Impact of Hospitalist System on Inpatient Utilization and Outcomes

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Yun Seo Jang

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Impact of Hospitalist System on Inpatient Utilization and Outcomes

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Background: Inpatient care is a core component of the healthcare system that consumes substantial resources. Indicators such as length of stay, medical expenses, readmission, and adverse events are widely used to assess the efficiency and quality of healthcare. However, traditional inpatient care models in Korea have faced structural limitations, including gaps in night and weekend coverage and reduced medical expertise due to reliance on resident-led care. To address these challenges, the Korean government introduced the hospitalist pilot project in 2016, which was expanded into a official project in 2021. Therefore, this study aimed to evaluate the impact of hospitalist wards on healthcare utilization and patient outcomes, and to examine differences by ward operation type and staffing levels.

Methods: Using customized cohort data from the National Health Insurance Service, a retrospective cohort study was conducted among 9,477,679 inpatients admitted to tertiary and general hospitals between 2017 and 2023. To adjust case-mix, we matched based on medical department, diagnosis, surgical status, hospital type, and admission timing between patient cases in hospitalist and conventional wards. A generalized estimating equation model was applied to account for repeated admissions. Additionally, difference-in-differences analysis was performed to assess changes in outcomes before and after the operation of hospitalist wards within institutions. The primary outcomes were lengths of stay, total expenditure, and hospital-acquired complications, with secondary outcomes including mortality and 30-day readmission.

Results: Hospitalist ward admission was associated with a significant reduction in lengths of stay (exp(β)=0.87, 95% CI: 0.86–0.88), total expenditure (exp(β)=0.88, 95% CI: 0.85–0.89), and out-of-pocket payments (exp(β): 0.87, 95% CI: 0.85–0.89), while expense per day didn't have association (exp(β): 1.00, 95% CI: 0.98–1.03). The risk of any hospital-acquired complication was 22% lower (exp(β)=0.78; 95% CI: 0.74–0.83), particularly for urinary tract infections, pneumonia, transfers to the intensive care unit, and post-procedural complications. In addition, in-hospital mortality and 30-day readmission were also lower. These effects were most pronounced in full-time, 7-day hospitalist wards. Furthermore, we confirmed consistent improvements in lengths of stay, expenditure, and hospital-acquired complication in institutions adopting hospitalist wards.

Conclusion: The findings of this study suggest that the hospitalist ward model is not merely a change in the inpatient care model, but a structural intervention that can significantly improve the overall efficiency, quality, and safety of inpatient care. Furthermore, an analysis of the temporal changes before and after the operation of hospitalist wards within institutions showed consistent results, supporting the interpretation that the observed effects are due to the structural intervention itself rather than differences in patient composition. For the further development of this system, it is necessary to standardize ward operation structures by department and diagnosis, secure an adequate number of hospitalists with appropriate compensation, and establish a continuity-of-care system that includes post-discharge management. To ensure sustainability, long-term policy planning and systematic follow-up evaluation must be pursued in parallel.

Keywords : Hospitalist, Healthcare utilization, Health outcomes, Efficiency, Patient safety, Quality of care

I. Introduction

1. Study Background

Improving the quality, safety, and efficiency of inpatient care has become a central imperative for modern health systems seeking to ensure equitable access, enhance population health outcomes, and maintain the sustainability of healthcare delivery.[1,2] Amid the rising burden of chronic diseases and increasing clinical complexity of hospitalized patients, inpatient care accounts for a substantial proportion of national healthcare expenditure and has a disproportionate influence on system-wide performance.[3]

Inpatient medical expenditures nearly doubled over the past decade, rising from KRW 231,737 billion in 2014 to KRW 474,210 billion in 2023, representing approximately 37.4% of the country's total medical expenditures in Korea.[4] According to the Organization for Economic Co-operation and Development (OECD) statistics, Korea's current health expenditure relative to Gross Domestic Product (GDP) reached 9.9%, slightly exceeding the OECD average of 9.2%.[5] Moreover, the annual growth rate of healthcare spending has averaged 6.0% since 2017 making Korea's spending trajectory one of the fastest-growing among OECD countries.[6] Compounding this financial strain is Korea's status as a super-aged society, where demand for hospitalization and resource-intensive care is rapidly increasing.[7] Notably, despite Korea's exceptionally long lengths of stay (LOS) compared to other OECD countries, the growth in the number of clinicians has failed to keep pace with the demand.[5,6,8]

The structure and organization of inpatient care service delivery, therefore, are no longer limited to institutional management but have emerged as critical national policy concerns. Fragmented care delivery, where physicians juggle both inpatient and outpatient responsibilities, has long been cited as a root cause of inefficiency and safety issues.[9-11] The split-responsibility model often leads to delays in clinical decisions, inadequate monitoring, and weakened communication across medical teams ultimately undermining care quality and patient safety.[10,11] These institutional shortcomings produce system wide consequences, including unnecessary LOS, inflated medical expenditures, and increased incidence of hospital-acquired complications (HACs), preventable deaths, and avoidable readmissions.[9,10,12,13]

Against this backdrop, health systems around the world have undertaken structural reforms in inpatient care delivery, aiming to reduce fragmentation, ensure timely decision-making, and enhance continuity of care. Historically, specialist treatment has centered on delivering disease-specific, evidence-based care, grounded in highly specialized knowledge and expertise.[14] It has played an essential role in managing complex procedures such as advanced surgeries and precise diagnostics.[14] However, with the growing prevalence of patients presenting with multiple chronic conditions, advanced age, and functional decline, the need for comprehensive, coordinated medical services has increased bringing greater attention to the importance of generalist management.[15,16] In current's inpatient environment, where multidisciplinary collaboration is essential and patients often require rapid clinical decision-making and continuity of care, a specialist-driven, single-disease focus is no longer sufficient. Under these circumstances, generalist roles such as hospitalists serve as critical coordinators within the hospital system.[16] They integrate fragmented care processes, manage the interplay among different specialties, and ensure seamless transitions across the care continuum.[16]

With the growing importance of generalist management, hospital medicine has emerged over the past decade as a distinct field, fundamentally reshaping the delivery of inpatient care across health systems worldwide.[17,18] It is dedicated to providing comprehensive medical care to hospitalized patients and encompasses a broad range of clinical services, including internal medicine, surgery, and various subspecialties.[18,19] Physicians who practice hospital medicine are commonly referred to as hospitalists, and they specialize in the management of inpatient care from admission to discharge.[19] Since the 1990s, countries such as the United States (US), Canada, and the United Kingdom (UK) have widely adopted the hospitalist model defined by the full-time presence of physicians dedicated exclusively to inpatient management.[20-23] By assuming comprehensive responsibility for hospitalized patients and maintaining continuous on-site presence, hospitalists are better positioned to deliver prompt interventions, monitor patient status closely, and coordinate efficiently across departments.[20] These structural advantages translate into reduced complications, more timely discharges, and minimized transitional errors all of which are crucial for improving patient safety and achieving institutional accountability.[24] Empirical evidence from previous studies has consistently demonstrated the model's effectiveness in reducing LOS, curbing medical expenses, and improving patient outcomes.[25]

In Korea, the traditional structure of inpatient care has long been characterized by fragmented care and limited availability of physicians, especially when clinical responsibility is often interrupted by division of labor between departments.[26] As a result, inpatients have frequently experienced delays in decision-making, inconsistent monitoring, and gaps in continuity of care.[26] As the economic and education level of the people have improved, the demand for safe and high-quality healthcare has been increasing.[27] However, as the absolute shortage of physicians, especially in general and tertiary hospitals, has occurred, it has become increasingly difficult to accommodate patients' needs.[28] To address these systemic issues, the Korean government launched the Hospitalist Pilot Project in September 2016, in which hospitalist assume primary responsibility for inpatient care.[29,30] Under this initiative, physicians were assigned to inpatient wards to deliver specialty care. Following the positive results reported during the pilot phase, the program was expanded and officially launched as a national policy in January 2021.

However, despite its promising premise, the policy level effectiveness of Korea's hospitalist system remains insufficiently assessed. Previous studies have largely relied on single-institution data, lacked appropriate control groups, or were confined to short-term observations, limiting their generalizability and policy relevance.[31-34] Moreover, substantial heterogeneity exists in the way hospitalist wards are operated across institutions. Some wards provide only weekday daytime coverage, while others offer full-time care throughout the week. These operational differences may influence the magnitude of impact, yet their specific effects on care quality and healthcare utilization remain poorly understood. Additionally, given the concurrent evolution of domestic healthcare environment, shifting clinical protocols, and regional disparities,[35,36] it is critical to isolate the unique contribution of the hospitalist system from these broader contextual changes.

Therefore, evaluation of the hospitalist system is warranted to determine whether it has fulfilled its intended objectives of improving the quality and efficiency of inpatient care. By analyzing variations in healthcare utilization and patient outcomes across different hospitalist ward operation types, this study seeks to generate evidence that is directly applicable to policy refinement and system-level improvement. Ultimately, the findings of this study aim to provide meaningful policy implications regarding the institutionalization and optimization of hospitalist care.

2. Study Objectives

This cohort study aims to evaluate the impact of hospitalist ward operation on inpatient healthcare utilization and health outcomes in Korea. Specifically, the study investigates to compare the differences in outcomes between hospitalist and conventional wards when a patient in the same condition is admitted to ward. Furthermore, it examines whether these outcomes have changed for all inpatients across the institution according to before and after the operation of the hospitalist wards within medical institution.

Details of the study objectives are as follows:

(1) To examine differences in inpatient healthcare utilization, including length of stay and total medical expenditure, between hospitalist and conventional wards.

(2) To assess differences in patient safety and quality outcomes, including hospital-acquired complications, mortality, and readmission, between hospitalist and conventional wards.

(3) To explore variations in outcomes according to hospitalist ward types, such as dedicated hours (daytime-only vs. full-time) and days (5-day vs. 7-day).

(4) To evaluate the impact of hospitalist ward operating by analyzing differential changes in healthcare utilization and outcomes before and after the intervention between institutions that operated hospitalist wards and those that did not.

II. Literature Review

1. Policy Background

1) Definition of Hospitalist

The term hospitalist was first coined in the US in the mid-1990s to describe a physician who specializes in the care of hospitalized patients.[20] Wachter and Goldman introduced the concept as a new physician model wherein doctors provide comprehensive medical care to inpatients throughout the entire course of hospitalization, distinct from traditional outpatient-based physicians.[18,20,21,37,38] Since then, the definition of hospitalist has evolved and been widely adopted in various health systems to denote physicians whose primary professional focus is the general medical care of hospitalized patients.[37]

Hospitalists are typically based within hospitals and are responsible for all aspects of inpatient care, including initial evaluation, treatment planning, coordination with subspecialties, discharge planning, and post-discharge communication.[37,39] Unlike traditional models where inpatient care is shared among multiple physicians or intermittently provided by outpatient specialists, hospitalists maintain continuous and concentrated involvement in a patient's care while admitted.[37] This structural distinction allows for improved efficiency in clinical decision-making, timeliness of intervention, and integration of multidisciplinary care, all of which contribute to improved patient outcomes and system-level performance.[37]

In Korea, the Ministry of Health and Welfare (MOHW) defines hospitalists as 'dedicated physicians who manage inpatient care within hospital wards, independent of outpatient duties, and are responsible for providing timely and continuous care to inpatients'.[40,41] The Korea hospitalist system was modeled after international precedents but has been uniquely institutionalized as a national policy tool to improve the quality and efficiency of inpatient care, particularly in internal medicine and general surgical wards of general and tertiary hospitals.[19,41] According to the operational guidelines in Korea, hospitalists are not only responsible for patient care but also play a key role in improving communication among medical staff, managing hospital related harms, and ensuring continuity across care transitions.[41]

Thus, the hospitalist model represents a significant structural innovation in the organization of inpatient care. By concentrating physician resources within inpatient wards and assigning clinical accountability to dedicated personnel, the model addresses long-standing issues of fragmented care, delayed treatment, and reduced patient safety in hospital settings. Its institutionalization as a distinct policy intervention further reflects a shift in how inpatient care is conceptualized—not merely as a component of physician workload, but as a specialized domain requiring focused expertise, coordination, and policy support.

2) Development of Hospitalist system in Major Countries

While differing in structure and nomenclature, major countries share the common goal of improving the safety, timeliness, and quality of inpatient care through hospitalist system presence.

(1) United States

In the US, even prior to the formal introduction of the hospitalist concept by Wachter in 1996, concerns had been raised regarding escalating healthcare costs and insufficient physician workforce capacity.[20] These systemic challenges prompted calls for a new type of clinician who could assume the inpatient care responsibilities traditionally managed by primary care physicians.[37] The inefficiencies associated with managing both outpatient and inpatient care by the same provider had become increasingly apparent, and a widely publicized incident involving a resident's prescription error further highlighted the need for a more dedicated inpatient care model.[37,42] In the late 1990s, the hospitalist model gained academic legitimacy with the publication of 'The Emerging Role of 'Hospitalists' in the American Health Care System' in the New England Journal of Medicine by Wachter and Goldman.[37] In this seminal work, they defined hospitalists as physicians who focus exclusively on the care of hospitalized patients.[20,37]

Since then, the number of hospitalists in the United States has grown rapidly, surpassing 50,000 by 2016.[43,44] Today, more than 75% of US hospitals employ hospitalists, reflecting the model's widespread institutional adoption.[44] Hospitalists are not only recognized for their clinical contributions but also for their roles as hospital leaders, medical educators, and key coordinators within multidisciplinary care teams.[44] From an institutional perspective, hospitalists have been credited with improving operational efficiency, reducing length of stay and costs, and enhancing overall patient outcomes.[44] Accordingly, many hospitals have actively promoted the expansion of hospitalist programs and continued to provide financial support for their integration into core clinical services.[44]

(2) United Kingdom

While the term "hospitalist" is not formally used in the UK, functionally equivalent systems have emerged through two key structures: the Acute Medicine Units (AMUs) subspecialty and the Specialist and Associate Specialist doctor workforce.[23,45-47] These two systems reflect the UK's strategic response to the growing need for continuity, timeliness, and accountability in inpatient care.

AMUs offer a consultant-led approach to the early phase of hospital admission, while the Specialist and Associate Specialist framework supports stable ward-based care through a dedicated non-consultant workforce.[47] Acute physicians typically work within AMUs, where they provide early assessment and treatment for patients admitted via emergency departments.[47] Their clinical responsibility generally covers the initial 24 to 72 hours of hospitalization, after which patients are either discharged or transferred to specialty wards.[47] In parallel, the UK has institutionalized the Specialist and Associate Specialist doctor system as a means of reinforcing the inpatient workforce.[46] They are experienced, full-time physicians who may not hold formal consultant status but possess substantial clinical expertise.[46] They often take charge of ward-based care, including evening and weekend coverage, and are particularly concentrated in specialties such as general medicine, geriatrics, and emergency medicine.[46]

(3) Canada

Canada was one of the earliest adopters of the hospitalist model outside the US, implementing it in the late 1990s as a response to growing gaps in inpatient care due to declining primary care physician involvement.[22,48] Hospitalists were introduced to provide continuous and comprehensive care, particularly for unassigned or complex inpatients, assuming responsibilities such as care coordination, discharge planning, and follow-up.[22,48] By the early 2010s, hospitalists became the fastest-growing physician group in Canada, with many urban hospitals particularly in Ontario and British Columbia reporting that over half of their inpatients were managed by hospitalists.[22,48]

(4) Others

Several countries in Asia have implemented hospitalist-like models to address challenges in inpatient care delivery. In Japan, the hospitalist concept was introduced in the 2010s under the "J-hospitalist" framework, which emphasizes comprehensive internal medicine-based inpatient care, particularly in regional hospitals.[49] Japanese hospitalists focus on managing complex chronic conditions and enhancing care coordination, especially for elderly patients in a rapidly aging society.[49] In Taiwan, hospitalist programs have been adopted mainly in large tertiary hospitals since the early 2010s.[50] Meanwhile, Singapore has pursued a family medicine-based hospitalist model, integrating generalist physicians into inpatient roles to bridge gaps in continuity and reduce care fragmentation.[17] This model has shown promise in enhancing efficiency, communication, and patient-centered care within hospital settings.[17]

3) Development of Hospitalist system in Korea

The hospitalist system in Korea has thus evolved from a policy idea to a national institutional model within a relatively short period, shaped by legislative reform, workforce restructuring, and multi-sectoral collaboration. Its development reflects both international influences and local adaptations, positioning it as a key strategy for enhancing the sustainability and quality of Korea's inpatient care system.

(1) Reduction in Resident Workforce and Reform of Training Environment

In the early 2010s, the quality of inpatient care and patient safety became critical concerns in the Korean healthcare system. Traditionally, inpatient care had been heavily dependent on residents, especially in tertiary and general hospitals.[51] However, this model became increasingly unsustainable due to both quantitative and qualitative changes in the healthcare workforce. The enactment of the "Act on the Improvement of Training Conditions and Status of Medical Residents" (hereafter referred to as the Resident Act) in 2015 introduced a legal cap on residents' working hours, limiting weekly working time to 80 hours.[52] At the same time, the number of residents in training began to decrease, exacerbating the existing gap in inpatient staffing. These changes underscored the urgent need for alternative models of inpatient care delivery that could both fill the workforce gap and ensure continuous, high-quality care. Consequently, discussions intensified around the introduction of a hospitalist model as a strategy to restructure inpatient physician roles and enhance clinical accountability.[53]

(2) National Assembly Forum

On May 7, 2015, the first public policy forum on the hospitalist model was held at the National Assembly under the title, "Strategies for Introducing Hospitalists to Improve Patient Safety and Quality of Care." During the discussions, the government emphasized that the hospitalist system should not be restricted to specific specialties but should be designed as a generalized care model with broad consensus across the medical community. Additionally, it was stressed that sustainable implementation would require a clear compensation framework and alignment with existing healthcare financing mechanisms. This forum played a pivotal role in initiating institutional dialogue and building policy legitimacy around the hospitalist concept.[53]

(3) Private Pilot Project

Following the forum, in August 2015, five major organizations including the Korean Medical Association, Korean Hospital Association, and Korean Academy of Medical Sciences formed a joint task force to private pilot the Korean hospitalist model in selected institutions including Asan Medical Center, Seoul National University Hospital, Bundang Seoul National University Hospital, and Chungbuk National University Hospital participated.[54] The private pilot focused on evaluating patient satisfaction, the frequency and timeliness of physician response to urgent calls, and perceptions among nurses, residents, and attending physicians.[54] The findings revealed high levels of patient satisfaction and suggested potential improvements in care delivery efficiency and team-based coordination.[54] These initial results provided a foundational rationale for scaling the model beyond institutional experimentation.[54]

(4) Government Pilot Project

Building on the favorable outcomes of the private pilot and in response to the implementation of the Resident Act, the MOHW officially launched a government-led hospitalist pilot program in September 2016. To qualify, hospitals were required to designate specific wards where hospitalists would be stationed setting time and take primary responsibility for inpatient care.[55] In the early phase of the pilot program, each participating hospital was instructed to operate one or two designated wards, focusing primarily on patients with higher clinical severity or those admitted through the emergency department.[55] Three ward models were established: integrated care hospitalist wards, short-stay hospitalist wards, and general hospitalist wards (Table 1).[55] Unlike the ward model classifications, the reimbursement scheme was determined based on each institution's staffing structure, specifically the number of beds assigned per hospitalist and the extent of on-site coverage hours.[55]

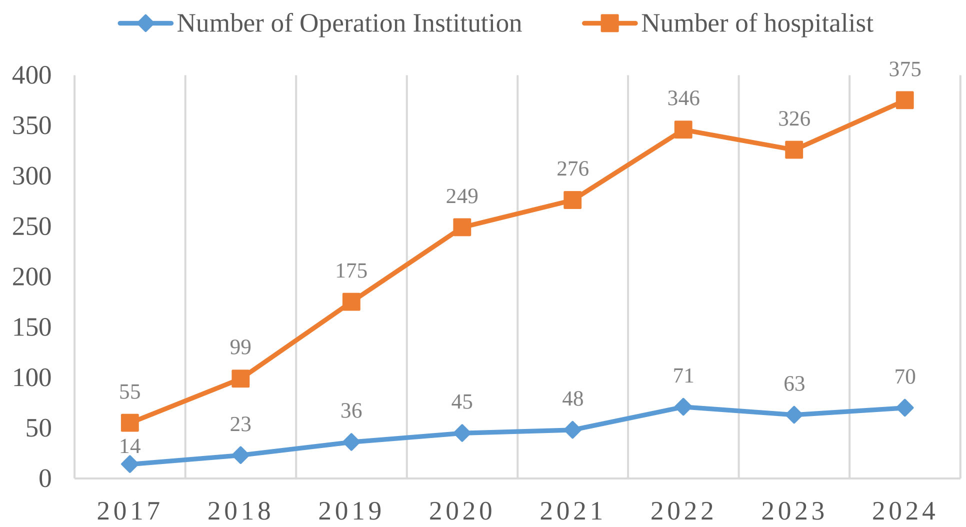
Table 1. Operation model of hospitalist ward in pilot project

Model	Definition
Integrated care hospitalist ward	- Managing multimorbid and older patients - Comprehensive inpatient care, with subspecialty consultations with several medical departments available as needed - 24-hour hospitalist coverage
Short-stay hospitalist ward	- Inpatient care for approximately 72 hours to patients admitted through the emergency department or those with chronic conditions such as cancer - Tertiary hospitals with emergency department overcrowding indices of 70–80% or higher - Internal medicine department wards for patients expected to be discharged within 48–72 hours after admission
General hospitalist ward	- High-acuity patients who are less severe than intensive care unit cases but still require specialist care - Staffed with at least two hospitalists working alongside residents

Source: Ministry of Health and Welfare. Overview of the pilot project of the hospitalist system. 2016.

(5) Government Official Project

Following the favorable outcomes observed during the four-year pilot phase, the Korean government officially incorporated the hospitalist program in January 2021. Under the formalized system, hospitalists are assigned to specific inpatient wards and hold primary responsibility for patient care.[56] To maintain service quality and avoid overburdening individual physicians, a maximum allowable ratio between hospitalists and their assigned patients is enforced.[56] Hospitalist wards are classified into three types based on the physician's spending times, and the reimbursement level varies according to the operational model.[56] Since becoming a permanent program, the system has continued to expand, with approximately 375 hospitalists practicing across 70 medical institutions by the end of 2024 (Figure 1).



Source: Jung YB. Ten years of the hospitalist system: A good direction of development. 2025 Inpatient Medical Integration Symposium. 2025

Figure 1. Status of hospitalist system in Korea

2. Previous Studies Evaluating the Effects of Hospitalist System

1) Evaluation of hospitalist system in other countries

(1) Healthcare utilization

Numerous international studies have demonstrated that the hospitalist model contributes to improved healthcare resource utilization and enhanced patient-centered care. Systematic reviews and meta-analyses found that hospitalist managed care significantly reduces LOS, while also improving clinical efficiency and patient satisfaction.[25,57] Similarly, the other study showed that hospitalists outperformed general practitioners and internists in reducing expenses.[58] Furthermore, the research reported that hospitalist care was associated with improved process and healthcare utilization.[58,59]

Additional studies have further highlighted the benefits of hospitalist programs in streamlining patient flow, optimizing resource allocation, and enhancing discharge planning.[60-62] Observational and comparative studies from countries such as Canada, Taiwan, and the UK likewise indicate that hospitalist models can increase the efficiency of hospital operations and contribute to safer, more coordinated inpatient care.[63-65] Collectively, this body of literature supports the hospitalist system as a policy-relevant model that improves inpatient care delivery through structural and operational reforms.

Previous studies that demonstrated the association between hospitalist system and healthcare utilization for inpatients are summarized in Table 2.

Table 2. Summary of previous studies on the effects of hospitalist on healthcare utilization

Author (Year)	Country	Data	Study Design	Summary
Auerbach AD et al. (2002)	US	1 hospitals database	Retrospective cohort, comparative study	Voluntary hospitalist service improved efficiency and patient outcomes in a teaching hospital.
Lindenauer PK et al. (2007)	US	45 hospitals database	Retrospective cohort, comparative study	Hospitalists more effective than GPs and internists in reducing expenses and improving outcomes.
Southern WN et al. (2007)	US	2 hospitals database	Retrospective cohort, comparative study	Hospitalist care reduced LOS for patients with complex discharge needs.
Scott I et al. (2009)	UK	PubMed, EPOC, CINAHL and ERIC database	Systematic review	Acute medical units (similar to hospitalist care) improved efficiency and safety of inpatient services.
Shu CC et al. (2011)	Taiwan	1 hospitals database	Prospective experimental study	Hospitalist transitional care reduced adverse discharge outcomes.
White HL & Glazier RH (2011)	Canada	PubMed, EPOC, CINAHL and ERIC	Systematic review	Hospitalists improve quality of inpatient care in terms of process, efficiency, and outcomes.
Rachoin JS et al. (2012)	Multi-national	PubMed	Systematic review and meta-analysis	Hospitalist care associated with shorter LOS and reduced hospital costs.

Yousefi V & Chong CA (2013)	Canada	National discharge database	Retrospective cohort, comparative study	Hospitalist program improved care quality and utilization in a community hospital.
Soong C et al. (2016)	US	Case report	Case study	Hospitalists played key role in improving patient flow and discharge planning.
Salim SA et al. (2019)	Multi-national	PubMed, EPOC, CINAHL and ERIC	Systematic review and meta-analysis	Hospitalists improve efficiency of inpatient care and patient satisfaction; reduced LOS.

(2) Health Outcomes

Several research suggests that hospitalist care not only enhances inpatient efficiency but also positively affects a range of patient health outcomes. Studies have shown that patients under hospitalist-led care experience lower rates of in-hospital mortality, intensive care unit (ICU) transfers, HACs, and readmissions.[59,64,66-68] In some settings, hospitalist presence was also associated with reductions in emergency department (ED) visits and wait times, particularly through improved discharge planning and continuity of care.[69] The implementation of hospitalist models in acute care units has contributed to safer and more timely intervention for high-risk patients, reducing the likelihood of deterioration and unplanned escalation to intensive care.[65] Furthermore, hospitalist systems often incorporate structured communication practices and multidisciplinary coordination, which have been linked to fewer adverse events, and enhanced medication safety.[67,68] These findings support the role of hospitalists as critical actors in improving not just care delivery efficiency, but also the overall safety, quality, and responsiveness of inpatient care systems.[70]

Table 3 provides a summary of previous studies that evaluated the association between hospitalist system and health outcomes for inpatients.

Table 3. Summary of previous studies on the effects of hospitalist on health outcomes

Author (Year)	Country	Data	Study Design	Summary
Auerbach AD et al. (2006)	US	Hospital Quality Alliance data & American Hospital Association data	Retrospective cohort, comparative study	Hospitalists were associated with better adherence to care guidelines and reduced adverse outcomes.
Kansagara D et al. (2009)	US	Hospital data & CMS clinical quality Score measures website	Implementation study	Hospitalist implementation in a critical access hospital improved care readmission and ED visits.
Shu CC et al. (2011)	Taiwan	1 hospitals database	Retrospective cohort, comparative study	Hospitalist system in Taiwan showed improved quality, reduced ICU transfers, and enhanced patient safety.
White HL & Glazier RH (2011)	Canada	PubMed, EPOC, CINAHL and ERIC database	Systematic review and meta-analysis	Hospitalists improved inpatient care delivery in terms of readmission and death.
Wright B et al. (2013)	US	PubMed and Website	Systematic review and meta-analysis	Hospitalists achieved better clinical outcomes and quality measures than non-hospitalists.

(3) Hospitalist and Patient Experience Assessment

Hospitalist care has demonstrated not only improvements in quantitative clinical outcomes but also positive effects on the lived experiences of patients, their families, and healthcare professionals. International studies have reported that hospitalist-led inpatient care enhances communication, increases patient understanding of their treatment, and improves overall satisfaction particularly in areas such as clarity of discharge planning and responsiveness to patient needs.[25,63,71] Structured and consistent communication with family members has also been emphasized, contributing to higher levels of trust and family satisfaction with the care process.[71]

From the provider perspective, the hospitalist model has been associated with increased job satisfaction, improved team collaboration, and reduced occupational stress.[25,63,72] The continuous on-site presence of hospitalists has been found to strengthen interprofessional communication, especially with nurses and resident physicians, and to contribute to a more cohesive care environment.[73,74] Furthermore, hospitalist systems help mitigate physician burnout by reducing fragmented workflows and distributing clinical responsibilities more evenly.[73,74] These findings highlight the broader value of hospitalist care as not only a tool for enhancing efficiency, but also a mechanism for fostering safer, more collaborative, and patient-centered hospital care environments.

Table 4 summarizes prior studies on the experiences of patients and healthcare providers with hospitalist care."

Table 4. Summary of previous studies on the effects of hospitalist on experience assessment

Author (Year)	Country	Data, Study design	Summary
O'Leary KJ et al. (2010)	US	Survey and interviews	Structured interdisciplinary rounds improved teamwork and nurse-physician communication.
Purdy N et al. (2015)	US	Qualitative interviews	Hospitalists facilitated interprofessional collaboration and team cohesion.
Auerbach AD et al. (2018)	US	Survey	Hospitalists emphasized the need for clear roles, timely feedback, and collaborative consult interactions.
Salim SA et al. (2019)	Multi-national	Systematic review and meta-analysis	Hospitalists associated with higher patient satisfaction.
Nguyen OK et al. (2021)	US	Case report	Structured family meetings improved communication and increased patient/family satisfaction.

2) Evaluation of hospitalist system in Korea

Several studies have evaluated the impact of hospitalist care on healthcare utilization and patient outcomes in Korea. Evidence from each institutions suggests that hospitalist-managed wards are associated with shorter LOS, reduced ED boarding times, lower rates of ICU transfers, fewer complications, and decreased preoperative waiting periods.[32,75-77] Patient survey-based studies have also reported improved communication, more frequent physician-patient interactions, and shorter time to clinical problem resolution in hospitalist-led settings.[31,33,34,78] These findings collectively indicate that the hospitalist model may contribute not only to institutional efficiency but also to improvements in the quality, responsiveness, and patient-centeredness of inpatient care in Korea.

However, despite these encouraging findings, current domestic research on the hospitalist system in Korea presents several notable limitations. First, the majority of existing studies are confined to single-center analyses or specific patient groups which limits the generalizability of the findings to broader patient populations. Second, most evaluations are based on relatively small sample sizes and short-term observational periods, thereby restricting the capacity to assess long-term impacts of the system on healthcare utilization and clinical outcomes. Third, much of the available evidence has been derived from the pilot program phase, and there remains a lack of robust empirical evaluation following the nationwide implementation of the hospitalist system in 2021. Additionally, qualitative assessments such as surveys measuring satisfaction and perceived improvements tend to outweigh objective indicators of clinical quality, safety, or cost-effectiveness in many studies. These limitations highlight the need for more comprehensive, large-scale, and methodologically rigorous studies to inform evidence-based refinement of the hospitalist system in Korea.

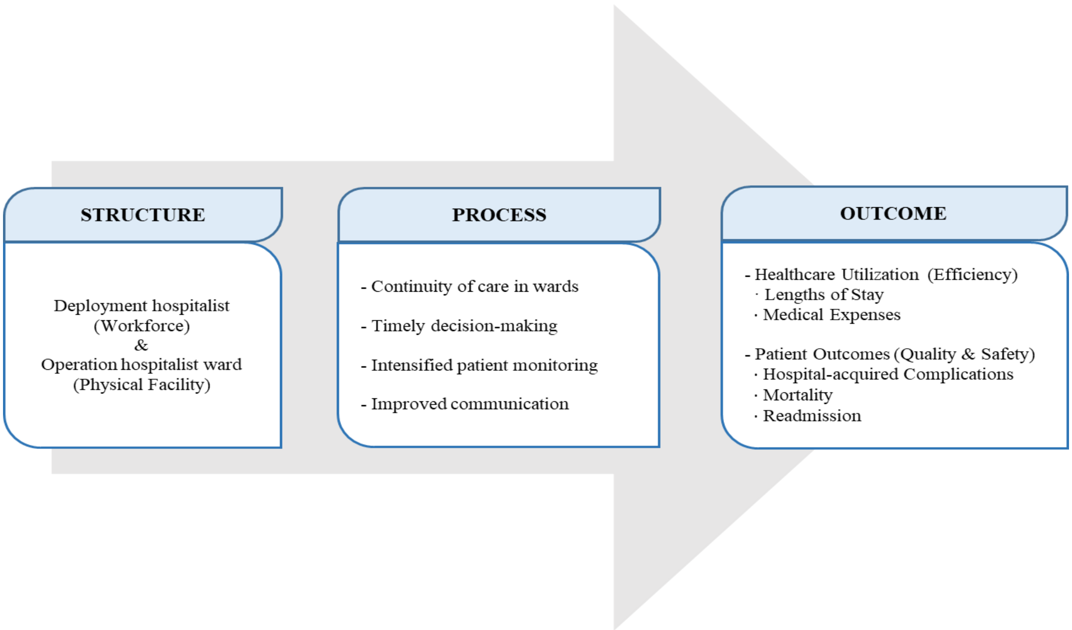
Table 5. Summary of previous studies on the evaluation of hospitalist system in Korea

Author (Year)	Data	Study Period	Study Population	Summary
Lee JH, et al. (2019)	Inha University Hospital data	Pilot (2017~2018)	Multi-Morbid Patients	Hospitalist model improved outcomes for patients with multiple chronic conditions.
Chae WJ, et al. (2021)	Survey and claim data	Pilot (2016.09~12)	Patients	Patients under hospitalist care reported higher satisfaction, especially in communication.
Chae WJ, et al. (2021)	Patient–doctor contact slip (survey)	Pilot (2017.09~12)	Patients	Real-time assessments showed more patient-doctor contact and faster problem resolution.
Jung YB, et al. (2021)	Severance Hospital data	Pilot (2017.09~12)	Inpatients in the department of surgery	Hospitalist surgical care reduced hospital costs and improved postoperative outcomes.
Jang SI, et al. (2022)	National claim data	Official (2021.01~12)	Entire	Hospitalists have reduced LOS, medical costs and complications
Kim HJ, et al. (2023)	Bundang Seoul University Hospital data	Pilot (2016~2017)	Inpatient who admitted through ED rooms	Hospitalist care reduced ICU transfers, complications, and improved discharge processes.
Kim SW, et al. (2023)	Bundang Seoul University Hospital data	Pilot, Official (2019~2021)	Cancer patients	HOME model improved hospitalization outcomes via hospitalist-oncologist collaboration.
Han SJ, et al. (2023)	Survey	Pilot, Official (2020~2022)	Hospitalists	Survey identified factors influencing motivation and sustainability of hospitalist careers.

Jung YB, et al. (2024)	Severance Hospital data	Official (2014~2022)	Surgical Patients in the department of Colorectal Surgery, Gastrointestinal Surgery, Hepatobiliary& Pancreatic Surgery	Intervention of Surgery Hospitalists can show to improve the prognosis of surgical patients and reduce medical costs.
Song SY, et al. (2025)	Survey	Official (2023.01~02)	Hospitalists	Assessed job satisfaction and workload among Korean hospitalists.

3. Conceptual framework

This study employed the Theoretical model proposed by Avedis Donabedian to evaluate the impact of hospitalist care on healthcare utilization and patient outcomes.[79-81] The Donabedian model, introduced in 1966, is widely used in health services research to assess the quality of care through three interdependent dimensions: structure, process, and outcome.[79] The framework of Donabedian model in this study is shown in Figure 2.



Source: Donabedian A. Evaluating the quality of medical care. The Milbank memorial fund quarterly 1966;44:166-206

Figure 2. Conceptual framework of study incorporating the Donabedian model

The structure refers to the organizational and contextual components that influence care delivery.[79,80] In this study, the structure is operationalized as the formal implementation of hospitalist wards, where physicians are exclusively dedicated to inpatient care, providing continuous presence and accountability. This institutional change represents a structural reform in Korea's inpatient care model, which has historically suffered from fragmentation due to dual outpatient–inpatient responsibilities and resident-centered coverage.

The process dimension captures the clinical and administrative activities involved in delivering care.[79,80] Based on this structural intervention, the process are not directly measurable in data, but theoretically inferred through proxies. In hospitalist-managed wards, this includes enhanced continuity of physician care, timely decision-making, intensified patient monitoring, improved communication among multidisciplinary teams, and more efficient discharge planning. This system embedded in the model's assumption that hospitalist wards fundamentally change how care is delivered on the ground. Also it is hypothesized to mediate the relationship between structural reform and patient outcomes.

The outcome dimension means evaluating the final results of care delivery,[81] and we evaluated the outcomes by dividing them into two indicators: (1) healthcare utilization, such as LOS, and medical expenditure; and (2) clinical outcomes, including HACs, in-hospital mortality, and 30-day readmissions. These outcomes reflect both system efficiency, patient safety and quality of care, a key domain emphasized in the Donabedian framework. This multi-dimensional outcome framework is grounded which posits that high-quality healthcare must be safe, efficient, and effective. Efficiency such as LOS and medical expenditure capture how well inpatient services are managed to avoid unnecessary resource use, prolonged hospitalization, and delays in care. These metrics reflect the system's operational performance and are especially relevant when evaluating models like hospitalist care, which aim to streamline patient flow and enhance coordination. Patient safety such as HACs reflect preventable adverse events that occur due to lapses in monitoring, communication, or clinical protocols. The reduction of HACs is a key target of patient safety strategies worldwide, and they serve as sentinel events for institutional performance. Quality such as mortality and readmission provide critical insight into the overall effectiveness and continuity of care. Mortality reflects the adequacy of acute clinical management, while 30-day readmission rates capture the sufficiency of discharge planning, follow-up coordination, and transitional care. Both are widely used in global hospital benchmarking and policy evaluations.

According to Donabedian's original framework, assessing either care processes or outcomes in isolation provides an incomplete picture of healthcare quality.[81] Measuring outcomes without understanding the underlying care processes obscures the causal pathway, while focusing solely on processes may not reveal whether desired health improvements were achieved.[81] Therefore, this study integrates all three components structural intervention, process-level changes, and final outcomes into a unified evaluation framework. Specifically, hospitalist ward implementation is conceptualized not merely as an operational change but as a policy intervention that restructures inpatient care delivery. This system is not merely a care delivery variant but a policy intervention with long-term implications for institutional design and workforce policy.

III. Material and Methods

1. Data Source

This population-based cohort study customized data from the Korean National Health Insurance Service (NHIS) database. Since the introduction of universal health coverage in 1989, all South Korean citizens have been covered by the NHIS, with currently insures approximately 98% of the population. The NHIS database contains comprehensive healthcare information, including health screening records, medical claims, sociodemographic details, and mortality data. Among these, the medical claims database is particularly robust, recording International Classification of Diseases code, Tenth Revision (ICD-10), prescriptions, procedures, lengths of stay, and expenditures for nearly the entire Korean population. The NHIS offers customized cohort datasets to researchers for policy development and academic investigations.[82]

To evaluate the impact of the hospitalist program, the analysis focused on inpatient episodes at tertiary and general hospitals eligible to operate the hospitalist system. Since the hospitalist system to be evaluated in this study has been converted into the main project since the pilot project began in 2017 and has been operated from 2021, the study period was set from 2017 to 2023, the most recent data. Therefore, the NHIS customized cohort we obtained consisted of random sampling of 50% of Korean patients who were admitted to tertiary or general hospital from 2017 to 2023, and included medical use records during hospitalization for a total of 23,366,281 inpatient cases.

2. Study Design and Population

1) Selection of Target Diseases

To determine the disease groups to be included in the analysis, inpatient cases were first reviewed to assess whether hospitalist system was provided, based on the primary disease classified as three-character categories of the ICD-10 diagnostic codes. Subsequently, disease groups that satisfied all of the following three criteria were identified and selected as the final target diseases for analysis (Figure 3).[56]

(1) Diseases with more than 100 inpatient claim cases across the final dataset

(2) Diseases for which at least 10% of hospitalizations occurred in hospitalist wards

(3) Diseases with an average of 10 or more inpatient claim cases per institution

As a result, 132 diseases were selected, and detailed diseases list are presented in the Appendix 1. Among the selected disease groups, the top 10 most frequently observed diagnoses in hospitalist-managed wards were as follows: Z51 (Other medical care), C34(Lung cancer), C50(Breast cancer), C22(Liver cancer), K80(Gallstone), C25(Pancreatic cancer), C18(Colon cancer), C16(Stomach cancer), C20(Rectal cancer), and D05(Ductal carcinoma in situ).

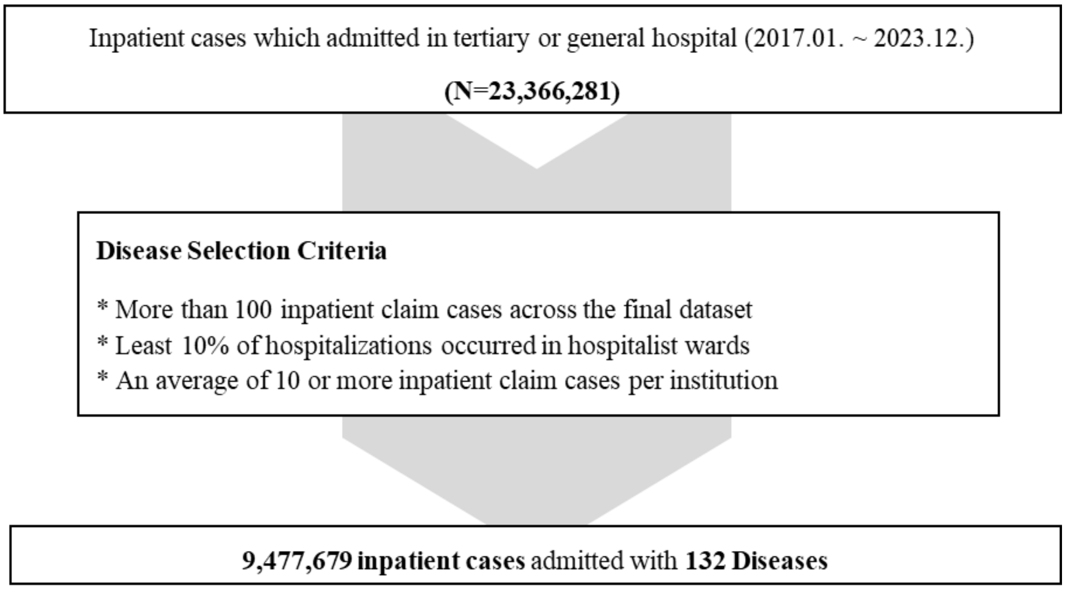


Figure 3. Study population after applying disease selection criteria

2) Overview of Study Design

This study was structured into two distinct analytical parts to evaluate the impact of the hospitalist system on inpatient outcomes using a retrospective cohort design based on the NHIS customized database (Figure 4). Inclusion and exclusion criteria were applied separately for each part to ensure consistency and validity of the study population.

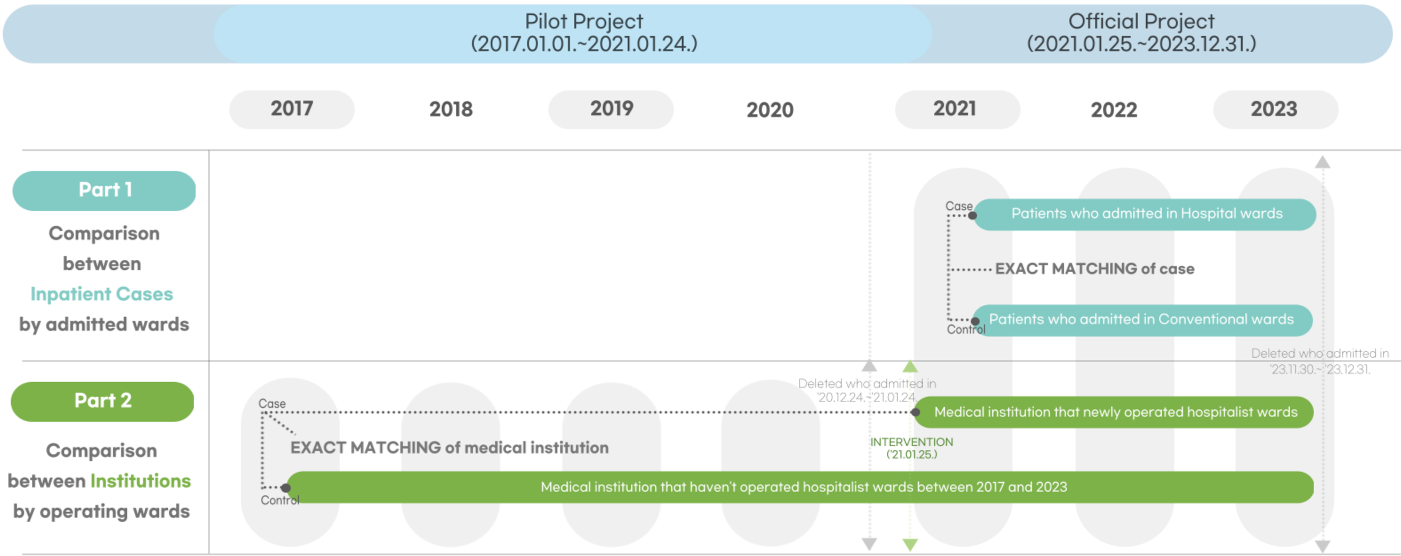


Figure 4. Overview of Study design

3) Study Population

(1) Part 1: Comparison between Inpatient Cases by admitted wards

The first part compared inpatient outcomes between patients admitted to hospitalist wards (case group) and those admitted to conventional wards (control group) during the official implementation period of the hospitalist program (Figure 5). The analysis period for this part was only restricted to the official implementation period, from January 25, 2021 to December 31, 2023. To maintain the integrity of exposure classification, patients admitted to hospitals with inconsistent hospitalist ward operation defined as institutions that intermittently implemented and discontinued the program were excluded (N=2,401,989). In addition, inpatient cases that were admitted prior to January 25, 2021 (N=3,794,061), or with missing values in any of variables were excluded (N=110,050). Additionally, patients admitted after November 30, 2023, were excluded to ensure completeness of follow-up (N=66,199).

In the case group, patients who transitioned between hospitalist wards and other conventional wards during the hospitalization period were excluded (N=116,940), as these transitions may impede clarity in assessing the effectiveness of the hospitalist system. In the control group, patients admitted to special wards such as rooming-in maternity ward, negative pressure isolation room (NPIR), aseptic room, day care room, neonatal unit, lead-shielded room, special management of psychiatric unit, seclusion/special observation in maximum security unit and others were excluded to ensure comparability between the conventional ward environment and hospitalist ward environment (N=1,591,337).

Finally, to adjust for differences in case-mix between case and control group, 1:1 exact matching was conducted using the following variables: sex, age, surgical status, hospitalization route, charlson comorbidity index (CCI) score, medical department, primary diagnosis, type of institution, hospital location, number of hospital beds, and admission year/month. Therefore, the final study population in Part 1 were 143,376 inpatient cases (case: 71,688, control: 71,688).

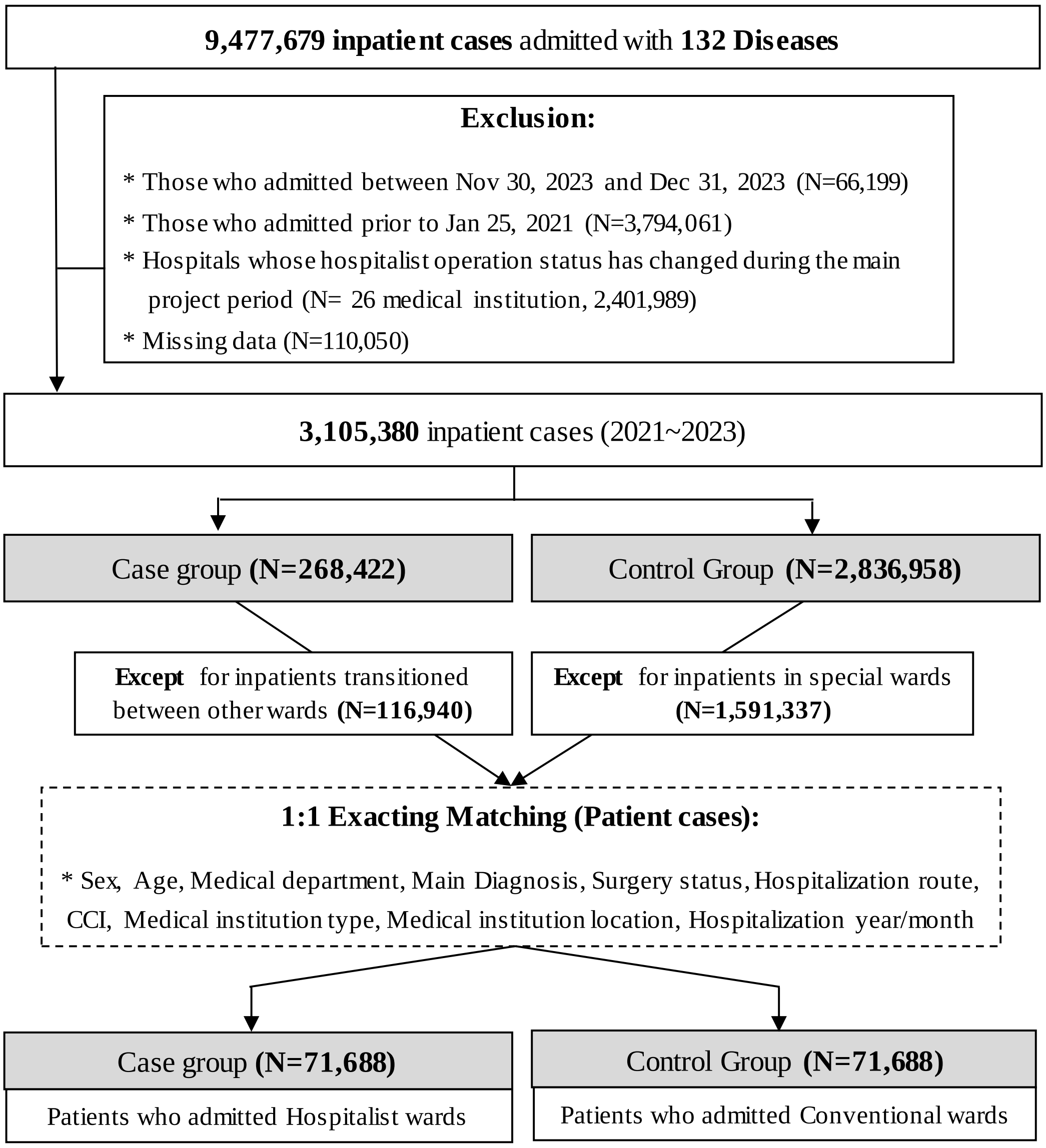


Figure 5. Flowchart of the study population in comparison between inpatient cases

(2) Part 2: Comparison between Institutions by Hospitalist System Operation

The second part of the study examined changes in inpatient outcomes before and after the official implementation of the hospitalist program (Figure 6), comparing institutions that adopted and continuously operated the hospitalist system (case group) with those that did not adopt the program (control group).

Several exclusion criteria for inpatients were applied to minimize exposure misclassification and to ensure sufficient follow-up time. Inpatients with admission dates prior to January 1, 2017, were excluded to align with the designated study period (N=1,825). In addition, patients admitted during the transitional phase (December 24, 2020, to January 24, 2021) were excluded due to ambiguity exposure status (N=40,508). Also, patients admitted after November 30, 2023, were excluded to ensure completeness of follow-up (N=66,199) and missing values were excluded (N=124,779).

The case group included hospitals that did not participate in the pilot project but newly introduced the hospitalist program during the official project and sustained continuous operation until the end of 2023 (n=10). The control group consisted of hospitals that did not operate the program during the entire observation period both the pilot and official project (n=286). The analysis period spanned from January 1, 2017, to December 31, 2023, includes both the pilot and official project period.

To ensure comparability between the case and control institutions, a 1:1 exact matching was conducted based on the following institutional characteristics: institution establishment type, location, average CCI score of inpatients, number of doctors per beds. As a result, 455,238 patients (case: 351,591, control: 103,647) admitted to 18 medical institutions (case institution: 9, control institution: 9) were included in the analysis (Appendix 5).

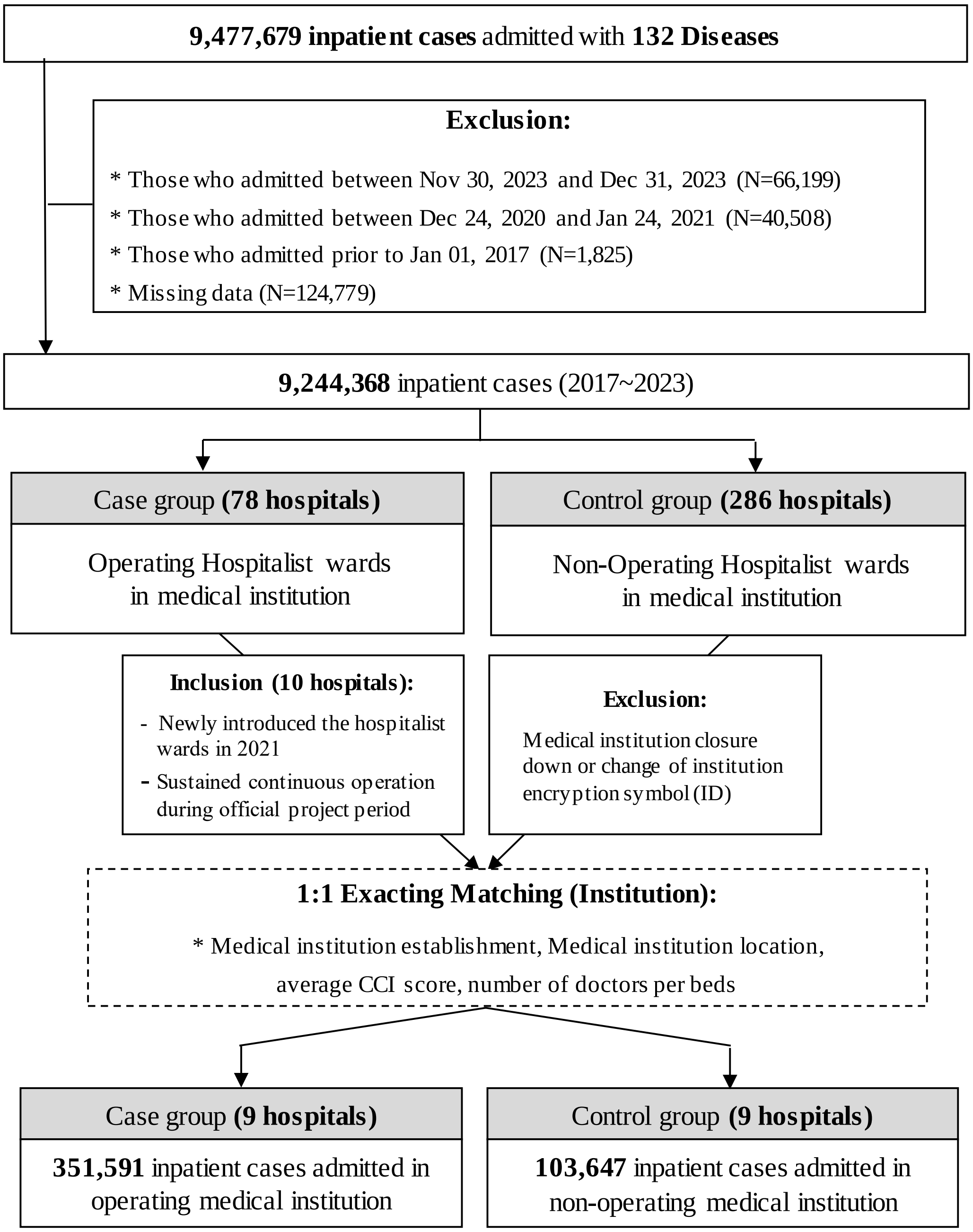


Figure 6. Flowchart of the study population in comparison between institutions

3. Definition of Variables

1) Dependent Variables

(1) Primary Outcomes

The main outcomes are healthcare utilization and HAC. Healthcare utilization was examined by the LOS and total expenditure per inpatient cases. LOS was calculated by subtracting the admission date from the discharge date and adding one day to include the admission date itself. Total expenditure was defined as the sum of all medical expenses charged during hospitalization, and are converted to medical expenses as of 2023 using the annual conversion index to ensure comparability across time.[83] In addition to total expenditure, both the out-of-pocket (OOP) and expense per day were separately analyzed as supplementary indicators within the primary outcome domain. HAC were defined as sub-diagnosis ICD codes that occurred during hospitalization,[84] including thromboembolism, pressure ulcers, urinary tract infection, pneumonia, post-procedural complications, and unplanned transfer to the intensive care unit, which collectively reflect the quality and safety of inpatient care. Details are shown in Table 6.

(2) Secondary Outcomes

The secondary outcomes included mortality and readmission. Mortality was classified into in-hospital death and death within 30 days after discharge. Readmission within 30 days was categorized into four types: (1) readmission to any hospital, (2) readmission to the same hospital, (3) readmission for the same diagnosis, and (4) readmission to the same hospital for the same diagnosis.

Table 6. Identification of primary outcome variables in claims data

Variables	Definition / Identification
Primary Outcomes	
Lengths of stay	Discharge date - Admission date + 1
Medical expenses	
Total expenditure	Total expenses during lengths of stay
Out-of-pocket	Legally mandated coinsurance rate
Expense per day	Total expenditure / Lengths of stay
Hospital-Acquired Complications	
Thromboembolism[a]	I26.0, I26.9, I63.1, I63.4, I74.x, I80.x, I81.x, I82.x, T79.0, T79.1
Pressure Ulcer[a]	L89.x
Urinary Tract Infection[a]	N10.x, N11.x, N12.x, N13.x, N15.x, N16.x, N30.x, N39.x
Pneumonia[a]	J12.x, J13.x, J14.x, J15.x, J16.x, J17.x, J18.x
Post-procedural complication[b]	E89.x, G97.x, H56.x, H95.x, I97.x, J95.x, K91x, M96.x, N99.x
Unplanned transfer to the intensive care unit	AC600, AC611, AC621, AC612, AC622, AJ001, AJ006, AJ003, AJ007, AJ100, AJ200, AJ300, AJ051, AJ052, AJ053, AJ054, AJ101, AJ201, AJ301, AJ004, AJ008, AJ005, AJ009, AJ043, AJ044, AJ045, AJ046, AJ102, AJ202, AJ302, AJ031, AJ010, AJ011, AJ020, AJ021, V5200, V5500, V5600, V5700

[a] ICD-10 codes
[b] Claim codes

2) Variable of Interest

(1) Part 1: Comparison between Inpatient Cases by admitted wards

The variable of interest was whether the patient was admitted to hospitalist wards, as identified by claim codes (Table 7). For the purpose of examining differences in outcomes associated with hospitalist system, patient cases were categorized into two groups: (1) patients admitted to conventional wards (control group, reference group) and (2) patients admitted to hospitalist wards (case group).

(2) Part 2: Comparison between Institutions by Hospitalist System Operation

In the analysis investigating differences in outcomes before and after the introducing of the hospitalist system, the variable of interest was the official project's launch date, January 25, 2021. Based on this date, inpatients were divided into two periods: before (January 1, 2017 to January 24, 2021) and after (January 25, 2021 to December 31, 2023). To evaluate difference effects across these time periods, hospitals were categorized into two groups: (1) institutions that did not operate hospitalist ward (control group, reference group), and (2) institutions that newly operated the hospitalist ward (case group). The operational status of the hospitalist program at each institution was determined on a quarterly basis using claim codes (Table 7). An institution was classified as operating the hospitalist program for a given quarter if it had at least one inpatient case with a hospitalist claim codes quarterly; otherwise, it was considered a non-operating institution for that period.

Table 7. Identification for hospitalist system for the analysis

Hospitalist Claim Codes	Operation Type
Pilot project	
IA990	Operating 24 hours and residing 4 hospitalists
IA991	Operating 24 hours and residing 5 or more hospitalists
IA995	Operating partial hours and residing 2 hospitalists
IA996	Operating partial hours and residing 3 or more hospitalists
Official project	
AC201	Type 1 (5 days a week - daytime)
AC202	Type 2 (7 days a week - daytime)
AC203	Type 3 (7 days a week - fulltime)

3) Independent Variables

The independent variables of this study were grouped into three categories: (1) socio-demographic factors, (2) health-related factors, and (3) hospital related factors. The detail categories of each independent variable were depicted in Table 8.

First, socio-demographic factors included in the analysis were sex, age, region, income level and health insurance type. Sex was categorized as male or female, and age was grouped in 10-year intervals (<10, 10-19, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, ≥80). Region of residence was classified into three categories: metropolitan areas (Seoul, Gyeonggi, Busan, Daegu, Incheon, Gwangju, Daejeon, and Ulsan), urban areas (sub- administrative districts as gu- in regions not included in the metropolitan category), and others (sub- administrative districts as gun- in non-urban regions). Income level was categorized into four groups based on a nationally standardized indicator that stratifies household income levels across the entire population (low, low-middle, middle-high, high). Type of health insurance type was classified into two categories: national health insurance (NHI) beneficiaries and medical aid.

Second, health-related factors included in the analysis were surgical status, hospitalization route, CCI score, medical department, main diagnosis, hospitalization year. Surgical status was defined as having undergone a surgical procedure during hospitalization or having a Korean Diagnosis Related Group classification code indicating surgical or other procedural care. hospitalization route was categorized based on whether the patient was admitted through the emergency department (through walk-in or outpatient, through emergency room). The CCI score was calculated using the weighting method proposed by Quan H et al. and Glasheen WP et al. (Appendix 2).[85-87] and was categorized into three groups (0-2, 3-4, 5-). Medical department was classified into internal medicine, general surgery, pediatrics, and others, reflecting the frequency from the hospitalist wards. Main diagnoses were grouped into each of the five frequent disease categories (Z51, C34, C50, C22, and K80) observed in hospitalist wards and into others category.

Third, hospital-related factors included type of medical institution, establishment, region, and number of hospital bed. Type of institution was categorized into tertiary hospitals and general hospitals, while establishment was classified as national/public and private. Hospital region was grouped into three categories in part 1 based on regional healthcare characteristics in Korea: (1) Seoul, (2) Gyeonggi and Incheon, and (3) others. In part 2, hospital region was grouped into two categories: (1) Seoul (Capital City), and (2) others. Number of hospital bed was categorized into quartiles according to the distribution within each type of medical institution.

Analysis to assess outcomes differences according to hospitalist care, adjusted only residential region, health insurance type, income level, medical department, main diagnosis, medical institution establishment, and hospitalization year excluding variables used for exact matching between the case and control groups. In the analysis examining differences in outcomes before and after the implementation of the hospitalist program, all covariates were adjusted for, except for the year of admission.

Table 8. Description of independent variables for the analysis

Variables	Description
Sociodemographic factors	
Sex	Men; Women
Age	<10; 10-19; 20-29; 30-39; 40-49; 50-59; 60-69; 70-79; ≥80
Region	Metropolitan (Seoul, Gyeonggi, Busan, Daegu, Incheon, Gwangju, Daejeon, and Ulsan); Urban (sub-administrative districts as gu-); Others (sub-administrative districts as gun-)
Income level	Low (0~5); Lower middle (6~10); Upper middle (11~15); High (16~20)
Health insurance type	National health insurance; Medical aid
Health-related factors	
Surgical status	Yes; No
Hospitalization route	Through walk-in or outpatient; Through Emergency room
CCI score	0-2; 3-4; ≥5
Medical department	Internal medicine; General surgery; Pediatrics; Others
Main Diagnosis	Z51(Other medical care); C34(Lung cancer); C50(Breast cancer); C22(Liver cancer); K80(Cholelithiasis); Others
Hospitalization year	2021; 2022; 2023
Hospital-related factors	
Medical institution type	Tertiary hospital; General hospital
Medical institution establishment	National or Public; Private
Medical institution location	Seoul (Capital city); Gyeonggi and Incheon; Others
Number of hospital bed	Low (Quartile 1); Low-middle (Quartile 2); Upper middle (Quartile 3); High (Quartile 4)

4. Statistical Methods

Descriptive statistics were used to summarize the characteristics of the study population. Categorical variables were expressed as frequencies (N) and percentages (%), while continuous variables were presented as means and standard deviations (SD). To compare differences in baseline characteristics between groups before and after matching, chi-square tests and standardized mean differences (SMD) were used as appropriate.

To estimate the effect of admission to hospitalist wards on patient outcomes, a generalized estimating equation (GEE) model was applied to account for the correlation within repeated admissions by the same individual.[88]

$$g(E[Y_{ij}])=\beta_0 + \beta_1(Case_{ij}) + \gamma X_{ij}$$

g: link function

E: expectation

$\mathbf{Y_j}$: outcome variables for the $_j$th admission

i: inpatient episode cases (i=1, 2, …, n)

Case: dummy variable that assigns 1 to patients admitted to hospitalist wards (hospitalist ward, case=1: case group, conventional ward, case=0: control group)

$\mathbf{X_{ij}}$: covariates (region, income level, health insurance type, surgery status, hospitalization route, CCI score, medical department, main diagnosis, medical institution establishment, hospitalization year)

Furthermore, to evaluate changes in healthcare utilization and health outcomes in the case group before and after the implementation of the hospitalist system, relative to changes in the control group, a difference-in-differences (DID) analytical approach was applied. The DID method is commonly used to evaluate policy effects in the healthcare sector and has been widely adopted in prior similar studies.[89,90] Accordingly, the effect of the hospitalist system was assessed by comparing the pre- and post-implementation differences between the case and control groups using the DID method. In the DID specification, a linear time period was added to control for secular trends that may affect both groups equally. Given that the pre-intervention trends between groups were parallel (Appendix 6), this adjustment allows for more accurate estimation of the policy effect without introducing bias. The following equation represents the DID analysis conducted using GEE:[88,91]

$$g(E[Y_{it}])=\beta_0 + \beta_1(Time_{it}) + \beta_2(Case_{it}) + \beta_3(Intervention_{it}) + \beta_4(Case_{it} \times Intervention_{it}) + \gamma X_{it}$$

g: link function

E: expectation

Y: outcome variables

i: inpatient episode cases (i=1, 2, …, n)

t: time period

Time: time variable before and after the implementation of the official project of the hospitalist system (continuous variable in units of one year (365 days))

Case: dummy variable that assigns 1 to patients admitted to a newly operated hospital during the official project of a hospitalist system (patients who admitted to a hospital newly operating on hospitalist wards, case=1: case group, case=0: control group)

Intervention: dummy variable that is assigned 1 if time is after hospitalist official project launch date, January 25, 2021 (intervention=1: after January 25, 2021, intervention=0: before January 25, 2021)

$\mathbf{X_{it}}$: covariates (sex, age, region, income level, health insurance type, surgery status, hospitalization route, CCI score, medical department, main diagnosis, medical institution type, medical institution establishment type, medical institution location, number of hospital bed)

Among the outcome variables, total expenditure was subdivided into OOP and expense per day, and HAC was sub-analyzed individually by complication type. Also we analyzed additional readmission and mortality as secondary outcomes. Additionally, as part of the subgroup analysis for the variable of interest, the outcomes were examined by type of hospitalist ward operation.

In all analyses using the GENMOD procedure, the estimated coefficient was converted to exponentials [exp(β)]. In the procedure, for binary outcomes such as HAC, mortality, and readmission, were analyzed using a binomial distribution and logit link function. For LOS, a poisson distribution with a log link function was used. For continuous skewed variables such as total expenditure, OOP, and expense per day, a gamma distribution with a log link function was applied. Also, GEE with and autoregressive (1) correlation matrix type was used to analyzed. This approach is recommended to address the positively skewed nature of the expenditure distribution and can be implemented through the procedure.[92,93] As the results of all analysis, we presented the exp(β) and 95% confidence intervals (95% CIs). Statistical analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC, USA) and two-sided p-values < 0.05 were considered statistically significant.

5. Ethics Statement

The study protocol was reviewed and approved by the Institutional Review Board (IRB) of Yonsei University Health System-Severance Hospital in accordance with the principles of the Declaration of Helsinki (IRB Number: 4-2024-0807). The requirement for informed consent was waived because the NHIS database obtained (NHIS-2025-01-1-066) does not contain any personally identifiable information.

IV. Results

1. Comparison between Inpatient Cases by admitted wards

1) General characteristic of the matched cohort

Table 9 presents the general characteristics of the 143,376 inpatient cases included after 1:1 exact matching, with 71,688 cases in both the hospitalist ward and conventional ward groups. Matching was conducted to minimize confounding and ensure comparability between groups, using key covariates such as age, sex, comorbidity, hospital characteristics, and diagnostic information, and the baseline characteristics before matching are in Appendix 3. The standardized mean differences across all matching variables were effectively minimized, indicating covariate balance between the case and control groups. This confirms the success of the matching process and the validity of subsequent comparative analyses.

A substantial proportion of the study population consisted of patients aged 50 to 79 years (N=107,134, 74.7%) and resided in metropolitan areas (N=98,024, 68.4%). Most patients were non-surgical cases (N=82,478, 57.5%) and were admitted through outpatient pathways rather than via emergency rooms (N=129,392, 90.2%), indicating planned admissions for medical management. Additionally, 65.9% of patients had a low CCI score (N=94,478, 65.9%) and the primary institutions providing care to study population were largely tertiary hospitals (N=113,954, 79.5%), predominantly in the private hospital (N=112,635, 78.6%), and mostly located in Seoul (N=73,682, 51.4%). This composition of the matched cohort closely mirrors the distribution of the original patient population admitted to hospitalist wards, as shown in Figure 7.

Table 9. General characteristic of the matched cohort

Variables	Total		Type of inpatient ward				*SMD*[a]
			Conventional ward		Hospitalist ward		
			N	%	N	%	
Total	143,376	100.0	71,688	50.0	71,688	50.0	
Sex							0.0000
Men	73,886	51.5	36,943	51.5	36,943	51.5	
Women	69,490	48.5	34,745	48.5	34,745	48.5	
Age							0.0000
-9	4,992	3.5	2,496	3.5	2,496	3.5	
10-19	2,226	1.6	1,113	1.6	1,113	1.6	
20-29	1,106	0.8	553	0.8	553	0.8	
30-39	3,854	2.7	1,927	2.7	1,927	2.7	
40-49	14,660	10.2	7,330	10.2	7,330	10.2	
50-59	30,512	21.3	15,256	21.3	15,256	21.3	
60-69	46,518	32.4	23,259	32.4	23,259	32.4	
70-79	30,104	21.0	15,052	21.0	15,052	21.0	
80-	9,404	6.6	4,702	6.6	4,702	6.6	
Region							0.0346
Metropolitan	98,024	68.4	48,396	67.5	49,628	69.2	
Urban	31,543	22.0	15,904	22.2	15,639	21.8	
Rural	13,809	9.6	7,388	10.3	6,421	9.0	
Income level							0.0264
Low	35,520	24.8	17,301	24.1	18,219	25.4	
Lower middle	24,826	17.3	12,403	17.3	12,423	17.3	
Upper middle	33,784	23.6	16,889	23.6	16,895	23.6	
High	49,246	34.3	25,095	35.0	24,151	33.7	
Health insurance type							0.0229
National health insurance	135,825	94.7	68,096	95.0	67,729	94.5	
Medical aid	7,551	5.3	3,592	5.0	3,959	5.5	
Surgery status							0.0000
No	82,478	57.5	41,239	57.5	41,239	57.5	
Yes	60,898	42.5	30,449	42.5	30,449	42.5	
Hospitalization route							0.0000
Through walk-in or outpatient	129,392	90.2	64,696	90.2	64,696	90.2	
Through Emergency room	13,984	9.8	6,992	9.8	6,992	9.8	

CCI score [b]							0.0000
0-2	94,478	65.9	47,239	65.9	47,239	65.9	
3-4	21,498	15.0	10,749	15.0	10,749	15.0	
5-	27,400	19.1	13,700	19.1	13,700	19.1	
Medical department							0.0000
Internal medicine	70,406	49.1	35,203	49.1	35,203	49.1	
General Surgery	56,858	39.7	28,429	39.7	28,429	39.7	
Pediatrics	6,982	4.9	3,491	4.9	3,491	4.9	
Others	9,130	6.4	4,565	6.4	4,565	6.4	
Main Diagnosis †							0.0000
Z51	33,986	23.7	16,993	23.7	16,993	23.7	
C34	14,180	9.9	7,090	9.9	7,090	9.9	
C50	13,924	9.7	6,962	9.7	6,962	9.7	
C22	9,706	6.8	4,853	6.8	4,853	6.8	
K80	9,702	6.8	4,851	6.8	4,851	6.8	
Others	61,878	43.2	30,939	43.2	30,939	43.2	
Medical institution type							0.0000
Tertiary hospital	113,954	79.5	56,977	79.5	56,977	79.5	
General hospital	29,422	20.5	14,711	20.5	14,711	20.5	
Medical institution establishment							0.0517
National or Public	30,741	21.4	14,610	20.4	16,131	22.5	
Private	112,635	78.6	57,078	79.6	55,557	77.5	
Medical institution location							0.0000
Seoul	73,682	51.4	36,841	51.4	36,841	51.4	
Gyeonggi, Incheon	35,888	25.0	17,944	25.0	17,944	25.0	
Others	33,806	23.6	16,903	23.6	16,903	23.6	
Number of Hospital bed ††							0.0000
Low	15,358	10.7	7,679	10.7	7,679	10.7	
Lower middle	50,848	35.5	25,424	35.5	25,424	35.5	
Upper middle	18,394	12.8	9,197	12.8	9,197	12.8	
High	58,776	41.0	29,388	41.0	29,388	41.0	
Hospitalization year							0.0000
2021	43,806	30.6	21,903	30.6	21,903	30.6	
2022	46,220	32.2	23,110	32.2	23,110	32.2	
2023	53,350	37.2	26,675	37.2	26,675	37.2	

† Z51(Other medical care); C34(Lung cancer); C50(Breast cancer); C22(Liver cancer); K80(Cholelithiasis);

†† General hospital (Q1: -299, Q2: 300-499, Q3: 500-699, Q4: 700-); Tertiary hospital (Q1: -699, Q2: 700-999, Q3: 1000-1499, Q4: 1500-);

Abbreviation; a Standard Mean Difference, b Charlson Comorbidity Index

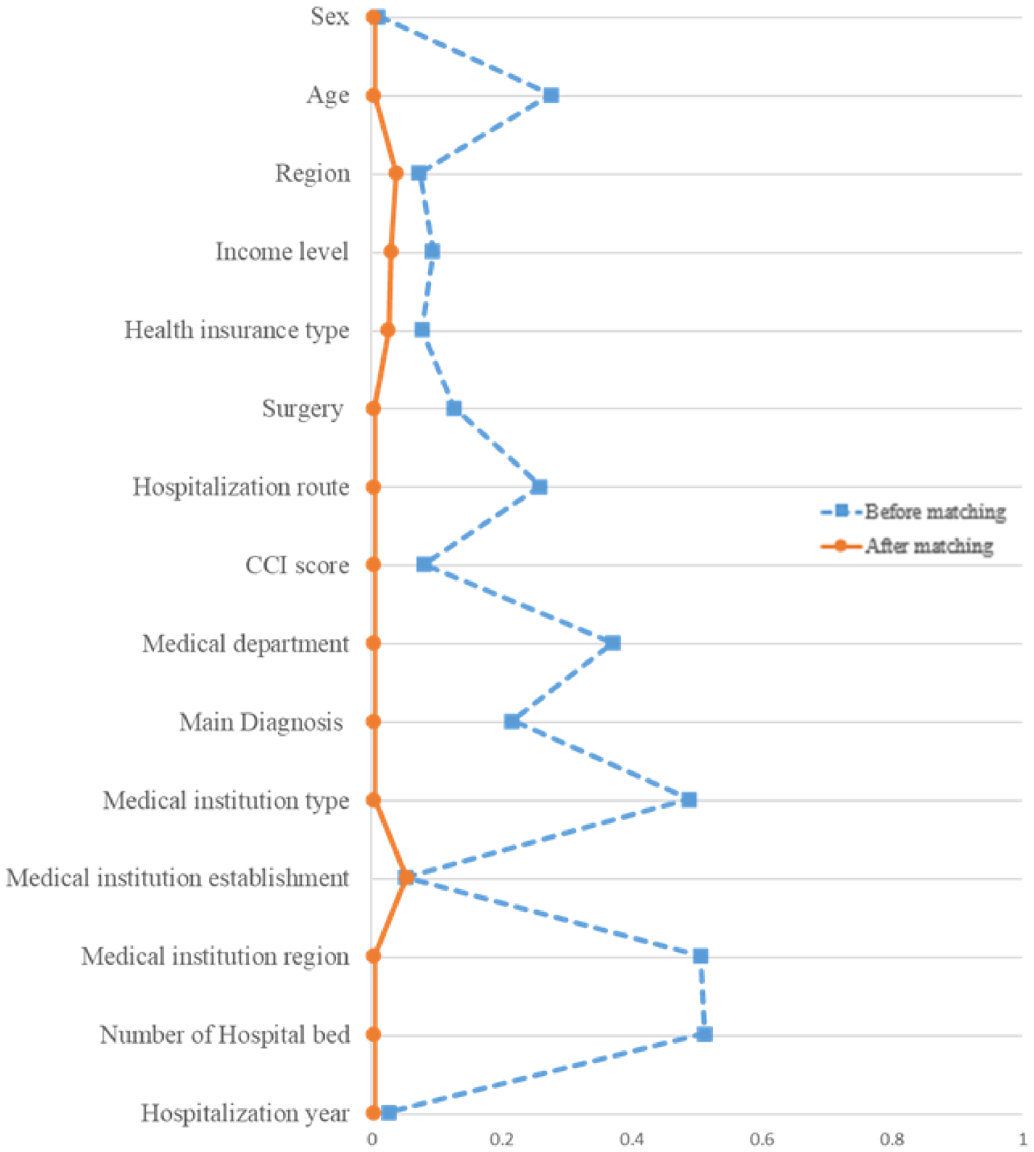


Figure 7. Standardized mean difference after exact matching

2) Difference in healthcare utilization according to the type of inpatient ward

Table 10 shows the unadjusted descriptive statistics for LOS and total expenditure among the matched cohort of 143,376 patients. On average, the overall LOS was 6.62 days, and the mean total expenditure per inpatient cases was approximately KRW 5,406,144. When comparing by ward type, patients admitted to hospitalist wards had shorter stays (hospitalist wards 5.81 days vs. conventional wards 6.72 days) and lower expenditures (hospitalist wards KRW 5,002,576 vs. conventional wards KRW 5,809,711) than those in conventional wards. These differences were statistically significant ($p < 0.0001$), suggesting more efficient care delivery in the hospitalist ward.

Table 11 presents the results of GEE analysis assessing the association between type of inpatient ward and healthcare utilization, specifically LOS and total expenditure. After adjusting for covariates, admission to hospitalist wards was associated with a 13% reduction LOS (exp(β)=0.87, 95% CI: 0.86–0.88) and a 12% reduction in total expenditure (exp(β)=0.88, 95% CI: 0.85–0.89) compared to conventional wards. These findings suggest that hospitalist care contributes to more efficient use of inpatient resources.

Table 10. Descriptive statistics on healthcare utilization

Variables	Lengths of stay		*P-value*	Total expenditure		*P-value*
	Mean	SD[a]		Mean	SD[a]	
Total	6.26	6.62		5,406,144	11,585,819	
Type of inpatient ward			<0.0001			<0.0001
Conventional ward	6.72	7.37		5,809,711	14,255,083	
Hospitalist ward	5.81	5.87		5,002,576	8,057,987	
Sex			<0.0001			<0.0001
Men	6.79	7.36		5,801,582	12,494,784	
Women	5.71	5.81		4,985,689	10,517,460	
Age			<0.0001			<0.0001
-9	6.76	10.83		8,805,753	45,238,838	
10-19	5.61	8.12		5,425,927	19,390,588	
20-29	5.63	6.25		5,682,944	14,083,591	
30-39	5.05	4.38		4,848,920	5,756,149	
40-49	5.13	4.38		4,811,704	5,706,279	
50-59	5.72	5.84		5,160,551	8,408,617	
60-69	6.30	6.54		5,263,775	8,434,325	
70-79	6.83	7.12		5,414,550	6,835,517	
80-	8.30	8.06		6,193,486	6,719,827	
Region			0.0505			0.0005
Metropolitan	6.21	6.69		5,450,053	10,977,478	
Urban	6.36	6.57		5,381,102	14,365,453	
Rural	6.41	6.78		5,151,649	8,175,137	
Income level			0.0935			<0.0001
Low	6.24	6.47		5,029,539	8,101,439	
Lower middle	6.15	6.75		5,335,493	15,493,039	
Upper middle	6.17	6.51		5,293,221	8,648,578	
High	6.41	6.88		5,790,865	13,072,538	
Medical insurance			0.1223			<0.0001
National health insurance	6.25	6.67		5,459,040	11,815,712	
Medical aid	6.55	6.80		4,454,668	6,042,361	
Surgery status			<0.0001			<0.0001
No	4.78	4.22		2,748,680	10,847,956	
Yes	8.28	8.58		9,005,315	11,581,592	
Hospitalization route			<0.0001			0.7216
Through walk-in or outpatient	6.01	6.39		5,366,904	11,866,332	
Through emergency room	8.66	8.49		5,769,228	8,556,854	

CCI score [b]			0.0004			<0.0001
0-2	6.57	6.70		6,005,908	12,532,897	
3-4	6.25	6.89		5,364,348	11,412,156	
5-6	5.23	6.27		3,370,888	7,295,600	
Medical department			<0.0001			<0.0001
Internal medicine	5.88	6.51		3,755,122	5,444,131	
General Surgery	6.69	6.37		6,793,534	9,284,322	
Pediatrics	5.94	8.62		6,388,827	38,501,098	
Others	6.83	7.74		8,746,396	12,816,498	
Main Diagnosis [†]			<0.0001			<0.0001
Z51	4.19	3.87		2,546,058	2,504,632	
C34	7.15	7.72		5,992,576	6,622,789	
C50	5.27	3.58		5,719,496	4,218,671	
C22	7.80	8.17		7,580,914	11,368,510	
K80	5.87	5.08		5,302,451	3,616,115	
Others	7.24	7.73		6,447,255	16,272,173	
Medical institution type			<0.0001			0.0001
Tertiary hospital	6.43	6.94		5,798,104	12,751,134	
General hospital	5.62	5.47		3,888,047	4,635,909	
Medical institution establishment			<0.0001			0.0001
National or Public	5.87	6.44		4,935,151	18,360,851	
Private	6.37	6.73		5,534,690	8,875,968	
Medical institution location			<0.0001			<0.0001
Seoul	6.69	7.22		6,857,714	15,316,561	
Gyeonggi, Incheon	5.86	5.77		4,077,449	4,743,193	
Others	5.76	6.27		3,652,893	4,955,495	
Number of Hospital bed [††]			<0.0001			<0.0001
Low	5.23	5.46		3,259,228	4,022,727	
Lower middle	5.78	6.29		4,187,119	5,270,437	
Upper middle	6.45	6.51		4,711,939	7,977,672	
High	6.89	7.24		7,238,975	16,530,772	
Hospitalization year			<0.0001			0.0005
2021	6.31	6.56		5,387,706	8,448,878	
2022	6.28	6.83		5,663,112	16,145,060	
2023	6.21	6.63		5,198,658	8,729,587	

[†] Z51(Other medical care); C34(Lung cancer); C50(Breast cancer); C22(Liver cancer); K80(Cholelithiasis);
[††] General hospital (Q1: -299, Q2: 300-499, Q3: 500-699, Q4: 700-); Tertiary hospital (Q1: -699, Q2: 700-999, Q3: 1000-1499, Q4: 1500-);
Abbreviation; a Standard Diviation, b Charlson Comorbidity Index

Table 11. Differences in healthcare utilization according to the type of inpatient ward

Variables	Lengths of stay		Total expenditure	
	exp(β)	95% CI	exp(β)	95% CI
Type of inpatient ward				
Conventional ward	1.00		1.00	
Hospitalist ward	0.87	(0.86 - 0.88)	0.88	(0.85 - 0.89)
Region				
Metropolitan	0.94	(0.92 - 0.96)	0.95	(0.92 - 0.98)
Urban	1.01	(0.99 - 1.04)	1.02	(0.98 - 1.06)
Rural	1.00		1.00	
Medical insurance				
National health insurance	0.90	(0.87 - 0.93)	0.99	(0.95 - 1.03)
Medical aid	1.00		1.00	
Income level				
Low	1.01	(0.99 - 1.02)	0.99	(0.96 - 1.01)
Lower middle	1.00	(0.98 - 1.02)	0.99	(0.95 - 1.03)
Upper middle	0.99	(0.98 - 1.01)	0.97	(0.94 - 0.99)
High	1.00		1.00	
Medical department				
Internal medicine	0.94	(0.91 - 0.97)	0.51	(0.49 - 0.53)
General Surgery	1.14	(1.11 - 1.18)	0.85	(0.81 - 0.88)
Pediatrics	0.83	(0.79 - 0.87)	0.72	(0.62 - 0.84)
Others	1.00		1.00	
Main Diagnosis †				
Z51	0.56	(0.55 - 0.57)	0.49	(0.47 - 0.50)
C34	1.04	(1.01 - 1.06)	1.08	(1.05 - 1.11)
C50	0.65	(0.64 - 0.66)	0.80	(0.78 - 0.81)
C22	1.05	(1.03 - 1.08)	1.27	(1.23 - 1.31)
K80	0.74	(0.72 - 0.75)	0.82	(0.80 - 0.84)
Others	1.00		1.00	
Medical institution establishment				
National or Public	0.91	(0.89 - 0.92)	0.90	(0.87 - 0.94)
Private	1.00		1.00	
Hospitalization year				
2021	1.02	(1.01 - 1.04)	1.02	(1.00 - 1.04)
2022	1.00	(0.99 - 1.01)	1.05	(1.02 - 1.08)
2023	1.00		1.00	

† Z51(Other medical care); C34(Lung cancer); C50(Breast cancer); C22(Liver cancer); K80(Cholelithiasis);
* adjusted for region, medical insurance, income level, medical department, main diagnosis, medical institution establishment, and hospitalization year

3) Difference in hospital-acquired complications according to the type of inpatient ward

Among the total study population of 143,376 patients, the overall incidence of HACs was 5.8% (N=8,321). As shown in Table 12, the descriptive percentage was 6.5% in conventional wards and 5.2% in hospitalist wards, with a statistically significant difference ($p < 0.0001$). This trend suggests a potential protective effect of hospitalist-managed care in preventing in-hospital complications.

After adjusting for covariates GEE model (Table 13), admission to hospitalist wards remained significantly associated with a lower risk of HACs. Specifically, patients admitted to hospitalist wards had a 22% lower odds of experiencing any HAC compared to those in conventional wards (exp(β)=0.78; 95% CI: 0.74–0.83).

Table 12. Descriptive statistics on hospital-acquired complications

Variables	Total	Hospital-Acquired Complications				*P-value*
		Yes		No		
		N	%	N	%	
Total	143,376	8,321	5.8	135,055	94.2	
Type of inpatient ward						<0.0001
Conventional ward	71,688	4,629	6.5	67,059	93.5	
Hospitalist ward	71,688	3,692	5.2	67,996	94.8	
Sex						0.0004
Men	73,886	4,445	6.0	69,441	94.0	
Women	69,490	3,876	5.6	65,614	94.4	
Age						<0.0001
-9	8,046	496	6.2	7,550	93.8	
10-19	2,226	112	5.0	2,114	95.0	
20-29	1,106	50	4.5	1,056	95.5	
30-39	3,854	124	3.2	3,730	96.8	
40-49	14,660	698	4.8	13,962	95.2	
50-59	30,512	1,485	4.9	29,027	95.1	
60-69	46,518	2,376	5.1	44,142	94.9	
70-79	30,104	1,975	6.6	28,129	93.4	
80-	9,404	1,005	10.7	8,399	89.3	
Region						<0.0001
Metropolitan	98,024	5,885	6.0	92,139	94.0	
Urban	31,543	1,603	5.1	29,940	94.9	
Rural	13,809	833	6.0	12,976	94.0	
Income level						<0.0001
Low	35,520	2,078	5.9	33,442	94.1	
Lower middle	24,826	1,426	5.7	23,400	94.3	
Upper middle	33,784	2,139	6.3	31,645	93.7	
High	49,246	2,678	5.4	46,568	94.6	
Medical insurance						0.1925
National health insurance	135,825	7,857	5.8	127,968	94.2	
Medical aid	7,551	464	6.1	7,087	93.9	
Surgery						<0.0001
No	82,478	5,656	6.9	76,822	93.1	
Yes	60,898	2,665	4.4	58,233	95.6	
Hospitalization route						0.2681
Through walk-in or outpatient	129,392	6,522	5.0	122,870	95.0	
Through emergency room	13,984	1,799	12.9	12,185	87.1	
CCI score [a]						<0.0001
0-2	94,478	5,546	5.9	88,932	94.1	
3-4	21,498	1,204	5.6	20,294	94.4	
5-6	27,400	1,571	5.7	25,829	94.3	

Medical department						<0.0001
Internal medicine	70,406	4,944	7.0	65,462	93.0	
General Surgery	56,858	2,445	4.3	54,413	95.7	
Pediatrics	6,982	596	8.5	6,386	91.5	
Others	9,130	336	3.7	8,794	96.3	
Main Diagnosis †						<0.0001
Z51	33,986	1,674	4.9	32,312	95.1	
C34	14,180	1,844	13.0	12,336	87.0	
C50	13,924	473	3.4	13,451	96.6	
C22	9,706	360	3.7	9,346	96.3	
K80	9,702	328	3.4	9,374	96.6	
Others	61,878	3,642	5.9	58,236	94.1	
Medical institution type						0.0856
Tertiary hospital	113,954	6,552	5.7	107,402	94.3	
General hospital	29,422	1,769	6.0	27,653	94.0	
Medical institution establishment						<0.0001
National or Public	30,741	1,475	4.8	29,266	95.2	
Private	112,635	6,846	6.1	105,789	93.9	
Medical institution region						<0.0001
Seoul	73,682	2,573	3.5	71,109	96.5	
Gyeonggi, Incheon	35,888	3,607	10.1	32,281	89.9	
Others	33,806	2,141	6.3	31,665	93.7	
Number of Hospital bed ††						<0.0001
Low	15,358	1,055	6.9	14,303	93.1	
Lower middle	50,848	3,850	7.6	46,998	92.4	
Upper middle	18,394	1,409	7.7	16,985	92.3	
High	58,776	2,007	3.4	56,769	96.6	
Hospitalization year						<0.0001
2021	43,806	2,697	6.2	41,109	93.8	
2022	46,220	2,372	5.1	43,848	94.9	
2023	53,350	3,252	6.1	50,098	93.9	

† Z51(Other medical care); C34(Lung cancer); C50(Breast cancer); C22(Liver cancer); K80(Cholelithiasis);
†† General hospital (Q1: -299, Q2: 300-499, Q3: 500-699, Q4: 700-); Tertiary hospital (Q1: -699, Q2: 700-999, Q3: 1000-1499, Q4: 1500-);
Abbreviation; a Charlson Comorbidity Index

Table 13. Differences in hospital-acquired complications according to the type of inpatient ward

Variables	Hospital-Acquired Complications	
	exp(β)	95% CI
Type of inpatient ward		
Conventional ward	1.00	
Hospitalist ward	0.78	(0.74 - 0.83)
Region		
Metropolitan	1.01	(0.90 - 1.13)
Urban	0.86	(0.76 - 0.98)
Rural	1.00	
Medical insurance		
National health insurance	1.00	(0.86 - 1.16)
Medical aid	1.00	
Income level		
Low	1.06	(0.96 - 1.17)
Lower middle	1.05	(0.96 - 1.16)
Upper middle	1.15	(1.05 - 1.26)
High	1.00	
Medical department		
Internal medicine	2.31	(2.02 - 2.65)
General Surgery	1.86	(1.59 - 2.17)
Pediatrics	3.07	(2.61 - 3.62)
Others	1.00	
Main Diagnosis †		
Z51	0.82	(0.73 - 0.92)
C34	2.43	(2.23 - 2.65)
C50	0.62	(0.55 - 0.70)
C22	0.63	(0.55 - 0.71)
K80	0.58	(0.51 - 0.65)
Others	1.00	
Medical institution establishment		
National or Public	0.75	(0.69 - 0.81)
Private	1.00	
Hospitalization year		
2021	1.02	(0.95 - 1.10)
2022	0.86	(0.81 - 0.93)
2023	1.00	

† Z51(Other medical care); C34(Lung cancer); C50(Breast cancer); C22(Liver cancer); K80(Cholelithiasis);
* adjusted for region, medical insurance, income level, medical department, main diagnosis, medical institution establishment, and hospitalization year

4) Difference in additional outcomes according to the type of inpatient ward

(1) Primary outcomes

For medical expenses, the OOP was 13% lower in hospitalist wards (exp(β): 0.87, 95% CI: 0.85–0.89) than conventional wards, while there was no meaningful difference in expense per day between the two groups (exp(β): 1.00, 95% CI: 0.98–1.03). With respect to HAC, several specific complications occurred significantly less frequently among patients in hospitalist wards than conventional wards (Table 14), The probability of urinary tract infection was 33% lower (exp(β): 0.67, 95% CI: 0.59–0.76), pneumonia was 20% lower (exp(β): 0.80, 95% CI: 0.72–0.88), intrahospital ICU transfer was 7% lower (exp(β): 0.93, 95% CI: 0.87–0.99), and post-procedural complications were reduced by 60% (exp(β): 0.40, 95% CI: 0.34–0.46). The differences in thromboembolism and pressure ulcer were not statistically significant (thromboembolism, exp(β): 0.96, 95% CI: 0.89–1.05; pressure ulcer, exp(β): 0.91, 95% CI: 0.77–1.09).

(2) Secondary outcomes

Regarding secondary outcomes (Table 14), in-hospital mortality was 14% lower in the hospitalist group (exp(β): 0.86, 95% CI: 0.77–0.96), and 30-day mortality after discharge was 11% lower (exp(β): 0.89, 95% CI: 0.83–0.95). Readmission within 30 days also tended to be lower in the hospitalist ward group. All-cause readmission was reduced by 4% (exp(β): 0.96, 95% CI: 0.93–0.98), readmission for the same disease by 6% (exp(β): 0.94, 95% CI: 0.92−0.97), and readmission to the same institution for the same disease by 5% (exp(β): 0.95, 95% CI: 0.92–0.97). In terms of readmission for the same institution, no statistically significant relative differences were observed (exp(β): 0.96, 95% CI: 0.93–1.00).

Table 14. Results for additional outcomes between type of inpatient ward

Variables*	Type of inpatient ward		
	Conventional ward	Hospitalist ward	
	exp(β)	exp(β)	95% CI
Primary Outcomes			
Medical Expenses			
Out of pocket	1.00	0.87	(0.85 - 0.89)
Expense per day	1.00	1.00	(0.98 - 1.03)
Hospital-acquired complications			
Thromboembolism	1.00	0.96	(0.89 - 1.05)
Pressure ulcer	1.00	0.91	(0.77 - 1.09)
Urinary Tract Infection	1.00	0.67	(0.59 - 0.76)
Pneumonia	1.00	0.80	(0.72 - 0.88)
Intrahospital ICU Transfers	1.00	0.93	(0.87 - 0.99)
Post-procedural complication	1.00	0.40	(0.34 - 0.46)
Secondary Outcomes			
Mortality			
In-hospital death	1.00	0.86	(0.77 - 0.96)
30-days mortality after discharge	1.00	0.89	(0.83 - 0.95)
30-days readmission	1.00		
All-cause readmission	1.00	0.96	(0.93 - 0.98)
Same institution	1.00	0.96	(0.93 - 1.00)
Same disease	1.00	0.94	(0.92 - 0.97)
Same institution and disease	1.00	0.95	(0.92 - 0.97)

* adjusted for region, medical insurance, income level, medical department, main diagnosis, medical institution establishment, and hospitalization year

5) Differences in healthcare utilization and health outcomes according to the hospitalist wards' type

Table 15 shows the results of subgroup analysis according to hospitalist ward type. Compared to conventional wards, LOS decreased across ward types: by 6% in Type 1 (exp(β): 0.94, 95% CI: 0.91–0.97), 9% in Type 2 (exp(β): 0.91, 95% CI: 0.88–0.94), and 13% in Type 3 (exp(β): 0.87, 95% CI: 0.85–0.90). Total expenditure also followed a decreasing pattern, with an 8% reduction in Type 1 (exp(β): 0.92, 95% CI: 0.89–0.96), 9% in Type 2 (exp(β): 0.91, 95% CI: 0.89–0.93), and 11% in Type 3 (exp(β): 0.89, 95% CI: 0.86–0.92). Similarly, the risk of HAC was 27% lower in Type 1 (exp(β): 0.73, 95% CI: 0.64–0.83), 28% lower in Type 2 (exp(β): 0.72, 95% CI: 0.68–0.77), and 45% lower in Type 3 (exp(β): 0.55, 95% CI: 0.49–0.62).

In terms of hospitalists' dedicated hour, full-time wards were associated with a 10% shorter LOS (exp(β): 0.90, 95% CI: 0.88–0.93), while daytime-only coverage led to a 5% reduction (exp(β): 0.95, 95% CI: 0.92–0.97). Total expenditure was 10% lower in full-time wards (exp(β): 0.90, 95% CI: 0.87–0.94), whereas daytime-only wards showed no significant difference compared to conventional wards (exp(β): 1.00, 95% CI: 0.97–1.02). HAC were 21% lower in full-time wards (exp(β): 0.79, 95% CI: 0.69–0.90), but not significantly different in daytime-only wards (exp(β): 0.96, 95% CI: 0.84–1.09).

Wards operating 7 days per week showed a 7% reduction in LOS (exp(β): 0.93, 95% CI: 0.92–0.95), while 5-day operation showed a smaller 2% reduction (exp(β): 0.98, 95% CI: 0.96–0.99), indicating that continuous weekly operation may contribute to more positive outcomes. Similarly, total expenditure decreased by 6% in 7-day wards (exp(β): 0.94, 95% CI: 0.92–0.96), with no significant difference in 5-day wards (exp(β): 1.01, 95% CI: 0.98–1.04). The probability of HAC were 22% lower in 7-day wards (exp(β): 0.78, 95% CI: 0.74–0.83) and 17% lower in 5-day wards (exp(β): 0.83, 95% CI: 0.76–0.91).

Table 15. Inpatient healthcare utilization and health outcomes by hospitalist dedicated type

Variables*	Lengths of stay		Total expenditure		HAC[a]	
	exp(β)	95% CI	exp(β)	95% CI	exp(β)	95% CI
Type of hospitalist ward						
Conventional	1.00		1.00		1.00	
Type 1[†]	0.94	(0.91 - 0.97)	0.92	(0.89 - 0.96)	0.83	(0.74 - 0.93)
Type 2[††]	0.91	(0.88 - 0.94)	0.91	(0.89 - 0.93)	0.72	(0.68 - 0.77)
Type 3[†††]	0.87	(0.85 - 0.90)	0.89	(0.86 - 0.92)	0.55	(0.49 - 0.62)
Dedicated hour						
Conventional	1.00		1.00		1.00	
Day-time	0.92	(0.89 - 0.94)	0.99	(0.95 - 1.03)	0.81	(0.77 - 0.86)
Full-time	0.87	(0.85 - 0.90)	0.98	(0.95 - 1.02)	0.63	(0.54 - 0.81)
Dedicated day						
Conventional	1.00		1.00		1.00	
5 days a week	0.95	(0.93 - 0.97)	0.93	(0.91 - 0.95)	0.87	(0.83 - 0.92)
7 days a week	0.91	(0.90 - 0.92)	0.91	(0.88 - 0.93)	0.61	(0.55 - 0.66)

[†] 5 days a week – daytime
[††] 7 days a week – daytime
[†††] 7 days a week – fulltime
* adjusted for region, medical insurance, income level, medical department, main diagnosis, medical institution establishment, and hospitalization year
Abbreviation; a Hospital-acquired complication

2. Comparison between Institutions by Hospitalist System Operation

1) General Characteristics of the Study Population

A total of 455,238 patients were included in the DID analysis to evaluate outcomes between patients admitted to medical institution that operated hospitalist wards and non-operated hospitalist wards (Table 16). Of these, 351,591 patients (77.2%) were admitted to hospitals that operated hospitalist wards (case group), and 103,647 patients (22.8%) were admitted to hospitals without hospitalist wards (control group). Within the case group, 212,781 patients (60.5%) were admitted before the launch date of hospitalist official project, and 138,810 patients (39.5%) were admitted after date. In contrast, within the control group, 66,325 patients (64.0%) were admitted before, and 37,322 patients (36.0%) were admitted after the same time point.

Across the total study population, middle-aged and older adults accounted for the majority of admissions, with the highest proportions observed in patients aged 50 to 79 years (N=311,989, 68.5%). A substantial portion of patients resided in metropolitan areas (N=370,271, 81.3%), and admissions were predominantly through outpatient or walk-in routes (N=306,948, 79.3%) rather than emergency departments. Most patients did not undergo surgery during hospitalization (N=306,490, 67.3%), and a large proportion had low CCI score (N=285,979, 62.8%). In terms of hospital characteristics, the majority of patients were admitted to private hospitals (N=416,147, 91.4%), particularly those located in Seoul (N=335,923, 73.8%).

Table 16. General characteristics of study population who admitted matched hospitals

Variables	Total		Case (Hospitalist institution)						Control (Non-Hospitalist institution)					
			Total		Before (2017~2021)		After (2021~2023)		Total		Before (2017~2021)		After (2021~2023)	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Total	455,238	100.0	351,591	100.0	212,781	60.5	138,810	39.5	103,647	100.0	66,325	64.0	37,322	36.0
Sex														
Male	232,625	51.1	181,554	51.6	110,603	52.0	70,951	51.1	51,071	49.3	33,476	50.5	17,595	47.1
Female	222,613	48.9	170,037	48.4	102,178	48.0	67,859	48.9	52,576	50.7	32,849	49.5	19,727	52.9
Age														
-9	13,755	3.0	9,671	2.8	7,108	3.3	2,563	1.8	4,084	3.9	3,246	4.9	838	2.2
10-19	8,163	1.8	6,906	2.0	4,206	2.0	2,700	1.9	1,257	1.2	948	1.4	309	0.8
20-29	11,405	2.5	8,712	2.5	6,097	2.9	2,615	1.9	2,693	2.6	1,810	2.7	883	2.4
30-39	20,286	4.5	15,215	4.3	10,278	4.8	4,937	3.6	5,071	4.9	3,259	4.9	1,812	4.9
40-49	48,965	10.8	38,401	10.9	24,723	11.6	13,678	9.9	10,564	10.2	6,664	10.0	3,900	10.4
50-59	93,500	20.5	74,152	21.1	45,399	21.3	28,753	20.7	19,348	18.7	12,455	18.8	6,893	18.5
60-69	124,669	27.4	99,084	28.2	56,386	26.5	42,698	30.8	25,585	24.7	15,623	23.6	9,962	26.7
70-79	93,820	20.6	71,866	20.4	42,863	20.1	29,003	20.9	21,954	21.2	14,060	21.2	7,894	21.2
80-	40,675	8.9	27,584	7.8	15,721	7.4	11,863	8.5	13,091	12.6	8,260	12.5	4,831	12.9
Region														
Metropolitan	370,271	81.3	282,194	80.3	171,800	80.7	110,394	79.5	88,077	85.0	56,320	84.9	31,757	85.1
Urban	48,014	10.5	39,867	11.3	23,430	11.0	16,437	11.8	8,147	7.9	5,133	7.7	3,014	8.1
Rural	36,953	8.1	29,530	8.4	17,551	8.2	11,979	8.6	7,423	7.2	4,872	7.3	2,551	6.8
Surgery														
No	306,490	67.3	236,841	67.4	143,848	67.6	92,993	67.0	69,649	67.2	45,103	68.0	24,546	65.8
Yes	148,748	32.7	114,750	32.6	68,933	32.4	45,817	33.0	33,998	32.8	21,222	32.0	12,776	34.2

Income level														
Low	117,072	25.7	87,439	24.9	50,672	23.8	36,767	26.5	29,633	28.6	18,368	27.7	11,265	30.2
Lower middle	80,630	17.7	62,086	17.7	39,042	18.3	23,044	16.6	18,544	17.9	12,252	18.5	6,292	16.9
Upper middle	104,827	23.0	80,847	23.0	49,814	23.4	31,033	22.4	23,980	23.1	15,510	23.4	8,470	22.7
High	152,709	33.5	121,219	34.5	73,253	34.4	47,966	34.6	31,490	30.4	20,195	30.4	11,295	30.3
Medical insurance														
National health insurance	424,157	93.2	330,360	94.0	200,418	94.2	129,942	93.6	93,797	90.5	60,103	90.6	33,694	90.3
Medical aid	31,081	6.8	21,231	6.0	12,363	5.8	8,868	6.4	9,850	9.5	6,222	9.4	3,628	9.7
Hospitalization route														
Through walk-in or outpatient	360,948	79.3	285,845	81.3	163,947	77.0	121,898	87.8	75,103	72.5	45,275	68.3	29,828	79.9
Through emergency room	94,290	20.7	65,746	18.7	48,834	23.0	16,912	12.2	28,544	27.5	21,050	31.7	7,494	20.1
CCI score [a]														
0-2	285,979	62.8	213,619	60.8	134,203	63.1	79,416	57.2	72,360	69.8	46,983	70.8	25,377	68.0
3-4	60,804	13.4	49,856	14.2	29,076	13.7	20,780	15.0	10,948	10.6	7,100	10.7	3,848	10.3
5-6	108,455	23.8	88,116	25.1	49,502	23.3	38,614	27.8	20,339	19.6	12,242	18.5	8,097	21.7
Medical department														
Internal medicine	230,897	50.7	179,925	51.2	107,691	50.6	72,234	52.0	50,972	49.2	33,050	49.8	17,922	48.0
General surgery	139,504	30.6	102,919	29.3	62,469	29.4	40,450	29.1	36,585	35.3	22,256	33.6	14,329	38.4
Pediatrics	18,893	4.2	14,147	4.0	9,469	4.5	4,678	3.4	4,746	4.6	3,733	5.6	1,013	2.7
Others	65,944	14.5	54,600	15.5	33,152	15.6	21,448	15.5	11,344	10.9	7,286	11.0	4,058	10.9

Main Diagnosis †														
Z51	90,785	19.9	71,721	20.4	32,940	15.5	38,781	27.9	19,064	18.4	8,602	13.0	10,462	28.0
C34	31,413	6.9	25,043	7.1	16,011	7.5	9,032	6.5	6,370	6.1	4,723	7.1	1,647	4.4
C50	33,698	7.4	28,169	8.0	18,448	8.7	9,721	7.0	5,529	5.3	3,641	5.5	1,888	5.1
C22	23,022	5.1	18,454	5.2	11,675	5.5	6,779	4.9	4,568	4.4	3,139	4.7	1,429	3.8
K80	25,469	5.6	16,891	4.8	10,279	4.8	6,612	4.8	8,578	8.3	5,328	8.0	3,250	8.7
Others	250,851	55.1	191,313	54.4	123,428	58.0	67,885	48.9	59,538	57.4	40,892	61.7	18,646	50.0
Medical institution type														
Tertiary hos. [b]	236,439	51.9	236,439	67.2	135,151	63.5	101,288	73.0	0	0.0	0	0.0	0	0.0
General hos. [b]	218,799	48.1	115,152	32.8	77,630	36.5	37,522	27.0	103,647	100.0	66,325	100.0	37,322	100.0
Medical institution establishment														
National or Public	39,091	8.6	37,702	10.7	23,144	10.9	14,558	10.5	1,389	1.3	1,166	1.8	223	0.6
Private	416,147	91.4	313,889	89.3	189,637	89.1	124,252	89.5	102,258	98.7	65,159	98.2	37,099	99.4
Medical institution region														
Seoul (Capital City)	335,932	73.8	267,672	76.1	165,146	77.6	102,526	73.9	68,260	65.9	42,966	64.8	25,294	67.8
Others	119,306	26.2	83,919	23.9	47,635	22.4	36,284	26.1	35,387	34.1	23,359	35.2	12,028	32.2
Number of Hospital bed ††														
Low	70,696	15.5	57,098	16.2	35,458	16.7	21,640	15.6	13,598	13.1	8,323	12.5	5,275	14.1
Lower middle	150,952	33.2	96,290	27.4	59,656	28.0	36,634	26.4	54,662	52.7	34,643	52.2	20,019	53.6
Upper middle	150,372	33.0	132,727	37.8	79,132	37.2	53,595	38.6	17,645	17.0	12,190	18.4	5,455	14.6
High	83,218	18.3	65,476	18.6	38,535	18.1	26,941	19.4	17,742	17.1	11,169	16.8	6,573	17.6

† Z51(Other medical care); C34(Lung cancer); C50(Breast cancer); C22(Liver cancer); K80(Cholelithiasis);
†† General hospital (Q1: -299, Q2: 300-499, Q3: 500-599, Q4: 600-); Tertiary hospital (Q1: -499, Q2: 500-799, Q3: 800-999, Q4: 1000-);
Abbreviation; a Charlson Comorbidity Index b Hospital

2) Differential Changes over time in healthcare utilization following hospitalist ward operation in medical institution

Descriptive statistics on healthcare utilization by before and after intervention presented in Table 17, the LOS was 7.07 days in the case group and 7.51 days in the control group. The total expenditure per admission episode was 4,655,748 KRW in the case group and 4,016,406 KRW in the control group. Following the start of the hospitalist project's official implementation period in 2021, in the case group, the average LOS decreased from 7.47 days before the program to 6.46 days after implementation, reflecting a reduction of 1.01 days. In contrast, the control group experienced a smaller decrease in LOS, from 7.72 days before to 7.13 days after, a reduction of 0.59 days. Similarly, total expenditure in the case group decreased from 4,572,241 KRW before implementation to 4,783,756 KRW after, indicating an increase of 211,515 KRW. On the other hand, the control group showed an increase in total expenditure, rising from 3,942,928 KRW before to 4,146,984 KRW after, an increase of 204,056 KRW.

Figure 8 shows the change in the healthcare utilization of the case and control groups by time point. The LOS and total expenditure met a parallel trend assumption in the case and control groups before intervention period (Appendix 6-7). The difference between the two groups before intervention was not statistically significant (LOS, p=0.2675; Total expenditure p=0.1177)

The results of the DID analysis of healthcare utilization before and after the intervention are shown in Table 18. This result present differential change of healthcare utilization in the case and control group. Specifically, the LOS decreased by 7% more in the case group relative to the control group (exp(β): 0.93, 95% CI: 0.91–0.95). In terms of total expenditure, while medical costs increased overall after the policy implementation, the relative increase was 4% lower in the case group compared to the control group (exp(β): 0.96, 95% CI: 0.93–0.99).

Table 17. Changes of healthcare utilization by before and after policy intervention

Variables	Lengths of stay				Total expenditure			
	Case (Hospitalist institution)		Control (Non-hospitalist institution)		Case (Hospitalist institution)		Control (Non-hospitalist institution)	
	Mean	SD[a]	Mean	SD[a]	Mean	SD[a]	Mean	SD[a]
Total	7.07	9.60	7.51	9.37	4,655,748	8,490,149	4,016,406	5,931,311
Policy								
Before (2017~2021)	7.47	10.39	7.72	10.21	4,572,241	7,730,499	3,942,928	6,269,023
After (2021~2023)	6.46	8.20	7.13	7.64	4,783,756	9,536,482	4,146,984	5,275,668
Sex								
Male	7.42	10.45	8.01	10.16	4,902,005	9,186,586	4,354,893	6,554,168
Female	6.69	8.58	7.03	8.51	4,392,812	7,668,416	3,687,609	5,235,233
Age								
-9	7.09	11.17	4.85	5.30	3,989,307	13,263,916	1,921,988	5,195,242
10-19	7.63	10.92	4.82	4.59	5,148,843	19,239,751	1,759,461	2,717,759
20-29	7.29	11.58	5.47	5.67	4,983,953	13,627,787	2,592,862	3,617,791
30-39	6.50	9.15	5.25	6.33	4,568,433	10,028,983	2,757,367	3,709,695
40-49	6.16	7.77	5.64	6.51	4,407,364	7,518,448	3,141,094	4,402,739
50-59	6.49	8.48	6.62	7.86	4,411,084	7,806,338	3,647,680	4,574,011
60-69	6.86	8.64	7.51	9.17	4,475,379	7,287,771	4,121,977	5,622,204
70-79	7.65	11.11	8.70	10.21	4,907,641	7,678,098	4,693,391	6,371,747
80-	9.22	11.69	10.73	13.24	5,705,588	7,845,503	5,576,724	8,834,203
Region								
Metropolitan	6.93	9.71	7.40	9.37	4,521,564	8,247,359	3,976,174	6,022,320
Urban	7.80	9.46	8.02	9.20	5,429,417	10,454,278	4,205,409	5,552,601
Rural	7.46	8.62	8.25	9.55	4,893,544	7,723,381	4,286,335	5,188,655

Income level								
Low	7.11	9.15	7.80	8.96	4,552,815	8,099,620	4,150,064	5,675,346
Lower middle	6.86	9.11	7.22	8.64	4,536,474	8,434,588	3,875,532	5,356,075
Upper middle	6.96	8.79	7.21	8.79	4,547,879	7,876,591	3,917,453	5,648,791
High	7.22	10.62	7.64	10.51	4,863,030	9,158,120	4,048,942	6,652,619
Medical insurance								
National health insurance	7.03	9.60	7.40	9.30	4,674,012	8,576,760	3,984,897	5,925,527
Medical aid	7.61	9.53	8.61	9.92	4,371,552	6,999,880	4,316,451	5,978,104
Surgery								
No	5.09	5.71	5.61	5.84	2,555,077	4,543,133	2,330,885	2,477,704
Yes	11.15	13.79	11.40	13.24	8,991,480	12,261,856	7,469,399	8,771,174
Hospitalization route								
Through walk-in or outpatient	6.55	8.79	6.71	8.45	4,428,580	7,582,149	3,726,573	5,341,438
Through Emergency room	9.34	12.26	9.61	11.17	5,643,410	11,590,241	4,778,996	7,202,441
CCI score [b]								
0-2	7.44	10.08	7.53	8.76	5,095,097	8,878,917	4,131,080	5,805,877
3-4	7.29	9.87	8.31	12.68	4,882,126	10,561,161	4,335,458	8,382,824
5-6	6.04	8.04	7.01	9.33	3,462,555	5,609,782	3,436,691	4,593,063
Medical department								
Internal medicine	7.25	9.51	8.56	10.20	4,397,252	8,067,975	4,235,695	6,096,764
General Surgery	6.69	7.47	6.54	7.45	5,007,928	7,488,293	4,074,932	5,303,241
Pediatrics	7.37	11.38	4.81	5.22	4,610,232	17,183,857	1,879,131	4,964,912
Others	7.11	12.50	7.07	11.53	4,855,526	8,183,757	3,736,499	7,154,929

Main Diagnosis †								
Z51	4.19	5.36	4.51	4.94	2,631,681	3,317,191	2,396,959	2,646,588
C34	8.93	10.16	9.80	11.24	6,193,687	7,562,362	5,563,315	6,829,366
C50	5.50	5.99	6.29	7.26	4,152,060	4,710,629	3,976,919	4,769,299
C22	8.22	9.52	9.86	11.28	5,715,797	8,377,340	5,400,708	5,526,860
K80	6.32	5.02	7.31	5.64	4,900,687	3,506,138	5,234,338	3,448,324
Others	8.09	11.12	8.19	10.38	5,163,516	10,367,509	4,091,429	6,810,427
Medical institution type								
Tertiary hospital	7.01	9.88	-	-	4,888,902	9,316,871	-	-
General hospital	7.19	8.98	7.51	9.37	4,177,018	6,443,220	4,016,406	5,931,312
Medical institution establishment								
National or Public	7.25	10.13	10.81	17.70	4,210,317	5,220,831	3,039,129	4,904,527
Private	7.05	9.53	7.47	9.20	4,709,250	8,800,009	4,029,681	5,942,951
Medical institution location								
Seoul (Capital City)	7.15	10.04	7.21	9.29	4,751,208	8,887,794	3,984,046	6,368,863
Others	6.82	8.04	8.10	9.50	4,351,265	7,065,428	4,078,828	4,979,340
Number of Hospital bed ††								
Low	7.10	9.34	6.04	8.98	4,008,030	5,015,425	2,853,519	4,165,735
Lower middle	6.48	10.84	7.50	9.34	3,964,322	7,018,794	4,265,281	6,777,861
Upper middle	6.70	8.03	8.39	9.20	4,356,322	7,069,432	4,104,195	4,737,320
High	8.65	10.56	7.81	9.78	6,844,378	13,613,888	4,053,600	5,208,907

† Z51(Other medical care); C34(Lung cancer); C50(Breast cancer); C22(Liver cancer); K80(Cholelithiasis);

†† General hospital (Q1: -299, Q2: 300-499, Q3: 500-599, Q4: 600-); Tertiary hospital (Q1: -499, Q2: 500-799, Q3: 800-999, Q4: 1000-);

Abbreviation; a Standard Deviation b Charlson Comorbidity Index

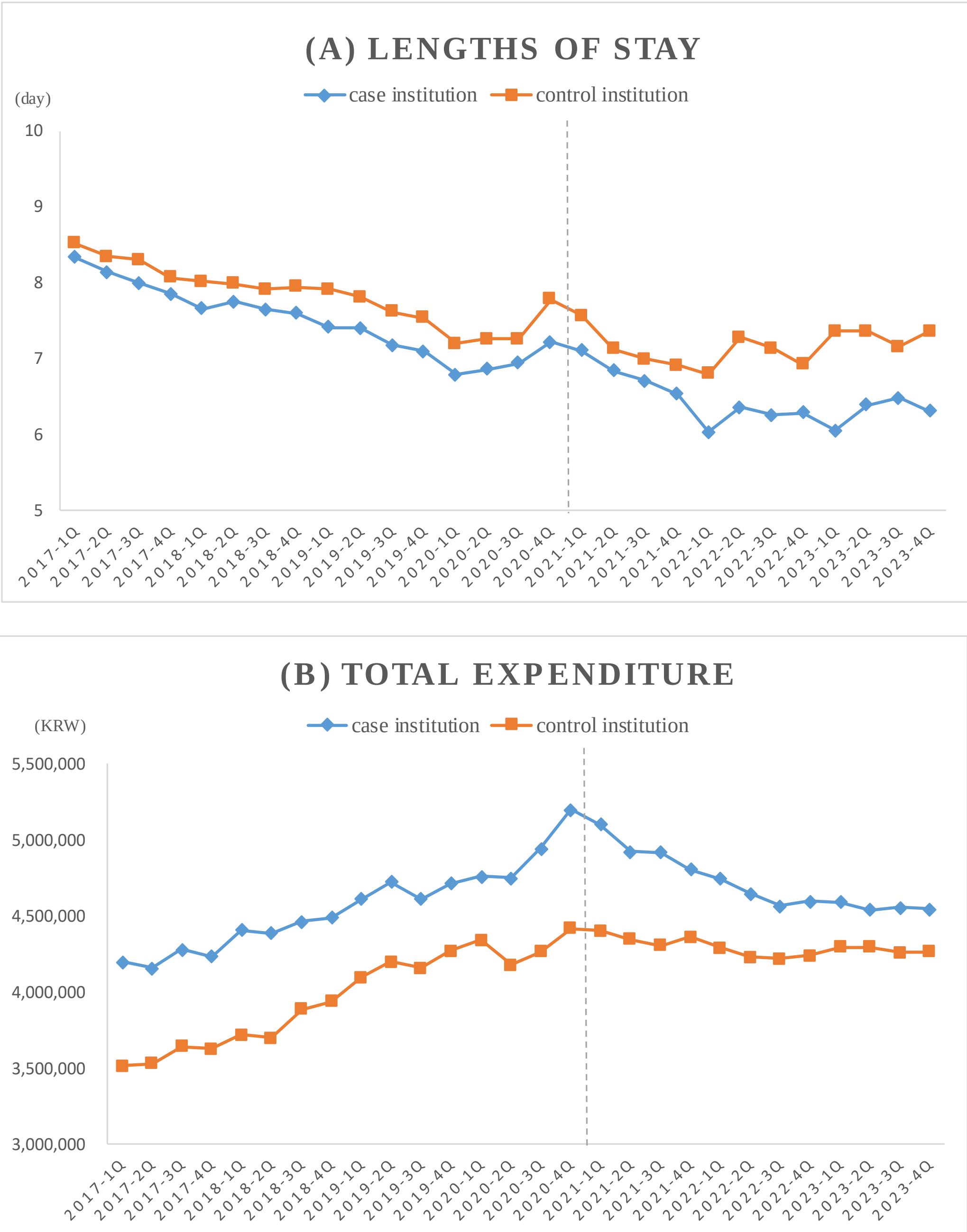


Figure 8. Trends in medical utilization according to hospitalist ward operation

Table 18. Differential change of healthcare utilization according to hospitalist ward operation in medical institution

Variables	Lengths of stay		Total expenditure	
	exp(β)	95% CI	exp(β)	95% CI
Time	0.97	(0.96 - 0.97)	1.05	(1.04 - 1.05)
Policy				
Before (2017~2021)	1.00		1.00	
After (2021~2023)	0.98	(0.97 - 1.00)	1.09	(1.06 - 1.11)
Case (Hospitalist institution)	0.97	(0.94 - 1.00)	1.14	(1.11 - 1.17)
Control (Non-Hospitalist institution)	1.00		1.00	
Case*Policy (difference, case-control)	0.93	(0.91 - 0.95)	0.96	(0.93 - 0.99)
Sex				
Male	1.01	(1.00 - 1.02)	1.05	(1.03 - 1.06)
Female	1.00		1.00	
Age				
-9	0.69	(0.64 - 0.74)	0.56	(0.48 - 0.65)
10-19	0.82	(0.78 - 0.87)	0.82	(0.73 - 0.92)
20-29	0.83	(0.80 - 0.86)	0.92	(0.87 - 0.97)
30-39	0.78	(0.76 - 0.81)	0.86	(0.83 - 0.89)
40-49	0.79	(0.78 - 0.81)	0.87	(0.85 - 0.90)
50-59	0.85	(0.83 - 0.86)	0.91	(0.89 - 0.93)
60-69	0.87	(0.86 - 0.89)	0.89	(0.87 - 0.90)
70-79	0.92	(0.90 - 0.93)	0.92	(0.90 - 0.94)
80-	1.00		1.00	
Region				
Metropolitan	0.96	(0.94 - 0.97)	0.95	(0.93 - 0.97)
Urban	1.05	(1.03 - 1.07)	1.05	(1.03 - 1.08)
Rural	1.00		1.00	
Income level				
Low	1.01	(1.00 - 1.03)	0.99	(0.97 - 1.01)
Lower middle	1.01	(0.99 - 1.02)	1.00	(0.98 - 1.02)
Upper middle	1.01	(1.00 - 1.02)	1.00	(0.98 - 1.02)
High	1.00		1.00	
Medical insurance				
National health insurance	0.92	(0.90 - 0.94)	0.99	(0.96 - 1.01)
Medical aid	1.00		1.00	
Surgery				
No	0.44	(0.44 - 0.44)	0.26	(0.26 - 0.26)
Yes	1.00		1.00	
Hospitalization route				
Through walk-in or outpatient	0.76	(0.75 - 0.77)	0.90	(0.89 - 0.92)
Through Emergency room	1.00		1.00	

CCI score								
0-2	0.93	(0.92	-	0.95)	1.00	(0.98	-	1.02)
3-4	0.98	(0.97	-	1.00)	1.02	(1.00	-	1.04)
5-6	1.00				1.00			
Medical department								
Internal medicine	1.11	(1.10	-	1.13)	1.20	(1.17	-	1.22)
General Surgery	0.93	(0.91	-	0.95)	0.94	(0.92	-	0.96)
Pediatrics	1.36	(1.28	-	1.46)	1.63	(1.42	-	1.86)
Others	1.00				1.00			
Main Diagnosis †								
Z51	0.73	(0.72	-	0.74)	1.00	(0.97	-	1.03)
C34	1.11	(1.09	-	1.13)	1.26	(1.23	-	1.28)
C50	0.76	(0.74	-	0.77)	0.89	(0.87	-	0.91)
C22	0.83	(0.81	-	0.85)	0.89	(0.87	-	0.92)
K80	0.58	(0.57	-	0.58)	0.63	(0.62	-	0.63)
Others	1.00				1.00			
Medical institution type								
Tertiary hospital	0.89	(0.88	-	0.91)	0.93	(0.91	-	0.96)
General hospital	1.00				1.00			
Medical institution establishment								
National or Public	1.14	(1.11	-	1.17)	1.21	(1.18	-	1.25)
Private	1.00				1.00			
Medical institution region								
Seoul (Capital City)	1.03	(1.02	-	1.05)	1.12	(1.09	-	1.15)
Others	1.00				1.00			
Number of Hospital bed ††								
Low	0.91	(0.89	-	0.93)	0.66	(0.63	-	0.68)
Lower middle	0.98	(0.97	-	1.00)	0.78	(0.76	-	0.80)
Upper middle	0.93	(0.91	-	0.94)	0.81	(0.80	-	0.83)
High	1.00				1.00			

† Z51(Other medical care); C34(Lung cancer); C50(Breast cancer); C22(Liver cancer); K80(Cholelithiasis);
†† General hospital (Q1: -299, Q2: 300-499, Q3: 500-599, Q4: 600-); Tertiary hospital (Q1: -499, Q2: 500-799, Q3: 800-999, Q4: 1000-);
* adjusted for sex, age, region, income level, medical insurance, surgery, hospitalization route, CCI score, medical department, main diagnosis, medical institution type, medical institution establishment, medical institution region, and number of hospital bed
Abbreviation; a Standard Deviation b Charlson Comorbidity Index

3) Differential changes over time in hospital-acquired complications following hospitalist ward operation in medical institution

The changes in the distribution of HAC before and after the intervention in the case and control groups are presented in Table 19. The overall incidence of HACs was 6.6% (N=23,331) in the case group and 5.9% (N=6,163) in the control group. Following the start of the hospitalist project's official implementation period in 2021, the HAC in the case group decreased from 8.2% (N=17,428) before implementation to 4.3% (N=5,903) after implementation, reflecting a reduction of 3.9 percentage points. In contrast, the control group showed a smaller decrease, from 6.2% (N=4,115) before to 5.5% (N=2,048) after, a decrease of 0.7 percentage points.

Figure 9 shows the change in the proportion of HAC of the case and control groups by time point. The HAC met a parallel trend assumption in the case and control groups before intervention period (Appendix 6-7). The difference between the two groups before intervention was not statistically significant (p=0.0673)

The results of the DID analysis of HAC before and after the intervention are shown in Table 20. This result presents the differential change of HAC in the case and control groups. The differential changes in HAC was 43% lower in the case group than in the control group (exp(β): 0.57, 95% CI: 0.52–0.63).

Table 19. Changes of hospital-acquired complications among inpatients by before and after policy intervention

Variables	Total	HAC (Hospital-acquired complications)											
		Case (Hospitalist institution)						Control (Non- Hospitalist institution)					
		Total		Yes		No		Total		Yes		No	
	N	N	%	N	%	N	%	N	%	N	%	N	%
Total	455,238	351,591	100.0	23,331	6.6	328,260	93.4	103,647	100.0	6,163	5.9	97,484	94.1
Policy													
Before (2017~2021)	279,106	212,781	60.5	17,428	8.2	207,788	97.7	66,325	64.0	4,115	6.2	62,210	93.8
After (2021~2023)	176,132	138,810	39.5	5,903	4.3	120,472	86.8	37,322	36.0	2,048	5.5	35,274	94.5
Sex													
Men	232,625	181,554	51.6	11,922	6.6	169,632	93.4	51,071	49.3	3,051	6.0	48,020	94.0
Women	222,613	170,037	48.4	11,409	6.7	158,628	93.3	52,576	50.7	3,112	5.9	49,464	94.1
Age													
-9	13,755	9,671	2.8	1,593	16.5	8,078	83.5	4,084	3.9	526	12.9	3,558	87.1
10-19	8,163	6,906	2.0	618	8.9	6,288	91.1	1,257	1.2	52	4.1	1,205	95.9
20-29	11,405	8,712	2.5	593	6.8	8,119	93.2	2,693	2.6	79	2.9	2,614	97.1
30-39	20,286	15,215	4.3	864	5.7	14,351	94.3	5,071	4.9	130	2.6	4,941	97.4
40-49	48,965	38,401	10.9	2,079	5.4	36,322	94.6	10,564	10.2	349	3.3	10,215	96.7
50-59	93,500	74,152	21.1	3,812	5.1	70,340	94.9	19,348	18.7	734	3.8	18,614	96.2
60-69	124,669	99,084	28.2	5,730	5.8	93,354	94.2	25,585	24.7	1,310	5.1	24,275	94.9
70-79	93,820	71,866	20.4	5,340	7.4	66,526	92.6	21,954	21.2	1,514	6.9	20,440	93.1
80-	40,675	27,584	7.8	2,702	9.8	24,882	90.2	13,091	12.6	1,469	11.2	11,622	88.8
Region													
Metropolitan	370,271	282,194	80.3	18,689	6.6	263,505	93.4	88,077	85.0	5,199	5.9	82,878	94.1
Urban	48,014	39,867	11.3	2,755	6.9	37,112	93.1	8,147	7.9	471	5.8	7,676	94.2
Rural	36,953	29,530	8.4	1,887	6.4	27,643	93.6	7,423	7.2	493	6.6	6,930	93.4

Income level													
Low	117,072	87,439	24.9	5,799	6.6	81,640	93.4	29,633	28.6	1,861	6.3	27,772	93.7
Lower middle	80,630	62,086	17.7	3,875	6.2	58,211	93.8	18,544	17.9	970	5.2	17,574	94.8
Upper middle	104,827	80,847	23.0	5,343	6.6	75,504	93.4	23,980	23.1	1,291	5.4	22,689	94.6
High	152,709	121,219	34.5	8,314	6.9	112,905	93.1	31,490	30.4	2,041	6.5	29,449	93.5
Medical insurance													
National health insurance	424,157	330,360	94.0	21,886	6.6	308,474	93.4	93,797	90.5	5,520	5.9	88,277	94.1
Medical aid	31,081	21,231	6.0	1,445	6.8	19,786	93.2	9,850	9.5	643	6.5	9,207	93.5
Surgery status													
No	306,490	236,841	67.4	14,866	6.3	221,975	93.7	69,649	67.2	3,815	5.5	65,834	94.5
Yes	148,748	114,750	32.6	8,465	7.4	106,285	92.6	33,998	32.8	2,348	6.9	31,650	93.1
Hospitalization route													
Through walk-in or outpatient	360,948	285,845	81.3	15,263	5.3	270,582	94.7	75,103	72.5	3,392	4.5	71,711	95.5
Through Emergency room	94,290	65,746	18.7	8,068	12.3	57,678	87.7	28,544	27.5	2,771	9.7	25,773	90.3
CCI score [a]													
0-2	285,979	213,619	60.8	14,349	6.7	199,270	93.3	72,360	69.8	4,307	6.0	68,053	94.0
3-4	60,804	49,856	14.2	3,339	6.7	46,517	93.3	10,948	10.6	784	7.2	10,164	92.8
5-6	108,455	88,116	25.1	5,643	6.4	82,473	93.6	20,339	19.6	1,072	5.3	19,267	94.7
Medical department													
Internal medicine	230,897	179,925	51.2	12,620	7.0	167,305	93.0	50,972	49.2	3,737	7.3	47,235	92.7
General Surgery	139,504	102,919	29.3	4,578	4.4	98,341	95.6	36,585	35.3	999	2.7	35,586	97.3
Pediatrics	18,893	14,147	4.0	2,018	14.3	12,129	85.7	4,746	4.6	559	11.8	4,187	88.2
Others	65,944	54,600	15.5	4,115	7.5	50,485	92.5	11,344	10.9	868	7.7	10,476	92.3

Main Diagnosis †													
Z51	90,785	71,721	20.4	1,813	2.5	69,908	97.5	19,064	18.4	316	1.7	18,748	98.3
C34	31,413	25,043	7.1	3,059	12.2	21,984	87.8	6,370	6.1	928	14.6	5,442	85.4
C50	33,698	28,169	8.0	1,862	6.6	26,307	93.4	5,529	5.3	205	3.7	5,324	96.3
C22	23,022	18,454	5.2	979	5.3	17,475	94.7	4,568	4.4	223	4.9	4,345	95.1
K80	25,469	16,891	4.8	538	3.2	16,353	96.8	8,578	8.3	227	2.6	8,351	97.4
Others	250,851	191,313	54.4	15,080	7.9	176,233	92.1	59,538	57.4	4,264	7.2	55,274	92.8
Medical institution type													
Tertiary hospital	236,439	236,439	67.2	15,775	6.7	220,664	93.3	0	0.0	-	-	-	-
General hospital	218,799	115,152	32.8	7,556	6.6	107,596	93.4	103,647	100.0	6,163	5.9	97,484	94.1
Medical institution establishment													
National or Public	39,091	37,702	10.7	2,514	6.7	35,188	93.3	1,389	1.3	200	14.4	1,189	85.6
Private	416,147	313,889	89.3	20,817	6.6	293,072	93.4	102,258	98.7	5,963	5.8	96,295	94.2
Medical institution location													
Seoul (Capital City)	335,932	267,672	76.1	18,234	6.8	249,438	93.2	68,260	65.9	3,986	5.8	64,274	94.2
Others	119,306	83,919	23.9	5,097	6.1	78,822	93.9	35,387	34.1	2,177	6.2	33,210	93.8
Number of Hospital bed ††													
Low	70,696	57,098	16.2	3,373	5.9	53,725	94.1	13,598	13.1	642	4.7	12,956	95.3
Lower middle	150,952	96,290	27.4	6,211	6.5	90,079	93.5	54,662	52.7	3,344	6.1	51,318	93.9
Upper middle	150,372	132,727	37.8	7,701	5.8	125,026	94.2	17,645	17.0	1,006	5.7	16,639	94.3
High	83,218	65,476	18.6	6,046	9.2	59,430	90.8	17,742	17.1	1,171	6.6	16,571	93.4

† Z51(Other medical care); C34(Lung cancer); C50(Breast cancer); C22(Liver cancer); K80(Cholelithiasis);
†† General hospital (Q1: -299, Q2: 300-499, Q3: 500-599, Q4: 600-); Tertiary hospital (Q1: -499, Q2: 500-799, Q3: 800-999, Q4: 1000-);
Abbreviation; a Charlson Comorbidity Index

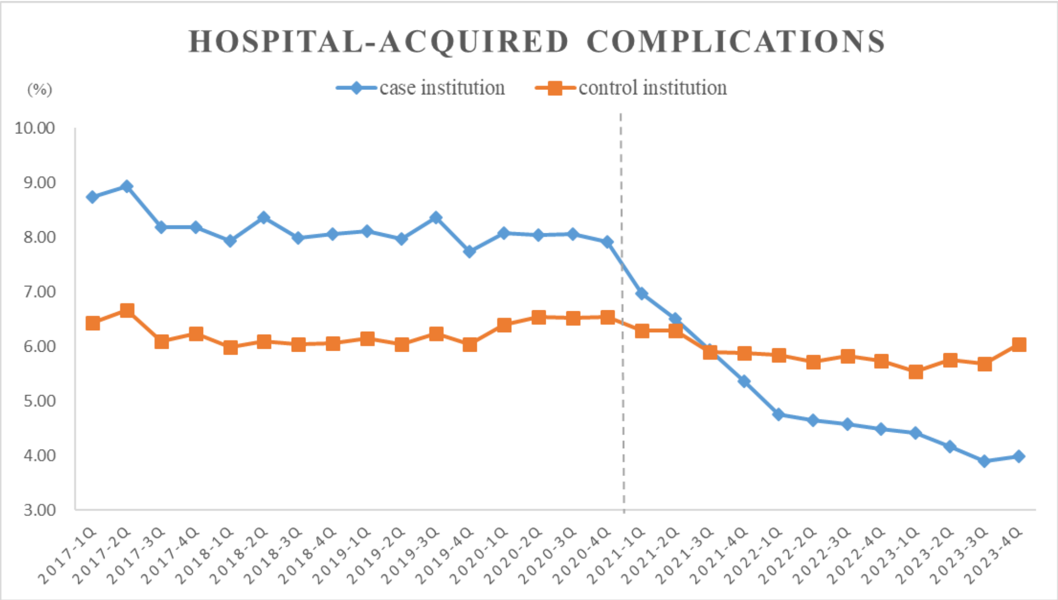


Figure 9. Trends in hospital-acquired complications according to hospitalist ward operation

Table 20. Differential change of hospital-acquired complications according to hospitalist ward operation in medical institution

Variables	HAC (Hospital-acquired complications)			
	exp(β)	95% CI		
Time	0.96	(0.94	-	0.98)
Policy				
Before (2017~2021)	1.00			
After (2021~2023)	0.63	(0.50	-	0.74)
Case (Hospitalist institution)	1.01	(0.97	-	1.08)
Control (Non-Hospitalist institution)	1.00			
Case*Policy (difference, case-control)	0.57	(0.52	-	0.63)
Sex				
Male	0.88	(0.85	-	0.92)
Female	1.00			
Age				
-9	1.01	(0.65	-	1.21)
10-19	0.49	(0.34	-	0.73)
20-29	0.51	(0.45	-	0.57)
30-39	0.52	(0.47	-	0.58)
40-49	0.59	(0.54	-	0.64)
50-59	0.58	(0.54	-	0.62)
60-69	0.64	(0.61	-	0.68)
70-79	0.79	(0.74	-	0.83)
80-	1.00			
Region				
Metropolitan	1.01	(0.94	-	1.08)
Urban	1.06	(0.97	-	1.16)
Rural	1.00			
Income level				
Low	1.09	(1.03	-	1.15)
Lower middle	1.02	(0.96	-	1.07)
Upper middle	1.01	(0.96	-	1.07)
High	1.00			
Medical insurance				
National health insurance	1.02	(0.93	-	1.11)
Medical aid	1.00			
Surgery				
No	0.74	(0.71	-	0.76)
Yes	1.00			

Hospitalization route				
Through walk-in or outpatient	0.47	(0.46	-	0.49)
Through Emergency room	1.00			
CCI score [a]				
0-2	0.76	(0.72	-	0.81)
3-4	0.89	(0.83	-	0.95)
5-6	1.00			
Medical department				
Internal medicine	1.02	(0.97	-	1.07)
General Surgery	0.63	(0.58	-	0.67)
Pediatrics	1.89	(1.37	-	2.57)
Others	1.00			
Main Diagnosis †				
Z51	0.39	(0.36	-	0.43)
C34	1.68	(1.58	-	1.78)
C50	1.20	(1.11	-	1.31)
C22	0.61	(0.56	-	0.69)
K80	0.39	(0.36	-	0.43)
Others	1.00			
Medical institution type				
Tertiary hospital	0.65	(0.60	-	0.70)
General hospital	1.00			
Medical institution establishment				
National or Public	1.57	(1.44	-	1.72)
Private	1.00			
Medical institution region				
Seoul (Capital City)	1.13	(1.04	-	1.23)
Others	1.00			
Number of Hospital bed††				
Low	0.52	(0.47	-	0.58)
Lower middle	0.95	(0.89	-	1.01)
Upper middle	0.71	(0.66	-	0.77)
High	1.00			

† Z51(Other medical care); C34(Lung cancer); C50(Breast cancer); C22(Liver cancer); K80(Cholelithiasis);
†† General hospital (Q1: -299, Q2: 300-499, Q3: 500-599, Q4: 600-); Tertiary hospital (Q1: -499, Q2: 500-799, Q3: 800-999, Q4: 1000-);
* adjusted for sex, age, region, income level, medical insurance, surgery, hospitalization route, CCI score, medical department, main diagnosis, medical institution type, medical institution establishment, medical institution region, and number of hospital bed
Abbreviation; a Charlson Comorbidity Index

4) Differential changes over time in additional outcomes following hospitalist ward operation in medical institution

(1) Primary outcome

Compared to the changes observed in the control group, the hospitalist ward group showed a 6% greater relative reduction in OOP after the policy implementation (exp(β): 0.94, 95% CI: 0.91–0.97). In contrast, expense per day increased by 8% more in the hospitalist group compared to the control group (exp(β): 1.08, 95% CI: 1.04–1.12). Additionally, compared to the control group, the case group had a 28% larger reduction in thromboembolism (exp(β): 0.72, 95% CI: 0.60–0.82), a 24% greater reduction in pressure ulcers (exp(β): 0.76, 95% CI: 0.67–0.88), a 22% greater reduction in urinary tract infections (exp(β): 0.68, 95% CI: 0.53–0.77), and a 24% greater reduction in pneumonia (exp(β): 0.66, 95% CI: 0.55–0.78). The reduction in intrahospital ICU transfers was 37% greater (exp(β): 0.63, 95% CI: 0.57–0.70), and the difference in post-procedural complications was the most substantial, with a 61% greater reduction in the hospitalist group compared to the control group (exp(β): 0.39, 95% CI: 0.29–0.53).

(2) Secondary outcome

Regarding mortality, the reduction in in-hospital death was 15% greater in the hospitalist group relative to the control group (exp(β): 0.85, 95% CI: 0.77–0.94), and 30-day post-discharge mortality was reduced by 10% more in the hospitalist group (exp(β): 0.90, 95% CI: 0.83–0.99). In terms of 30-day readmission outcomes, no statistically significant relative differences were observed between the case and control groups (Table 21).

Table 21. Differential changes over time in additional outcomes following hospitalist ward operation in medical institution

Variables*	Case*Policy (difference, case-control)	
	exp(β)	95% CI
Primary Outcomes		
Medical Expenses		
Out of pocket	0.94	(0.91 - 0.97)
Expense per day	1.08	(1.04 - 1.12)
Hospital-acquired complications		
Thromboembolism	0.72	(0.60 - 0.82)
Pressure ulcer	0.76	(0.67 - 0.88)
Urinary Tract Infection	0.68	(0.53 - 0.77)
Pneumonia	0.66	(0.55 - 0.78)
Intrahospital ICU Transfers	0.63	(0.57 - 0.70)
Post-procedural complication	0.39	(0.29 - 0.53)
Secondary Outcomes		
Mortality		
In-hospital death	0.85	(0.77 - 0.94)
30-days mortality after discharge	0.90	(0.83 - 0.99)
30-days readmission		
All-cause readmission	0.95	(0.90 - 1.01)
Same institution	0.96	(0.91 - 1.02)
Same disease	0.95	(0.89 - 1.01)
Same institution and disease	1.00	(0.93 - 1.06)

* adjusted for sex, age, region, income level, medical insurance, surgery, hospitalization route, CCI score, medical department, main diagnosis, medical institution type, medical institution establishment, medical institution region, and number of hospital bed

V. Discussion

1. Discussion of the Study Methods

This study was designed as a nationwide observational study using claims cohort data from the NHIS to evaluate the effectiveness of the hospitalist system in Korea. To enhance internal validity and minimize heterogeneity between patient groups according to ward type, we applied exact matching on key clinical variables such as medical department, primary diagnosis, hospital type, and surgical status, thereby ensuring balanced case-mix between the hospitalist and conventional ward groups. This methodological approach distinguishes our study from prior research on the Korea hospitalist system, which often relied on data from single institutions or focused disproportionately on large tertiary hospitals where patients tend to present with greater clinical severity.[32,75-77] Such earlier studies, while valuable, may have understated the effects of hospitalist care due to unmeasured confounding related to hospital-level characteristics or patient acuity.

Given the potential for repeated admissions within individuals, we employed GEE models to analyze the data. GEE accounts for the within-subject correlation inherent in repeated measures and prevents the underestimation of standard errors, thereby yielding robust parameter estimates. Beyond assessing average differences between conventional and hospitalist wards, this study conducted stratified analyses based on the operational type of hospitalist wards. This analytic approach allowed us to explore how structural variations in ward design influence patient-level healthcare utilization, offering empirical evidence for optimizing ward organization and physician staffing in policy planning. Furthermore, to estimate the causal impact of the hospitalist program implementation, we incorporated a DID approach as a quasi-experimental analytical strategy.[89,90] By comparing changes in outcomes before and after the program implementation between case and control institutions, the DID model enabled us to isolate the effect attributable to the introduction of hospitalist wards, rather than pre-existing differences.[91] Matching was performed at the hospital level, ensuring that the program initiation timing and ward type status were properly aligned across institutions, thereby reducing the potential for endogeneity due to ward transitions.

While conventional epidemiological designs such as cohort and case-control studies are instrumental in elucidating disease etiology, their applicability to intervention studies is often limited due to confounding from baseline group differences and biases like the healthy user effect.[94] Although randomized controlled trials are considered the gold standard for evaluating intervention efficacy, they are not always feasible particularly in the context of population-wide health policies or retrospective assessments of interventions already implemented without randomization or control groups.[95] Therefore, our methodological strategies collectively enhanced the analytical precision and policy relevance of this study, providing a rigorous and multidimensional assessment of the hospitalist system impact.

Therefore, from a methodological standpoint, this study is distinguished by several strengths. First, we utilized population-based NHIS inpatient claims data, allowing for a nationally representative analysis with broad generalizability. Second, we assessed both patient-level and institution-level outcomes, thereby providing a multidimensional evaluation of the hospitalist model from clinical and operational perspectives. Third, the integration of robust analytic techniques improved internal validity and supported causal inference. Lastly, the classification of hospitalist ward types by structural and operational features enabled a nuanced assessment of heterogeneous effects, offering evidence-based guidance for optimizing hospitalist service delivery. Together, these methodological approaches go beyond simple outcome comparisons and contribute to a more understanding of the hospitalist system as a structural healthcare reform.

Nevertheless, this study has several limitations that warrant consideration. First, the claims data used in this analysis do not capture important clinical and psychosocial variables, such as illness severity, functional status, patient preferences, or socioeconomic context. Although matching and covariate adjustment were conducted using available variables, the possibility of residual confounding cannot be entirely excluded. Second, ward-level contextual factors such as organizational culture, nursing workforce capacity, leadership engagement, and adherence to clinical protocols were not directly measured in this study. These unobserved variables may influence the effectiveness of hospitalist care and could partly explain the variation observed across different ward types. Future research incorporating qualitative data or mixed-method designs could further elucidate how institutional environments mediate the effects of hospitalist implementation. Third, while this study focused on patient-centered outcomes and healthcare utilization metrics, it did not examine how the hospitalist model affects the clinical workforce particularly physician burnout, job satisfaction, or inter-professional collaboration. Understanding how hospitalist implementation affects provider well-being and team dynamics is essential for evaluating the long-term sustainability of the model. Fourth, this study was conducted using data from the early stages of hospitalist official program implementation in Korea. As such, it may not reflect the long-term impacts of the program, such as the cumulative effects of physician learning, institutional adaptation, or system-level scaling. Longitudinal follow-up studies are needed to capture the evolving dynamics of hospitalist model maturity over time. Fifth, this study excluded inpatient cases in which patients moved between hospitalist and general wards during a single hospitalization. While some may argue this conflicts with the intention-to-treat principle or selectively excludes more severe patients, such transitions introduce ambiguity in attributing outcomes to a specific ward type. Moreover, claims data do not indicate the sequence of ward assignments, limiting causal interpretation. ICU transfers were included, as they are relevant to outcome evaluation, but the order of ICU and hospitalist ward stays remains indeterminable.

Nonetheless, ICU-to-hospitalist transitions are rare in practice, and the potential impact on study validity is likely minimal. Sixth, this study applied GEE using individual cases to account due to repeated admissions. However, a known limitation of GEE models is their sensitivity to missing data, particularly when applied at the individual data. Since GEE relies on complete cases to estimate correlation structures, even partial missingness in repeated measures can lead to case-wise deletion and potential sample loss. Future studies may consider aggregate level to test the robustness of results under different missing data assumptions. Lastly, as the NHIS cohort database was originally designed for administrative and billing purposes, the ICD-10 diagnostic codes used in claims may lack sufficient clinical granularity to fully capture patients' conditions. Additionally, the possibility of incomplete or inconsistent coding raises concerns regarding potential misclassification or underestimation of certain outcomes.[96-98]

2. Discussion of the Results

This study evaluated the impact of hospitalist ward implementation on healthcare utilization and health outcomes among inpatients using comprehensive claims data from the Korean National Health Insurance Service. By employing two frameworks, the study aimed to assess not only the average treatment effect of hospitalist wards but also the structural and temporal heterogeneity of their impact, offering a multidimensional understanding of the effectiveness of this inpatient care model.

First, patients admitted to hospitalist wards had significantly shorter LOS and lower medical expenditures than those in conventional wards. These findings can be attributed to the structural characteristics of hospitalist wards, which facilitate continuous and accountable care by enabling attending physicians to remain physically present throughout the hospitalization period. These results are consistent with prior international studies, which have shown that hospitalists improve clinical efficiency by reducing delays in care processes and expediting discharge planning.[25,57,60,61] Notably, no significant difference was observed in expense per day between groups; in fact, a slight increase in per diem expenditure was found in some analyses. This likely reflects more intensive care delivered over a shorter duration, suggesting that hospitalist wards may compress the trajectory of care without compromising quality.[99]

Second, the incidence of HACs was significantly lower in hospitalist wards, especially in terms of urinary tract infections, pneumonia, ICU transfers, and postoperative complications. This likely reflects the ability of hospitalists to closely monitor patients, rapidly identify clinical deterioration, and implement timely interventions[62,64]. However, no significant group differences were observed for thromboembolism and pressure ulcers. These outcomes may be influenced by factors beyond ward structure, including baseline immobility, nutritional status, and comorbid conditions.[100,101] Moreover, evidence suggests that adherence to standardized prophylactic protocols particularly for thromboembolism may attenuate inter-ward variability in these complications.[102] . In the case of pressure ulcers, environmental factors and nursing care processes likely play a more decisive role, suggesting that hospitalist presence alone may not suffice to reduce these events.[100]

Third, both in-hospital and 30-day post-discharge mortality rates were significantly lower in hospitalist wards. The larger effect size observed for in-hospital mortality suggests that hospitalist presence contributes to early recognition of clinical deterioration and more rapid initiation of life-saving interventions.[103] Additionally, all-cause 30-day readmissions, readmissions for the same diagnosis, and same-diagnosis/same-hospital readmissions were significantly reduced in the hospitalist ward group. Interestingly, readmissions to the same hospital for different diagnoses did not differ significantly between groups. This could be interpreted as a consequence of increased patient satisfaction and continuity of care, whereby patients who received hospitalist-led care may prefer to return to the same institution for future, unrelated health issues.[104] Alternatively, it is possible that hospitalists, by identifying previously undiagnosed comorbidities during the initial admission, proactively planned post-discharge follow-up with other departments, thus increasing cross-specialty re-engagement with the same facility.[105]

Fourth, among the various ward operational models, the most substantial improvements were observed in Type 3 wards defined as full-time, 7-day hospitalist coverage. Compared to Type 1 (weekday daytime only) and Type 2 (7-day daytime), Type 3 wards ensure uninterrupted physician presence, allowing for comprehensive monitoring and immediate decision-making during nights and weekends. This aligns with prior evidence suggesting that round-the-clock hospitalist coverage is associated with improved clinical outcomes, particularly for high-risk patients.[106] These findings highlight that the magnitude of hospitalist effects is not uniform but varies according to staffing intensity and temporal coverage.

Finally, the study incorporated two analyses to address potential biases and strengthen causal inference. While GEE models provide valid population-averaged estimates by accounting for within-subject correlation in repeated admissions, they are inherently limited by potential selection bias particularly in non-randomized settings. For instance, hospitals may have preferentially assigned low-acuity patients to hospitalist wards following implementation, leading to an overestimation of ward effects. To address this, we conducted a DID analysis that compared outcome trajectories before and after hospitalist ward adoption between matched intervention and control hospitals. The DID results corroborated the GEE findings, showing significantly greater reductions in LOS, medical expenditures, HAC incidence, and mortality in intervention hospitals, thus reinforcing the interpretation that these improvements were attributable to the intervention itself, rather than to selection effects. Moreover, assuming that hospitals did not substantially reallocate patient case-mix between ward types, the consistency of hospital-level improvements provides a defensible argument against unmeasured confounding. The only exception was per diem costs, which increased following hospitalist ward implementation. This may reflect higher care intensity per day as a natural consequence of reduced LOS and more focused resource utilization.[99]

In sum, this study provides robust evidence that hospitalist ward implementation enhances the efficiency and safety of inpatient care by improving discharge planning, reducing avoidable complications, and facilitating timely medical decision-making. The heterogeneity of effects across ward types further underscores the importance of operational design in realizing the full potential of hospitalist systems. As Korea moves toward national expansion of this model, our findings suggest that merely staffing wards with hospitalists is not sufficient; rather, structural features such as full-time coverage, longitudinal accountability, and incentive alignment will be critical to optimize outcomes and sustain system-level improvements.

3. Policy Implications

The results of this study underscore the hospitalist model as a compelling intervention for enhancing the efficiency, quality, and continuity of inpatient care in Korea. Given the increasing complexity of medical care, high bed occupancy rates, and the chronic shortage of medical personnel in general and tertiary hospitals, a system in which hospitalists manage inpatients continuously holds substantial promise for structural improvement in care delivery.

Reductions in length of stay and healthcare expenditures observed in hospitalist wards indicate a substantial optimization of inpatient resource use. These outcomes offer empirical support for expanding hospitalist services within institutions that struggle with throughput inefficiencies and fragmented care. To translate these effects into scalable system reform, institutional policies should prioritize infrastructure investment and workforce stabilization for hospitalist-led wards, particularly those providing full-time, seven-day coverage. National reimbursement policy could reflect this by offering tiered payment systems or performance-based incentives to hospitals that meet defined standards for hospitalist staffing and operations. In addition, the variation in effectiveness by ward operational model highlights the critical importance of how the hospitalist system is implemented.[106] The superior outcomes associated with full-time, seven-day staffing models point to the need for sustained physician presence and longitudinal accountability, particularly in high-acuity care settings.

Beyond efficiency, the hospitalist system contributes meaningfully to patient safety and clinical outcomes. The decline in hospital-acquired complications such as urinary tract infections and pneumonia suggests that continuous in-ward presence facilitates earlier detection and intervention, reducing the burden of preventable harm. These results provide a strong rationale for integrating hospitalist ward structures into broader national quality strategies and health system performance frameworks. Linking hospital accreditation or evaluation to hospitalist coverage and care intensity may be a viable pathway to institutionalize quality-driven reform. Furthermore, it strengthens the policy argument that hospitalist implementation can exert measurable impacts at the institutional level, regardless of internal patient sorting. Improvements in mortality and readmission rates further reveal the hospitalist system's capacity to bridge inpatient and post-discharge care. By maintaining responsibility throughout hospitalization, hospitalists are positioned to identify clinical deterioration early, coordinate timely discharge, and establish appropriate follow-up care plans. These capabilities suggest the need for greater formal integration between hospitalist wards and outpatient or community-based care systems.

A final but essential consideration concerns the sustainability of the hospitalist workforce. Without deliberate investment in physician recruitment and retention, the expansion of this model will face structural bottlenecks.[34] Policy frameworks must include targeted support for hospitalist training programs, career development tracks, and professional recognition systems. The elevation of the hospitalist role in medical education and governance is critical to maintaining the long-term viability of this care model. To support the widespread implementation of hospitalist, policy frameworks should strengthen the operational capacity of healthcare institutions by revising reimbursement structures and regulatory mechanisms, and by integrating performance-based evaluation to align institutional incentives with quality-driven care delivery.

Taken together, these findings provide a foundation for the strategic expansion of hospitalist services in Korea. Institutional commitment, regulatory clarity, and human capital development will be essential for translating this care model from pilot program to system-wide policy. The hospitalist model offers not only a mechanism for improving inpatient care, but a structural pivot point for reforming how hospitals organize, deliver, and sustain high-quality services.

VI. Conclusion

This study evaluated the impact of hospitalist wards on healthcare utilization and patient outcomes using nationwide claims data from Korea. Hospitalist ward admission was associated with significantly shorter lengths of stay, lower total and out-of-pocket medical costs, and reduced incidence of major hospital-acquired complications such as urinary tract infections, pneumonia, and postoperative events. In-hospital and 30-day mortality, as well as readmission rates, also declined. These effects were most prominent in wards with full-time, seven-day hospitalist coverage, highlighting the importance of continuous physician presence and operational design. The findings are consistent with international evidence, suggesting that the Korean hospitalist model yields comparable benefits in efficiency and safety. We support the hospitalist system as a scalable policy strategy for improving inpatient care in Korea. Future implementation should prioritize structural standardization, workforce investment, and reimbursement structures. Continued evaluation, including long-term and organizational outcomes, will be essential for sustainable integration of hospitalist care into the broader health system.

Abbreviations

AMUs — Acute Medicine Units

CCI — Charlson Comorbidity Index

CIs — Confidence Intervals

DID — Difference-in-Differences

ED — Emergency Department

GEE — Generalized Estimating Equation

GDP — Gross Domestic Product

HAC — Hospital-acquired Complications

ICD-10 — International Classification of Diseases Version 10

ICU — Intensive Care Unit

IRB — Institutional Review Board

NHIS — Korean National Health Insurance Service

LOS — Length of Stay

MOHW — Ministry of Health and Welfare

NPIR — Negative Pressure Isolation Room

NHI — National Health Insurance

OECD — Organization for Economic Co-operation and Development

OOP — Out-of-Pocket

SD — Standard Deviations

SMD — Standardized Mean Differences

UK — United Kingdom

US — United States

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Appendix

Appendix 1. Disease Selection in study

Categories classification of Disease	ICD-10 Codes (three-character)
Certain infectious and parasitic diseases	A02, A04, A49, A75, B15, B17, B27, B49
Neoplasm	C05, C10, C13, C15, C16, C17, C18, C19, C20, C21, C22, C23, C24, C25, C30, C34, C37, C38, C40, C41, C45, C47, C48, C49, C50, C51, C62, C64, C69, C71, C74, C75, C76, C78, C80, C86, C91, C92, C93, C96, D01, D05, D09, D30, D37, D44, D70
Endocrine, nutritional and metabolic diseases	E23, E34, E66, E71, E74, E75, E76
Diseases of the nervous system	G03, G04, G11, G12, G20, G23, G24, G30, G35, G36, G37, G40, G61, G70, G71, G93, G96
Diseases of the circulatory system	I85, I98
Diseases of the respiratory system	J12, J15, J69, J85, J86
Diseases of the digestive system	K26, K42, K43, K50, K51, K55,K56, K57, K61, K62, K65, K71, K75,K76, K80, K81, K82, K83, K85, K86, K91
Diseases of the genitourinary system	N10, N15, N35, N60
Congenital malformations, deformations and chromosomal abnormalities	Q05, Q20, Q21, Q22, Q23, Q24, Q25, Q43, Q44, Q85, Q87, Q93
Symptoms, signs and abnormal clinical and laboratory findings, NEC	R17, R89, R94
Factors influencing health status and contact with health services	Z08, Z40, Z43, Z51, Z52, Z93

Appendix 2. Weighted index applied to calculate CCI score

Conditions	ICD-10 Codes	Assigned weights
Myocardial infarction	I21, I252	1
Congestive heart failure	I50	1
Peripheral vascular disease	I702, I73	1
Cerebrovascular disease	I60, I61, I62, I63, I64, I69	1
Dementia	F00, F01, F02, F03, F051, G30, G311	1
Chronic pulmonary disease	J42, J43, J44, J45, J46, J47, J60, J61, J62, J63, J64, J65, J66, J67, J701, J703	1
Connective tissue disease	M05, M06, M30, M31, M32, M33, M34, M35, M36, M45	1
Peptic ulcer	K25, K26, K27, K28	1
Mild liver disease	B18, K704, K711, K7131, K714, K715, K73, Z944	1
Diabetes without chronic complication	E100, E101, E106, E108, E109,E110, E111, E116, E118, E119, E120, E121, E126, E128, E129, E130, E131, E136, E138, E139, E140, E141, E146, E148, E149	1
Diabetes with chronic complication	E102, E103, E104, E105, E107, E112, E113, E114, E115, E117, E122, E123, E124, E125, E127, E132, E133, E134, E135, E137, E142, E143, E144, E145, E147	2
Hemiplegia	G041, G114, G801, G81, G82, G830, G831, G832, G833, G834, G839	2
Chronic renal disease	N18, Z940, Z491, Z492, Z992, T861	2
Cancer without metastasis	C00,C01,C02,C03,C04,C05,C06,C07,C08,C09, C10,C11,C12,C13,C14,C15,C16,C17,C18,C19, C20,C21,C22,C23,C24,C25,C26,C30,C31,C32, C33,C34,C37,C38,C39,C40,C41,C43,C45,C46, C47,C48,C49,C50,C51,C52,C53,C54,C55,C56, C57,C58,C60,C61,C62,C63,C64,C65,C66,C67, C68,C69,C70,C71,C72,C73,C74,C75,C76,C81, C82,C83,C84,C85,C88,C90,C91,C92,C93,C94, C95,C96,C97	2
Moderate or severe liver disease	K703, K717, K721, K729, K743, K744, K745, K746, I85, I864, I982	3
Metastatic carcinoma	C77, C78, C79, C80	6
AIDS	B20, B21, B22, B24	6

Appendix 3. Covariate balance of all study population before matching

Variables	Total		Type of inpatient ward				*SMD*[a]
			Conventional ward		Hospitalist ward		
			N	%	N	%	
Total	1,397,103	100.0	1,245,621	89.2	151,482	10.8	
Sex							0.0063
Male	716,372	51.3	638,275	51.2	78,097	51.6	
Female	680,731	48.7	607,346	48.8	73,385	48.4	
Age							0.2809
-9	39,984	2.9	30,080	2.4	9,904	6.5	
10-19	25,438	1.8	18,977	1.5	6,461	4.3	
20-29	31,960	2.3	28,518	2.3	3,442	2.3	
30-39	60,642	4.3	54,704	4.4	5,938	3.9	
40-49	148,742	10.6	134,353	10.8	14,389	9.5	
50-59	273,201	19.6	245,377	19.7	27,824	18.4	
60-69	392,471	28.1	351,276	28.2	41,195	27.2	
70-79	285,660	20.4	256,517	20.6	29,143	19.2	
80-	139,005	9.9	125,819	10.1	13,186	8.7	
Region							0.0720
Metropolitan	906,702	64.9	804,047	64.5	102,655	67.8	
Urban	344,693	24.7	310,727	24.9	33,966	22.4	
Rural	145,708	10.4	130,847	10.5	14,861	9.8	
Income level							0.0934
Low	384,047	27.5	345,982	27.8	38,065	25.1	
Lower middle	237,495	17.0	212,704	17.1	24,791	16.4	
Upper middle	323,284	23.1	287,983	23.1	35,301	23.3	
High	452,277	32.4	398,952	32.0	53,325	35.2	
Medical insurance							0.0757
National health insurance	1,300,566	93.1	1,157,087	92.9	143,479	94.7	
Medical aid	96,537	6.9	88,534	7.1	8,003	5.3	
Surgery							0.1265
No	873,223	62.5	786,894	63.2	86,329	57.0	
Yes	523,880	37.5	458,727	36.8	65,153	43.0	
Hospitalization route							0.2637
Through walk-in or outpatient	1,202,072	86.0	1,085,266	87.1	116,806	77.1	
Through emergency room	195,031	14.0	160,355	12.9	34,676	22.9	
CCI score [b]							0.0790
0-2	901,576	64.5	800,357	64.3	101,219	66.8	
3-4	222,194	15.9	197,946	15.9	24,248	16.0	
5-6	273,333	19.6	247,318	19.9	26,015	17.2	

Medical department							0.3800
Internal medicine	722,973	51.7	656,018	52.7	66,955	44.2	
General Surgery	416,552	29.8	363,324	29.2	53,228	35.1	
Pediatrics	57,804	4.1	41,333	3.3	16,471	10.9	
Others	199,774	14.3	184,946	14.8	14,828	9.8	
Main Diagnosis †							0.2194
Z51	286,279	20.5	263,969	21.2	22,310	14.7	
C34	94,840	6.8	83,615	6.7	11,225	7.4	
C50	92,347	6.6	82,529	6.6	9,818	6.5	
C18	80,014	5.7	72,188	5.8	7,826	5.2	
C16	93,809	6.7	86,523	6.9	7,286	4.8	
Others	749,814	53.7	656,797	52.7	93,017	61.4	
Medical institution type							0.5016
Tertiary hospital	826,137	59.1	705,916	56.7	120,221	79.4	
General hospital	570,966	40.9	539,705	43.3	31,261	20.6	
Medical institution establishment							0.0495
National or Public	283,989	20.3	250,468	20.1	33,521	22.1	
Private	1,113,114	79.7	995,153	79.9	117,961	77.9	
Medical institution location							0.5197
Seoul	489,689	35.1	407,493	32.7	82,196	54.3	
Gyeonggi, Incheon	337,282	24.1	299,220	24.0	38,062	25.1	
Others	570,132	40.8	538,908	43.3	31,224	20.6	
Number of Hospital bed ††							0.5255
Low	276,143	19.8	260,060	20.9	16,083	10.6	
Lower middle	519,553	37.2	475,945	38.2	43,608	28.8	
Upper middle	278,154	19.9	253,783	20.4	24,371	16.1	
High	323,253	23.1	255,833	20.5	67,420	44.5	
Hospitalization year							0.0246
2021	443,720	31.8	397,387	31.9	46,333	30.6	
2022	468,706	33.5	417,879	33.5	50,827	33.6	
2023	484,677	34.7	430,355	34.5	54,322	35.9	

† Z51(Other medical care); C34(Lung cancer); C50(Breast cancer); C22(Liver cancer); K80(Cholelithiasis);
†† General hospital (Q1: -299, Q2: 300-499, Q3: 500-699, Q4: 700-); Tertiary hospital (Q1: -699, Q2: 700-999, Q3: 1000-1499, Q4: 1500-);
Abbreviation; a Standard Mean Difference, b Charlson Comorbidity Index

Appendix 4. Results of subgroup analysis stratified by covariates between inpatient cases

Variables	Conventional ward	Hospitalist ward					
		Lengths of stay		Total expenditure		HAC[b]	
	exp(β)	exp(β)	95% CI	exp(β)	95% CI	exp(β)	95% CI
Sex							
Men	1.00	0.87	(0.86 - 0.89)	0.85	(0.83 - 0.88)	0.95	. - .
Women	1.00	0.86	(0.85 - 0.87)	0.89	(0.87 - 0.91)	0.63	(0.58 - 0.68)
Age							
-9	1.00	0.98	(0.89 - 1.07)	1.00	(0.83 - 1.19)	0.88	. - .
10-19	1.00	0.67	(0.60 - 0.75)	0.52	(0.40 - 0.67)	0.85	. - .
20-29	1.00	0.88	(0.78 - 0.99)	0.81	(0.62 - 1.06)	1.11	. - .
30-39	1.00	0.86	(0.81 - 0.91)	0.90	(0.83 - 0.97)	0.61	(0.40 - 0.93)
40-49	1.00	0.85	(0.83 - 0.88)	0.91	(0.88 - 0.95)	0.43	. - .
50-59	1.00	0.88	(0.86 - 0.90)	0.90	(0.87 - 0.93)	0.61	. - .
60-69	1.00	0.87	(0.85 - 0.89)	0.88	(0.86 - 0.90)	0.91	(0.82 - 1.01)
70-79	1.00	0.86	(0.84 - 0.88)	0.86	(0.84 - 0.88)	0.88	(0.79 - 0.98)
80-	1.00	0.85	(0.81 - 0.88)	0.85	(0.81 - 0.88)	0.86	(0.75 - 0.99)
Region							
Metropolitan	1.00	0.87	(0.86 - 0.88)	0.89	(0.87 - 0.91)	0.74	(0.69 - 0.79)
Urban	1.00	0.87	(0.85 - 0.90)	0.84	(0.80 - 0.88)	0.87	(0.78 - 0.98)
Rural	1.00	0.85	(0.82 - 0.88)	0.86	(0.82 - 0.90)	0.92	(0.79 - 1.08)
Medical insurance							
National health insurance	1.00	0.87	(0.86 - 0.88)	0.87	(0.85 - 0.89)	0.77	(0.73 - 0.82)
Medical aid	1.00	0.88	(0.83 - 0.92)	0.86	(0.81 - 0.92)	1.00	(0.80 - 1.25)
Income level							
Low	1.00	0.89	(0.87 - 0.91)	0.89	(0.87 - 0.92)	0.86	(0.77 - 0.95)
Lower middle	1.00	0.88	(0.86 - 0.90)	0.87	(0.83 - 0.91)	0.68	(0.60 - 0.78)
Upper middle	1.00	0.87	(0.85 - 0.89)	0.89	(0.86 - 0.92)	0.82	(0.73 - 0.91)
High	1.00	0.84	(0.83 - 0.86)	0.85	(0.82 - 0.88)	0.76	(0.69 - 0.83)
Surgery							
No	1.00	0.88	(0.86 - 0.89)	0.86	(0.83 - 0.89)	0.78	(0.73 - 0.84)
Yes	1.00	0.86	(0.85 - 0.87)	0.87	(0.86 - 0.89)	0.78	(0.72 - 0.84)

Hospitalization route							
Through walk-in or outpatient	1.00	0.88	(0.87 - 0.89)	0.88	(0.86 - 0.90)	0.74	(0.70 - 0.79)
Through Emergency room	1.00	0.81	(0.78 - 0.84)	0.80	(0.76 - 0.85)	0.94	(0.84 - 1.05)
CCI score [a]							
0-2	1.00	0.87	(0.86 - 0.88)	0.88	(0.86 - 0.90)	0.71	(0.66 - 0.76)
3-4	1.00	0.85	(0.82 - 0.87)	0.85	(0.82 - 0.89)	1.00	(0.87 - 1.16)
5-6	1.00	0.87	(0.84 - 0.89)	0.86	(0.82 - 0.89)	0.91	. - .
Medical department							
Internal medicine	1.00	0.85	(0.84 - 0.87)	0.84	(0.82 - 0.86)	0.96	(0.89 - 1.03)
General Surgery	1.00	0.85	(0.84 - 0.86)	0.90	(0.88 - 0.92)	0.50	(0.45 - 0.56)
Pediatrics	1.00	0.91	(0.84 - 0.97)	0.82	(0.69 - 0.97)	0.90	. - .
Others	1.00	0.93	(0.88 - 0.97)	0.91	(0.86 - 0.97)	0.90	. - .
Main Diagnosis [†]							
Z51	1.00	0.87	(0.85 - 0.90)	0.94	(0.91 - 0.96)	0.54	. - .
C34	1.00	0.87	(0.84 - 0.90)	0.88	(0.85 - 0.92)	1.08	(0.97 - 1.21)
C50	1.00	0.88	(0.86 - 0.91)	0.95	(0.92 - 0.98)	0.80	(0.66 - 0.98)
C22	1.00	0.77	(0.74 - 0.80)	0.82	(0.78 - 0.87)	0.84	. - .
K80	1.00	0.87	(0.85 - 0.90)	0.90	(0.88 - 0.93)	0.64	(0.51 - 0.81)
Others	1.00	0.87	(0.86 - 0.89)	0.81	(0.78 - 0.85)	0.80	(0.75 - 0.86)
Medical institution type							
Tertiary hospital	1.00	0.86	(0.85 - 0.87)	0.86	(0.84 - 0.88)	0.81	(0.76 - 0.87)
General hospital	1.00	0.92	(0.90 - 0.94)	0.92	(0.90 - 0.95)	0.65	(0.58 - 0.73)
Medical institution establishment							
National or Public	1.00	0.91	(0.88 - 0.93)	0.87	(0.83 - 0.91)	0.86	(0.75 - 0.97)
Private	1.00	0.85	(0.84 - 0.86)	0.87	(0.85 - 0.88)	0.78	(0.74 - 0.83)
Medical institution region							
Seoul	1.00	0.86	(0.85 - 0.87)	0.83	(0.81 - 0.85)	0.85	(0.78 - 0.92)
Gyeonggi, Incheon	1.00	0.86	(0.84 - 0.88)	0.94	(0.91 - 0.96)	0.65	(0.59 - 0.71)
Others	1.00	0.90	(0.88 - 0.93)	0.92	(0.90 - 0.95)	0.94	(0.84 - 1.04)

Number of Hospital bed[††]																		
Low	1.00	0.89	(0.86	-	0.91)	0.93	(0.90	-	0.96)	0.74	(0.65	-	0.84)
Lower middle	1.00	0.90	(0.88	-	0.92)	0.90	(0.88	-	0.92)	0.77	(0.70	-	0.84)
Upper middle	1.00	0.85	(0.82	-	0.87)	0.85	(0.80	-	0.90)	0.69	(0.61	-	0.79)
High	1.00	0.85	(0.83	-	0.86)	0.83	(0.80	-	0.86)	0.84	(0.76	-	0.92)
Hospitalization year													
2021	1.00	0.86	(0.84	-	0.88)	0.87	(0.85	-	0.89)	0.64	(0.58	-	0.71)
2022	1.00	0.87	(0.85	-	0.89)	0.86	(0.83	-	0.90)	0.85	(0.77	-	0.93)
2023	1.00	0.87	(0.86	-	0.89)	0.88	(0.86	-	0.91)	0.87	(0.80	-	0.94)

[†] Z51(Other medical care); C34(Lung cancer); C50(Breast cancer); C22(Liver cancer); K80(Cholelithiasis);
[††] General hospital (Q1: -299, Q2: 300-499, Q3: 500-699, Q4: 700-); Tertiary hospital (Q1: -699, Q2: 700-999, Q3: 1000-1499, Q4: 1500-);
* adjusted for region, medical insurance, income level, medical department, main diagnosis, medical institution establishment, and hospitalization year (except strata variables)
Abbreviation; a Charlson Comorbidity Index; b Hospital-Acquired Complications

Appendix 5. Results before and after matching target medical institutions

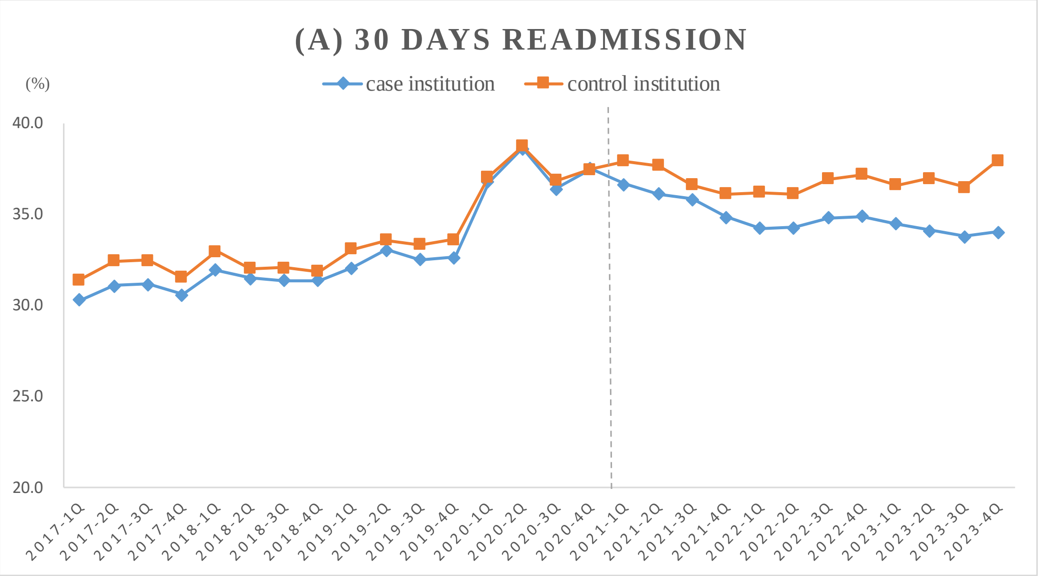
Variables	Before							After						
	Total		Case		Control		*Standard difference*	Total		Case		Control		*Standard difference*
	N	%	N	%	N	%		N	%	N	%	N	%	
Total	296	100.0	10	3.4	286	96.6		18	100.0	9	50.0	9	50.0	
Number of doctors per bed							0.1654							0.0000
< 2.0	13	4.4	7	70.0	6	2.1		12	4.1	6	60.0	6	2.1	
2-2.5	11	3.7	1	10.0	10	3.5		2	0.7	1	10.0	1	0.3	
2.5-3.0	11	3.7	2	20.0	9	3.1		4	1.4	2	20.0	2	0.7	
> 3.0	261	88.2	0	0.0	261	91.3		0	0.0	0	0.0	0	0.0	
Medical institution establishment							0.0925							0.0000
National or Public	49	16.6	2	20.0	47	16.4		2	0.7	1	10.0	1	0.3	
Private	247	83.4	8	80.0	239	83.6		10	3.4	8	80.0	2	0.7	
Medical institution location†							0.0925							0.0000
Metropolitan†	103	34.8	7	70.0	96	33.6		14	4.7	7	70.0	7	2.4	
Urban††	78	26.4	3	30.0	75	26.2		4	1.4	2	20.0	2	0.7	
Others	115	38.9	0	0.0	115	40.2		0	0.0	0	0.0	0	0.0	
Average CCI score							1.5650							0.0000
≤ 2.0	282	95.3	4	40.0	278	97.2		6	2.0	3	30.0	3	1.0	
> 2.0	14	4.7	6	60.0	8	2.8		12	4.1	6	60.0	6	2.1	

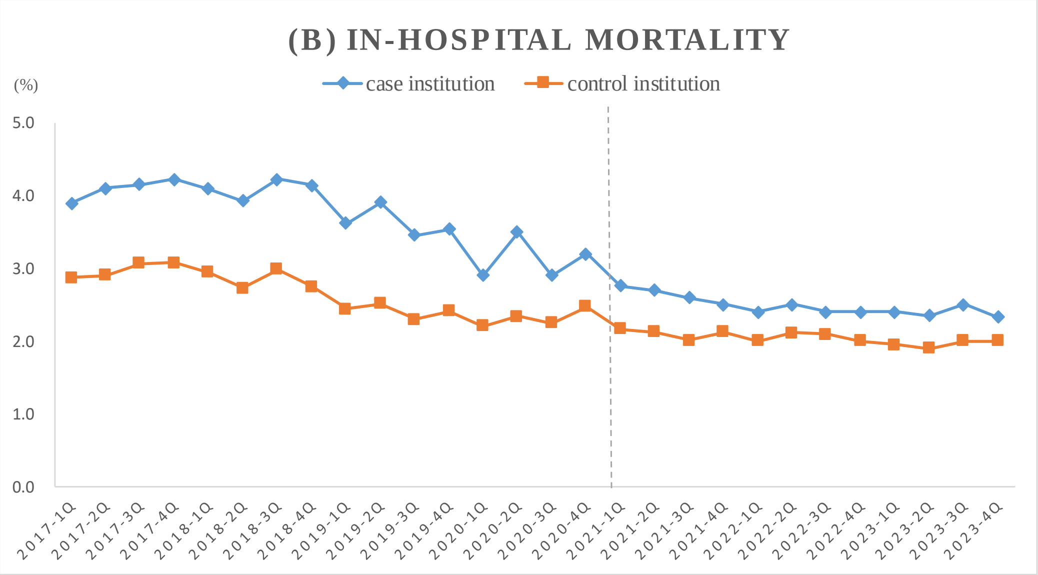
† Metropolitan(Seoul, Incheon, Gyeonggi); Urban(Busan, Daegu, Gwangju, Daejeon, Ulsan, Sejong)

Appendix 6. Results of parallel trend test assessing the validity of DID model

Variables	Case*Time (Interaction effect)		
	β	**SE**	***p*-value**
Primary Outcomes			
Lengths of stay	0.0063	0.0057	0.2675
Total expenditure	-0.0102	0.0065	0.1177
Hospital-Acquired Complications	-0.0202	0.0110	0.0673
Secondary Outcomes			
Mortality	0.0035	0.0260	0.8924
30-days Readmission	0.0163	0.0149	0.2731

Appendix 7. Trends in secondary outcomes according to hospitalist ward operation





Abstract in Korean

입원전담전문의 제도가
입원환자의 의료이용 및 건강결과에 미치는 영향

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장윤서

서론: 입원환자 진료는 재원일수 및 의료비가 증가하는 국내 의료체계 내에서 가장 많은 자원이 투입되는 영역으로, 재입원, 의료 사고 등 환자 예후와 관련된 지표는 병원 운영의 효율성과 환자 치료 결과를 평가하는 핵심 기준이 된다. 그러나 기존의 입원환자 진료 체계는 야간 및 휴일의 진료 공백, 전공의 중심의 진료로 전문성 감소 및 인력 공백 등 구조적 한계를 안고 있으며, 이는 환자 안전과 의료의 질 저하로 이어질 수 있다. 이러한 문제를 해소하기 위한 대안으로 2016 년부터 보건복지부는 입원전담전문의 제도를 시범 도입하여, 2021 년 본사업으로 전환하였다. 입원전담전문의를 배치함으로써 해당 병동에 상주하여 진료 전 과정인 입원부터 퇴원까지 입원 환자를 직접적으로 책임지도록 하였다. 이 연구는 이러한 입원전담전문의 제도의 의료 이용 효과를 실증적으로 평가하고, 병동의 운영 유형 및 전문의 배치 수준에 따른 차이를 분석함으로써 향후 제도 확대의 정책적 근거를 마련하고자 한다.

연구방법: 이 연구는 국민건강보험공단의 맞춤형 코호트 자료를 활용한 후향적 코호트 연구로, 2017 년 1 월부터 2023 년 12 월까지 상급종합병원 및 종합병원에 입원한 환자 중 입원전담전문의 병동에 입원된 질병군을 추려 추출한 결과, 9,477,679 명이 분석에 포함되었다. 첫째, 2021 년부터 2023 년 사이 입원전담전문의 병동과 일반병동 간 case-mix 조정 후 두 그룹간 비교를 위해 진료과, 주요 진단명, 수술 여부, 병원 유형, 입원 시기 등을 기준으로 매칭을 하여 환자군의 동질성을

확보하였다. 또한 입원전담전문의 환자의 반복 입원을 고려하기 위해 일반화 추정 방정식(Generalized Estimating Equation) 모형을 적용하였다. 둘째, 입원전담전문의 병동 운영 여부에 따라 의료기관내 결과 차이 변화도 확인하고자 이중차이분석(Difference in differences) 분석을 수행하였다. 이는 2021 년 본사업 시작 기간에 새로 입원전담전문의 병동을 운영하였으며 이후 운영상태를 꾸준히 유지한 의료기관과 2017 년부터 2023 년까지 입원전담전문의 병동을 한번도 운영하지 않은 의료기관의 병상당 의사 수, CCI 평균, 설립 구분, 의료기관 지역을 매칭하여 비교하였다. 모든 분석의 주요 결과변수는 다음 세 가지로, (1) 재원일수, (2) 의료비 지출, 그리고 (3) 병원내 위해사건이며, 추가적으로 재입원, 사망도 설정되었다.

연구결과: 입원전담전문의 병동 입원환자는 일반병동 입원환자 대비 재원일수 (exp(β)=0.87, 95% CI: 0.86-0.88), 총 의료비 (exp(β)=0.88, 95% CI: 0.85-0.89), 본인부담금 (exp(β): 0.87, 95% CI: 0.85-0.89) 감소와 관련되었으며, 일당 의료비는 차이가 없었다 (exp(β): 1.00, 95% CI: 0.98-1.03). 병원내 위해사건 발생 위험도도 (exp(β)=0.78; 95% CI: 0.74-0.83) 낮았으며, 그 중 요로감염, 폐렴, 입원 중 중환자실 이동, 수술 및 시술 후 관련 합병증이 감소하였다. 추가적으로 원내 사망 (exp(β): 0.86, 95% CI: 0.77-0.96), 30 일내 재입원 (exp(β): 0.96, 95% CI: 0.93-0.98)도 감소하였다. 이는 병동 유형을 입원전담전문의 상주 시간, 주간 운영일수에 따라 나누어 보았을, 특히 full-time 및 주 7 일 운영 병동에서 더 큰 효과가 확인되었다. 의료기관내 입원전담전문의 병동 운영 전후의 분석에서도 앞선 분석 결과와 마찬가지로 운영기관에서 전체 입원환자의 재원일수, 총 의료비, 병원내 위해사건이 상대적으로 더 크게 감소하였으며, 일부 합병증과 사망률에서도 유의한 개선 효과가 관찰되었다.

결론: 이 연구 결과는 입원전담전문의 병동이 단순한 입원진료 모델의 변화에 그치지 않고 입원 진료 전반의 효율성과 질, 환자 안전을 향상시킬 수 있는 정책임을 시사하였다. 의료기관에서 병동 도입 전후의 시간적 변화를 분석한 결과, 일반 병동과 입원전담전문의 병동에 입원한 환자간 비교했던 분석과 일관된 방향성을 보였으며,

이는 제도 도입에 따른 효과가 환자 구성의 차이에 기인한 것이 아닌 구조적 개입의 실질적 영향임을 뒷받침하는 근거로 해석된다는 점에서 의의가 있다. 향후 제도 발전을 위해서는 진료과 및 환자 진단별 병동 운영 구조의 표준화, 입원전담전문의 인력 확보 및 충분한 보상, 퇴원 후 진료 연계를 포함한 연속성 있는 관리 체계의 구축이 필요하며, 이를 지속 가능하게 유지하기 위한 장기적 정책 설계와 체계적인 후속 평가가 병행되어야 할 것이다.

핵심되는 말 : 입원전담전문의, 의료 이용, 건강 결과, 효율성, 환자 안전, 의료의 질