#### 4.3.2 Unlisted small biopsy (2 slides)

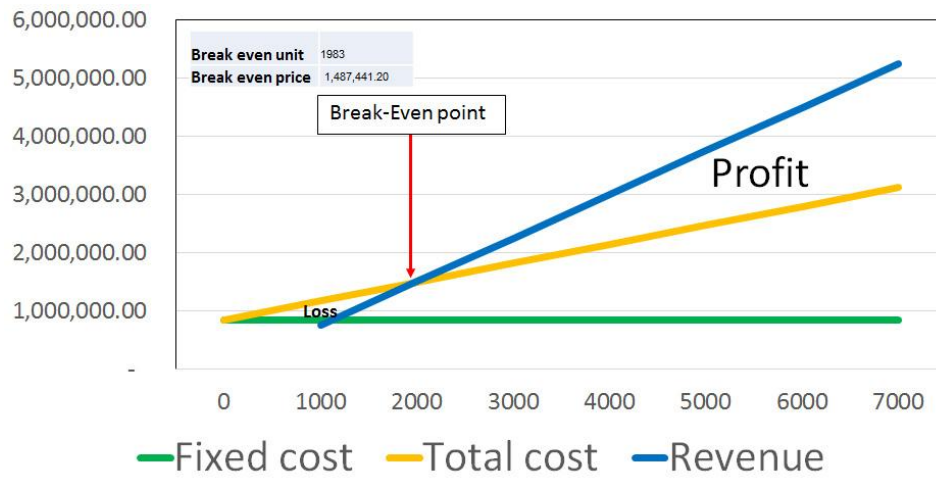


Figure 10: Unlisted small biopsy (2 slides)

Break-event point of this test when using 2 slide per test was 1983 units. Unit price is 750 baht.

#### 4.3.3 Unlisted small biopsy (4 slides)

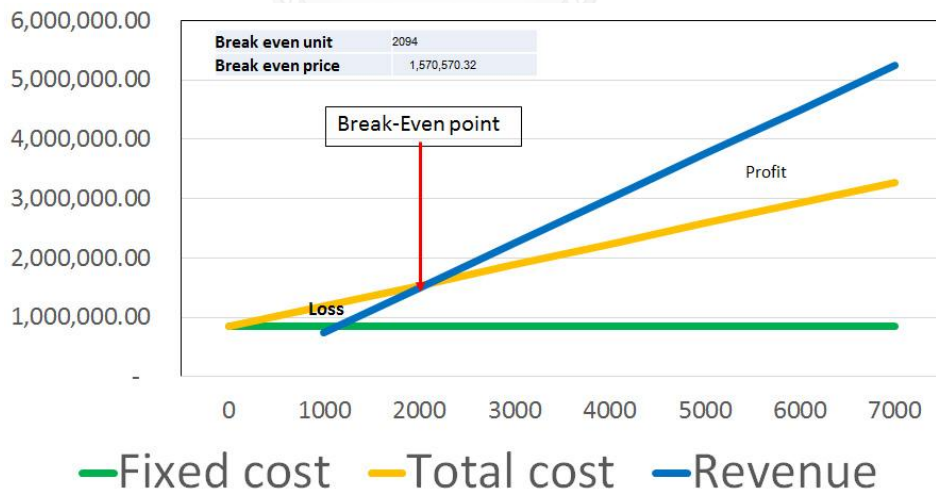


Figure 11: Unlisted small biopsy (4 slides)

Break-event point of this test when using 4 slides per test was 2094 units. Unit price is 750 baht.

#### 4.3.4 Unlisted medium specimen (6 slides)



Figure 12: Unlisted medium specimen (6 slides)

Break-event point of this test when using 6 slides per test was 891 units.

Unit price is 750 baht.

#### 4.3.5 Unlisted medium specimen ( 15 slides )

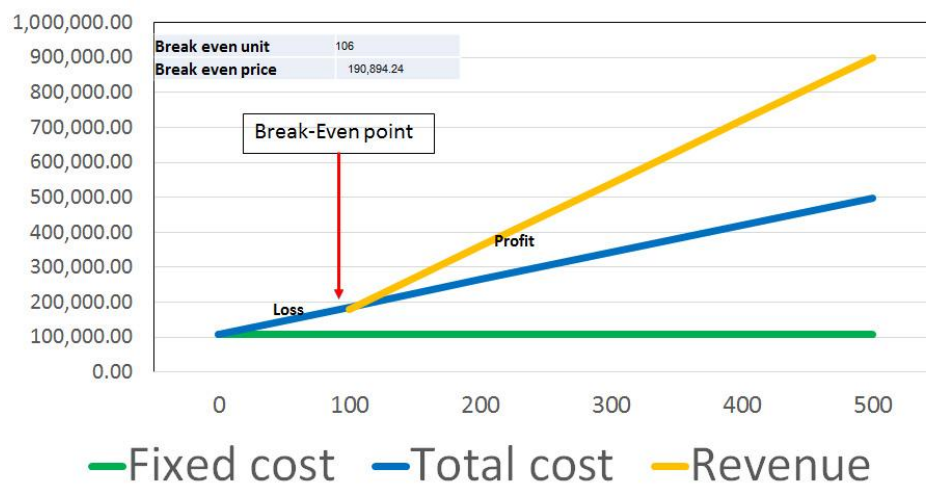


Figure 13: Unlisted medium specimen ( 15 slides )

Break-event point of this test when using 15 slides per test was 106 units. Unit price is

1800 baht.

#### 4.3.6 Unlisted large specimen (30 slides)

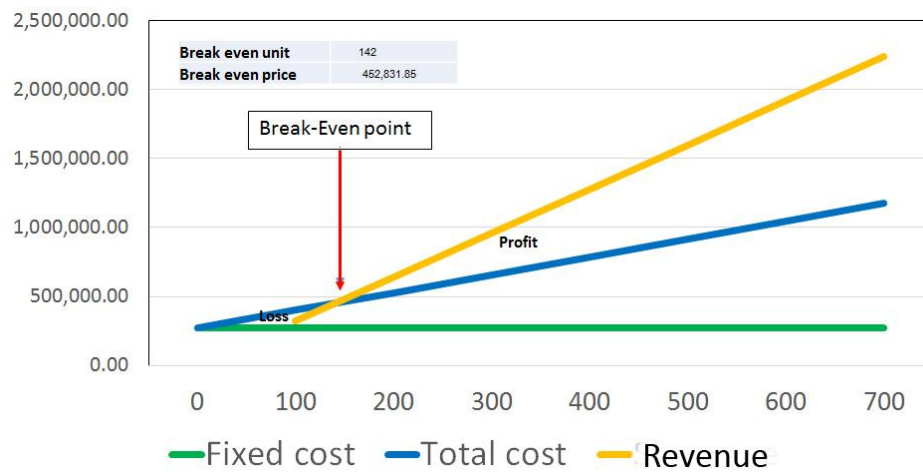


Figure 14: Unlisted large specimen (30 slides)

Break-event point of this test when using 30 slide per test was 142 units.

Unit price is 3200 baht.

#### 4.3.7 Appendix

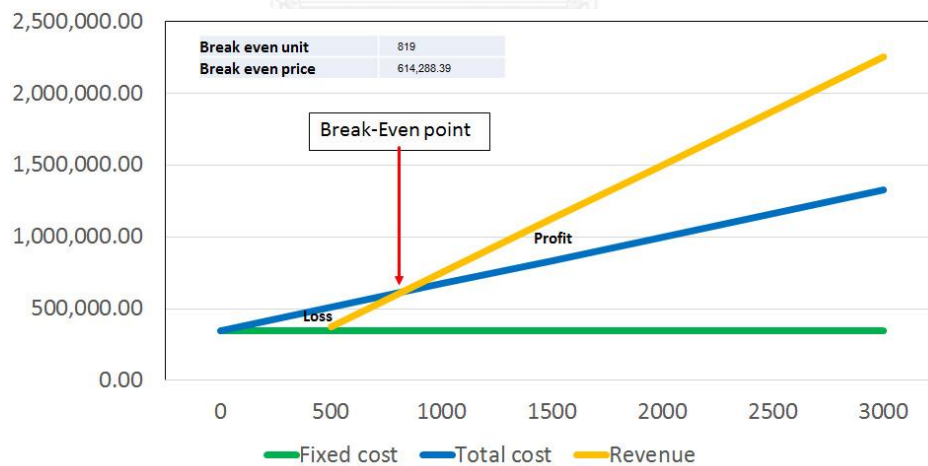


Figure 15: Fig 13. Appendix

Break-event point of this test when using 2 slides per test was 819 units. Unit price is

750 baht.

#### 4.3.8 Gallbladder

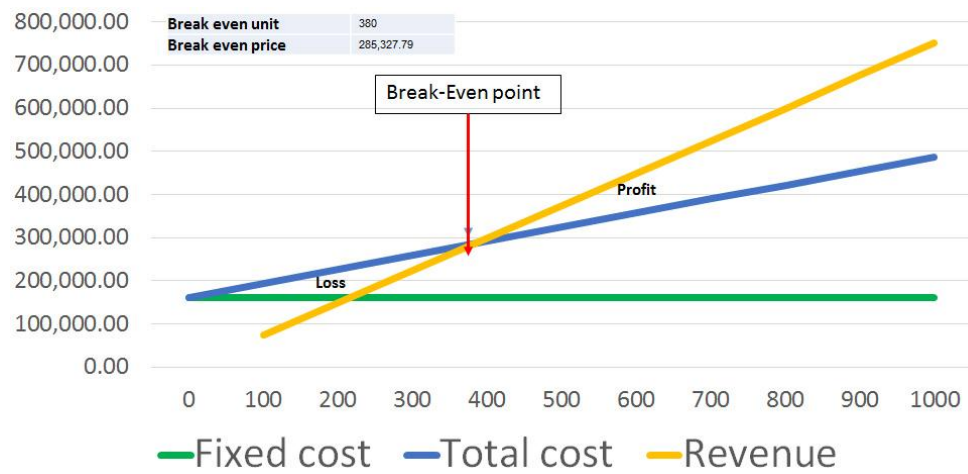


Figure 16: Gallbladder

Break-event point of this test when using 2 slides per test was 380 units. Unit price was 750 baht.

#### 4.3.9 Kidney biopsy with direct immunofluorescence.



Figure 17: Kidney biopsy with direct immunofluorescence.

Break-event point of this test was 27 units. Number of tests in 2016 was 822 tests.

#### 4.3.10 Frozen Section

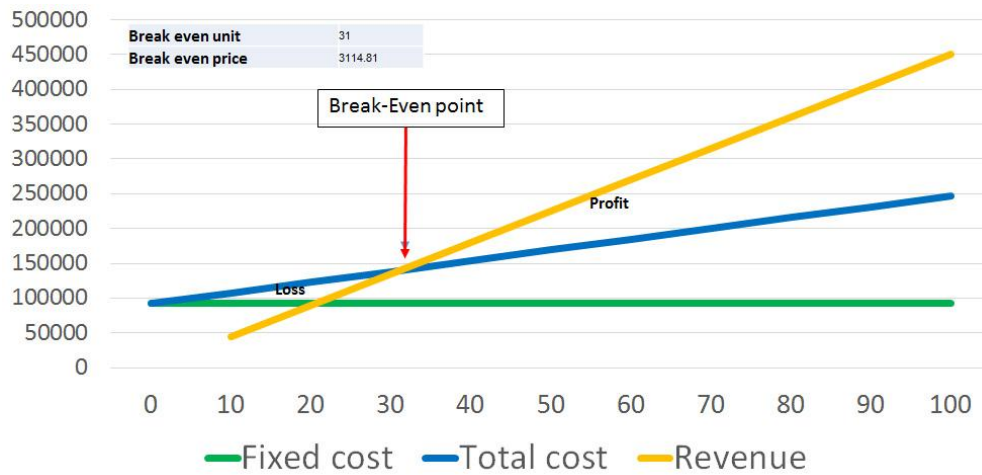


Figure 18: Frozen section

Break-event point of this test was 31 units. Number of this test in 2016 was 401 tests.

#### 4.3.11 Pap smear

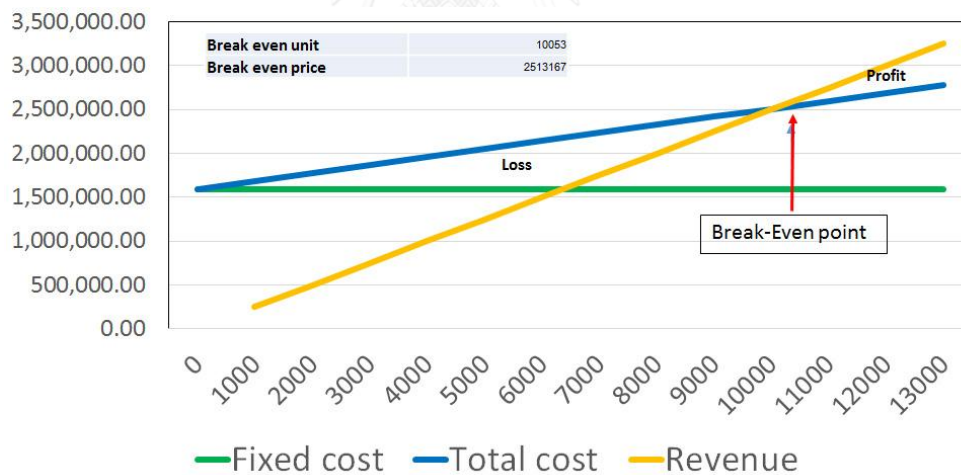


Figure 19: Pap smear

Break-event point of this test was 10053 units. Number of this test in 2016 was 12722 tests.

#### 4.3.12 Fluid cytology

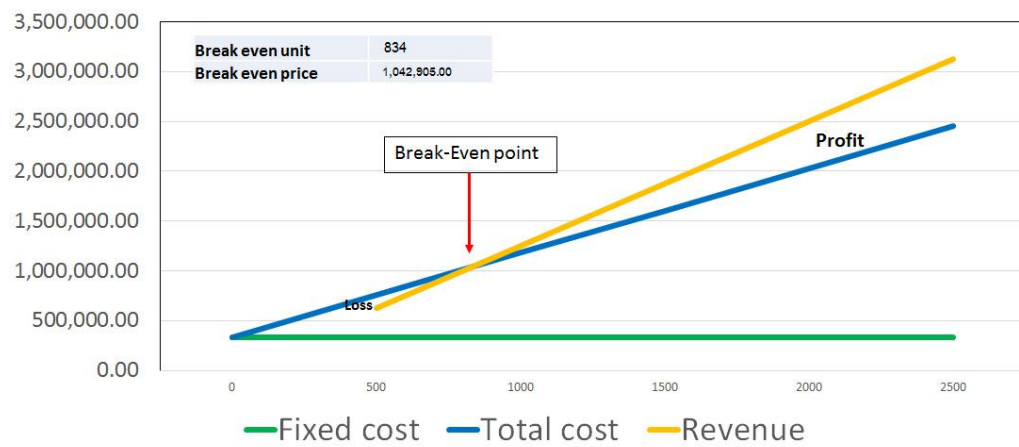


Figure 20: Fluid cytology

Break-event point of this test was 834 units. Number of this test in 2016 was 834 tests.

#### 4.3.13 Special stains



Figure 21: Special stains

Break-event point of this test was 1162 units. Number of this test in 2016 was 717 tests.



#### 4.3.14 Immunohisto-ER

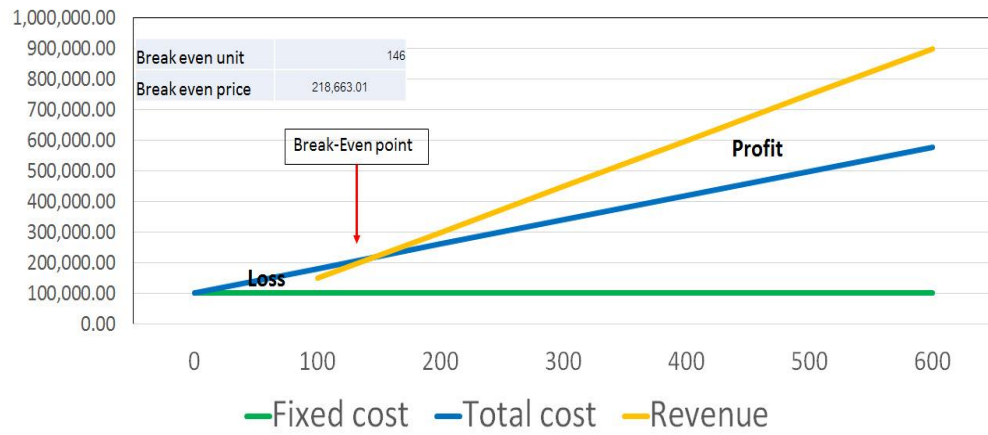


Figure 22: Immunohisto-ER

Break-event point of this test was 146 units. Number of this test in 2016 was 488 tests.

#### 4.3.15 Immunohisto-PR

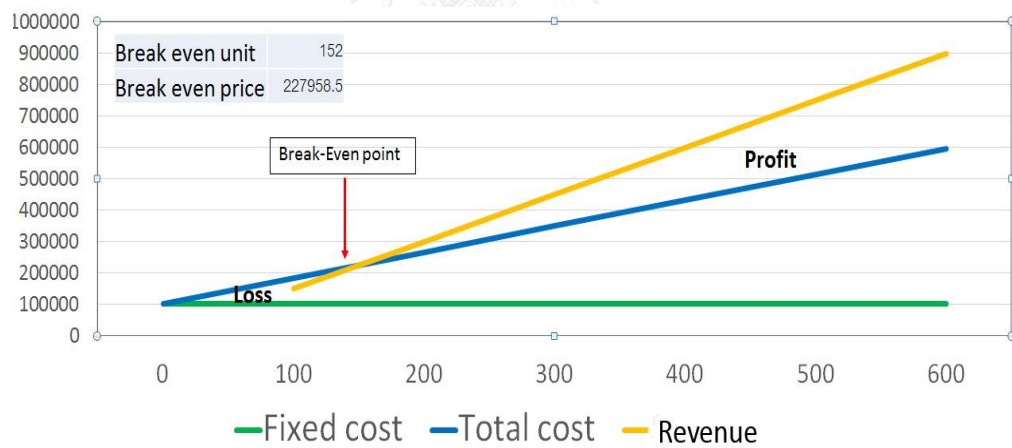


Figure 23: Immunohisto-PR

Break-event point of this test was 152 units. Number of this test in 2016 was 488 tests.



#### 4.3.16 Immunohisto-HER2

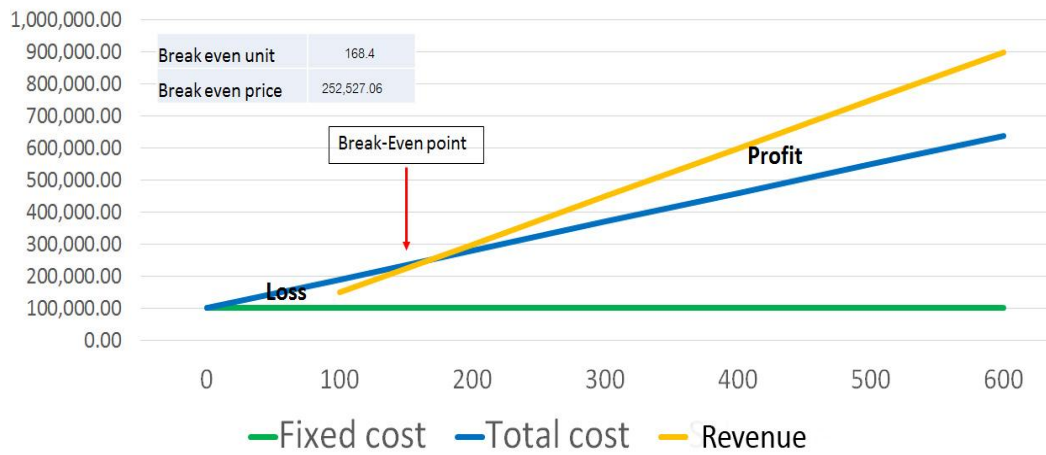


Figure 24: Immunohisto-HER2

Break-even point of this test was 168 units. Number of this test in 2016 was 474 tests.

#### 4.3.17 Immunohisto-Ki-67

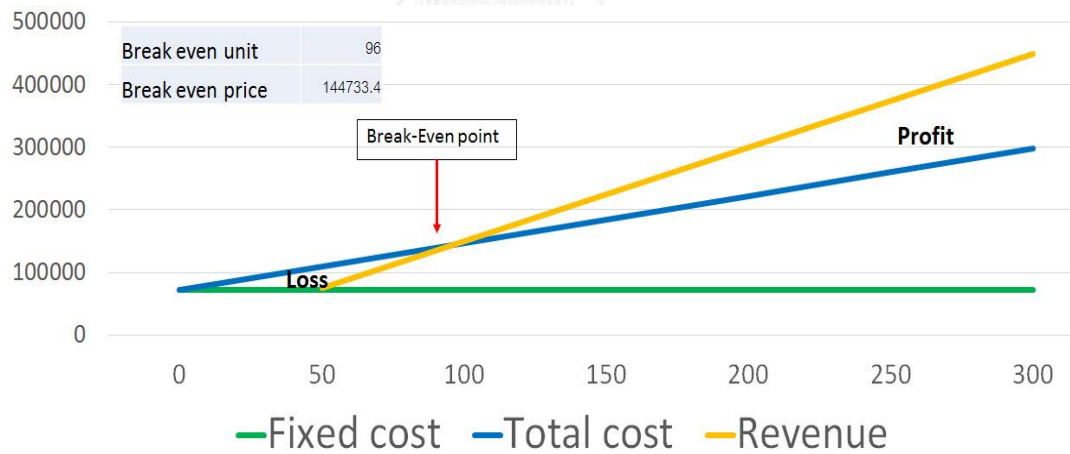


Figure 25: Immunohisto-Ki-67

Break-even point of this test was 96 units. Number of this test in 2016 was 250 tests.

#### 4.3.18. Immunohisto- p53

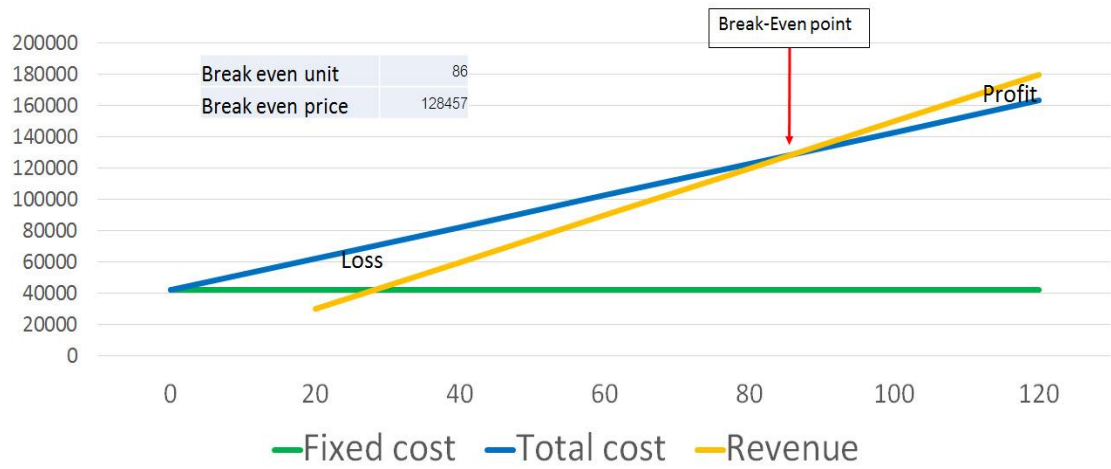


Figure 26: Immunohisto-p53

Break-event point of this test was 86 units. Number of this test in 2016 was 18 tests.

#### 4.3.19. Immunohisto-CKHMW

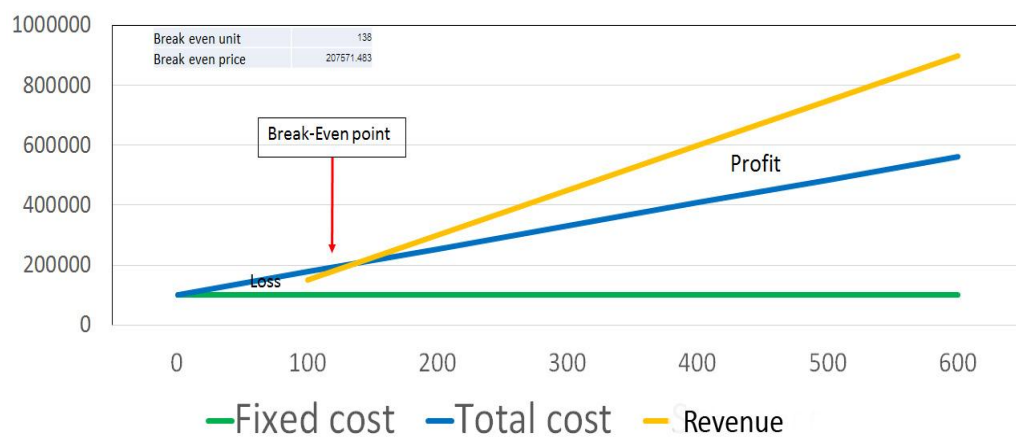


Figure 27: Immunohisto-CKHMW

Break-event point of this test was 138 units. Number of this test in 2016 was 474 tests.

#### 4.3.20. Immunohisto-ALKD5F3

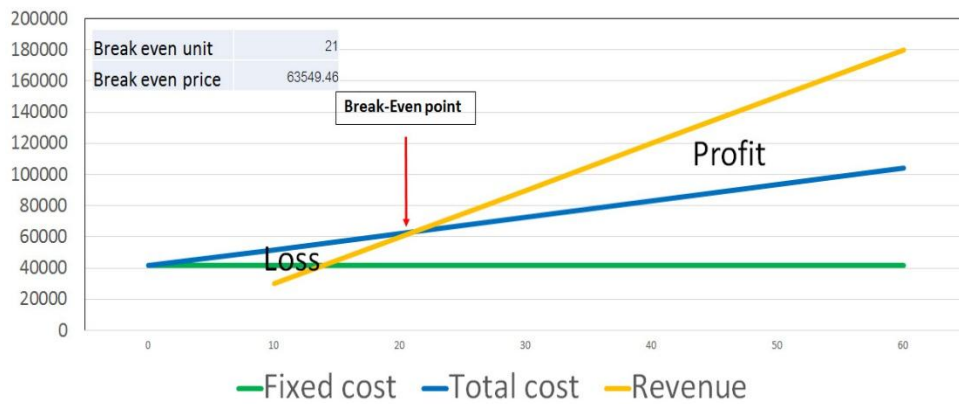


Figure 28: Immunohisto-ALKD5F3

Break-event point of this test was 21 units. Number of this test in 2016 was 14 tests.

#### 4.3.21. Immunohisto-C4D



Figure 29: Immunohisto-C4D

Number of this test in 2016 was 46 tests. There is no break –even point in this tests due to the price is not relevant with the cost of this tests.

#### 4.3.22. Immunohisto-CK20



Figure 30: Immunohisto-CK20

Break-event point of this test was 59 units. Number of this test in 2016 was 11 tests.

#### 4.3.23 Immunohisto-CK7

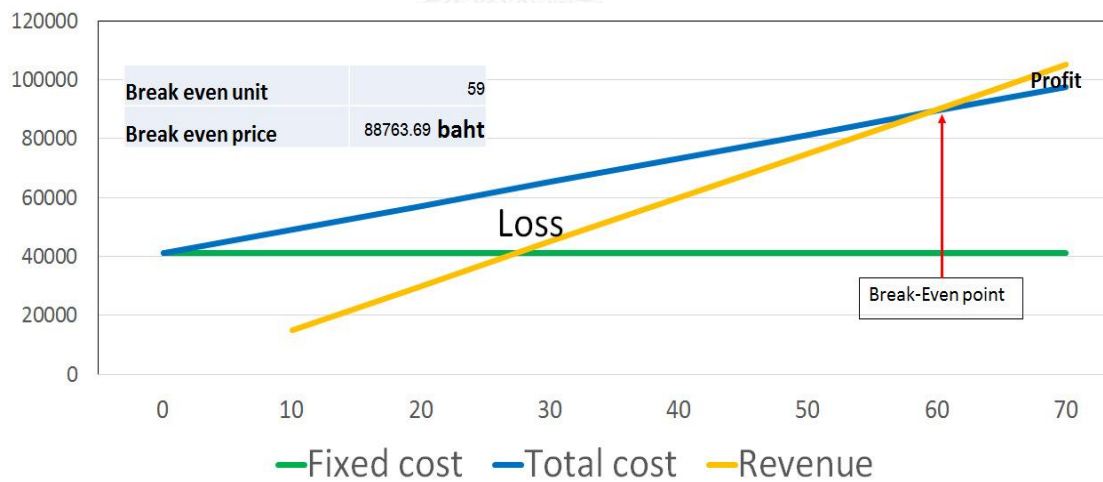


Figure 31: Immunohisto-CK7

Break-event point of this test was 59 units. Number of this test in 2016 was 13 tests.

## CHAPTER 5 DISCUSSION AND CONCLUSION

### 5.1 Discussion

This study focused on cost analysis of anatomical pathology laboratory and unit cost costs of pathology examinations. Financial data and service statistics of private laboratory were collected retrospectively and laboratory activities were observed during data collecting by the researcher. Financial data and service statistics of public laboratory were obtained from the previous study of Hospital cost analysis and the annual report of the hospital (Khotthong, 2015). Total direct cost of the laboratories were calculated according to each of cost components (labor costs, material costs and capital costs). In order to calculate the unit cost of pathology examination, total direct cost in 2016 are the sum of the operating cost and supporting cost. The operating cost calculated by classification of the activities in the laboratory divided by output of that activities and total indirect cost (supporting cost) divided by total laboratory.

The total direct costs were found 131,391,274.70 baht. in private laboratory and 12,374,841.66 baht in public laboratory. In private laboratory, the highest cost was found in labor cost 65,535,577.75 baht (49.88% of the total). The percentage of labor costs: material cost: capital costs was found to be 49.88%, 48.2% and 1.91%. However, the increasing in cost on labor and material are not the cause of negative profit of the company but this did effect on the profit goal. In public laboratory, the

highest cost was also found in labor cost 7,858,516.88 baht. Among the cost component of histopathology, the study found that supporting cost represent highest proportion, 70.37%. Also found in the cost component of cytopathology, the supporting cost revealed the highest percentage of 53.66%.

In private laboratory, the operating cost was found 105,509,380.12 baht. The material cost 49,795,988.80 baht (47.19%) represent the highest cost of the total operating cost. This high costs due to the number of laboratory tests and the laboratory management.

The unit costs of pathology tests were found that HER2 GENE 9,961.12 baht was the highest cost of private laboratory and kidney with immunofluorescence 845.39 baht was the highest cost of public laboratory. The lowest cost was found in Pap smear 217 baht in private and 106.76 baht in public laboratory.

The unit cost of private laboratory compare to the company's price were found most of them are positive profit except for C4D and special stain (average all special stain tests). Comparison of the unit cost with the CGD's price was found to be negative profit except the C4d and HER2 GENE. The setting of C4D price of private is not relevant with the unit cost and the HER2 GENE is the new test and the CGD's price was sent to relevant to the actual unit and negative profit when compare with the company's price list but positive profit when compare with the CGD's price list. In some way, company offers the lower than the CGD's price lists for competition in order to get the

higher number of laboratory test (volume) this eventually have an effect to the profit of the company.

The unit costs of public laboratory were found to be negative sign for surgical specimens compare with the CGD's price lists.

As the aboved paragraphs the labor costs were found to be the highest cost in both private laboratory and public laboratory in every activities. Cost of labor and material will vary by the unit of output in each activity.

Break-even analysis of private pathology laboratory of the tests in 2016 indicate that increasing in number of tests will gain more profit. The C4d test was the only test that face loss in all unit because of the setting of the price is not correct and it is lower than the CGD's price.

This study was a provider perspective and it was analyzed only direct cost of the laboratory. However, the study provides some information in relevant to the cost in each activity.

## 5.2 Conclusion

Among laboratory medicines, Pathology laboratory is one important unit in hospital setting and healthcare system. Pathology laboratory plays the vital role in cancer treatment and the other diseases. Pathology results remain the gold standard to diagnosis carcinoma.

The main principle of the pathology laboratory is not just only to find the cancer in the examination of human living tissue and fluid but to make a definite diagnosis and be consultation for clinician and physician.

Public hospitals are the payer for public side and there are different scheme for reimbursement, one of that using the CGD's price.

The objective of this study was to calculate the cost of pathology laboratory and unit cost of laboratory tests in private and public laboratory. Then compare the unit cost to the CGD's price lists. The results of this study are useful for company management and policy makers to understand the resource of pathology laboratory, price setting, market strategy and competition in order to achieve the company's goals.

The resources used in private laboratory were higher than the public laboratory due to the amount of laboratory tests.

In this study, the unit costs of pathology examination of surgical specimens were found to be negative comparing with the CGD's price lists both in private and public laboratory.

The units cost of surgical specimen which are unlisted small specimen, unlisted medium specimen and unlisted large specimens are as follow

Private laboratory.

Unlisted small specimen was 427.87 baht.

Unlisted medium specimen was 1173.76 baht.

Unlisted large specimen was 2070.64 baht.



Public laboratory.

Unlisted small specimen was 381.62 baht.

Unlisted medium specimen was 752.12 baht.

Unlisted large specimen was 1281.22 baht.

The CGD's price for the specimens above are 290, 600 and 1200 baht in which are lower than the total costs of both laboratories.

### 5.3 Limitation of the study

This study has a lot of limitations according to the unavailability of the complete data, one in accessing to the whole data of public laboratory of anatomical laboratory in public site was obtained from only one of the previous study. Therefore the sensitivity analysis was performed in the study.

This is the first formal study of pathology laboratory tests in Thailand since there is no other study regarding the cost analysis of anatomical pathology laboratory in Thailand in order to compare the result.

The data in public anatomical laboratory is not available to calculate completely in all activities and processes. The calculation was estimated base on unit cost of material items in private laboratory. The method for calculation of capital cost in private was not the same as public laboratory. The process of histology and cytology is similar but details of each activity and cost components are different between private and public laboratory.

#### 5.4 Recommendation

In order to expand the service and reduce the cost of anatomical pathology; analysis of the factor that effect to the unit cost of pathology together with finding the method to control the cost of pathology laboratory in each activity are suggested to perform beneficial to reduce the cost of laboratory. For instance, set up the plan for reducing the unnecessary recut slides or repeating laboratory tests.

Cost analysis is useful to private and public side and laboratory medicine like anatomical pathology should perform their own cost analysis in order to manage and improve the quality and efficiency of laboratory tests and cost reduction. The direct cost allocation method is suitable for private while for public laboratory should consider the other cost allocation methods. The CGD's price listed needs to be revised in order to reflect the real cost of pathology examination.

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APPENDIX

The CGD's price lists of anatomical pathology services.

Table 28: The CGD's price lists of anatomical pathology services.

รหัส	ชื่อรายการ	ราคา
38516	34-beta-E12	420
38002	Adenoid gland	600
38002	Adrenal gland, adrenalectomy	600
38504	AE1/AE3 (cytokeratin)	360
38301	AFB	75
38505	AFP	350
38301	Alcian blue	75
38506	ALK protein	505
38507	Alpha-Inhibin	470
38106	Appendix, appendectomy	290
38512	Bcl-2	435
38513	Bcl-6	505
38562	Beta-catenin	420
38518	Beta-hCG	350
38002	Biopsy หรือชิ้นเนื้อที่มีความยาว 2-5 ซม.	600
38001	Biopsy หรือชิ้นเนื้อที่มีความยาวมาก	290
38003	Biopsy หรือชิ้นเนื้อที่มีความยาวมากกว่า 5 ซม.	1,200
38001	Biopsy หรือชิ้นเนื้อที่มีความยาวไม่เกิน 2 ซม.	290
38521	BOB-1	650
38190	Bone (tumor : en bloc resection)	2,880
38191	Bone marrow biopsy	290
38223	Breast (core needle biopsy, multiple)	1,440
38221	Breast (mass, excision, > 5 cm)	1,200
38220	Breast (mass, excision, 2-5 cm)	600
38222	Breast (mass, excision, less than 2 c	290
38224	Breast (simple mastectomy)	1,440
38225	Breast(mastectomy) with axillary content	2,880
38225	Breast, mastectomy (simple, radical,	2,880
38999	C4d	2,400
38527	Calretinin	470
38535	CD10	520
38552	CD117 (c-kit)	675

38999	CD123	625
38553	CD138	375
38536	CD15	360
38999	CD19	640
38530	CD1a	865
38552	CD2	675
38537	CD20	435
38538	CD21	360
38539	CD23	590
38531	CD3	520
38540	CD30	400
38571	CD33	520
38542	CD34	470
38648	CD38	540
38532	CD4	505
38544	CD43	410
38545	CD45 (LCA)	410
38533	CD5	480
38546	CD56	420
38547	CD57	495
38656	CD61	375
38548	CD68 KP1	385
38548	CD68 PGM	385
38594	CD7	520
38550	CD79a	480
38534	CD8	580
38551	CD99	435
38557	CDX-2	385
38558	CEA	385
38181	Cervical conization, LEEP	1,440
38181	Cervix, conization/LEEP/LLETZ	1,440
38560	Chromogranin A	540
38564	CK-19	420
38565	CK-20	410
38562	CK-7	420
38566	CMV	385
38567	c-Myc	480
38107	Colon, colectomy	1,440
38108	Colon, colectomy	2,880

38108	Colon, colectomy with node dissection	2,880
38301	Congored	75
38301	Crystal violet	75
38002	Curettage, each specimen	600
38640	CXCL13	555
38571	Cyclin D1	520
38999	D2-40	550
38301	Deeper cut	75
38572	Desmin	410
38578	E-cadherin	435
38301	Elastic	75
38580	EMA	340
38002	Endocervix, curettage	600
38002	Endometrium, curettage	600
38582	ER	685
38100	Esophagus, esophagectomy	1,440
38101	Esophagus, esophagectomy	2,880
38101	Esophagus, esophagectomy with node di	2,880
38006	Excisional biopsy with margin examination	1,200
38210	Extremities, amputation with tumor	3,600
38211	Extremity, amputation (non tumor)	2,880
38210	Extremity, amputation (tumor)	3,600
38040	Eye ball, enucleation	600
38041	Eye ball, excenteration	1,200
38583	Factor VIII	375
38174	Fallopian tube, salpingectomy	290
38174	Fallopian tube, tubal pregnancy	290
38173	Fallopian tube, Tubal sterilization	290
38210	Femur/leg amputation, bone and soft tissue tumor	3,600
38301	Fite	75
38301	FNA, body fluid	600
38301	Fontana	75
38010	Frozen section (คิดเป็นราย)	1,395
38124	Gallbladder	600
38589	GCDFP 15	480
38590	GFAP	400
38301	Giemsa	75
38592	Glycophorin A (CD235)	460
38527	Glypican-3	470



38301	GMS	75
38401	GMS/IRON เฉพาะสไลด์เคมียัวร์	75
38594	Granzyme B	520
38596	H.pylori	385
38080	Heart valve	1,200
38602	Hepatocyte	445
38603	HER2	890
37999	HER2DISH	12,000
38604	HHF-35 (MSA)	410
38606	HMB45	435
38999	IDH1 R132H	865
38610	IgA	340
38612	IgG	340
38999	IgG4	505
38613	IgM	300
38141	Immunofluorescence	2,820
38999	INI1	520
38301	IRON	75
38004	Jaw/mandible, resection	1,440
38005	Jaw/mandible, resection with neck content	2,880
38615	Kappa	340
38618	Ki-67 (MIB-1)	470
38140	Kidney needle biopsy	900
38141	Kidney needle biopsy (with Direct IF)	2,820
38142	Kidney, nephrectomy	1,440
38142	Kidney, nephrectomy and partial	1,440
38143	Kidney, wedge biopsy	600
38619	Lambda	360
38108	Large intestine, resection	2,880
38004	Larynx, laryngectomy	1,440
38005	Larynx, laryngectomy with neck content	2,880
38211	Leg, amputation (AK, BK) for non-tumo	2,880
38211	Leg, amputation for gangrene	2,880
	Liquid-based Pap smear	720
38121	Liver needle biopsy	600
38123	Liver resection	1,440
38122	Liver wedge biopsy	600
38123	Liver, resection	1,440
38999	LMP-1	300

38071	Lung, lobectomy	1,440
38072	Lung, lobectomy with lymph nodes	2,880
38070	Lung, wedge biopsy	1,200
38090	Lymph node, radical dissection	1,440
38301	Masson	75
38625	Melan-A	480
38524	MLH1	530
38524	MSH2	530
38524	MSH6	530
38301	Mucin	75
38631	MUM-1	495
38200	Muscle biopsy	600
38201	Muscle biopsy with special study	2,880
38633	Myeloperoxidase (MPO)	375
38634	MyoD1	460
38634	Myogenin	460
38999	Napsin A	450
38020	Nerve with resin study	1,620
38640	NSE	555
38130	Omentectomy	600
38130	Omentum, omentectomy	600
38172	Ovarian mass	1,440
38172	Ovary, oophorectomy for tumor	1,440
38999	P16	500
38646	p53	470
38648	P63	540
38301	PAMS	75
38002	Paraffin block 1 block	600
38003	Paraffin block 2 block ขึ้นไป	1,200
38003	Paraffin block ตั้งแต่ 2 block ขึ้นไป	1,200
38005	Parotid/salivary gland with neck node	2,880
38301	PAS	75
38301	PASD	75
38532	PAX5	505
38170	Pelvic exenteration	3,600
38004	Penis, amputation	1,440
38005	Penis, amputation with groin nodes	2,880
38003	Placenta, whole	1,200
38654	PLAP	385

38539	PMS2	590
38539	PMS2	590
38658	PR	685
38152	Prostate gland, prostatectomy for BPH	1,200
38153	Prostate gland, prostatectomy with node dissection	2,880
38153	Prostate gland, prostatectomy with ra	2,880
38151	Prostate gland, prostatic chips (TUR	1,740
38151	Prostate gland, TUR-P/prostatectomy	1,740
38150	Prostate, needle biopsy	1,200
38660	PSA	350
38109	Rectum	1,440
38110	Rectum with node dissection	2,880
38110	Rectum, resection	2,880
38301	Reticulin	75
38664	S-100	375
38005	Salivary gland with neck node	2,880
38230	Skin biopsy (Dermatosis)	600
38104	Small bowel, resection	1,440
38105	Small bowel, resection	2,880
38105	Small bowel, resection with node diss	2,880
38671	Smooth muscle actin (SMA)	375
38301	Spirochete	75
38004	Spleen, resection/splenectomy	1,440
38102	Stomach, gastrectomy	1,440
38103	Stomach, gastrectomy	2,880
38103	Stomach, gastrectomy with node dissec	2,880
38676	Synaptophysin	435
38999	TCR Beta F1	675
38640	TCR Gramma+Delta	555
38678	TdT	805
38160	Testis, unilateral or bilateral orchi	600
38031	Thyroid gland with node dissection	2,880
38030	Thyroid gland, lobectomy/subtotal/total	1,440
38030	Thyroidectomy (lobectomy or subtotal	1,440
38031	Thyroidectomy with node dissection	2,880
38681	TIA-1	470
38005	Tongue with neck nodes	2,880
38060	Tonsil, each specimen	290
38060	Tonsils, tonsillectomy	290

38682	TTF-1	480
38144	Urinary bladder, cystectomy	1,440
38145	Urinary bladder, cystectomy with/without lymph nodes	2,880
38146	Urinary bladder, cystoscopic biopsy	290
38147	Urinary bladder, TUR-BT	600
38147	Urinary bladder, TUR-tumor	600
38176	Uterus with cervical conization	2,880
38176	Uterus with cervical dysplasia	2,880
38177	Uterus with multiple groups of lymph	2,880
38171	Uterus with multiple groups of lymph nodes	3,600
38180	Uterus with or without adnexa	1,440
38178	Uterus with ovarian tumor	2,880
38179	Uterus, hysterectomy (TAH)	1,200
38180	Uterus, hysterectomy with adnexa	1,440
38161	Vas deferens, vasectomy	290
38161	Vasectomy (unilateral or bilateral)	290
38687	Villin	400
38688	Vimentin	435
38004	Vulva, vulvectomy	1,440
38005	Vulva, vulvectomy with lymph nodes	2,880
38171	Wertheim's operation	3,600
38120	Whipple's operation	2,880
38120	Whipple's specimen	2,880
38689	Wilms' tumor	445
38302	การตรวจเซลล์วิทยา - Gynecological	120
38301	การตรวจเซลล์วิทยา - Non-Gynecological	600
38010	การตรวจด้วยวิธี Frozen section	1,395
38005	อวัยวะหรือส่วนของอวัยวะที่ต้องเลาะต่อมน้ำเหลือง	2,880
38004	อวัยวะหรือส่วนของอวัยวะที่ไม่ต้องเลาะ	1,440

Source: <http://www.pathology.psu.ac.th/index.php/18-services/apservice/199-aptests>

## Material, equipment and capital for step in processing surgical specimen

Table 29: Specimen received materials and equipment.

เครื่องมือ/อุปกรณ์	Price/Depreciation (baht)
ตะกร้า	120
ภาชนะสแตนเลสใส่ชิ้นเนื้อขนาดใหญ่	0
แก้วสแตนเลสใส่ชิ้นเนื้อที่บรรจุมาในถุง	0
กรรไกร	28
คัตเตอร์	33
post-it เพื่อซีบ่ง case RR	100
computer 3 เครื่อง	2426.47
Barcode Printer 3 เครื่อง	14.64
Barcode Reader 2 เครื่อง	9.76
-sticker size 2x5cm	3424
-ตัวตอกเบอร์ 2 ตัว	0
-แท่น stamp วันที่รับตัวอย่าง	0
-ตารางประทับวันที่	0
-หมึกเติมสีแดงและสีดำ	22.5
-ปากกา pilot ปากเล็กสีแดงและสีดำเพื่อเขียน HX และ HB บนใบ request	174
-คลิปหนีบกระดาษ	120
-หนังยาง	300
-กระดาษสำหรับพิมพ์หมายเลขใส่ block	96
รถเข็น 4 คัน	349.93 baht
ภาชนะสแตนเลสใส่ชิ้นเนื้อ	0

Table 30: Gross Examination materials and equipment.

เครื่องมือ/อุปกรณ์	Price/Depreciation(baht)
trimming path hood 2 เครื่อง	70081.82
อุปกรณ์ผ่าตัด forcept มีดเล็ก มีดใหญ่	23573
กล้องถ่ายภาพรูป 2 ตัว	1609.56
โต๊ะวางเนื้อสำหรับถ่ายภาพ	1
ขาตั้งไฟสำหรับถ่ายภาพ	1
ไม้บรรทัด	0
เครื่องชั่งน้ำหนัก	670.64
เขียง	0
ตลับใส่เนื้อสีต่างๆ	67666.87
ขวดใส่ formalin	0
Indian ink	480
เลื่อย	0

Table 31 : Tissue processing materials and equipment.

เครื่องมือ/อุปกรณ์	Price/Depreciation (baht)
Tissue process machine 2 เครื่อง	127,132.44
Formalin (2 ตะกร้า/เครื่อง ตะกร้าละ 1 kg)	28.90 baht/kg
95%alcohol (2 ตะกร้า/เครื่อง ตะกร้าละ 1 kg)	56.00 baht/kg
Absolute (2 ตะกร้า/เครื่อง ตะกร้าละ 1 kg)	157.00 baht/kg
Acitone (2 ตะกร้า/เครื่อง ตะกร้าละ 1 kg)	71.00 baht/kg
Xylene (2 ตะกร้า/เครื่อง ตะกร้าละ 1 kg)	72.28 baht/kg
Paraplast (2 ตะกร้า/เครื่อง ตะกร้าละ 1 kg)	205.47 baht/1000ml

Table 32: Tissue embedding materials and equipment

เครื่องมือ/อุปกรณ์	Price/Depreciation (baht)
embedding machine 2 เครื่อง	170546.53 baht
paraplast dispensor	90510.1330 baht
mold ขนาดต่างๆ สำหรับ embedding	0
forcept	0
มีดสำหรับตัดแต่ง tissue block	0
Paraplast (5ml/1cassette)	205.47 baht/1000ml
Embeding cassettes	1.2 baht/Cassette

Table 33: Paraffin block sectioning materials and equipment.

เครื่องมือ/อุปกรณ์	Price/Depreciation (baht)
microtrome 3 เครื่อง	106184.56
slide frosted	0.49/slide
microtrome blade	347389.92
cool plate 1 เครื่อง	1513.92
hot plate 2 เครื่อง	221.87
oven 2 เครื่อง	4.88x2
rack ใส่สไลด์เพื่อย้อม	1745.66
water bath 3 เครื่อง	9.76
ดินสอ	1161.25
oven high temperature 1 เครื่อง	4.88
Gelatin fluga	8.13 baht/ 1 gram

Table 34 : H&amp;E staining materials and equipment.

เครื่องมือ/อุปกรณ์	Price/Depreciation (baht)
staining machine 1 เครื่อง	141009.81
jar ใส่สีย้อมเนื้อเยื่อ manual	
mounting medium	29532
ขวดใส่ mounting medium	0
cover glass size 20x50	0.94 each
cover glass size 20x60	0.89 each
ภาชนะใส่สไลด์	11235
oven low temperature	4.88
sticker size 2x2.5 cm.	5617.5
Hematoxylin	1.93/CC
Eosin	1.55/CC
95%Alcohol	0.55/CC

Table 35: Diagnosis and reporting materials and equipment.

เครื่องมือ/อุปกรณ์	Price/Depreciation (baht)
Microscope 11 ตัว	7638.41
Computers 6 เครื่อง	29.28
Printer	0
Ink-Printer	93585.1
Papers	0.14/each

Table 36: Indirect material and capital for histology.

เครื่องมือ/อุปกรณ์	Price/Depreciation (baht)
Indirect capital	
MICROSCOPE UNIT	
Refrigerator 2 door Z-Cool 2-8	
Digital Weight BSA3202S-CW	
Std. Chemical Cabinet Steelab	
UNIVERSAL CASSETTE CLAMP	
UNIVERSAL CASSETTE CLAMP	
FUME HOOD	
Renovate Lab	
	Total Depreciation 52,044.3
Indirect material	
Mask	
Tissue Hand towel	
Gown	
Glove	
Cap	
Clip	
Tape	
Gauze	
	Total price 156,232.96



Table 37: Direct Material and capital for cytology

เครื่องมือ/อุปกรณ์	Price/Depreciation (baht)
SurePath	3067985.919
ThinPrep Pap smear	19207461.08
Fluidy Cytology (ThinPrep)	2336809.934
Other test	820228.3166
95 % Alcohol	0.07 / cc
Ethyl Alcohol	0.16/cc
Xyline	53290.45
Mouthing Medium	6848
Microscopes 5 ตัว	917.16

Table 34: Indirect Material and capital for cytology

เครื่องมือ/อุปกรณ์	Price/Depreciation (baht)
Indirect material Cover Slip 24 x 60 mm. Sticker Pen Pencil Filter Thinprep Rack Tissue Hand towel	Total 83,728.7 baht
Indirect capital Auto Pipette 0.5-10 UL Proline Pipette 0.5-10UL  Refrigerator 2 door Z-Cool 2-8 Renovate lab	Total depreciation 4,917.25

Table 35: Reagents for Special stain, Immunohistochemistry and HER2 GENE DISH

เครื่องมือ/อุปกรณ์	Price (baht)
PAS	1402.105
AFB	3937.6
GMS	1679.82
Giemsa	2553.62
Masson Trichome	8079.44
Alcian Blue	3599
Mucin	2942.5
ER	180720
PR	194826.61
HER2	226880.5
Ki67	101869.83
P53	12453.9
CKHMW	166693
ALKD5F3	13780.9
C4D	75369.84
CK20	4695.68
CK7	5549.44

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