Nurse's Lean Management Practices and Hospital Discharge Time Improvement

Berlianda Nur Sabilla[1], Muhammad Almanfaluthi[1]
[1]Faculty of Medicine, Universitas Muhammadiyah Purwokerto, Indonesia

ARTICLE INFO

ABSTRACT

Lean management is a dedicated, effective system for resource optimization, time efficiency, waste reduction, and care improvement. We aimed to evaluate the implementation of lean management in our hospital setting. We expect significant improvement in time efficiency, particularly in discharge time, administrative collection, and payment mechanism. We randomly collected 494 patients' medical records regarding time departure after treatment—308 of 494 representing the period before lean implementation. We performed additional nested randomization stratified by hospital class services (first class, second class, third class, and VIP). The results confirmed substantial time reduction (Mann Whitney test < 0.01 with high effect sizes r-rank biserial = .98) in discharge time in the nursing administration and cashier sections before and after lean implementation. Moreover, these findings were consistent across class services (nested-Mann-Whitney <.0.01). The downward waiting time was visible if the patient was hospitalized in the first, second, third, or VIP class. Implementing lean management reduces to 78% waiting time compared to the period before implementation (95%CI IRR negative binomial regression 77-79%). Lean management practice among nurses slashes patient discharge waiting time by 78%, proving its power to streamline hospital operations and boost efficiency across all service classes.

Corresponding Author:
Muhammad Almanfaluthi
Faculty of Medicine, Universitas Muhammadiyah Purwokerto,
KH. Ahmad Dahlan, Dusun III, Dukuhwaluh, Banyumas, Indonesia
Email: m.luthfi.a@ump.ac.id

1. INTRODUCTION

The healthcare sector has experienced significant transformations in recent years, driven by advancements in technology such as telemedicine and the Health 4.0 movement. Alongside these innovations, economic pressures and demographic shifts, particularly an aging population, have necessitated new approaches to maintaining the quality of healthcare services. Hospitals are now tasked with meeting rising patient demands while working with shrinking budgets, all under increasing scrutiny from stakeholders and society, especially in the aftermath of the COVID-19 pandemic. This changing landscape has created an urgent need for healthcare providers to adopt more efficient management methods [1]. In response to these challenges, many healthcare providers have begun exploring management techniques traditionally used in industrial sectors.

Continuous improvement practices, such as kaizen, total quality management (TQM), just-in-time (JIT), six sigma, and lean management, have been recognized for their potential to improve efficiency and competitiveness in the healthcare setting [2]. Lean management, in particular, has been widely lauded for its ability to optimize processes, reduce waste, and enhance quality, especially in manufacturing and

supply chain management [3].However, adopting lean management in healthcare has yielded mixed results. While some studies have demonstrated positive outcomes in terms of hospital administration efficiency [4], other analyses highlight deviations from its intended goals, such as unintended effects in large-scale implementations like the U.S. national project [5]. Challenges related to sustainability, standardization, and resistance to change have also been noted [6]. Despite these concerns, the lean management approach promises to improve healthcare services, enhancing time efficiency and reducing patient wait times.

This study aims to re-evaluate the effectiveness of lean management within a hospital setting, focusing on its impact on patient waiting times. This research addresses existing gaps by employing a rigorous study design to assess whether lean management can achieve consistent improvements in efficiency across different patient demographics. Specifically, we hypothesize that (i) lean management implementation will substantially reduce patient waiting times with a moderate to high effect size and (ii) the impact of lean management will be robust regardless of patient class or gender. By building on recent literature and addressing critical concerns such as study design and statistical rigor [2], this study aims to provide a comprehensive evaluation of lean management's role in enhancing hospital efficiency.

2. RESEARCH METHOD

This study utilized a cross-sectional descriptive design to assess the impact of lean management implementation on time efficiency in patient care. The dataset was obtained from Islamic Hospital Purwokerto, Aisyiyah Hospital Malang, and Muhammadiyah General Hospital in Delanggu Klaten, Indonesia. The population targeted for this study includes hospitals across Indonesia, with the dataset stratified into two categories: periods before and after lean implementation. The study's sample comprises 494 participants, with 186 datasets representing the period after lean management implementation. To ensure a balanced comparison, a matching analysis was performed with a 2:1 ratio, considering factors like gender, class, and subclass of treatment [7]. This approach ensured a robust evaluation by controlling for confounding variables and enabling more precise insights into the impact of lean management on patient waiting times.

The data was pooled from the hospital database and consisted of time-related variables for each participant, including the duration of nurse administration and payment at the hospital cashier. The study included data from the period after lean management was introduced. These variables are critical to determining whether lean management has improved the efficiency of hospital services, particularly by reducing waiting times for patients. The matching analysis (2:1 ratio) was based on gender, class, and subclass of treatment, ensuring that the before- and after-implementation groups were comparable. Four hundred ninety-four datasets were used in the final analysis, allowing for sufficient statistical power.

All statistical analyses were conducted using R and RStudio [8]. The analysis followed three key steps: Descriptive Analysis: Basic participant characteristics stratified by lean implementation (before and after) were summarized using the gtsummary package [9, 10]. This provided a clear overview of the demographic distribution and other relevant characteristics. The lean management impact was explored further by visualizing the waiting time (both overall and broken down by nurse administration and payment at the cashier) using the ggstatplot and ggpubr packages [11]. These visualizations showed how different variables (e.g., class, subclass, and gender) interacted with the changes in time efficiency. This nested analysis allowed a deeper understanding of lean implementation's differential impact across patient demographics. Multivariate Analysis: To account for overdispersion in the data, negative binomial regression was used instead of Poisson regression for the multivariate analysis [12]. The regression adjusted for all examined parameters and assessed the direct impact of lean management on patient waiting times, with results reported as 95% confidence intervals (CIs). Following a frequentist approach, statistical significance was set at a p-value of .05. The study's statistical power was calculated using the power and webpower packages [13]. With a total sample size of 494 participants, the analysis was confirmed to have sufficient power to detect meaningful differences in time efficiency between the pre-and post-lean implementation periods.

3. RESULTS AND DISCUSSIONS
3.1. Participants Characteristics

The lean group was matched by gender (p = 0.5) and class (p = 0.8) with the before the lean group (table 1), so we got a balance impression of the dataset. We found that time (waiting time to be discharged) has a significant difference before and after lean implementation (Mann-Whitney test < 0.001). This is happening not only in the room (administrative nurse section) but also cashier (hospital billing payment) (

Table 1).

Table 1. Participant's Characteristics (n=494)

Variable	N	Before Lean N = 308[1]	Lean implementation N = 186[1]	p-value[2]
GENDER	494			0.5
Female		209 (68%)	132 (71%)	
Male		99 (32%)	54 (29%)	
CLASS	494			0.8
Third Class		131 (43%)	85 (46%)	
Second Class		87 (28%)	48 (26%)	
First Class		57 (19%)	37 (20%)	
VIP		33 (11%)	16 (8.6%)	
TIME	494	570 (360, 840)	50 (30, 60)	<0.001***
ROOM	494	142 (90, 210)	5 (5, 8)	<0.001***
CASHIER	494	370 (234, 546)	21 (9, 30)	<0.001***

[1]n (%); Median (Q1, Q3)
[2]*p<0.05; **p<0.01; ***p<0.001

3.2. Result of Lean Implementations

We found significantly different in time efficiency ($p < 0.001$) before and after lean implementation with medium to high effect sizes (r-biserial = 0.93-1) in all study settings. The nurse administrative (panel B figure 2) and cashier (panel C figure 2) sections experienced significant changes in time. This condition also happens if we stratified based on the class of treatment in the VIP group (panel D figure 2), First class (panel E figure 2), second class (panel F figure 2), and third class (panel G **Figure 1**).
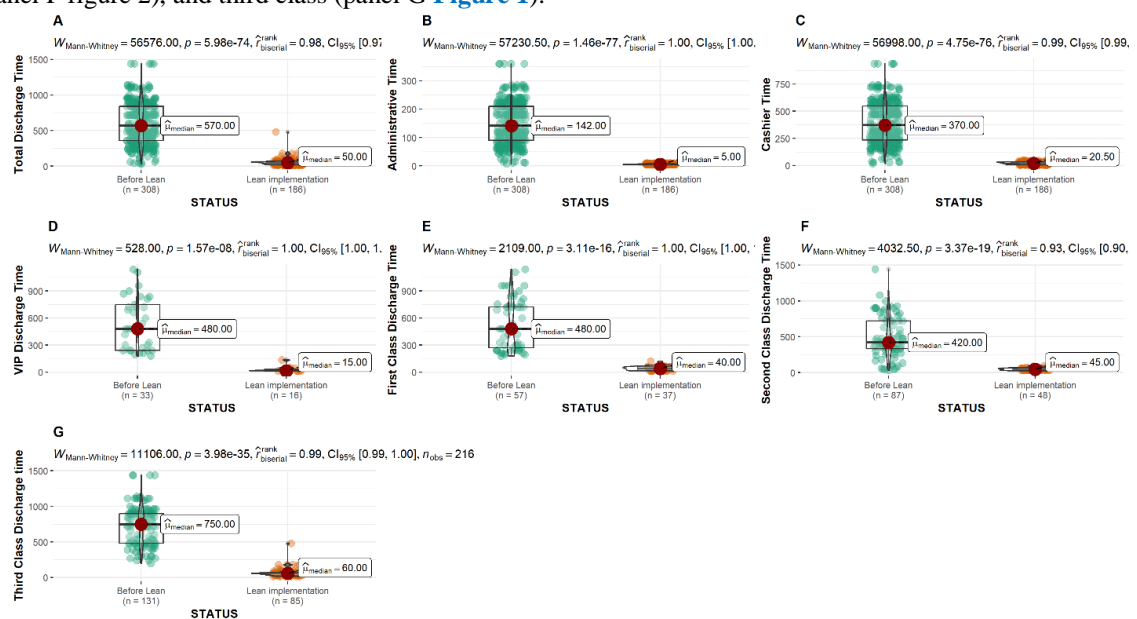

Figure 1. The Bivariate Comparison Analysis Before and After Lean Implementation

We performed multivariate analysis to challenge the lean impact after adjusting by different factors examined in this study, and we found IRR = 0.22 (1-0.22 = .78 or 78%). Lean implementation significantly gave a reduction impression to time efficiency as high as 78% compared to the period before lean ($p < 0.001$). On top of that, each class follows this phenomenon significantly, even though the reduction varies from 3%-6%. The nursing administrative section substantially reduces waiting time, whereas the cashier section shows the opposite. Male participants also significantly experienced a 5% delay time compared to their female counterparts (**Table 2**). In this study, we tried to challenge the impact of lean management implementation on time efficiency in our hospital setting, especially in the nursing administrative section and cashier. We found strong evidence that lean implementation has a better impact on the hospital system (78% time efficiency compared to before implementation).

Our findings support the previous report on lean implementation in OBG disciplines [14, 15]. Another study from a psychiatric ward showed that the time required for stocktaking was shortened, waiting time was shortened, and efficiency increased from 66% to 90%. Lean management improved efficiency and handover and

maximized nursing value and benefit [16]. A similar result also comes from oncology disciplines [17], sleep units in Spain [18], special healthcare units [19], and hospital management [4, 20, 21].

Table 2. Regression Analysis For The Impact of Lean Implementation on Time Efficiency

Characteristic	IRR[1]	SE[1]	p-value[2]
STATUS			
Before Lean	—	—	
Lean implementation	0.22	0.013	<0.001***
CLASS			
Third Class	—	—	
Second Class	0.94	0.006	<0.001***
First Class	0.96	0.007	<0.001***
VIP	0.96	0.008	<0.001***
ROOM	0.97	0.002	<0.001***
CASHIER	1.02	0.001	<0.001***
GENDER			
Female	—	—	
Male	1.05	0.005	<0.001***

[1]IRR = Incidence Rate Ratio, SE = Standard Error
[2]*p<0.05; **p<0.01; ***p<0.001

We report consistency of lean impact across different classes (VIP, first, second, and third treatment) even after controlling with several parameters. Our study answers the concern of the extensive published review [2] Involving 52 articles emphasizing that Research on Lean Management Systems in health care needs to be improved due to weak study designs and lack of statistical rigor. Regarding the rigor, we also deploy multivariate analysis to challenge our findings. Sustainability is another concern regarding lean implementation beyond our scope [6]. We proposed a longitudinal study/series continuing this study to evaluate the short – medium – long long-term impact of lean sustainability as highlighted in several publications [22, 23]. To ensure the sustainability of lean implementation, one study from the Iran Republic recommends that the involvement of technology is crucial for the long-term goal [24].

We got two interesting findings: First, the nursing section experience faster performance rather than the cashier, even with the same lean protocol, supervision, and burden evaluation conducted. Second, we expect both male and female patients to have equally fast processing time regardless of diagnosis and treatment since lean management's primary purpose is efficiency in all sectors. Unfortunately, our findings showed different trends, as demonstrated in Portuguese and Sweden. There was gender bias in surgery and eye operation waiting time; males tended to have shorter times than females [25]. This phenomenon is not uncommon since the performance of a unit is influenced by multifactorial as described by several previous lean articles [26]. Our strengths include using better study design and taking recommendations from earlier studies (matching groups to minimize the bias and multivariate analysis with controlling several parameters of interest). Hence, the impact of lean implementation was visible.

Our study strengthens the previous findings regarding the superiority of lean management. Unfortunately, we cannot warrant it in the long run. A longitudinal study is an absolute consideration for future research as part of our limitation. Another area for improvement is that our scope of the study is limited to local, even though the sample size power is sufficient compared to the national lean evaluation program [5] A better bird' s-eye view would be gained in the latter research. We recommend collaborative and longitudinal multi-center research to get the best result to validate the predicted direction of the lean impact.

4. CONCLUSIONS

Lean management holds immense importance in patient care by promoting waste reduction, enhancing efficiency, fostering continuous improvement, and embracing patient-centered care. Despite its numerous benefits, as we demonstrated in the time efficiency aspect, lean management also presents challenges, including resistance to change and the complexity of healthcare. By understanding these challenges, healthcare organizations can implement lean management principles effectively while ensuring that patient care remains the central focus.

REFERENCES

[1] L. Gautier *et al.*, "Hospital Governance During the COVID-19 Pandemic: A Multiple-Country Case Study," (in English), *Health systems and reform,* Article vol. 9, no. 2, p. 2173551, 2023.https://doi.org/10.1080/23288604.2023.2173551

[2] L. E. Winner, E. Reinhardt, L. Benishek, and J. A. Marsteller, "Lean Management Systems in Health Care: A Review of the Literature," (in English), *Quality Management in Health Care,* Review vol. 31, no. 4, pp. 221-230, 2022.https://doi.org/10.1097/QMH.0000000000000353

[3] V. L. Bittencourt, A. C. Alves, and C. P. Leão, "Industry 4.0 triggered by Lean Thinking: insights from a systematic literature review," *International Journal of Production Research,* vol. 59, no. 5, pp. 1496-1510, 2020.https://doi.org/10.1080/00207543.2020.1832274

[4] S. T. Khorasani, J. Cross, and O. Maghazei, "Lean supply chain management in healthcare: a systematic review and meta-study," *International Journal of Lean Six Sigma,* vol. 11, no. 1, pp. 1-34, 2020.https://doi.org/10.1108/ijlss-07-2018-0069

[5] T. G. Rundall, S. M. Shortell, J. C. Blodgett, R. M. Henke, and D. Foster, "Adoption of Lean management and hospital performance: Results from a national survey," *Health Care Manage Rev,* vol. 46, no. 1, pp. E10-E19, Jan/Mar 2021.https://doi.org/10.1097/HMR.0000000000000287

[6] M. Marsilio and M. Pisarra, "Lean management in health care: a review of reviews of socio-technical components for effective impact," (in English), *Journal of Health Organization and Management,* Article vol. 35, no. 4, pp. 475-491, 2020.https://doi.org/10.1108/JHOM-06-2020-0241

[7] D. E. Meyer D, Hornik K, Weingessel A, Leisch F, Chang CC,, "Misc Functions of the Department of Statistics, Probability Theory Group," *R-Project,* vol. 17, no. 13, 2023.

[8] RCoreTeam, "R: A language and environment for statistical computing. R Foundation for Statistical Computing," *Vienna, Austria,* 2022.https://doi.org/https://www.R-project.org/

[9] W. K. Sjoberg DD, Curry M, Lavery JA, Larmarange J, "Reproducible summary tables with the gtsummary package," *The R Journal,* vol. 13, no. 570, p. 80, 2021.

[10] H. Wickham *et al.*, "Welcome to the Tidyverse," *Journal of Open Source Software,* vol. 4, no. 43, p. 1686, 2019.https://doi.org/10.21105/joss.01686

[11] A. Kassambara, "ggpubr: 'ggplot2' Based Publication Ready Plots," *R package version 0.6.0,* 2023.

[12] B. R. W N Venables, *Modern Applied Statistics with S*, Fourth ed. New York: Springer, 2022.

[13] Y. M. Zhiyong Z, "WebPower: Basic and Advanced Statistical Power Analysis," *R package,* vol. 9, no. 3, 2023.

[14] R. Muharam and F. Firman, "Lean Management Improves the Process Efficiency of Controlled Ovarian Stimulation Monitoring in IVF Treatment," (in English), *Journal of Healthcare Engineering,* Article vol. 2022, 2022, Art. no. 6229181.https://doi.org/10.1155/2022/6229181

[15] S. Fu, X. G. Wu, L. Zhang, L. F. Wu, Z. M. Luo, and Q. L. Hu, "Service quality improvement of outpatient blood collection by lean management," (in English), *Patient Preference and Adherence,* Article vol. 15, pp. 1537-1543, 2021.https://doi.org/10.2147/PPA.S320163

[16] H. C. Kuo, P. C. Wei, Y. C. Chang, T. M. Hung, and S. P. Chou, "The utilization of lean management in nursing handover at a psychiatric acute ward," (in Chinese), *Journal of Nursing,* Article vol. 67, no. 5, pp. 65-73, 2020.https://doi.org/10.6224/JN.202010_67(5).09

[17] O. Ayaad, R. Al-Dewiri, L. Kasht, B. Qaddumi, and M. Ayyad, "Adopting Lean Management in Quality of Services, Cost Containment, and Time Management," (in English), *Asian Pacific Journal of Cancer Prevention,* Article vol. 23, no. 8, pp. 2835-2842, 2022.https://doi.org/10.31557/APJCP.2022.23.8.2835

[18] J. C. Prado-Prado, A. J. Fernández-González, M. Mosteiro-Añón, and J. García-Arca, "Increasing competitiveness through the implementation of lean management in healthcare," (in English), *International Journal of Environmental Research and Public Health,* Article vol. 17, no. 14, pp. 1-26, 2020, Art. no. 4981.https://doi.org/10.3390/ijerph17144981

[19] S. Hihnala, L. Kettunen, M. Suhonen, and H. Tiirinki, "The Finnish healthcare services lean management: Health services managers' experiences in a special health care unit," (in English), *Leadership in Health Services,* Article vol. 31, no. 1, pp. 17-32, 2018.https://doi.org/10.1108/LHS-03-2017-0020

[20] A. A. Abdallah, "Healthcare Engineering: A Lean Management Approach," *J Healthc Eng,* vol. 2020, p. 8875902, 2020.https://doi.org/10.1155/2020/8875902

[21] C. Ahn, T. G. Rundall, S. M. Shortell, J. C. Blodgett, and E. Reponen, "Lean Management and Breakthrough Performance Improvement in Health Care," (in English), *Quality Management in Health Care,* Article vol. 30, no. 1, pp. 6-12, 2021.https://doi.org/10.1097/QMH.0000000000000282

[22] K. Sugumar, A. C. Chidambaram, and D. Gunasekaran, "Assessment of neurological sequelae and new-onset symptoms in the long-term follow-up of paediatric Guillain–Barre syndrome: A longitudinal study

from India," (in English), *Journal of Paediatrics and Child Health,* Article vol. 58, no. 12, pp. 2211-2217, 2022.https://doi.org/10.1111/jpc.16185

[23] M. Almanfaluthi, S. Widodo, S. Suttiprapa, T. Wongsaroj, and B. Sripa, "The burden of opisthorchiasis and leptospirosis in Thailand: A nationwide syndemic analysis," *Acta Trop,* vol. 226, p. 106227, Feb 2022.https://doi.org/10.1016/j.actatropica.2021.106227

[24] L. Gholizadeh, I. M. Asl, K. Hajinabi, and P. R. Dehkordi, "Lean management in hospitals: Key factors for successful implementation: (an investigation of factors affecting lean management in public hospitals in kohgiluyeh and boyerahmad and bushehr provinces)," (in English), *Journal of Advanced Pharmacy Education and Research,* Article vol. 8, pp. 88-92, 2018.

[25] J. Cima, P. Guimarães, and A. Almeida, "Explaining the Gender Gap in Waiting Times for Scheduled Surgery in the Portuguese National Health Service," (in English), *Portuguese Journal of Public Health,* Article vol. 39, no. 1, pp. 3-10, 2021.https://doi.org/10.1159/000514798

[26] M. Dochain and A. S. Nyssen, "The Lean paradox: Does applying Lean Management increase protocol deviations? A case study of cleaning staff in the hospital sector," (in English), *International Journal of Healthcare Management,* Article vol. 13, no. S1, pp. 311-317, 2020.https://doi.org/10.1080/20479700.2018.1540185