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ORIGINAL ARTICLE

An evaluation of the wastes and obstacles within the context of lean management in emergency services

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Abstract

The objective of this study is to evaluate the types of waste within the context of lean management practices in emergency departments and to provide recommendations for addressing the challenges associated with their implementation. The vision is to enhance the effectiveness of performance improvement processes and to improve patient satisfaction. The opinions of eight experts in the field were collected and analysed using fuzzy AHP. The study followed the STROBE checklist to ensure comprehensive reporting to study. The analysis revealed that defects (29%) are the most common type of waste in emergency departments, with a significant impact on efficiency and patient safety. This is followed by extra handling (15%) and waiting time (13%). Addressing these issues, along with other types of waste such as wasted talent, movement, transportation, inventory, and overproduction, is critical to improving overall operational performance. The overcoming of integration challenges necessitates the implementation of a multifaceted strategy, which should encompass the commitment of leadership, the engagement of staff, multidisciplinary collaboration, process streamlining, the ability to navigate resistance to change, and the establishment of a culture of continuous improvement. Additionally, processes must be redesigned with the objective of enhancing their efficiency, and this endeavour must be supported by continuous training and regular monitoring of progress.

Keywords: Hospital emergency services, decision making, lean six sigma

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Introduction

The complex and multidisciplinary nature of healthcare services, their non-postponability and the necessity to be provided 24/7, the financial pressures faced by healthcare organizations and the goals to be achieved have made it necessary to make changes in existing management mechanisms [1,2]. Especially in units working under high demand such as emergency services, the increasing population, the spread of chronic diseases and the increase in the number of emergencies increase the workload day by day. This workload may lead to an increase in medical errors, decrease in service quality, and patient dissatisfaction. In order to reduce such negativities in health services, some practices regulate patient flow such as triage systems. While the triage system aims to meet more patient demand with limited resources, it also brings new problems such as long waiting times. This situation causes dissatisfaction and resistance to the system among patients and their relatives [3]. In this regard, the importance of lean management approach in healthcare services has increased as it provides a solution to operational inefficiencies, resistance to change, and process bottlenecks identified in emergency departments. Lean management is defined as a management system that aims to produce with fewer resources, in a shorter time, at low cost, and error-free production. As stated by Lopez et al. (2013), lean thinking is defined as a system that will best meet customer demand, minimize waste, and use production factors in the most efficient way [4].

Lean management implementations are used in the field of healthcare services, especially to improve emergency services, intensive care, and operating theatre processes, reduce waiting times, and improve service quality [5]. These practices are based on value, value flow, continuous flow, and excellence, the basic principles of lean thinking in hospitals [6]. This approach, called Lean Healthcare, has goals such as reorganizing patient flows, producing new care and management indicators in healthcare services, and improving service processes [7].

Lean management in healthcare aims not only to solve big issues but also to solve hundreds of small problems that hospitals face every day. Solving these small issues can lead to important results such as preventing delays in processes, ensuring patient safety, enabling healthcare organizations to grow and generate more revenue, and reducing costs [8]. Lean management also promotes operational changes that are necessary to make the delivery of healthcare services more efficient. In this process, identifying and eliminating waste is one of the most important goals of lean techniques [9].

Lean management is critical to minimizing waste in healthcare, improving service quality and ensuring patient satisfaction. Lean management is seen as an effective tool to optimize patient flow, reduce waiting times, and improve service quality, especially in emergency services. In this context, the design and management of healthcare organizations is considered as a complex multivariate problem where medical, technical, and social factors are considered together [10]. To overcome this complexity, lean philosophy and tools have been adopted as a solution in healthcare management [9].

Types of waste in lean management concept, examples and difficulties in implementation

In addition to the 7 types of waste defined by Toyota within the scope of the lean management concept, Liker (2014) defined underutilization of human potential and creativity as the eighth type of waste [11,12]. Explanations of waste types and examples specific to hospitals are shown in Table 1.

Although the advantages of integrating lean management and which wastes can be avoided are clear, some difficulties in implementation have been experienced and published in research. As a matter of fact, in some studies, many barriers such as the need to create a multidisciplinary team, and lack of senior management and leadership support, make it difficult to implement lean management in emergency services. These obstacles make it difficult to integrate lean principles into the organization and increase the training requirements of the staff [13-17]. However, operational factors such as difficulties in process redesign, health safety

concerns, management issues, and management of high patient flow further complicate the adoption of lean management in emergency departments [18]. These processes create the need for cost analysis and require rapid and accurate clinical assessments for effective management of emergencies, especially when dealing with critical cases such as traumatic injuries [19].

Other barriers to lean management in emergency departments include waiting times, procedural uncertainty, and resistance to change [13,15,17,20-22]. In addition, problems such as increasing patient demand and overcrowding in emergency services directly affect the quality of healthcare services, making it difficult to sustain improvements [15,22,23]. As stated above, the barriers to integrating lean management in emergency health services are shown in Table 2.

The study aims to evaluate the types of waste within the context of lean management practices in emergency departments and then uncover importance of challenges associated to lean management. By this way making performance improvement processes in emergency services more effective and increase patient satisfaction. In distinguishing itself from previous studies the

Table 1. Waste types in lean manufacturing and samples from healthcare.

Kod	Waste type	Explanation	Samples
OVP	Overproduction	The production of quantities exceeding the required levels is a common phenomenon.	Unnecessary diagnostic (tests, tests, *etc.*) procedures
INV	Inventory	Costs such as transport and storage by keeping excess stock	End of life of medicines and medical consumables, increase in depreciation of other consumables
EXP	Extra processing	Carrying out non-value-creating works and transactions	Use of patient forms not included in the evidence processing process, need for re-examination
MOT	Motion	Actions of staff that do not add value to the process within the organization	The necessity for staff to visit different areas or units as a result of architectural or legal regulations, movements to collect tools, materials, *etc*.
TRA	Transportation	Transport of the product in unnecessary places within the system	Long distances between patient registration, laboratory and data processing units
UNT	Unused talent	Lack of decision support systems that enable career development of the personnel and take their ideas into consideration	Waiting for the diagnostic results to start the patient's treatment
WAT	Waiting	The prolongation of the time in the transactions in the process keeps the subsequent transactions waiting	Waiting of patients due to delays in processes such as registration procedures, hospitalisation procedures, etc. in emergency services
DEF	Defects	In case of inaccuracies in processes and controls, the time spent for the related errors (detection and correction, *etc*.)	Injecting the wrong dose of medication to the patient or patients, giving the wrong medication to the wrong patient, wrong procedure, *etc*.

References: [8,11,12]

study doesn't merely entail the identification of wastes in the department; it's also a guide for decision makers on how to create customized solutions for these barriers related to their importance evaluated by experts from field.

Materials and Methods

The study design and reporting were guided by STROBE checklist, ensuring to key standards. Each checklist item was addressed to enhance the rigor and transparency of study.

Ethical Approval

Ethical approval for this study was granted by the İstanbul Medipol University Ethics Committee for Non-Interventional Clinical Studies (reference number E-10840098-202.3.02-6056, dated 26.09.2024).

Participants

This cross-sectional study was conducted between 29.09.2024-03.10.2024. The study involved an analysis of the evaluations of eight participants with at least ten years of experience

Table 2. The barriers to the integration of lean management in emergency departments.

Barriers	References
Multidisciplinary team formation	[13,14]
Lack of top management/leadership support	[13,15-17,24]
The need for process redesign	[15,18]
Health safety concerns	[18]
Governance issues	[13,18,20]
Intensive patient flow	[18,22,23]
Waiting times	[13,20-22]
Procedural uncertainties	[15,21]
Resistance to change	[15-17,21]
Lack of staff and/or irresponsible duties	[25]

Table 3. Decision makers' details.

Decision makers	Profession	Education	Position	Experience
DM1	Health Management	PhD	Prof. /University	15 years
DM2	Health Management	PhD	Assoc. Prof. /University	10 years
DM3	Health Management	PhD	Asst. Prof. /University	8 years
DM4	Manag. and Organisation	PhD	Prof. /University	11 years
DM5	Hospital Administration	Master's Degree	Administrator/Hospital	13 years
DM6	Hospital Administration	Master's Degree	Administrator/Hospital	18 years
DM7	Emergency Service	Bachelor	Nurse/Hospital	20 years
DM8	Emergency Service	Bachelor	Nurse/Hospital	20 years

in health management, hospital administration, and emergency service provision. Further details about the participants are presented in Table 3.

Fuzzy-AHP

The Analytic Hierarchy Process (AHP) method was employed for the assessment and analysis of participant views. In situations characterized by complexity and uncertainty, AHP provides a structured approach to the prioritization of options and the formulation of informed decisions. By the AHP method, a matrix is generated through the pairwise comparison of each alternative criterion on a scale of 1 to 9, in alignment with the expert opinions. In this comparison, 1 represents equal importance, and 9 represents the highest importance [26]. AHP is frequently an effective instrument for resolving the ambiguity of human judgment, particularly when decision-makers are required to assign exact numerical values to their preferences. However, AHP also has some disadvantages, as outlined [27]. For instance, the ordering of AHP outcomes is not exact due to the subjective assessment of decision-makers. To address this issue, numerous researchers have employed the Fuzzy AHP approach, which integrates fuzzy theory and the AHP [28,29].

Fuzzy AHP addresses this issue by enabling decision-makers to articulate their preferences through the use of linguistic terms, which are subsequently transformed into fuzzy numbers, typically triangular or trapezoidal, to reflect the inherent ambiguity in their judgments [30,31]. In other words, decision-makers are initially requested to provide linguistic terms and pairwise comparisons on a scale of 1–9. Subsequently, the pairwise comparisons provided by the decision makers are transformed into triangular fuzzy numbers, as illustrated in Table 4.

The application of fuzzy AHP usually involves several stages. These stages are completed by the following process [30-34];

1. A hierarchical structure is established, whereby the decision problem is decomposed into a set of criteria and sub-criteria.

2. Construction of Pairwise Comparison Matrices with Fuzzy sets.

3. Normalization of Fuzzy Pairwise Comparison Matrices

4. Calculation of Fuzzy Weights (With fuzzy sets, fuzzy priority weights are calculated for each criterion from pairwise comparison matrices.)

5. Defuzzification (Fuzzy numbers are converted into crisp scores for easy comparison and decision-making.)

6. Final weight calculation (The final ranking of alternatives is made.)

7. Consistency check (Verify the consistency of pairwise comparisons by the consistency ratio)

Results

By employing pairwise comparison matrices, the necessary information to use the Fuzzy AHP method was obtained. For example, overproduction (OVP) and transportation

Table 4. Triangular fuzzy sets and their reciprocal forms.

Linguistic term	Relative importance	Triangular fuzzy set	Triangular fuzzy set
Equal (E)	1	(1, 1, 1)	1,1,1
Moderate (M)	3	(2, 3, 4)	1/4,1/3,1/2
Strong (S)	5	(4, 5, 6)	1/6,1/5,1/4
Very Strong (VS)	7	(6, 7, 8)	1/8,1/7,1/6
Extremely Strong (ES)	9	(9, 9, 9)	1/9,1/9,1/9
Intermediate Values (IV)	2, 4, 6, 8	(1, 2, 3), (3, 4, 5), (5, 6, 7), (7, 8, 9)	(1/3, 1/2, 1), (1/5, 1/4, 1/3), (1/7, 1/6, 1/5), (1/9, 1/8, 1/7)

(TRA) were compared using the question *'How critical/important is "overproduction" compared to "transportation" for the integration of lean management in the delivery of emergency health services?'*. If the answer is linguistic 'Extremely strong', the corresponding cell in the triangular fuzzy scale matrices will have '9,9,9'. An example of the comparative evaluation of waste types is shown in Table 5.

As a result of the analysis, the CR (consistency ratio) value expressing the reliability of the AHS technique was calculated using the integrated matrix and found to be 0.082. This value is expected to be less than 0.10 [35]. It means that the obtained result indicates that the study is quite reliable.

After collecting the data through pairwise comparison matrices, the relevant matrices were transformed into triangular fuzzy numbers specified in Table 4. The integrated matrix was constructed using the geometric means of the evaluations of each expert (Table 6).

The fuzzy priority weights for each criterion and alternative were calculated using fuzzy arithmetic, based on the pairwise comparison matrices. The fuzzy weights were then aggregated to derive the fuzzy priority values for each alternative. The centroid method was employed for defuzzification, whereby the fuzzy numbers were converted into crisp scores, thus facilitating comparison and decision-making. The final weights are listed in Table 7.

Tablo 5. An example of a pairwise comparison matrix of waste types.

	OVP	**INV**	**EXP**	**MOT**	**TRA**	**UNT**	**WAT**	**DEF**
OVP	1	1/ES	1/ES	S	1/S	1/S	ES	E
INV		1	1/VS	1/ES	E	1/MS	VS	E
EXP			1	VS	E	MS	ES	E
MOT				1	E	ES	E	1/ES
TRA					1	ES	ES	1/ES
UNT						1	1/VS	1/VS
WAT							1	1/ES
DEF								1

Table 6. The integrated matrix.

	OVP	**INV**	**EXP**	**MOT**	**TRA**	**UNT**	**WAT**	**DEF**
OVP	(1.00, 1.00, 1.00)	(0.31, 0.37, 0.45)	(0.36, 0.41, 0.46)	(0.87, 1.08, 1.30)	(0.43, 0.52, 0.63)	(0.30, 0.36, 0.42)	(0.48, 0.60, 0.73)	(0.22, 0.24, 0.27)
INV	(3.22, 2.70, 2.25)	(1.00, 1.00, 1.00)	(0.30, 0.35, 0.41)	(0.95, 1.17, 1.39)	(0.66, 0.78, 0.90)	(0.39, 0.47, 0.59)	(0.23, 0.27, 0.33)	(0.22, 0.24, 0.26)
EXP	(2.81, 2.46, 2.17)	(3.29, 2.88, 2.45)	(1.00, 1.00, 1.00)	(1.59, 1.85, 2.10)	(1.15, 1.29, 1.44)	(0.87, 1.04, 1.21)	(0.95, 1.15, 1.36)	(0.59, 0.65, 0.73)
MOT	(1.15, 0.93, 0.77)	(1.05, 0.85, 0.72)	(0.63, 0.54, 0.48)	(1.00, 1.00, 1.00)	(2.14, 2.35, 2.54)	(1.59, 1.97, 2.33)	(0.54, 0.66, 0.79)	(0.25, 0.29, 0.35)
TRA	(2.33, 1.91, 1.59)	(1.51, 1.29, 1.11)	(0.87, 0.78, 0.70)	(0.47, 0.42, 0.39)	(1.00, 1.00, 1.00)	(2.52, 2.79, 3.08)	(0.64, 0.74, 0.87)	(0.14, 0.16, 0.18)
UNT	(3.29, 2.79, 2.36)	(2.59, 2.14, 1.71)	(1.15, 0.96, 0.82)	(0.63, 0.51, 0.43)	(0.40, 0.36, 0.32)	(1.00, 1.00, 1.00)	(0.96, 1.12, 1.32)	(0.50, 0.60, 0.71)
WAT	(2.07, 1.68, 1.36)	(4.27, 3.67, 3.06)	(1.05, 0.87, 0.73)	(1.86, 1.53, 1.27)	(1.57, 1.36, 1.15)	(1.04, 0.89, 0.76)	(1.00, 1.00, 1.00)	(0.32, 0.37, 0.44)
DEF	(4.49, 4.08, 3.64)	(4.56, 4.21, 3.83)	(1.70, 1.53, 1.36)	(3.97, 3.44, 2.85)	(7.14, 6.36, 5.50)	(2.00, 1.68, 1.41)	(3.11, 2.67, 2.28)	(1.00, 1.00, 1.00)

Table 7. The final weights.

Code	**Waste type**	**Weight**	**Rank**
OVP	Overproduction	0,056144	8
INV	Inventory	0,069968	7
EXP	Extra processing	0,151494	2
MOT	Motion	0,097720	5
TRA	Transportation	0,093644	6
UNT	Unused talent	0,105825	4
WAT	Waiting	0,130536	3
DEF	Defects	0,294670	1

As revealed by the analysis, defects (DEF) represent the most prevalent type of waste encountered in emergency departments, accounting for 29% of the total waste generated in such settings. This finding indicates that deficiencies in quality represent a critical factor impeding the efficiency of processes within emergency departments. Defective procedures and errors have been demonstrated to have a detrimental effect on patient safety and service quality, underscoring the necessity for enhancements in this domain.

Furthermore, the category of extra processing (EXP) waste represents 15% of the total waste, ranking as the second most crucial type. This indicates that superfluous steps or an excessively heavy workload in the processes are impeding the effective utilization of resources, thereby necessitating a process of streamlining. The third most significant type of waste is waiting time (WAT), which accounted for 13% of the total waste. This result underscores the fact that delays in patient flow and operational bottlenecks are major sources of waste.

Other notable waste types, in descending order, are unused talent (UNT) (11%), motion (MOT) (10%), Transportation (TRA) (9%), inventory (INV) (7%), and finally, OVP (5%). These results demonstrate that while each type of waste is critical in the operational processes, some types are more significant than others in terms of prioritization for improvement.

This ranking provides valuable insight into which areas should be prioritized for improvement in emergency department operations. Particularly, addressing defects and errors has the potential to significantly enhance emergency department performance, while optimizing other waste types will further increase operational efficiency.

Discussion

The integration of lean management in emergency departments presents a complex challenge, particularly considering the diverse forms of waste identified through expert assessment. Here, study aims investigate wastes and obstacles for lean management. Then evaluate them for implementation on emergency department. The relative weights assigned to the various types of waste serve to identify critical areas for improvement, with defects and errors being the most significant, followed by excessive handling and waiting times. This emphasizes the necessity for targeted interventions that address the underlying causes of wastage, which can impede the efficiency and effectiveness of emergency services. Furthermore, the integration of lean management presents additional complexities, including the challenges of multidisciplinary collaboration, the need for leadership, and the necessity of process redesign.

Defects have the potential to result in considerable delays and the misallocation of resources within emergency departments. The presence of defects has been demonstrated to affect patient outcomes, as well as to result in increased operational costs and lower staff morale. The principles of lean management place a strong emphasis on the necessity of maintaining quality at each stage of the process and advocate for the pursuit of continuous improvement and the reduction of defects. However, this integration process is often met with resistance, particularly in environments characterized by high stress and rapidly changing conditions, such as those encountered in emergency services [36,37]. It is imperative that a robust leadership framework is established which promotes a culture of quality and accountability. This will ensure that all team members are aligned with lean goals [37,38]. Indeed, with the backing of senior management and efficacious leadership strategies pertaining to this category of waste, it is feasible to surmount the errors identified as the most significant type of waste [13,15-17,24].

The prevalence of excessive procedures and prolonged waiting times is closely associated with the inefficiencies that are pervasive within emergency departments. The lean philosophy advocates the implementation of processes that aim to minimize unnecessary steps and optimize patient flow. However, the integration of lean practices is often impeded by procedural ambiguities and governance issues that can create confusion and impede decision-making [39,40]. For instance, the absence of transparent protocols may result in over-processing as staff navigate ambiguous processes, which could

ultimately lead to prolonged waiting times for patients. In order to address these challenges, it is necessary to adopt a comprehensive approach that encompasses the redesign of processes and the establishment of transparent governance structures. This will facilitate effective communication and coordination between multidisciplinary teams [40,41].

It is essential to acknowledge and utilize the diverse skills and expertise of team members to optimize patient care and operational efficiency. The tenets of lean management place considerable emphasis on the necessity of engaging all personnel in the process of improvement. However, instances of resistance to change frequently emerge when employees perceive a lack of appreciation for their abilities or a disregard for their input [42,43]. Such resistance can be further compounded by concerns pertaining to health and safety, particularly in high-risk environments such as emergency departments, where the ramifications of errors can be grave. It is of the utmost importance to surmount these obstacles and guarantee that all members of the team are empowered to contribute to lean initiatives [42,43]. It is similarly possible to circumvent this type of wastage, particularly through the implementation of effective leadership processes.

The inefficient movement of people and materials serves to compound the inefficiencies that are endemic to emergency departments. The objective of lean management is to eliminate these movements through process optimization and layout redesign. However, implementing such changes can face significant challenges. The necessity for effective patient flow management frequently results in a reactive rather than a proactive approach to process improvement, thereby creating a cyclical pattern of inefficiency that is challenging to break [44,45]. Furthermore, the implementation of lean principles necessitates a paradigm shift in the mindset of the staff, who may be accustomed to traditional workflows that prioritize speed over efficiency. Such a cultural shift necessitates robust leadership and continuous training to guarantee that all team members comprehend and adopt lean methodologies [42,45].

While less heavily weighted in the assessment, excess inventory and overproduction nonetheless represent critical areas for improvement. The lean philosophy advocates the implementation of just-in-time inventory management practices with the objective of reducing waste and improving responsiveness to patient needs. However, the complexity of emergency department operations, characterized by fluctuating demand and unpredictable patient flow, can present challenges to the effective implementation of these principles [46,47]. The challenge is to achieve a balance between the need for adequate resources and the imperative to minimize waste. This requires careful planning and coordination among the various stakeholders involved [48,49].

Conclusion

In conclusion, the integration of lean management in emergency departments is beset with challenges arising from both operational inefficiencies and resistance. An assessment of the types of waste reveals critical areas for intervention and highlights the necessity for a comprehensive approach that addresses leadership, process redesign, and team dynamics. The integration of lean management principles into emergency departments represents a crucial endeavour, to enhance operational efficiency and improving patient care. An evaluation of the types of waste, as identified through expert judgment, indicates that defects and errors represent the most significant area of concern, followed by excessive handling and waiting times.

By cultivating a culture of continuous improvement and engaging all staff in the lean journey, emergency departments can enhance their operational efficiency, improve patient outcomes, and, ultimately, establish a more sustainable healthcare environment. The integration of lean management presents several challenges, including the formation of multidisciplinary teams, the lack of leadership, the redesign of processes, and resistance to change. These factors serve to illustrate the complexity of implementing these principles in high-risk settings. The overcoming of these integration challenges necessitates the implementation of a

multifaceted strategy, which should encompass the commitment of leadership, the engagement of staff, and the establishment of a culture of continuous improvement.

This study presents a discussion of the critical strategies for the successful integration of lean management practices in emergency departments. The success of lean management is contingent upon several factors, including leadership support, multidisciplinary collaboration, process streamlining, and the ability to navigate resistance to change. Additionally, exploring the role of leadership in driving lean initiatives and fostering cross-disciplinary collaborations may be crucial for successful implementation. The fundamentals of these processes are the reinforcement of senior management's commitment to lean principles and the promotion of effective collaboration among employees. Furthermore, processes must be redesigned with the objective of enhancing their efficiency, and this endeavour must be supported by continuous training and regular monitoring of progress. The integration of lean management into a culture of health, safety, and quality will make a significant contribution to the improvement of patient outcomes and the enhancement of operational efficiency.

Future studies further explore the underlying reasons for resistance to lean management principles and figure out pathways to overcome barriers. Authors could also focus on evaluating the long-term sustainability of lean practices in emergency departments and the use of artificial intelligence tools for both creating data and managing them. Also, examining the influences of lean management on patient-centred outcomes would provide novel perspectives.

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Conflict of interest

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Data availability statement

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