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Effectiveness of Early Spinal Fixation for Thoracolumbar Spine Fractures: A Quasi-Experimental Study

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Purpose: We aimed to evaluate the effectiveness of early spinal fixation for thoracic and lumbar spine fractures.
Methods: We employed a quasi-experimental design with prospective treatment and retrospective control groups (n=37 each). The treatment group received early spinal fixation within 72 hours according to the Royal College of Orthopedic Surgeons of Thailand guidelines, while the control group underwent late fixation after 72 hours. Data from patient medical records were analyzed using statistical tests. Statistical significance was set at $p < 0.05$.
Results: We observed that the treatment group had a significantly lower morphine consumption compared with the control group within the first 24 hours postoperatively (mean difference 5.8, 95% Confidence Interval [CI] 2.4 to 9.3 and overall mean difference 2.8, 95%CI 0.2 to 5.6), and significantly higher scores in activities of daily living (ADL) at 1 week (mean difference 3.1, 95%CI 0.6 to 5.6) and 8 weeks (mean difference 4.0, 95%CI 1.1 to 6.8) postoperatively, with an overall mean difference of 3.5 (95%CI 0.7 to 6.3), indicating a faster functional recovery. Pain scores and the hospital length of stay did not differ significantly between the groups. The general medical expenses (mean difference 17,982, 95%CI 3,670 to 32,295) and total medical expenses (mean difference 20,174, 95%CI 2,415 to 37,933) were significantly higher in the treatment group, whereas implant costs did not differ significantly.
Conclusions: Early spinal fixation surgery is effective in improving functional recovery for thoracic and lumbar spine fractures. Proper resource planning and further evaluation of cost-effectiveness are recommended.

Keywords: Thoracic spine fracture, lumbar spine fracture, early spinal fixation, spine surgery

Spinal injuries, including those to the spinal cord, are major public health concerns worldwide. The thoracic and lumbar regions of the spine are the most commonly affected areas. Injuries to these regions can compress or directly damage the spinal cord. Such trauma may result in permanent neurological deficits. Globally, thoracolumbar spinal fractures remain a significant public health problem. According to a review by Zileli et al. [21], the incidence of spinal injuries is approximately 30 cases per 100,000 population. The United States National Spinal Cord Injury Statistical Center reports about 17,000 new cases of spinal cord injury each year. Currently, over 250,000 individuals live

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with permanent disabilities resulting from such injuries. The most common causes are traffic accidents (38%), falls from a height (30%), violence-related injuries (14%), and sports accidents (9%)[14].

Spinal injuries have profound physical and socioeconomic impacts at both individual and societal levels. Effective management requires prompt and accurate diagnosis. Appropriate treatment is essential to prevent further spinal cord damage and minimize complications. The prognosis depends primarily on the level of spinal cord injury and the severity of neurological impairment. Without timely intervention, patients may sustain further damage, resulting in permanent disability and serious complications. Therefore, rapid assessment is crucial to determine the location and severity of the injury. This enables timely decisions regarding surgical or conservative management. Patient management must consider multiple factors, from initial assessment and stabilization to long-term rehabilitation, to optimize recovery[17,20].

Various approaches are available for managing thoracolumbar spinal fractures. Nonoperative treatments include medication and physical therapy, while surgical intervention may be considered when the symptoms fail to improve. However, considerable controversy persists regarding the treatment strategy that would be most appropriate. Decisions depend on multiple factors, including the nature of the injury, clinical presentation, overall patient condition, and radiographic findings[18]. Surgical intervention for thoracic and lumbar fractures is often preferable to nonoperative management, particularly for patients who cannot tolerate prolonged bracing. In general, these procedures facilitate earlier mobilization and are associated with shorter hospital stays[16].

Early spinal fixation for thoracic and lumbar fractures offers several potential benefits. These include reduced morbidity and mortality through earlier mobilization, as well as decreased incidence and severity of sepsis and respiratory failure. However, early surgical intervention also carries potential drawbacks. The most debated disadvantage is increased physiological stress, which may inadvertently elevate morbidity and mortality rates. Surgery performed in patients with associated injuries, those unsuitable for complex procedures, or when critical resources are limited, may further complicate outcomes[1].

A systematic review[1] indicated that early stabilization of thoracic fractures reduces the duration of mechanical ventilation, as well as length of stay in the intensive care unit and the hospital. It also lowers the incidence of respiratory complications compared with those in the late stabilization stage. Treatment is primarily recommended within 72 hours for patients with unstable thoracic fractures. However, the review concluded that there is insufficient evidence to determine whether early spinal fixation accelerates overall recovery or reduces mortality[1].

Yasothon hospital is a tertiary care facility capable of performing surgery for thoracic and lumbar spinal fractures. These interventions are carried out by experienced orthopedic surgeons. In 2025, the hospital implemented a policy of early spinal fixation for such patients, aiming to reduce morbidity and mortality. Although previous studies have suggested that this approach can shorten hospital stay, robust evidence regarding its effectiveness, particularly in terms of patient recovery and treatment costs, remains limited. Moreover, although several studies recommend this approach, some have reported inconsistent results. Earlier research may also be outdated due to advancements in diagnostic and surgical techniques. This limits the applicability of previous findings to current practice[1,6]. In Thailand, and particularly in Yasothon province, no studies have evaluated the effectiveness of this treatment approach. As a result, there is a lack of clear evidence to support appropriate decision-making and treatment planning for patients. Therefore, this study was conducted to evaluate the effectiveness of early spinal fixation surgery among patients with thoracolumbar spinal fractures at our hospital. These findings will provide concrete evidence regarding the effectiveness of the early spinal fixation approach and serve as an important resource for planning appropriate treatment for patients with thoraco-lumbar spinal fractures at Yasothon hospital and other facilities. Moreover, the results will contribute to policy recommendations for the future management of thoracolumbar spinal fractures.

The present study aimed to evaluate the effectiveness of early spinal fixation in patients with thoracic and lumbar fractures. The findings are expected to provide evidence-based guidance for clinical decision-making and support hospital and provincial policy development. They may also contribute to improved management of thoracolumbar spinal fractures in similar healthcare settings.

MATERIALS AND METHODS

Study Design

This study employed a quasi-experimental design with a historical control, comprising prospective treatment and retrospective control groups. The study was conducted from January to September 2025.

The study included all patients with thoracic and lumbar spinal fractures treated at Yasothon hospital from January 2024 to September 2025. A total of 74 patients were included in the study cohort, and were divided into two groups as follows. The treatment group (n = 37) included patients with thoracic and lumbar fractures who received early spinal fixation (within 72 hours) between January and September 2025. The control group (n = 37) included patients with thoracic and lumbar fractures who received late spinal fixation (after 72 hours) during a retrospective period from January to December 2024.

Sample Size Determination

The sample size calculation was performed using G*Power software [5] with the following steps: 1) Test Family: t-test, 2) Statistical Test: Means: difference between two independent means (two groups) 3) Type of Test: Two-tailed, 4) Input Parameters: Power (1-β): 90% (0.9), Alpha (α): 0.05, Effect Size: Large (0.8)[3] The initial calculated sample size was 34 participants per group. To account for potential dropouts or participants who were unable to complete the study, an additional 10% (4 participants per group) of patients were added. Thus, the final sample size was 38 participants per group. Inclusion Criteria: Patients diagnosed with thoracic or lumbar spinal fractures, and those who voluntarily agreed to participate were included in the study.

Exclusion Criteria

Patients diagnosed with cervical spinal fractures, traumatic brain injury and a Glasgow Coma Scale score < 15, and those who wished to withdraw were excluded from the study. Eligible patients in both groups met the same inclusion and exclusion criteria and were treated by the same surgical team following identical postoperative protocols.

Research Instruments

1) A surgical program for early spinal fixation in patients with thoracic and lumbar fractures, based on the clinical practice guidelines of Yasothon hospital. These guidelines were developed by specialist orthopedic surgeons and are aligned with the standards of the Royal College of Orthopedic Surgeons of Thailand[15]. 2) Data collection tool: Data were collected using a medical record abstraction form developed by us that was based on a review of the relevant literature. The form consisted of three sections: Section 1: General patient information (seven items) including sex, age, weight, height, occupation, education level, and cause of injury. Section 2: Treatment history (13 items) including wait time for surgery, length of stay (LOS), morphine dosage at 24 hours preoperatively and at 24, 48, and 72 hours postoperatively, pain scores at 24 hours preoperatively and at 24, 48, and 72 hours postoperatively, and activities of daily living (ADL) scores preoperatively, at 1 week and 2 months postoperatively. ADL scores were evaluated using the standardized 10-item ADL assessment form, which is routinely used in clinical practice. The scale comprises ten self-care and mobility items, each scored from 0 to 2, yielding a total score ranging from 0 to 20, with higher scores indicating greater functional independence. Although this instrument is not identical to the traditional Barthel Index, it is adapted from commonly used ADL assessment tools and has been routinely applied in the hospital for functional evaluation, providing

acceptable clinical face and content validity for use in this study. Section 3: Treatment costs (three items) including general treatment costs, implant costs, and total costs. Instrument Validity: The content validity of the data collection form was assessed using Item Objective Congruence (IOC) by three experts. The IOC values for individual items ranged from 0.67 to 1.0, indicating acceptable content validity.

Research procedure: Members of the treatment group who met the inclusion criteria and were indicated for early spinal fixation were consecutively enrolled for surgery after providing informed consent. Preoperative assessments included evaluation of back pain and ADL. Early spinal fixation was carried out in accordance with the standards of the Royal College of Orthopedic Surgeons of Thailand, and patients were monitored for treatment outcomes. The control group consisted of patients treated in 2024 who met the same eligibility criteria and received standard care, with spinal fixation conducted more than 72 hours after injury. Both groups were managed by the same surgical team and received identical postoperative care protocols.

To reduce selection bias, both groups were selected using the same inclusion and exclusion criteria and were treated and managed by the same surgical team. Baseline characteristics, including age, sex, occupation, body mass index, and cause of injury, were compared to ensure similarity between groups.

Statistical Analysis

The baseline characteristics of the study cohort were analyzed using descriptive statistics, including frequencies, percentages, means, and standard deviations. The effectiveness of early spinal fixation was evaluated using inferential statistics. The baseline characteristics of the sample were compared using the Chi-square and t-tests. Treatment outcomes between the treatment and control groups, including morphine dosage, pain scores, and ADL scores, were analyzed using analysis of covariance (ANCOVA). Overall comparisons were conducted using generalized estimating equations to estimate parameters within a generalized linear model framework. The mean differences in LOS and treatment costs were compared using the t-test. A p-value of 0.05 was considered statistically significant for all analyses.

Research Ethics

This study was approved by the Ethics Committee of Yasothon hospital on December 20, 2024 (Ethical Approval No. 2024-36).

RESULTS

One patient in the treatment group withdrew from the study due to travel to another province, leaving 37 participants in the treatment group. Accordingly, 37 participants were selected in the control group to match the treatment group.

The baseline characteristics of participants in both groups were as follows. The majority were men: 70.3% in the treatment group and 59.5% in the control group. The mean age was 48.2 ± 14.7 years in the treatment and 49.8 ± 11.2 years in the control group. The occupation was agriculture in 75.7% and 73.0% of the two groups, respectively. The mean body mass index (BMI) value was 23.4 ± 3.4 and 22.1 ± 3.2 in the two groups, respectively. The cause of injury was fall from a height in 70.3% of the treatment group and 86.5% of the control group. Statistical analysis revealed no significant differences in baseline characteristics between the two groups ($p > 0.05$) (Table 1).

The clinical outcomes, including morphine use, pain scores, and functional recovery were as follows. Comparisons between the treatment and control groups revealed that the treatment group exhibited a significantly lower morphine consumption compared with the control group within the first 24 hours postoperatively (mean difference 5.8, 95% CI 2.4 to 9.3), but no significant differences were observed at 48 hours (mean difference -0.5, 95% CI -4.3 to 3.2) and 72 hours (mean difference 3.2, 95% CI -0.3 to 6.9) postoperatively. However, the overall analysis showed that the treatment group used significantly less morphine than the control group (mean difference 2.8, 95% CI 0.2 to 5.6).

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Table 1 Demographic data and baseline characteristics.

Variables	Treatment Group (n=37)		Control Group (n=37)		P-value
	n	%	n	%	
Sex					0.330[a]
Men	26	70.3	22	59.5	
Women	11	29.7	15	40.5	
Age (year) (Mean, SD)	48.2	14.7	49.8	11.2	0.589[b]
Occupation					0.923[a]
Agriculture	28	75.7	27	73.0	
Unemployed	6	16.2	6	16.2	
Employed	3	8.1	4	10.8	
Education					0.764[a]
Lower secondary school	28	75.7	27	73.0	
Secondary school and upper	9	24.3	10	27.0	
Body mass index (Mean, SD)	23.4	3.4	22.1	3.2	0.083[b]
Cause					0.090[a]
Fall	26	70.3	32	86.5	
Traffic accident	11	29.7	5	13.5	

[a] Chi-square test, [b] t-test, SD; Standard Deviation.

Table 2 Multivariate analysis of treatment and control groups.

Outcomes	Treatment Group $\bar{x}$ (SD)	Control Group $\bar{x}$ (SD)	Mean Difference	95%CI	P-value
A. Morphine use; (mg)					
24 hrs.	22.4 ±6.8	27.5 ±7.9	5.8	2.4 to 9.3	0.001
48 hrs.	19.7 ±8.7	18.5 ±7.7	-0.5	-4.3 to 3.2	0.774
72 hrs.	6.9 ±7.8	8.6 ±8.1	3.2	-0.3 to 6.9	0.074
Overall			2.8	0.2 to 5.6	0.041
B. Pain score					
24 hrs.	4.1 ±0.9	4.5 ±1.2	0.4	-0.04 to 0.9	0.073
48 hrs.	3.5 ±0.9	3.6 ±0.9	0.2	-0.4 to 0.4	0.894
72 hrs.	2.6 ±1.0	2.8 ±1.1	0.08	-0.4 to 0.6	0.742
Overall			0.2	-0.02 to 0.6	0.242
C. Barthel index (ADL)					
Weeks 1	15.9 ±4.8	14.6 ±5.6	3.1	0.6 to 5.6	0.016
Weeks 8	19.4 ±5.2	16.9 ±6.3	4.0	1.1 to 6.8	0.007
Overall			3.5	0.7 to 6.3	0.015

Note: Multivariate analysis presented as mean differences and their 95% confidence intervals (CI) comparisons between the treatment and control groups according to A) Morphine (mg), B) Pain score, and C) Barthel index (Activities of Daily Living [ADL])

Pain Scores

No significant differences were observed in pain scores between the two groups at each time point postoperatively and in overall comparisons. The mean difference data were as follows: at 24 hours (mean difference 0.4, 95% CI -0.04 to 0.9); at 48 hours (mean difference 0.2, 95% CI: -0.4 to 0.4); at 72 hours (mean difference 0.08, 95% CI -0.4 to 0.6); and in overall comparisons (mean difference 0.2, 95% CI -0.02 to 0.6).

ADL Scores

Postoperative ADL scores were significantly higher in the treatment group compared with the control group as follows: at 1 week (mean difference 3.1, 95% CI 0.6 to 5.6); at 8 weeks (mean difference 4.0, 95% CI 1.1 to 6.8); and in overall comparisons (mean difference 3.5 (95% CI 0.7 to 6.3) (Table 2).

The mean difference was adjusted for baseline measurements, and age, Body Mass Index (BMI), cause of accident, for each visit using analysis of covariance (ANCOVA), and for overall comparisons using generalized estimating equations (GEE) implemented under a generalized linear model (GLM) framework.

Comparison of LOS and treatment costs: The mean LOS value in the inpatient ward was 8.1 days for the treatment group and 8.3 days for the control group, with no statistically significant difference (95%CI -1.2 to 0.8, p 0.669). General medical expenses: The treatment group had a significantly higher mean medical cost value than the control group as measured by Thai Baht (THB) 17,982 per patient (95%CI 3,670 to 32,295, p 0.014). Implant costs: The mean implant cost value in the treatment group was THB 2,191 higher than in the control group, but this difference was not statistically significant (95%CI -5,550 to 9,934, p 0.574). The total medical expenses in the treatment group were THB 20,174 higher than in the control group, which was statistically significant (95%CI 2,415 to 37,933, p 0.026) (Table 3). However, in terms of mortality, no postoperative deaths were observed in either the treatment or control groups.

Table 3 Comparison between length of stay and treatment costs for the treatment and control groups.

Variables	Treatment Group		Control Group		Mean difference	95% CI	P-value
	$\bar{x}$	SD	$\bar{x}$	SD			
Length of stay	8.1	3.2	8.3	4.3	-0.2	-1.2 to 0.8	0.669
General medical expenses[a]	90,669	29,660	72,686	32,053	17,982	3,670 to 32,295	0.014
Implant costs[a]	60,760	14,793	58,568	18,419	2,191	-5,550 to 9,934	0.574
Total medical expenses[a]	151,430	33,187	131,255	42,838	20,174	2,415 to 37,933	0.026

[a]Thai baht, [b]The p-values obtained from student t-tests

DISCUSSION

Our analysis comparing baseline characteristics between the two groups revealed no statistically significant differences ($p > 0.05$). This indicates that members of the treatment and control groups were comparable at baseline, allowing for a reliable and valid assessment of the outcomes of early spinal fixation.

Morphine consumption differed significantly between the treatment and control groups during the first 24 hours postoperatively. However, no significant differences were observed at 48 and 72 hours after surgery. When analyzed overall, the treatment group used significantly less morphine than the control group. These findings indicate that early spinal fixation (within 72 hours) significantly reduces postoperative opioid requirements, particularly in the first 24 hours, which is typically when patients experience the most severe pain [8,13,19]. This highlights the effectiveness of early spinal fixation in managing postoperative pain and promoting patient recovery.

Pain scores at each time point and overall did not differ significantly between the treatment and control groups. Although the treatment group consumed significantly less morphine, patient-reported pain levels were comparable to those in the control group. This suggests that early spinal fixation reduces analgesic use without increasing postoperative pain(8,19). Our present findings suggest that early spinal fixation can decrease opioid requirements while maintaining effective pain control, consistent with the principle that rapid stabilization minimizes fracture movement, reduces the inflammatory response, and facilitates faster recovery without additional postoperative discomfort (7). This apparent paradox (lower opioid consumption despite similar pain scores) may reflect the subjective nature of pain assessment, which varies according to individual pain thresholds and psychological factors, limiting the sensitivity of pain scales to detect subtle differences. A ceiling effect may also occur when postoperative pain remains within a moderate range in both groups. In contrast, opioid use provides a more objective indicator of analgesic need. Thus, the reduced opioid requirement in the early fixation group suggests that physiological pain stimuli were effectively diminished by timely stabilization, even though self-reported pain intensity did not differ markedly(7,8,19).

The comparison of ADL scores after surgery revealed that the treatment group had significantly higher ADL scores than the control group at 1 week, 8 weeks, and in overall comparisons. This indicates that early spinal fixation is effective in both short- and mid-term recovery, promoting functional restoration more efficiently than delayed fixation. Significant differences were observed in both the early phase (week 1) and the follow-up period (week 8), demonstrating that early spinal fixation accelerates recovery and supports the return of patients to functional independence(7,11). Clinically, higher ADL scores reflect a faster improvement in self-care ability and earlier mobilization, enabling patients to resume normal activities sooner. Improved functional outcomes may reduce rehabilitation demands, shorten hospital stays, and lessen caregiver burden. These findings suggest that early spinal fixation offers meaningful clinical benefits.

The comparison of LOS revealed a mean value of 8.1 days in the treatment and 8.3 days in the control group, with no statistically significant difference. Currently, there is insufficient evidence to conclude that the two groups differ in hospitalization duration. This lack of statistical significance may reflect a limited sample size or high variability in hospital stay, which can be influenced by multiple factors such as postoperative complications, patient age, delays in discharge planning, and readiness of the rehabilitation team (10). These findings are consistent with the study by Chuwongkomol et al.(2) which reported no significant difference in hospital stay between patients undergoing minimally invasive short-segment fixation and those receiving conventional long-segment fixation. Although early spinal fixation facilitates faster mobilization and functional recovery, it may not necessarily shorten hospitallization due to system-level factors. Discharge decisions often depend not only on the physical readiness of patients but also on administrative processes, rehabilitation scheduling, and caregiver preparedness. Consequently, some patients may remain hospitalized for postoperative monitoring or coordination of discharge support despite achieving early mobility.

Regarding treatment costs, the treatment group had significantly higher mean general medical costs than the control group. Implant costs were higher in the treatment group, but the difference was not statistically significant. Total treatment costs were significantly higher, primarily due to greater utilization of hospital resources, including medications, diagnostic tests, nursing care, and additional services such as early rehabilitation and postoperative monitoring. Costs were not adjusted for inflation or economic changes over the 2-year study period, which may limit comparability. While early spinal fixation incurs higher initial costs, the potential long-term economic impact such as possible reductions in rehabilitation duration or caregiver burden remains speculative and would require a formal cost-effectiveness analysis for confirmation[5,12]. Regarding mortality, no deaths related to surgery were observed in either the treatment or control groups. This suggests that the surgical procedures in both groups were performed according to the standards of the Royal College of Orthopedic Surgeons of Thailand. Factors influencing mortality include age, comorbidities, and injury severity, which appear to be consistent across the two groups. Therefore, although the two surgical approaches differ in technique and short-term outcomes, they showed no significant difference in mortality[9].

This study was conducted at a single hospital, which may limit the generalizability of the findings to other populations or healthcare settings. The use of a non-concurrent historical control group represents a major methodological limitation, as it may introduce substantial selection and informational bias. Patients in the historical cohort may differ from those in the early fixation group in terms of injury severity, treatment practices, or hospital resources available at the time, while the reliance on retrospective medical records increases the risk of incomplete or inconsistent data. These sources of bias could influence both the effect estimates and the internal validity of the study, and the findings should therefore be interpreted with caution. Cost data were not adjusted for inflation or economic changes; given the 2-year data collection period, minor effects of price fluctuations on cost comparisons may have occurred.

Additionally, the study did not include information on the Arbeitsgemeinschaft für Osteosynthesefragen (AO) foundation spine classification, the American Spinal Injury Association (ASIA) score, underlying diseases, smoking status, or the use of medications such as aspirin or warfarin, all of which may influence surgical duration or postoperative recovery. These factors may act as potential confounders because they are closely related to baseline injury severity, neurological function, physiological recovery, and postoperative complication risk. For example, AO classification and ASIA score strongly influence expected recovery trajectories, while comorbidities and smoking can delay wound healing, prolong hospitalization, and increase analgesic requirements. The omission of these variables limits the ability to fully adjust for their impact on outcomes, and therefore, the observed differences may partially reflect unmeasured clinical heterogeneity. Although early spinal fixation was associated with improved functional recovery, other outcomes such as LOS and total treatment costs may have been affected by factors including patient age, postoperative complications, discharge planning, and caregiver availability.

Although ANCOVA was applied to adjust for baseline characteristics (age, BMI, cause of accident, and baseline ADL), the absence of fracture classification and baseline neurological data limits the ability to fully control for confounding factors, and unmeasured clinical variables may still have influenced the results.

Early spinal fixation for thoracic and lumbar fractures is recommended to accelerate recovery and reduce caregiver burden. Careful planning of hospital resources and treatment costs is essential to maximize clinical benefits. Future research should include larger sample sizes, using randomized controlled trials, longer follow-up durations, and better control of potential confounding factors such as AO spine classification, ASIA score, patient age, postoperative complications, underlying diseases, smoking status, medication use, and discharge support to clarify the long-term clinical and economic outcomes.

CONCLUSION

The effectiveness of early spinal fixation in patients with thoracic and lumbar fractures was demonstrated by significantly better recovery of ADL in the treatment compared with the control group at 1 week, 8 weeks, and in overall comparisons. These results indicate that early spinal fixation facilitates a faster return to independence. Regarding LOS, no significant differences were observed between groups, suggesting that although functional recovery improved, hospitalization duration was not reduced. This may have been influenced by other factors such as postoperative complications, patient age, and discharge planning. Mortality was not observed in either group, indicating the safety of the procedure. In terms of treatment costs, general and total costs were significantly higher in the treatment group, while implant costs were higher but not statistically significantly in the treatment group. These findings suggest that early spinal fixation consumes more resources but provides enhanced clinical outcomes. Overall, early spinal fixation can be considered an effective treatment strategy and may serve as a basis for developing institutional or national policy guidelines to optimize spine fracture care, with the potential for further evaluation of its cost-effectiveness in future studies. To enhance the external validity and applicability of these results, future multicenter prospective studies involving diverse healthcare settings are recommended.

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