Applying Lean Six Sigma for Public Healthcare Services

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ABSTRACT – After the Subprime mortgage crisis or hamburger crisis in USA, every global business has struggled to cut cost, but those struggles are aggravated in healthcare services. As healthcare service is not compromise with cost and quality. Cost reduction may not be a good option for developing country healthcare services. According to healthcare and culture of public healthcare services (PHS) in developing country is least competitive already when compare to private healthcare services sector. The government has a long term planning to rise up public healthcare services to achieve international standard such as health insurance portability and accountability act (HIPAA) of international services but as the same time they must have to sustain on the same quality of services. The improvement of healthcare services on competitive advantage and maintain on service quality are the primary purpose of this research. The design approach of this research is to develop service operations improvement in term of speed, accuracy, availability and quality of electronic medical records (EMR). The public healthcare service model is applied two concepts of Lean and Six Sigma to develop strategic model. Lean concept is to improve the process lifecycle and eliminate waste in processes of healthcare services in form of lead time and delivery time. Service operations improvement (SOI) is took a place of the annual budgeting plan; annual investment and daily operations, and expected service quality delivery (SQD). The quality service delivery measures from levels of satisfaction from all stakeholders such as patients, employees, shareholders, and suppliers. The result of improvement is not only increased customer's satisfaction levels but also increased more chance to save more people. Six Sigma helps continue improvement in lifecycle process of service quality subject to resource utilization, increasing capability of service without cost reduction, and eliminate defect or error from diagnosis, operations, and admissions process. Lean Six Sigma is creating a new value stream for our customer's satisfaction and growth at low cost for employees and stakeholders, that means public healthcare services have more profits to sustain operations, revitalize reserves, and refund on the capital investment. Moreover, Lean Six Sigma is initiating value stream; minimizing work-in-process; mistake-proofing work by eliminating the chances for human error; and increasing image and reputation for public healthcare services.

KEYWORDS – Public Healthcare Services; Service Operations Improvement; Service Quality Delivery; Electronic Medical Records; Lean Six Sigma

1. Introduction

Many developing countries are not adequately delivering basic healthcare services, including medicines, to their populations especial in South-East Asia. Thailand is one of the case that under developing or /and implementing the new technology and medical services for public healthcare. The public healthcare services (PHS) mostly are blame for unproductive, inefficiency, poorly motivated, and unfriendly. Most public sector salaries are most often unfair that leads to de-motivation and lack of commitment. Peopleware in PHS is the first concern to create a psychological change on service quality. Process and policy on PHS need to be clarify and approachable such as Healthcare Accreditation (HA), Joint Commission International (JCI), or Healthcare Insurance Portability and Accountability Act (HIPAA), and ISO 27799 standards that request to comply and achieve [2], [9]. HIPAA provides a uniform international standard for electronic healthcare transactions and code sets, and regulations for healthcare information privacy and security. Software and Hardware are fundamental combination of hospital information system (HIS) that this integrating system creates the next generation of medical treatment process. Electrical medical record (EMR) integrates the patient's medical history, admission, diagnosis, and treatment plan. Moreover, EMR is fast responding and easy to use for helping doctors, nurses, and other clinicians to diagnose their patients more accuracy and real time; wherever and whenever, than ever [13]. It includes both transaction data and medical images which use for high accurate diagnosis and billing insurers or patients [17]. Since 21st century, this is the third wave of electronic era, digital information technology is changing the world barriers in term of distance and time. As healthcare as service segment, healthcare relies on the sensible using quality of speed, accurate, security, and available information, therefore the next generation of medical healthcare services is going be digital hospital [15]. HIS service quality can perform at anytime and anywhere to create the competitive advantage such as; solve problems and increasing efficiency; increase customers and employees satisfaction; control and evaluate service operations, cost reduction and increase revenue, improve medical services and easy to management, crate business opportunities and expand medical service based. IT and IS are encouraged as tools to improve healthcare efficiency, safety, reliability in medical and hospital facility operations. However, IT and IS alone may not solve all problems during HIS services operations. Hospital policy and human factors are sensitive issues that necessitate as the first priority for all PHS researchers need to concentrate on. This research is not only investigated the existing IT and IS of PHS and created collaboration and integration of service oriented approach model but also examined rooted cause analysis of problems in each process and data flow from PHS operations.

2. Total Life Cycle of Lean Six Sigma Thinking

Healthcare operators and supporters need to access the complete or incomplete medical information or EMS in order to make the best medical decisions and provide cost effectiveness and service quality for medical care [12]. The planning framework for improvement service quality in HIS concentrates on integration during implementing and improving IT infrastructure library (ITIL) and Lean concepts within an healthcare service organization and deliberates aspects such as when and where to start, organization change, process definition, process change, project and programme planning, performance and quality improvement, project implementation, project monitor and control, and project evaluation and improvement as seen in Figure 1. Even though several system suppliers already provide solutions which integrate with other systems, healthcare facilities today are still threatening with incompatibility, missing format, mismatch topology and protocol; such as DICOM, HL7; and collaboration challenge of information systems with several problems [5]. Lean Six Sigma concept does not start or end with the service process. Within PHS organization needs an elementary change from their legacy processes, obsolete technologies, and traditional activities [3]. Fundamental of Lean Six Sigma eliminates unnecessary process or task out from service life cycle, as the same time, it tries to minimize or eradicate mistake or error in action processes. Majority accidents are from human error or ignore step-check-list. Moreover, it also provides preventive actions after analyzing the rooted cause analyses from corrective actions. The system of healthcare informatics constructs from steps investigation; rooted cause analysis, corrective actions, and preventive actions. It acts as PDCA model (Plan-Do-Check-Act) [2]. Every process cycle creates problems solving skills, knowledge based, experiences, system thinks, and breakthrough from existing process or technology. Service operations teamwork concentrates on quality cycle and emphasis on "Kaizen", continuous quality improvement which requires re-skilled, problems analysis, utilizing flexible process, and rapid changeover to different models, designs, and services [11].

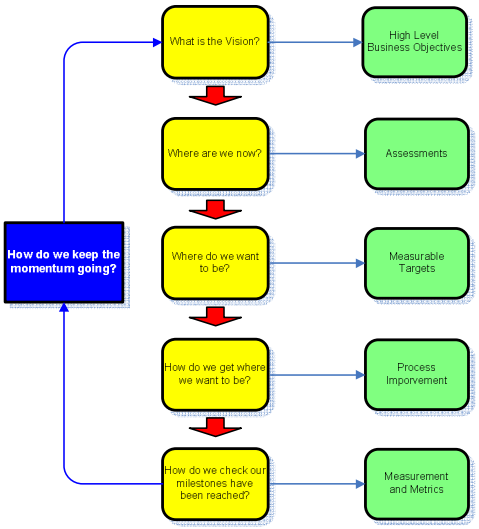

Figure 1. Planning Framework for Implement Service Quality in HIS

3. Legacy Public Healthcare Constraints and Problems

3.1 Group Survey and Scope

Manual operations are the traditional process of public healthcare service in developing country. Since research took 6 months or 24 weeks investigated 6 public hospitals in Thailand. Direct interview were conducted with 12 physicians, 12 nurses, 30 operations staffs, 2 strategic advisors of medical equipment & technology, and 100 random patients; deliver facility; cleaners; securities; emergency room; canteen; twice times and four hours per week. In level of management and healthcare services are paper based operations that have many risks in term of miss reading, interpreting, hand writing, lost document, etc. from requester to delegate person. In level of operator and staff services are verbal orders and many have no paper based records. Many times they forget or mistake in actions because they are not clear or understood in orders and cannot find who should repeat and explain the orders. These problems are non-productivities, wasting time on redo processes or recovery processes, increasing time and operations cost, decreasing customer's satisfaction, sometime may cause injures or life.

Special commends from two, Prof.Assoc.Dr.; two, Prof.Asst.Dr.; and two, 2 strategic advisors of medical equipment & technology; of my direct interviews:

- Normal international standards or processes people must change to process excepted for public healthcare services but at here process need to adjust to people.
- Software standard cannot fit to public healthcare services therefore customization requires.
- Decision on 'last responsible moment' for healthcare systems and equipment takes long time.
- If customization is not performed on applications or projects, it cannot be delivered.
- The average of applications which implement in private hospital took only one-third of public hospital.
- Culture of public healthcare services; system must adjust or adapt to people not people adjust or adapt to system.
- Technology life cycle took more than 5 to 10 years before change or more than that if it is still working.

Moreover researcher cross the line to interviews and discusses with two hospital software implementers or developers; one is local with 24 year experiences and other is international software company with 3 year experiences. Conclusion from both of them is there is still not have any software that are fully integrated HIS functions; front office and back office; implementation in Thailand. This gab is an opportunity for them to keep going on expanding markets but the problems are so many impediments such as no need to change system, do not want to change system, no budget, ever sees anyone doing before, do not know what to do with the existing system, no idea about new technology platform, policy not stable, no standard regulations, not have experience and skill manpower, high risks, etc.

3.2 Results of Traditional Lead Time of Public Hospital

The existing medical healthcare service system based on manual system and is very slow and result poor performances. Most of patients complain about long waiting queue in each process. It is wasting time and cost to go to hospital to get the high quality of service.

Several variables monitored in this project were data on patient's waiting time, work process, number of doctors available and number of staffs at the registration counter. Three major collection methods were used in this project. The first method was observation. Data were collected through

direct observation on the subjects involved in the various working processes in each hospital. Measurements of time spent from registration until consultation by a doctor were made using a stopwatch. The second method is through interview. In carrying out this research, some of the management IT directors and other staff were interviewed to obtain information on the working process in the hospital. Patients were also interviewed to find out their problems and needs. The third method involves collecting data from patients through questionnaires.

The time observation results of out patient department (OPD) and in patient department (IPD) show in Table 1 and Table 2 respectively. The average result of waiting through end process time between private hospital and private hospital is closed to twice times.

Annotations:

T0: Waiting time in queue; capability management, technology

T1: Input patient information; technology

T2: Resource management; availability, experiences, skills, technology and information supports

T3: Medical operations management; physicians; technology, experiences, skills, supplier supports

T4: Hospital operations management; technology, healthcare services, medical services,

(duration-of-admission).

T5: Waiting time in queue; back office process

Table 1. OPD Lead Time of Public Hospital Compare with Private Hospital

No	Hospital	Process (1) mins	Process (2) mins	Process (3) mins	Process (4) mins	Process (5) mins	Total process time (mins)
Public Hospital							
1	**A**	15	25	35	45	37	157
2	**B**	18	23	32	48	40	161
3	**C**	18	24	34	43	41	160
4	**D**	19	21	36	40	36	152
5	**E**	20	18	40	46	42	166
6	**F**	22	22	30	39	35	148
Average Waiting Time		18.67	22.17	34.50	43.50	38.50	157.33
Private Hospital							
1	**I**	8	8	18	25	18	77
		T0	**T1+T2**	**T3**	**T4**	**T5**	**Total lead time**

Table 2. IPD Lead Time of Public Hospital Compare with Private Hospital

No	Hospital	Process (1) mins	Process (2) mins	Process (3) mins	Process (4) mins	Normal or Serious Case (days)	Process (5) mins	Total Process Time (mins)
Public Hospital								
1	**A**	15	25	38	45	3-7	31	154
2	**B**	20	23	35	48	2-10	40	166
3	**C**	18	24	40	43	3-12	26	151
4	**D**	22	21	39	40	3-5	30	152
5	**E**	19	18	42	46	2-9	35	160
6	**F**	23	22	32	39	3-10	31	147
Average Waiting Time		19.50	22.17	37.67	43.50	5.75	32.17	155.00
Private Hospital								
1	**I**	10	8	20	28	4	15	85
		T0	**T1+T2**	**T3**	**T4**		**T5**	**Total Lead Time**

4. Collaborative Healthcare Information System

The latest IT and IS platforms are major driven factors of HIS. As overtime, the obsolete technology in legacy HIS may cause the problems of healthcare information services, since the traditional healthcare services are running in multiple operating system individually [4]. Moreover, in each system have their own authentication, authorization, accountability, and processes (AAAP) for service operations. While staffs, nurses, physicians and assistants require operating online and real-time among different systems, they need to logon each system separately. These multiple processes logon interrupts physicians and staffs. It also creates non efficient productivities and generates the system downgrade in security logon policy by delegated to other persons or no properly logon to system. This situation may cause security and risk concerns regarding to regulations and accuracy of patient's data and records. Moreover, it can stimulate threats and risks to patient's diagnosis health and life. A single sign-on (SSO) facility is a neo design and future architecture process improvement for healthcare operations, as illustrated in Figure 2. A SSO is classified by group object-oriented access by classes of authorization, authentication, accountability, and responsibility (AAAP). The purpose is for security and compliance with international standard such as HIPAA and ISO 27799 [2].

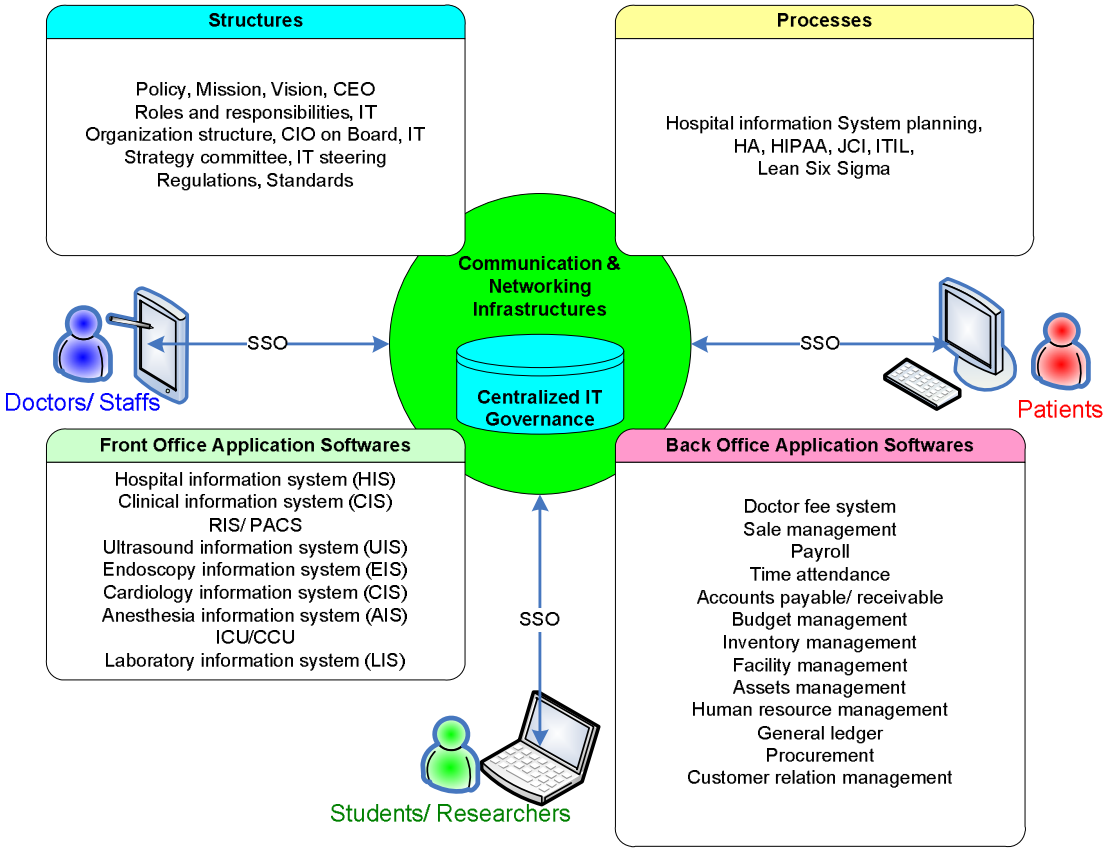

Figure 2. Necessary Components of HIS Governance Framework [1]

5. Service Oriented Integration Approach (SOIA)

The next generation of healthcare service oriented integration approach must support at anytime and anyplace with maximum efficiency and optimal operations; access speed, accuracy, availability, reliability of electronic medical record. A synergic collaboration and integration approach of hardware, software, peopleware, and processes is the critical key success factors of healthcare services operations. The SOIA model is established on the expectations from many dimensions as follows [6];

- Accelerate the development of HIS; concern on medical time and specific medical requirements
- Reduce the associated costs; recovery and replacement, penalty, reputation (difficult to measure)
- Reduce time; unproductive process, duplicated tasks, waiting in queue, waiting of work in process (WIP), lost documents
- Help to communicate innovative ideas and best practices; service quality-Six Sigma
- Reduce the risk of failure; medical equipment, power outage, network failure, human error, etc.

After investigated the existing IT and IS of PHS and created collaboration and integration of service oriented approach model by concern on two point of process flow and data flow diagram, the result is shown in Figure 3 that explains the flow of process from the beginning when patient registration, go to nurse counter, waiting for diagnosis, OPD or IPD, and payment for medication. Each ending process flow the HIS system will create data flow at hot sport of activity as EMR, as see in light-blue color in Figure 3. The final of each patient's EMR will accumulate knowledge management, integration and distribution, through database for future references by physician during diagnosis process [16].

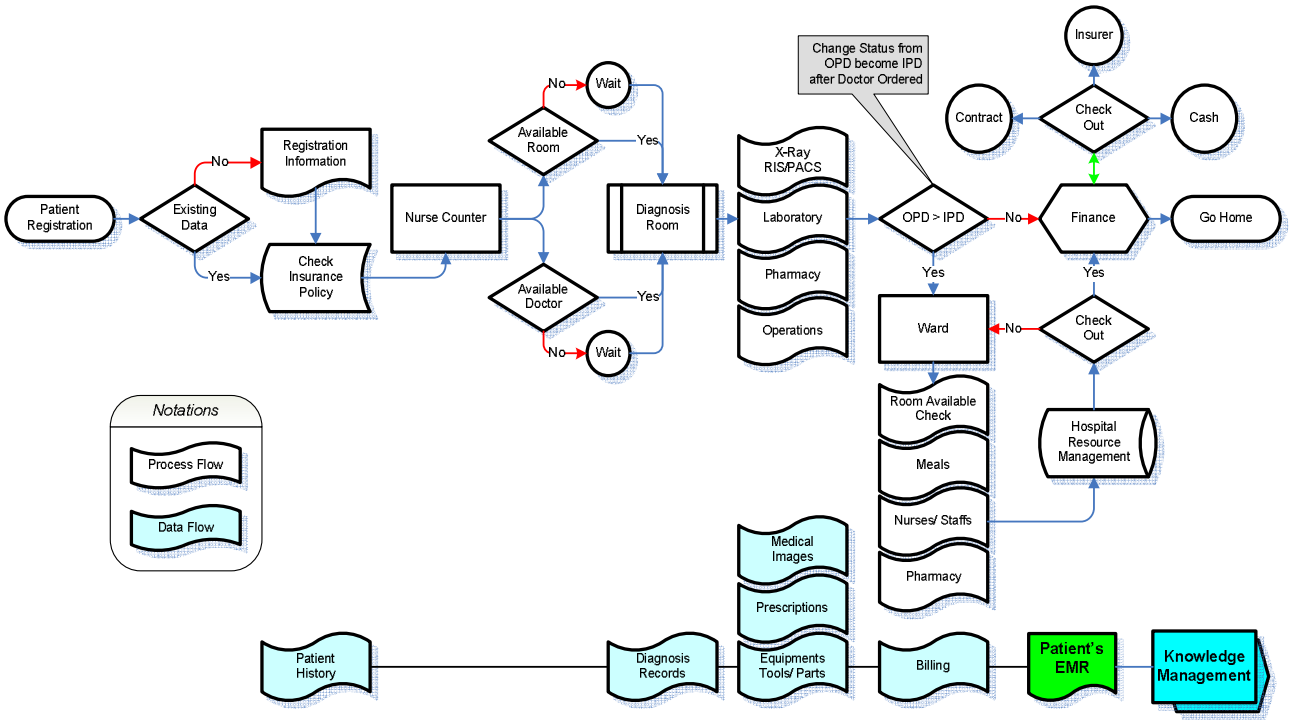

Figure 3. Hospital Process and Data Flow

LCT-OPD called total life cycle of OPD in PHS that imply number of hours used in each patient from the beginning until go home. The difference between Lean cycle time of OPD and IPD is T4; duration-of-admission, that affect public healthcare income (PHI) in different insurance policy as seen in Figure 4.

The SOIA by applying Lean concept to healthcare services promise huge benefits in term of both patient service quality of medication and reduces of PHS expenditure. A value stream model proposed by McClean et. al. are essential stochastic flow models that let researcher to cluster patient processes and characterise heterogeneity with respect to patient duration of admission [8]. In Figure 4, researcher can quantify the prospective reduction cost, if duration-of-admission (T4) in particular insurance policies are reduced.

Type of Insurance policy between patient and public hospital is classified into three groups: ***Contract***, ***Cash***, and ***Social Insurance*** as depicted in Figure 4.

If T4 > 3 days in case ***contract*** and ***cash*** PHI is positive

If T4 ≤ 3 days in case ***contract*** and ***cash*** PHI is still positive

If T4 > 3 days in case ***social insurance*** PHI is negative

If T4 ≤ 3 days in case ***social insurance*** PHI is equal or positive with budget that government subsidised

How to balance and make positive PHI is under number of patients that use different insurance policies among: ***contract, cash*** and ***social insurance*** in public healthcare operations.

T0+T1+T2+T3+T5 = Lean Cycle Time of OPD (Out-Patient Department): LCT-OPD

T0+T1+T2+T3+T4+T5 = Lean Cycle Time of IPD (In-Patient Department): LCT-IPD

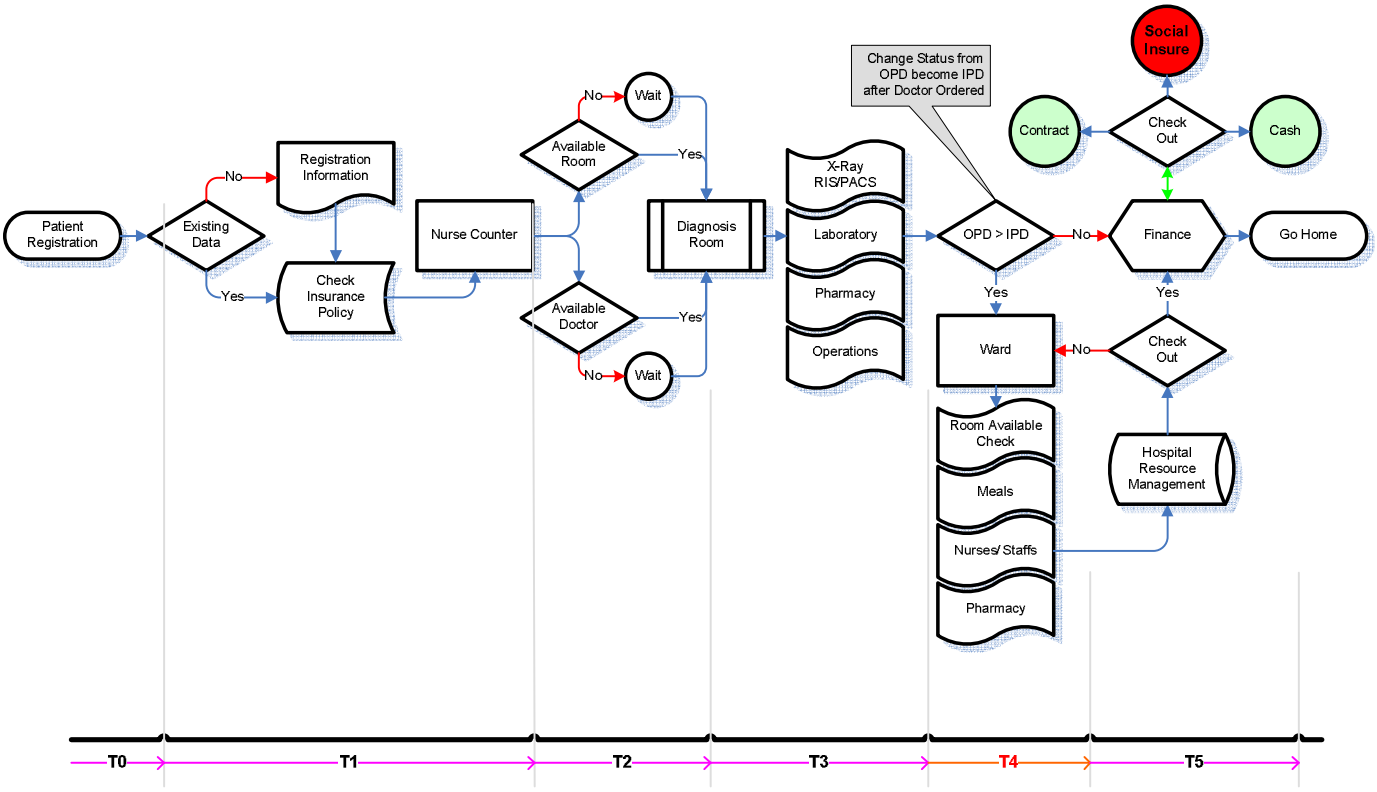

Figure 4. Lean Process Improvement

The traditional healthcare information system are based on legacy communication data services through fax machines, telephone cells, regular mailing system, which are costly, slow, non-reliable, lost risk, hare to maintain, and redundancy system design for filing information. The next generation of digital hospital relies on digital form, as a result all patient records or EMRs need to change a form. Designing and implementing the transition to a fully digital hospital is inevitable. RIS/ PACS/ LIS is one form of digital that based on an open architecture highly relying on the DICOM standard [14].

The objective of Six Sigma for healthcare is increasing service operations improvement (SOI) and replacing traditional communication technologies with international standard protocols; TCP/IP, DICOM, HL7, XML, etc. [7], [10]. Moreover, it must be easy to management, interoperable system, compatible system, and support for future expansion, as shown in Figure 5.

EMR in healthcare transactions are based on different technological requirements and investment. Properly design matching of minimum bandwidth requirement on each medical healthcare portal may save cost for only short run but long run may need to reinvest again. It is double jeopardized subject to downtime cost on operation system and reinvestment. However, if design under than application or system requirement it may cause slow in process, quality of service not pass standards, and dissatisfaction of service quality delivery (SQD). They are many types of medical transmission services for EMR, as illustrated in Figure 5. These lists below are average speed of media transmission based in Thailand.

- Web Based Plate Form (Internet)/ Remote Access (VPN/ VLAN: 56Kbps-10Mbps)
- Leaded Line/ Frame Relay; Point-to-Point (64Kbps-100Mbps)
- Low speed intranet infrastructure: Cat5e, Cat6, Cat6a (Ethernet 10/ 100/ 1,000 Mbps; ATM 10Mbps-155Mbps)
- High speed intranet infrastructure or Core backbone switchs: Fibre Optic (10 Gbps)
- Wireless Local Area Network (WLAN: 10Mbps-100Mbps)
- Wired Communication Services (PSTN: 64Kbps-2Mbps)
- Wireless Communication Services (WiMax: 10Mbps-Under license approval process, WiFi:2Mbps-10Mbps, GSM:64Kbps-2Mbps, CDMA: 64Kbps-8Mbps)

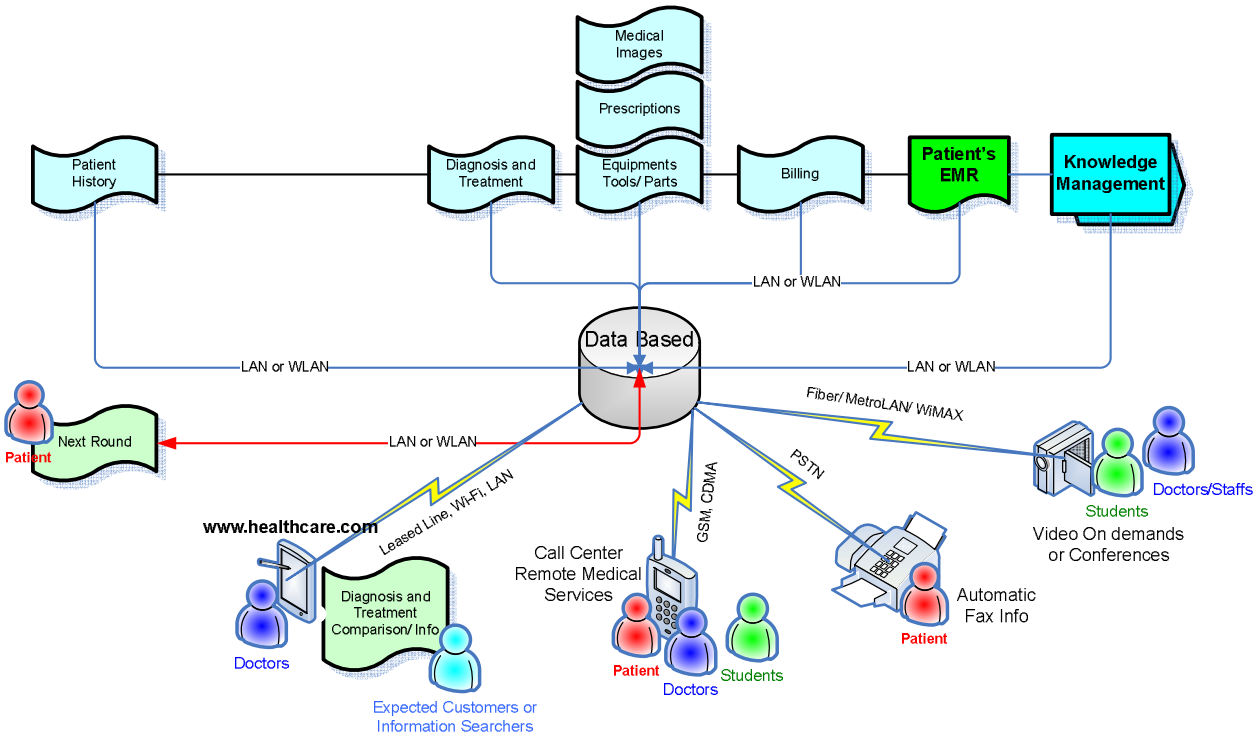

Figure 5. Six Sigma for Healthcare Service Improvement

Since the hospital infrastructure some part was built from different times and vendors, some is on building, and some is on planning, thus HIS infrastructure and system integration is required compatibility or standards [19], [20]. Table 3 refers to typical transmission standard modes and required data rate of each digital devices. This standard shall integrate all heterogeneous systems and make all EMRs including clinical reports, lat tests, medical images available anytime and anywhere when doctors are needed [18].

Table 3. Requirements for Transporting Digital Medical Image and Data [8]

Digital device	Typical image size (Mbytes)	Typical transmission modes and required data rates
Digital blood pressure monitor	NA	Less than 10 Kbps
Digital thermometer	NA	Less than 10 Kbps
Digital audio stethoscope and integrated electrocardiogram	NA	Less than 10 Kbps
Ultrasound, angiogram	0.256	ISDN (Integrated Services Digital Network): 256 to 1,920 Kbps
Magnetic-resonance image	0.125	Dial-up modem: 56 Kbps LAN: 10 Mbps
Scanned x-ray	1.8	Dial-up modem: 56 Kbps LAN: 10 Mbps
Digital radiography	6	ISDN: 256 Kbps ATM (asynchronous transfer mode) network: 10 Mbps (MPEG video)
Computerized tomography scan	0.500	Dial-up modem: 56 Kbps LAN: 10 Mbps
Mammogram (complete exam)	184	1.6 Mbps (for 15 minute download) to 1.5 Gbps (for 1 second download)
Compressed and full motion video	NA	ISDN: 384 Kbps ATM network: 40 Mbps (MPEG video; depends on required quality)
Telesurgery	NA	ATM network: 10 to 155 Mbps

6. Discussion

Security management is not just only defined as protect access patient's information or EMR but also means protection or prevention; sometimes called risk management; in case of system shutdown, power outage, sabotage, nature disaster. PHS shall apply a concept of business continuity management (BCM) to handle with unexpected satiations. Moreover, it must support business continuity management (BCM) by applying concept of load balancing (Transport Layer: Layer 4) technology to support both low congestion and back up EMR site; best solution. Other solution concept is active standby which cover only back up EMR.

Implementation project such as HIS, there are many factors involved and forced project to success or failure. In the same time critical success factors are the same with significant failure causes. One factor can turn up and down project, it depends on how deep understand on factors, problem analyses, and ability of solving skills/ experiences of project team. This is list of critical failure factors;

- Secure and realistic funding that must support by policy and top level of management
- Project governance that needs well establish informed technology steering committee and a clear last responsible moment for decision policy
- Ensure end users involve and have their own responded in project
- Have comprehensible technological objectives bonded to medical practice objectives
- Employ technological refreshment strategy for major system
- Take risk assessment strategy to minimize cost & time over runs and variation orders
- Agree consultants and vendors of choice based on history of past contracts and experiences
- Early conduct asset review of equipment and technology for transfer to new hospital system

- Assure strong transition planning components/ systems/ processes/ trainings/ operations
- Issue proper terms of reference (TOR) for consultant/ contractor tender
- Select consultant/ contractor that has a strong track record with similar projects
- Contract shall be clarify on scope (TOR), term of payment, specifications & deliveries; bill of quantity (BOQ), system warrantee, service level agreement, and maintenance agreement

7. Conclusion

Public healthcare service (PHS) shall construct a healthcare information system (HIS) for collaboration and integration as unified management system that acts in response with information security, requirements of confidentiality, unified format, integrity, speed access, accuracy, availability, and reliability system. Process improvement of Lean Six Sigma is concentrated on access speed, accuracy, security, availability of EMR for any requesters subject to create, update, exchange, retrieve, storage, copy, archive, delete, and distribute EMR. Since the advance of telecommunication technology in medical healthcare services can perform in anytime and anywhere, therefore next generation of EMR and HIS in PHS breakthroughs the way of medical diagnosis and treatment is not only cure more people as the same time; operating capacity evolution, but also save more life; speed and precise medication. Increase probability of saving life from applying Lean Six Sigma to PHS proves healthcare service quality delivery (SQD) and hospital reputation.

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