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The Impact of Health Information Technology on Hospital Performance: A Systematic Integrative Literature Review

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Abstract

Objective: To review, categorise, and synthesise findings from literature on health information technology (HIT) functionalities, HIT use, and the impact of HIT on hospital performance. **Materials and Methods:** We conducted a systematic integrative literature review based on a comprehensive database search. To organise, categorise and synthesise the existing literature, we adopted the affordance actualization theory. To align the literature with our research framework, we used four categories: 1) the functionalities of HIT and how these functionalities are measured; 2) use and immediate outcomes of HIT functionalities; 3) different performance indicators and how HIT functionalities affect them; and 4) what hospital characteristics influence the outcome of hospital performance. **Results:** Fifty-two studies were included. We identified four types of HIT. Only ten studies (19.2%) define the use of HIT by explicitly measuring the use rate of HIT. We identified five dimensions of hospital performance indicators. Every dimension showed mixed results; however, in general, HIT has a positive impact on mortality and patient readmissions. We found several hospital characteristics that may affect the relationship between HIT and hospital-level outcomes. **Discussion:** Further efforts should focus on embedded research on HIT functionalities, use and effects of HIT implementations with more performance indicators and adjusted for hospital characteristics. **Conclusion:** The proposed framework could help hospitals and researchers make decisions regarding the functionalities, use and effects of HIT implementation in hospitals. Given our research outcomes, we suggest future research opportunities to improve understanding of how HIT affects hospital performance.

Keywords

Health Information Technology, HIT Functionalities, Hospital Performance Indicators

1. Introduction

To maximise the effectiveness and efficiency of clinical care delivery, hospitals improve their performance by using digital technologies, referred to as health information technology (HIT). HIT includes different types of functionalities, such as electronic clinical documentation, results viewing, computerised provider order entry, and decision support [1]-[7]. These functionalities may be integrated in one application, e.g., in electronic health records or electronic medical records (EHR), or they are supported by separate applications with interfaces for data exchange. HIT applications recognise different types of users, such as medical doctors, nurses, pharmacists, and patients [8].

Yet, despite their importance, we still have a limited understanding of how HIT affects hospital performance, as well as an insight in what this impact of HIT functionalities on hospital performance is. There are two reasons for this. First, the current literature does not provide a conclusive answer whether HIT contributes to hospital performance, despite many studies on the impact of HIT [9]. Second, HIT is by nature a multidisciplinary research field, and it only has been studied separately within the medical, information system or information management research streams, leaving us with only a fragmented understanding of the effect of HIT on hospital performance.

Given our limited understanding and the amount of time and money hospitals spent on implementing HIT, there is a need for a cross-disciplinary synthesis of the HIT studies by making a connection between divergent literature streams. Therefore, we systematically synthesise the quantitative and qualitative studies of HIT as well as provide research directions for researchers studying HIT. By doing so, we provide an overview of what is known, and we develop an integrative understanding of what and how specific types of HIT impacts specific hospital performance indicators. We use a three step approach. First, we organise our research in a framework that encompasses the various aspects of HIT, using an affordance actualization lens [10] [11]. Second, we use this framework to identify what is already known and what remains unknown. Third, we identify future research opportunities.

Our research makes several contributions. First, it provides a framework to organise and categorise the existing literature on HIT, HIT use and hospital performance. The research framework enables us to give an integrative overview of the current status of HIT studies in hospitals and supports us in identifying research gaps and research opportunities. Second, using our framework, we suggest a distinction in types of HIT functionalities and specific dimensions of hospital performance indicators. This categorization helps us to understand mixed results. The proposed framework could help hospitals and researchers to make decisions regarding HIT functionalities and the effects of HIT use in hospitals.

Given our research outcomes, we suggest three overarching future research opportunities to further improve our insight on the impact of HIT on hospital performance. First, future studies should use a reference to types of HIT functionalities to research various aspects of HIT implementation and use. Second, there is a need to study use of HIT. Third, research should examine multiple hospital performance indicators to elucidate trade-offs and interactions in hospital-level outcomes, while differentiating between hospital characteristics.

2. Materials and Methods

2.1. Design and Search

We aimed to systematically review the quantitative and qualitative studies in HIT across multiple disciplines. We therefore mapped existing research to our theoretical research framework, to create an overview of what has been studied and to identify gaps and propose directions for future research. We followed an integrative literature review for searching, screening and synthesis of literature [12] [13].

We used the Discover! Search engine. Discover! includes many databases, such as EBSCO, Science Direct, Emerald, Springer, Sage, NARCIS and Wiley-Blackwell. To capture as many relevant studies as possible, we developed a broad search string. The search string consists of three parts, roughly "Health Information technology" and "performance indicators" and "hospitals". Each part contains several keywords. For our search string, see **Appendix A**. The searches were conducted on August 13th 2022, by searching the abstract of the studies, published in English and Dutch from 2010 to 2023. We choose 2010 as a 'base line' given the impact of Agarwal, Gao, DesRoches *et al.*'s (2010) [9] research. The studies were then uploaded to Mendeley Software and we removed duplicates. Given the broad scope of our research, we could not further tighten the search string. Hence, we included the top 10 journals from multiple research streams as suggested by Webster and Watson (2002) [12]; namely information systems research, healthcare research, medical research and management and accounting research. In order to obtain the most comprehensive understanding, we included nine different journal guides: Academic Journal Guide 2021 Information management, Academic Journal Guide 2021 Operations and Technology Management, SJR Information systems and management, SJR Management information systems, Academic Journal Guide 2021 Public sector and Health Care, SJR Health professions, SJR Medicine, SJR Pharmacology, Toxicology and Pharmaceutics and SJR Business, management and Accounting. We also included via snowballing "Journal of the American Medical Informatics Association" and "Health Policy and Technology".

In our first screening step, we screened the titles and abstracts. We included studies that reported on HIT and at least one of our outcome variables. We excluded studies that focused on medical research without HIT use, healthcare system research without hospital performance, research that focused on HIT or outcome variables not both, or research focused on specific HIT applications such as telemedicine, electronic prescription and big data analytics. In our second screening step, we read the selected studies in full text. We excluded one study because the full text was not available and we excluded other studies because, on closer inspection, they were about specific HIT sub-applications, such as supply chain logistics, Internet of Things, revenue cycle management and electronic drug prescription systems only.

2.2. Data Collection and Synthesis

We followed Jiang and Cameron (2020) [11] to categorise and synthesise our literature review by adapting Strong, Volkoff, Johnson *et al.*'s (2014) [10] affordance actualization theory. Affordance actualization theory explains how HIT functionalities influence hospital goals through the use of HIT. An IT affordance is' the potential for behaviours associated with achieving an immediate concrete outcome and arising from the relation between an artefact and a goal-oriented actor or actors [10]. To align literature to our research framework, we made a general profile of the included studies by using four categories: 1) the functionalities of HIT and how these functionalities are measured, 2) use and immediate outcomes of HIT functionalities 3) different performance indicators and how HIT functionalities affect them and 4) what hospital characteristics influence the outcome of hospital performance.

3. Results

Our primary search yielded 62,658 references (see **Figure 1**). After uploading

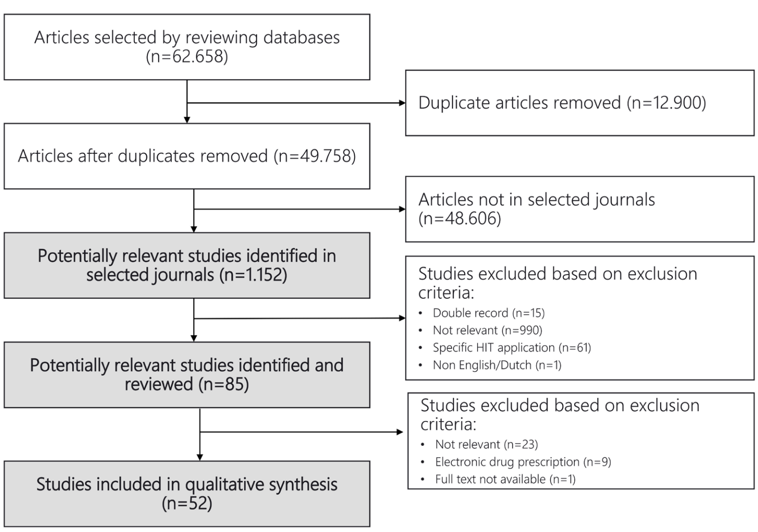

Figure 1. Selection process.

the references to Mendely Reference Manager and removing duplicates, 49,758 unique studies remained. After selection of journals based on the nine included journal guides, our review included 1152 studies from 81 unique journals. After our screening of these studies based on our exclusion criteria, we included 85 studies that reported on HIT and at least one of our selected outcome variables or on HIT and use. After our second screening based on our exclusion criteria, 52 studies were included from 15 unique journals. From each study, we extracted the study identification information such as author name(s), title, journal name and year of publication. We also extracted study characteristics such as study setting, type of HIT, use of HIT, performance indicator measures, and HIT data source(s). For a complete overview of the results, see **Appendix B**.

3.1. Characteristics of the Included Studies

Most studies appear in the information system and information management research stream. In the medical research stream, based on journals selected from the journal guides in this discipline, we did not find any relevant studies including HIT and the impact of HIT. The US is the country in which the impact of HIT on hospital performance has been studied the most, with 32 out of 52 studies. Only eight studies focused on countries outside North America and Europe. The level of analysis of the studies within our literature review varies, differing from hospital level studies (71%), medical department level (10%), disease specific level (10%) and a combination of levels (9%). Most study designs (81%) used quantitative research to analyze the impact of HIT, as opposed to qualitative research (13%). Some authors use a combination of methods (6%).

3.2. HIT Functionalities and Their Measurement

In the literature, different authors use a range of definitions referring to HIT and categorise HIT into different functionalities and their affordances [14] [15]. Our analysis of the literature revealed four types of HIT: clinical HIT, decision support HIT, administrative HIT and patient engagement HIT. Clinical HIT describes basic functionalities like record keeping and results viewing and are referred to by names such as clinical information systems, EHR or health information

	CORE FUNCTIONALITIES	NUMBER OF PUBLICATIONS AND % OF TOTAL PUBLICATIONS
Clinical HIT	Electronic Clinical Documentation, Results Viewing, Computerised Provider Order Entry	38 (73,1%)
Decision suport HIT	Tools to analyse large amounts of data to assist physicians and nurses with clinical workflow and decision-making	27 (51,9%)
Administrative HIT	Enterprise Resource Planning and data analytics	14 (26,9%)
Patient engagement HIT	Enables remote diagnoses, monitors patient health status, patient portal and enables patients to upload self collected data	9 (17,3%)

Figure 2. HIT functionalities.

systems [1] [2] [3] [4]. Decision support HIT (or advanced clinical HIT) describes enhanced features to bolster decision-making capabilities [4] [5] [6] [7]. Patient engagement HIT describes functionalities such as patient monitoring or telehealth [16]. Administrative HIT describes functionalities such as ERP systems that integrate and manage various administrative and financial processes within hospitals [1] [3] [17]. For an overview of types of HIT functionalities in hospitals, see **Figure 2**.

The lack of a standardised HIT definition also affects the way HIT functionalities are measured. We found that HIT functionalities are measured roughly in four ways: 1) seven studies used the American Hospital Association Annual Information Technology Survey[1], 2) twelve studies used the Healthcare Information and Management Systems Society[2] Analytics Database, 3) four studies used a combination of AHA and HIMSS data and 4) twenty-six studies used other (self-developed) questionnaires, secondary data or meta-analyses.

3.3. HIT Use and Immediate Outcomes

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According to affordance theory, the actual use of HIT functions and their affordances enable medical professionals to achieve their goals and tasks [18]. Therefore, HIT use is an important variable to consider [5] [6] [15] [19] [20] [21] [22]. However, in our review only ten studies (19.2%) define the use of HIT by explicitly measuring the use rate of HIT, for example by using the technology acceptance model (TAM) or the unified theory of acceptance and use of technology (UTAUT) [23]. These studies show there are factors that influence the use rate of HIT, for example user characteristics, the existence of technical and organisational infrastructure to facilitate the use of a system and the culture of a country [24] [25]. Thirteen (25%) studies refer to the use of HIT, but only measure parts of the HIT functionality. For example, measuring "meaningful use" based on the CMS programme data. Fourteen (27%) studies in our literature review implementation and adoption are used interchangeably but are not separately measured. Therefore saying little about actual use [1] [7]. Fifteen (29%) studies in our literature review do not mention the use of HIT at all.

Only two studies explicitly measure the use of HIT in relation to hospital per-

[1]The American Hospital Association IT survey database is often used in quantitative research, allowing researchers to include thousands of hospitals in their research. The AHA IT survey focuses on the clinical domain and particularly investigates 31 HIT functionalities and other functionalities (such as telehealth and remote patient monitoring).

[2]The Healthcare Information and Management Systems Society (HIMSS) is a global non-profit organization and collects data in the US on the functionalities and use of HIT. The different surveys that are used based on the HIMSS multiple databases include HIT functionalities such as EHR, ERP, clinical decision support, radiology and nurse staffing (Gardner 2015, Oh 2018), depending on the database that is used.

formance indicators. These studies show a positive impact of HIT use on medical professional satisfaction and HIS use on patient satisfaction [16] [26].

To measure usage, process quality indicators might be useful. Process quality indicators provide insight if the process of providing care is delivered as intended. For example, whether aspirin is given on time or whether certain actions are performed in a timely manner. Process quality indicators thus say something about the assimilation of HIT with work processes, and this assimilation is necessary to increase hospital performance like mortality and patient satisfaction [1] [27].

3.4. Hospital Performance and HIT

3.4.1. Performance Indicator Dimensions

In our literature review, 35 studies apply hospital performance indicators, varying in dimensions, such as quality of care, efficiency (costs), medical professional's satisfaction and patient satisfaction. Of the 35 studies, 19 studies address only one dimension such as quality of care or efficiency, while another 13 studies address two dimensions. Two studies, which were conducted outside the US before 2014, encompass three dimensions. Only one study was found covering all dimensions.

3.4.2. Quality of Care

In general, studies on quality of care indicate that HIT lowers admissions, readmissions or mortality [1] [15] [21] [28] [29] [30]. Others suggest that HIT has no effect on readmissions or mortality [22] [28] [30]. Studies also find negative effects

Table 1. HIT functionalities and effects on quality of care in hospitals. Explanation of symbols and colours: ↑ higher, ↓ lower, colour green positive, colour red negative.

Hospital performance indicator	Definition	Effect	Reference
Quality of Care (16 studies)	Admissions	↓	[28]
	30 day readmission	↓	[34] [35]
		no effect	[22]
	Readmissions	no effect	[28] [30]
		↓	[15] [21] [36]
	Complications	↑	[29]
	Mortality	no effect	[22]
		↓	[1] [21] [29] [30]
	IQI 91	↓ and ↑	[5]
	Medication errors and near misses	↓	[37]
	Disease specific measures	↑	[31]
		↓ and ↑	[32]
	Safety	↑	[27]
		↓ and ↑	[33]

of HIT on complications and disease specific measures [29] [31] or found mixed results on safety, disease specific measures and the IQI, a general measure of quality of care [5] [32] [33]. Sometimes, inconsistencies can also be observed within the same study, adding to the complexity of the findings [29]. However, as **Table 1** suggests, in general, HIT has a positive impact on mortality and patient readmissions in hospitals.

3.4.3. Efficiency

Evidence on the effects of HIT on efficiency also shows mixed results. HIT is found to reduce costs [2] [30] [36] [38] and the number of radiology exams [37] [38]. However, studies also suggest that HIT increases hospital costs and nurse staffing levels [6] [29]. Contrary to expectation, studies showed mixed results to reduce length of stay [15] [29] [30] [34] [35] [36]. HIT increases resource use [4] and hospitals had lower productivity gains compared to facilities that have not yet implemented HIT [39]. Also the use of HIT leads to a higher number of patients that face diagnosis related groups, indicating that HIT use could lead to higher patient costs through up coding [40]. For more information see **Table 2**.

3.4.4. Medical Professional Satisfaction

Studies suggests positive outcomes of HIT on medical professional satisfaction, support of decision making when prescribing mediations, and ease of requesting laboratory tests [43] [45] [46]. However, medical professionals also experience HIT as cumbersome to use and adding to their workload [26] [33] [45] [47]. For a complete overview of the studies and these effects of HIT, see **Table 3**.

Table 2. HIT functionalities and effects on efficiency in hospitals. Explanation of symbols and colours: ↑ higher, ↓ lower, colour green positive, colour red negative. The IQI 91 is a hospital-wide quality indicator that measures multiple quality indicators.

Hospital performance indicator	Definition	Effect	Reference
Efficiency (18 studies)	Length of stay	no effect	[29] [30] [34]
		↓	[15] [35] [36]
	Operating expenses	↑	[6]
		↓ and ↑	[41]
		↓	[2]
	Cost per patient (for example inpatient day or admission)	No effect	[42]
		↓	[30] [36] [38]
		↑	[29]
	Healthcare costs for acute and chronic conditions	↓ and ↑	[5]
	Productivity	↓ and ↑	[39]
		↑	[41]
	Other (for example net patient revenue, resource use, waiting times, reduction in CT scans)	↑	[4] [27] [29] [37] [38] [43] [44]
		no effect	[38]

Table 3. HIT functionalities and effects on medical professional satisfaction. Explanation of symbols and colours: ↑ higher, ↓ lower, colour green positive, colour red negative.

Hospital performance indicator	Definition	Effect	Reference
Medical professional Satisfaction (6 studies)	Medical professional satisfaction	↓ and ↑	[26] [45] [47]
		↑	[43] [46]
	Workload	↑	[33] [45]

Table 4. HIT functionalities and effects on patient satisfaction. Explanation of symbols and colours: ↑ higher, ↓ lower, colour green positive, colour red negative..

Hospital performance indicator	Definition	Effect	Reference
Patient Satisfaction (8 studies)	Patient satisfaction	↓ and ↑	[32] [49]
		↓	[46]
		↑	[1] [16] [42] [43] [48]
	Loyalty	↑	[1]
		↓ and ↑	[32]

3.4.5. Patient Satisfaction

As for patient satisfaction, studies show positive effects of HIT use on patient satisfaction and patient loyalty [1] [16] [42] [43] [48]. However, some HIT functions, such as documentation and health information exchange improve patient outcomes, whereas clinical decision support functions negatively affect these outcomes [32]. Meyerhoefer, Sherer, Deily *et al.* (2018) [46] specifically found that HIT systems negatively impacted patient satisfaction during implementation. For a complete overview of the studies and these effects of HIT, see **Table 4**.

3.4.6. Other

We found seven performance indicators [17] [21] [27] [33] [40] [50] that do not fit within the four previously mentioned dimensions. For example, number of lawsuits, [17] malpractice insurance premium [21], and reuse of data [33]. We bundled these performance indicators into the category "other". For more information see **Appendix B**.

3.4.7. Influencing Hospital Characteristics

The literature review reveals several hospital characteristics that may affect the relationship between HIT and hospital-level outcomes. First, Agarwal, Gao, DesRoches *et al.*'s (2010) [9] research suggests that future studies should differentiate between the various types of hospitals, such as ownership status, location, teaching status, system affiliation and hospital size. Of the 46 quantitative studies included in our research, ten studies do not examine the impact of HIT on hospital performance but focus on studying HIT usage and factors for satisfaction. In six of these 46 studies the hospital population consisted of only one or a few hospitals, therefore these studies show no statistically relevant results. Six other studies did not distinguish between hospital characteristics. The remaining 24 did distinguish between different hospital characteristics, although sometimes only as a control variable. Only 14 studies explicitly indicate whether they discover variances, and these results show a fragmented picture [1] [2] [3] [5] [7] [21] [28] [30] [34] [35] [36] [40] [44] [49]. For example, HIT more positively affects process quality in small rural hospitals [7], HIT more positively affects costs and readmissions in large hospitals that treat less complex cases [36] and HIT leads to a higher amount of readmissions and mortality in for profit hospitals than in not for profit hospitals [30].

Furthermore, the impact of HIT on a single performance indicator may conceal trade-offs between indicators. For example, dissatisfaction of medical professionals with HIT and difficulties incorporating HIT into patient care may negatively impact patient satisfaction [46].

Also, HIT consists of many subsystems, which may lead to varying influence on performance metrics. We found four reasons for these variations: hospitals implemented subsystems in a different sequence [5], hospitals implemented subsystems with a different strategy (bottom up versus top down or big bag versus phased) [20] [39], hospitals implemented subsystems to support different type of illness (chronic or acute) [5] and hospitals implemented different combinations of subsystems [5] [32] [35] [41].

Finally, the duration of HIT usage also affects performance indicators. This duration is called a "lag"; the time between implementing a system and the moment of measuring its influence on hospital performance. Many researchers discuss that including a lag is important, although they have not always done so themselves [2] [7] [25] [27] [34]. In studies that do include a lag, it varies in time: up to a year after implementation [4] [29] [30] [37] [41] [42] [48], one to one and a half years after implementation [51], two years after implementation [1] [5] [29], three years after implementation [29] [44], and two to six years after implementation [41].

4. Discussion

Our literature review identifies four HIT functionalities and five dimensions of hospital performance indicators, highlights their respective impacts as described in literature, and offers a conceptual research framework to better understand how these technologies are used. **Figure 3** summarises all the suggestions.

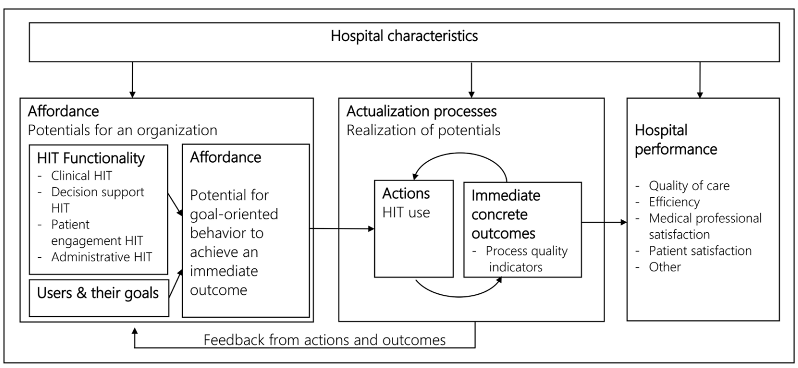

Figure 3. Research framework.

Our review reveals several issues in the HIT literature. First, our research shows that comparing outcomes from previous studies is challenging because of differences in HIT definitions. Therefore, forthcoming studies should establish a unified definition of HIT to facilitate further advancement in the field. We believe that the identified types of HIT in this study are able to properly incorporate new technological developments in this domain. Additionally, an exploration is warranted into how diverse combinations of HIT applications [5] [32] [35] [41], their support of chronic versus acute medical conditions [5], their implementation sequencing [5], and implementation strategies [20] [39] impact hospital performance.

Second, our research underscores that simply implementing HIT is not enough, HIT must be properly used to influence performance [7] [22] [39]. Yet, only a few studies to date have examined the combination of HIT functionalities, usage and performance indicators. And when they did, they did not measure use of HIT the way it was intended, which calls for more research into its use. As hospitals may concurrently implement other procedural enhancements alongside HIT functionalities, forthcoming research can integrate process indicators to measure immediate outcomes of HIT use [6] [17] [22] [39].

Third, our research shows that previous studies show a partial understanding of hospital performance, by reducing outcome to one or two performance indicator dimensions, such as quality of care and efficiency. And even within dimensions, most studies focus on only one or two performance indicators. The question arises whether a single indicator is representative of an entire dimension. Consequently, more research is needed that examines more performance indicators simultaneously and future research can also examine trade-off effects or interactions between hospital level outcomes [2] [3] [6] [7] [29] [43] [51]. Future research must also differentiate between hospital characteristics, such as ownership type (for-profit or not-for-profit), teaching status, healthcare system affiliations and the duration of use (lag).

Our research is not without limitations. First, we conducted a literature search using a broad search strategy. Although this strategy allowed us to include a wide range of studies, it also required us to select studies from 81 unique journals, excluding other studies. Second, we cannot make generic statements about the influence of HIT on hospital performance because HIT definitions are not standardised and different outcome measures are used. Our study thus provides a good overview of the current state of research, but also shows that much remains to be researched.

5. Conclusion

The value of HIT has been extensively studied, and our literature review provides an overview of what is known about how HIT influences hospital performance. Unfortunately, the results of previous studies contradict each other: some are positive, some neutral and some negative. Our findings suggest that different definitions circulate in the existing literature, and therefore the scope of studies differs, which makes it hard to compare results. Additionally, results of previous studies may be distorted, as studies examine HIT with a limited number of performance indicators, distinguish different kind of hospital characteristics, and rarely measure the combination of HIT functionalities, usage and performance indicators. Given the amount of time and money spent by hospitals on implementing HIT, we propose that an intensified exploration into the value of HIT is imperative, encompassing actual use analysis and the establishment of uniform HIT definitions. The proposed framework could help hospitals and researchers to make decisions regarding HIT functionalities and the effects of HIT use in hospitals.

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Contributors

AW: concept and design, data acquisition and analysis, drafting of the manuscript, revision of the manuscript, and approval of the final version. CH: concept and design, revision of the manuscript and approval of the final version. WJB: concept and design and approval of the final version.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix A

Research String

We used the following search string: (health information technology) or HIT or (electronic health records) or (electronic health record) or EHR or (electronic medical record) or (electronic medical records) or EMR or (health it) or (health-care IT) or (health care IT) AND (quality of patient care) or (quality of care) or (quality) or (patient safety) or efficient or efficiency or performance or (value based healthcare) or VBHC or satisfaction or productive or productivity or cost or costs or (patient flow) or usage AND hospital or hospitals.

Appendix B

Table 1. Literature review overview.

Study	Journal	Setting (area)	Level	HIT name*	HIT scope (domain)**	Usage/ adoption***	Type of research	Sample size	Performance measure(s) + Outcome ****	HIT data source
[42]	Health Services Research	US	Hospital	EHR	Clinical, decision support and patient engagement	CMS MU stage 1	Quantitative	Between 9.328 - 11.363 hospital year observations	Efficiency (expenditures to patient days n) Process quality (process adherence ↑) Patient satisfaction (↑)	AHA
[52]	Journal of Soft Computing and Decision Support Systems	n/a	Divers levels	HIS	Clinical, decision support and administrative	TOE framework, Institutional theory and HOT-fit Model	Qualitative	Unknown	n/a (only usage/adoption)	N/a (literature review)
[1]	Journal of Management Information Systems	US	Medical Department	Clinical IT & Administrative IT	Clinical, decision support and administrative	=	Quantitative	2.179 profit and not for profit hospitals	Process quality (6 measures) versus Quality of Care (Mortality ↓) and Patient satisfaction (loyalty and patient rating ↑)	HIMSS (Analytics Database)
[53]	JAMIA	US	Hospital	EHR	Clinical, decision support, patient engagement and administrative.	=	Quantitative	3.643 unique U.S. nonfederal acute care hospitals	n/a (only usage/adoption)	AHA
[51]	Health Services Research	US	Hospital	EHR	Clinical and decision support	-	Quantitative	3.921 hospitals	Process quality (↑ and ↓)	HIMSS (Analytics Database)
[2]	Decision Support Systems	US	Disease specific	HIT	Clinical, decision support and administrative	=	Quantitative	2664 to 2727 hospitals per medical condition	Efficiency (operating expenses ↓) Process Quality (↑)	HIMSS (Analytics Database)
[54]	Health Services Research	North America and Europe	Hospital	EHR	Clinical	-	Qualitative	21 publications where analyzed	n/a (only usage/adoption)	N/a (literature review)
[32]	Decision Support Systems	US	Hospital	HIT	Clinical and decision support	-	Quantitative	7.871 to 11.286 observations on patient outcomes, 1.862 to 3.479 hospitals	Quality of Care (heart attack mortality ↓ and ↑) Patient satisfaction (satisfaction & loyalty ↑ and ↓)	HIMSS (Analytics Database) and AHA
[43]	International Journal of Information Management	Portugal	Hospital	Clinical Information System	Clinical and administrative	=	Qualitative + Quantitative	1 hospital,	Efficiency (↓) Patient satisfaction (↑) Medical Professional Satisfaction (↑) Quality of care (medical errors ↓)	Other (self-collected data)

Continued

[47]	Government Information Quaterley	Taiwan (China)	Hospital	EMR	Clinical	-	Quantitative	217 physicians/nurses and 25 hospitals	Medical Professional Satisfaction (↑and ↓)	Other (self-collected data)
[14]	Information and management	33 Countries	Divers levels	HIT	Patient engagement	TAM, UTAUT	Quantitative	214 independent samples reported in 193 articles, 83.619 technology users	n/a (only usage/adoption)	Other (meta-analysis)
[33]	JAMIA	England	Hospital	CPOE and CDS	Clinical and decision support	Self-made framework	Qualitative	2 hospitals	Other (workload ↑, reuse of data ↑) Quality of care (safety ↑ and ↓)	Other (self-collected data)
[34]	Health Policy & Technology	US	Disease specific	HIT and HIE	Clinical and decision support	=	Quantitative	3200 hospitals	Quality of Care (30 day readmissions ↓) Efficiency (average length of stay n)	HIMSS (analytic data) and AHA
[41]	IEEE transactions on engineering management	Washington state (US)	Hospital	PMIT, TSIT, CIT, AIT	Clinical and Administrative	-	Quantitative	47 hospitals	Efficiency (operating expenses (↑ and ↓) and medical and administrative labor productivity (↑)	Other (secondary data)
[29]	Health Services Research	California (US)	Hospital	EMR	Clinical and decision support	-	Quantitative	326 shot-term general acute care hospitals	Efficiency (costs per patient day ↑, length of stay n, nurse cost per hour ↑, nurse staffing levels ↑) Quality of Care (complications ↑ and mortality ↓)	HIMSS (Analytics Database)
[49]	Journal of Operations management	US	Hospital	HIT	Clinical and Administrative	=	Quantitative	258 hospitals	Quality of Care (comply with standardized evidence-based clinical care processes ↑ and ↓) Patient satisfaction (↑ and ↓)	HIMSS (Analytics Database)
[19]	Health Services Research	33 OECD/UE countries	Divers levels	Health Technologies	n/a	Self-made framework	Qualitative	33 articles	n/a (only usage/adoption)	N/a (literature review)
[25]	International Journal of Information Management	Bangladesh	Hospital	EHR	n/a	UTAUT	Quantitative	249 participants, from private and public hospitals	n/a (only usage/adoption)	Other (self-collected data)
[39]	Decision Support Systems	US	Hospital	EHR	Clinical, decision support and patient engagement	=	Quantitative	4165 hospitals	Efficiency (total factor productivity ↑ and ↓)	AHA

Continued

[3]	MIS Quaterley	US	Hospital	HIT	Clinical, decision support, administrative and patient engagement	Literature review: Bourdieu's Forms of Capital Data analysis: =	Qualitative + Quantitative	953 hospitals	n/a (only usage/adoption)	HIMSS (Analytics database) and AHA
[38]	Health Services Research	California (US)	Medical Department	EHR	n/a	-	Quantitative	9,970 unique ambulance patient visits	Efficiency (reduction in CT scans ↓, throughput time n, other imaging studies n, cost savings per patient ↓)	Other (self-collected data)
[20]	Health Services Research	Turkey	Hospital	EHR	Clinical and decision support	=	Quantitative	State hospitals. 600 survey's	n/a (only usage/adoption)	HIMSS (EMRAM)
[28]	Health Services Research	US	Divers levels	EHR	Clinical and decision support	=	Quantitative	14,9 million beneficiaries,	Quality of Care (admissions ↓ and readmissions n)	AHA
[40]	Health Policy & Technology	California (US)	Hospital	HIT	n/a	-	Quantitative	180 hospitals	Other (CMI value ↑)	Other (secondary data)
[55]	Health Services Research	Italy	Hospital	Information System	Clinical	TAM/ Information System Success Model	Quantitative	1 public and 1 private hospital. 172 respondent.	n/a (only usage/adoption)	Other (self-collected data)
[50]	Health Services Research	US	Medical Department	HIT	n/a	Self-made framework	Qualitative	3 academic hospitals	Other (less communication ↓)	Other (self-collected data)
[16]	Information and management	China	Hospital	HIS	Clinical and patient engagement	Four dimension theory of service fairness	Quantitative	1 hospital, 229 filled-in and valid questionnaires	Patient Satisfaction (↑)	Other (self-collected data)
[7]	Information Systems research	US	Hospital	EHR	Clinical, decision support and patient engagement	HIMSS: adoption, MU1 and MU2	Quantitative	2507 nonfederal acute care hospitals	Process quality (↑)	HIMSS (Analytics Database)
[56]	JAMIA	England	Hospital	EHR	n/a	Semiotic Interoperability Evaluation Framework	Quantitative	12 NHS hospitals	n/a (only usage/adoption)	Other (secondary data)
[21]	Information Systems Research	Washington State (US)	Hospital	HIT	n/a	-	Quantitative	66 hospitals	Quality of care (Readmissions and mortality ↓) Other (malpractice insurance premium ↓)	Other (secondary data)
[24]	Health Services Research	Italy	Hospital	HIT	n/a	TAM	Quantitative	1 hospital, 160 questionnaires, filled-in	n/a (only usage/adoption)	Other (self-collected data)

Continued

[46]	JAMIA	Eastern Pennsylvania (US)	Medical Department	EHR	Clinical	-	Qualitative + Quantitative	8071 patient survey's, 325 clinical and non-clinical staff survey's	Medical professional satisfaction (↑) Patient satisfaction (↓)	Other (self-collected data)
[5]	Information Systems research	US	Hospital	HIT	Clinical and decision support	-	Quantitative	Between 499 and 715 hospitals	Quality of care (IQI 91 ↑ and ↓) Efficiency (health-care costs for acute and chronic conditions↑ and ↓)	AHA
[57]	JAMIA	US	Hospital	EHR	Clinical and decision support	Self-made framework	Quantitative	100 general acute care children's hospitals	n/a (only usage/adoption)	Other (self-collected data)
[35]	Production and Operations Management	North Texas (US)	Disease specific	HIT	Clinical, decision support and administrative	=	Quantitative	67 non-federal hospitals	Efficiency (LOS ↓) Quality of care (30 day readmission ↓)	HIMSS (Analytics Database)
[30]	International Journal of Production Economics	Pennsylvania (US)	Hospital	EHR and HIE	Clinical, decision support and patient engagement	=	Quantitative	115 acute care hospitals	Efficiency (cost per inpatient day, cost per inpatient admission ↓, LOS n) Quality of care (mortality ↓, readmission n)	AHA
[44]	Journal of the Association for Information Systems	California (US)	Hospital	Clinical IT and business IT	Clinical and administrative	-	Quantitative	Between 2968 and 3155 observations	Efficiency (net patient revenue ↑, uncompensated care ratio ↓)	HIMSS (Analytics Database)
[45]	Health Services Research	Norwegian	Hospital	EHR	Clinical and decision support	Self-made framework	Quantitative	3 hospitals, 208 questionnaires filled in by physicians	Medical Professional Satisfaction (↑ and ↓, workload ↑)	Other (self-collected data)
[23]	Health Services Research	Turkey	Hospital	HIS	n/a	Computer end-users' satisfaction model	Quantitative	543 employees	n/a (factors for satisfaction)	Other (self-collected data)
[4]	Health Services Research	US	Medical Department	HIT	Clinical and decision support	=	Quantitative	105.709 visits, 442 Emergency Departments	Efficiency (resource use ↑ and waiting times ↓)	Other (secondary data)
[36]	Information and management	California (US)	Hospital	EHR	Clinical, decision support and administrative	-	Quantitative	137 hospitals	Efficiency (cost per patient, LOS ↓) Quality of Care (readmission rate ↓)	HIMSS and AHA

Continued

[6]	Journal of Operations management	US	Hospital	HIT	Clinical, decision support and administrative	=	Quantitative	3615 hospitals	Efficiency (total hospital operating expenses per bed ↑) Process quality (conformance quality and experiential quality ↑)	HIMSS (Analytics)
[17]	Production and Operations Management	England	Hospital	HIT	Clinical, decision support and administrative	=	Quantitative	168 acute care hospitals	Other (lawsuits ↓)	HIMSS (Analytics)
[48]	JAMIA	US?	Hospital	EMR	Clinical and decision support	Self-made framework	Quantitative	151 physicians and 8440 patient satisfaction surveys	Patient Satisfaction (↑)	Other (self-collected data)
[26]	Health Services Research	England	Hospital	EHR	N/a	Sociotechnical changing framework	Qualitative (mixed method)	1 hospital, 48 interviews, 26 hour observations and 65 documents	Medical professional satisfaction (↑ and ↓)	Other (self-collected data)
[31]	Health Services Research	New York (US)	Disease specific	EHR	N/a	-	Quantitative	2 tertiary care teaching hospitals	Quality of care (composite, postoperative removal of urinary catheter and post– cardiac surgery glucose control ↑)	Other (self-collected data)
[58]	Information and management	Turkey	Hospital	HIT	N/a	Self-made framework	Quantitative	public and private hospitals, 93 complete responses	n/a (IT issues)	Other (self-collected data)
[15]	Journal of Operations management	California (US)	Disease specific	EHR	Clinical and decision support	CMS MU	Quantitative	269 hospitals	Efficiency (LOS ↓) Quality of Care (readmission ↓)	HIMSS (not further specified)
[59]	Health Services Research	Tanzania	Hospital	HIS	Clinical and administrative	Self-made framework	Qualitative	Divers per method, and numbers not always available	n/a (only usage/adoption)	Other (self-collected data)
[27]	International Journal of Information Management	Taiwan (China)	Hospital	E-health	n/a	Self-made framework	Quantitative	104 respondents	Safety, effectiveness, efficiency, timeliness, patient centeredness and equity of care (↑)	Other (self-collected data)
[22]	JAMIA	US	Hospital and Disease specific	EHR	Clinical, decision support and patient engagement	CMS MU stage 1 and 2	Quantitative	1246 hospitals	Process quality (11 process measures ↑) Quality of Care (30-day hospital readmission and mortality n)	AHA

Continued

[37]	JAMIA	Wisconsin (US)	Hospital	EHR	Clinical	-	Quantitative	1 hospital	Efficiency (Laboratory tests, Radiology examinations, transcription costs↓) Quality of Care (medication errors, medication near misses ↓)	Other (self-collected data)

Source: * *Abbreviations: HIT* Health Information Technology, *HIS* Hospital Information System, *CPOE* Computerized Physician Order Entry, *CDS* Clinical Decision Support, *EHR* Electronic Health Record, *EMR* Electronic Medical Record, *PMIT* Patient Management IT, *TSIT* Transactional Support IT, *CIT* Communications IT, *AIT* Administrative IT, *HIE* Health Information Exchange; ** HIT scope *Clinical* means for example documenting, viewing and ordering, *decision support* means one or more decision support systems for medical professionals, *administrative* means administrative systems for example Enterprise Resource Planning and data analytics, *patient engagement* means systems like tele monitoring and a portal for patient self-collected data, *n/a* means in the publication a definition of the HIT is lacking.; *** Usage or adoption measured as mentioned in the publication. "–" means that usage and adoption are not measured, "=" means that usage and adoption is in these articles is the same as HIT implementation and are not separately measured (authors therefore use usage/adoption and implementation as interchangeable definitions). *CMS MU* means Centers for Medicare and Medicaid Services Meaningful Use; *** Explanation of symbols and colors: ↑ higher, ↓ lower, n neutral, *colourgreen* positive, *colour red* negative.