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Review article

Successfully implementing a national electronic health record: a rapid umbrella review

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ABSTRACT

Aim: To summarize the findings from literature reviews with a view to identifying and exploring the key factors which impact on the success of an EHR implementation across different healthcare contexts.

Introduction: Despite the widely recognised benefits of electronic health records (EHRs), their full potential has not always been achieved, often as a consequence of the implementation process. As more countries launch national EHR programmes, it is critical that the most up-to-date and relevant international learnings are shared with key stakeholders.

Methods: A rapid umbrella review was undertaken in collaboration with a multidisciplinary panel of knowledge-users and experts from Ireland. A comprehensive literature review was completed (2019) across several search engines (PubMed, CINAHL, Scopus, Embase, Web of Science, IEEE Xplore, ACM Digital Library, ProQuest, Cochrane) and Gray literature. Identified studies (n = 5,040) were subject to eligibility criterion and identified barriers and facilitators were analysed, reviewed, discussed and interpreted by the expert panel.

Results: Twenty-seven literature reviews were identified which captured the key organizational, human and technological factors for a successful EHR implementation according to various stakeholders across different settings. Although the size, type and culture of the healthcare setting impacted on the organizational factors, each was deemed important for EHR success; *Governance, leadership and culture, End-user involvement, Training, Support, Resourcing*, and *Workflows*. As well as organizational differences, individual end-users have varying *Skills and characteristics, Perceived benefits and incentives*, and *Perceived changes to the health ecosystem* which were also critical to success. Finally, the success of the EHR technology depended on *Usability, Interoperability, Adaptability, Infrastructure, Regulation, standards and policies*, and *Testing*.

Conclusion: Fifteen inter-linked organizational, human and technological factors emerged as important for successful EHR implementations across primary, secondary and long-term care settings. In determining how to employ these factors, the local context, individual end-users and advancing technology must also be considered.

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1. Introduction

Capturing and effectively using clinical information and knowledge to ensure a quality, safe and sustainable healthcare service is widely recognised as important [1,2] and data from electronic health records (EHRs) have been vital to decision-making on public health policies during the COVID-19 pandemic [3]. An EHR provides a longitudinal record of information regarding the health status of an individual in computer-processible form across practices and specialists, and enables authorised access to clinical records in real-time [4,5]. As well as expanding the capacity to utilise clinical data for monitoring of patient outcomes and conducting audits and research [6,7], the EHR provides access to patient information in a timely manner, enabling healthcare professionals (HCPs) to spend more time with patients [8], reducing duplication of tests and work, and improving the safety and quality of care provided [4,7,9–14]. Additionally, integration of other functions and software, such as clinical decision support and bar code medication administration, further expand its potential benefits [15,16].

Electronic patient records (EPRs) or electronic medical records (EMRs) also offer many of these benefits but solely contain the records from an individual organization. Whilst shared or summary care records and patient portals respectively store and facilitate access to specific patient information required by HCPs [17] and patients [18]. Despite the number of benefits which can be derived from these systems, challenges have been met in implementing a fully interoperable EHR between primary and secondary care [13,19], often attributed to the implementation process as opposed to the product supplied by the EHR vendor [20,21]. Therefore, the implementation process is critical [22] and must be considered as an ongoing process beginning during procurement and continuing throughout each phase of design, development, testing, 'Go Live' and optimization.

Whilst hospital information systems (HIS) in the USA have been in existence since the 1960s [23], HIS are a more recent phenomenon in the Republic of Ireland where public healthcare is managed by the Health Service Executive (HSE) which co-exists with a private health system. The Office of the Chief Information Officer (CIO) has overall responsibility for embedding technology within the health infrastructure [24] and to date, EPRs have been implemented in some individual private and public hospitals and the majority of general practitioner (GP) offices (i.e., private primary care physicians often with HSE contracts), as well as for specific cohorts of patients (e.g., maternal and newborn, and epilepsy) [25]. However, many other hospitals and HSE primary care (i.e., community) centres remain largely paper-based. With an EHR in the pipeline [24,26], three national projects have been planned by eHealth Ireland which is led by the Office of the CIO; Acute EHR, Community EHR and the Shared and Integrated Care Record. Therefore, this is an opportune time for policy-makers and other key stakeholders to review the learnings from the implementations of health information technology (HIT) both in Ireland and internationally.

However, a vast amount of literature is published on topics such as EHRs which renders it difficult for policy-makers to remain up-to-date [27,28], perhaps amplifying the "know-do" gap. Additionally, healthcare is a complex and adaptive system which needs to be recognized and acknowledged when attempting to replicate successes in another context [29]. The EHR programme in Ireland is also already underway and therefore, it's critical that knowledge is generated to provide actionable and relevant key considerations in a timely manner aligned with the policy and decision-making cycles [30]. Therefore, the aim of this review is to identify and explore the key factors which promote a successful EHR implementation across healthcare settings, with active collaboration from key stakeholders in the Irish context.

Table 1
Positions held by the members of the Expert Panel (n = 10).

National Clinical Information Officer for Nursing and Midwifery, HSE.
Professor of Health Informatics, UCD.
Group Chief Information Officer, Ireland East Hospital Group, HSE.
ICT Project Manager, Office of the Clinical Information Officer, HSE.
Senior Clinical Psychologist, National Rehabilitation Hospital, Dublin.
Clinical Health and Social Care Professional Lead in the Clinical Management System, National Rehabilitation Hospital.
Associate Professor in Physiotherapy, UCD.
Business Manager, National MN-CMS Project Team.
Community EHR Senior Project Manager, HSE.
General Practitioner (GP).
National Co-ordinator of the GPIT Project at the Irish College of General Practitioners.
Senior Professional Officer, Northern Ireland Practice and Education Council for Nursing and Midwifery.
EPR Project Manager, St. James' Hospital, Dublin.
Engagement and Delivery Lead, Informatics Directorate, St. James's Hospital, Dublin.
Physiotherapist.

Note: Some members of the expert panel had more than one position. Health Service Executive (HSE), government-funded organisation responsible for the provision of health and personal social services; UCD, University College Dublin; Ireland East Hospital Group, one of seven hospital groups in Ireland comprising of 11 hospitals and four community healthcare organisations; ICT, Information Communication Technology; Maternal and Newborn Clinical Management System (MN-CMS), an EHR for all women and babies being cared for across maternity and new born services in Ireland; GPIT, General Practice Information Technology; EPR, Electronic Patient Record.

2. Methods

2.1. Design

A rapid umbrella review was conducted and guided by the World Health Organisation (WHO) practical guide for *Rapid Reviews to Strengthen Health Policy and Systems* [31]. Unlike a systematic review, an umbrella review also known as a review of reviews, compiles evidence from several research syntheses across different healthcare contexts and stakeholder groups [32,33]. Active collaboration with an expert panel of knowledge users facilitated the acceleration of the systematic review process [30] and to facilitate uptake and use of these findings by planners and decision-makers, the synthesized findings were also presented in a report format [34].

2.2. Expert panel of knowledge users

A multi-disciplinary panel of experts and knowledge users (n = 10) were engaged and involved throughout the review process to inform its methodology, validate the generalizability and relevance of the review findings [35], and ensure it reflects current thinking and is useful [27]. The panel was convened in January 2019 by the Office of Nursing and Midwifery Services Director (HSE) and comprised of those currently involved in large HIT implementation projects across primary and secondary care at local and national levels in Ireland, as well as clinicians, health service researchers and academic partners from healthcare and health informatic backgrounds (Table 1). Five consultative in-person group meetings and several individual meetings and email exchanges within the group were conducted throughout the review process.

2.3. Research question and search strategy

An initial exploratory scope of the EHR literature in the PubMed database was reviewed by the expert panel and the final research question, methodology and search strategy were developed and agreed. A large number of search terms to describe *"Electronic Health Record", "Implementation"* and "*Literature Review"* were identified from previous systematic reviews [7,36–40], additional literature [17], medical subject heading and controlled vocabulary and via consultation with the

Table 2
Criteria for inclusion and exclusion of identified literature reviews.

Inclusion Criteria	Exclusion criteria
Literature review (i.e., provides a comprehensive search and summary of previous research). Reviewed the implementation of an electronic health record (EHR) and/or EHR component including EMRs, EPRs and computer physician order entries. Identified factors impacting on EHR implementation including barriers, facilitators. Conducted within a healthcare organisation.	Primary studies and editorial discussions. Not conducted within a healthcare organisation.

expert panel and an experienced information technologist at the Health Sciences Library, UCD [Appendix]. The search string was tailored to the indexing language of each database and in March 2019, it was executed across PubMed, CINAHL, Scopus, Embase, Web of Science, IEEE Xplore, ACM Digital Library, ProQuest and Cochrane, with limitations of English language and published since 2010. Grey literature including reports and conference proceedings were also searched (international Health Informatics Societies, the World Health Organization (WHO), European e-health network, Kings Fund, Gartner and Lenus). Panellists also drew on their expertise to identify any additional relevant sources [35].

2.4. Identification of literature reviews

Identified articles were calibrated in the citation management software Endnote version x9.2 and titles and abstracts were screened by one researcher using the inclusion and exclusion criteria agreed with the expert panel (Table 2). Full text articles were then accessed and screened by the same researcher, with any doubts regarding inclusion or exclusion discussed with the panel to overcome any risk of errors or inconsistencies associated with using one reviewer [31]. In line with our chosen rapid review methodology, a quality assessment of identified reviews was not conducted.

2.5. Data extraction and synthesis

A standardized data extraction form was developed and included authors, year of publication, study design, participants, healthcare setting, included studies and findings related to factors impacting on the implementation (i.e., themes and/or paragraphs as required). Following data extraction, a qualitative content analysis of the factors impacting on the EHR implementation was undertaken by the researcher [41]. Using an iterative process, a list of codes representing the identified factors from each of the literature reviews was formed [42]. The expert panel reviewed these codes via an adapted nominal group technique, which saw collated appraisals distributed amongst the panellists [43] to assess whether they were comprehensive of the literature and their own experiences, and to determine whether the findings could be transferred to Irish contexts and settings [42]. Having reached a final consensus regarding the factors for a successful EHR implementation, these factors were further categorized into a theoretical framework [10] and resulted in the generation of key considerations [42].

3. Results

3.1. Characteristics of literature reviews

Of the 5,040 articles retrieved, 27 literature reviews were identified which captured factors deemed important for the successful implementation of EHRs, as well as other HIT implementations (Fig. 1). Fifteen were classified as systematic reviews, whilst the others were umbrella reviews (n = 3), scoping reviews (n = 2), interpretive review (n = 1), literature review with a meta-narrative (n = 1) and other non-systematic literature reviews (n = 5). Overlap in included publications existed across the literature reviews with 974 unique studies, literature

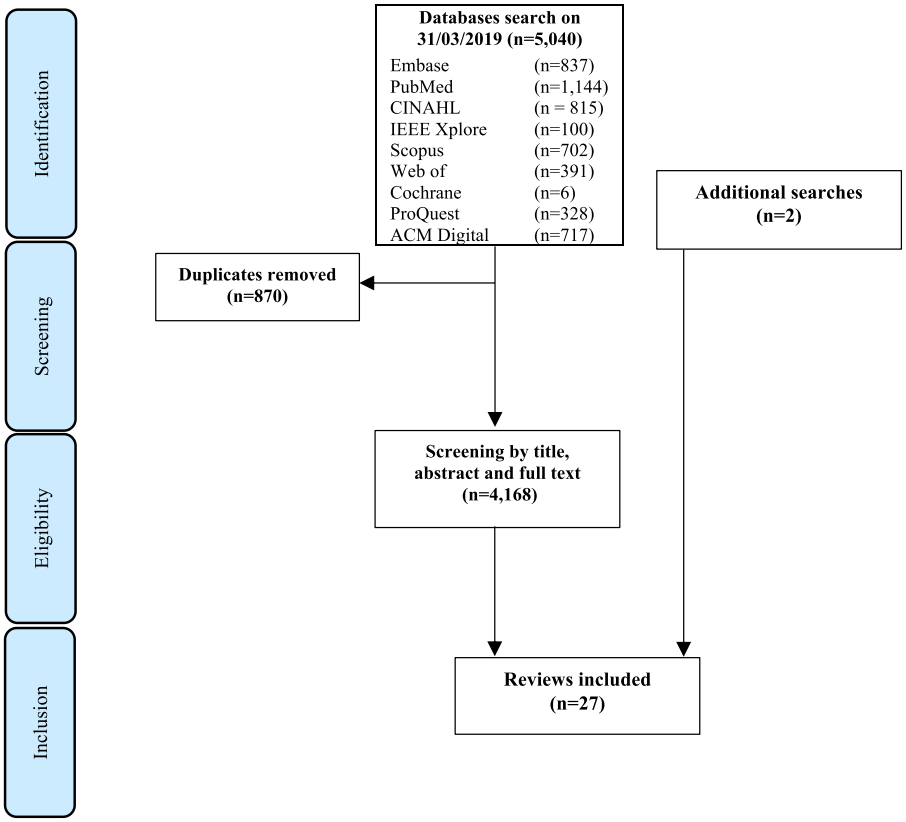

Fig. 1. PRISMA Flow Diagram.

Table 3
Identified literature reviews which reviewed the key factors for a successful EHR implementation.

Author (Year)	Design	Focus	Setting/ participants	Studies	Inclusion criteria	Identified factors		
Ajami and Bagheri-tadi [12]	Non-systematic review	Barriers to EHR adoption	Physicians in hospital or community	20	n/a	**Governance, leadership and culture** Vendor trust & experience Communication among users **Training** Formal training **Support** Expert & technical **Resourcing** Time & cost **Workflows** Workflow disruption	**Skills and characteristics** Computer literacy & skill Ability to select & effectively install system **Perceived benefits and incentives** Lack of incentives **Perceived changes to the health ecosystem** Concerns about data entry, patient acceptance, security & privacy Interfaces with doctor-patient relationship	**Usability** Complexity **Interoperability** Inadequate data exchange Interinstitutional integration **Infrastructure** Access to computers Reliability, speed & wireless connectivity Physical space
Ben-Zion et al. [52]	Literature review and prescriptive analysis	Success factors for EHR adoption	No restriction on healthcare setting or participants identified	55	2001-2013 English	**Governance, leadership and culture** Firm strategy Scope & project controls Interactions across communities Motivation to collaborate Culture change Knowledge management Process change **End-user involvement** IT alignment with firm strategy	**Support** Executive management Process change **Training** Process change **Resourcing** IT resources & cost **Workflows** Process change **Perceived benefits and incentives** Economic competitiveness	Motivation to collaborate **Usability** Accessibility & usability **Interoperability** IT integration with external networks **Infrastructure** IT innovation System Architecture & Infrastructure **Regulations, standards and policies** Shared language & narratives IT integration with external networks
Boonstra et al. [36]	Systematic review	EHR implementation lessons	Project team, doctors, nurses, technical & clerical personnel, administrators, IT personnel, psychiatrists, directors, CEOs, CIOs, managers, vendors, healthcare practitioners, pharmacists in hospitals	21	Up until 2013 English Peer-reviewed Empirical	**Governance, leadership and culture** Large not-for-profit teaching hospital Readiness for change Mature vendor Culture supporting collaboration & teamwork Little bureaucracy & considerable flexibility Comprehensive implementation strategy Interdisciplinary implementation group Champions among clinical staff **End-user involvement** Participation of clinical staff **Training**	**Support** Real-time support Management support **Resourcing** Financial capabilities Sufficient number of staff **Workflows** System fitting hospital's needs Creating a fit by adapting technology & work **Skills and characteristics** Previous experience of HIT Resistance of clinical staff	**Perceived changes to healthcare ecosystem** Ensuring care activities **Usability** User-friendly software Adequate safeguards **Infrastructure** Hardware System reliability (speed, availability & lack of failures) **Adaptability** Vendor willing to adapt
Boonstra et al. [53]	Systematic review	Barriers to acceptance of EMRs	Physicians in any healthcare organisations	22	1998-2009	**Governance, leadership and culture** Vendor uncertainty Lack of participation	**Resourcing** Start-up & ongoing costs Time to select, learn & convert patient records	Interference with doctor-patient relationship Privacy or security concerns **Usability**

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Table 3 (*continued*)

Author (Year)	Design	Focus	Setting/ participants	Studies	Inclusion criteria	Identified factors		
						Lack of leadership Organizational size & type Change Process **Training** Technical training **Support** Technical support External party support Support from organizational culture, other colleagues & management level	**Skills and characteristics** Lack computer skills Need for control **Perceived benefits and incentives** Return on investment More time per patient Lack of belief in EMRs Lack of incentives **Perceived changes to healthcare ecosystem** Time required to enter data	Complexity Limitations **Interoperability** Interconnectivity/ standardization **Adaptability** Lack of customizability **Infrastructure** Reliability Computers/ hardware
Castillo et al. 11	Systematic review	EHR adoption	Physicians in inpatients & outpatients in hospitals & primary care	68	1985-2010 English	**Governance, leadership and culture** Communication among users	**Support** Technical & expert **Workflows** Workflow impact	**Perceived benefits and incentives** User attitude **Interoperability** Interoperability
Cresswell and Sheikh [54]	Interpretive review	Organisational barriers to HIT implementation and adoption	No restriction on healthcare setting or participants identified	13	1997-2010 Systematic reviews	**Governance, leadership and culture** Open communication channels Senior leadership & "champion" Strong organizational leadership & management Avoidance of "scope creep" Appropriate implementation approach Plan for potentially extreme contingencies **End-user involvement** On-going involvement of key stakeholders **Support**	Lead professional support **Resourcing** Costs & additional time available **Workflows** Fits in with existing organizational processes **Skills and characteristics** IT literacy & general competencies of users Personal & peer attitudes **Perceived benefits and incentives** Offers relative advantages over existing practices	Useful Early demonstrable benefits **Usability** Perceived ease of use Supports inter-professional roles and working **Interoperability** Interoperable with existing technology Interoperability considerations **Adaptability** **Testing** Field testing of early prototypes
De Grood et al. [55]	Scoping review	Barriers to and opportunities for e-health technology adoption	Physicians in any healthcare organisations	74	1995-2015	**Governance, leadership and culture** Ownership & size of practice **Training** **Support** **Resourcing** Cost	Lack of time & workload **Perceived benefits and incentives** Pre-analysis of data Proof of utility Productivity **Perceived changes to healthcare ecosystem**	Privacy & security concerns Liability issues Patient and physician interaction Threatened clinical autonomy **Usability** Design
Fritz et al. [48]	Systematic review	Success criteria for EMR implementation	Hospital or community in low resource countries	47	English	**Governance, leadership and culture** Political Organizational **Training**	**Resourcing** Financial **Perceived changes to the healthcare ecosystem** Ethical	**Usability** Functionality **Infrastructure** Technical
Gagnon et al. [44]	Systematic review	Barriers and facilitators to implementing	Physicians, nurses, other HCPs, admin,	34	Empirical Design e-	**Governance, leadership and culture**	**Workflows** Work process **Skills and**	**Perceived changes to healthcare ecosystem**

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Table 3 (*continued*)

Author (Year)	Design	Focus	Setting/ participants	Studies	Inclusion criteria	Identified factors		
		electronic prescription	management in primary care		prescribing Link with primary care	Other professionals' performance Developer & vendor Implementation strategies Characteristics of the health structure Influence of leadership Macro organisational elements Professional interaction **Support** Support & promotion by colleagues Organisational support **Resourcing** Time issues Resources Cost issues	**characteristics** Agreement with e-prescribing Familiarity with technology Patients' attitudes & preferences Self-efficacy Socio-demographic characteristic Confidence in e-prescribing **Perceived benefits and incentives** Perceived usefulness Impact on clinical uncertainty Risk–benefit equation Outcome expectancy Time saving	Privacy and security concerns Patient/clinician interaction Autonomy Impact on professional security **Usability** Design Content appropriate & satisfactory Generic substitution options Data accuracy & legibility Ease of use Efficiency Patient security **Interoperability** **Infrastructure** System reliability or dependability
Gesulga et al. [56]	Structured literature review	Barriers to the implementation of adoption of EHR or EMR readiness	No restriction on healthcare setting or participants identified	38	English Until July 2016	**Governance, leadership and culture** Change in culture Lack of project planning Implementation issues Number of vendors Competitiveness External factors **End-user involvement** Involvement in design & implementation **Training** Lack of education & training **Support** Administrative & policy support Upgrading & maintaining the system **Resourcing** Lack of technical expertise Inadequate staff Implementation, maintenance, initial, equipment & training cost Lack of available funding	Increase of nurses & physician's workload **Workflows** Communication among users on data entry Reduces productivity & disturbs workflow **Skills and characteristics** User resistance Lack of computer skills Provider or patients age Illiteracy Physicians' experience with poor products Lack of capacity Unrealistic expectation about ease of installation **Perceived benefits and incentives** Lack of awareness of EHR/EMR & importance Concern that system will become obsolete Concern on return on investment Waiting to see if subsidies develop **Perceived changes to healthcare ecosystem**	Affects physician-patient interaction Concerns about privacy & confidentiality Physicians' legal liability **Usability** User access limitation Data accuracy & quality Capacity to use real-time data **Infrastructure** Centralized healthcare database National health information network Data Security Hardware functionality issues Internet connectivity Network communication infrastructure Network speed Lack of IT facilities & equipment **Regulations, standards and policies** Lack of health information data standards Health terminology & classification Risk of new regulatory requirements
Gill et al. [57]	Scoping review	Adoption of EHRs or EMRs	No restriction on healthcare setting or participants identified	39	Case studies English 2010-2015	**End-user involvement** Use of stakeholders throughout the process **Training**	Sufficient time spent on training clinicians **Support** Executive	**Usability** System designed & built as per requirements
Kruse et al. [58]	Systematic review	Facilitators & barriers to the	Public health	55	2012-2017 English	**Governance, leadership and**	Disease management	Complex Ease of use

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Table 3 (*continued*)

Author (Year)	Design	Focus	Setting/ participants	Studies	Inclusion criteria	Identified factors		
		adoption of an EHR for population health				**culture** Communication **Support** Limited staff support **Resourcing** Cost Financial assistance Productivity loss **Skills and characteristics** Resistance to change **Perceived benefits and incentives**	Critical thinking/ treatment decisions Quality Surveillance Preventative care Decision support Health outcomes **Perceived changes to the healthcare ecosystem** Privacy concerns **Usability**	Accessibility/ utilization Satisfaction Data management / Missing data & errors Efficiency **Interoperability** **Regulations, standards and policies** No standards **Infrastructure** Current technology
Kruse et al. [51]	Systematic review	Barriers to EHR adoption	Any patient care facility in the USA	21	2012-2016 English	**Governance, leadership and culture** Need organizational cultural change Facility location Competitiveness Consensus within the practice External factors Eligibility criteria **Training** **Support** Technical support **Resourcing** Initial & maintenance/ ongoing costs Insufficient time Effort needed to select system Staff shortages Productivity loss **Workflows** Workflow challenges	**Skills and characteristics** Resistance to changing work habits Physician attitude Race & income disparities Provider or patient age User acceptance IMGs less likely to adopt **Perceived benefits and incentives** Financial incentives Return on investment Perceived usefulness Penalties Medical errors **Perceived changes to the healthcare ecosystem** Privacy concerns Physician autonomy	**Usability** Technical concerns Inability to easily input historic medical record data Complexity of system Limitations of system Missing data **Interoperability** Interoperability Degree of integration **Adaptability** Agility to make changes **Infrastructure** Technical infrastructure Upgrades **Regulations, standards and policies** Clarity of Federal and State policies
Kruse et al. [50]	Systematic review	Barriers & facilitators to EHR adoption	Any patient care facility in the USA	36 (31 unique)	2012-2015	**Governance, leadership and culture** Facility location Implementation issues External factors Organizational cultural change Hospital size Project planning Alignment with strategy Competitiveness Communication **Training** **Support** Maintenance Executive management support **Resourcing** Cost	Time-consuming Lack of tech assistance Staff shortages/ overworked **Skills and characteristics** User/patient resistance Lack of tech experience Provider or patient age Race & income disparities IMGs less likely to adapt **Perceived benefits and incentives** User perception/ perceived lack of usefulness Incentives Long run cost savings Error reduction Improved	**Usability** Transition of data Missing data Access to patient data Efficiency Privacy & security **Interoperability** Ability to transfer information Continuity of care document **Infrastructure** Upgrades Lack of infrastructure & space for systems **Adaptability** Lack of agility to make changes **Regulations, standards and policies** Standard protocols for data exchange

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Table 3 (*continued*)

Author (Year)	Design	Focus	Setting/ participants	Studies	Inclusion criteria	Identified factors		
							population health Medical error	
Kruse et al. [46]	Systematic review	Adoption factors for EHR introduction	LTC	22	2009-2014 English USA-based	**Governance, leadership and culture** Project planning Facility characteristics Implementation issues Cultural change External factors **Training** Training Implementation issues	**Resourcing** Cost Staff retention **Perceived benefits and incentives** Error reduction Cost savings Health outcomes User perceptions Time savings	**Perceived changes to the healthcare ecosystem** **Usability** Implementation issues Clinical and administrative efficiency Security Access & transfer to information **Regulations, standards and policies** Implementation issues
Kruse et al. [59]	Systematic review	Internal organizational and external environmental factors associated with adoption of HIT	No restriction on healthcare setting or participants identified	17	1993-2013 English	**Governance, leadership and culture** Competitiveness Location & size Interdependence Ownership Strategic alliances Communication among users	Physician arrangements Teaching status **Support** Technical & expert Unity of effort **Resourcing** Payers Capital expenditure	**Workflows** Workflow impact Complexity of care **Skills and characteristics** Patients & users User attitude toward information Computer anxiety **Interoperability**
Lluch [19]	Literature review	Organisational barriers to HIT implementation	OECD and EFTA countries	79	2007-2010 English	**Governance, leadership and culture** Hierarchy Teamwork & cooperation Centre of gravity and autonomy **Training** Training, IT/HIT skills **Support** **Workflows**	Changes in work processes & routines **Skills and characteristics** Training, IT/HIT skills **Perceived benefits and incentives** Incentives **Perceived changes to the healthcare ecosystem** Autonomy	Face-to-face interaction versus new ways of working Trust & liability Accountability to employer & policy makers **Interoperability** Information & decision processes **Regulations, standards and policies** Lack of legal framework
Mair et al. [60]	Explanatory systematic review of reviews	Factors that promote or inhibit e-health technology implementation	No restriction on healthcare setting or participants identified	37	Literature reviews 1990-2009	**Governance, leadership and culture** Coherence Cognitive participation Addressing organizational issues Reflexive monitoring **End-user involvement** Cognitive participation **Training** Roles, responsibilities & training **Support**	Addressing organizational issues Roles, responsibilities & training **Resourcing** Addressing organizational issues **Skills and characteristics** Cognitive participation **Perceived benefits and incentives** Cognitive participation Confidence and accountability Reflexive monitoring	**Perceived changes to the healthcare ecosystem** Effects on healthcare tasks Confidence and accountability **Usability** Effects on healthcare tasks **Interoperability** Addressing organizational issues **Regulations, standards and policies** Addressing organizational issues
McGinn et al. [49]	Systematic review	EHR implementation barriers and facilitators	Physicians, HCPs, pharmacists, admin, midwives, social workers, patients in health services comparable to Canada	60	1999-2009 Empirical	**Resourcing** Lack of time & workload Cost issues **Skills and characteristics** Familiarity &	Productivity Motivation to use EHR **Perceived changes to the healthcare ecosystem**	Privacy & security concerns **Usability** Perceived ease of use **Interoperability** **Infrastructure**

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Table 3 (*continued*)

Author (Year)	Design	Focus	Setting/ participants	Studies	Inclusion criteria	Identified factors		
						ability with EHR **Perceived benefits and incentives**	Patient & health professional interaction Design or technical concerns	Design or technical concerns
Nguyen et al. [7]	Systematic review	EHR impact and issues	Clinicians, patients, doctors, nurses, management, administration, organizations & IT staff across primary, secondary, LTC, ambulatory & community care	98	2001-2011 English Empirical Peer -reviewed	**Governance, leadership and culture** Implementation Organizational Adoption rate Systems development **End-user involvement** Systems development Implementation **Training** Service quality Implementation **Support** Service quality Implementation **Resourcing** Implementation Organizational	**Workflows** Changes to workflow **Skills and attitudes** Attitudes Adoption rate Implementation **Perceived benefits and incentives** Attitude Quality and safety of care Administrative efficiency & cost reduction Changes to workload & productivity Clinical documentation practice & quality Information quality Implementation **Perceived changes to the healthcare ecosystem**	Clinician-patient relationships Systems quality **Usability** Systems quality Information quality Adoption rate User satisfaction & use **Interoperability** Systems quality Implementation **Infrastructure** Service quality **Regulations, standards and policies** Systems development **Testing** Implementation
Nguyen et al. [7]	Literature review	Organisational success factors for HIT	No restriction on healthcare setting or participants identified	36	English Peer-reviewed 2001-2013	**Governance, leadership and culture** Champion Openness of the organization to change & innovation Collaboration with vendors **End-user involvement** End-user participation Collaboration among administration, IT & clinical functions	**Training** **Support** Technical support **Resourcing** Sufficient resources **Workflows** Collaboration among administration, IT, & clinical functions	**Perceived benefits and incentives** Incentives Provision of information System, service & information quality **Infrastructure** Infrastructure quality **Regulations, standards and policies** Regulation
O'Donnell et al. [13]	Systematic review and evidence synthesis	EMR adoption	Physicians in primary care	33	1996-2017	**Governance, leadership and culture** Organization Implementation **Training** Implementation **Support** Quality of information, system & service **Resourcing** Funding & incentives **Workflows**	Use & user satisfaction **Skills and characteristics** People **Perceived benefits and incentives** Net benefits in terms of care quality, productivity & access Funding & incentives **Perceived changes to the healthcare ecosystem** Use & user satisfaction	**Usability** Quality of information, system & service **Interoperability** Quality of information, system & service **Infrastructure** Quality of information, system & service **Regulations, standards and policies** Legislation, policy &governance
				119	2004-2009			

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Table 3 (*continued*)

Author (Year)	Design	Focus	Setting/ participants	Studies	Inclusion criteria	Identified factors		
Police et al. [45]	Systematic review	Benefits and barriers to HIT implementation	Physicians in primary care			**Governance, leadership and culture** Practice-based predictors & barriers External policies & organizational barriers Impact of practice culture **Training** Educational barriers	**Resourcing** Financial barriers **Perceived benefits and incentives** Staff-related barriers **Perceived changes to the healthcare ecosystem** Technological barriers	**Interoperability** Technological barriers **Infrastructure** Technological barriers **Regulations, standards and policies** External policies & organizational barriers Technological barriers
Ratwani et al. [37]	Systematic review	EHR safety and usability challenges	No restriction on healthcare setting or participants identified	55	2010-2016 English Peer-reviewed	**Governance, leadership and culture** Governance & consensus building **End-user involvement** Governance & consensus building **Training** **Support** Training	**Resourcing** Cost and resources **Workflows** Clinical workflow **Skills and characteristics** Training **Usability**	Customization Usability testing **Adaptability** Customization **Testing** Risk assessment Usability testing
Ross et al. [62]	Umbrella review	Implementation of e-health	No restriction on healthcare setting or participants identified	44	2009-2014	**Governance, leadership and culture** Implementation climate Planning Engaging Reflecting & evaluating Leadership engagement Champions **End-user involvement** Key stakeholders **Support** **Training** Access to knowledge & information	**Resourcing** Cost Available resources **Workflows** Compatibility **Skills and characteristics** Knowledge & beliefs Other personal attributes **Perceived benefits and incentives** Incentives Reflecting and evaluating	**Perceived changes to the healthcare ecosystem** Knowledge & beliefs **Usability** Complexity **Interoperability** **Infrastructure** Complexity **Regulations, standards and policies** External policy **Adaptability**
Sligo et al. [10]	Literature review with a meta-narrative	Large scale HIT planning, implementation and evaluation	No restriction on healthcare setting or participants identified	382	n/a	**Governance, leadership and culture** Structural/ contextual/ organizational factors Technical factors **End-user involvement** Structural/ contextual/ organizational factors Technical factors **Training** Human factors **Support** Structural/ contextual/ organizational factors	**Resourcing** Structural/ contextual/ organizational factors Human factors **Workflows** Human factors **Skills and characteristics** Human factors **Perceived benefits and incentives** Technical factors **Perceived changes to the healthcare ecosystem**	Human Factors **Usability** Technical factors **Interoperability** Technical factors **Infrastructure** Technical factors **Adaptability** Technical factors **Testing** Technical factors
Strudwick and Eyasu [47]	Literature review	Experiences with EHR implementation	Nurses in mental health settings	7	English	**End-user involvement** **Skills and characteristics** Characteristics of nurses Experience and	**Perceived benefits and incentives** Perceived benefits **Perceived changes to the healthcare**	**Usability** **Infrastructure** Physical space Lack of computers

(*continued on next page*)

Table 3 (*continued*)

Author (Year)	Design	Focus	Setting/ participants	Studies	Inclusion criteria	Identified factors	
						interest in computers	**ecosystem** Privacy and confidentiality concerns

Note: EHR, Electronic health record; LTC, long-term care; HIT, Health Information Technology; OECD, Organisation for Economic Co-operation and Development; EFTA, European Free Trade Association; HCPs, Health and Social Care Professionals.

reviews, reports, books and guidelines identified. Perspectives of a variety of stakeholders were captured in these reviews including GPs (or primary care physicians), other doctors, nurses, health and social care professionals (HCPs), patients, policymakers, vendors and IT consultants (Table 3). Although many literature reviews encompassed studies from a variety of healthcare settings, others were specific to primary care (i.e., community) [13,44,45], long term care [46] and mental health settings [47] or within specific countries or groups of countries [19,48–51].

3.2. Synthesized findings

Fifteen common factors were identified and classified as organizational, human and technological. Each of these factors are discussed in detail below as well as how they interact within different contexts.

3.2.1. Organizational factors

Factors relating to the processes by which the EHR was introduced and incorporated into routine care were categorized as organizational [54]. Whilst each of the six factors were important across all contexts, the size and type of organization impacted on how each triggered success during the EHR implementation [46,53,61].

3.2.1.1. Governance, leadership and culture. The governance of the EHR implementation [13,19,37], as well as leaders [7,10,36,44,48,52–54,62,63] and organizational culture, were identified as paramount in ensuring a successful EHR system [7,10,13,36,45,50–53,56,59,62]. Whilst top-down, middle-out and bottom-up governance structures have been utilised, ongoing political willingness, national policies and some independence at an individual organizational level regarding EHR procurement, development and design, were recommended to promote engagement, usability and interoperability [13,48,51,62]. It was also important that executive leaders such as CIOs and project management teams establish good and trusting relationships with vendors and consulting firms [12,44,52,56,63], and designed the implementation strategy with clear measurable objectives [10,50,52], a fitting implementation process (e.g., big-bang or phased) [44,46,51,58], and clear roles and divisions of labour [10,60]. A shift away from the dominance of top and middle management has also been recommended [10,19,36], with the appointment of local leaders or *champions*, and supporting of internal and external communication and collaboration [10,11,19,52,59], innovation and continual improvement [52], and patient-centred care [19]. This also helps to create a favourable [10,36,44,63] and flexible [52] culture.

3.2.1.2. End-user involvement. During each stage of the EHR implementation process, end-user involvement was highlighted as important [7,10,37,47,48,52,54,56,57,60,62,63], as it helps to ensure that the EHR meets end-users' needs and workflows, as well as promoting a sense of ownership [37] and acceptance amongst staff [10,37,63]. Engaging end-users from each stakeholder group was recommended [36], and this has often been done in the form of appointing *champions*. These leaders should be respected amongst their colleagues as well as having the relevant knowledge to act as a bridge between the end-users and IT staff [60,62,63]. However, *champions* may sometimes need to be shared between organizations [10].

3.2.1.3. Training. Basic computer and EHR-specific training were identified as key to a successful EHR implementation [7,10,12,13,19,36,37,45,46,48,50–53,56,57,60,61,63]. However, the effectiveness and resource-efficiency of training depended on the appropriateness of the appointed trainers, training content, timing of training (i.e., as close to *Go Live* as possible [36]) and methods of training e.g., classroom based versus eLearning [57]. EHR training was also recommended on an ongoing basis for new staff, as well as existing staff to optimize their use of the system [37,53].

3.2.1.4. Support. Expert, technical, executive and external support have been critical to successful EHR implementations [7,10–13,19,36,37,44,50–53,56–58,60–63]. Expert or peer support, often referred to as *super-users*, reportedly helped end-users to optimize their use of the EHR [7,11,12,36,53], whereas technical support staff helped solve IT issues [51,62]. During *Go Live* (often first 3-4 weeks [37]), technical and peer support should be available 24/7 seven days a week in hospitals [12,36]. However, this may not be feasible or required in primary care centres but channels to obtain support during working hours remain important. Other crucial support comes from an executive or policy level [19,50,52,53,56,57,60,63] and professional networks or external parties [19,53]. Although maintenance support for servers and networks was not as evidenced in the identified literature [50], the expert panel also deemed this as important.

3.2.1.5. Resourcing. The availability of resources in terms of finance, skilled workforce and time was also important [7,10,12,13,36,37,44–46,48,49,51–54,56,59–63]. Financial resourcing was often highlighted as a barrier especially by primary care doctors [12,13] and those in lower income countries [48], and scope creep of the budget was a common occurrence for larger hospitals [10,52,54]. Therefore, a cost analysis which encompasses infrastructure, personnel, maintenance and ongoing optimization was critical [36,62]. Having a skilled workforce in-house who understand the clinical workflows was also recommended [53,61] as it can reduce dependence on and cost of vendors [12,36]. However, this may not be feasible for smaller organizations, and larger organizations also reportedly had issues with IT staff retention [10,13,36,48,51]. Adequate time for end-user involvement and habituation to the EHR was also vital [7,10,12] to ensure organizational readiness [7,13,51,53].

3.2.1.6. Workflows. Inability of the EHR system to meet the workflows of end-users and organizations was commonly cited as negatively impacting on success [7,10–12,36,37,51,52,54,56,62,63], including end-user efficiency, productivity, satisfaction and acceptance of the EHR [7,11,63]. Although replicating existing paper-based practices may minimize disruptions for end-users [7,13,19,62], re-engineering of workflows during digitization to make them safer and more efficient was recommended [19,62,63].

3.2.2. Human factors

Ability of healthcare organizations to successfully adopt an EHR system was largely determined by the individual end-users [10,54], and three overarching human factors were identified.

3.2.2.1. Skills and characteristics. IT skills as well as personal characteristics of individuals impacted on the success of an EHR implementation [10,12,50,51,53,56,58,60,62,13,19,36,37,44,47–49]. Assessing computer literacy of end-users enabled provision of basic computer training to those requiring it, prior to effective EHR training [36,48]. Whilst the research assessing the impact of age, gender and clinical experience on acceptance of the EHR reported in the identified reviews was inconclusive, personal traits such as being open-to-change and a problem-solver appeared to contribute to success [56,62]. However, resistance to embracing the EHR could also be attributed to unusable technology [10,51].

3.2.2.2. Perceived benefits and incentives. Where individual end-users perceived the EHR to positively impact on patient care and workload, this reportedly facilitated a successful implementation [10,12,50,51,56,58,60,13,19,36,37,44,47–49]. However, realistic benefits and timeframes specific to the organization should be communicated with end-users [44,45,62]. Monetary incentives or penalties have also been shown to be important, especially for privately-governed organizations [13,45,59].

3.2.2.3. Perceived changes to the healthcare ecosystem. End-users' concerns with changes to data privacy and security, patient-clinician relationships and their roles and responsibilities, appeared to negatively impact on EHR implementations [7,10,51,53,56,58,60–62,12,13,19,36,44,47–49]. These concerns may differ depending on the specific setting and type of sensitive personal information being collected (e.g., mental health) [47]. Therefore, specific concerns and their causes of concerns should be identified and addressed as soon as possible to mitigate their impact on EHR implementations [19,36].

3.2.3. Technological factors

Six factors relating to the technology aspect of the EHR implementation were identified as critical to its success and were intrinsically linked to the organizational and human factors.

3.2.3.1. Usability. EHR usability was deemed important across several reviews [7,10,11,13,36,37,44,46,47,49,51,52,54,58,60,62], as it impacted on end-user efficiency, patient-facing time [12,13,37,53], quality of care [12], patient-clinician relationships [52] and safety [37]. However, a simple and intuitive system in one setting may not be transferrable to another, and therefore, end-user involvement in development, design [10,37,62] and usability testing were recommended at each site [37]. Additionally, enabling personalization of the EHR interface [53] and access to legacy paper-based records [50,51] as well as consideration of data quality and accuracy [13,44,51] with use of health terminologies and classifications [56] was recommended. However, usability needs to be balanced with security [44].

3.2.3.2. Interoperability. To enable health information exchange both within and across healthcare organizations, interoperability was identified as critical [7,10–13,19,37,44,45,49–52,54,58,60,62]. Local contextual factors within countries such as two tier and fully private health systems, lack of employment of national standards [45,53,62], inconsistent data capture in incompatible formats [12], have rendered the creation of a fully interoperable EHR as difficult. Therefore, technical standards and communication between organizations were recommended to ensure interoperability was built in from the outset including for legacy and existing health IT systems [7].

3.2.3.3. Infrastructure. Procurement or enhancement of infrastructure, including software (e.g., EHR, anti-viral), hardware (e.g., data-entry devices, Wi-Fi, power outlets) and furniture, accounted for a large proportion of the financial resourcing and were deemed critical for the success of the overall EHR implementation [10,12,56,62,63,36,47–53]. The existing and new hardware and software must be compatible with the specific EHR product [45], reliable and functional [13,36,44,53,56], and enable sufficient accessibility to the EHR for end-users [36,45,52,56]. According to the expert panel and additional literature reviewed, selection of mobile and stationary data-entry devices also require consideration of vendor certification, healthcare setting (e.g., outpatients versus isolation rooms), required functions and workflows (e.g., checklists versus long narrative notes), and end-user preferences for usability.

3.2.3.4. Regulation, standards and policies. As stated earlier, national and international standards as well as regulation and policies were critical for interoperability and addressing privacy and security concerns [7,13,19,45,46,51,52,56,58,60,62,63]. Therefore, messaging and language standards [45,52,56], as well as robust privacy laws and policies [13,44,52,56,62] were recommended. Where healthcare organizations were permitted to procure their own EHR product, these standards would likely be especially important.

3.2.3.5. Adaptability. Many of the literature reviews reported that adaptability of the software was important to facilitate customization of the EHR software to meet the needs of the end-users and organizations [10,36,37,50,51,53,54,62]. This reportedly required the software vendors to be open to sharing code development data and willing to adapt their product [36,37,53], and the organization to have access to a skilled workforce with the capabilities to adapt the EHR to clinical workflows [37]. Where interoperability standards exist, the need for adaptations to the software may be reduced [37].

3.2.3.6. Testing. Comprehensive testing of the system was critical to ensure usability and safety [7,10,37,54], and was more commonly cited as important by IT staff and management than by HCPs [7]. This rigorous, resource-intensive, multi-step testing process of each EHR function needed to be conducted within live environments with actual end-users [54] and should not be underestimated.

4. Discussion

This umbrella review distilled the large volume of evidence available regarding the successful implementation of a national EHR and these findings were corroborated by an expert panel as being relevant to the Irish healthcare context. Fifteen key organizational, human and technological factors were identified as critical and by synthesizing the findings from several stakeholder groups and clinical settings, such as doctors in primary or secondary care [11,13,45,53,58,61] and nurses in a mental health setting [47], this review of reviews identified that each of these factors were also relevant and important to EHR and other HIT implementations across different healthcare contexts.

However, between country differences including health service management, politics, economics, regulation and socio-culture impact on how the identified factors influence success. This was evident in the literature reviews which largely focused on studies conducted in the predominantly private health service in the USA where return on investment and productivity were perceived benefits and incentives of EHRs or EMRs [50,51,56]. Additionally whilst the governance approach was identified as important, a successful approach in one country cannot necessarily be replicated in another, as occurred in the UK where the top-down approach successfully employed in the Netherlands resulted in disengaged healthcare organizations across the UK [22]. Therefore, these factors need to be employed with consideration of the national context and in the Republic of Ireland this will also require close collaboration and communication across the co-existing public and private health sectors [64,65], as well as with those in Northern Ireland (UK). Additionally, European Union (EU) citizens may avail of healthcare from any member state under the Cross-Border Healthcare

Summary points

What was already known on the topic:

- Despite recognition of the huge potential for EHRs to improve the delivery of healthcare, huge challenges have been met in implementing a fully interoperable EHR across acute and community care.
- The implementation process of EHRs is critical to their success and needs to be carefully planned and considered across the complex and adapting healthcare landscape.
- A vast amount of literature exists on EHRs which has been relevant to specific stakeholder groups and healthcare contexts.

What this study adds:

- A comprehensive and clear overview of factors influencing the success of an EHR implementation across primary, secondary and long term care and different stakeholder groups is presented.
- Validation of these factors for the Irish healthcare context via co-production and transfer of knowledge with key knowledge-users.
- Generation of key considerations for each of these factors for policy-makers and other knowledge-users.

Directive (2011/24/EU) and thus, efficient exchange of health data across borders is a major priority [66] and is a pillar of EU4Health 2021-2027 [67]. Therefore, the EU interoperability policies and frameworks [14] as well as standards such as the International Patient Summary, the General Data Protection Regulation (GDPR) and standardised terminologies [4] to support these frameworks need to be employed.

Despite the expansion in internationally-recognised standards (e.g., HL7 FHIR) and significant regulatory and financial incentives created by the HITECH Act and "Meaningful Use" requirements in the USA, factors such as *Usability* and *Regulations, standards and policies* continue to be highlighted as important for success as opposed to being assumed components of EHR products. Whilst the inclusion of older studies by these reviews perhaps contributed to this, it is also likely that standards and requirements alone will not ensure an interoperable and usable EHR. In fact, it is the dynamic interaction between each of the identified factors which promotes a successful EHR [68]. However, placing more emphasis on an individual factor can reduce the resources required for others. For example, promoting *Usability* and *Standards* can respectively reduce the burden of training and support, as well as adaptability [37]. Additionally, this may be achieved by advances in evidence and technology such as artificial intelligence (AI) including automated testing [69], eLearning modules [70,71], and personalization of the EHR interface [72]. Therefore, it is recommended that those involved in each aspect of the implementation process communicate throughout it and review the latest evidence regarding technology including peer-reviewed publications and white papers.

At a more local or meso level, the size of the organization, infrastructure, organizational readiness and culture, capabilities and beliefs of the workforce, and available finance [36,37], were also identified as important when considering the application of the identified factors. Certain aspects of the internal context can also be enhanced to improve the likelihood of EHR success such as employing change management to create a clear and realistic vision of the EHR [73] and providing basic computer training [36,48]. However, the size of the organization and its workforce will likely remain more limited compared to their larger counterparts [10,37]. Therefore, sharing of resources such as champions, support staff and trainers between larger and smaller hospitals or primary care settings has been recommended, with some countries creating networks or encouraging collaboration between existing regional groups of healthcare organizations [73,74].

4.1. Strengths and Limitations

Undertaking a rapid qualitative evidence synthesis requires acceleration of many of the research processes, is dependent on the reporting in the original reviews [32] and could risk losing the context and complexity of the original research setting [32,42,75]. Additionally, five of the literature reviews were conducted by the same lead author which could lead to bias of individual study inclusion. However, the inclusion of literature reviews, consideration of the inclusion criteria of each literature review and ongoing collaboration with an expert panel [30], provided a degree of confidence regarding the coherence, relevance and adequacy of the findings and their generalisability across healthcare settings [76]. Additionally, actively involving knowledge-users who were undertaking HIT implementations led to the concurrent translation of this knowledge into practice [77].

5. Conclusion

The key organizational, human and technological factors identified in this review provide policy-makers and other key stakeholders with a foundation for making evidence-based decisions during the implementation of a fully interoperable EHR across primary, secondary and long-term care. However, consideration of the specific contextual influences is critical to the successful application of these factors. Additionally, the end-users, existing technological standards and policies, and advances in technology and research in the area, will impact on how these factors dynamically interact during the EHR implementation and will influence success.

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Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix A. Search Strategy

Electronic Health record
Electronic health record*
Electronic Healthcare Record*
Electronic patient record*
Computeri?ed health record*
Electronic medical record*
Online health record*
Digital health record*
Computeri?ed medical record*
Electronic Medical Record
Automated medical records
Electronic health record
Electronic health records
Electronic medical record
Computerized medical records
Automated medical records
Electronic Record System*
Clinical Information system*
Electronic Health Record System*
Medical Information System
Computerized medical systems
Computerized medical systems
Clinical data repositor*
Health Records System*
Medical Records System*
Health information system*
Hospital information system*
Health Information Systems
Medical records system, Computerized
Electronic health record system
Medical information system
electronic prescribing
e-prescri*
eprescri*
Electronic pharmaceutical record
Electronic Order Entry
computerized ordering
Medical Order Entry System*
Drug Information System
Order comm*
Computeri?ed Physician Order Management
Computeri?ed Provider Order Entry
Computeri?ed Provider Order Management
Computeri?ed Physician Order Entry
Medical Order Entry Systems
Electronic Order Entry
Computerized provider order entry
Personal health record*
Patient health record*
Electronic patient record*
Patient portal*
Shared care record*
Summary care record*
Patient data repositor*
Interoperability
Health Care Information Exchange*
Medical record linkage*
Health Information Exchange
Patient Portals
Health Information Interoperability
Data interoperability Interoperability
Health Information Exchange
Medical Record Linkage EHR
PHR
EHCR

(*continued on next page*)

(*continued*)

EPR
EMR
CIS
EHRS
DIS
CPOM
CPOE
EPR
EHRS
HIE
Implementation
Implement*
Introduc*
Adopt*
Develop*
Establish*
Process*
Execut*
Employ*
Instigat*
Launch*
Re-launch
Commence*
Initiat*
Uptake*
Configuration*
Customization*
Re-optimi*
Optimi*
Rollout*
Evaluat*
Assess*
Design
Facilitate*
Barrier*
Challeng*
Benefit*
Success
Failure
Systems Development
Systems Implementation
Literature Review
Systematic Review
Scoping Review
Meta Analysis
Literature review
Systematic review
Scoping review
Meta-analysis
Meta-synthesis
Systematic interpretive review
Systematic methodological review
Systematic meta-review
Systematic literature review
Qualitative synthesis
***Note:** *, truncation; ?, wildcard; italicised terms, refer to subject headings which were exploded in the relevant databases.*

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