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Six Sigma Technique to Reduce Waiting Time: A Practical Application in Passport Affairs Directorate

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Abstract:

This study investigates the impact of the Six Sigma methodology on improving waiting times in passport directorates. The Six Sigma methodology is crucial for enhancing efficiency and effectiveness in passport directorates, aiming to reduce waiting times and increase customer satisfaction by organizing services more effectively. The research was conducted in the Passport Affairs Department (Mansour Passports) from November 8, 2022, to April 19, 2023, with a sample size of 53 employees and citizens. The problem of this study is to shed light on the role played by the Six Sigma methodology in improving waiting time at the Passport Affairs Department. The study adopted the DMAIC methodology (Define, Measure, Analyze, Improve, and Control) and used statistical software (SPSS) to calculate Six Sigma levels for both citizens and employees. Access and service data analysis was conducted using Win QSB software, and arrival and service times were calculated for all stages (counter employees, accounts, and manager's computer). The most significant results indicate that the directorate operates at the first level of Sigma levels, while citizens are at the second level. There is a significant and inverse effect of Six Sigma principles on waiting. The total time a citizen waits from entering the passport office to receiving their passport is very long.

Paper type: Research Paper
Keywords: Queuing systems, the Six Sigma methodology **,** DMAIC methodology

1. Introduction:

Queueing theory is considered a branch of operations research because its results are often used when making decisions about the necessary resources for service delivery. The analysis of queues aims to reduce the required waiting time and improve certain systems by altering some of the methods used to provide the service, to increase system efficiency. The Six Sigma methodology has been integrated with a multi-channel Queueing model. Queueing theory is significant in operations research, where it can be employed to analyze and enhance systems dealing with waiting, such as customer queues in healthcare facilities, institutions, banks, and so on. The model addresses the challenge of predicting customer numbers and their waiting times due to uncontrollable factors, such as human intervention. The Six Sigma Methodology aims to improve processes and reduce waste by blending principles of agility and the Lean Six Sigma philosophy. It applies advanced statistical tools and techniques, working to enhance customer satisfaction and achieve continuous improvement in services and operations. The Six Sigma Methodology is a comprehensive and integrated approach based on facts and the analysis of statistical data. The objective of this methodology is to eliminate wasteful activities and reduce operational variability. The Six Sigma methodology consists of a set of statistical tools and techniques and requires a trained and qualified team to implement them. This Methodology is implemented using the (DMAIC) (define, measure, analyze, improve, and control). This model focuses on teamwork and shared tasks and responsibilities, with a focus on improving the quality of services and operations. The Six Sigma methodology aims to improve the effectiveness of operations and reduce all kinds of waste (waiting, effort, and money) by focusing on correcting errors and continuously improving. It also aims to increase client satisfaction and achieve tangible improvements. The significance of the Six Sigma technique lies in providing a systematic framework and tools for sustainable analysis and improvement of processes. Sigma, or a sigma level (σ), is the twelfth letter of the Greek alphabet and is used in statistics to measure the extent of variation or deviation in a specific process. Sigma is employed to assess the performance and consistency of an economic unit's operations. The sigma level is estimated concerning the unit's processes and serves as an indicator of the quality of those processes. Traditionally, economic units operate within a level of 3 or 4 sigma, meaning they produce products or services with an error or defect rate ranging from 6,210 to 66,807 per million opportunities. Consequently, as the number of errors or defects may decrease, the sigma level may increase, and the quality of the processes may improve.

1.1 Literature Review:

Many studies have discussed the Six Sigma variable. For example, Faleeh et al (2019) conducted a study on the concepts of agility and Six Sigma, focusing on their similarities and differences. They explored the application of Lean Six Sigma in General Electric Industries, highlighting its objectives, principles, and application. The research found that Six Sigma implementation represents a cultural shift at all economic levels, emphasizing top management's commitment to enhance agility for competitive advantage.

Aouane et al (2021) applied the DMAIC process in an automotive company. After identification, a thorough and systematic analysis was conducted to determine the root causes of these defects, followed by the implementation of relevant actions. The goal was to reduce the defect rate to enhance product quality. The utilization of this approach significantly reduced the defect rate. Using the Six Sigma methodology can play a pivotal role in enhancing product quality, along with financial gains for various companies. It remains a highly effective method adopted by many companies to improve their quality and productivity. According to the Six Sigma approach, most companies have succeeded in their operations in terms of product quality and financial aspects. To remain competitive in the global market, environmental awareness leads companies to comply with environmental regulations. It is widely acknowledged that the Six Sigma method does not only bring financial improvements but also allows companies to obtain environmentally friendly products and services.

Orbak et al (2023) employed to reduce the logistics cost for a pipe manufacturing company. As a result, a step-by-step DMAIC (Define, Measure, Analyze, Improve, and Control) approach was adopted. For the improvement phase of the DMAIC approach, the company's logistics system was first examined, and its fundamental problems were systematically identified and resolved. For further enhancements, two mathematical models were developed and solved using MPL software to assess open areas in the factory as potential storage areas. Due to all these improvements, the total outbound logistics time significantly decreased, and the loading capacity doubled compared to the previous state. The company continues to assess the feasibility of the new logistics system with containers supported by the combined results of this Six Sigma and mathematical improvement approach.

Achib et al (2023) evaluated the impact of Six Sigma and lean manufacturing on the performance of Moroccan companies, focusing on improving quality, productivity, and customer satisfaction. Data was collected from 45 companies across various sectors in Morocco, and a statistical analysis was conducted using SPSS software. The results showed that companies using Six Sigma and Lean Manufacturing methodologies showed positive financial and operational performance compared to those using Lean Manufacturing alone or not using Six Sigma or Lean Manufacturing. Therefore, the combination of Six Sigma and lean manufacturing is considered the optimal approach for continuous improvement in companies.

Khaskheli et al. (2021) published research on the contribution of queuing theory and discrete event simulation to addressing healthcare challenges in Pakistan. Data was collected from reports of the World Health Organization and the World Bank and organized into tables using MS Excel. The simulation methodology closely adhered to the queuing theory aspect, focusing on solutions proposed by previous researchers as well. A multi-server queuing model and discrete event simulation (DES) were used. The findings revealed that the interaction between healthcare staff and incoming patients is problematic in the public sector. Additionally, service delays, long waiting times, and limited capacity in departments such as emergency rooms, outpatient clinics, and laboratories were identified as issues patients face. Furthermore, the number of doctors available was found to be insufficient.

Mozan(2021)aimed to improve the driver's license issuance service at the Central Registration Complex in Husseinia, which faces significant congestion during official working hours. This has led to long waiting lines for customers. The study's significance lies in its potential to provide a new internal arrangement model that can reduce customer waiting times in the queue and within the system, ultimately serving a larger number of customers. The researcher employed a case study methodology, using quantitative methods such as queueing theory, to assess the queueing system and propose a new internal arrangement. The simulation was used to simulate both the proposed and current internal arrangements and compare them using queueing performance metrics. The study concluded that the proposed internal arrangement outperformed the existing arrangement, resulting in a significant improvement in performance metrics. The study recommends adopting the proposed internal arrangement for smooth customer flow and reduced waiting times in both the queue and the system.

Michael et al. (2023) conducted a study on outpatient clinic services during the COVID-19 pandemic. They investigated patient arrival rates and service times at the University College Hospital in Ibadan. The study used the Poisson process to determine traffic congestion density, expected patient numbers, queue length, waiting times, total waiting time, and average patient numbers. Results showed that more patients visited clinics daily due to high traffic congestion and extended hospital stays. Waiting times on Saturdays and Tuesdays were significantly higher than on other days.

Pandey et al (2023) used data from a government hospital was utilized to conduct studies on patient waiting times. The primary challenge faced by healthcare professionals in many hospitals is the extended duration patients have to wait to receive services. These trends are becoming more widespread, posing a threat to healthcare services. Prolonged waiting times for medical care can lead to various issues, including fatalities. Several server queuing models were employed to assess the efficiency of services at the government hospital in this study. Primary data was collected at the hospital over two weeks using observation methods and questionnaires to identify a queuing model that reduces patient waiting times. The results indicated that most patients were dissatisfied with the quality of services at the hospital. This dissatisfaction is linked to the fact that the hospital is overcrowded with patients. Consequently, hospital staff are under pressure and often forced to discharge patients without comprehensive treatment, leading to patient dissatisfaction. The findings also revealed that the higher the quality of service, the more satisfied customers were with the hospital. An alternative queuing model might be considered for the proposed research.

The problem of this study is to shed light on the role of the Six Sigma methodology in improving waiting times at the Passport Office. It is noted that the Six Sigma methodology contributes to achieving this goal by reducing errors to a reasonable extent, estimated at 3.4 errors per million opportunities for data entry until the required documents are issued. This research aims to reduce waiting times for individuals seeking services by studying and addressing the waiting problem they experience. The research also aims to develop suitable solutions to minimize these waiting times and enhance the efficiency of the service provided to them using the Six Sigma methodology. The study also involves the development of a system within the Passport Office to reduce both waiting and service times using a multi-stage queuing model. The importance of the research lies in Assisting the management of the department in understanding the current level of Six Sigma and the recurring defects and their impact on waiting times. Elevating the Six Sigma level to higher standards after implementing the study's results and recommendations, highlighting the significance of implementing Six Sigma techniques in improving waiting times for the department.

2. Materials and Methods:

This study aims to highlight the role played by the Six Sigma Methodology in improving waiting times at the Passport Affairs Directorate. The DMAIC methodology (Define, Measure, Analyze, Improve, and Control) was adopted to apply Six Sigma and Queuing theory to assess improvement levels and reduce waiting times. This may involve identifying the root causes of waiting at the Passport Affairs Directorate, which, in turn, contribute to a decrease in their quality levels, and devise appropriate solutions for them.

2.1 Queuing Theory:

Queuing theory, a branch of operations research, originated in 1909 when a Danish engineer conducted experiments on changes in telecommunications and telephone service requests. His report on delays in the automatic call request device was published eight years later (Al-Shamarti, 2010). By the end of World War II, the theory was extended to address more general problems and administrative applications. Queuing theory is applicable in various aspects of life, such as traffic flow, scheduling, and facility design. It has valuable applications in probability literature, operations research, management science, and industrial engineering. Queuing theory also studies waiting in various fields, such as machine manufacturing, vehicle unloading, and airplanes. Causes of waiting can be insufficient service channels, an excessively high arrival rate of service-seeking units, or a slow rate of service delivery per service-seeking unit, leading to long queues (Mahmoud, 2001). Queuing theory does not aim for perfection but serves as a practical approach to providing general information about the problem under investigation.

2.1.1 Performance Measure For The Queue System:

When studying mathematical models of queuing systems, several indicators describe the system's behaviour over a specific period, enabling an assessment of the system's status
Table 1 shows the symbols used in the queue system (Ibrahim, 2017).

Table 1: The Symbols Used to Indicate The Performance Measures of The Queue in 1961, the mathematician John D. C. Little demonstrated the following (Abdul Amir, 2013):

Performance Metrics	Symbol
Average number of customers requesting service in line	Lq
The average number of customers requesting the service in the system	Ls
Average time spent in line	Wq
Average time spent on the system	Ws
The system may be empty of customers	P o
Probability of having (n) customers in the system	P n
Flow density, the ratio between access rate (λ) and service rate (μ)	ρ

• There exists a set of general relationships that connect performance measures Wq , Ws, Lq, and Ls
which can be used for all queuing models. These relationships are as follows:

$$L_s = L_q + \frac{\lambda}{\mu} = \lambda W_s \qquad (1)$$

$$L_q = L_s - \frac{\lambda}{\mu} = \lambda W_q \qquad (2)$$

$$W_s = W_q + \frac{1}{\mu} = \frac{L_s}{\lambda} \qquad (3)$$

$$W_q = W_s - \frac{1}{\mu} = \frac{L_q}{\lambda} \qquad (4)$$

2.1.2 Birth and Death Process:

The process of arrival and departure is one of the random processes that impact a queuing or service system. The idea behind the arrival and departure process stems from fluctuations in the customer system. In this context, each state in the arrival and departure process can be described by the number of customers present in the system (Al-Zalaq ,2006). Since a state transition represents a change in the system from one state to another, arrival corresponds to a transition from state (n) to state (n+1) with a probability λ_n, while departure represents a transition from state (n) to state (n-1) with a probability μ_n. The following paragraph represents state transitions in the arrival and departure process, with states numbered (0, 1, 2, … n), and arrival and service rates denoted as μ_i and λ_i, respectively. Figure 1 represents the steady-state in the arrival and departure process (Boudrissa, 2002).

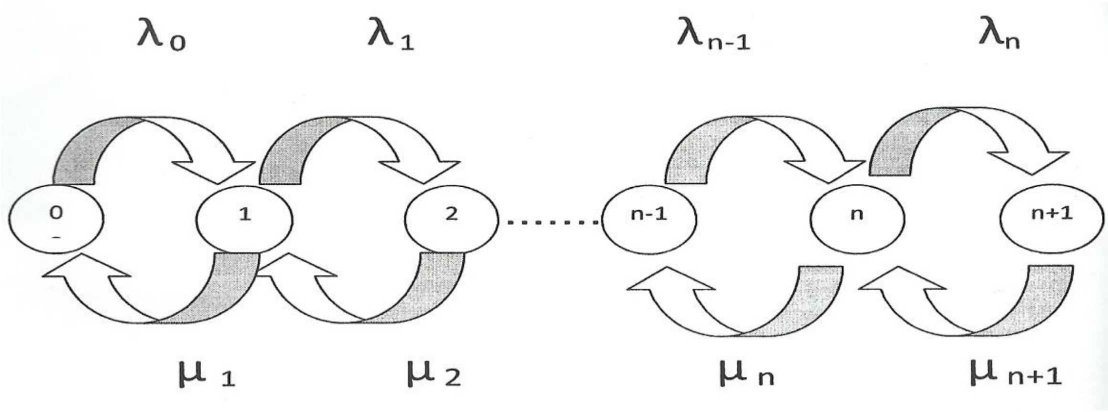

Figure 1: Represents the steady-state in the arrival and departure process.

2.1.3 The research mathematical model :

The system of "First-Come-First-Serve (FCFS)" was used, with an unlimited population, an unlimited system size, and multiple service channels. Depending on the type of data considered in the study, it is denoted as (M/M/C\∞\∞ FCFS). For the waiting processes subject to this model, the following must be satisfied (Ibrahim, 2013):

1. The number of arriving and departing units follows some probability distribution, with the probability distribution of unit arrivals being a Poisson distribution with a constant rate λ, and the probability distribution of service units being an exponential distribution with a constant rate 1/μ for all units.
2. There are C service stations that provide service to citizens.
3. The population size is unlimited.
4. There are no limits on the capacity of the queuing system.

2.1.4 Indicators for the Queuing System (M/M/C): (FCFS/∞/∞)

1. Average number of customers in the waiting queue (Ahmed,2007):

$$\mathrm{Lq} = \sum_{n=0}^{\infty} (n-c) P_n = \sum_{n=0}^{\infty} (n-c) \frac{\rho^n}{c!\, c^{n-c}} P_0 \qquad (5)$$

Assuming (k=n-c), then:

$$\mathrm{Lq} = \sum_{k=0}^{\infty} k \frac{\rho^{k+c}}{c!\, c^k} P_0 \qquad (6)$$

$$\mathrm{Lq} = P_0 \frac{\rho^n}{c!} \cdot \frac{\rho}{c} \sum_{k=0}^{\infty} k \left(\frac{\rho}{c}\right)^{k-1} \qquad (7)$$

$$= P_0 \frac{\rho^{c+1}}{c!.\, c} \cdot \frac{d}{d\left(\frac{\rho}{c}\right)} \sum_{k=0}^{\infty} \left(\frac{\rho}{c}\right)^k \qquad (8)$$

$$= P_0 \frac{\rho^{c+1}}{c!.\, c} \cdot \frac{d}{d\left(\frac{\rho}{c}\right)} \cdot \frac{1}{1-\frac{\rho}{c}} \qquad (9)$$

$$\therefore \mathrm{Lq} = \frac{\rho^{c+1}}{c!.\, c} \cdot \frac{1}{\left(1-\frac{\rho}{c}\right)^2} P_0 \qquad (10)$$

Using the above formula for Lq and Little's Formula, which relates queuing system indicators, the remaining indicators for the queuing system (M/M/C): (FCFS/∞/∞) are as follows (Abeddiab,1986):

2. Average number of customers in the system:

$$Ls = Lq + \rho \quad (11)$$

3. Average waiting time in the queue:

$$Wq = Lq \setminus \lambda \quad (12)$$

4. Average waiting time in the system:

$$WS = Wq + \frac{1}{\mu} \quad (13)$$

5. System utilization, the ratio of arrival rate (λ) to service rate (μ):

$$\rho = \lambda / (\mu) \quad (14)$$

2.2 Six Sigma:

2.2.1 The concept of Six Sigma:

Six Sigma is a widely adopted quality improvement and process enhancement approach, focusing on eliminating defects in processes. Originally developed by Motorola, it has been adopted by companies like General Electric, Ford, General Motors, and Xerox. The primary goal is to reduce variation in products and processes to achieve quality levels below 3.4 defects per million opportunities in design, production, and administrative processes. This approach minimizes variation in processes, enhancing customer satisfaction and cost reduction. It uses statistical tools to solve problems and improve performance, ultimately leading to increased profits. (Vasu ,2008). Six Sigma is a comprehensive and integrated approach based on facts and statistical data analysis. It combines two methods of process optimization, combining the principles of Lean and the philosophy of Six Sigma into one integrated philosophy. The goal of this methodology is to eliminate wasted activities and reduce variation in processes. The Six Sigma diffraction methodology consists of a set of statistical tools and techniques and requires a trained and qualified team to implement it. This methodology is implemented using the DMAIC model, which is an abbreviation for the following steps: Define, Measure, Analyze, Improve, and Control. This model focuses on teamwork and the sharing of tasks and responsibilities, with a focus on improving the quality of services and processes. The Six Sigma diffraction methodology aims to improve the efficiency of operations and reduce all types of waste (waiting, effort, and money) by focusing on error correction and continuous improvement. It also aims to increase customer satisfaction and achieve tangible improvements (Aouane et al., 2021).

2.2.2 The objectives of Six Sigma:

Six Sigma seeks to achieve the folowing aims:

1. Improving customer satisfaction
2. Producing high-quality products and services
3. Reducing defects in products or services to a rate of 3.4 defects per million opportunities for defects to occur
4. Enhancing process capability by reducing variation and discrepancies in the process
5. Continuously improving products and services provided to customers
6. Reducing costs through more efficient and effective operations.

2.2.3 Critical Success Factors for The Application of Six Sigma:

Critical success factors are essential for organizations to achieve their goals and objectives, considering opportunities, costs, and monitoring. These factors are strategies and methodologies that allow for the flow of information to the right person at the right time (Abu Zeid, 2011). Identifying these factors helps managers determine the necessary information for achieving goals, as failure to align with these factors could lead to the organization's failure. Key factors include training, customer support, quality, organizational culture, and strategy.

2.2.4 The Methodology (DMAIC):

The DMAIC process, a crucial aspect of Six Sigma management, is a flexible strategy that enables real improvements and tangible results. It is a roadmap for problem-solving and product enhancement, allowing for iterative work when necessary (Geffen, 2013). The DMAIC process is illustrated in Figure 2.

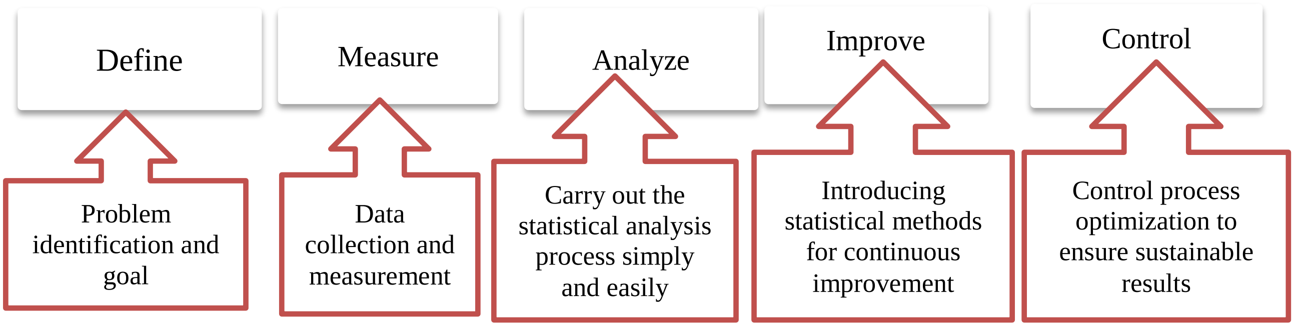

Figure 2 : Depicting the Stages of the DMAIC Methodology

2.2.5 Defects Per Unit (DPU):

It is the sum of defects for "n" defective units divided by the total number of units (Kuriea, 2018).

$$\text{The unit defect rate} = \frac{\text{number of defective units}}{\text{the total number of units}} \quad (15)$$

2.2.6 Defects per opportunity (DPO):

It is measured by the number of defect cases per unit divided by the total number of services provided (Kuriea, 2018).

$$\text{Defects per Opportunity (DPO)} = \frac{\text{Number of Defects}}{\text{Number of Services Provided100X}} \quad (16)$$

$$\text{The accuracy rate in the processe} = 1 - \text{defect rate} \quad (17)$$

$$\text{Defects per million opportunities (DPMO) (Nabil et al ,2013)} = \text{DPO} \times 1000000 \;. (18)$$

2.2.7 Six Sigma Quality Level:

The Sigma Quality Level measures the likelihood of defects, emphasizing the need to control both mean and variability. It starts at 691,462 defects per million products, negatively impacting production, and decreases to 3.4 at the sixth level, ideal for quality decision-making in service institutions and production companies Table 2 shows the Levels of Six Sigma. (Wang et al, 2022).

Table2: Levels of Six Sigma Performance

Sigma Level	Defects Per Million Opportunities(DPMO)
1	691,462
2	308,537
3	66,807
4	6,210
5	233
6	3.4

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3.Discussion and Result:

3.1 Collecting Data Related to Waiting Queues :

Due to the lack of data and information regarding the number of service seekers, arrival times, service provision times, and departure times, I had to conduct daily research during official working hours, which start at 8:00 a.m. and end at 3:00 p.m., for approximately one and a half months. This was necessary to collect accurate data on the arrival times, service times, and departure times of visitors.

3.2 Test of Data:

The data test was conducted using the statistical software (Easy fit professional/5.5). Easy fit is one of the statistical software programs used for data testing and determining their statistical distributions It allows testing the data, identifying their statistical distributions, and visualizing the data. The data is tested using the Goodness of Fit method through three approaches, Kolmogorov-Smirnov, Anderson-Darling, and chi-squared.

3.3 Solutions were generated using the ready-made software (Win QSB) :

to address the momentum issue at the Directorate of Passports in Al-Mansour. This software is designed to solve various problems in operations research, and among the problems it addresses is the queue management issue by inputting data into the program. By inputting the data into the program, the results appeared as follows:

1.Stage One (Counter Staff):

The values were input into the Win Q.S.B. program, extracted from the statistical program Easyfit. These values include:

• Number of service channels 8.
• Service time distribution follows a Poisson distribution.
• Service time mean2.8090.
• Arrival time distribution also follows a Poisson distribution.
• Arrival time mean 19.89, as shown in the table3.

Table 3: Solutions by using the ready-made software (Win QSB)

No.	Performance Measure	Rusult
1	System:M/M/8	From Formula
2	The customer arrival rate(λ) per hour	19.89
3	The service rate per server(µ) per hour	2.8090
4	The overall system effective arrival rate per hour	19.89
5	The overall system effective servicerate per hour	19.89
6	The overall system ulilization	88.51%
7	The average number of customers in the system (L)	12.1778
8	The average number of customers in the queue (Lq)	5.09
9	The average time customer spends in the system (w)	0.6123 hours
10	The average time customer spends in the queue (wq)	0.25637hours

1.System Utilization (Busy Percentage): The system's utilization rate is 88.5101%, indicating that the system is busy 88.51% of the time. This means that employees at the Directorate of Passport Control are consistently engaged in their work. This high utilization suggests a significant volume of citizens at the Passport Control Directorate.

2..Expected Number of Citizens in the System: On average, there are approximately 12 citizens per hour in the system. This indicates the rate at which citizens are processed within the system.

3.Expected Number of Citizens in the Waiting Queue: There are approximately 5 citizens in the waiting queue per hour. This signifies that, on average, five citizens are waiting in line per hour before they are served.

4.Wait Time in the System: The wait time within the system is 0.6123 hours (approximately 37 minutes). This represents the time a citizen spends in the system, from entering the facility to completing their service, which takes about 37 minutes.

5.Wait Time in the Queue: The wait time in the queue is 0.2563 hours (approximately 15 minutes). This signifies that citizens spend an average of 15 minutes waiting in line before they reach a service channel within the system.

2.Stage Two (Accounting Stage)

- Number of service channels1.
- Service time distribution constant.
- Service time is 7.45.
- Arrival time distribution Poisson distribution
- Arrival time mean 3.878, as illustrated in Table 4

Table 4: Solutions by Using the Ready-Made Software (Win QSB)

No.	Performance Measure	Rusult
1	System:M/M/1	From Formula
2	The customer arrival rate(ג) per hour	7.87
3	The service rate per server(µ) per hour	7.45
4	The overall system effective arrival rate per hour	3.87
5	The overall system effective service rate per hour	3.87
6	The overall system utilization	52.05%
7	The average number of customers in the system (L)	1.09
8	The average number of customers in the queue (Lq)	0.565
9	The average time customer spends in the system (w)	0.28 hours
10	The average time customer spends in the queue(wq)=	0.1457 hours

1.System Utilization (Busy Percentage): The system's utilization rate is 3752.05%, indicating that the system is busy 52% of the time. This means that employees at the Directorate of Passport Control are occupied approximately 52% of the time, which signals a significant influx of citizens at the Passport Control Directorate.

2.Expected Number of Citizens in the System: On average, there are approximately 1.0857 citizens in the system per hour. This indicates the rate at which citizens are processed within the system.

3.Expected Number of Citizens in the Waiting Queue: There are approximately 0.5651 citizens in the waiting queue per hour. This signifies that, on average, roughly 1 citizen is waiting in line per hour before they are served.

4.Wait Time in the System: The wait time within the system is 0.2800 hours (approximately 17 minutes). This represents the time a citizen spends in the system, from entering the accounting stage to completing their service, which takes about 17 minutes.

5.Wait Time in the Queue: The wait time in the queue is 0.1457 hours (approximately 9 minutes). This signifies that citizens spend an average of 9 minutes waiting in line before they reach a service channel within the accounting stage.

3.Stage Three (Director's Calculation Stage)

- Number of service channels 1.

Service time distribution constant.
Service time mean 7.0440.
Arrival time distribution Poisson distribution
Arrival time mean: 3.833, as illustrated in Table 5

Table 5: Solutions by Using the Ready-Made Software (Win Q SB)

No.	Performance Measure	Rusult
1.	System:M/M/1	From Formula
2.	The customer arrival rate(λ) per hour	3.833
3.	The service rate per server(μ) per hour	7.044
4.	The overall system effective arrival rate per hour	3.83
5.	The overall system effective service rate per hour	3.83
6.	The overall system utilization	54.41%
7.	The average number of customers in the system(L)	1.1937
8.	The average number of customers in the queue(Lq)	0.6496
9.	The average time customer spends in the system(w)	0.3114 hours
10.	The average time customer spends in the queue(wq)	0.1695 hours

1.System Utilization (Busy Percentage) :The system's utilization rate is 54.4151%, indicating that the system is busy 54% of the time. This means that employees at the Directorate of Passport Control are occupied approximately 54% of the time, which signals a significant influx of citizens at the Passport Control Directorate.

2.Expected Number of Citizens in the System: On average, there are approximately 1.1937 citizens in the system per hour. This indicates the rate at which citizens are processed within the system.

3.Expected Number of Citizens in the Waiting Queue: There are approximately 0.6496 citizens in the waiting queue per hour. This signifies that, on average, roughly 1 citizen is waiting in line per hour before they are served.

4.Wait Time in the System: The wait time within the system is 0.3114 hours (approximately 18 minutes). This represents the time a citizen spends in the system, from entering the director's calculator stage to completing their service, which takes about 18 minutes.

5.Wait Time in the Queue: The wait time in the queue is 0.1695 hours (approximately 10 minutes). This signifies that citizens spend an average of 10 minutes waiting in line before they reach a service channel within the director's calculator stage.

3.4 The DMAIC Methodology:

3.1.4 Define phase:

The define phase is used to identify and clarify the components of a specific process or project. The SIPOC diagram serves as a valuable tool in this phase, helping to analyse and understanding the relationships between various components and the stakeholders involved in the process. Surveys were distributed to gather customer opinions and feedback, guiding actions and decisions based on the voice of the customer.

3.2.4 Phase Measure:

In this phase, descriptive and analytical methods were employed using a practical approach to collect and analyze data and test hypotheses. In this study, both primary and secondary data were utilized. The primary data for the model were collected through a questionnaire. After conducting a comprehensive literature review related to business intelligence, decision support, and decision-making quality, the researchers formulated the survey instrument for this study.

3.3.4 Stability of the Study Tool:

The study tool's reliability is evaluated using Cronbach's alpha coefficient, indicating its stability. The coefficient should exceed 0.70 for scales and variables. This, ensures validity and reliability for further analysis (Sekaran, 2003). Tables 6 illustrate classification levels.

Table 6: Cronbach's Alpha Values for Study Variables and the Scale.

Dimensions	Conservator
The organization's strategy in adopting a methodology of Six Sigma	0.824
Senior management support and commitment in adopting a methodology of Six Sigma	0.819
The organization's culture in adopting a methodology of Six Sigma	0.734
Quality	0.815
Training	0.774
Six Sigma	0.852
Waiting	0.759

The source: prepared by the researchers based on the outputs (Spss.v.26)

The Cronbach's alpha coefficient values are all greater than 0.70, indicating the reliability and stability of both the scale and its variables.

3.3.5 The Descriptive Analysis of the Six Sigma Variable:

The Six Sigma variable consists of five dimensions, and statistical methods (mean, standard deviation, coefficient of variation) are applied to them, as shown in Table 7 below

Table 7: Arithmetic mean, Standard deviation, Coefficient of the study sample of the main dimensions of the Variable of Six Sigma

Dimensions	Arithmetic Mean	Standard Deviation	Coefficient
The organization's strategy in adopting a methodology of Six Sigma	2.042	0.305	14.94%
Senior management support and commitment in adopting a methodology of Six Sigma	2.469	0.414	16.75%
The organization's culture in adopting a methodology of Six Sigma	2.307	0.412	17.87%
quality	2.792	0.732	26.20%
Training	2.788	0.603	21.64%
Six Sigma	2.480	0.302	12.19%
Waiting	4.173	0.634	15.19%

The source: prepared by the researchers based on the outputs (Spss.v.26)

The table above indicates that the dimension of quality in adopting the Six Sigma methodology ranked first, with a mean score of 2.792, suggesting a moderate level of quality. However, there is a slight dispersion in the opinions of the studied sample, as reflected in the standard deviation (0.732) and the relative difference coefficient (26.20%), indicating the need for improvement and enhancing the adoption and understanding of these methods. As for the dimension of training in adopting the Six Sigma methodology, which ranked second, its mean score was 2.788, indicating a moderate level. The standard deviation (0.603) and the relative difference coefficient (21.64%) suggest a positive interaction among employees regarding this type of training. Regarding the dimension of support and commitment from top management in adopting the Six Sigma methodology, which ranked third, its mean score was 2.469, indicating a weak level. This highlights the necessity to increase support and commitment from top management toward this methodology, the dimension of organizational culture in adopting the Six Sigma methodology, which ranked fourth, had a mean score of 2.307, also indicating a weak level. This underscores the urgent need to enhance the organizational culture and raise awareness about this approach within the organization. The dimension of the organization's strategy in adopting the Six Sigma methodology ranked fifth, with a mean score of 2.042, indicating a weak availability. The standard deviation (0.305) and the relative difference coefficient (14.94%) suggest a slight dispersion in the sample's opinions, under research. This signifies a weak strategy by the organization concerning the adoption of the Six Sigma methodology. Improvement in this dimension might require increased interaction and guidance from top leadership and efforts to enhance the adoption of this methodology and leverage its benefits more effectively. The variable (waiting) had a mean score of 4.173, indicating a very high availability. The standard deviation (0.634) suggested a slight dispersion in the opinions of the sample under study, and the coefficient of variation was 15.19%. These results indicate that the level of waiting in the department is very high.

3.6 Calculating The Level Of Sigma:

1.The study evaluates the effectiveness of Six Sigma techniques in reducing errors, deviations, and waiting times by analysing employee responses, with "disagree" to "strongly disagree" responses indicating deviations or errors due to non-compliance with specific standards. Six Sigma involves calculating errors or defects in each dimension through five steps: define, measure, analyse, improve, and control. This process helps identify areas for improvement, enabling actions to enhance performance, reduce errors, and prevent future repetition. Where the total number of defects for the five dimensions from the survey distributed to employees reached 599 defects or errors .The survey distributed to employees includes 22 items, representing the overall dimensions of Six Sigma. The total number of sample individuals (department employees) was 53, so:(22 x 53 = 1166), which means that these Six Sigma dimensions (1166) should be present in the total number of transactions, thus making the services provided 100% quality. However, since these dimensions have not been fully achieved, the defect rate will be calculated for these dimensions as follows: Defect Rate = (599 / 1166) x 100 = 51.37,% Where 599 represents the number of defects, Accuracy Rate in Operations =1-Defect Rate =1-51.37%=46.3, Defects per million opportunities = 51.37x 1,000,000 = 513700 defects or errors.The Cymma level is calculated through the next equation : Sigma Equality Level = 0.8406 + 29.37 − 2.221 x ln (DPMO),Sigma Level=1

2.The survey distributed to customers includes six items, representing the overall dimensions of Six Sigma. The total number of sample individuals (department employees) was 53, so:(6 x 53 = 318), which means that these Six Sigma dimensions (318) should be present in the total number of transactions, thus making the services provided 100% quality. However, since these dimensions have not been fully achieved, the defect rate will be calculated for these dimensions as follows: Defect Rate = (95 / 318) x100=. 29.87 % ,Where 95 represents the number of defects, Accuracy Rate in Operations = 1- Defect Rate = 1-29.87 =% 70.13 ,, Defects per million

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opportunities=29.87 x1000000=298700 defects or errors. Sigma Equality Level= 0.8406 + 29.37 − 2.221× ln (DPMO) =0.8406 + 29.37 − 2.221× ln(298700), Sigma Equality Level=2.2.

3.3.7 Phase Analysis :

This step is considered one of the crucial phases among the steps of implementing the Six Sigma (SS) methodology. The main objective of the analysis phase is to conduct an in-depth analysis of the root causes and influencing factors of waiting times using the Mansour Passports Directorate research sample. Through the analysis step, the focus is on dissecting the reasons behind these issues by relying on the survey results, as well as conducting interviews with some of the directors in the directorate and field observations at the Mansour Passports Directorate.

3.3.8 Phase improvement:

The improvement phase focuses on addressing deviations in performance by employees or management and adjusting the Directorate's methods to improve service quality. The process involves recalculating the directorate's sigma level and identifying defects through a second survey. The success of this phase depends on the directorate's responsiveness to suggestions for improvement. An increase in the sigma level indicates the success of this phase in reducing errors and improving service quality.

3.3.9 Phase Control:

The control phase in the Six Sigma methodology ensures the continuity of success and preservation of improvements made in previous stages, achieving lasting benefits and performance improvement within the directorate. It involves identifying errors, measuring them, analyzing their causes, and taking necessary actions. The process is then continuously monitored and controlled, using specific indicators and scrutinizing results and data.

3. Conclusions:

The study findings revealed the presence of three significant dimensions exerting a substantial and inverse impact on waiting times. Notably, the adoption of the Six Sigma methodology, particularly in the realm of quality, exhibited the most significant inverse effect. This implies that higher quality in the implementation of Six Sigma correlates with reduced waiting times. However, heightened quality standards in Six Sigma implementation correspond to decreased waiting durations. As the quality level of Six Sigma adoption increases, waiting times decrease proportionately. Following closely, the impact of training in Six Sigma adoption on waiting times emerged as the second most influential factor, displaying a negative and statistically significant relationship. This suggests that training in Six Sigma adoption has an adverse effect on waiting times. Subsequently, the support and commitment of top management in adopting the Six Sigma methodology were identified as the third influential factor, also demonstrating a negative and statistically significant impact. This implies that top management's support and commitment inversely affect waiting times. A negative value in the context of top management's support and commitment to Six Sigma adoption signifies a corresponding decrease in waiting times. In essence, increased support and commitment from top management in Six Sigma implementation lead to shorter waiting durations.The results underscored that the existing waiting time is unsatisfactory, resulting in unjustified delays in customer transactions. This delay not only disrupts customer schedules but also escalates their dissatisfaction levels. Moreover, customers, upon completing their travel documents, often have other pressing matters to attend to, and the prolonged waiting period leads to a considerable waste of their time. Consequently, the extended waiting time contributes to a negative customer experience. Specifically, concerning the duration a citizen spends at the Mansour Passports Directorate from entry to exit after completing the passport issuance process, the study revealed an average waiting time of 3 hours and 12 minutes. Such a protracted waiting period is highly inconvenient for all segments of society.

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Authors Declaration:
Conflicts of Interest: None
-We Hereby Confirm That All The Figures and Tables In The Manuscript Are Mine and Ours. Besides, The Figures and Images, Which are Not Mine, Have Been Permitted Republication and Attached to The Manuscript.
- Ethical Clearance: The Research Was Approved By The Local Ethical Committee in The University.

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تقليل وقت الانتظار باستخدام تقنية الحيود السداسي مع التطبيق العملي في مديرية الاحوال المدنية والجوازات والاقامة

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مستخلص البحث:
تبحث هذه الدراسة في تأثير منهجية Six Sigma على تحسين أوقات الانتظار في مديريات الجوازات. تعتبر منهجية Six Sigma ضرورية لتعزيز الكفاءة والفعالية في مديريات الجوازات ، بهدف تقليل أوقات الانتظار وزيادة رضا الزبائن من خلال تنظيم الخدمات بشكل أكثر فعالية. تم إجراء البحث في مديرية الاحوال المدنية والجوازات والاقامة (فرع المنصور) في الفترة من 8 نوفمبر 2022 إلى 19 أبريل 2023 ، بحجم عينة 53 موظفا ومواطنا. تكمن مشكلة هذه الدراسة في تسليط الضوء على الدور الذي تلعبه منهجية Six Sigma في تحسين وقت الانتظار في إدارة شؤون الجوازات. اعتمدت الدراسة منهجية DMAIC (التعريف والقياس والتحليل والتحسين والرقابة) واستخدمت الباحثة البرمجيات الإحصائية (SPSS) لحساب مستويات six sigma لكل من المواطنين والموظفين. تم إجراء تحليل بيانات الوصول والخدمة باستخدام برنامج Win QSB ، وتم حساب أوقات الوصول والخدمة لجميع المراحل (موظفي الكاونتر، الحسابات ، حاسية المدير). وتشير أهم النتائج إلى أن الموظفين يعملون على المستوى الأول من مستويات سيجما، بينما يعمل المواطنون في المستوى الثاني. هناك تأثير كبير وعكسي لمبادئ Six Sigma على الانتظار. وإجمالي الوقت الذي ينتظره المواطن من دخول مكتب الجوازات حتى استلام جواز سفره طويل جدا.

نوع البحث: ورقة بحثية .
الكلمات المفتاحية: صفوف الانتظار , منهجية DMAIC, Six Sigma

*البحث مستل من رسالة ماجستير