# Optimized Patients' Length of Hospital Stay With Interventions Based on Health Information Technology: A Review Study

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**Abstract.** Background: Information and communications technologies (ICTs) may facilitate shorting length of stay (LOS) of patients through the optimization of processes and delivery services. Objectives: This study aims to provide technology-based solutions and interventions based on health information technology (HIT) that have optimization potentials of patients' LOS. Methods: This review study searched papers in PubMed, Scopus as well as Google Scholar without presuming time limits by the end of 2019. English and Persian Papers were included, which addressed an association between the ICT and LOS as well as its positive effect in shortening LOS. Results: Identified technologies were finally classified into eleven groups. Based on the findings, common health technologies such as health information systems, telemedicine especially tele-consultation, electronic discharge planning tools, and visual analytical dashboards in order to expedite the process and help to optimize LOS seem appropriate. Conclusions: HIT-based interventions have potential that may support better management of processes related to patients` admission, hospitalization, and discharge. However consistently evaluation along with using any new technology is necessary.

**Keywords.** length of stay, hospital, information technology, medical informatics

## 1. Introduction

The increasing cost of healthcare has forced policymakers and planners to seek new solutions for cost control and the proper utility of limited resources [1]. Limitations and shortcomings in treatment centers, staff, equipment, as well as increasing costs of

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healthcare services, may cause more attention to optimize the patients' length of stay in hospitals [2].

Length of stay (LOS) which is one of the most important hospital management indicators defined as the interval between admission and discharge of a hospitalized patient. This indicator commonly is used to assess the use of medical services, the efficiency of hospital management, quality of care, and functional evaluation [3].

Since hospitals contain a network of relevant activities (e.g. administrative, management, and clinical activities) with different groups involved in the diagnosis, treatment, and care of patients, better and more timely communications of the teams could result in shorter treatment-related processes [4]. In hospitals, in order to improve and accelerate the services delivery by healthcare providers plus minimize medication errors, the need for supportive tools is more than necessary [5]. In the meantime, information and communications technologies (ICTs) are one of the interventional approaches. Several review studies despite identifying some limitations have addressed the positive effect of technologies and eHealth interventions in reducing medication errors, increasing patient safety, improving processes, and organizational efficiency [6, 7].

Fewer review studies have provided technology-based solutions with their capabilities comprehensively in line with optimizing the patient's length of stay. In this study, based on related literature, some of the technologies that were useful in this regard will be reviewed. Thus, this study aimed to identify provided solutions in studies based on health information technology (HIT) toward LOS optimization.

## 2. Methods

This review study will answer the question of which technologies could potentially have an effective role in reducing patients' length of stay. This study was conducted in 2019. The researchers reviewed all forms and types of solutions and interventions based on HIT to optimize patients' length of stay through electronic search of available English and Persian papers. So, the combination of main concepts including "hospital", "length of stay", and "health information technology" were searched in PubMed, Scopus databases as well as Google Scholar without presuming time limits by the end of 2019. Terms shown in table 1 were searched in the title and abstract level of articles. In addition, some references of retrieved papers were reviewed. Papers were included, that addressed an association between the ICT and LOS, then raised the positive effect of technology in shortening LOS. After the targeted retrieving of technologies and extracting their capabilities, finally classified and then approved by the research team.

**Table 1.** Search terms (terms included in search strategy)

| | Category Name | Search Terms |
|---|---|---|
| **1.** | Hospital | Hospital, Patient, Inpatient |
| **2.** | Length of Stay | Length of Stay, Length of Hospital Stay, Hospital Stay, length of hospitalization, Duration of hospitalization, |
| **3.** | Health Information Technology | Information Technology, Information and Communications Technology, Health Information Technology, Technology, Medical Informatics, eHealth, Digital Health |
| **4.** | - | 1 AND 2 AND 3 |

## 3. Results

Based on the information retrieved from the papers, technologies that affect patients' LOS directly (significantly) or non-directly, are classified into eleven categories as shown in table 2. In our study, in order to obtain results with more evidence, in addition to original articles, review studies were also investigated.

According to table 2, there are tools based on their capabilities could be considered as solutions to the optimization of patients' length of stay. These eleven technology-based categories might be involved in the pre-diagnosis, diagnosis, treatment, and post-care processes. Indeed, these technologies affect the workflow of admission, hospitalization, transfer, discharge, and even the post-discharge management.

Some of the technologies mentioned including robotic surgery, wearable tools, smart clinical dashboards, and electronic post-discharge follow-up systems have been used recently. So compared to other eHealth solutions, fewer studies have addressed them.

**Table 2.** Summary of HIT-based Interventions Capabilities for Optimize LOS

| Categories | Capabilities[Ref] |
|---|---|
| **Hospital Information System (HIS)** | - The integrated HISs improves the processes of admission, hospitalization, and discharge of patients due to better communication, sharing information, integration of clinical, management, and hospital data as well as removing repetitive and unnecessary procedures [8, 9] |
| **Electronic Health Records (EHR)/ Electronic Medical Record (EMR)** | - The integrity of clinical and health-related data, improve clinical workflow and safety.<br>- Observation of patient's medical records with more complete and readable documentation in real-time [10]<br>- Provide alarms and reminders by embedded rule-based CDSS:<br>- Prevent from the repetition of diagnostic tests.<br>- Detection of drug interventions, drug side-effects or sensitivities, and clinical deterioration [11, 12] |
| **Computerized Provider Order Entry (CPOE)/ Electronic Prescription** | - CPOE implementation as a statistically significant predictor of LOS (LOS was shortened) [13]<br>- Quicker reception of physician's orders, then quicker implementation of the orders [14].<br>- Timely and correct prescription of drugs, identification of problems related to drugs side-effects and interactions, reduction of medications error, and better consideration of clinical instructions [15] |
| **Clinical Decision Support System (CDSS)** | - CDSS based on treatment instructions, protocols, and caring standards could improve and facilitate diagnosis and treatment processes by recommending a series of care-related processes such as doing tests or prescribing drugs to patients with typical and uncomplicated diagnoses (for example administration of antibiotics and heparin in surgical patients [16]).<br>- Admission scheduling [17] and discharge planning based on individual patients. |
| **Radio-frequency Identification (RFID) and Barcode Technology** | - Tracing of patients' location and monitoring of patient turnover [18].<br>- Exact monitoring of discharging time and facilitated the identification of empty beds [19].<br>- Drug safety and facilitation of drug therapy by confidence in targeting correct patients, the correct dose of the intended drug by cross-checking [20].<br>- Identification and warning related to mismatch, drug-related errors, and overdose by comparison of the patient's identity and intended drug dose.<br>- Improve the quality of caring, prevent medical errors and enable more efficient use of proper resources.<br>- Reduce the workload of nurses and eliminate unnecessary processes and steps of caring patients [21] |

**Table 2.** Summary of HIT-based Interventions Capabilities for Optimize LOS (continued)

| Categories | Capabilities[Ref] |
|---|---|
| **Monitoring Systems, Wireless Sensors, and Wearable Tools** | - Timely and early detecting of the clinical condition and vital signs changes and abnormalities [22, 23], especially in high-risk patients.<br>- Preventing from reinforcement of unpredicted consequences related to treatment activities or surgery. |
| **Telemedicine** | - A lot of potentials for shorten patients' length of stay by this technology [24-26].<br>- Remote presence [27], remote consultation [28] along with electronic planning of consultation [29].<br>- Tele-education interventions for educating health workers in order to improve the care and outcomes of critically ill cases. (shorter ICU and hospital LOS) [30].<br>- Tele-pathology [31], tele-radiology [32] and picture archiving and communication system (PACS) for forwarding pathologic and radiologic images to specialists and reception of their viewpoints will help in shortening diagnostic and therapeutic processes [32, 33]. |
| **Robotic Surgery** | - As an instance of high-tech surgical innovation, robot-assisted minimally invasive surgeries help to reduced surgical complications, infections, pain, and bleeding.<br>- Post-operation recovery quality and reduce patients' LOS [34-36] |
| **Smart Management and Clinical Dashboards** | - Continuous monitoring of significant indicators for managers' decision-making as well as identification of procedural problems [20, 37], plus better visualization and dynamic analysis of patients' pathways during the hospital stay.<br>- Show the patients' monitoring results in hospital wards and determine waiting times (e.g. waiting to enter operation room or exit delays, transfer or reception of blood, and clinical consultation)<br>- The use of artificial intelligence and machine learning [38] in dashboard analyses will contribute to the estimation of LOS and better planning of patients' discharge. |
| **Electronic Discharge Planning Tools** | - Better management of processes related to discharge and reduce patients' LOS [39, 40] |
| **Electronic Post-Discharge Follow-up System** | - Reduced re-hospitalization by post-discharge follow-up and patients care through ICT, mobile health, wearable monitoring tools, or smart houses based on internet of things (IoT)<br>- Remote monitoring and post-discharge follow-up of patients [41, 42] based on patients' condition (especially high-risk groups such as diabetic or elderly patients, also people with immunodeficiency)<br>- Timely and early detection of unwanted changes in patients' clinical conditions can lead to a reduction in LOS of patients who have been re-admitted [43] |

Common applications of health information technologies include IT systems such as HIS, EHR, PACS, also telemedicine especially tele-consultation as well as discharge planning tools alongside visual analytical dashboards in order to expedite the process of diagnosis and treatment are appropriate. So these can help to optimize LOS.

## 4. Discussion

In this study, our main goal was a general overview of articles to identify the technologies developed in improving hospital workflow. Then to gain a better understanding of the effective technologies in this field, we focused only on articles that reported a positive impact on the length of stay. Therefore, identifying the potential benefits along with the disadvantages or risks of each of these technologies is needed. Identification of their advantages and limitations is significant for confidence in the quality and safety of care.

The identified technologies generally were classified into eleven categories. Based on findings, HIT-based interventions integrated into workflows, according to their capabilities may influence LOS through the optimization of the processes in the hospital setting (Figure 1).

**Figure 1.** Technology support services and optimize LOS

In relation to the impact of HIT on clinical outcomes and hospital practice including the LOS index, several systematic reviews, and meta-analyses studies were conducted which some studies have pointed to the positive impact of one or several technologies on shortening LOS. In contrast, others didn't report the same effect. For example, Keasberry et al. in a narrative review evaluated the impacts of eHealth technologies (EMRs, CPOE, CDSS, and ePrescribing) in hospital practice. They found moderate-quality evidence for reduced LOS related to EMR functions. Finally, they concluded that eHealth technologies, especially ePrescribing and CDSS, appear effective in improving efficiency and appropriateness of care, prescribing safety, and control of the disease [6]. Prgomet et al. with a systematic review and meta-analysis studied the impact of commercial CPOE and CDSSs on medication errors, LOS, and mortality in ICUs. According to the result, meta-analyses of LOS did not demonstrate a significant change [44]. In another systematic review, Thompson et al. show that HIT has not a substantial effect on mortality, LOS, or cost [45]. According to Kalankesh's study, the effect of telehealth interventions on hospitalization indicators such as on LOS was found to significantly decrease in 36 percent of the studies that reported this outcome [46]. Nadar et al. in a systematic review indicated that synchronous telemedicine resulted in a shorter length of stay in pediatric acute care settings. Although in this study mentioned lacking high-quality evidence [47].

It is noteworthy that patients' length of stay can be affected by a variety of factors other than technology-based interventions [46]. So conclude definitively about observed associations due to the intervention applied is difficult. Therefore, any study that aimed at examining the impact of technologies on this indicator should be designed and conducted taking into account other factors, in order to obtain valid results. Accordingly, our goal wasn't to confirm or deny a particular technology, only we tried to identify and introduce existing technologies in this topic.

Despite the growing technology development in the health field, but dissatisfaction or lack of technology adoption among some healthcare providers remains a barrier to achieving the potential of HIT [7]. Since the adoption of a health-IT innovation can alter the process of healthcare delivery, depending on perceptions of its value by stakeholders [48], so strategies for facilitating more adoption are needed.

In general, with emerging any new HIT-based services, evaluation and validation by a multidisciplinary team of clinicians and technical experts as main stakeholders are necessary. To avoid complications arising from technology, improving standardization in the design and the development of programs can be helpful [5]. Moreover, substantially costs and long-term cost-effectiveness in the implementation of IT-based programs should be analyzed. Also, the ethical and legal consequences must be established.

Although this paper, not a systematic review and we do not claim that this study is comprehensive, it can be useful as a directive for future research. Also, we hope that the findings of this study will inspire researchers, clinicians, and decision-makers to look into more productivity and targeted investment in health-IT services.

## 5. Conclusion

Our review showed that ICTs and HIT-based interventions have potential that may support better management of processes related to patients' admission, stay, transfer, and discharge. Although these technologies could be raised as solutions to the optimization of patients' length of stay, the need to be consistently evaluated along with extensive studies before and after using any new technology is necessary.

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