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Review article

A literature review for large-scale health information system project planning, implementation and evaluation

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ABSTRACT

Information technology is perceived as a potential panacea for healthcare organisations to manage pressure to improve services in the face of increased demand. However, the implementation and evaluation of health information systems (HIS) is plagued with problems and implementation shortcomings and failures are rife. HIS implementation is complex and relies on organisational, structural, technological, and human factors to be successful. It also requires reflective, nuanced, multidimensional evaluation to provide ongoing feedback to ensure success. This article provides a comprehensive review of the literature about evaluating and implementing HIS, detailing the challenges and recommendations for both evaluators and healthcare organisations. The factors that inhibit or promote successful HIS implementation are identified and effective evaluation strategies are described with the goal of informing teams evaluating complex HIS.

1. Introduction

This literature review was instigated with the specific purpose of providing the background for an evaluation project being undertaken by the authors. During the process of reviewing the literature the authors became aware that there was currently no comprehensive review of the crucial pre-requisite and likely inhibitory factors of successful implementation of complex health information systems (HIS) that linked this information with their evaluation. This review builds on other reviews in the literature with this summary and linkage.

Healthcare organisations with limited financial resources are faced with mounting pressures in response to epidemiological and demographic changes. Governments, policy makers, information technology businesses, healthcare organisations and consumers have expectations that these challenges can be addressed via technological innovations. Health information systems (HIS) have potential to increase efficiency and save considerable amounts of health expenditure [1]. Effective technology can reduce clinical errors, support clinicians, improve information management and increase patients' access to health services, remote care and continuity of services [2–6]. HIS would be expected to have social and economic benefits for patients, families and healthcare providers [7].

However, current rates of adoption of health information technology are low [8] and health information systems are underutilised [9]. Healthcare is slow to adopt technology compared to other industries [10]. An examination of HIS adoption in seven industrialized nations showed that while many nations have achieved high levels of primary care electronic health record (EHR) adoption, they all lagged with respect to inpatient EHRs and health information exchange systems [11]. Technology is frequently not well accepted, used sparingly or not at all [12] and HIS has been described as "high tech with a low impact"[13]. There are serious issues with the implementation of HIS and reports of HIS implementation failure are not hard to find in the literature [9,14–21]. Implementation is defined as the process of planning, testing, adopting, and integrating HIS so that the technology becomes routinely used in the organisation. Kaplan [22] notes that "there has been a long history of difficulties in achieving clinical use of some kinds of clinical informatics applications. " Within this context, it is imperative that HIS implementation is evaluated and features of successful implementation identified.

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The authors of this article are currently immersed in the evaluation of an ongoing HIS intervention which is being implemented in parallel with an organisational redesign process across a hospital and associated health care services, including primary care. The process of the implementation of technology in this setting has evolved and changed course, requiring the evaluation to evolve in parallel. Reviewing the international literature was paramount in order to provide background for understanding the complex, nonlinear, and unpredictable nature of HIS implementation. The literature review, therefore, became a key part of the evaluation methodology. The literature review specifically focused on the potential challenges and benefits of implementing HIS and the difficulties in evaluating such implementations. In this regard, it represents the most up-to-date review for those evaluating large-scale HIS projects. This article summarises that literature in order to assist other researchers embarking on similar evaluation endeavours.

This literature review has five sections: the methods provide a brief overview of the literature search strategy, which is followed by a brief explanation of definitions used in the literature. The next section backgrounds the meaning, purpose and types of ehealth interventions, and summarises the literature evaluating the effectiveness of health information technology initiatives. The third section addresses the need for evaluation of health information technology and its implementation, and outlines some of the challenges involved in evaluation and recommendations for quality evaluation. Next, the factors which have been shown to increase the likelihood of successful implementation of health information technology innovations are summarised before the final section describing the factors that inhibit successful implementation.

2. Method

This literature search had two strategies undertaken by the first author in consultation with the other authors. The first was a systematic search of nine general and medical databases for transformational/complex and program/me, hospital/healthcare and IT/IS (or technology). The focus was on large scale and transformational technology implementation with the goal of identifying the multiple factors involved in successful implementation of complex HIS. The intention was to avoid the plethora of literature regarding implementation of technology devices and small systems where implementation is more straightforward and complexity is less of a concern. The search strategy is detailed in Appendix A. Across each database, several thousand results were retrieved. Abstracts were then reviewed and details of pertinent articles included in an endnote database. In this filtering process special attention was paid to successful implementation of complex, large healthcare technology initiatives in order to identify positive models for the intervention team. Evaluation literature was also reviewed and detailed. In our search for positive examples of the implementation of complex, transformation HIS we encountered an abundance of examples of unsuccessful projects and challenges to implementation, which allowed us to also identify the factors that are likely to impede successful HIS implementation along with the factors that promote successful implementation.

A second strategy was similar to that used by Potts et al. [23], which they call a 'meta-narrative literature review'. This involves an exploratory informal searching phase followed by identification of key concepts, theories and preferred methods to make sense of complex, heterogeneous bodies of literature. The initial search described in the paragraph above indicated that the literature included theoretical and evaluative articles which had methodological and design differences from different disciplines and theoretical perspectives. To ensure that this literature review encapsulated all of this diversity in the literature, fourteen further systematic reviews were identified [3,5,6,10,24–33].

In total 367 relevant publications were identified and read.

Using these two search strategies enabled the authors to focus on factors that were particularly relevant for the evaluation of the implementation of this specific transformational change and HIS, while also identifying and detailing factors that promote or inhibit HIS implementation in general.

3. Definitions

Information technology innovations in healthcare organisations encompass an enormous range of technologies, which is rapidly increasing in number and diversifying in purpose [3,34,35]. Hersh [27] noted that there were 450 telemedicine programmes available worldwide at the time of writing. Rye and Kimberley's [31] systematic review noted that there were 255 unique innovations described in 55 studies. There is significant variation in terminology around this technology: the all-encompassing term 'eHealth' is used [36–40], which may refer to a range of technologies and systems [13,41].

Others use the term 'telemedicine' [9,27,42] which, in simple terms, refers to "the delivery of medical health services at a distance, [although] there is no single or uniform telemedicine application" [43] and includes a range of technologies. 'Telehealth' [7,44–46] is another term introduced to reflect a broader scope of health-related functions such as education and administration [47]. The literature also includes terms like 'health information technology' (HIT) [2,24,26,32,48–55] or 'health information systems' (HIS) [2,17,51,54,56–61] and variations on these terms like healthcare information networks [62], healthcare innovations [63,64], and healthcare transformations [65,66]. They may be linked to the setting, as in 'hospital information systems' or 'hospital information technology' [60,67–70]. Thus, the terminology in this field of study suffers from a lack of clarity and an absence of agreement about the definitions of the concepts [47], which has led to uncertainty among academics, policymakers, providers and consumers.

In the absence of any consensus around a consistent use of terminology, this literature review uses the term 'health information systems' (HIS) to encompass the widest range of possible information technology used in healthcare systems. Yusof et al. [71] provides an overview of the meaning of HIS:

> HIS assist healthcare organisations to gather, process, and disseminate information within the organisation and their environment. HIS incorporates a range of different types of systems, which include patient information systems, administrative systems, radiology and pharmacy information systems, telemedicine and hospital information systems, such as computerised physician entry systems.

4. Rationale and effectiveness of health information systems

Researchers, health professionals, patients and policy makers have high expectations of information technology in health care organisations and there is considerable international interest in exploiting the potential of HIS [6,16,25]. The World Health Organisation has an eHealth unit and the 58th World Health Assembly in Geneva in 2005 recognised the potential of eHealth to strengthen health systems and to improve quality, safety and access to care, and encouraged Member States to take action to incorporate eHealth in health systems and services [72].

Eysenbach [73] summarises the goals of technology in healthcare, suggesting that eHealth should be: (1) Efficient, thereby decreasing costs, (2) Enhance quality of care, (3) Evidence based,

proven by rigorous scientific evaluation, (4) Empowering for consumers and patients, (5) Encouraging a partnership relationship between patient and health professional, (6) Educate physicians and consumers, (7) Enabling information exchange and communication in a standardized way between health care establishments, (8) Extending the scope of health care beyond its geographical and conceptual boundaries, (9) Ethical – e-health involves new forms of patient-physician interaction and poses new challenges and threats to ethical issues, and (10) Equitable. Haux [59] identified seven general tasks of HIS over time. These are [59]: (1) to move paper-based processing and storage to computer-based; (2) to move from local to national and global HIS; (3) to include patients as HIS users; (4) to use HIS data for healthcare planning, clinical and epidemiological research (aside from patient care and administration); (5) to change the focus from technical aspects of HIS to management change and strategic information management; (6) to place more emphasis on image and molecular data; and, (7) to acknowledge the steady increase of new types of technologies, perhaps as yet unimagined.

4.1. The rationale for HIS

The reasons cited in favour of the implementation of HIS are primarily around efficiency, cost, quality and safety [4,26]. Healthcare organisations are increasingly required to address the growing costs of delivering healthcare to aging populations without compromising quality, access, or equity, and are required to integrate new scientific evidence into practice [25,39,74,75]. There is some evidence to suggest that HIS can lower costs, increase efficiency and productivity and provide a positive return on investments [1,3–5]. Implementing HIS presents potential for increased safety [76] and improved clinical practice via reduced clinical errors, fewer adverse drug events, increased availability of current quality patient information, and clinician diagnosis support Koppel [2]. Benefits for patients include having greater engagement with their own care [77], monitoring of chronic illness, disease prevention and increased efficiency in hospital settings [1]. HIS makes home-based care for patients in remote areas or with chronic conditions a possibility [49,78] and social media has been heralded as a means of transforming healthcare practices [79]. HIS implementation can lead to positive changes in the organisation and delivery of healthcare [23,39,80].

4.2. How effective are HIS?

A review of the literature on the effectiveness of HIS requires a reflection on the concepts of 'failure' and 'success'. Doherty et al. [80] suggest that one of the reasons that information systems across different settings are seen as 'failing' is because of the way success and failure are perceived by different stakeholders. They note that IT project management will judge an intervention as successful if it is delivered on time, on budget and to specification while the organisation will perceive success in the ultimate delivery of the intended benefits (for example, usability, efficiency, safety). The issue of the definitions and implications of how these terms are understood is revisited below in the section "Characteristics of Successful HIS Implementation".

No matter how success or failure is defined (if it is) the evidence of effectiveness is generally weak and inconsistent [6]. Information systems of all types notoriously fall short of their expectations and fail to deliver benefits (see for example, Gauld and Goldfinch [81]. Shpilberg et al. [82] reported that only 15% of business executives surveyed believed that their company's IT capability was highly effective, ran reliably, and delivered projects with promised functionality, timing, and cost. Systematic reviews of healthcare settings consistently find that there is little evidence that care provided by technological innovations is any better than traditional methods [23,25–28]. Whitten's [33] systematic review of HIS cost-effectiveness found that there is no conclusive evidence that telemedicine is a cost effective way of delivering healthcare. Mistry [29] reviewed the cost-effectiveness literature ten years later and concluded that the results of their review were consistent with previous findings: there is no further conclusive evidence that technological interventions are cost effective compared to conventional healthcare. However, it is also the case that these reviews noted methodological shortcomings in studies evaluating cost effectiveness. These were particularly around the amount of methodological detail provided and the methods used to measure cost effectiveness [29,33].

While there is also some evidence that complex HIS can be successful [39,83–87], Heeks [17] attributes the number of accounts of successful HIS to the negative bias against publication of failures, and it is noted that most accounts of successful health information technology are from specific applications in a single location [8,10] creating serious doubts about the generalisability of the HIS benefits recorded in these (often elite) settings [32]. The scientific basis of claims of improved care have not been consistently established and evaluation studies challenge existing findings as often as they corroborate them [88]. McLean [28] concludes that "Policy makers and planners need to be aware that investment in telehealthcare will not inevitably yield clinical or economic benefits."

However, systematic reviews indicate that there does appear to be evidence of some increase in quality improvement as a result of HIS. Chaudhry et al. [25] reviewed 257 studies from 1995 until 2004 and found that there were some benefits to quality, primarily in the domain of preventive health along with increased adherence to guideline-based care, enhanced surveillance and monitoring, and decreased medication errors. The major efficiency benefit shown was decreased utilization of care but the lack of data around cost effectiveness was noted. However, 25% of the articles reviewed came from only four academic institutions, termed 'health IT leaders' by Chaudhry et al. [25]. These institutions had implemented internally developed systems and these authors queried whether other institutions would be able to achieve similar benefits. Goldzweig et al. [26] replicated Chaudhry et al.'s [25] methodology and reviewed 179 studies published between 2004 and 2007. They found a proliferation of 'stand alone' applications that had mixed evidence of benefits. Like Chaudhry et al. [25], Goldzweig et al. [26] noted the paucity of cost-benefit data, and in reviewing the refinement of interventions in the health IT leader institutions noted that most of the new studies reported few benefits from the HIS.

Buntin et al. [24] used the same inclusion criteria as Chaudhry et al. [25] and Goldzweig et al. [26] to review 154 articles from 2007 until 2010 and categorised the articles as positive (improvement in one or more aspects of care and no worse), neutral (no demonstrated change in care or care setting), mixed positive (an overall positive conclusion: generally about 3 positives for each negative) and negative. Sixty two percent were evaluated as positive and 92% considered positive or mixed-positive. Unlike the earlier reviews, the results for the projects describing 'health IT leaders' projects no longer differed from other studies. These authors conceded that there is likely to be positive bias due to non-publication of negative results. It is also the case that their methodology for assessing the literature varied from the earlier systematic reviews and appears a rather crude measure of success. However, the evidence from the Buntin et al. [24] review indicates that not only health IT leaders are experiencing the positive effects of HIS. Thus, there appears to be some scope for cautious optimism around the potential benefits of HIS. This does need to be viewed in the light of other reviews that find little evidence that HIS are cost effective or provide better quality healthcare. However, it is also important to remember

that absence of evidence does not equate with evidence of ineffectiveness [6]. Perhaps the best summary of the evidence regarding the effectiveness of HIS comes from Karsh et al. [8] who state that "current research demonstrates that health information technology (HIT) can improve patient safety and healthcare quality in certain circumstances."

There is ample evidence that unanticipated consequences of implementation of HIS can occur [89–95]. Blosomrosen [96] categorises unintended consequences four ways: desirable or undesirable, anticipated or unanticipated, direct or indirect, and latent or obvious. Unanticipated and undesirable consequences can undermine patient safety practices and occasionally harm patients. Different types of technological interventions and devices can have different types of unanticipated results and may result from user error or workarounds [8,97]. For example, Ash et al. [98] describe the 'silent errors' in the use of patient care information systems (PCIS), which occurred in the process of entering and retrieving information, and in the communication and coordination process that the PCIS is supposed to support. Computerized provider order entry (CPOE) implementation can have clinical unintended adverse consequences such as more or new work for clinicians, unfavourable workflow issues, continual system demands, problems with paper persistence; negative changes in communication patterns and practices, user dissatisfaction, errors, unexpected changes in power structures and overdependence on the technology [99]. The compromise of patient confidentiality and privacy is another unintended consequence that can occur with the implementation of new technology, particularly record keeping [100]. Unanticipated consequences can also produce desirable results, such as improved communication or new and enhanced work systems [101,102].

4.3. Implementing HIS

Implementation of HIS is not a simple straightforward linear process. Adoption and implementation of HIS are not the same thing [31]: just because an HIS has been adopted, it does not necessarily mean it is being used (or used in the way it was intended). Successful implementation may involve a lengthy process starting with planning, designing, and piloting before moving into being (possibly intermittently) used, modified, accepted (or not) until it is considered routine [10,103]. The more comprehensive the technology, or the wider the span of the implementation, the more difficult it appears to be to achieve success [20]. A healthcare organisation encompasses a complex web of inter-related clinical, cultural, and technical issues situated within a wider societal and political environment. Implementing HIS is not merely about technical issues, it is about complex and multidimensional organisational changes [25]. Car et al. state that "even when high quality interventions are developed, they frequently fail to live up to their potential when deployed in the 'real world' [36].

Implementing HIS is expensive [1]. Most countries dedicate not less than 2 to 6% of their health budget to information technology [2,4]. In one survey, the majority of both economists and physicians identified technological change as the primary reason for the increase in the health sector's share of GDP in the last 30 years (Fuchs, cited in Rye and Kimberley) [31]. There are other costs involved in the implementation of HIS: it can be hugely disruptive for staff and organisations [77,104–106], since it can be a profound agent for change [12,18]. Despite evidence that HIS can impact negatively or positively on patient care and the identification of health information technology as being amongst the least reliable [107] there are no regulatory requirements to evaluate HIS safety [8] (although in the United States the Health Information Technology for Economic and Clinical Health Act, 2010 identified a set of objectives for the 'meaningful use' of EHRs, which enable them to support improved healthcare [108]. This was prompted by the concern that merely adopting EHRs was inadequate to substantially improve care [109]). The majority of HIS have not been developed using the rigorous software engineering methods used in other safety–critical environments such as the airline or railway signalling industries [12]. Thus, implementing HIS is a risky business. This perhaps explains, at least in part, why some organisations might be tentative venturing into an expensive HIS implementation.

To summarise, current research suggests that HIS can be effective at improving healthcare and patient safety in certain circumstances, although there is no convincing evidence that they are cost-effective compared to conventional modes of delivering healthcare. HIS are complex and may have unforeseen outcomes, which can be positive or negative. There are high risks in implementing HIS and implementation levels remain generally low [11].

5. Evaluation

Effective evaluation allows us to understand how and under what conditions HIS work, and determine the safety and effectiveness of the system [2,71,110]. Evaluation can provide guidance to the implementation process and mitigate unplanned negative outcomes [17,111]. Ammenwerth [112] defines evaluation as "the act of measuring or exploring attributes of a health information system (in planning, development, implementation, or operation), the result of which informs a decision to be made concerning that system in a specific context." This should include the inevitable organisational change which accompanies the implementation of HIS [80]. Early approaches to evaluation focused on the "measurement of changes in processes and of the consequences of these changes" [113] while more recently attention has been paid to the complex, iterative and multidimensional implementation process [30]. Effective evaluation accompanies the whole life cycle of HIS [2,17], evaluating technology against a comprehensive set of measures throughout all stages [6].

Measuring the success of HIS is not straightforward and the challenges in the organisation and setting of HIS make both implementation and evaluation of the HIS difficult. Evaluation processes are also often flawed. The recognised difficulties with evaluations are briefly outlined below.

5.1. Healthcare settings and the nature of HIS provide challenges for evaluation

Healthcare settings are complex. A complex system is one that adapts to changes in its local environment, comprises other complex systems [such as people] and acts in a non-linear fashion [114,115]. Healthcare settings are multiprofessional organisations, which often include a dual hierarchical structure involving clinicians and managers. Clinicians also have a high degree of autonomy (collectively and individually) and decentralised decision making is common [30]. Healthcare organisations operate at different levels and may involve several linked institutions, a large conglomeration of small healthcare settings, single hospitals with many departments, primary care organisations and/or any combination of these. These may be funded and administered in different ways and have links to other organisations at the same and different levels. Healthcare organisations are also responsible to their funders, which may include private, industry, or governmental bodies. Healthcare organisations are likely to experience competing tensions between their obligations at these different levels when implementing HIS [23]. Such complexity can cause complications for HIS implementation, including multi-stakeholder perspectives, power asymmetry and politically led changes [34].

HIS are also complex [115]. HIS implementation needs to be understood and evaluated as a socio-technical process [71]. Implementation of HIS usually involves the procurement of technology and complex support systems from outside organisations, which add extra complexity to managerial and governance structures. The healthcare organisation's existing IT infrastructure is required to be responsive and become compatible with the new HIS [17]. HIS may comprise different types of devices, technology and be used for any number of healthcare functions from imaging to communication to prescribing to recording to diagnosis. Technology is rapidly changing and healthcare organisations are not equipped for quick changes with their highly institutionalised structures and practices [16]. All these features of HIS make their implementation into an already complex healthcare system challenging.

Challenges for evaluations include attributing causality in a system which is dynamic and non-linear. Consequences are likely to be multiple and have spin off effects requiring measurement of outcomes at multiple levels [115]. This also means that evaluations are likely to be time-intensive and expensive. Outcomes are difficult to quantify [34]. Evaluating HIS implementation combines healthcare, information technology, biomedical science and medical informatics [104] and may require knowledge of human factors/systems ergonomics, organisational/occupational/social psychology, management (particularly organisational change management) and information systems [10]. Perhaps because of these difficulties, the quality of studies evaluating HIS implementation is generally low [6,17,27,28,31,33].

5.2. Evaluation of HIS has varied in quality

The body of evidence about the success of HIS and its implementation is plagued by variation in the quality, methods, theoretical approaches and multidisciplinary perspectives of evaluation studies. While variation in approaches and perspectives can be useful given the range of HIS, implementation stages and processes, evaluation disparity makes it difficult to draw conclusions about what effective HIS implementation looks like. Even the conceptualisation of implementation of HIS is not consistent: it is variously perceived as adoption, deployment, diffusion, implementation, infusion, integration, normalisation, embedding or routinisation [10,64,75,116,117] depending on the perspective and timing of the evaluation. Brender [110] notes that evaluation is required at all phases of the development and the purpose of evaluation depends on whether the HIS is in its explorative, technical development or adaptation phase. The heterogeneity of terminology, methodology and design means that it is difficult to draw conclusions about the effectiveness of HIS or the factors that promote or inhibit their implementation [7,23,31,33]. Systematic reviews note the anecdotal nature and retrospective nature of HIS evaluation, often based on case studies or implementation of small interventions in single organisations [10,25,27] or on expensive, tailored hospital based HIS [25,26,31]. Evaluation studies are often short term while HIS implementation is a lengthy process [25,33,115]. Few studies include a cost benefit analysis [6,25,26,28]. When cost-benefit analysis is included, it is generally restricted to simple cost comparisons from a narrow perspective [7,29,33,118], focusing on whether the project came in within budget [80] or describing potential benefits from economies of scale [33].

Much of the criticism of HIS evaluations is that they do not address the complexity of the context of an HIS implementation and that measurement is simplistic [5,6,25,31,119]. Kaplan [22] notes that studies with pre-specified dependent measures miss unanticipated consequences and enduring emergent effects. Systematic reviews claim that evaluations of HIS implementation are under-theorised and have not adequately addressed the relationship between the technological, human and contextual features [10,13,30,31,119]. Robert et al. [30] identify two approaches to evaluation, one which views the implementation of HIS as a sequential process of stages of implementation where organisational variables are associated with higher or lower rates of adoption, and; a more complex, iterative and multidimensional process. This second approach to evaluation allows the evaluation to incorporate the social, political, organisational and related processes as they unfold over time [22]. There is an increasing acknowledgement of the importance of context in the evaluation literature [34].

Theoretical perspectives are increasingly being used to provide a framework for understanding HIS implementation. This includes actor network theory (ANT), diffusion of innovation theory, the theory of fit between individuals, task & technology (FITT), and social construction of technology theory [103,104,117,120–124]. Frameworks for understanding the interdependencies between the technological, human, and socioeconomic environments provide structures for understanding the factors that promote and inhibit implementation of HIS and the conditions under which HIS provide benefits (see van Gemert-Pijnen et al. for a systematic review of this literature) [13].

5.3. Recommendations to improve the quality of HIS evaluations

Because of the problems described above with the consistency, methodologies, and lack of depth and breadth of HIS evaluations, recommendations to address these difficulties have been identified. Evaluations should systematically assess the impact of the HIS on various stakeholders over time [2,75,110], clarifying goals and theoretical perspectives [13]. The process of implementation is not static but is vulnerable to changes in the organisation and larger context, requiring the evaluation to adapt and change in synchronisation with the implementation, paying particular attention to the sequence of the implementation [113,125–127] and the difference between technology design and reality of implementation [17].

The gap between the individual(s), task and technology should also be addressed in evaluations [13,39,71,128,129]. Other suggestions for improving evaluation include meticulous documentation of assessment methods and research decisions made [2] and paying more attention to stakeholders' disengagement from HIS [31]. To summarise this literature: well-funded, meticulously planned, rigorous, multidisciplinary research which assesses outcomes across the multiple dimensions of HIS impact (human, technological, contextual) throughout the life cycle of the HIS (from conception, through design and implementation, to maintenance) is required [2,31,115,127,129]. Although there are shortcomings with the evaluations of HIS implementation, the evaluative literature is large and has been able to identify factors that make successful implementation more likely. These are discussed below.

6. Characteristics of successful HIS implementation

Evaluating the implementation of HIS as successful (or not) is not straightforward. Evaluation is subject to the vagaries of timing: today's HIS success may be tomorrow's HIS failure and vice versa [17]. The use or non-use of the technology is not a criterion for success [8]. For example, technology can be used incorrectly or create more work for the user indicating that use is not necessarily an endorsement that the HIS is successful. The complexity of HIS implementation means that successful implementation can be interpreted differently by various stakeholders [75,80].

While it is true that many evaluations do not explicitly define 'success', quantitative evaluation literature generally measure outcomes of HIS compared to its original goals [6] and qualitative and mixed methods evaluations are more likely to measure 'success'

contextually [13,23]. It is also true that the correlates of successful HIS inevitably fall into human, technological and organisational or contextual domains [3,10,31,71]. These factors are interrelated and have complex relationships with each other and there is an increasing understanding that the degree of alignment between them is of prime importance [10]. The factors associated with successful HIS implementation are discussed below within the classifications of these three dimensions. It is important to bear in mind that these categories are not discrete.

6.1. Structural/contextual/organisational factors that promote successful HIS implementation

This category includes everything that needs to be in place prior to and during the implementation of HIS. Factors in the organisational dimension are crucial[6] but have a tendency to go unnoticed because precedence is given to technical and clinical characteristics [74]. Robert et al. [30] identify eleven key characteristics in an organisation to be ready for assimilating innovations. These are: (1) Money, staff and other resources are available; (2) A clear division of labour between departments and units, with each concentrating on its own strengths; (3) Decentralised management; (4) People in the organisation are familiar with basic concepts and can apply them to a new project; (5) Staff have the skills and capacity to horizon-scan and capture new ideas; (6) Knowledge sharing within and outside the organisation is enabled and promoted by senior staff; (7) Top management provides strong and competent leadership and vision; (8) Good relationships and communication at middle management level; (9) A risk-taking climate where people are rewarded for taking risks; (10) Goals and priorities are clearly articulated; and, (11) There is timely feedback on the success of innovations. Visionary leadership of the organisation and implementation process are also key factors in the success of HIS implementation [130–134]. Perhaps the provision of adequate funding to purchase and implement the HIS is the primary organisational requirement [5,39,100].

Communication between levels of the organisation and between management, clinicians and information staff is crucial to the success of HIS implementation [9,77,135–138]. This includes ensuring that there is someone to liaise between IT staff, clinicians and management, facilitating workflows and highlighting problems [10,23,138]. Key organisational structures required for successful implementation of HIS include clear management and governance structures, task orientated structures (as opposed to output orientated structures), minimal staff turnover, good capacity of staff, who are released from other duties and reimbursed for their role in the implementation, realistic timelines, well arranged logistical procedures related to the innovation and an understanding that the implementation is an ongoing process [75,80,135,139,140].

Along with systems and structures within the organisation, successful HIS implementation requires support from external organisations, which are also part of the organisational context. Central and local government support is integral: policy or personnel changes (sometimes via elections) at these levels can completely destabilise HIS implementation or even be the cause of its demise while strong support, communication and funding can provide strong impetus for successful implementation [16,139,141,142]. In New Zealand, where we are conducting an evaluation that required this literature review, there is a centralised government and public health system, but there are complicated and frequently changing health system structures [143]. An example of how complex historical and policy factors combine to increase adoption of HIS (in this case electronic health records in ambulatory care settings) comes from Jha et al.'s [11] comparison of HIS adoption across seven nations. They found relatively high levels of EHR use in New Zealand, which they attributed to "a combination of factors in which the government played an important but indirect role: requirement of GPs to submit claims and capture other data electronically". Implementation of HIS can also involve legal, administrative, and governance issues that require higher level communication and support [100].

Cresswell and Sheik [10] remind us that organisations and their structures are made up and determined by people and that these dimensions are closely related. The human factors that are likely to facilitate successful HIS implementation are addressed below.

6.2. Human factors that promote successful HIS implementation

Human factors include those characteristics and issues that make individual users more likely to accept and operate technology as well as concerns with human resource factors such as personnel, training and relationships between individuals. Li et al.'s [5] systematic review of the eHealth adoption literature summarised characteristics of healthcare providers that make them more likely to accept and use technology. They acknowledge that there were some contradictions in the results but identified some characteristics that were noted across much of the literature. These included having some previous experience with technology, having a perception that using the technology was *not* voluntary or optional and perceiving that the technology would be easy to understand and use. It was also helpful if users judged themselves as capable of operating the new system. People were more likely to use the system if they deemed it to be effective and better than previous systems or workflows. It was also essential that new users did not perceive the innovation as time consuming and that it should enhance their work. If individuals thought that their colleagues or significant others should adopt the system, they were more likely to use it. Users also required adequate training and time to become familiar with the new system. Time and effort involved in learning new technologies can be a significant barrier to uptake [100].

The most commonly cited facilitating factor in the human domain is the perception of the benefits of the innovation [3,5,10,31,75,144,145]. It is crucial to have the ongoing involvement of key stakeholders, right from the conception and design stages [21,30,139]. The opportunity for end users to test prototypes in the healthcare setting can help ensure technology is used by professionals and patients [10].

Good communication is required so that information flows from management and information technology staff to clinical and administrative staff and that end-users are able to take ownership of the process and new technology [87,140,145]. Dedicated effort to foster high levels of trust and early engagement with end users can bring about widespread 'buy in' from clinicians, patients, and other stakeholders [146]. Research evidence supports the benefits of having 'champions', senior leaders who support the new system providing information, support and take on the liaison role between management, technology staff and clinicians [3,10,75,77,147]. Paré et al.'s [148] study of risk factors in implementing HIS found that HIS project managers considered the lack of a project champion was the biggest risk to successful implementation.

Sufficient time for training and testing [117,138], which needs to be well-resourced [84] is also important for successfully implementing HIS. Information technology support for end-users assists confidence with the new technology [30,49,87,138]. The fit between clinical work tasks and the design of the technology (workflow issues) significantly impacts on the likelihood of HIS acceptance [145].

6.3. Technical factors that promote successful HIS implementation

Technical factors are intrinsically linked with the human factors described above because people use the technology. The technical domain is also immersed in the organisational structures described earlier. Bearing these connections in mind, it is possible to identify features of the technological domain that can promote successful HIS implementation.

Firstly, the existing ICT infrastructure must be able to assimilate the new system. This requires the collection of baseline data to determine the capabilities of the current infrastructure and ensure that it is compatible with how it is expected to perform with the new technology [17,21,128]. Technology implementation also needs to be managed effectively. Caccia-Bava et al. [149] recommend that managers develop knowledge of how to get the best technology available, effective use of specific technologies, and benchmarking the use of specific technologies against lead organisations. Information technology implementation teams are required to provide sufficient on-site training as well as on-going support as the implementation occurs [3,75,77,80,135,150].

A good 'fit' between the needs of the users and the technology is required [13,39,128] across the chronology of the implementation – at pre, during, and post HIS implementation [151]. This involves adequate design, testing, prototypes and the ability to adapt the technology as required as this process occurs. The literature is consistent in finding that end-user involvement across all stages is conducive to more effective implementation [26,35,54,134,140,152,153]. Although meeting the needs of the organisation appears to be one of the key factors in the technological domain, this needs to be balanced against the requirement for interoperability. The need for interoperability should be taken seriously: interoperability of HIS in different organisations bridges information gaps, reducing redundant clinical procedures and increasing patient safety [154], accessing the full benefits of EHRs [155] and potentially reducing costs [156,157]. However, there are challenges and barriers to effective interoperability (see Eden et al. [158] for a systematic review of these) and the quest for interoperability can cause compromises to be made that are not beneficial to a local HIS [21,23,74,100,159].

There are characteristics of the technology, devices and tools which make up the HIS that are important for successful implementation. They should be easy to use, clear and understandable; easy to learn to operate; flexible; and have easy navigation with easy to remember tasks [160]. The technology should be intuitive, easily customised, have quality interface design and require little training [3,26,144,153].

Communication is also crucial: between the design team and the implementation team [104] as well as the organisation and the vendor [161]. The healthcare provider's perception of the IT provider as trustworthy and reputable is a factor in the successful adoption of HIS [5]. Effective communication between the information technology staff and the clinical and managerial staff to ensure adequate staff training and support is also crucial [3,39,62,75,77,101,135,144].

Health information technology is expensive, and requires adequate funding for successful implementation. Gabriel [49] suggests that collaborating with other healthcare organisations can decrease costs of the technology via economy of scale. 'Scope creep' can also raise the risk of exceeding the budget [2,10,162] when the HIS is not thoroughly defined before the project's start causing costs and timeframes to explode [148].

It is clear that successful HIS implementation is a process that involves organisational change. It requires more than software delivery or the adoption of technology. This requires a healthcare organisational context and structures that are receptive to a new system. The literature identifies some factors that inhibit successful HIS implementation and these are briefly discussed below prior to the conclusion.

7. Factors that inhibit successful HIS implementation

Some of the features of a healthcare organisation that are likely to hinder or constrain successful HIS implementation are contrary and opposite characteristics to those described above as factors promoting success. These 'opposites' include inadequate funding, lack of IT infrastructure, poor leadership, inadequate end-user engagement and unrealistic timelines. The lack of compatibility of the HIS with current work processes and the organisational culture and vision are commonly cited as factors that impede successful HIS implementation [3,30,57,62,150,163]. Here, attention is paid to the factors that are not related to those discussed above. These include particular challenges with technology, the factors that contribute to user resistance, features of the organisation that make it difficult to change and the importance of ongoing evaluation.

The challenge to successful implementation is primarily around the socio-technical and contextual domains. However, there are risks to implementation that can be attributed to the technology. These include procuring a poor product, being lured into the leading edge of technology that has not been adequately tested, and insufficient long term IT planning, leading to piecemeal interventions that do not align with the organisation's goals [21,162,164–166]. Innovation characteristics (safety, performance, value, risk, characteristics, purpose) are intuitively linked to the success of implementation, even if the evidence is inconclusive [31]. This lack of evidence is partly because of the breadth and range of technologies, making it difficult to generalise.

Addressing the reasons people do not use HIS is also important. "Resistance to change is a phenomenon that is so pervasive and widely recognised that it scarcely requires documentation" [148]. Clinician resistance is a frequently cited risk to the successful implementation of HIS [26,39,125,128,137], although this is not necessarily merely a resistance to change per se. Morrison's [167] study of the implementation of a care records system in the NHS found that staff were not reluctant users of the system but the systems had poor functionality so were difficult to implement. Other studies have found that other end users resist new technology because it is time-consuming to use, cumbersome or because they have not been made aware of the benefits [168–170]. Clinicians may express concern about patient privacy and confidentiality [28,144], a concern echoed by others in the healthcare organisation with a legal responsibility to ensure patient confidentiality [101]. Clinicians also fear that new kinds of errors are made because of clinical systems [98] and query the impact on relationships with patients [137]. Technologies which inadvertently undermine perceived authority or professional autonomy are likely to be resisted by users [10]. Suggestions for combating clinician resistance include initiating change with the technology which will provide the greatest benefit to clinicians [84] and providing financial incentives for training [5].

Successful implementation relies on the understanding of the unique organisational structures and practices of healthcare organisations, which are not characterised by an ability to integrate quick changes [16,21]. If the healthcare organisation's leaders are risk averse, there can be reluctance to adequately invest in the implementation [21,128]. High staff turnover [75] and turbulence in the organisational environment [148] also create risks for the successful implementation of HIS. Likewise, when there are conflicting goals at different levels of the organisation, or if the information technology and managerial teams are not aligned, it is unlikely that end-users will successfully implement a new system [84,92,163].

Morrison [167] also found that it was important for the organisation's long and short term goals to be aligned.

The final factor that is likely to inhibit the successful implementation of HIS is not organising independent, robust, ongoing evaluation of the implementation [12,21,111], which is fed back to the organisation and implementation team so they can respond as required and build a culture of learning. Reflexive monitoring can reveal how users perceive and interact with the technology, provide appraisal of the costs and benefits, and provide feedback to continually adapt the innovation and/or implementation on the basis of evidence [124].

8. Conclusion

Healthcare organisations are complex and under some pressure to integrate technology into their practice in order to transform care and become more efficient. However, evidence of the effectiveness of technology in healthcare settings is mixed and the uptake is generally low. Evaluating the implementation of HIS has been historically inadequate, plagued by simplistic and diverse approaches making it difficult to generalise the results. Publication bias has possibly created an unrealistic impression of the success rates of HIS implementation. It is now recognised that a more nuanced approach to evaluation is required due to the organisational change that is implicit in implementing HIS. Implementation of HIS is a socio-technical process and evaluations need to incorporate organisational/contextual, human/social, and technological dimensions. These dimensions are interrelated and co-exist but the exact nature of the relationship between the dimensions is less clear and requires more attention [171].

There is a large body of evidence about the implementation of HIS and some factors have been consistently identified as contributing to successful implementation. This literature review, up-to-date at the time of writing, has described these factors and referenced all key sources.[1] Therefore, it provides a working resource for those involved in planning and evaluating large HIS evaluations. The factors identified in this literature review cross the socio-technical dimensions and include ensuring that there is sufficient funding to purchase the appropriate technology and support its implementation through the entire chronology of the process. Strong 'top-down' leadership guidance and support is required and a crucial aspect of this leadership is effective communication across managerial, information technology, administrative, and clinical boundaries. A 'champion' of the HIS can personify this communication and ensure that end users are kept informed of the progress of the implementation. End users should be involved throughout all aspects of the implementation and need to know the potential benefits so that they are prepared to tolerate the inevitable disruption of the implementation. Sufficient time and adequate resourcing for quality information technology training and support is also crucial. End users need to have confidence that they can use the technology and that it will work effectively. When individuals within the organisation understand the possible benefits to care and are aware that all efforts have been taken to mitigate potential risks, they are more likely to support and use the HIS. A vital element in this process is having quality, easy to use technology which improves the way that people deliver healthcare. Robust evaluation of HIS implementation is required at all stages to provide ongoing feedback. Perhaps the most important awareness for all those involved in the implementation of HIS is that it is complex and requires a transformation in the culture of the organisation, which takes time, adequate resourcing, support and commitment at all levels.

[1] The recent book by Ammenworth and Rigby [172], published after the time period of this review, is another key source/resource for planning and evaluating HIS.

Summary points

This article reviews and summarises the literature on the implementation and evaluation of health information systems (HIS). The authors outline the challenges in implementation, which have resulted in the failure of many HIS to be effectively adopted and used in healthcare settings. Factors which promote and inhibit successful HIS implementation are identified from across the literature and are discussed within organisational, technological and human domains. The HIS evaluation literature is also summarised and recommendations for effective evaluation are detailed. This article provides a robust, current review of the literature regarding all aspects of HIS implementation and evaluation. This creates a foundational resource for organisations and evaluators implementing and evaluating HIS.

Author contributions

Study conception and design: Sligo, Roberts, Gauld, Villa.
Acquisition of data: Sligo.
Analysis and interpretation of data: Sligo.
Drafting of manuscript: Sligo.
Critical revision: Sligo, Roberts, Gauld, Villa.

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Appendix A. Search strategy

Systematic search strategy in medical and relevant social science databases:

Searched in the databases below for Search terms:
Transformat* and healthcare or hospital
Hospital or healthcare and IT or IS or technolog* or program*
Items were excluded if they were published before 2000, focused on specific technological devices, were duplicates of items found in other databases, were not complex or transformational initiatives

1. Emerald:
http://www.emeraldinsight.com/

566 results for "Transformat* and technology and healthcare" and got 326 results. 62 were included.

222 results for "hospital and technolog and program**". 23 were included after reviewing abstracts.

2. Factiva
https://global.factiva.com/

88,428 results for "Transformat* and healthcare" which seem to be mostly articles by journalists (newspapers, online). Filtered by subject (health) and industry (hospital care & computing) = 96 results. These are nearly all press releases or short articles. Included 16.

3. Google Scholar
https://scholar.google.co.nz/

36,100 results for "Transformation and healthcare" Added technology to search and took it back to 336,000. Refined search to

post 2000, which gave 19,100 results. Searched and reviewed first 500 entries ceasing at patents, non-refereed journals and foreign language articles. Included 31 articles.

4a. Medline (via proquest)

http://search.proquest.com/medline/medline/advanced

Searched for 'transformat*' and "healthcare or hospital" from 2000 to 2016. Got 15,895 results so searched within them for 'technologic*' and got 65 results and 'information technolog* transformation' and hospital'. Reviewed 168 and included 28 articles.

4b. Medline (via ovid)

http://ovidsp.tx.ovid.com/

Searched for 'hospital and transformat*' and limited search to post 2000 in the categories of health technology assessment and health administration journals and got 1891 results. Used the tree for information systems and branch of information sciences which includes category of information systems, which has a subcategory integrated advanced information systems. 288 results were reviewed and 11 included.

5. Proquest

http://search.proquest.com/health/advanced?accountid=14700

Searched for 'information and technolog* and transformat*' and 'healthcare' or 'hospital' and got 111,197 results so added complex to 'information technology transformation' and got 42,434 results. Limited to hospitals OR health care OR health care industry OR information technology OR health care management and got 5446 results. Proquest has several databases so can limit which it's accessing – Proquest Health Management had 2638 results and Proquest Health and Medical Complete had 1163. Sorted by subject to start with hospitals and include articles about hospitals that had subcategories organisational change, innovations, case studies, technological change, hospital information systems and got 425 results. Reviewed and included 29.

6. Pubmed

http://www.ncbi.nlm.nih.gov/pubmed

Searched for 'hospital' and 'information technology' (which gave option of 'information technology system' in indexing so used that) and evaluation studies (550 results). Reviewed first 400 sorted by relevance which were primarily about evaluations of specific IT interventions. Included 13 articles.

7. Scopus

https://www.scopus.com/

Searched information AND technology AND hospital. Refined by keyword – 'hospital information systems' and got 1960. Searched within these for 'transformation' and got 60 results; 'complex' and 'technolog*' and got 211. Reviewed both of these searches. Included 39.

8. SSRN

http://papers.ssrn.com/sol3/DisplayAbstractSearch.cfm

Searched for 'hospital' and 'information technolog*' across the two research areas Health Economics, Information Systems & eBusiness. Got 69 results. Reviewed and included 2.

Web of Science

http://apps.webofknowledge.com.ezproxy.otago.ac.nz/

Search for 'hospital' and "information technology" gave 1751 results. Refining by keyword 'transformation' gave 39 results. Included 8.

Search for 'complex' within 'hospital' and "information technology" results and got 132 results. Reviewed and included 13.

Two further separate searches were also conducted. The first focuses on identifying the literature about evaluation methods of transformational HIS. This garnered 21 relevant articles. The second search was to identify systematic reviews of HIS implementation articles. Fourteen relevant systematic reviews were included.

A 'meta-narrative review' as described in the methods section of the article obtained 57 further relevant publications.

A total of 382 publications was reviewed for this review.

Appendix B. Key references for factors that promoting and inhibiting successful HIS implementation

Key References for Factors that Promote or Inhibit Successful HIS Implementation

Promoting Factor	References
Organisational and technological structures in place	Currie and Finnegan [16], Doherty et al. [80], Fleuren [140], Harrison and Kimani [135], Hunter et al. [139], Robert et al. [30], Takian [87]
Ongoing Evaluation throughout implementation process	Abraham and Jungla [77], Black et al. [6], Brender [110], Nykänen et al. [127], Oates et al. [111], Takian [87], Wyatt and Wyatt [12]
Communication across the organisation	Anderson and Stafford [138], Cresswell et al. [74], Potts et al. [23], Waterson et al. [145]
Strong leadership	Bernstein et al. [134], Degeling and Carr [130], Doolan et al. [84]Erskine et al. [132], White et al. [133]
Adequate resourcing, including time/support for training	Doolan et al. [84], Li et al. [5], Morrow et al. [75], Robert et al. [30], Sharma et al. [117]
User involvement at all stages of implementation	Kushniruk et al. [153], Li et al. [5], Sherer et al. [152], Takian [87], Themistocleous and Morobito [54], van Gemert-Pijnen et al. [13]
End users understand perceived benefits of HIS	Cresswell and Sheikh [10], Ludwick and Doucette [144], Rye and Kimberley [31]
IT is fit for purpose	Goldzweig et al. [26], Morrison et al. [167], Takian [87], Yusof et al. [128]
'Champion' of the technology is involved	Gagnon et al. [3], Pare et al. [148], Udechukwu et al. [147]

Inhibiting Factor	References
User resistance	Gagnon [3], Hendy et al. [169], Rivard and LaPointe [170], Takian et al. [168]
Poor quality technology	Ancker et al. [165], Lorenzi and Riley [162], Powell-Cope et al. [166]
Organisational inflexibility and/or instability	Avison [21], Ellingsen and Monteiro [57], Harrison et al. [92], Kaplan and Salamone [163]
Lack of 'fit' between social, technological and organisational domains	Ammenwerth et al. [129], Cresswell and Sheikh [10], Tsiknakis and Kouroubali [39] Robert [30]

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