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Quality Improvement of The Public Service of The Metal Contamination Testing Laboratory Using Lean Six Sigma Approach (Case Study)

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ABSTRACT

Testing laboratory public services play an important role in providing services to the public in various sectors. Currently, many laboratories only focus on the quality of testing but forget about the timeliness of testing services which affects customer satisfaction as a metric of public service performanceTherefore, to improve quality by achieving timeliness of testing services, this research uses a Lean and Six Sigma approach and risk management. Through the tools used such as Value Stream Mapping (VSM), Spaghetti Diagram, Fish-bone Diagram, PICK Chart in the Define, Measure, Analyze, Improve, and Control (DMAIC) phase of Lean Six Sigma, problems can be identified, analyzed and corrected for improvement. In the measure phase, the completion time for testing services was 17 working days so it did not meet the service time standard (timeliness) which is 16 working days. After the improve phase solution is implemented, the service turnaround time becomes 7 working days. Apart from achieving faster completion times for testing services, the improvement rate for eliminating NVAA was 99.5%, eliminating waiting and over-processing waste by 100%. In order for this achievement to remain controlled, risk statements regarding the timeliness of testing services are identified, analyzed, controlled and monitored. The results of improvement trials on samples, SPM testing services for Pb, Cd, Hg, As metal contamination in food reached 100%.

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INTRODUCTION

Public services have an important role in economic growth and development, their contribution is to create and provide sustainable economic growth strategies in facing existing challenges (Fourie dan Poggenpoel, 2017). Public services are activities or series of activities in order to fulfill service needs in accordance with statutory regulations for every citizen and resident for goods, services and/or administrative services provided by public service providers (Law of the Republic of Indonesia, 2009). The need for public services to provide higher quality services is increasing, making it increasingly urgent to improve public sector performance. Most public services serve citizens, the private sector or other stakeholders as customers for free or at subsidized prices. Because of this, many public sectors have developed new models through process improvements to improve their supply chains, gain efficiencies, reduce time and save costs (Moullin, 2017). Even though this development leads to complexity (Raja Sreedharan dkk., 2017), it must be done for customer satisfaction. Because customer satisfaction is one of the public service performance metrics that shows improvements in service quality. In maintaining customer satisfaction, many public sector organizations around the world are trying to reduce organizational bureaucracy (Lukrafka dkk., 2020). One way to overcome this problem is to involve staff in innovating and providing high-quality services in a cost-effective manner, while meeting increasing external expectations and demands (Elliott, 2020; Suseno dkk., 2020).

To respond to these demands, several organizations have adopted operational excellence, namely a strategy of continuous improvement and innovation (Lukrafka dkk., 2020). For many businesses such as manufacturing industries, service industries and public services,*Quality improvement* (QI)dan*Continuous improvement* (CI) has become a very important business strategy (Antony dkk., 2017). An important component of the long-term performance of modern companies is the development of effective QI or CI (Juliani dan Nawangpalupi, 2020).

According to (van Lierop dan El-Geneidy (2016), a testing service in a public sector organization must be able to provide satisfaction to its customers to achieve growth in a positive direction. Testing laboratories play an important role in many decisions making such as diagnosis, product quality and treatment (Ibrahim dkk., 2022). Testing laboratories have traditionally focused on internal indicators, namely the quality of testing, even though timeliness (*timeliness*) is also a major satisfaction factor (Kappelmayer and Toth, 2016; Tsai et al., 2019). Laboratories usually evaluate timeliness by measuring the completion time (*Turn Around Time*), which is generally defined as the time from receipt of the specimen in the laboratory to availability of validated results; or by calculating the percentage of timeliness based on reporting time (Tsai., 2019)

According to (Vignesh dkk., 2016), in improving service quality and helping to reduce or eliminate waste, an effective method to apply is the*Lean*. The customer perspective is used to define value in Lean (Ibrahim dkk., 2022). What customers want and don't want from a good or service is determined by value-added activities (VAA) and non-value-added activities (NVAA) (Cohen, 2018). The essence of the approach*Lean* is the elimination of waste (Ibrahim dkk., 2022). Types of waste include waste waiting (waiting), waste*motion* (movement) such as movement between buildings, and waste defect (defects) such as not meeting the timeliness of the process (Cohen, 2018).

Organizations have adopted several techniques to break down barriers through service integration with concept six *sigma* (Salah dkk., 2010), change management (Asnan dkk., 2015), and knowledge management (Zhao dkk., 2016). According to Ibrahim dkk. (2022), speed is the main focus of lean, while structure*Define, Measure, Analyze, Improve, Control* (DMAIC)*Six Sigma* provides more analytical tools for control and diagnosis. *Lean* and*Six Sigma* are two quality improvement approaches that work well together especially for timeliness targets (Yaduvanshi dan Sharma, 2017). Because their work relies on testing and measurement, testing laboratory services are no strangers to statistical precision and quality control (Lippi dan Plebani, 2018), making testing laboratories potential candidates for implementation*Lean Six Sigma*. There is currently very little research describing use*Lean Six Sigma* in clinical laboratories (Henrique dan Godinho Filho, 2020), and even fewer use them to improve timeliness. Inal dkk. (2018) reported use*Lean Six Sigma* to improve timeliness in the laboratory with significant success.

At a government testing laboratory in Indonesia, laboratory service problems related to the timeliness of testing resulted in the failure to fulfill public service quality targets as indicated by*Key Performance Indicator* (IKU). KPI is an indicator or measure used to control the performance of an organization, work unit, or individual, in achieving predetermined strategic goals (BKN, 2022). The testing laboratory has KPIs for 2023, one of which is compliance with Minimum Service Standards (SPM) of 98%; which cannot be achieved in 2023 because the SPM monitoring results are 93%. Of the 210 testing orders received for service, 15 orders experienced delays and 87% came from orders for testing metal contamination in food. Obstacles in achieving SPM due to timeliness testing for metal contamination in food has still not been achieved, namely 16 (sixteen) working days as stipulated in the testing service implementation procedures. Metal contamination testing is a test parameter that indicates the amount of metal content, in this case the metals Pb, Cd, Hg and As, which are detected in food. The testing procedure for metal contamination Pb, Cd, Hg refers to SNI 01-2896-1998 and for metal contamination as refers to SNI 01-4866-1998. An interview with the Team Leader as the KPI owner has been carried out, but follow-up has not yet been carried out. This can have an impact on the feedback given by customers when taking the Test Results Report (LHU). Therefore, management must determine new strategies to overcome these obstacles with effective methods (Cigolini dkk., 2008).

Until now, there has not been much empirical research published regarding implementation*Lean Six Sigma* in public service organizations testing technical services for quality improvement. Empirical research is based on real-world observations by collecting naturally occurring data or experiment-based data; through experience in the field rather than simulation (Jasti dan Kodali, 2015). Therefore, the case of testing laboratories in public services needs to be examined because testing services are a core activity to achieve organizational goals.

Based on a review of the importance of quality public services,*Lean Six Sigma*, and the case faced above, thus there is*gap* which can be filled in by the author is research regarding improving public services in testing laboratory technical services, especially in the field of testing metal contamination in food using the Lean Six Sigma approach. This research aims to determine the causes of time delays and waste that occur and how to achieve punctuality according to testing service targets. The results of the improvements are expected to improve the quality of metal contamination testing laboratory services.

THEORETICAL REVIEW

The term "Lean Six Sigma" was widely used in the late 1990s and early 2000s (Byrne dkk., 2007; George, 2003) to describe a combination of ways of thinking*Lean* and*Six Sigma*. Systematically combining the concepts and principles of "production lean" which illustrates a situation into a map called*Current State Map* (CSM) with DMAIC framework to generate process improvements is the core of the methodology "*Lean Six Sigma*" (Isa dan Usmen, 2015). This integration is focused on overcoming the setbacks of these two methodologies. The integration of these two continuous improvement methodologies is a guide for organizations to increase their improvement potential (Bhuiyan dan Baghel, 2005). *Lean Six Sigma* described as strategies and methodologies in business that improve process performance, and increase customer satisfaction, leadership, and profit results by improving quality, speed, and cost (Snee, 2010). Business cases that have high impact and no clue about the root cause of the problem or unknown solutions from the start of problem definition are the most suitable for projects*Lean Six Sigma* (Antony dkk., 2018).

Success story*Lean Six Sigma* as one of the techniques best *practice*' Continuous improvement' has invited many organizations around the world to implement it in order to improve their operating processes and become more competitive. In public sector organizations, Lean Six Sigma (LSS) has become a popular operational excellence methodology worldwide, to increase customer/public satisfaction, speed up processes, reduce costs and maximize stakeholder (Alblooshi dkk., 2021; Antony, Rodgers, dkk., 2017; Raja Sreedharan dkk., 2017).

The objectives of each stage of DMAIC are explained below (Kaushik and Khanduja, 2010; Vijaya Sunder, 2015):

1. *Define*: describes the business problem, the impact of the problem, the scope of the project and defines the processes to be improved.
2. *Measure*: understand and document the current state of the process to be improved, collect information*The Voice of Customer* (VOC), and validate the applicable measurement system.
3. *Analyze*: analyze collected data related to VOCs and processes to identify

root causes of process problems.

4. *Improve*: identifying recommendations for improvement, designing future conditions, implementing pilot projects, training and documenting new processes.
5. *Control*: sustaining better results from pilot projects, managing change on a wider scale; reporting data scorecards and control plans as well as identifying replication opportunities and developing plans for further improvement.

METHODOLOGY

This research uses a case study research strategy. This research follows the DMAIC methodology (Stern, 2018) to define problems and customer needs, measure the basic performance of current processes, analyze data to find the causes of problems, improve processes to eliminate NVAA and waste, and control processes so that waste does not recur.

The data collection process was carried out by observing, interviewing 6 selected informants, and reviewing documents. Primary data was obtained through direct observation of the time required for testing services and in-depth interviews with the sample registration section, sample handling section, sample destruction section, sample reading section, data processing section, and the Test Results Report (LHU) publishing section. The selection of informants is based on several conditions, including suitability and adequacy. Informants are also still directly involved in research activities and can provide adequate time to be asked for information within the scope of the research time. Based on these provisions, the informants in this research were from the public service unit (1 person), sample handling officer (1 person), laboratory analyst (1 person), laboratory supervisor (1 person), laboratory team leader (1 person) and head of organization (1 person). The document review was carried out by studying policies, guidelines and standard operational procedures related to Pb, Cd, Hg and as metal contamination testing services in food. This research was conducted in June 2023-March 2024. To ensure that the information we obtained from the research data was accurate, quantitative data processing and analysis was carried out using univariate analysis by calculating the average value, maximum value and minimum value to describe the time taken. required for each testing service process (*lead time),* and to find out the time of activities that provide added value- or value-added time (VAT) and non-value-added time (NVAT). Qualitative analysis was carried out by recapitulating the results of observations combined with the results of relevant in-depth interviews and then narrating descriptively.

Details of data collection and analysis are mentioned in each stage separately. Various tools and techniques are used including bar charts, flow charts, Spaghetti diagrams, CVSM, fishbone diagrams, FSVM, as well as comparison of results current and future.

Implementation of Lean Six Sigma

Phase *Define*

1. Determining research priorities is carried out based on the KPI in the field of Testing for 2023. This KPI is the timeliness of testing services which is reduced to the work results plan in the form of monitoring Laboratory Minimum Service Standards (SPM). SPM monitoring in 2023 has a target of 98% and achievement of 93% so it is categorized as below expectations.
2. Customer feedback is very essential to public services, so a 2023 Community Satisfaction Index survey was conducted. A total of 120 customers were respondents to the 2023 IKM survey with results ranging from 3.66 - 3.91 for the nine survey questions. When compared between the nine survey categories, the service timeliness category is in the lowest position. Because of this, timeliness of testing is increasingly becoming a focus of research.
3. Test Parameters In obtaining the test parameters that are the focus of the research, it is necessary to consider the 2023 SPM monitoring results in more detail (Table 1) obtained from the documentation of SPM monitoring officers. Based on this table, the timeliness of testing that is most frequently not achieved is food commodities for testing for lead (Pb), cadmium (Cd), mercury (Hg) and arsenic (As) metal contamination. Of the SPM monitoring of 93%, 7% did not meet the timeliness of testing and the biggest contribution was testing for metal contamination in food at 87%.

Table 1. SPM Monitoring in 2023

SPM Testing Laboratory 2023		TMS Testing Laboratory 2023	
TMS (Not Entered SPM)	15	TMS (Not Entered SPM)	15
MS (Enter SPM)	206	TMS does not contain metal contamination in food	13
Total Test Orders	221	TMS does not contain metal contamination in food	2
Realization of SPM 2023	93,12 %	Realization of SPM for metal pollution 2023	87 %

4. Process Limitations The process in determining the SPM starts from registering the order by the customer until the customer obtains the Test Results Report (LHU). Testing service procedures are currently prepared generally for all testing laboratory services and there is no completion time study stage for each testing process.

Phase Measure

In phase*Measure*, data collection based on observations was carried out. Testing service procedures and their activities do not yet cover the actual conditions of the testing service flow. Observation results are written in the observation document in the same format as the testing service procedure document from the sample received from the customer until the Test Results Report (LHU) is received by the customer. The results of testing service observations can be seen in Table 2.

Carrying out testing services, from the administration process to sample testing, is carried out in two buildings. The number of technicians who carry out testing for Pb, Cd, Hg, as metal contamination in food is 1 (one) person for sample handling and 1 (one) person for carrying out sample preparation, sample testing and data processing. The testing service time is 6.5 hours a day (working days: Monday-Friday) with the analyst working time in the laboratory being 5.5 hours a day (working days: Monday-Friday).

Table 2. Service Process for Testing Metal Contamination in Food

No.	Aktivitas	Pelaksana									Waktu	Keterangan
		Pelanggan	Petugas UPP	Bendahara Penerimaan	Penyelia Laboratorium	Petugas penanganan contoh uji	Analis Laboratorium	Admin Sertifikat	Ketua Tim PKIV	Kepala Balai		
1	Membawa contoh uji dan mengajukan permohonan pengujian										1 menit	registrasi sampel
2	Memeriksa contoh uji dan menerbitkan BPCU										2,5 menit	registrasi sampel
3	Menerbitkan e-Billing										0,5 menit	registrasi sampel
4	Melakukan pembayaran										120 menit	registrasi sampel
5	Menerbitkan Surat Perintah Kerja Pengujian (SPKP)										1 menit	registrasi sampel
6	Memverifikasi SPKP dan contoh uji										1 menit	registrasi sampel
7	Melaksanakan penanganan contoh/sampel uji										30 menit	penanganan sampel
8	Melaksanakan pengujian (preparasi dan pembacaan contoh uji) dan mengolah data hasil pengujian										16 hari	desktruksi sampel (8), pembacaan sampel (4), pengolahan data (4) SNI 01-2896-1998 SNI 01-4886-1998
9	Melakukan verifikasi pengolahan data hasil uji										120 menit	pengolahan data
10	Melaksanakan penerbitan Laporan Hasil Uji (LHU)										15 menit	Penerbitan LHU
11	Validasi lembar kedua LHU										5 menit	penerbitan LHU
12	Validasi lembar pertama LHU										10 menit	penerbitan LHU
13	Mengesahkan LHU										1 menit	Penerbitan LHU
14	Menerima LHU										1 menit	Penerbitan LHU
15	Penyerahan LHU										1 menit	Penerbitan LHU

1. *Current Value Stream Mapping (CVSM)*

The observation process to measure the time of metal contamination testing services is carried out using the time and motion study method by recording the time of value-added activities (VAA) and non-value-added activities (NVAA) from each stage of the metal contamination testing service process flow, starting from when the customer registers the sample until the Test Results Report (LHU) is received by the customer. Each personnel activity in the testing service process is followed, and Value-Added Time (VAT), Non-Value-Added Time (NVAT), Cycle Time (CT) for each stage, and Lead Time (LT) are calculated. An overview of the Current Value Stream Mapping (VSM) testing service can be seen in the image below:

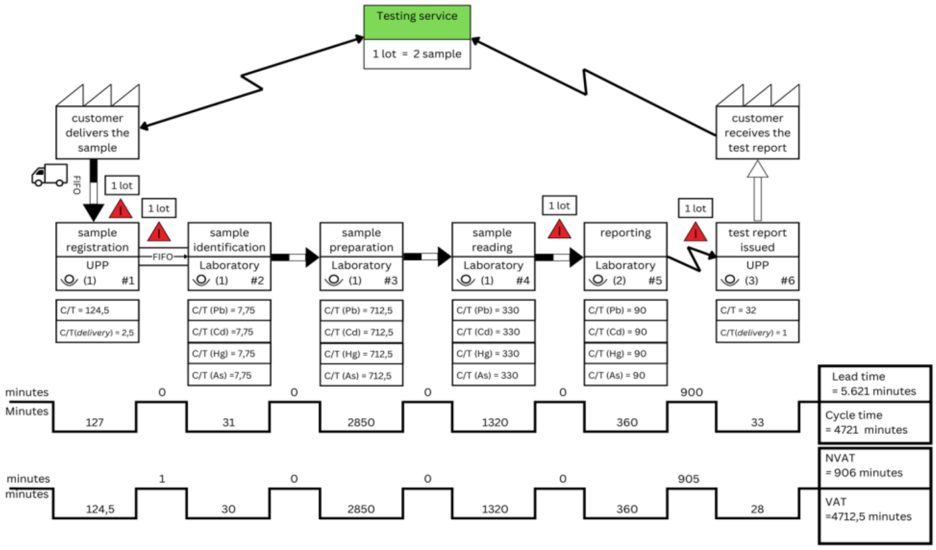

Figure 2. An overview of the Current Value Stream Mapping (VSM)

2. *Identify VA and NVA Activities*

The results of direct observation, apart from calculating time, also observing and recording value-added activities and non-value-added activities from each stage of the testing service process flow are shown in Table 3.

Tabel 3 Value Added and Non-value-added Activities Pada CVSM

	Value Added Activities		Non-Value-Added Activities	
Process activity	BOAT	VAT (minutes)	NVAA	NVAT
Sample registration	Customer requests testing	0,5	-	-
	The UPP officer examines the test samples, prepares a sample receipt report	2,5	-	-
	The revenue treasurer issues	0,5	-	-

	the Simponi Kemenkeu e-billing			
	Customers pay e-billing	120	-	-
	UPP officers issue Testing Work Orders (SPKP)	1	-	-
Sample handling	-	-	Laboratory supervisor inspects SPKP	1
	Samples are handled and stored in the sample storage room	30	-	-
Sample testing	Sample destruction	2850	-	-
	Reading on AAS device	1320	-	-
Data processing	Laboratory analysts carry out data processing	240	Waiting time	900
	The laboratory supervisor checks the results of data processing	120	-	-
Publication of LHU	LHU typing	15		
	-	-	LHU is initialed by the Laboratory Supervisor	5
	The LHU is initiated by the Team LeaderPKIV	10	-	-
	LHU signed by Head of Station	1	-	-
	LHU is handed over to the customer	1	-	-

Based on the results of observations, NVAT was found during the re-examination of the Testing Work Order (SPKP) by the laboratory supervisor, where the SPKP should have been handed over directly to the sample handling officer. The longest delay is the waiting time between data processing for a metal and sample preparation time for subsequent metal destruction. This waiting time is used by laboratory analysts to clean all the glass equipment so that it is ready to be used for further destruction. Apart from that, the laboratory supervisor carried out a re-examination of the LHU so that this activity could be categorized as NVA.

3. *Spaghetti Diagram (Layout andMotion)*

On Spaghetti the diagram is drawn layout and motion parties involved in testing services as in Figure 2. With this diagram, motion is a waste (*waste*) can be identified.

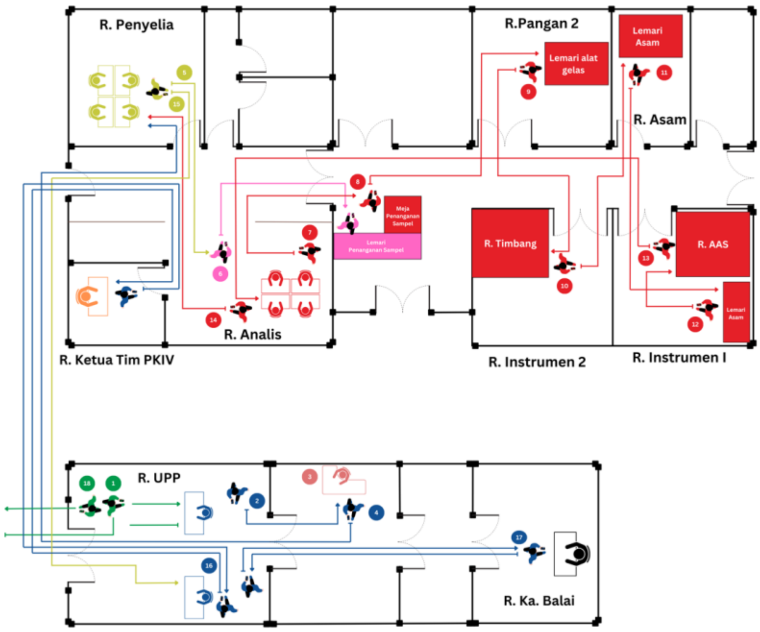

Figure 3. Spaghetti Diagram (*Layout* and*Motion*)

From measurements motion, to carry out PB, Cd, Hg, and as metal contamination testing services, motion 9-14 must be repeated 4 times because each metal test must carry out the same motion. So, the total motion in the metal contamination testing service is 36 motions.

4. *Waste (waste)*

Waste that can be identified from non-value-added activities can be seen in Table 4.

Table 4. Types Waste based on*Non-Value Added Activities*

	Non-Value-Added Activities		Type*waste*
Process activity	NVAA	NVAT	
Sample handling	Laboratory supervisor inspects SPKP	1	*overprocessing*
Data processing	Waiting time for data processing	900	*waiting*
Publication of LHU	LHU is initialed by the Laboratory Supervisor	5	*overprocessing*

Based on Table 4, 3 non-value-added activities were found in metal contamination testing services with 99% being waste *waiting* with tNVAT= 900 minutes, and 1% of the activity is waste over processing with a total non-value added time of 2 minutes.

Data Fase Analyz

1. CVSM Analysis

CVSM that has been prepared in phases measured analyzed by stakeholder related to the Laboratory Management Review Meeting (RTM) for the first quarter of 2024 held by the team leader, one of the agendas was the evaluation of the 2023 SPM which was unable to meet the target of 98% on time service and there were customer complaints regarding testing service times. From the results of CVSM observations, preparation and reading of PB, Cd, Hg, as metal contamination test samples takes the longest time, namely 4170 minutes (69.5 hours) from lead *time* 5621 minutes (93.7 hours). If the working time for laboratory personnel in the laboratory is 5.5 hours, then:

Sample testing working days $=\frac{69{,}5\ jam}{5{,}5\ jam} * 1\ working\ day = 13\ working\ days$ and if the working time for activities outside of testing is 6.5 hours, then:

Working days other service activities and waiting times =

$$\frac{(93{,}7 - 69{,}5)\ jam}{6{,}5\ jam} * 1\ working\ day = 4\ working\ days$$

Based on CVSM, waiting time (*waiting time*) from the data processing process for one metal to the next metal preparation process is 15 hours (3 working days). This is difficult to avoid because the subsequent metal contamination testing preparation process is an uninterrupted process that needs to be carried out in one working day. The standard service time according to testing service procedures of 16 working days is certainly difficult to achieve with the measurement of working days for testing services for metal contamination of Pb, Cd, Hg, as in food amounting to:

Completion time for metal contamination testing $= 13\ working\ days + 4\ working\ days = 17\ working\ days$

2. Diagram Fish-Bone

To identify the causes of long test completion times, the presence of NVA and waste, a root cause analysis is carried out using a fishbone diagram as in Figure 4.

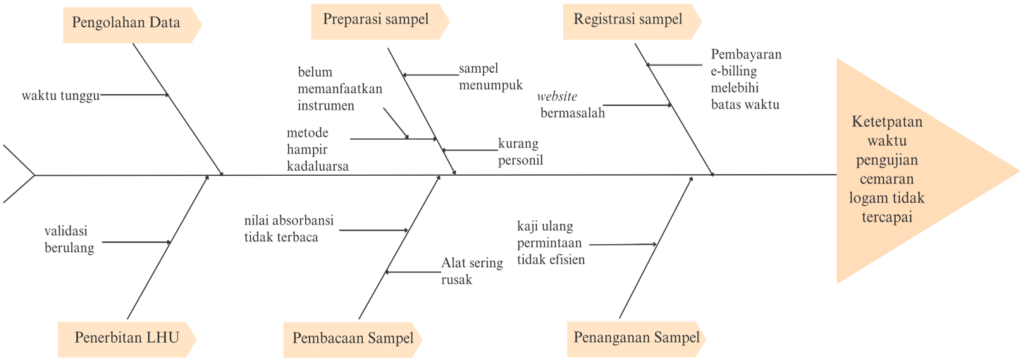

Figure 4. Fishbone Diagram

Based on this diagram, the identification results obtained include:

1. During the sample registration process, the website application for services often experiences damage so forms that should be automatically printed in the application must be created manually.
2. In the sample handling process, a review of test requests in the form of SPKP is carried out every time there is a test request so that there are repeated checks and are considered inefficient.
3. In the sample preparation process, the testing work instructions still use the old method, namely SNI 01-2896-1998 and do not utilize digestion instruments so it takes a lot of time in the process. Apart from that, if the samples arrive at the same time, the samples will accumulate during the digestion process because it takes a long time. The laboratory personnel who handle sample digestion and reading are the same analysts so they cannot carry out parallel work.
4. During the sample reading process, the equipment is often damaged so that the absorbance value cannot be read.
5. In data processing, there is a waiting time for the destruction process for the next metal which the analyst uses as time for cleaning the glassware so that it is ready to be used for the destruction process.
6. In the LHU issuance process, LHU validation is carried out repeatedly, namely by the Team Leader and laboratory supervisor.

RESULTS

Phase ResultsImprove

Through the Management Review Meeting for the first quarter of 2024, solutions to the roots of the problem were put forward and it was determined which solutions could be implemented immediately through the Possible, Implement, Challenge, Kill (PICK)*chart*. The established solution is:

Possible: eliminates wasteful overprocessing such as re-inspection activities.

SPKP inspection activities every time there is a request for testing by the laboratory supervisor, are carried out at the beginning of the working day before the testing service time. This is also called a demand review. Review requests, namely ensuring that on the day of service, all personnel, equipment, chemicals and test methods are ready to be used to provide services. When this is done, NVAT is reduced by 1 minute and motion 5 doesn't need to be there. Samples and SPKP can only be received directly by the sample handling officer.

In addition, by eliminating validation or affixing initials to the LHU by the laboratory supervisor, NVAT can be reduced by 5 minutes because validation can only be carried out by the Team Leader.

Challenge: developing a method for testing metal contamination in food to shorten test completion times and overcome waiting times in data processing.

Through the development of test methods, the focus is on developing destruction methods using destruction instruments. Before being tested, the method to be developed must be verified first, whether it meets the requirements for linearity, repeatability and accuracy. After meeting the method verification requirements, method development work instructions are then prepared and tested. Trials were carried out on food products, namely sago flour. The product will be tested for metal contamination using method development. As a result, the destruction process does not need to be carried out separately for each metal. The sample destruction and blank digestion processes can be carried out simultaneously because the digestion instrument has 16 vessels which can destroy 8 metals at once. Even though the readings on the AAS instrument remain individual to each metal, the short digestion process greatly reduces the time to complete the metal contamination test. In addition, there is no need for waiting time for data processing because laboratory analysts no longer need to prepare digestion glassware for further metals. Waste that will also be reduced is motion. Because destruction does not need to be done repeatedly for 4 metals, motions 9-14, except motion 13, can be reduced 3 times. The results of this improvement will be more visible on*Future Value Stream Mapping* (FVSM).

A. *Future Value Stream Mapping* (FVSM)

The above solution as an improvement strategy for improving public metal contamination testing services is depicted in FVSM which can be seen in Figure 45.

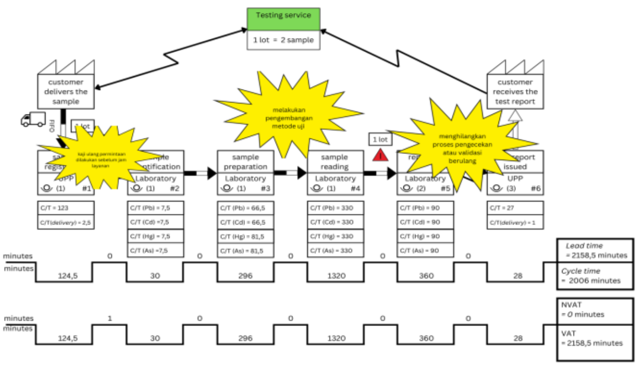

Figure 5. Future Value Stream Mapping (FVSM)

From the results of FVSM observations, sample preparation for PB, Cd, Hg, As metal contamination testing after the development of the test method, experienced a decrease in completion time. Completion time can be shortened to 296 minutes or reduced by 89.6% compared to sample digestion completion time with the previous test method. The testing process time (sample digestion and reading) is 1616 minutes (26.9 hours) with*lead time* 2158.5 minutes (35.98 hours). If the working time for laboratory personnel in the laboratory is 5.5 hours, then:

Sample testing working days $=\frac{26{,}9\ jam}{5{,}5\ jam} * 1\ working\ day = 5\ working\ days$

and if the working time for activities outside of testing is 6.5 hours, then:

Working days other service activities and waiting times =

$$\frac{(35{,}98 - 26{,}9)\ jam}{6{,}5\ jam} * 1\ working\ day = 2\ working\ days$$

Completion time for metal contamination testing $= 5\ working\ days + 2\ working\ days = 7\ working\ days$

Based on FVSM, waiting time (*waiting time*) from the data processing process for one metal to the next metal preparation process can be eliminated because the destruction process can be carried out at once. As a comparison of improvement results from current state to future state; lead time, VAT, NVAT,*waste* will be compared in Table 5.

Table 5. Comparison*Current State* and*Future State*

	Current State	*Future State*	*Improvement Rate (%)*
value-added time	4712.5 minutes	2158.5 minutes	45,8
non-value added time	906 minutes	0 minutes	100
movement (*motion*)	36 motion	20 motion	55,6
waiting time (*waiting time*)	900 minutes	0 minutes	100
0ver processing	6 minutes	0 minutes	100

The research results found that there were 2 non-value-added activities, namely the waste waiting and overprocessing categories. Apart from that, waste motion must also be taken into account. Waste waiting is an ineffective process and wastes time when one process still has to start while another process has finished, even though the process flow should run smoothly and continuously (Yuliati, 2021).

The type of waste overprocessing is in second place in this research. Over processing waste is adding work that is not needed. Overprocessing as one of the seven wastes is caused by unclear standards and specifications. Some operators often try to provide the best service, but are not always aware of the factors that truly add value to the product.

B. *Phase Control*

The results of the improvement phase, namely work instructions for developing test methods, are then distributed to laboratory personnel. Documentation of methods and results from previous stages, as well as the verification process, are managed by the laboratory supervisor. Laboratories must be able to communicate these documents effectively and ensure that activities are performed consistently over time. A control plan is created with the team leader, laboratory supervisor and laboratory analyst to maintain the achievements achieved. Control variables, specification limits and actions taken to address out-of-control results are determined by laboratory personnel, taking into account the feasibility of the measurements.

DISCUSSION

Inaccuracy of test results is a major cause of customer dissatisfaction. Timeliness can be measured by TAT (expressed in minutes or hours) or reporting against an established standard measure (expressed as a percentage). TAT evaluates the process that produces the service, while standard time is used as a boundary to evaluate the desired outcome of the service.Howanitz (2005), also recommends that the TAT goal be expressed as a percentage of all outcomes completed within a time interval.Based on the improvement results, the application of Lean Six Sigma has proven that this method was successfully used to achieve the research objective, namely achieving timely testing. With the completion time of testing results improvement is 7 working days, this must still be controlled so that Minimum Service Standards are still achieved. The expected long-term implication for the performance of laboratory services testing metal contamination in food is to increase confidence in the timeliness of laboratory testing, thereby potentially increasing Community Index Survey results in the coming years.

CONCLUSION AND SUGGESTION

This research shows that the use of Lean Six Sigma has succeeded in increasing the timeliness of testing services for Pb, Cd, Hg and as metal contamination as the main causes of customer dissatisfaction. The results of the improvement phase show that timeliness is able to reach 100% SPM compared to the measurement phase which exceeds the standard service time. Laboratory management support and commitment in generating and implementing quality improvement ideas is the key to success. The process changes used to produce improvements tend to be simple, and specific to current processes and people.

However, the principles and tools used are universal, so they can be adapted and used in other sets of processes, people and places.

REFERENCES

Alblooshi, M., Shamsuzzaman, M., Khoo, M. B. C., Rahim, A., & Haridy, S. (2021). Requirements, challenges and impacts of Lean Six Sigma applications – a narrative synthesis of qualitative research. In *International Journal of Lean Six Sigma* (Vol. 12, Issue 2, pp. 318–367). Emerald Group Holdings Ltd. https://doi.org/10.1108/IJLSS-06-2019-0067

Antony, J., Gupta, S., Sunder M, V., & Gijo, E. V. (2018). Ten commandments of Lean Six Sigma: a practitioners' perspective. *International Journal of Productivity and Performance Management*, *67*(6), 1033–1044. https://doi.org/10.1108/IJPPM-07-2017-0170

Antony, J., Rodgers, B., & Cudney, E. A. (2017). Lean Six Sigma for public sector organizations: is it a myth or reality? *International Journal of Quality and Reliability Management*, *34*(9), 1402–1411. https://doi.org/10.1108/IJQRM-08-2016-0127

Antony, J., Snee, R., & Hoerl, R. (2017). Lean Six Sigma: yesterday, today and tomorrow. *International Journal of Quality and Reliability Management*, *34*(7), 1073–1093. https://doi.org/10.1108/IJQRM-03-2016-0035

Asnan, R., Nordin, N., & Othman, S. N. (2015). Managing Change on Lean Implementation in Service Sector. *Procedia - Social and Behavioral Sciences*, *211*, 313–319. https://doi.org/10.1016/j.sbspro.2015.11.040

Bhuiyan, N., & Baghel, A. (2005). An overview of continuous improvement: From the past to the present. In *Management Decision* (Vol. 43, Issue 5, pp. 761–771). https://doi.org/10.1108/00251740510597761

Byrne, G., Lubowe, D., & Blitz, A. (2007). Using a Lean Six Sigma approach to drive innovation. *Strategy & Leadership*, *35*(2), 5–10. https://doi.org/10.1108/10878570710734480

Cigolini, R., Fedele, L., & Villa, A. N. (2008). Managing facilities under the multi-service result-oriented approach: Some insights coming from the field in Italy. *Production Planning and Control*, *19*(4), 312–326. https://doi.org/10.1080/09537280802034075

Cohen, R. I. (2018). Lean Methodology in Health Care. In *Chest* (Vol. 154, Issue 6, pp. 1448–1454). Elsevier Inc. https://doi.org/10.1016/j.chest.2018.06.005

Elliott, I. C. (2020). Organisational learning and change in a public sector context. *Teaching Public Administration*, *38*(3), 270–283. https://doi.org/10.1177/0144739420903783

Fourie, D., & Poggenpoel, W. (2017). Public sector inefficiencies: Are we addressing the root causes? *South African Journal of Accounting Research*, *31*(3), 169–180. https://doi.org/10.1080/10291954.2016.1160197

George, M. L. (2003). *Lean Six Sigma for Service.* McGraw-Hill Professional Publishing.

Henrique, D. B., & Godinho Filho, M. (2020). A systematic literature review of empirical research in Lean and Six Sigma in healthcare. In *Total Quality Management and Business Excellence* (Vol. 31, Issues 3–4, pp. 429–449). Routledge. https://doi.org/10.1080/14783363.2018.1429259

Ibrahim, I., Sultan, M., Yassine, O. G., Zaki, A., Elamir, H., & Guirguis, W. (2022). Using Lean Six Sigma to improve timeliness of clinical laboratory test results in a university hospital in Egypt. *International Journal of Lean Six Sigma*, *13*(5), 1159–1183. https://doi.org/10.1108/IJLSS-08-2021-0138

Inal, T. C., Goruroglu Ozturk, O., Kibar, F., Cetiner, S., Matyar, S., Daglioglu, G., & Yaman, A. (2018). Lean six sigma methodologies improve clinical laboratory efficiency and reduce turnaround times. *Journal of Clinical Laboratory Analysis*, *32*(1). https://doi.org/10.1002/jcla.22180

Isa, M. F. M., & Usmen, M. (2015). Improving university facilities services using Lean Six Sigma: a case study. *Journal of Facilities Management*, *13*(1), 70–84. https://doi.org/10.1108/JFM-09-2013-0048

Jastia, N. V. K., & Kodali, R. (2015). Lean production: Literature review and trends. *International Journal of Production Research*, *53*(3), 867–885. https://doi.org/10.1080/00207543.2014.937508

Juliani, J., & Nawangpalupi, C. B. (2020). Peningkatan Kualitas Pelayanan Publik Bidang Verifikasi Standar Ukuran dan Kalibrasi Alat Ukur Metrologi Teknis dengan Pendekatan Lean Six Sigma. *Jurnal INTECH Teknik Industri Universitas Serang Raya*, *6*(2), 141–154. https://doi.org/10.30656/intech.v6i2.2519

Lippi, G., & Plebani, M. (2018). A Six-Sigma approach for comparing diagnostic errors in healthcare—where does laboratory medicine stand? *Annals of Translational Medicine*, *6*(10), 180–180. https://doi.org/10.21037/atm.2018.04.02

Lukrafka, T. O., Silva, D. S., & Echeveste, M. (2020). A geographic picture of Lean adoption in the public sector: Cases, approaches, and a refreshed agenda. *European Management Journal*, *38*(3), 506–517. https://doi.org/10.1016/j.emj.2020.02.004

Moullin, M. (2017). Improving and evaluating performance with the Public Sector Scorecard. *International Journal of Productivity and Performance Management*, *66*(4), 442–458. https://doi.org/10.1108/IJPPM-06-2015-0092

Raja Sreedharan, V., Raju, R., & Srivatsa Srinivas, S. (2017). A review of the quality evolution in various organisations. In *Total Quality Management and Business Excellence* (Vol. 28, Issues 3–4, pp. 351–365). Routledge. https://doi.org/10.1080/14783363.2015.1082421

Salah, S., Rahim, A., & Carretero, J. A. (2010). The integration of Six Sigma and lean management. *International Journal of Lean Six Sigma*, *1*(3), 249–274. https://doi.org/10.1108/20401461011075035

Snee, R. D. (2010). Lean Six Sigma – getting better all the time. *International Journal of Lean Six Sigma*, *1*(1), 9–29. https://doi.org/10.1108/20401461011033130

Suseno, Y., Standing, C., Gengatharen, D., & Nguyen, D. (2020). Innovative work behaviour in the public sector: The roles of task characteristics, social support, and proactivity. *Australian Journal of Public Administration*, *79*(1), 41–59. https://doi.org/10.1111/1467-8500.12378

van Lierop, D., & El-Geneidy, A. (2016). Enjoying loyalty: The relationship between service quality, customer satisfaction, and behavioral intentions in public transit. *Research in Transportation Economics*, *59*, 50–59. https://doi.org/10.1016/j.retrec.2016.04.001

Vignesh, V., Suresh, M., & Aramvalarthan, S. (2016). Lean in service industries: A literature review. *IOP Conference Series: Materials Science and Engineering*, *149*(1). https://doi.org/10.1088/1757-899X/149/1/012008

Yaduvanshi, D., & Sharma, A. (2017). Lean Six Sigma in Health Operations: Challenges and Opportunities—'Nirvana for Operational Efficiency in Hospitals in a Resource Limited Settings.' *Journal of Health Management*, *19*(2), 203–213. https://doi.org/10.1177/0972063417699665

Zhao, P., Rasovska, I., & Rose, B. (2016). Integrating Lean perspectives and Knowledge Management in Services: application to the service department of a CNC manufacturer. *IFAC-PapersOnLine*, *49*(12), 77–82. https://doi.org/10.1016/j.ifacol.2016.07.553