The characteristics and capabilities of the available open source health information technologies supporting healthcare

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Systematic review

The characteristics and capabilities of the available open source health information technologies supporting healthcare: a scoping review protocol

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ABSTRACT

Introduction Due to the many advantages of open source software (OSS), including reduced cost of licensing, more flexibility in terms of customisation and redistribution, better quality and no vendor lock-in, OSS in healthcare is increasingly gaining importance. Various open source health information technologies (OS-HITs) are continuously being designed and developed for different areas of healthcare to increase organisational efficiencies and quality of care at minimum costs. The objective of this scoping review is to identify the kinds of existing OS-HITs, their characteristics (*e.g.* functions) and capabilities (*e.g.* advantages/disadvantages) for various healthcare stakeholders (physicians and patients) and healthcare sectors (*e.g.* clinical, administrative).

Methods We will conduct a scoping review to identify the range of available OS-HITs in international literature from 1980 to September 2018. Searches will be conducted in six major international databases, namely: Cumulative Index to Nursing and Allied Health Literature Plus, Excerpta Medica Database, Global Health, Library Information Science and Technology Abstracts, Medline and Web of Science to identify relevant published research. We will also search the Google search engine and Google Scholar for on-going and unpublished work and the grey literature. Searches will be peer-reviewed by two independent reviewers and will not be limited by methodology or language. Next, selected references will be tabulated for study characteristics by author affiliation, country of origin, the name of OS-HIT, healthcare area/sector, system requirements, stakeholders, complete solution and web link. Furthermore, functions, benefits/advantages, disadvantages and outcomes (*e.g.* usability) of OS-HITs will be extracted. Narrative and interpretative synthesis of data will be undertaken.

Results We will report our findings in a peer-reviewed journal.

Keywords: health information technology, open source, systematic scoping review

BACKGROUND

Source code of open source software (OSS) is publicly available for end-users who can examine, add, modify or distribute it, whereas source code of proprietary or 'closed source' software is only available to the person or vendor who developed it,[1] and users are solely dependent on the vendor for any modification. Due to the many benefits of OSS, such as low cost of licensing, flexibility (can be easily customised and redistributable), reliability (abundant support from peer developers), enhanced quality (patchwork for bugs) and no vendor lock-in, OSS in healthcare is increasingly being adopted worldwide.[2–4]

Health care leaders are showing keen interest in open source health information technologies (OS-HITs) [an array of technologies (licensed software with its source code available and with the rights to modify, distribute and study) to save, exchange and analyse health information], such as electronic health/medical records (EHRs/EMRs) [*e.g.* United States' Veterans Health Information Systems and Technology Architecture (VistA) and Canada's OSCAR], district health information systems (DHIS) [*e.g.* DHIS2 (www.dhis2.org)] and Picture Archiving and Communication Systems (PACS), for example, Dicoogle[5] to avail themselves of the advantages of OSS.[2,6–8] For example, VistA, a free and OS EHR built and maintained by the United States Department of Public Health Services is considered to be the largest health information systems acquired globally.[9] It has been used extensively by the Indian Health Services, Mexican Government and many other healthcare facilities around the world.[2,9]

Moreover, National Health Service (NHS) England recently supported an initiative called Code4Health, which is an OS platform, a community and a learning tool, which aims to deliver safe and improved patient outcomes by enabling the use of OS digital technology and tools.[10–12] By using Code4Health, NHS England intends to create workable OS solutions, ensure to reuse and share all code created in the NHS through a library of assets, provide evidence of value of OSS to the health and social care community, achieve a self-sufficient eco-system of communities and provide equal opportunity for infrastructure services and OS commodities.[11]

Another example is the study on the availability of OS-HITs commissioned by the Office of the National Coordinator for Health Information Technology under the terms of the Health Information Technology for Economic and Clinical Health (HITECH) Act.[13] This study focused on the availability of the OS EHRs for community clinics and safety-net providers (providers in the United States which offer access to healthcare to low-income people, including those who are uninsured and/or have limited or no access to healthcare); the comparison of total cost of OS EHR and the proprietary system; the ability of OS EHR to meet the needs of diverse populations (such as disabled, elderly and children); its interoperability with other disparate systems (such as claims processing systems and practice management system) and its conformity to the Meaningful Use requirements as per HITECH legislation. The authors concluded that OS EHRs can provide cost-effective and reliable solutions for safety-net providers, maintaining the same level of functionality required for Meaningful Use when compared with proprietary systems. Moreover, it can be customised efficiently by creating templates and modules to address and capture the various specific needs of the community.[13] In addition, the OS community and developers can offer substantial support to the community health centres as they continuously improve their products.[13] Finally, the deployment of OS EHRs may provide the most suitable solutions maintaining pace with the evolving requirements of Meaningful Use and changes in the health industry.[13]

In a survey conducted by GatePoint Research, more than 100 healthcare executives affirmed that OSS, unlike propriety software, can be created with the collaboration of thousands of developers and people from the healthcare industry, such as clinicians who can use, improve and modify the OSS according to their needs.[2,14] According to a survey conducted by the World Health Organization,[2] OS-HIT is also gaining popularity in economically-developing countries due to the unaffordability of propriety systems and the fact that these often do not offer solutions for local health problems. OSS has strengthened the innovative capacity of HIT in many areas of healthcare in low- and middle-income countries. Biometric attendance monitoring of tuberculosis in India; mobile supply chain management tool for logistic management in Ghana and Tanzania; rapid short messaging service (SMS) to provide availability of essential medicines in Malawi and a telemedicine network in Congo, Egypt and Mali are a few examples of several OS-HITs used in developing countries.[15] Low cost or free OSS is beneficial for resource-constrained countries, however, countries with ageing population (over 65 years) such as Germany, Greece Italy, Japan and the UK are considering/planning lowering healthcare costs with better treatment options by adopting OS-HITs.[16–18]

OS-HITs are also being used in fighting viral outbreaks such as Ebola.[19] The available commercial EHRs were not appropriate to use by clinicians in the Ebola outbreak but required a customisable software that could be used in the Red Zone (units to hold patients in isolation suspected with the Ebola disease[20]) while wearing protective suits with minimal typing, high contrast colour schemes, large touch buttons for gloved hands and large fonts to see clearly within the protective masks.[19] Moreover, paper prescriptions and medical notes cannot be carried out to the treatment centre in the Red Zone as the virus can live on hard surfaces, which made it difficult for healthcare professionals to collect and manage information.[19] The OpenMRS community in collaboration with Save the Children and ThroughtWorks and partnership with Google Doctors Without Borders responded to the Ebola epidemic and provided data management and reporting solutions according to the needs of clinicians and staff.[19,21] Fortunately, this Ebola OS project, which can be easily customisable, can also become the groundwork for any subsequent solution required for another disease outbreak in future and could be deployed in days than in weeks.[19]

These strengths, amongst others, have increasingly led the development and adoptability of OS-HITs. It is thus

necessary for healthcare providers and managers to know the kinds of OS-HITs available for healthcare stakeholders (*e.g.* healthcare professionals, managers and patients) in various healthcare sectors to effectively select the most appropriate low-cost adaptable technology solutions based on their functions, advantages and usability; and their barriers and facilitators to the implementation or utilisation. A previous systematic review reviewed only the utilisation of OS EHRs globally from the year 1990–2012 using six scientific databases, namely, Cumulative Index to Nursing and Allied Health Literature (CINAHL), Excerpta Medica Database (EMBASE), Library Information Science and Technology Abstracts (LISTA), Medline, Scopus and Web of Science.[22] Language selection of the selected papers was not given. The review found 13 OS EHRs (such as openEHR, OpenMRS and WorldVista) being utilised in 31 countries worldwide. We will employ a more comprehensive search strategy that may not only cover EHRs but may also include other OS-HITs, such as clinical decision support systems and PACS, to conduct a comprehensive systematic scoping review to identify and characterise all the OS-HITs available for several healthcare areas.

METHODS

A scoping review is a technique used to map the current literature in a field of interest, the key concepts underpinning a research area and the main sources and kinds of evidence available.[23,24] It was first defined by Mays *et al*.[24] noting that a scoping review *aims to map rapidly the key concepts underpinning a research area and the main sources and types of evidence available*. It has become an increasingly popular method for synthesising research evidence,[25,26] which can be of particular use when the topic is of complex and heterogeneous nature or has not been comprehensively studied.[24]

There are different ways of conceptualising scoping reviews.[27] For example, according to Arksey and O'Malley,[23] a scoping study seeks to provide the broad coverage of the existing literature with varying degrees of depth to investigate the extent, range and nature of research activity; determine the value and potential cost of undertaking a full systematic review; summarise and disseminate research findings to the interested readers and identify research gaps in the existing literature.[23] Another purpose is 'literature mapping' to describe the literature and to synthesise findings from different types of studies; or 'conceptual mapping' to establish how a particular term is used by whom, for what purpose and in what literature[28,29] or 'policy mapping' to identify the relevant documents from government and professional agencies.[30] According to the National Institute for Health Research Service Delivery and Organisation Research and Development Programme, it is also useful for the elucidation of working definitions and conceptual boundaries of a particular topic area, conducted systematically,[28] but explicitly excluding quality appraisal (which is an integral component of a systematic review), to establish a frame of reference.[27] It can also be used as a preliminary step to a systematic review as it provides a rigorous and transparent approach for mapping areas of research.[23]

The scoping review is registered with the Open Science Framework. It can be accessed at the following URL: https://osf.io/rvfwm/

We will use a six-staged scoping review framework developed by Arksey and O'Malley[23,31] and further built by Levac *et al*.[27] to accomplish the objective of this scoping review (see also Preferred Reporting Items for Systematic review and Meta-Analysis Protocols)] 2015 checklist in Appendix 1.[32] The six stages are described as follows:

Stage 1: Identifying the research question

Research questions for scoping reviews should be broad so as to summarise the breadth of available evidence.[23] The research question for this review is 'what are the characteristics and capabilities of different kinds/types of OS-HITs (such as PACS, health information systems and DHIS) available internationally in various healthcare areas (such as clinical, healthcare administrative and radiology) and/or for specific diseases (such as diabetes and dengue)'? For details on the characteristics and capabilities of OS-HITs, see Stage 4 (charting the data) below.

Stage 2: Identify the relevant studies

Stage 2 involves developing a robust search strategy and identifying relevant studies. We used the Peer Review of Electronic Search Strategies 2015 Guideline statement[33] to develop and test search strategies for different databases to search literature from 1980 till September 2018 (see Appendix 2 for MEDLINE search strategy). This starting date has been chosen because the term 'OS' was coined in February 1998 during a strategy session in Palo Alto, CA when Netscape announced the release of its source code.[34] Six scientific databases will be searched for published work on OS-HITs, namely:

- CINAHL Plus,
- EMBASE,
- Global Health,
- LISTA,
- Medline and
- Web of Science.

Searches in the academic databases will not be limited to methodology (such as qualitative, quantitative, mixed methods and implementation studies) and language. References will be scanned from included studies to identify additional potentially eligible papers.

We will also search the Google search engine and Google Scholar [first 100 results being considered for each phrase/term searched (see Appendix 2 for search terms)] for grey literature that may include websites and reports.

Stage 3: Study selection

After initial screening and deduplication of studies, two reviewers will independently check titles and abstracts against the inclusion/exclusion criteria as follows:

Inclusion criteria

Participants and care settings

These will comprise various healthcare stakeholders, such as healthcare providers, carers, patients, facility managers and government/non-governmental authorities involved in using OS-HITs in different healthcare areas/sectors (such as clinical, administrative, surveillance and imaging) and diseases (such as diabetes, mental health and heart diseases).

Interventions

Studies describing or elucidating the development, implementation and usage of OS applications/software end products (such as PACS, DHIS, EHRs and clinical decision support systems) in healthcare.

Exclusion criteria

We will exclude studies not falling in the healthcare domain; studies which have used OS technologies such as Hadoop to develop proprietary software or which describe OSS frameworks in healthcare instead of OS applications/software end products. Also, applications/software which are available for free (*e.g.* mobile apps) but do not provide access to their source codes will be excluded.

Stage 4: Charting the data

We will use customised forms to extract data from the eligible studies for this review. Two reviewers independently will tabulate the characteristics of OS-HITs by author affiliation and year of publication, country of origin, study design, the name of OS-HIT, intervention for a specific disease, intervention for the healthcare sector, system requirements (where available), complete solution and web link. Furthermore, functions, benefits/advantages (such as low maintenance cost, system/software reliability, real-time processing, processing speed, availability of tutorials and information system support), disadvantages (such as insecurity of data, incompatible with other system/software and unavailable system support) and outcomes (such as efficient workflow and optimised performance) of OS-HITs will be abstracted for analysis (see Appendix 3 for pilot data extraction forms).

Stage 5: Collating, summarising and reporting results

The results will be analysed descriptively and thematically[35] in terms of characteristics and capabilities (functions, benefits and outcomes) taking into consideration healthcare domains, study designs, technologies and/or interventions, contexts in which OS-HITs have been used, and will identify those actively under development. Results will be summarised in terms of different themes of OS-HITs available, in particular, healthcare domains.

Stage 6: Consultation

We will share the list of identified studies with experts to enquire about unpublished/on-going or published studies that we may have missed. Experts may also pinpoint the key developments of some OS-HITs that may not have been written up or are now out-dated.

DISCUSSION

The proposed scoping review will make several contributions to the HIT literature. First, it will provide healthcare stakeholders the corpus of available OS-HITs in different healthcare domains around the world, such as storing patient information in EHRs, collecting field data (such as malaria, tuberculosis, etc.) using mobile technology and providing remote healthcare through telemedicine. Second, the list of categorised OS-HITs [in terms of healthcare areas/sectors (clinical, administrative and/or finance), diseases (diabetes and malaria); characteristics; functions; advantages and outcomes] will be useful for healthcare managers and administrators to select from and implement the most appropriate OS-HIT that support their healthcare services. In addition, healthcare managers will be able to compare the available OS-HITs with their proprietary HITs, if any, running in their facilities. Third, this review will identify saturation of specific OS-HITs, such as EHRs and will identify needs and gaps for software developers to design OS-HITs for unsaturated areas of HIT. Fourth, this scoping review will help map the literature on OS-HITs and will catalyse subsequent more focused systematic reviews on specific OS-HIT in specific healthcare domains. For instance, one anticipated systematic review will be to assess the challenges and benefits of using OS PACS. Finally, this review will be valuable for policymakers involved in the planning, evaluation and procurement of HIT.

CONCLUSION

Results of this review will be published in a peer-reviewed journal. This scoping review will raise awareness of OS-HITs and benefit healthcare stakeholders to make informed judgements based on the characteristics and capabilities of OS-HITs when deploying or developing them in their healthcare facilities.

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Contributorship statement

Study conception and design: Ather Akhlaq, Brian McKinstry and Aziz Sheikh

Drafting of the manuscript: Ather Akhlaq

Critical revision: Ather Akhlaq, Brian McKinstry and Aziz Sheikh

Conflict of Interests

No, there are no competing interests.

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APPENDICES

APPENDIX 1

PRISMA-P (Preferred Reporting Items for Systematic review and Meta-Analysis Protocols) 2015 checklist: recommended items to address in a systematic review protocol*

Section and topic	Item No	Checklist item
		Administrative information
Title:		
Identification	1a	Identify the report as a protocol of a systematic review The characteristics and capabilities of the available open source health information technologies supporting healthcare: A systematic scoping review protocol
Update	1b	(NA) If the protocol is for an update of a previous systematic review, identify as such
Registration	2	If registered, provide the name of the registry (such as PROSPERO) and registration number Registered with Open Science Framework https://osf.io/rvfwm/registrations/
Authors:		
Contact	3a	Provide name, institutional affiliation and e-mail address of all protocol authors; provide physical mailing address of corresponding author Ather Akhlaq[1], Brian McKinstry[2] and Aziz Sheikh[2] 1 Centre for Health Informatics, Department of Health and Hospital Management, Institute of Business Management, Korangi Creek, Karachi, Pakistan. 2 Centre for Medical Informatics, Usher Institute of Population Health Sciences and Informatics, The Medical School, The University of Edinburgh, Edinburgh, Scotland, UK. Dr Ather Akhlaq Room 218, Centre for Health Informatics, Department of Health and Hospital Management, Institute of Business Management, Korangi Creek, Karachi, Pakistan. Phone: 0092 21 111 002 004, Extension: 433 Email: ather.akhlaq@iobm.edu.pk
Contributions	3b	Describe contributions of protocol authors and identify the guarantor of the review Study conception and design: Ather Akhlaq, Brian McKinstry, Aziz Sheikh Drafting of manuscript: Ather Akhlaq Critical revision: Ather Akhlaq, Brian McKinstry, Aziz Sheikh Guarantor: Institute of Business Management, Karachi, Pakistan
Amendments	4	(NA) If the protocol represents an amendment of a previously completed or published protocol, identify as such and list changes; otherwise, state plan for documenting important protocol amendments
Support:		
Sources	5a	(NA) Indicate sources of financial or other support for the review

Sponsor	5b	Provide name for the review funder and/or sponsor: Institute of Business Management, Karachi, Pakistan
Role of sponsor or funder	5c	(NA) Describe roles of funder(s), sponsor(s) and/or institution(s), if any, in developing the protocol
Introduction		
Rationale	6	See last para of Background
Objectives	7	See last para of Background. See Methods – Stage 1
Methods		
Eligibility criteria	8	See Methods – Stages 1–4
Information sources	9	See Methods – Stages 1–4
Search strategy	10	Present draft of search strategy to be used for at least one electronic database, including planned limits, such that it could be repeated See Appendix 2
Study records:		
Data management	11a	Describe the mechanism(s) that will be used to manage records and data throughout the review All references will be recorded in Endnote.
Selection process	11b	State the process that will be used for selecting studies (such as two independent reviewers) through each phase of the review (that is, screening, eligibility and inclusion in meta-analysis) Two independent reviewers will conduct searches using PRESS.
Data collection process	11c	Describe planned method of extracting data from reports (such as piloting forms, done independently, in duplicate), any processes for obtaining and confirming data from investigators Data will extracted into data extraction forms (see Appendix 3)
Data items	12	List and define all variables for which data will be sought (such as PICO items, funding sources), any pre-planned data assumptions and simplifications See data extraction forms in Appendix 3.
Outcomes and prioritisation	13	List and define all outcomes for which data will be sought, including prioritisation of main and additional outcomes, with rationale Characteristics and capabilities of OS-HITs available worldwide.
Risk of bias in individual studies	14	(NA) Describe anticipated methods for assessing risk of bias of individual studies, including whether this will be done at the outcome or study level, or both; state how this information will be used in data synthesis
Data synthesis	15a	(NA) Describe criteria under which study data will be quantitatively synthesised
	15b	(NA) If data are appropriate for quantitative synthesis, describe planned summary measures, methods of handling data and methods of combining data from studies, including any planned exploration of consistency (such as I^2, Kendall's τ)
	15c	(NA) Describe any proposed additional analyses (such as sensitivity or subgroup analyses, meta-regression)
	15d	If quantitative synthesis is not appropriate, describe the type of summary planned. Narrative and interpretative analysis.
Meta-bias(es)	16	(NA) Specify any planned assessment of meta-bias(es) (such as publication bias across studies, selective reporting within studies)
Confidence in cumulative evidence	17	(NA) Describe how the strength of the body of evidence will be assessed (such as GRADE)

*It is strongly recommended that this checklist be read in conjunction with the PRISMA-P Explanation and Elaboration (cite when available) for important clarification on the items. Amendments to a review protocol should be tracked and dated. The copyright for PRISMA-P (including checklist) is held by the PRISMA-P Group and is distributed under a Creative Commons Attribution Licence 4.0.

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APPENDIX 2

Medline

1. (eHealth or e health or e-health).mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
2. telemedicine/
3. Telehealth.mp. or telehealth/
4. Telehealthcare.mp.

5. Telecare.mp.
6. (Electronic Prescribing or ePrescribing or e-prescribing).mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
7. Electronic prescri*.mp.
8. Health information technology.mp. or Medical Informatics/
9. Hospital information systems.mp. or Hospital Information Systems/
10. information systems.mp. or Information Systems/
11. Medical Records Systems, Computerised/ or medical records systems.mp.
12. Medical information system*.mp.
13. Health information system*.mp.
14. Health informatics.mp.
15. (Management information systems or management information system*).mp. [mp = title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
16. Integrated Advanced Information Management Systems/Integrated advanced information management.mp.
17. Electronic health records.mp. or Electronic Health Records/
18. Computerised patient record*.mp.
19. Health Records, Personal/Personal health record*.mp.
20. Decision support system*.mp.
21. Computerised decision support.mp.
22. Computerised order entry.mp.
23. Electronic patient record.mp.
24. Computerised decision support system*.mp.
25. Medical order entry systems.mp. or Medical Order Entry Systems/
26. Medical Records Systems, Computerised/medical records systems.mp.
27. Computerised physician order entry.mp.
28. Computerised physician order entry system*.mp.
29. Computerised provider order entry.mp.
30. (Picture archiving and communication system*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
31. Health information management system*.mp.
32. Health management information system*.mp.
33. Decision Support Systems, Clinical/
34. Health information exchange.mp. or Health Information Exchange/
35. Open source software.mp.
36. Open source technology.mp.
37. Open source hardware.mp.
38. Open source information technology.mp.
39. Free software.mp.
40. Open source healthcare.mp.
41. Open source.mp.
42. (m health or m-health or mHealth).mp. [mp=title, abstract, original title, name of substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier]
43. Mobile health.mp.
44. Mobile healthcare.mp.
45. Geographic Information Systems/geographical information system*.mp.
46. Global positioning system*.mp.
47. Open-source.mp.
48. 1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 43 or 44 or 45 or 46
49. 35 or 36 or 37 or 38 or 39 or 40 or 41 or 47
50. 48 and 49
51. limit 50 to yr = ‘1980–2017’

Free Field Format/Web of Science

[(eHealth) or (e health) or (e-health) or (telemedicine) or (telehealth) or (telecare) or (telehealthcare) or (electronic prescri*) or (e-prescribing) or (eprescribing) or (health information technology) or (medical informatics) or (medical information system*) or (health information system*) or (health informatics) or (computerised medical record* system*) or (computerised medical record* system*) or (hospital information system*) or (management information system*) or (electronic health record*) or (computerised patient record*) or (computerised patient record*) or (personal health record*) or (decision support system*) or (clinical decision support system*) or (computerised decision support) or (computerised decision support) or (computerised order entry) or (computerised order entry) or (electronic patient record*) or (medical order entry system*) or (computerised physician order entry system*) or (computerised provider order entry) or (computerised physician order entry system*) or (computerised provider order entry) or (picture archiving and communication system*) or (health information management system*) or (health management information system*) or (decision support system*) or (health information exchange) or (m health) or (m-health) or (mHealth) or (mobile health) or (mobile healthcare) or (geographic information systems) or (geographical information system*) or (global positioning system*)]

And

[(open source software) or (open source technology) or (open source hardware) or (open source information technology) or (free software) or (open source healthcare) or (open source) or (open-source)]

Google search engine and Google Scholar

Open source OR open-source OR health information technology* OR health communication technology* OR open source healthcare OR free software OR open source clinical care OR open source health systems OR open source health information

APPENDIX 3

Data extraction forms

A. Characteristics of studies

Author/year	Country of Origin	Study design	Name of OS-HIT	Intervention for specific disease	Intervention for specific healthcare sector	System requirements	Complete solution	Web link

B. Capabilities of OS-HITs

Author	Name of OS-HIT	Functions	Benefits/Advantages	Outcomes	Disadvantages