

Midocean University

College of Business Administration
MBA Program — Healthcare Management

The Effect of Clinical Resource Optimization on Cost Efficiency in Intensive Care Units: A Field Study in Saudi Public Hospitals

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1. Introduction

Intensive Care Units (ICUs) are among the most resource-intensive environments in modern healthcare systems. They require continuous patient monitoring, advanced life-support technology, and highly specialized clinical staff — all of which generate substantial operational costs. Globally, critical care accounts for approximately 13–20% of total hospital expenditure, despite ICU beds representing only 5–10% of a hospital's total capacity (Halpern and Pastores, 2015). In Saudi Arabia, the rapid expansion of healthcare infrastructure under Vision 2030 has amplified both the scale and complexity of ICU operations across public hospitals.

Saudi Arabia's Vision 2030 health transformation program explicitly targets improved efficiency in public healthcare spending, reduction of preventable costs, and advancement of evidence-based clinical practices. The Ministry of Health (MOH) has identified ICU cost management as a priority area, given that ICU-related expenditure in Saudi public hospitals has increased significantly in parallel with capacity expansion (MOH Annual Report, 2022). Despite this, systematic evidence on how clinical resource optimization — specifically the management of medications and respiratory equipment — influences ICU financial efficiency in the Saudi context remains limited.

Clinical resource optimization refers to the systematic application of evidence-based protocols and administrative controls to ensure that clinical resources — including pharmaceuticals, medical devices, and personnel time — are used appropriately, efficiently, and in alignment with patient clinical needs. When poorly managed, resources such as respiratory equipment may be used beyond clinical indication or without structured de-escalation protocols, leading to avoidable costs without improvements in patient outcomes (Kahn et al., 2017).

This study examines the relationship between clinical resource optimization — with a focus on medication utilization and respiratory equipment management — and cost reduction in ICUs across Saudi public hospitals. By generating quantitative evidence from clinicians directly responsible for ICU resource decisions, this research aims to support hospital administrators and policymakers in developing targeted strategies for sustainable ICU cost management.

2. Problem Statement

ICU departments in Saudi public hospitals face persistent inefficiencies in clinical resource utilization that contribute to avoidable expenditure. According to the Saudi Ministry of Health, ICU operational costs in government hospitals have risen by over 20% between 2018 and 2022, driven in part by increased device utilization and pharmaceutical consumption (MOH, 2022). Internationally, studies estimate that 30–40% of ICU costs may be attributable to suboptimal resource utilization, including prolonged mechanical ventilation, unnecessary medication administration, and inadequate protocol adherence (Dasta et al., 2005; Rapoport et al., 2018).

In the Saudi context, Al-Dorzi et al. (2020) documented wide variation in ICU clinical practices across Saudi hospitals, including inconsistent use of weaning protocols and medication stewardship programs. These variations directly affect both patient outcomes and operational costs. Despite this, there is a notable absence of empirical research quantifying the relationship between specific resource optimization practices and measurable cost outcomes in Saudi public ICUs.

This study therefore addresses the following central research question:

To what extent does clinical resource optimization — encompassing medication utilization and respiratory equipment management — contribute to cost efficiency in Intensive Care Units in Saudi public hospitals?

3. Importance of the Study

Scientific Importance

This study contributes to the academic literature on healthcare management by generating quantitative evidence on the relationship between clinical resource optimization and cost efficiency in a Saudi Arabian ICU context — an area underrepresented in current research. It applies healthcare resource management theory and cost efficiency theory to a new empirical setting, extending the applicability of these frameworks beyond Western healthcare systems. The study also advances understanding of how Vision 2030 policy objectives translate into measurable operational outcomes at the ICU level.

Practical Importance

The findings of this study are directly relevant to multiple stakeholder groups:

- Hospital administrators and ICU department heads: evidence to support the development of resource optimization protocols and cost control strategies.
- The Saudi Ministry of Health and Vision 2030 policymakers: data to inform national ICU efficiency guidelines and healthcare expenditure management programs.
- Respiratory therapy and pharmacy departments: actionable insights on equipment utilization and medication stewardship practices.
- Academic researchers: a validated instrument and baseline data for future longitudinal and comparative ICU cost studies in Saudi Arabia.

4. Objectives of the Study

Main Objective: To examine the effect of clinical resource optimization on cost efficiency in Intensive Care Units in Saudi public hospitals.

Secondary Objectives:

- Assess current medication utilization practices in ICU departments of Saudi public hospitals and their impact on operational costs.
- Evaluate respiratory equipment utilization patterns, including adherence to weaning and de-escalation protocols, and their financial implications.
- Examine the relationship between clinical resource optimization policies and ICU financial efficiency.
- Identify organizational and clinical barriers to effective resource optimization in Saudi public ICUs.
- Provide evidence-based recommendations to improve ICU resource management and reduce avoidable expenditure.

5. Research Questions

Main Question: To what extent does clinical resource optimization affect cost efficiency in Intensive Care Units in Saudi public hospitals?

Sub-Questions:

Q1: To what extent does medication utilization influence ICU operational costs in Saudi public hospitals? (Links to Objective 1)

Q2: How does respiratory equipment utilization — including adherence to weaning protocols — affect ICU financial efficiency? (Links to Objective 2)

Q3: What is the relationship between the implementation of clinical resource optimization policies and ICU cost reduction? (Links to Objective 3)

Q4: What organizational and clinical factors influence the effectiveness of resource optimization practices in Saudi public ICUs? (Links to Objective 4)

Q5: What management strategies can be recommended to improve ICU cost efficiency through clinical resource optimization? (Links to Objective 5)

6. Research Hypotheses

The following hypotheses are derived from the study objectives and are operationalized based on the main and sub-research questions:

H1 (Main Hypothesis): *Clinical resource optimization has a statistically significant positive effect on cost efficiency in ICUs in Saudi public hospitals.*

H1a: *Efficient medication utilization practices have a statistically significant positive effect on ICU cost reduction.*

H1b: *Improved respiratory equipment utilization — including adherence to weaning and de-escalation protocols — has a statistically significant positive effect on ICU financial efficiency.*

***H1c:** The implementation of formal clinical resource optimization policies is positively associated with improved ICU cost efficiency.*

***H0:** Clinical resource optimization has no statistically significant effect on cost efficiency in ICUs in Saudi public hospitals.*

7. Literature Review

The following review presents prior studies ordered chronologically within each thematic axis. Each study is summarized by author, year, objective, methodology, and key findings, followed by an analysis of similarities, differences, and the gap this study addresses.

7.1 ICU Cost Management and Resource Utilization

Dasta et al. (2005) — Objective: To quantify the daily cost contribution of mechanical ventilation to total ICU expenditure. Methodology: Retrospective cost analysis across U.S. ICUs. Key Findings: Mechanical ventilation accounted for a disproportionate share of daily ICU costs; ventilator days were the strongest predictor of total episode cost.

Halpern and Pastores (2015) — Objective: To describe the scope and cost structure of critical care medicine in the United States. Methodology: Descriptive analysis of national hospital and cost data. Key Findings: ICUs represent 13–20% of hospital costs despite a small proportion of beds; personnel and device utilization are the primary cost drivers.

Kaplan and Porter (2016) — Objective: To propose a value-based framework for hospital cost management. Methodology: Conceptual and case-study analysis. Key Findings: Time-driven activity-based costing reveals significant waste in resource utilization; optimizing clinical processes reduces costs without compromising outcomes.

Kahn et al. (2017) — Objective: To analyze the relationship between ICU resource utilization practices and patient/financial outcomes. Methodology: Multi-center observational study in U.S. ICUs. Key Findings: Better coordination of clinical resources reduces unnecessary utilization and improves both patient outcomes and financial sustainability.

Rapoport et al. (2018) — Objective: To examine inefficient clinical practices contributing to ICU expenditure. Methodology: Prospective observational study in critical care settings. Key Findings: Prolonged equipment use and unnecessary treatments contributed substantially to avoidable ICU costs; structured protocols reduced resource consumption.

Al-Dorzi et al. (2020) — Objective: To document ICU clinical practice variation and outcomes across Saudi hospitals. Methodology: Multi-center observational study in Saudi public hospitals. Key Findings: Significant variation in protocol adherence across Saudi ICUs; inconsistent weaning practices associated with prolonged ventilator days and increased costs.

Al Saeed (2021) — Objective: To examine healthcare cost efficiency in Saudi hospital settings. Methodology: Descriptive survey-based study in Saudi public hospitals. Key Findings:

Improved clinical resource management can measurably reduce operational spending; administrative oversight gaps are a primary barrier.

Alotaibi et al. (2022) — Objective: To assess the impact of structured respiratory therapy protocols on ICU outcomes and costs in Saudi Arabia. Methodology: Retrospective clinical audit in Saudi ICUs. Key Findings: Protocol-directed respiratory therapy reduced average ventilation duration and associated supply costs; structured interventions improved cost efficiency.

7.2 Comparative Analysis and Research Gap

Across the reviewed studies, a consistent finding emerges: suboptimal clinical resource utilization — particularly in medication administration and respiratory equipment management — is a significant and modifiable driver of ICU costs. Studies from Western contexts (Dasta et al., 2005; Kahn et al., 2017; Rapoport et al., 2018) provide strong quantitative evidence of this relationship, while Saudi-based studies (Al-Dorzi et al., 2020; Alotaibi et al., 2022) confirm that the same patterns exist in the local context, though with less rigorous quantification.

A key distinction is that international studies typically use objective cost records and clinical databases, while Saudi studies have relied predominantly on observational or audit methods without direct cost measurement. Furthermore, no existing study combines both medication utilization and respiratory equipment management as joint predictors of ICU cost efficiency in Saudi public hospitals using primary survey data from practicing clinicians. This study directly addresses that gap by providing the first structured quantitative analysis of both variables in the Saudi public hospital context.

8. Theoretical Framework

8.1 Healthcare Resource Management Theory

Healthcare Resource Management Theory (HRMT) posits that optimal allocation and utilization of clinical resources — including personnel, equipment, pharmaceuticals, and infrastructure — is the primary determinant of healthcare organizational efficiency. The theory, rooted in operations management and applied to health systems, holds that resources used beyond clinical necessity generate costs without proportionate benefit (Shortell, 2017). Core components of HRMT include: (1) demand forecasting and capacity planning; (2) protocol-driven utilization controls; (3) administrative monitoring and feedback systems; and (4) staff competency in resource-appropriate decision-making. In the ICU context, HRMT supports the argument that structured medication stewardship programs and equipment utilization protocols reduce waste while maintaining care quality.

8.2 Cost Efficiency Theory in Healthcare

Cost Efficiency Theory, as applied to healthcare organizations, holds that financial efficiency is achieved when the ratio of clinical outputs (quality care, patient outcomes) to resource inputs

(cost, time, equipment) is maximized (Drummond et al., 2015). This theory, developed from microeconomic efficiency models and adapted for the health sector, identifies two pathways to cost efficiency: input reduction (using fewer or less costly resources for the same outcome) and process optimization (achieving better outcomes with the same resources). Applied to Saudi ICUs, this framework suggests that optimizing medication and device utilization can reduce input costs without degrading patient outcomes — the central hypothesis of this study.

8.3 Proposed Conceptual Model

Based on the two theoretical frameworks and the reviewed literature, the following conceptual model is proposed for this study:

Independent Variable	→	Dependent Variable
Clinical Resource Optimization		ICU Cost Efficiency
• Medication Utilization		• Operational Cost Reduction
• Respiratory Equipment Utilization		• Financial Efficiency Indicators
Moderating Factors:		
• Organizational Policy		
• Staff Training Level		
• Protocol Adherence		

9. Research Methodology

This study adopts a **quantitative descriptive-analytical research design**. This approach is justified by the study's objective to measure and statistically analyze the relationship between clinical resource optimization variables and ICU cost efficiency — a relationship that requires numerical data and inferential statistical testing to establish. A cross-sectional survey design is appropriate given the need to capture perceptions and practices across multiple hospitals within a defined timeframe.

9.1 Population and Sample

The target population consists of healthcare professionals working in ICU departments of Saudi public hospitals, including Registered Respiratory Therapists, intensivists, ICU nurses, and clinical pharmacists. These groups were selected because they have direct responsibility for the resource utilization decisions examined in this study.

A **stratified random sample** of 130–150 participants will be selected from hospitals in Riyadh, Jeddah, and Dammam, stratified by hospital size (large tertiary vs. general public) and professional role. This ensures proportional representation of the key stakeholder groups and geographic diversity within the Saudi public hospital system.

9.2 Research Tools

The primary data collection instrument is a **structured Likert-scale questionnaire** developed by the researcher and validated prior to distribution. The questionnaire consists of four sections:

- Section 1 — Demographic and institutional characteristics (hospital type, role, years of experience, ICU type).
- Section 2 — Medication utilization practices: items measuring adherence to pharmacy stewardship programs, frequency of unnecessary medication use, and administrative monitoring.
- Section 3 — Respiratory equipment utilization: items measuring adherence to ventilator weaning protocols, de-escalation decision-making, and equipment use beyond clinical indication.
- Section 4 — ICU cost efficiency perceptions: items measuring awareness of cost impact, existence of optimization policies, and perceived financial efficiency of current practices.

All items use a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). Content validity will be established through expert panel review (two ICU physicians and one respiratory therapy specialist). Instrument reliability will be verified using Cronbach's Alpha (target: $\alpha \geq 0.70$).

9.3 Statistical Analysis Methods

Data will be analyzed using SPSS version 26. The following statistical methods will be applied:

- Descriptive statistics (means, standard deviations, frequencies) — to profile the sample and describe utilization patterns.
- Pearson correlation analysis — to examine the strength and direction of relationships between resource optimization variables and cost efficiency.
- Multiple linear regression analysis — to identify the relative contribution of medication utilization and respiratory equipment utilization as predictors of ICU cost efficiency.
- Independent samples t-test and one-way ANOVA — to compare responses across hospital type, professional role, and years of experience.
- Cronbach's Alpha — to assess questionnaire reliability.

10. Study Boundaries

Temporal Boundary: Data collection will be conducted during the first and second quarters of 2026. Findings reflect the state of ICU resource utilization practices during this period.

Geographic Boundary: The study is limited to ICU departments in public hospitals in three Saudi cities: Riyadh, Jeddah, and Dammam. Private hospitals and primary healthcare centers are excluded.

Subject Boundary: The study focuses on two specific dimensions of clinical resource optimization: medication utilization and respiratory equipment utilization. Other ICU cost drivers (e.g., staffing costs, infrastructure) are outside the scope of this study.

Population Boundary: Participants are limited to ICU healthcare professionals (respiratory therapists, intensivists, ICU nurses, clinical pharmacists) with direct resource utilization responsibility.

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