Original Article

A Time-and-Motion Study to Increase the Efficiency among Service Levels of Various Scaled Hospitals in Thailand : A Case Study

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This study was the experience of direct and continuous observation of a physical check-up task among three hospitals in Thailand, using a time-keeping device (a digital stopwatch or a cellular-phone timer) to record the time taken to accomplish the tasks from a patient's perspective. The main objective was to identify problems in the operational work process, explore the steps of the medical transactions, and solve them by proposing a more efficient work process for each hospital. The improvement was executed by combining some specific and typical steps to eliminate the bottlenecks and re-arranging the physical layout of each hospital to reduce the time utilized and distance traveled by the patients. At each hospital, the research team will provide appropriate recommendations to remove the obstacles made at the end of the three months of the study. Earlier, the hospital marketing staff confirmed that with time freed up from our research, they could develop a robust campaign to attract additional check-up patients to fill up the expanded capacity, resulting in additional revenues. With the ensuing nine-month implementation of our action plans, the ended results at all the three hospitals enhanced the performance of the check-up/wellness programs and significant benefits of time-and-motion savings, leading to eventual patient satisfaction and revenue generation.

Keywords: Time motion study, Efficient work process, Patient satisfaction, Operations management

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INTRODUCTION

A time-and-motion study is an efficient technique, combining the Time Study work of Frederick W. Taylor with the Motion Study work of Frank and Lillian Gilbreth [1]. After its first introduction, time study developed in the direction of establishing standard times, while motion study evolved into a technique for improving work methods. Being a major part of scientific management, the two techniques became integrated and refined into a widely accepted method applicable to the upgrading and betterment of work systems. Our literature review applies today to industrial and service organizations, such as banks, schools, health services, and hospitals in the United States but not in Thai hospitals prior to our study. The interest in this study was prompted by the fact that the number 1 rank of complaints in any Thai hospital, big or small, public or private, is "waiting time" which usually creates and reflects a poor service level and is the bottleneck for total system throughput in the hospital. As such, hospital management attempts to minimize the waiting time. However, there is no optimization for the waiting line unless the total could be analyzed carefully. And one way to minimize such waiting time is to increase the speed of the task through a time-and-motion study. Nevertheless, improving this process-engineering requires understanding the business process first with the following key characteristics [2] (1) total cycle time- the difference between the start and finish time, (2) the number of tasks performed during the given period, (3) details of specific tasks (such as document identifier, a person performing the task, time of the day, day of the week, and the number of observation), and (4) the study of inputs received from one step and outputs delivered to the next step.

The Arterex Institute (arterex.com) in collaboration with the Medical Association of Thailand (MAT; https://www.mat-thailand.org/17038863/arterex) is aware of this problem and wants to improve physician's capabilities. Then, the collaboration provides monthly training to physicians and other healthcare professionals on various Hospital-Management topics. On the particular issue under this study, only though and analysis of the details of each step in entire process can we truly identify and achieve a deliverable of reducing pateints' "time-and-motion".

This cross-sectional qualitative and quantitative study provides the experience of conducting time-and-motion research in each of the three private hospitals with background information, as shown in Table 1. They belong to the same hospital chain with a typical structure, system, and strategy, while each hospital management usually faces similar challenges.

METHODOLOGY

This cross-sectional qualitative and quantitative study was conducted over one year at each enrolled hospital. Nevertheless, the methodology was the same. The initial data collection and analysis steps took about three months, followed by another nine months for

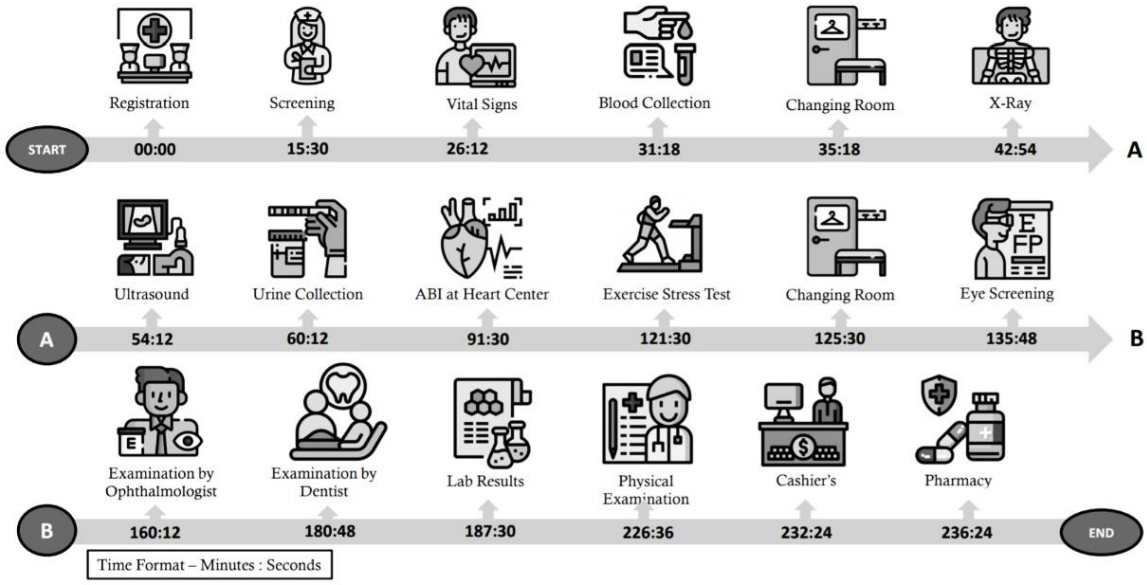

Figure 1: A 2-Dimensional Flow Diagram of a Typical Procedure During a Physical Check-up Service (Source: modified the animated physical check-up flow from the website https://www.flaticon.com/ free version).

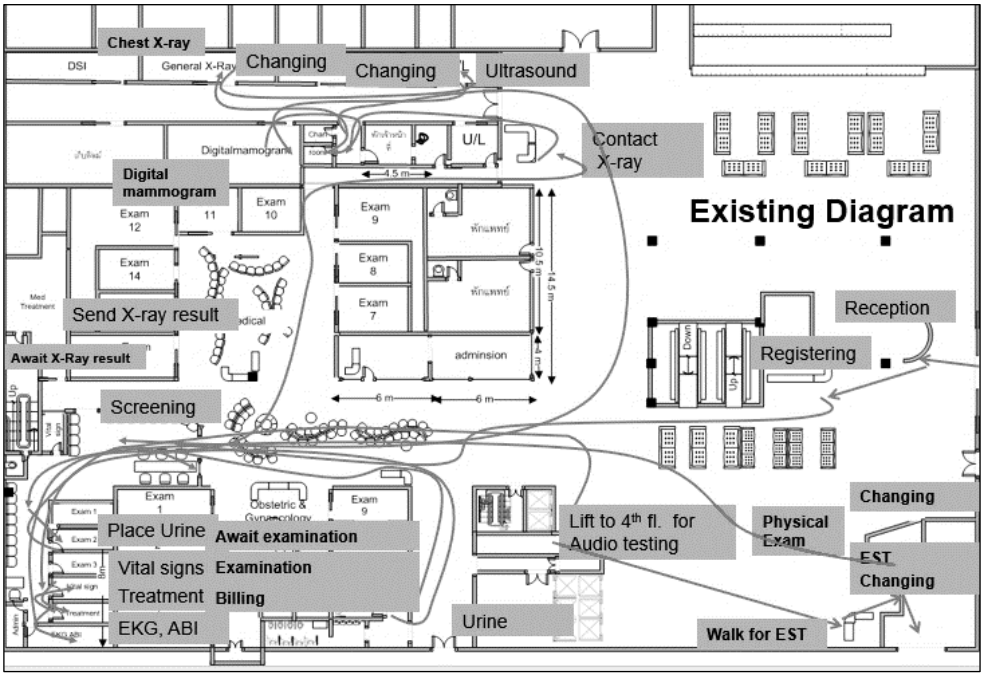

Figure 2: Spaghetti Diagram at a Physical Check-up Unit, example one from the study site.

Table 1: Background Information of the three hospitals enrolled in the study.

Study Sites	Size	Location	Check-up Plan & Package	Average Check-up Patients/month
A. One of 10 Network Hospitals	Medium	Songkhla	Standard	1,501
B. One Stand-Alone Hospital	Small	Bangkok	Gold	2,163
C. One of 3 Group Hospitals	Large	Bangkok	Wellness 1	2,310

implementation and follow-up to fully ensure the realization of the benefits. The time-and-motion study began with a decimal-minute stopwatch or a cellular-phone timer and a log sheet at each hospital. All of the key characteristics mentioned earlier were documented in a simple log based on a patient's perspective. The most standard critical data were to identify the specific start and finish time for each motion. However, there were other factors to consider and record, especially the distance traveled by the patients.

A few hundred patients over the three months were employed in each hospital to ensure statistical representation. The fact that the patients did not know about our tracking of their flow also eliminated the chance of a common bias of the Hawthorne Effect [3]– a phenomenon in which people behave or react differently from normal situations when they know they are being watched. The researchers applied the digital time-keeping device and observations. The specific steps in the entire process were documented to produce the total cycle time and the total travel distance (motion). Also, informed consent was obtained from relevant hospital staff before the observations [4]. Both quantitative and qualitative data were collected and analyzed to understand the actual root causes. Then appropriate recommendations were made with strategies and initiatives in an action plan to improve the efficiency.

Define the Problems

If best practice and service management are assured, the physical check-up business unit is usually a profitable hospital segment. Hence, each strategic direction of the three hospitals was interested in expanding the service capacity, given the existing layout

No		Description	Distance (m)	Time (min)					Cumulative (m)	Cumulative (min)	Resource
A	1	Walk to reception counter	3	0.2		1			3.0	0.2	patient
B	2	Contact receptionist		0.5	1				3.0	0.7	patient,receptionist
C	3	Walk to register counter	3	0.2		1			6.0	0.8	patient
D	4	Issue ID card		0.3	1				6.0	1.1	patient
E	5	Searching profile		0.5			1		6.0	1.6	register admin.
F	6	Registering		3.0			1		6.0	4.6	registering admin.
G	7	Print out visit slip, OPD card		1.0			1		6.0	5.6	registering admin.
H	8	Preparing patient profile		0.5			1		6.0	6.1	registering admin.
I	9	Verify information in OPD card		0.5				1	6.0	6.6	patient
J	10	Walk to checkup reception counter	42	2.1		1			48.0	8.7	patient
K	11	Handout visit slip to admin		0.1	1				48.0	8.8	patient
L	12	Print out patient name label		1.0			1		48.0	9.8	Admin.
M	13	Affix label on urine container		0.5			1		48.0	10.3	Admin.
N	14	Screening		2.0			1		48.0	12.3	Admin.
O	15	Explain check program and process		15.0			1		48.0	27.3	Admin.
P	16	Choose checkup package		1.0	1				48.0	28.3	patient
Q	17	Order entry in medtrak		1.0			1		48.0	29.3	Admin.
R	18	Print out lab no. label		0.5			1		48.0	29.8	Admin.
S	19	Hand urine container to patient		0.2			1		48.0	30.0	Admin.
T	20	Receipt urine container		0.2	1				48.0	30.2	patient
U	21	Walk to rest room	44	2.2		1			92.0	32.4	patient
V	22	Urine		5.0	1				92.0	37.4	patient
W	23	Walk to urine tray	62	3.1		1			154.0	40.5	patient
X	24	Walk to vital sign room	3	0.2		1			157.0	40.7	patient
Y	25	Measuring, V/S		3.0			1		157.0	43.7	Nurse
Z	26	Walk to blood collecting room	3	0.2		1			160.0	43.8	patient
AA	27	Blood collecting		3.0			1		160.0	46.8	Nurse
AB	28	Walk to EKG	5	0.3		1			165.0	47.1	patient
AC	29	EKG		5.0			1		165.0	52.1	Nurse
AD	30	ABI		10.0			1		165.0	62.1	Nurse
AE	31	Walk to X-Ray counter	40	2.0		1			205.0	64.1	patient
AF	32	Verify patient name		0.5			1		205.0	64.6	X-ray admin.
AG	33	Walk to suite changing room	15	0.8		1			220.0	65.3	patient
AH	34	Changing suite		3.0	1				220.0	68.3	patient
AI	35	Walk to chest x-ray room	10	0.5		1			230.0	68.8	patient
AJ	36	Chest X-ray operating		2.0			1		230.0	70.8	Technicial
AK	37	Walk to digital mamogram room	6	0.3		1			236.0	71.1	patient
AL	38	Digitalmamogram operating		15.0			1		236.0	86.1	Technicial
AM	39	Walk to ultrasound room	12	0.6		1			248.0	86.7	patient
AN	40	Utrasound operating		15.0			1		248.0	101.7	Technicial
AO	41	Walk to changing room	12	0.6		1			260.0	102.3	patient
AP	42	Changing suite		3.0	1				260.0	105.3	patient
AQ	43	Walk to checkup reception counter	72	3.6		1			332.0	108.9	patient
AR	44	Walk to lift	45	2.3		1			377.0	111.2	patient
AS	45	Liting to 4th floor		0.2			1		377.0	111.4	patient
AT	46	Walk to audiogram testing	17	0.9		1			394.0	112.2	patient
AU	47	Audiogram testing		5.0			1		394.0	117.2	physician
AV	48	Walk to lift	17	0.9		1			411.0	118.1	patient
AW	49	Lift to 2rd floor		0.2			1		411.0	118.3	patient
AX	50	Walk to EST room	18	0.9		1			429.0	119.2	patient
AY	51	Physical examination before EST		5.0			1		429.0	124.2	Physician
AZ	52	Walk to changing room	7	0.4		1			436.0	124.5	patient
BA	53	Changing suite		3.0	1				436.0	127.5	patient
BB	54	Walk to EST room	7	0.4		1			443.0	127.9	patient
BC	55	EST		15.0	1				443.0	142.9	patient
BD	56	Walk to changing room	7	0.4		1			450.0	143.2	patient
BE	57	Changing suite		3.0	1				450.0	146.2	patient
BF	58	Walk to at checkup	62	3.1		1			512.0	149.3	patient
BG	59	Walk to examination room	5	0.3		1			517.0	149.6	patient
BH	60	Examinating		15.0			1		517.0	164.6	physician
BI	61	Walk to finance counter	10	0.5		1			527.0	165.1	patient
BJ	62	Billing		3.0	1				527.0	168.1	patient
			527.0	168.1	12	26	24	1			
					37.1	26.4	104	0.6			

Figure 3: A Typical Worksheet of the Study, Combining both Time and Motion

of each hospital. Facility improvements were allowed but without significant investment in the renovations. The marketing staff of each hospital confirmed that with any amount of time being freed up from our study, they could develop a robust campaign to attract additional check-up patients to fill up the capacity, resulting in additional revenues and enhanced patient satisfaction [5].

The research team started with the medium-sized hospital because of its simplistic program; it had only one simplified standard package of check-ups. The next step was the small-sized hospital, which offered four different comprehensive packages: Classic, Gold, Male Platinum, and Female Platinum. The Gold package was chosen as a prototype of this study because it's the most popular (premium) one at a cost almost doubled that of the standard package and needs to ensure the best service. The researcher selected the large-scale hospital in the last step, which offered three check-up programs. The Wellness 1 package was chosen as the study prototype because it's the most comprehensive coverage (high-end) at a price almost doubled that of the "Gold" package.

The Solution

A basic flow chart describes the designed system's workflow and entities. It depicts the stage of the process. To facilitate identifying a bottleneck, we decided to simplify the process flow diagram to reflect only the core work process while ignoring marginal and unusual ones. Our initial measurement for each service station is the total time, including the actual processing time and the waiting time or the so-called "gross time". The basic flowchart is expanded into a two-dimensional diagram that presents the various stations in the hospital which perform different tasks in the physical check-up unit. Adding time to a basic flow chart (Ronen, 2006) [6] is essential in improving communications among the

Table 2. Distance Saving to Enhance Patient Satisfaction

Study sites	Monthly Check-up Patients	Existing Time (Minutes) (average)	Existing Distance, Meters (average)	Proposed Distance, Meters (average)	Distance Saving (Meters) (average)	Distance Saving (%)	Compared Time-Motion Before and After Study (p-value)
Hospital A. (Medium)							
• Standard	1,501	168.1	527	257	270	51.23%	< 0.001
Hospital B. (Small)	2,163	168.6	430.8	378	52.8	12.26%	< 0.001
• Gold (Premium)							
Hospital C. (Large)	2,310	247.7	376.5	344	32.5	8.63%	< 0.001
• Wellness 1 (High-end)							

hospital staff. It is a simple visual aid that helps staff understand the entire workflow. The actual drawing of a process flow diagram provides people with new insights into their tasks, which have been a routine for them for many years. Analyzing the gross time of a typical entity, such as patient, medical records, services, etc., in different parts of the system enables identification of the station where the patients spend a long time. This station is usually a system constraint. From our experience, the long time is generally due to waiting in line before the constraint.

Steps of the Time-and-Motion Study

The following are steps in undertaking this project (Langabeer II, 2008) [2]:

- Choose a sizeable random sample of patients who take the motion, temporally distributed, to be proper representatives.
- Observe specific details of each motion being taken and the total time for each step using the digital stopwatch or a cellular-phone timer and a log sheet.
- Record any unusual environment aspect about the patients, hospital staff, or the process that may skew the outcomes.
- Document the process motions in a flowchart, using standard symbols that industrial engineers use.
- Plot out all patient-travel observations and draw associated spaghetti diagrams from the patient's perspective.
- Calculate the average observed cycle time and adjust for non-productive time, e.g., a break or work delay.
- Attempt to identify problems and their related root causes, with the recommendation of an action plan consisting of strategies and initiatives to solve them.

To effectively utilize hospital resources, it's essential to have tracking systems in place. These systems are tools that monitor the position, flow, and movement of resources. In this regard, the time-and-motion study allows hospitals to track the patients' time spent, and distance traveled. A patient typically goes through a standard procedure during a physical check-up service, as shown in Figure 1. At each process, time was recorded in minutes and seconds on an accumulative basis. In our particular example, it took the patient 236 minutes (or 3 hours, 56 minutes and 24 seconds) from the time they walked into the hospital to the time they walked out of the hospital.

We used a similar "tracer" approach of Joint Commission International (JCI - an American non-profit organization that certifies hospital accreditation with increasing popularity in Thailand) for tracking the patient flow from start to finish. Besides, each of the elements or sub-components of the entire process was monitored based on systematic planning as in previous work by Sing R, et al. (2019) [7]. Then, the researchers summarized and drew a spaghetti diagram, as shown in Figure 2 to reflect the patients flow from entry until discharge from the hospital. We also tracked the time the patient went through each station and the distance they had to walk to receive service at the next station, see Figure 3.

Undertaking this study, we intentionally tackled only the non-clinical portions in the process (i.e., leaving all

Table 3: Revenue Generation from the Time-Saving.

Study Sites	Existing (Minute)	Proposed (Minute)	Savings (Minute)	Add. Mo. Patients	Service/ Package cost	Add. Yr. Revenue
Hospital A. (Medium)						
• Standard Package:						
○ Operations	12.0	10.0	2.0			
○ Transport	24.0	20.0	5.0			182 x 12 x
○ Inspection	25.0	25.0	0.0	1,501/168.1		฿3,700 =
○ Total	168.1	147.7	20.4	x 20.4= 182	฿3,700	฿8,080,800
Hospital B. (Small)						
• Gold Package:						
○ Operations	147	147	0			42 x 12 x
○ Transport	21.6	18.3	3.3	2,163/168.6		฿7,000
○ Total	168.6	165.3	3.3	x 3.3 =42	฿7,000	฿3,528,000
Hospital C. (Large)						
• Wellness 1 Package:						
○ Operations	151.3	144.3	7.0			
○ Transport	12.4	10.8	1.6			108 x 12 x
○ Inspection	84.0	81.0	3.0	2,310/247.7		฿13,000 =
○ Total	247.7	236.1	11.6	x 11.6 =108	฿13,000	฿16,848,000

clinical requirements intact) in order not to jeopardize the patient's safety. We also believe that patients feel happier seeing the physicians necessary to complete the physical check-up service. In addition, we expect patients to feel more satisfied if the distance they have to travel can be shortened to the extent possible, especially in the private sector, where they expect to get their money's worth in terms of time and motion. A worksheet, which combines time and distance was shown in Figure 3 with standard industrial-engineering symbols of O = operations (e.g., vital signs and triage by the nurse), ⇨= transport (e.g., patient in motion), D = delay (e.g., examination by the physician), and □= inspection (e.g., patient identification or verification) at the top of the table. The patients went over the process flow in detail and analyzed time and motion at every station of the entire system, identifying the waiting time in the gross time to derive the actual net time, where the crux of the issue lies. We then made suggestions on several changes for process improvement, which were essentially executed by combining specific steps, eliminating bottlenecks, and re-arranging several physical layouts of each hospital. Based on the numbers in Table 2, we could eventually reduce the patients' time spent (measured in minutes and seconds), and distance traveled (measured in meters).

In comparison to Figure 2, where the so-called "Existing Diagram" appeared to be a messy work process, our recommended changes with the "Proposed Diagram" resulted in a much-cleaner workflow for the patients, as shown in Figure 4 (Proposed Diagram) .

RESULTS

As for the motion study, patients would save distances. The medium-sized hospital (Hospital A) showed monthly patients of 1,501 cases and an average existing time of 168.1 minutes. In Hospital A, patients traveled 51.23% less from 527 meters to 257 meters (p-vale <0.001). The small-sized hospital (Hospital B) had a monthly patient of 2,163 cases and an average existing time of 168.6 minutes. Patients traveled 12.26% less from 430.8 meters to 378 meters (p-value < 0.001). Further, a Large-scale hospital (Hospital C) has a monthly average of 2,310 patients and an average existing time of 247.7 minutes. In Hospital C, the patients traveled 8.63% less, from 376.5 to 344 meters (p-value <0.001), see Table 2.

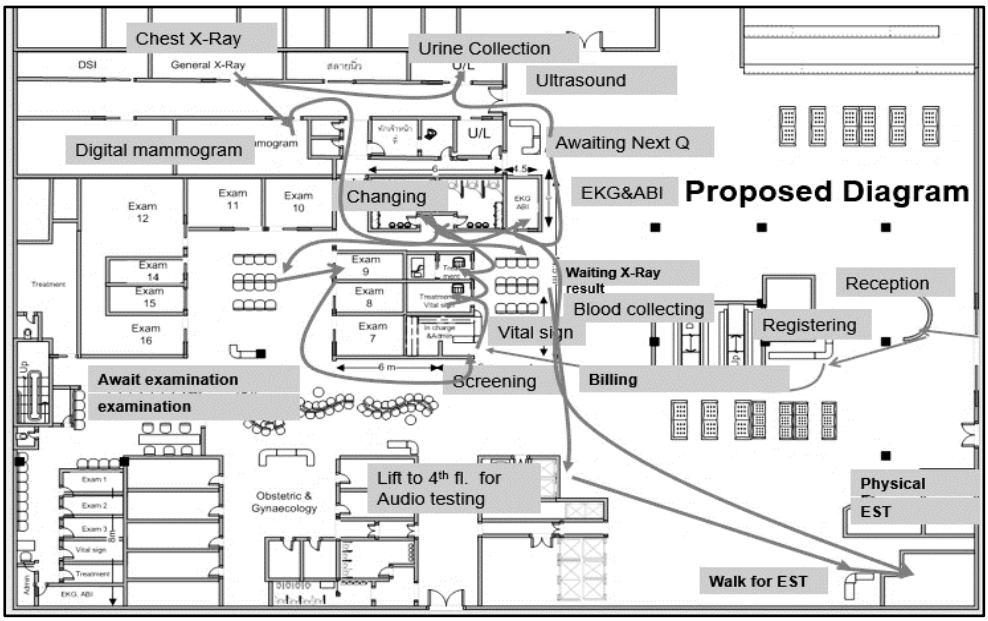

Figure 4: The modified spaghetti diagram after the proposed changes were implemented.

As for the time study, the various hospital scale would benefit from additional revenues, as shown in Table 3. With monthly standard patients of 1,501 and an existing time of 168.1 minutes in Hospital A, the time saving of 20.4 minutes per patient would result in the expanded capacity that additional 182 patients could fill up, thereby generating an additional ฿8 million+ per annum at the package price of ฿3,700.

Also, with monthly premium patients of 2,163 and an existing time of 168.6 minutes in Hospital B, the time saving of 3.3 minutes per patient would result in an expanded capacity that additional 42 patients could fill up, thereby generating an additional ฿3.5 million+ per annum at the package price of ฿7,000. Further, with monthly high-end patients of 2,310 and an existing time of 247.7 minutes in Hospital C, the time saving of 11.6 minutes per patient would result in an expanded capacity that additional 108 patients could fill up, thereby generating additional ฿16.8 million+ per annum at the package price of ฿13,000. The significant revenue return was based on increased efficiency, reduced time by time-motion study, and low or high service level costs. The increase in service prices at various levels should be reasonable and worth the service received. To calculate the cost of services among different hospital levels, an analytical unit is required with specialized expertise in calculating cost and the break-even point of the hospital.

CONCLUSION

Hospital operations management depends heavily on advanced methods and technologies to enhance operational excellence, reduce costs and waste, and improve cycle time. This, in turn, requires various resources, including equipment, materials, staff, and time. With non-participatory direct observations, attempts were made to increase the speed of the physical check-up process at three hospitals of the same chain by reducing the time spent and motion traveled by patients in operations, transport, and inspection. For patient-safety reasons, clinical delay and clinical examination were left untouched. Even with these restraints, the time-and-motion study of non-clinical operations, transport, and inspection resulted in an additional saving of service hours. From the patient's perspective, the patients would feel much more satisfied with less distance to travel and less time to spend in the entire physical check-up process. In contrast, the hospitals would enjoy freeing up time for attracting additional patients, from whom they could derive additional revenues.

For further research, the authors recommend other interest perspectives beyond the scope of this study. The subsequent research should include how the hospital healthcare professionals (nurse, pharmacist, laboratory technologist, sonographer, etc.) at each station spend their time and energy (movement) delivering their

services to the patients, as Hendrich A, et al. (2008) [8] have been studying. And the amount of care needed by surgical patients and trends over time as the study by van Oostveen CJ, et al, (2013) [9, 10]. These objectives might help to identify drivers of inefficiency in the work-unit process and re-design for improvements to the work environment in the future.

Author Contributions: WM & PN contributed mainly to conceptualization, methodology, data collection, data validation, data analysis, data curation, and writing—final draft preparation, review, and proof. **WM & PM** contributed as principal investigators.**PT& SAV**contributed conceptualization, methodology, healthcare content expert, approving and correcting final manuscripts. **SAV** contributed as corresponding authors, review, and proofreading. All authors analyzed the results and wrote and reviewed the manuscript.

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