The effect of lean six sigma toward maternal emergency lead time in Penembahan Senopati Hospital, Bantul, Yogyakarta

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ABSTRACT

Introduction: Indonesia is one of the countries with high Maternal Mortality Rate (MMR). The main causes of maternal mortality in Indonesia are hemorrhage, hypertension, infection, abortion related sequelae, and prolonged labor. Several Interventions have been developed to lower MMR such as improvement in antenatal care, helpers’ skill (in community, clinic, or hospital), access to emergency unit, and postnatal care. However, the delayed maternal emergency care still continues to occur nowadays.

Long waiting time is caused by management inefficiency that may result in obstruction of flow, underutilized resources, and imbalance between the number of patients with the availability of care facilities and the alternative care strategies for the patient at a particular time. Therefore, an accurate time measurement is important as the first step in improving the health care service. Service time standards are different between each health care unit. For example, the standard waiting time from decision until incision is 30 minutes. Thus, eliminating long waiting time will reduce unnecessary cost and prevent poor outcomes. Combined with management flow adjustment, it can further improve service flow and patients’ volume, hence, increasing the financial profit, provider image and patient satisfaction.

One approach which can be used to decrease waiting time is Lean Six Sigma (LSS). Lean concept and Six Sigma have been recommended by the Institute of Medicine (IOM) for hospitals to overcome several problems such as waiting time and to improve the efficiency without compromising the service quality. According to Ahmed et al., LSS implementation was proven to decrease several aspects in health care service such as emergency patient waiting time, time cycle during diagnostics, length of stay (LOS) and medication error. Lean can overcome inefficient process while Six Sigma reduces process variety. In principle, Lean and Six Sigma complements each other.

INTRODUCTION

Indonesia is one of the countries with high MMR. The main causes of maternal mortality in Indonesia are hemorrhage, hypertension, infection, abortion related sequelae, and prolonged labor. Several Interventions have been developed to lower MMR such as improvement in antenatal care, helpers’ skill (in community, clinic, or hospital), access to emergency unit, and postnatal care. However, the delayed maternal emergency care still continues to occur nowadays.

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According to Liker, any organizations and businesses can implement the Lean model successfully. However, despite of the promising results, health care professionals, providers and policy makers still need to learn about this approach and conduct more health care research. Studies on substantial
scope and on specific topics are required, in this case, the maternal emergency unit.

Several studies about LSS implementation in health care services have shown its potential in improving service quality. The advantage of its implementation included decrease treatment cost and eliminating several obstacles such as complicated system, errors and negligence which could increase the risk of patient safety. LSS has been proved to decrease waiting time and increase patient satisfaction. In emergency units, LSS improved patient flow, increases patient satisfaction and the outcomes. In one study, the patient occupancy rate was increased from 70% to 90%, employee satisfaction was increased from 30% to 90%, and another study showed decreased waiting time from arrival to physical examination by the physician. In this study, we examined the impact of LSS implementation on lead time in maternal emergency cases.

METHODS

Study setting
This research was conducted for 12 months (March 2017-February 2018) in Penembahan Senopati Hospital (PSH), a government regional hospital of Bantul District, Yogyakarta special province, Indonesia. Bantul district has a population of 985,527 and has the highest maternal mortality rate in Yogyakarta special province. PSH is a fully accredited hospital and a referral hospital for the Southern region of Yogyakarta, including for maternal emergencies. The hospital has 289 beds and offers outpatient, inpatient, and emergency services. The Emergency Maternal Unit at PSH has Comprehensive Emergency Obstetric and Neonatal Care (CEmONC) rooms as part of the emergency department and maternal care unit (MCU) which are about 50m behind the CEmONC room.

This maternal emergency unit serves on average more than 200 maternal delivers with about a third of them with caesarean section per moths. The unit has four obstetric doctors and 19 midwives.

Study design
Participatory Action Research (PAR) approach was applied in this study as a selected method of subject enrollment. The researchers worked with all midwives (19 staff) in the maternal emergency unit as active participants and operating room staff as observers. The qualitative data were gathered from management staff, including: the director, medical service vice director, head of medical service and support office, head of nursing and quality office, head of nursing and midwifery section, head of quality and clinical audit section. The population used was all maternal emergency cases. The cases included in this study were maternal emergency cases with complete observation data during the 6-week observation (before 27 cases and after 24 cases). According to PAR stages according to Kemmis and McTaggart, the study steps were: Planning a change, Acting and observing the process and consequences of the change, Re-planning, citing and further observing, and the final Reflecting. Each stage consists of part or all of the Lean Six Sigma stages which adopt and develop the LSS implementation stages from Yeh et al.: Define-Value, Measure-Value Stream, Analyze-Flow, Improve-Pull, and Control-Perfection.

Implementation Process
Cycle I: Deployment (March-September 2017)
This cycle started with the Planning stage: communicating with the hospital director and management, delivering ethical clearance, gathering initial data on number of cases, resources and maternal emergency case service, and obtaining agreement, willingness and commitment from the top and operational management as participants in the research. The next stage was Action, i.e. Disseminating Lean Six Sigma concept through training. The training addressed the following topics: Hospital service quality, Lean basic concept, Six Sigma tools, Procedures and Implementation, LSS Supporting and barriers factors that have been experienced. The correspondents were experts in: Hospital quality service, Lean and hospital practitioners who have experiences implement lean. The tools and Six Sigma methods were delivered by the researcher. The training participants were all hospital management and most of the participants (midwives). In total, 22 management staff, 15 midwives, and 1 doctor obstetric participated in this study. The training was conducted for one day at the maternal emergency unit. To evaluate the training, participants completed a questionnaire before the training, during and after LSS implementation.

The next step was to form five improvement teams with 4-5 members in each team and a facilitator. Each team was responsible for two types of emergency cases; caesarean section and vacuum extraction (VC) (team 1), eclampsia/pre-eclampsia and hypertension (team 2), abortion and hemorrhage case (team 3), general improvement (team 4), and operating theatre (team 5). The facilitators were observing the operating room service which include the head of outpatient, inpatient and emergency unit, nursery and midwifery section, quality and clinical audit section, and obstetrics/
gynecology specialists. The team was formed by a decree from the hospital director.

Implementation of LSS was conducted in parallel between the Six Sigma and Lean thinking principles. The following DMAIC cycle was used generally as a framework for process improvement. **Define/Value:** The team identified the common values in emergency case services through direct survey and brainstorming among the staff. The value of patients was then converted into Critical to Quality (CTQ) data. The team compiled SIPOC (Suppliers, Inputs, Process, Output, Customers). At this stage the team designed a project charter according to each case. **Measure/Value Stream:** The team followed the process for each team with an on-site walkabout (gemba-walk) to identify the waste, which is the inefficiency in the system or the management processes. The gemba walk of patients started from arrival at emergency unit until being received by midwives in the MCU. The next process was conducted by the midwives in the MCU, including measurement of cycle time and lead time of process. The next step was creating current state mapping, analyzing observation data and inefficiency in the process. **Analyze/Flow:** The next step was analyzing wastes from the gemba walk and observations, identifying the underlying cause, how to eliminate waste through brainstorming and pooling improvement ideas. All Ideas were written on an idea board. The chosen ideas were explored with everyone including with other teams. The team then generated a future state mapping. **Improve/Pull:** Each team chose the improvement that will be implemented. The general team directly delivered the improvement using available resources especially 5S practice and visual management to eliminate waste. **Control/Perfection:** This step evaluated the outcome of implementation using 5S tools, and visual management and implementation procedures from midwives. It also facilitate which of the good implementation outcome that will become the new standard by continuously performed improvement out of recurring problems and reeducated the midwives about the skills to use the tools and problem solving procedure by human resource department.

The final step involved conducting meetings with the team including the managements to reflect on the current process. The team explored the results, initial implementation and implementation plan. The focus was on brainstorming follow-up implementation procedures especially for inter-stakeholder implementation.

**Cycle II: Doing (September-November 2017)**

During the general meeting, the teams reflected on re-planning. The re-planning included time, technique, tools, resources needed for improvement implementation. The team then conducted DMAIC II: **Define/Value:** The team identified value and waste priority; CS emergency: The team found details of SIPOC in CS case. The team then developed a current detail project charter. **Measure/Value Stream:** The team developed current state map, filled in cycle time, waiting time, and process lead time. **Analyze/Flow:** The next step analyzed the dominant waste, which were waste of waiting and over processing, identifying the root cause of the waste, how to eliminate the waste through brainstorming and pooling improvement ideas. The team generated a future state mapping. **Improve/Pull:** The chosen improvement was eliminating “Call Procedure” over processing in emergency team. The team can directly call emergency team leader, without calling through the call center/operator. In this process, the team was using dedicated mobile phones. **Control/Perfection:** To evaluate the result by gathering data of cycle, lead time from the emergency CS cases was processed. After six weeks of evaluation, the teams conducted the reflection process, and analyzed the outcome and improvement of implementation process through general meeting with the whole team. The reflection included the general improvement to eliminate waste.

**Cycle III: Evaluating (November 2017-February 2018)**

The team continued on DMAIC III action. **Define/Value:** The team identified another existing waste, and identified SIPOC of the waste. The team developed another plan to eliminate the waste. **Measure/Value Stream:** The team calculated the resources and efficiency gain potential by eliminating the waste. **Analyze/Flow:** This step analyzed the process and design so that resources areas are easily available and obtained as needed. **Improve/Pull:** The team created visual management tools to be used in CS emergency patients and other emergency cases. The team revised the process flow to be the new Standard Operating Procedure (SOP). The team created Clinical Pathways (CP) for emergency CS cases. **Control/Perfection:** This step evaluated the CP instrument, and conducted trials for the new CP and SOP.

The evaluation covered the overall LSS implementation in one general meeting. The team also evaluated participants’ understanding after 12 months being introduced to LSS concepts and implementing its methodology.

**Data Gathering**

Quantitative data were gathered before and after the implementation of LSS, including cycle time
and lead time. Lead time is the total time from the
first patient contact with the ED/CEmONC until
the patient completed the entire process. Cycle
time is total of time for finishing one step process. Cycle
time and lead time were gathered in two stages. The
first stage started from patient admission at ED/
CEmONC until definitive diagnosis was made for
all emergency cases, i.e. obstructed labor (CS and
vacuum extraction indication), abortion, hemor-
rhage, severe pre-eclampsia, hypertension, and
other high risk cases. The second stage was from
decision to undergo CS until the incision. Data
were taken from observing the participants and
verified using medical records. The qualitative
data were collected by asking the understanding and
perceptions of the participants (19 midwives) three
times i.e. at pre, mid and post LSS implementation.
Perceptions of the participants were only taken
after the implementation.

Data Analysis
Difference in the mean time before and after LSS
implementation was analyzed. The cases were
emergency cases which occurred during obser-
vation and had a complete observation data. CS
cases were analyzed separately because they had
follow-up procedures outside the maternal emer-
gency unit (operating room).

Ethic Approval
This research had been approved by the Health
and Medical Research Ethics Committee, Faculty
of Medicine, Public Health and Nursing, UGM
Yogyakarta with approval letter number KE/
FK/0192/EC/2017. Permission to conduct the study
was obtained from the hospital.

RESULTS
Lead Time
LSS implementation reduced 26 minutes (16.4%)
of patient lead time from admission to definitive
diagnosis in Cesarean Section (CS). While for
abortion-hemorrhage and Severe Pre Eclampsia-
hypertension, patient lead time was actually
increased (Table 1).

Cycle time
The general steps in maternal emergency services
are: admission, health care checking by midwife
or doctor, transfer to maternal care unit, accepted
in maternal care unit and evaluation by midwife
at maternal care unit, reporting to the doctor in
charge, and establishment of definitive diagnosis.
From the entire process, the longest average cycle
time was health care checking by midwife or doctor
in emergency unit/CEmONC. After being checked
by midwife or doctor the patient will be observed
and has to wait for the result of supporting exam-
ination or wait in a vacant maternal care room.
For CS patients, the highest process variety was in
the health checking process by the midwife until
reporting and diagnosis by doctor (68.08 minutes).
Either before or after LSS implementation, the
checking process by midwife or doctor in the
emergency unit until delivered to maternal care in
SPE-Hypertension case still had the highest variety
(pre 90.51 minutes, post 174.35 minutes). However,
before LSS implementation, the lowest variety was
in the process of delivery to maternal care and
checked by midwife (00.00 minutes) (see Table 2).
In general, this research shows that the process
after implementation of LSS also varied either
in CEmONC or in the maternal care unit. In
the maternal care unit, even though it had more
midwives available, they also had more patients.
In ED, CEmONC is located at the rearmost area. The
midwife station is located in the same room as other
staffs who responsible for general patients in ED.
In CEmONC, the midwife collaborated with general
practitioners, while many diagnostic and admin-
istrative procedures were related with other unit.
Continuous improvement (Kaizen) and 5S imple-
mentation to improve the workflow were mostly done in maternal care unit.

CS Emergency Case
The general, the processes for CS emergency
patients are: Decision to perform CS, patient/family
approval, patient sent to OR, admitted in OR, anes-
thesia and incision/operation. In this study the
average lead time decreased after implementation
of LSS compared to prior implementation (26%).

Table 1 Average Patient Lead Time from admission to definitive diagnosis in Maternal
Emergency Unit (minutes)

| Case                      | Lead Time (minutes) | Changes (Minutes / %) |
|---------------------------|---------------------|-----------------------|
| Caesarean Section         | 158.40              | (-) 26 / 16.4%        |
| Abortion-hemorrhage       | 75.40               | (+) 12 / 15.4%        |
| Severe Pre Eclampsia-Hipertensive | 145          | (+) 38 / 26.5%        |
| Other high risk conditions| 70.30               | (-) 15 / 21.7%        |
Table 2  Average Patient Cycle Time Description for Emergency Case (minutes)

| Parameters      | Admission | Patient Examination | Sent to MCU | Admitted at MCU | Check by MW | Report to doctor- Dx definitive |
|-----------------|-----------|---------------------|-------------|-----------------|-------------|-------------------------------|
|                 | Pre       | Post                | Pre         | Post            | Pre         | Post                          | Pre         | Post            | Pre         | Post            | Pre         | Post            | Pre         | Post            | Pre         | Post            |
| Mean            |           |                     |             |                 |             |                               |             |                 |             |                 |             |                 |             |                 |             |                 |
| CS              | 3.5       | 3.13                | 95.1        | 77.37           | 6.3         | 12.15                         | 4.1         | 3.03            | 11.4        | 27.03           | 38.00       | 9.25            |
| Abortion-HR     | 3.40      | 3.20                | 57.20       | 43.20           | 5.40        | 15.40                         | 2.00        | 11.20           | 3.00        | 7.20            | 4.40        | 6.40            |
| SPE-HT          | 1.50      | 3.00                | 124.00      | 142.00          | 5.00        | 15.00                         | 3.00        | 5.50            | 1.00        | 5.50            | 10.50       | 12.50           |
| Other high risk | 5.00      | 3.29                | 33.30       | 32.18           | 10.00       | 6.22                          | 2.20        | 2.56            | 9.30        | 6.11            | 10.10       | 4.29            |
| Standard Deviation |         |                     |             |                 |             |                               |             |                 |             |                 |             |                 |             |                 |             |                 |
| CS              | 3.21      | 2.42                | 58.26       | 65.56           | 3.11        | 17.16                         | 3.41        | 3.29            | 18.07       | 68.08           | 34.21       | 13.06           |
| Abortion-HR     | 5.37      | 2.49                | 64.58       | 43.53           | 5.55        | 18.04                         | 1.73        | 18.44           | 2.00        | 5.00            | 2.19        | 6.07            |
| SPE-HT          | 1.11      | 3.13                | 90.51       | 174.35          | 0.00        | 7.07                          | 3.33        | 6.36            | 0.00        | 6.36            | 13.44       | 3.54            |
| Other high risk | 7.56      | 2.03                | 22.35       | 31.02           | 5.57        | 2.28                          | 2.33        | 2.28            | 14.12       | 5.40            | 7.20        | 2.36            |
| Minimum         |           |                     |             |                 |             |                               |             |                 |             |                 |             |                 |             |                 |             |                 |
| CS              | 1         | 1                   | 15          | 30              | 1           | 5                             | 1           | 1               | 1           | 1               | 1           | 1               |
| Abortion-HR     | 1         | 1                   | 5           | 3               | 1           | 1                             | 1           | 1               | 4           | 1               | 1           | 1               |
| SPE-HT          | 1         | 1                   | 60          | 19              | 5           | 10                            | 1           | 1               | 1           | 1               | 1           | 10              |
| Other high risk | 1         | 1                   | 2           | 1               | 4           | 4                             | 1           | 1               | 1           | 1               | 1           | 0               |
| Maximum         |           |                     |             |                 |             |                               |             |                 |             |                 |             |                 |             |                 |
| CS              | 10        | 7                   | 200         | 235             | 10          | 54                            | 12          | 10              | 60          | 195             | 95          | 38              |
| Abortion-HR     | 13        | 7                   | 155         | 111             | 15          | 45                            | 5           | 44              | 5           | 14              | 7           | 15              |
| SPE-HT          | 2         | 5                   | 188         | 265             | 5           | 20                            | 5           | 10              | 1           | 10              | 20          | 15              |
| Other high risk | 24        | 5                   | 70          | 90              | 21          | 10                            | 5           | 5               | 45          | 18              | 25          | 5               |
| N               | 27        | 24                  |             |                 |             |                               |             |                 |             |                 |             |                 |             |                 |

Table 3  Cycle Time and CS Emergency Patient Process Variety

| Treatment decision | Patient Approval | Sent to OR | Admitted in OR | Anesthetized- Incision | Lead Time |
|--------------------|------------------|------------|----------------|------------------------|-----------|
|                    | Pre              | Post       | Pre            | Post                   | Pre       | Post       | Pre          | Post       | Pre          | Post       | Pre          | Post       |
| Mean               | 20.57            | 27.09      | 64.33          | 35.31                  | 5.50      | 4.27       | 23.50        | 18.55      | 11.11        | 7.13       | 126.21       | 93.15 |
| Standard Deviation | 21.76            | 39.83      | 49.58          | 25.61                  | 3.35      | 1.62       | 29.34        | 16.59      | 3.31         | 2.41       | 33.06 minutes (26%) |
| N                  | 14               | 11         | 14             | 11                     | 14        | 11         | 14           | 11         | 14           | 11         | 14           | 11         |

Table 4  The perception of the midwives about supporting factors, barriers, and benefit after LSS implementation in Emergency Maternal Unit.

| Supporting | Barrier | Beneficial |
|------------|---------|------------|
| Teamwork   | Lack of support from management | Faster service and communication |
| Management and leadership support | Limited facility, resource, and time | Understand shortcoming and help works |
| Additional resource: Facility, human resource and funding | Patient overcapacity | Change mindset and knowledge improvement |
| Improve awareness | | |
|            | Teamwork | Others |
Before the implementation, the lead time was 126.21 minutes while after implementation the lead was reduced to 93.15 minutes. The highest process variety was occurred in patient approval until being sent to operating room. However, the result was still the same after implementation of LSS, where the highest process variety occurred in patient approval until being sent to operating room (Table 3).

During value stream mapping, there was waste of overproduction that was calling emergency operating team via operator after the decision. The operator would contact the emergency operating team and called back the midwife. The waste was eliminated by omitting the calling procedure via operator. The communication was conducted directly by midwife to chief or emergency CS team. According to the result, the LSS application not only lowered the lead time, but also cycle time (CT), waiting time (WT), non-value added (NVA), while increased the value added ratio (VAR).

Knowledge and Perception on LSS Implementation

In this research, the average score of participants’ understanding before implementation was 43.67 while after 2 months implementation the average score was increased to 47.65 (increased by 9%). Furthermore, after implementation, the average understandings of participants were 97.89 (increased by 105%) (Figure 3).

During this study, participants tended to have perception that the easiest tools to be implemented were the 5S: Sort/Seiri, Straighten/Set-in-order/Seiton, Shine/Seiso, Standardize/Seiketsu, and Sustain/Shitsuke. The most useful tool in checking the process time was Value Stream Mapping. The other tools were adjusted according to the LSS implementation stage. After LSS implementation, there were also several supporting factors, barriers and beneficial in implementation being perceived by the participants (Table 4).

DISCUSSION

In this study, the average lead time after patient admission to definitive diagnosis decreased after implementation. In CS cases the lead time from before and after implementation decreased by 16%, and in other high risk cases it decreased by 21.7%. This decrease was due to the understanding about the previous process time. The interviews showed that after LSS implementation, especially value stream mapping process, the participants had realized the shortcomings and also had a change of mindset. One of them is to accelerate the process. According to Althabe et al., education and feedback are one of the strategies in improving maternal health care. Participants also considered LSS as positive aspect in improving their work and the communication between teams. This finding is in line with Timmons et al., who reported that the good acceptance of a method would bring positive impact towards the outcomes, including Lean Six Sigma methods.

In abortion-hemorrhage and SPE-hypertension cases there were no decreases in lead time, instead
it was increasing. One of the causes was because those two cases have specific characteristics and treatment, just like in severe pre-eclampsia with hypertension. Hypertension does not always lead to pre-eclampsia, but hypertension with other symptoms (e.g., proteinuria) is an indication of pre-eclampsia.

The other factor is the time of event. In the pre-implementation stage, 60% occurred in the afternoon, but post implementation, 75% of the cases observed in the midnight. This phenomenon resulted in high variation rate in this process including the length of response time of service for patients who were admitted in midnight. However, this findings are in line with the results of study conducted by Welch, et al. who reported that the longest average turnaround time of patients in the ED is 04.00-07.00 in the morning and then started to decrease from 6:00 p.m.

The variation in the process occurred after implementation either in CEmONC or the maternal care unit was because LSS implementation was only implemented in the emergency maternal unit (CEmONC and maternal care). On the other hand, the implementation in the emergency maternal unit has to collaborate with the other units or stakeholders. LSS implementation will bring greater impact if it is conducted in the whole organization.

The longest average cycle time was the process of health care checking by midwife or doctor in the emergency unit/CEmONC. It was because this process is mandatory and pre-requisite for all patients who admitted to ED. The patient then would be observed or had to wait for supporting diagnostic procedures or waiting for a vacant bed in maternal care unit. According to Sinreich and Marmor (2006), the waiting time before being checked by the doctor and additional checking are the main component of the waiting time in ED.

The total waiting time is 51-63% of the total time for patient care in ED. In this research, the longest time since patient admission to being checked by the doctor is 5 minutes. But after being checked, the patient sometimes had to wait until 142 minutes. The same result is shown in Esimai and Omoniyi-Esan, where the patient for antenatal care had to wait for 51.2 minutes before being checked by the nurse/midwife and 2 hours 29 minutes by the doctor.

In CS emergency cases, the average lead time was decreased after implementation compared to before implementation (26%). From the result of analysis on value stream mapping process, it was found that communication process redesign for a CS emergency patient was the main factor. Before the implementation, the patient has to contact CS emergency through the operator and the operator would contact the CS emergency, and then confirmed back to the midwife. This procedure was abandoned and midwives now can contact the head or SC emergency team directly. By eliminating the inefficiency of overproduction, the process variety after patient approval before operation until being delivered to operation room was decreased by 48%. According to Gijo and Antony LSS implementation decreased the average waiting time by 57% and the standard deviation by 70%. Even though it was not statistically significant, the decrease has positive impact toward the service for patients, considering that the current lead time is still far above the minimum standard stated by government regulation (45 minutes) or by NICE (Category 1: 30 minutes; and Category 2: 30-75 minutes). The accurate timing and patient service management is related to the survival of patients since lengthy delay was significantly related to the adverse outcomes and the VA time was also lowered which resulted from deleted VAs in the eliminated processes in the end.

Tools are important elements in LSS implementation. According to Harrison, the method of choice, tools, and techniques are important elements that determine the success of LSS implementation. The most useful tool in this research was Value Stream Mapping. VSM could show the cycle time, waiting time, and lead time of the process in detail. According to Ramaswamy et al., VSM is the method to improve the clinical and quality service by involving the staffs. In the VSM process, the participants can identify the inefficiency, and find the solution to eliminate it. VSM is the method to understand and determine which steps are valuable or not. VSM can also identify the time needed to complete one process as well as the waiting time between the steps in that process. The other tools used in LSS implementation stage were Project Charter, SIPOC, Root cause Analysis, Visual management and tools for standardized process (Standard Operating Procedure and Clinical Pathway). According to Protzman et al., lean implementation is achieved by balancing the implementation between tools usage and cultural change within an organization.

Participants and management perceived that the important factors in supporting or obstructing LSS implementation were: Leadership and support from management, teamwork, resources and emergency unit status. This is in line with the research by Alhuraish et al. (2016), that found the keys for a successful LSS implementation included commitment and support from top management, staff involvement, education and training, communication, linking LSS method with business strategy,
the level of understanding of the employees on the tools and techniques of LSS, cultural change, Kaizen team, and reward system. It is also in line with the study by Hendartini et al. about the factors that support Lean implementation in 8 hospitals in Indonesia. The factors included compatibility with the target or strategy of the hospital, support and commitment from management, implementation in stages, resource support, acknowledgment and reward.

According to LSS implementation and its result, Lean Six Sigma will bring more impact to the overall activities in hospital according to the participants, so that the decision for improvement could be made quickly and implemented collectively. The limitation of this research is the number of samples which were less than expected due to the limited resources and time of research. Patient treatment should be put in the first place compared to observation of LSS implementation. It is recommended that the research be conducted by full timers with full access for all the process besides the participants. Hospital managers and policy makers can adopt LSS concepts to accelerate the process and improve other hospital service quality.

CONCLUSION
The implementation of Lean Six Sigma in the Maternal Emergency Unit has high potential to decrease the lead time for section caesarean cases and the other high risk maternal care. The staffs have positive perception towards the implementation of Lean Six Sigma. Lean Six Sigma implementation could result in significant improvement if being supported fully by the management and other units. The other factor that influenced this approach was human resource availability including staff’s skill to implement the tools.

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CONFLICT OF INTEREST
The author reports no conflicts of interest regarding the publication of this article.

AUTHOR CONTRIBUTION
All authors were equally contributed in this study, manuscript writing, and revision.

REFERENCES
1. Cameron L, Cornwell K. Understanding the Causes of Maternal Mortality in Indonesia. 2016; Available from: http://www.mampu.or.id/sites/default/files/1.1. MAMPU_Monash Maternal Mortality Literature Review CLEAN.pdf
2. WHO. Indonesia: Maternal mortality in 1990-2015. WHO, UNICEF, UNFPA, World Bank Group, United Nations Popul Div Matern Mortal Estim Inter-Agency Gr [Internet]. 2015;1–5. Available from: http://www.who.int/gho/maternal_health/countries/idn.pdf
3. UNICEF Indonesia. Maternal and child health. Jakarta: UNICEF Indonesia; 2012. p. 1–6.
4. Ministry of Health. Mother Health Situation. Jakarta: Center of Information and Data, Indonesian Ministry of Health; 2014.
5. Morrow M, Dayal P, Zhen J. Reducing maternal, newborn and child deaths in the Asia Pacific, 2008;
6. Belton S, Myers B, Ngana FR. Maternal deaths in eastern Indonesia: 20 years and still walking: an ethnographic study. BMC Pregnancy Childbirth [Internet]. 2014;14:39. Available from: http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3901769&tool=pmcentrez&rendertype=abstract
7. Mazzocato P, Savage C, Brommels M, Aronsson H, Thor J, Lean thinking in healthcare: a realist review of the literature. Qual Saf Heal Care. 2010;376–83.
8. Young TR, Mclean SI. A critical look at Lean Thinking in healthcare A critical look at Lean Thinking in healthcare. 2008;382–6.
9. Edson W, Burkhalter B. Timeliness of care for eclampsia and pre-ecmpasia in Benin, Ecuador, and Jamaica. Qual Assur. 2007;209–14.
10. Farrell S, Roye C, Crane J, Davis D, Heywood M, Lalonde A, etc Statement on Wait Times in Obstetrics and Gynaecology. J Obs Gynaecol Can. 2008;3(3):248–257.
11. NICE. Caesarean section Clinical Guidelines [Internet]. 2018 [cited 2018 Mar 5]. Available from: Caesarean section
12. Wendy Edson, Burkhalter B, Harvey S, Boucar M, Djibrina S, Bermida J, et al. Safe Motherhood Studies — Timeliness of in-Hospital Care for Treating Obstetric Emergencies Safe Motherhood Studies — Timeliness of in-Hospital Care for Treating Obstetric Emergencies. Oper Res. 2006(March).
13. Brandenburg L, Gabow P, Steele G, Toussaint J, Tyson BJ, Steele G, et al. Innovation and Best Practices in Health Care Scheduling. National Academy of Sciences; 2015.
14. Gilboy N, Tanabe P, Travers D, Rosenau AM. Emergency Severity Index (ESI) A Triage Tool for Emergency Department Care, Version 4. Rockville, MD: Agency for Healthcare Research and Quality; 2012. AHRQ Publication No. 12-0014.
15. Sinsky CA, Willard-Grace R, Schutzbank AM, Sinsky TA, Margolius D, Bodenheimer T. In Search of Joy in Practice: A Report of 23 High-Functioning Primary Care Practice. Ann Fam Med. 2013;11:272–8.
16. Kaplan G, Bazzoli J, Benneyan J, Dentzer S, Lee E, Litvak E, et al. Report Brief: Transforming Health Care Scheduling and Access [Internet]. Washington, DC: 2015. Available from: http://www.ncbi.nlm.nih.gov/books/NBK316132/
17. Crema M, Verbano C. Guidelines for overcoming hospital managerial challenges: a systematic literature review. Ther Clin Risk Manag. 2013;427–41.
18. NLC, Continuous Quality Improvement (CQI) Strategies to Optimize your Practice. 2013.
19. Ahmed S, Manaf NHA, Islam R. Effects of Lean Six Sigma application in healthcare services: A literature review. Rev Environ Health. 2013;28(4):189–94.
20. Antony J, Laureani A. Standards for Lean Six Sigma certification. Int J Product Perform Manag. 2011;61(1):110–20.
21. Arumugam V, Antony J, Douglas A. Observation: a Lean tool for improving the effectiveness of Lean Six Sigma. TQM J. 2012;24(3):275–87.
22. Bentley W, Davis PT. Lean Six Sigma Secrets for The Cio. Vol. 1, The effects of brief mindfulness intervention on acute pain experience: An examination of individual difference. 2010.
23. Knowles G. Six Sigma. Copenhagen: Ventus Publishing (Bookboon.com); 2011.
24. Pande PS, Neuman RP, Cavanagh RR. The Six Sigma Way How GE, Motorola, and Other Top Companies Are Honing Their Performance. New York: McGraw-Hill Companies, Inc.; 2000.
25. Liker JK. The Toyota Way: 14 Management Principles from the World’s Greatest Manufacturer. History. New York: McGraw Hill; 2004.
26. Andrearatto AD, Ianni L, Lega F, Sargiacomo M. Lean in healthcare: A comprehensive review. Health Policy (New York) [Internet]. 2015;119(9):119–209. Available from: http://dx.doi.org/10.1016/j.healthpol.2015.02.002
27. Sunder M V, Ganesh LS, Marathe RR. A morphological analysis of research literature on Lean Six Sigma for services. Int J Oper Prod Manag [Internet]. 2017;00–00. Available from: http://www.emeraldinsight.com/doi/10.1108/IJOPM-05-2016-0273
28. Huang Y, Li X, Wilck J, Berg T. Cost reduction in healthcare via Lean Six Sigma. 62nd IIE Annu Conf Expo 2012 [Internet]. 2012;1263–70. Available from: http://www.scopus.com/inward.record.uri?eid=2-s2.0-84900322478&partnerID=ZTox3y1
29. Stamatis DH. Essentials for the Improvement of Healthcare Using Lean & Six Sigma. New York: Taylor & Francis Group, LLC; 2011.
30. Gijo E V, Antony J. Reducing patient waiting time in outpatient department using lean six sigma methodology. Qual Relia Eng Int. 2013;30(8):1481–91.
31. Graban M. Lean hospitals: improving quality, patient safety, and employee satisfaction. Third. Boca Raton: CRC Press/Taylor & Francis Group; LLC; 2007.
32. Arthur J. Lean Six Sigma for Hospital. Simple Step to Fast, Affordable, Flawless Healthcare. New York: McGraw Hill; 2011; 1–348 p.
33. Gil-Moreno LG. Impact of a Localized Lean Six Sigma Implementation on Overall Patient Safety and Process Efficiency [Internet]. Old Dominion University Follow; 2017. Available from: http://digitalcommons.odu.edu/emse_edts/16
34. Kemmis S, McTaggart R. Participatory Action Research. 2007;271–330.
35. Yeh H, Lin C, Su C, Wang P. Applying lean six sigma to improve healthcare: An empirical study. 2011;5(31):12356–70.
36. Alhabe F, Bergel E, Luisa M, Gibbons L, Ciapponi A, Aleman A. Strategies for improving the quality of health care in maternal and child health in low- and middle-income countries: an overview of systematic reviews. Strategies. 2008;22:42–60.
37. Timmons S, Coffey F, Vezyridis P. Implementing lean methods in the Emergency Department. J Health Organ Manag. 2014;28(2):214–28.
38. Duley L. Pre-eclampsia , eclampsia , and hypertension. Search date July 2007 Pre-eclampsia , eclampsia , and hypertension. Clin Evid (Online). 2008;(July 2007):1–20.
39. Welch SL, Jones SS, Allen T. Mapping the 24-Hour Emergency department Cycle to Improve patient Flow. J Comm J Qual Patient Saf. 2007;33(5):247–55.
40. Sinreich D, Marmor Y. Ways to reduce patient turnaround time and improve service quality in emergency departments. J Health Organ Manag. 2006;19(2):88–105.
41. Esimai O, Omoniyi-Esan GO. Wait time and service satisfaction at Antenatal Clinic, Obafemi Awolowo University Ille-Ife. Vol. 6, East African journal of public health. 2009. 309–311 p.
42. Pacagnella RC, Cecatti JG, Parpinelli MA, Sousa MH, Haddad SM, Costa ML, et al. Delays in receiving obstetric care and poor maternal outcomes: Results from a national multicentre cross-sectional study. BMC Pregnancy Childbirth. 2014;14(1):1–15.
43. Harrison A. What makes Lean/Six Sigma Succeed. In: Antony J, Kumar M, editors. Lean Six Sigma: Research and Practice. Ventus Publishing ApS; 2011. p. 175–89.
44. Ramaswamy R, Roithschild C, Alabi F, Wachira E, Muigai F, Pearson N. Using Value Stream Mapping to improve quality of care in low-resource facility settings. Int J Qual Heal Care. 2017;29(7):961–5.
45. Gaspersz V. Lean Six Sigma for Manufacturing and Service Industries. Jakarta: PT. Gramedia Pustaka Utama; 2007.
46. Polk JD. Lean Six Sigma, Innovation, and the Change Acceleration Process Can Work Together. Physician Exec [Internet]. 2011;37(1):38–42. Available from: https://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=57457680&lang=es&site=eds-live&scope=cite
47. Protzman C, Whiton F, Kerparj J, Lewadowski CR, Steenberg S, Grounds P. The Lean Practitioner’s Field Book. Boca Raton: CRC Press/Taylor & Francis Group; LLC; 2016.
48. Alhuraish I, Robledo C, Kobi A. The Key Success Factors for Lean Manufacturing versus Six Sigma. 7th Toulon-Verona Int Conf Excell Serv. 2012;12(2):169–82.
49. Hendartini J, Meliala A, Firman, Endartiwii SS, Bismantara H. Training Evaluation: Value Based Service In Healthcare With Lean Management (Kirkpatrick-WHO Method For Training Evaluation). Yogyakarta; 2016.