Computers in Biology and Medicine 137 (2021) 104785

Contents lists available at ScienceDirect

Computers in Biology and Medicine

journal homepage: www.elsevier.com/locate/compbiomed

# Obstacles and features of health information systems: A systematic literature review

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ARTICLE INFO

*Keywords:*
Health information system
Systematic literature review
Features of HIS
Obstacles to HIS
State-of-the-art
Electronic health record

ABSTRACT

*Background:* Currently many healthcare systems are supported by an increasing set of Health Information Systems (HISs), which assist the activities for multiple stakeholders. The literature on HISs is, however, fragmented and a solid overview of the current state of HISs is missing. This impedes the understanding and characterization of the required HISs for the healthcare domain.
*Methods:* In this article, we present the results of a Systematic Literature Review (SLR) that identifies the HISs, their domains, stakeholders, features, and obstacles.
*Results:* In the SLR, we identified 1340 papers from which we selected 136 studies, on which we performed a full-text analysis. After the synthesis of the data, we were able to report on 33 different domains, 41 stakeholders, 73 features, and 69 obstacles. We discussed how these domains, features, and obstacles interact with each other and presented suggestions to overcome the identified obstacles. We recognized five groups of obstacles: technical problems, operational functionality, maintenance & support, usage problems, and quality problems. Obstacles from all groups require to be solved to pave the way for further research and application of HISs.
*Conclusion:* This study shows that there is a plentitude of HISs with unique features and that there is no consensus on the requirements and types of HISs in the literature.

## 1. Introduction

Nowadays the healthcare sector is becoming increasingly dependent on the supporting information systems. Currently, for example, almost every registration happens digitally and digitization in healthcare is rising [2]. Only a few decades back, the first transition was made from the paper-based record to the electronic health record [14], today we discuss using techniques such as blockchain to exchange health data [1]. The first digitization arrived at academic medical facilities [11,14], but since then also other domains of the healthcare sector use their information systems. For example, a General Practitioner (GP) uses a GP information system, a pharmacist a pharmacy information system, and a laboratory technician a laboratory information system. All these systems can be categorized as Health Information Systems (HISs).

Typically HISs assist healthcare organizations in processing data, information, and knowledge in order to contribute to high-quality, efficient patient care [16,17,53]. The HIS is considered as a building block of the complete health system, and therefore a well-functioning HIS is a vital aspect for delivering excellent care and receiving reimbursement for the care given [41,48]. This importance also emerges from the following statement of the WHO [48]: "*A well-functioning health information system is one that ensures the production, analysis, dissemination and use of reliable and timely information on health determinants, health system performance and health status.*" For this article, we consider a comprehensive HIS from all different domains of the healthcare sector.

Whereas in the past registration was often done on a dedicated desktop computer, today it is also increasingly done on other platforms such as mobile phones, tablets, or a central computer server [6,19,40]. Due to the differences between healthcare domains and deployment methods of HISs, each HIS has unique characteristics, which we define as system features. HISs used to have the sole function of keeping track of medical history, but the range of features is currently much wider. All

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https://doi.org/10.1016/j.compbiomed.2021.104785
Received 14 April 2021; Received in revised form 18 August 2021; Accepted 18 August 2021
Available online 27 August 2021

features together define the functionality of the HIS. Widely used features of HISs are, for example, clinical notes, medication registration, and electronic health record management [8,15,51].

In practice, several obstacles can be identified related to the development, usage, and maintenance of these HISs. Similar to the features of HISs, these obstacles have been reported in different studies. Although HISs have been considered in multiple studies, it remains unclear which features are provided by an HIS, which are the obstacles of HISs, and which stakeholders and healthcare domains they support. The objective of this study is to use a systematic literature review (SLR) to assess the current state of HISs. By current state, we mean mapping who is using the systems (stakeholders), where they are using it (domain), how they are using it (deployment), what they are using it for (features) and what they are facing in this use (obstacles).

Most previous literature reviews focus on one or two obstacles, such as privacy [33,35], interoperability [1,25], or quality [7,43]. These reviews attempted to find solutions to these obstacles based on the articles identified. However, a literature review that identifies and quantifies all the different types of obstacles is not currently available. Such a literature review could help provide an overview of the wide range of obstacles faced by the various stakeholders. The study can be of benefit for both practitioners and researchers. Practitioners could identify the obstacles and take these into account for developing the required system. Researchers can focus on the identified obstacles and challenges and thus further advance the research in this domain.

We use the guidelines of Kitchenham et al. [22] for performing SLRs, which were developed for the software engineering domain. Therefore, this is not a generic narrative literature review but focuses on a limited number of aspects of HISs that we want to quantify in this study. We begin by presenting the review protocol in Section 2, and the paper continues with the results in Section 3. Section 4 presents the discussion, and finally, Section 5 provides the conclusions.

## 2. Review protocol

For the SLR, we followed the guidelines presented by Kitchenham et al. [22] in which guidelines from, amongst others, the Cochrane Collaboration [9], are adapted for software engineering.

Our review protocol is presented in Fig. 1. It started with the definition of the search strategy to construct the query; this was an iterative process until we got a search string that we found sufficient. Then, in the second step, a set of study inclusion and exclusion criteria was identified. To exclude low-quality studies, we designed the quality assessment method in step three. In the fourth step, we designed a data extraction form with which we could extract the elements (healthcare domains, stakeholders, features, and obstacles) needed to answer the research questions. In the fifth step, a synthesis method was determined to summarize the different text elements identified into results in the fifth step.

### 2.1. Search strategy

We performed an automated search for full papers in three bibliographic databases: Web of Science (the most general library), IEEE Xplore (that aims at IT and computer sciences), and PubMed (that focuses on health and biomedical sciences) using standard filtering options

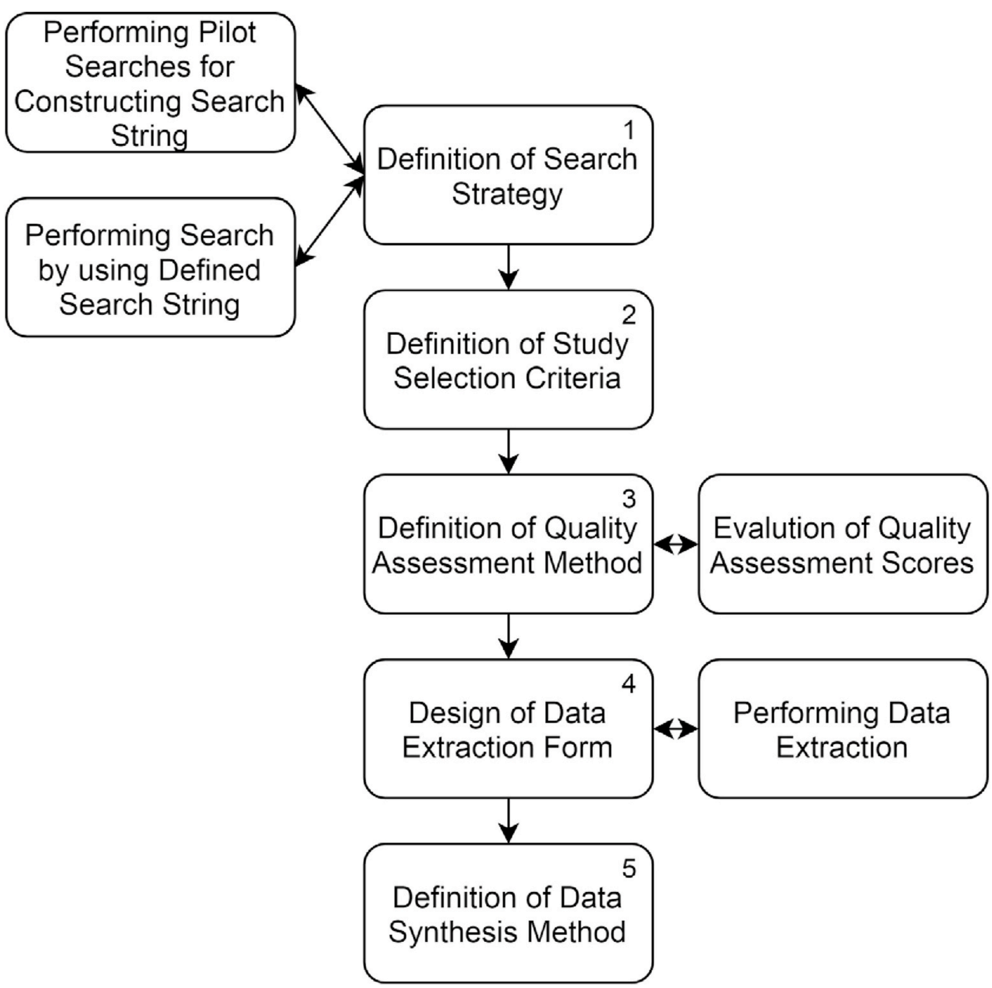


**Fig. 1.** Review protocol for our SLR. Adapted from Kitchenham et al. [22].

to search for articles in computer science, medical information system, and medical informatics. The search query consisted of four building blocks (Table 1) and was performed on the title and abstracts.

The first three building blocks were used to ensure articles related to ICT and computer science on information systems used in health care. The last block, "*Characteristics*", was added to make sure that the articles actually describe an HIS. The final search for papers published in 2009–2020 was performed on May 27th, 2021. The search yielded a total of 1480 articles, and after removing duplicates 1340 unique articles remained (see Fig. 2).

### 2.2. Study selection criteria

We split the study selection criteria into inclusion and exclusion criteria (Table 2). These criteria were developed in an iterative process involving all authors and a random sample of 20 abstracts. We excluded studies that met any of the nine exclusion criteria and included studies that met inclusion criteria only. Two authors followed this strategy on a randomly chosen set of 23 abstracts, yielding an inter-rater agreement of 78%. If the authors disagreed, the abstract was discussed until consensus was reached. After applying the selection criteria on abstracts, 281 articles (see Fig. 2) remained for which the full text was sought.

All articles could be retrieved, and in the process of reading the full papers, another 118 articles were discarded based on the selection criteria from Table 2, which left 162 articles for the quality assessment.

### 2.3. Study quality assessment

The third step from the review protocol was the quality assessment of the 162 remaining articles. The quality assessment criteria (Table 3) were adapted from Kitchenham et al. [22]. For each of the eight criteria up to 1 point could be obtained (1 point for a fully met criterion, ½ for partly met, and 0 for not met at all), yielding quality scores between zero and eight points. For example, if the study's aim was clearly stated in the introduction (anticipated place), a full point (1.0) was awarded, and if the study's aim was not expressed, no point was awarded. If the aim was vaguely specified or not at the expected location, a half-point (0.5) was granted. These assessment criteria were the same or almost the same as those in Refs. [3,21,45–47].

To be included, the articles required a score of four or higher, resulting in an analytic set of 136 articles (see Fig. 2). The distribution of the quality scores is depicted in Appendix A.

**Table 1**
The search query used for this SLR. The syntax presented below was used for Web of Science, the other two databases required a slightly different syntax but contained the same building blocks.

| Building Block | Syntax | |
|---|---|---|
| Information technology | "Information Technolog*" or ICT or "Information and Communication Technolog*" or "Computer system" or "Information System" or Informatics | AND |
| Information System | "electronic health record" OR "Electronic medical record" OR "Electronic patient record" OR "patient record system" OR "Clinical decision support system" OR "Computer Patient Record" OR "Patient care information system" OR "Electronic client record" OR ((Health* OR Medical OR Patient OR Client) NEAR/4 (Manage* OR Informat*)) NEAR/4 (Software OR System* OR Tool OR Platform) | AND |
| Healthcare domain | Health* OR "General practitioner" OR "Family practice" OR Hospital or Physi* OR "Primary care" OR Paramedic OR Disease OR Prevent* OR care OR cure OR GP OR doctor OR dent* OR medic* OR pharma* OR psycho* | AND |
| Characteristics | Feature$ OR Function* OR Module$ OR Obstacle$ OR Problem$ OR Demand* | |

### 2.4. Data extraction

The development of the data extraction form was an iterative process where initially, the form converged after about a dozen papers into the form depicted in Fig. 3 and was used for all 281 full-text articles. If a primary study mentioned one or more elements of the data extraction form, we wrote them down. We did not look for an exact match between article and form. For example, what we call targeted domain was amongst others called context, scope or sector in articles, and if an article listed actors to refer to stakeholders, we entered the list of actors in the form, maintaining the original wording. All elements from the data extraction form are explained in Appendix B.

With the form, we identified that authors mentioned a total of 114 different healthcare domains, 437 stakeholders, 1926 features, and 982 obstacles.

### 2.5. Data synthesis

The synthesis for this study was done for the stakeholders, healthcare domains, features, and obstacles identified in the analytic set of 136 studies. For each of the elements (Healthcare Domains, Stakeholders, Features, and Obstacles) the following protocol was followed. After identification of duplicates and spelling dissimilarities, (near) synonym words were clustered into categories using a bottom-up strategy. The first author categorized all elements. The other authors categorized at least one element. The final categorization presented in this paper was a consensus decision based on plenary discussions. After the categorization, we got a total of 33 healthcare domains, 41 stakeholders, 73 features, and 69 obstacles.

## 3. Results

This section begins with a description of the 136 papers included in the analytic set and continues with the results for each research question. The references of the 136 included studies are listed in Appendix C.

### 3.1. Analytic set description

We included studies from the last twelve years; each year yielded at least 5 articles, the maximum being 21 articles from 2020 (for more detail see Fig. 4). The most frequently occurring journal was the International Journal of Medical Informatics, with 23 occurrences. On the second place was BMC Medical Informatics and Decision Making closely followed by the journal of the American Medical Informatics Association, with fifteen and thirteen occurrences respectively. Forty-six journals only appeared once in the analytic set. The frequency distribution over the journals can be found in Table 4.

### 3.2. Which HISs are described in the literature?

In total, 128 unique HISs could be identified. The most frequently mentioned HIS was EPIC, but the vast majority appeared only once. Typically there seems to be a relation between the HISs and the healthcare domains, although some HISs seemed to have a broader scope and appeared in multiple healthcare domains. Different ways to cater to specific needs of functionality were observed: e.g. a mobile application to record blood sugar measurements, or a desktop application if much text needs to be entered. Most studies did not mention the deployment model of the HISs, others investigated multiple HISs and provided few details only. We identified that 28 studies mentioned a Web/Client-server application as the deployment model, eleven studies a Mobile application, and only seven studies mentioned the Standalone/desktop application as the deployment model.

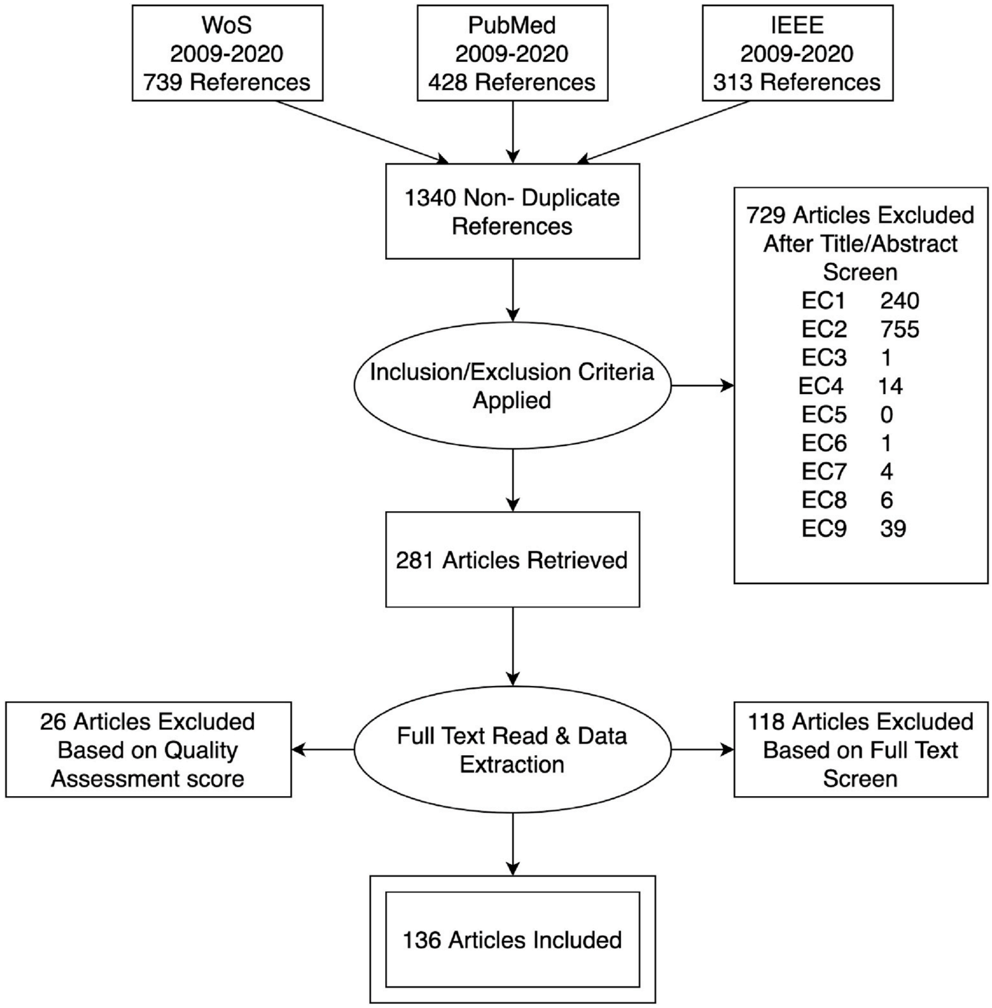


**Fig. 2.** PRISMA statement flow diagram [29].

**Table 2**
Study exclusion and inclusion criteria.

| *No.* | Exclusion Criteria |
|---|---|
| EC1 | The abstract does not describe one or multiple Health Information Systems |
| EC2 | Study using an HIS, but study not targeted on an HIS |
| EC3 | Health Information System for animals |
| EC4 | Other than survey studies within an HIS as PROMIS |
| EC5 | Papers without full text available |
| EC6 | Papers not written in English |
| EC7 | Duplicate publication from multiple sources |
| EC8 | Papers do not relate to the health sector |
| EC9 | Literature Review papers |
| *No.* | **Inclusion Criteria** |
| IC1 | Study that develops one or multiple HIS |
| IC2 | Study that reflects one or multiple HIS |
| IC3 | Study that develops a new module for an HIS |
| IC4 | Study that reflects on an module of an HIS |
| IC5 | The system is actually implemented or is a prototype under development |

### 3.3. Healthcare domains

We identified 33 different healthcare domains for the HISs (Table 5), of which some domains were location-specific (e.g. *hospital*) and others disease-specific domains such as *ophthalmology*. *Hospital* occurred most frequently followed by the *primary care* domain. In the articles from 2020, COVID-19 was mentioned three times as *infectious disease* domain.

**Table 3**
Quality assessment criteria.

| No. | Question |
|---|---|
| Q1 | Are the aims of the study clearly stated? |
| Q2 | Are the scope and context and research design of the study clearly defined? |
| Q3 | Are the variables in the study likely to be valid and reliable? |
| Q4 | Is the research process documented adequately? |
| Q5 | Are all the study questions answered? |
| Q6 | Are the negative findings presented? |
| Q7 | Are the main findings stated clearly? regarding creditability, validity, and reliability? |
| Q8 | Do the conclusions relate to the aim of the purpose of the study? Reliable? |

### 3.4. Stakeholders

We identified 41 different stakeholders in the data, which we grouped according to their in/direct use or technical involvement in the HISs (Table 6). The largest group were the direct users of the HISs (mentioned in 114 articles). Indeed, *Physician* without further details and *Nurse* were the most frequently mentioned stakeholders. Seventy-eighth of the articles mentioned indirect system users who are influenced by the system, but do not utilize the system themselves such as *Patients*. Forty-five articles referred to technical stakeholders, such as *IT staff*. Articles related to the *hospital* domain had a focus on direct system users, whereas in-direct system users such as *patients* were mentioned in relatively few papers. Articles in the *primary care* domain identified a

| # | *Extraction Element* | *Contents* |
|---|---|---|
| General Information | | |
| 1 | ID | |
| 2 | Title | |
| 3 | Date of extraction | |
| 4 | Year | |
| 5 | Authors | |
| 6 | Repository | |
| 7 | SLR Category | ☐ Include ☐ Exclude |
| Description | | |
| 8 | Targeted Domain | |
| 9 | Main theme of study *EC | |
| 10 | Assessment Approach *EC | ☐ Case study ☐ Short example ☐ Experiment ☐ Literature review ☐ Survey study ☐ Interview |
| 11 | Delivery model | ☐ Desktop application ☐ Server application ☐ Plug-in ☐ Web application ☐ Mobile application ☐ Other: |
| 12 | Name of HIS | |
| 13 | Mentioned Stakeholders | |
| 14 | Constraints/limitations *QA | |
| 15 | Mentioned Obstacles | |
| 16 | Mentioned Features | |
| 17 | Saved data in HIS | ☐ NM ☐ NA |
| 18 | Used country/place | |
| Evaluation | | |
| 19 | Personal note | |
| 20 | Additional notes | |
| 21 | Quality Assessment | Q1: Q2: Q3: Q4: Q5: Q6: Q7: Q8: tot: |

**Fig. 3.** The data extraction form used in this study. NA = Not applicable, NM = Not mentioned.

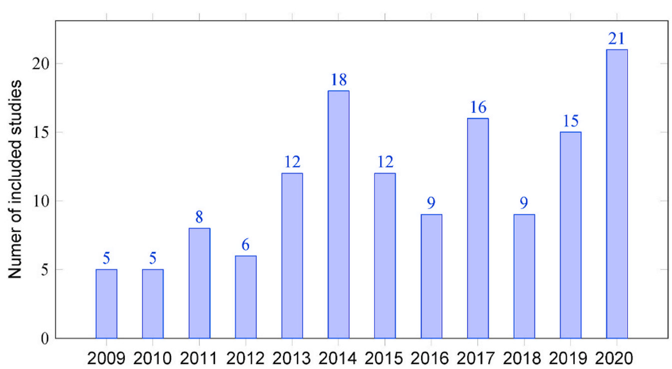


**Fig. 4.** The year-wise distribution for the 136 studies in the analytic set.

**Table 4**
Journals that published two or more of the 136 studies in the analytic set.

| | |
|---|---|
| International Journal of Medical Informatics | 23 |
| BMC Medical Informatics and Decision Making | 15 |
| Journal of the American Medical Informatics Association | 13 |
| Applied Clinical Informatics | 7 |
| Journal of Medical Systems | 6 |
| Methods of Information in Medicine | 4 |
| Health Informatics Journal | 3 |
| IEEE Access | 3 |
| JMIR Medical Informatics | 3 |
| CIN-Computers, Informatics, Nursing | 2 |
| Computer | 2 |
| EGEMS (Washington DC) | 2 |
| IEEE Journal of Biomedical and Health Informatics | 2 |
| Journal of Biomedical Informatics | 2 |
| Studies in Health Technology and Informatics | 2 |

relatively large number of stakeholders and often represented opinions and experiences of direct users, in-direct users, and IT staff.

### 3.5. Features

We could identify 72 unique categories of features based on 128 of the 136 papers (see Table 7). The data on features differed in the level of abstraction due to the bottom-up approach we applied: they range from general features such as *Quality control* to specific functionalities such as *Death registration*. We then grouped the features into two types: general features, and sector-specific features. General features such as *Documentation* and *Reporting* relate to information systems in general, not necessarily to HISs, and were listed in 123 papers out of 136 papers. In addition, 125 papers mentioned sector-specific features. We observed that articles aiming at a specific medical domain, such as *radiology* or *neurology*, included sector-specific features, for example, related to medical imaging, without ignoring the general features.

### 3.6. Obstacles

We obtained a set of 69 obstacles, presented in Table 8. Most

**Table 5**
The identified healthcare domains from the analytic set of 136 studies and the number of articles in which they occur.

| Hospital | 49 | Allergy and immunology | 2 |
|---|---|---|---|
| Primary care | 20 | Brain disorder | 2 |
| Pediatrics | 8 | Cardiology | 2 |
| Infectious disease care | 7 | Community health | 2 |
| Laboratory | 5 | Nursing | 2 |
| Medication | 5 | Surgery | 2 |
| Outpatient care | 5 | Telehealth | 2 |
| Radiology | 5 | Alternative medicine | 1 |
| Diabetes care | 4 | Care for homeless | 1 |
| Care for chronically ill | 3 | Emergency care | 1 |
| Dentistry | 3 | Geriatric care | 1 |
| Maternal-fetal medicine | 3 | Ophthalmology | 1 |
| Mental health | 3 | Public health unit | 1 |
| Neurology | 3 | Rare diseases | 1 |
| Oncology | 3 | Telemedicine | 1 |
| Palliative care | 3 | Transmural care | 1 |
| Pulmonology | 3 | | |

identified obstacles relate to missing features of the HISs and limited use of the system. We grouped the obstacles into five different groups: Technical problems, Usage problems, Quality problems, Operational functionality, and Maintenance & support. Technical problems include obstacles related to the installation of HISs, hardware availability, and network speed and availability. These technical problems are often a problem of the mediocre design of HISs. Often the root of these problems lies in the inadequate infrastructure of information and communication technologies.

Many usage problems such as poor system usability and problems with user training were identified. Fruther, several articles described a low adoption rate of HISs, leading to limited use. This is probably due to issues such as low user satisfaction and lack of limited education of stakeholders, which leads to the system being used less. Quality problems are often related to poor data quality but also to the poor quality of the HIS itself. Some studies even reported the loss of data and the failure of systems, which can affect patient safety. Many of these quality problems came from poor interoperability between different systems and the data in these systems. Obstacles related to the operational functionality of the system often resulted from missing features or problems with specific features of the system. This often led to users having to use multiple systems. Furthermore, the fit with the clinical workflow was not always optimal; often there was a different sequence here, which again could lead to taking away from the patient's attention.

Maintenance & support obstacles were reported to come from a lack of professional support and poor system maintenance. Often, care professionals found communication with the IT department to be poor to nonexistent, and furthermore, the documentation of the HISs was often not up to par either.

**Table 6**
The identified stakeholders from the analytic set of 136 studies and the number of articles in which they occur.

| | | | | | |
|---|---|---|---|---|---|
| Direct system users | Physician | 84 | In-direct system users | Patient | 44 |
| | Nurse | 63 | | Healthcare manager | 30 |
| | Medical specialist | 43 | | Researcher | 13 |
| | Administrative Staff | 29 | | Patients family/relatives/representatives | 5 |
| | Pharmacist | 19 | | Student | 5 |
| | Laboratory technician | 16 | | Counselor | 2 |
| | Therapist | 14 | | System administrator | 2 |
| | Medical assistant | 13 | | Healthcare association | 1 |
| | Regulator/policy maker | 9 | | Insurance company | 1 |
| | Resident physician | 7 | | National expert | 1 |
| | Secretary | 7 | | Health promotion worker | 1 |
| | Educator | 6 | Technical stakeholder | IT-staff | 22 |
| | Healthcare consultant | 6 | | Healthcare informatician | 18 |
| | Data clerk | 5 | | System developer | 12 |
| | Dentist | 5 | | Software vendor | 7 |
| | Receptionist | 4 | | Statistician | 4 |
| | Social worker | 3 | | Technical staff | 3 |
| | Biomedical engineer | 2 | | IT expert | 3 |
| | Hospice staff | 2 | | System manager | 1 |
| | Alternative medicine practitioner | 1 | | Technical writer | 1 |
| | | | | External system | 1 |

**Table 7**
Identified features from the analytic set of 136 studies and the number of articles in which they occur.

| Sector specific | | General features | |
|---|---|---|---|
| Medication recording | 68 | Reporting | 57 |
| Patient record | 62 | Order management | 47 |
| Lab test results | 54 | Reminders and alerts | 45 |
| Clinical decision support and guidelines | 47 | Administration and finance | 43 |
| Diagnosis/clinical assessment | 47 | Video and image analysis | 40 |
| Patient tracking and monitoring | 41 | Documentation | 39 |
| Clinical notes | 37 | Appointments and scheduling | 33 |
| Treatment planning | 33 | Recording demographics | 28 |
| Recording vital signs | 32 | Problem list | 27 |
| Laboratory functionality | 31 | Internal communication | 27 |
| Specialist care feature | 28 | Data visualization | 20 |
| Medication prescription | 26 | Data import and export | 20 |
| Disease monitoring | 25 | Data and record exchange | 20 |
| Patient admission and registration | 24 | Staff and patient education | 17 |
| Radiology management | 24 | Data storage | 17 |
| Patient health status registration | 22 | External communication | 15 |
| Allergy recording | 19 | Data and system integration | 14 |
| Patient care overview and summaries | 19 | Security and risk management | 12 |
| Immunization and vaccination registration | 16 | Inventory management | 11 |
| Making discharge summaries | 15 | Data search | 10 |
| Consultation documentation | 14 | Workflow support | 9 |
| Referrals | 14 | Quality control | 9 |
| Patient portal | 14 | Authentication | 7 |
| Pharmacy functionality | 12 | Task management | 6 |
| Recording blood values | 10 | Remote access | 6 |
| Medical forms and questionnaires | 9 | Human resource mgmt. | 6 |
| Medical data analysis | 8 | Evaluation and benchmarking | 5 |
| Recording symptoms | 8 | Sensor management | 3 |
| Care coordination | 5 | Voice control | 2 |
| Clinical measurements | 5 | Setting goals | 2 |
| Food management | 5 | Prognosis | 2 |
| Death registrations | 4 | Help function | 2 |
| Telehealth | 4 | To do list | 1 |
| Visit management | 3 | Data sharing | 1 |
| Family planning | 1 | | |
| Informing patient and family | 1 | | |
| Lifestyle suggestions | 1 | | |
| Pain recording | 1 | | |

Nearly two out of three papers mentioned obstacles related to Technical problems (81 out of 136 papers) or Usage problems (80 papers). Obstacles related to Quality problems, Operational functionality, and Maintenance & support were mentioned in 67, 66, and 47 papers, respectively. Most obstacles seem to be generic and not related to a certain domain. Furthermore, we could not discover any connections between the obstacles, stakeholders, and features.

## 4. Discussion

To the best of our knowledge, this is the first SLR for HISs that identified the current state of HISs by focusing on the healthcare domains, stakeholders, features, and obstacles. In this discussion, we critically reflect on the results, compare this study with related work, and discuss possible threats to validity.

### 4.1. Critical reflection on the results

Following the guidelines of Kitchenham et al. [22], we identified 136 primary articles from which we extracted data to identify the current state of HISs. A large percentage of the articles focused on HISs for hospitals and related domains, such as surgery and pathology. The dominance of HISs for hospitals probably influenced the distribution of categories of stakeholders and features we report. We think this influence is much smaller in the obstacles because the only health sector-specific category appears to be Usage problems.

The stakeholders we identified were mainly medical; not many different technical stakeholders were identified. This may be due to the dominance of medical informatics journals in our analytic set (see Table 4). Researchers or developers of HISs can use this list of stakeholders as input for stakeholder analysis, using a mapping technique such as that of Mendelow [27]. In the relatively few articles that mentioned delivery method, the web application was most often mentioned. This is a contradiction with practice, where still a lot of stand-alone applications are used, although the use of smartphones in healthcare is rising [28]. This contrast between the state-of-the-practice and the state-of-the-art may have to do with health care providers' concerns about hygiene and data leakage [44].

A better design of HISs may help overcome many of the obstacles related to technical problems. For example, one could use the guidelines from Zahabi et al. [54] or the standards from ISO 9241 part 12 [30] to develop user-friendly and secure user interface for HISs. Other technical problems can often be overcome by using the right architecture for the right deployment. For example, in developing countries with frequent power and/or internet outages, having a desktop computer in combination with a web application is not very useful. A mobile application on the other hand, with a (temporary) local storage, can also function during power and/or internet outages [18]. The obstacles in the Usage problem group can often be overcome by more and better education and training for users of HISs. Younge et al. [52] reviewed multiple training methods for end-users with HISs and concluded that it is most effective to use a combination of training approaches and provide and continue training during implementation, orientation, and post-implementation. This can lead to the users appreciating the systems more and increasing the efficiency of using the HIS.

The obstacles related to the Quality of HISs and their data can be a significant barrier for further adoption and use, including the application of techniques such as machine learning. In order to ensure interoperability with other systems, standards such as HL7 FHIR should be used [5]. Furthermore, the diagnoses in the systems should also be standardized using codes such as ICPC-2 or ICD11 [49,50]. Developers of HISs can use one of the many standards for healthcare data, such as reviewed in Schulz et al. [39], although there is minimal international consensus on the use of these standards.

Multiple obstacles are related to (missing) operational functionality of HIS, which might be because of the rapidly changing and increasing complexity of care. An overview of the available features helps to overcome problems related to the operational functionality. Additionally, it is important to ensure that the HISs integrate well with the clinical workflow. This can be done by a workflow assessment in multiple steps, as was done for example in Schleyer et al. [38]. Problems related to maintenance and systems support can be solved by better assistance from healthcare organizations, as well as from software vendors. According to Dehaghani and Hajrahimi [12], proper maintenance is key to the lifespan of HISs and it is crucial to determine the costs of maintenance in advance so that the costs are not getting out of hand. Good cooperation between the healthcare organization and the software supplier is key to solve the problems related to maintenance and support while keeping the costs under control. Furthermore, each HIS must have solid documentation and a manual that is understandable to the healthcare professional. This documentation must meet several requirements, as described in the IEEE/ISO/IEC 26511-2018 standard.

We foresee that the development of HISs in terms of features may go in two directions. There could be complete systems that contain almost all features, or there could be a switch to a platform structure that works with plug-ins from different developers. In order to move towards a platform structure, it is important to have a clear view of the architecture of HISs. A reference architecture for HISs would support HIS design by serving as a guideline. To the best of our knowledge, a reference architecture is, however, not yet available for HISs.

**Table 8**
Identified Obstacles from the analytic set of 136 studies and the number of articles in which they occur.

| | | | | | |
|---|---|---|---|---|---|
| Technical problems | Poor interface design | 27 | Usage problems | Limited use | 36 |
| | Lack of standards | 24 | | Time consuming to use | 21 |
| | Poor security | 19 | | Lacking user training | 21 |
| | Lack of data and system integration | 18 | | Poor system usability | 21 |
| | Hardware/Power problems | 16 | | High system complexity | 20 |
| | Poor privacy | 14 | | Uneducated users | 15 |
| | Poor data and system availability | 13 | | Data and system inefficiency | 13 |
| | Performance problems | 11 | | Duplicate documentation | 10 |
| | System limitations | 10 | | Manual work | 7 |
| | Network problems | 10 | | Incorrect usage | 6 |
| | Poor hardware availability | 10 | | Navigation issues | 6 |
| | Poor data exchange | 7 | | Low trust in system | 6 |
| | Poor system accessibility | 7 | | Low user satisfaction | 5 |
| | Lacking infrastructure | 6 | | User disagreement with system | 4 |
| | Data and system reliability | 6 | | Finding data | 4 |
| | System down | 6 | | Problems related to meeting user needs | 4 |
| | System installation problems | 2 | | Information overload | 2 |
| | Poor scalability | 2 | | Lack of awareness | 2 |
| | Problems with data and system storage | 1 | | Maximum use of system to usage | 2 |
| Operational func. | Missing features | 47 | | Low system usefulness | 2 |
| | Bad fit with clinical workflow | 17 | | Hygiene problems | 1 |
| | Problems with specific features | 14 | | Use of free text for registrations | 1 |
| | Captures attention away from patients | 12 | Quality problems | Lack of data and system interoperability | 24 |
| | Requirement of multiple systems | 6 | | Low data quality | 21 |
| | Need to work in unique and specific setting | 5 | | Poor system development | 12 |
| | Poor working environment | 4 | | Data and system inconsistencies | 11 |
| Maintenance & Support | Lacking professional support | 25 | | Data loss | 10 |
| | High system costs | 23 | | Faulty system | 9 |
| | Poor communication | 11 | | Data input/output/Propagation problems | 8 |
| | Legal and bureaucratic problems | 9 | | Poor data integrity | 4 |
| | Lack of help and documentation | 7 | | Low system accuracy | 4 |
| | Poor system updates | 5 | | Poor patient safety | 2 |
| | Low trust in supplier | 3 | | Fragmented data | 2 |
| | | | | Medical error | 2 |
| | | 18 | | Poor system natural language | 2 |
| | | | | Data interpretability | 1 |

In this paper we scrutinized articles on the operational usage of HISs and suggest the importance of the yet lacking reference architecture. Future work will, therefore, involve the creation of a reference architecture for HISs based on domains, stakeholders, features, and obstacles identified.

### 4.2. Related work

Other reviews on HISs [34,42] had a different focus or goal compared to this paper. Rahimi and Vimarlund [34] reviewed methods used to evaluate HISs but did not focus on the HISs themselves. They did indicate several obstacles that we also identified to user satisfaction, such as timeliness and usability, and costs of HISs. Sligo et al. [42] reviewed the literature on HISs project planning, evaluation, and implementation in their study on HIS influence on organizational change. Commonalities between this review and ours are mainly on obstacles, for example limited use, and the lack of trust in the IT capability of the supplier. These reviews [34,42] studied the interaction with the system, and consequently identified many stakeholders' concerns, whereas we systematically looked at the system's side.

There are many more reviews (than [34,42]) for specific health care domains [4,10,20]. This means that the literature on HISs is fragmented which impedes the understanding and characterization of HISs for the healthcare sector. A solid comprehensive overview of the current state of HIS was missing. E.g. Ball [4] presented perspectives on problems and prospects for hospital information systems. The article by Janett and Yeracaris [20] presents challenges with electronic medical records in U. S. primary care. Like our article, they present the lack of interoperability and missing standardization as an obstacle for further system development. All kinds of stakeholders, features, and obstacles presented in Ball [4] and Janett and Yeracaris [20] were also found in our study, but our study had a broader scope and, therefore, presented more diverse stakeholders, features, and obstacles.

Some articles do not give a complete overview of HISs but focus on one aspect only. For example [26], does a stakeholder analysis to identify users of HISs. They identify only three major types of stakeholders, which they further detail in use cases: Physicians, clinicians, and patients, which are also present in Table 6 with more detail. Kumar et al. [24] identified research gaps in routine health information systems by means of a literature review for low- and middle-income countries. From 316 studies they identified obstacles related to data quality, data use, and system design. They present several related obstacles but do, unfortunately, not present them in a structured manner, which makes comparison with our article difficult.

Kruse et al. [23] performed an SLR with 55 primary studies on how electronic health records support population health. They identified a set of facilitators and barriers for the adoption. These barriers show many similarities with our obstacles, such as missing data, interoperability, productivity loss, and complex technology. They suggest more comprehensive standards for the interoperability of electronic health records. A study that mentions the key features of a European Union health information system is Rosenkötter et al. [37]. Unfortunately, they have a different notion of feature as in our study. The focus is on the most important aspects for developing a new system; for example, a feature in this study is "Sustainabilty". The four main functions of HISs according to the WHO [32] are data generation, compilation, analysis and synthesis, and communication and use. These functions are performed by the features that are in Table 7 under the "general features" group. Interestingly the WHO does not mention functions that are in our "Sector-specific" features group.

Papers which describes the challenges of HISs are Ngafeeson [31] and Roehrs et al. [36]. Ngafeeson [31] mention IT adoption as a challenge, but otherwise group the problems into four groups: related to the technology itself, the healthcare setting, the users of the system, and the regulatory environment. These challenges are all reflected in the obstacles in Table 8, where we provide more detail on the obstacles. The SLR with 48 primary studies from Roehrs et al. [36] on personal health records identifies many challenges and open issues for personalised health records (PHR). Furthermore, they also identify 20 data types in personal health records, which show many similarities with our identified features, such as demographics, documents, prescriptions, and scheduling. Subsequently, they provide an analysis on the architecture types of personal health records and list eighteen standards.

### 4.3. Addressing threats to validity

The main threats to validity for any SLR are publication bias, selection bias, data extraction, and classification [13]. We tried to mitigate the risk for publication bias by selecting three bibliographic databases with different focuses; negative results for a WoS journal may have been particularly interesting for an IEEE journal (e.g. technical details into an authentication protocol). There is always a chance that we missed some papers due to our search protocol. The journal filter and search query were quite specific. Furthermore, we did not apply snowballing nor did we include grey literature. Nonetheless, many articles had to be discarded because they appeared off-topic when relying on the abstract. Selection bias was mitigated by discussing and testing the inclusion/exclusion criteria by the multidisciplinary set of authors on several occasions. 136 articles from three different bibliographic libraries remained for analysis and we expect that adding more articles would add little new information.

Threats to data extraction and classification are related to researcher bias. We mitigated these threats by thoroughly and repeatedly discussing the data extraction form and operationalization of each classification in the full author team. We decided to maintain the different levels of abstraction of the stakeholders, features, and obstacles from the articles. This way we limited uncertainty and bias in the classification, and give the reader better insight in the heterogeneity of the articles. Furthermore, we tried to mitigate the risk of overlooking a relevant text fragment or misinterpreting semantic relationships by a close reading of each article.

With the measures described, we believe we mitigated the main threats to validity for this review as much as possible.

## 5. Conclusion

In this study, we systematically reviewed 136 articles on HISs that appeared in three different bibliographic databases over the past twelve years. The current state of HISs was described by focusing on the elements: healthcare domains, stakeholders, features, and obstacles. With this SLR, we believe we present a broad and comprehensive overview of HISs.

According to the literature, most HISs are aimed at hospital care, whereas few studies referred to HISs in tele-health and telemedicine. Nonetheless, a wide range of direct system users, in-direct systems users, and technical stakeholders were identified. The literature described a wide variety of features related to general information systems, as well as a wide variety of features related to the health care setting. Despite dependency on HISs, more than 70 different obstacles could be distinguished. The huge heterogeneity in features and obstacles may not only stem from the diversity of health settings studied, but also from a lack of basic consensus.

In conclusion, the results of the presented work are useful for HIS researchers, users, developers, and scientists. The lists of stakeholders, features, and obstacles presented, may help managers in decision making and in system development or adaptation. The overview of features and obstacles may be explored further by scientists and system developers in order to design better HISs tailored to the healthcare domain. Scientists from different disciplines may use this study to identify new research areas on HISs and HISs data. In our future work, we will aim to develop an HIS reference architecture using the lessons learned from this SLR.

## Authors' contributions

Author 1 read all articles, performed data extraction, and prepared the concept paper. Authors 1 and 5 were involved in the establishment of interrater-agreement. Authors 1 and 3 prepared the final manuscript for submission. All authors contributed to the research design, the development and application of in/exclusion criteria, the data extraction form, the data synthesis, and the manuscript.

## Declaration of competing interest

The authors have no competing interests to declare.


## Acknowledgements

None.


## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.compbiomed.2021.104785.


## Funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. It is part of a larger set of projects that have been funded by the Dutch Ministry of Health, Welfare, and Sport.


## Summary table

What was already known on the topic:

- Studies tend to focus on HISs from specific health domains
- The technical side of HISs have been less studied

What this study added to our knowledge:

- This study has a broad scope as it studied the literature on HISs in all health domains
- Although most individual studies focused on specific health domains, many features and obstacles they re-ported are not specific to the health sector
- Extensive sets of features and obstacles are presented, useful for decision-makers and information systems developers

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