ORIENTATION

Buy, Build, or Adapt How to decide?

A Guide to Open Source
Electronic Health Records (EHRs)

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Executive Summary

This report is for those who want to learn more about open source software (OSS) and the benefits of its use in health care, with particular emphasis on electronic health records (EHRs). It describes what OSS is, where it is used, and what the differences are between OSS, open standards, and open data. It then describes the benefits and disadvantages of open source versus proprietary EHRs and the considerations for deciding between them.

Key Takeaways

- Open source software (OSS) is software with freely available source code. Unlike proprietary software, anyone can modify and distribute the code without licensing fees, as defined in the software's license.
- The term "open source" does not imply that the data in an open source system is available to anyone. In fact, many argue that open source systems are safer than proprietary systems.
- Open data and open standards are different than open source. Open data means the data that has been gathered is open to anyone. Open standards promotes standards that are freely available and all should adopt.
- No system is free. All systems will have implementation and maintenance costs. It is critical to understand the total cost of ownership before making the final decision about which software and vendor (if any) to use.
- Open source systems can have vendors who develop, implement, and/or provide support. There are several examples in health and other markets.
- Open source software generally provides greater flexibility to select and switch vendors and make changes to the software.
- Many countries in Latin America and the Caribbean (LAC) have promoted OSS in their laws, though few have used open source EHRs.
- Various successful open source health information technology (IT) and EHR projects exist and should be evaluated before creating a system or purchasing a proprietary system.

Open Source Worldwide: Definition, Types of Licenses, Successful Projects, and Business Models

The term "open source" was coined in 1998 to describe freely available software that allowed for collaboration following certain principles. Over the last 20 years, projects and businesses worldwide have become open source, using those principles and software as the foundation of practices that have changed the way information is managed, including in health care.

Yet OSS is not as widely known or understood as proprietary software. OSS is software with freely available source code, which anyone may modify and distribute their own versions of without incurring licensing fees. This ability to modify the code and redistribute it is specified in OSS licenses. The **Open Source Initiative**, an open source education and advocacy organization, provides a detailed definition of open source and the requirements for a project to call itself **open source**. "Free software" is similar to OSS (the full definition is available from the **Free Software Foundation**), and for practical purposes the two are the same, since "free software" is not only free[1] to use but also open source.

Unlike OSS, proprietary software (such as Microsoft's Windows or Office) does not have publicly available source code, so a customer receives only the file that runs the program. Any fixes, modifications, or improvements must be done by the company or individual that owns the software.

This report covers the differences between OSS and proprietary software, as well as delving into the specific case of EHRs.

>> Open Source Licenses: Types and Avoiding Ambiguity

There are hundreds of open source licenses, which can create confusion. Because of this, the Open Source Initiative created a **list of open source licenses** that meet its definition of OSS. Of those, nine are widely used or used by robust software developer communities such as the Apache, GPL, or MIT licenses. Each license may have different requirements for publishing modifications, attributions, or other changes.

[1] Free software is different than freeware. The first one refers to software that users can run, adapt, and redistribute without legal restraint, and the second refers to software—often proprietary—that is available at no cost.

In general, open source licenses fall into one of two categories: permissive or copyleft. Permissive licenses allow organizations to build proprietary code on top of the original and sell it, as long as credit is provided to the original creator. One example of permissive licensing is the Mac OS (operating system) for all Apple computers, which is based on Unix but is proprietary. In contrast, copyleft licenses require that any code written on top of the original use the same license as the original work. This means that the new software cannot be proprietary.

>>   ## Successful Open Source Projects and Business Models

OSS is essential to how software runs today. The internet would not work without OSS; as of March, 2018, 64 percent of all active websites were running on web servers using OSS such as Apache or nginx. A 2008 report found that OSS resulted in savings of approximately US$60 billion per year to consumers. Finally, of all websites using content management systems, 69 percent use one that is open source such as WordPress, Joomla, or Drupal.

There are many successful open source projects and businesses. One of the largest is the operating system Linux, currently used in over 68 percent of all servers. The company Red Hat, which provides technical support for Red Hat Linux, was acquired in 2018 by IBM for US$34 billion. Firefox is a web browser used in approximately 10 percent of all computers in 2018. The Mozilla Foundation owns Firefox and had over US$520 million in revenue in 2016, mostly from advertising and royalties.

There are at least 18 different ways of monetizing OSS. The most popular ones are providing support or cloud services, offering premium plans, using OSS components while building a proprietary system, or accepting advertising. In the EHR market, the two most common methods are providing services, maintenance, and development and receiving funding from third parties, such as foundations. Both methods have been used by OpenMRS, OpenEMR, and OpenVistA, though the proportions of which is used varies. For example, OpenVistA's origins are in VistA, an EHR created by the US Department of Veterans Affairs for its 1,200 hospitals and clinics. The software was then open sourced through the Freedom of Information Act, and several companies, including MedSphere, are vendors, providing implementation and support for OpenVistA.

Difference between Open Source Software, Open Standards, and Open Data

OSS, open standards, and open data are three separate concepts. There is a common misperception that data entered into an OSS system is open and available to the public, but it is not. In fact, there is an ongoing debate about if whether **OSS or proprietary software is more secure**.

Open data is the term that refers to open access to data, and open data is not related to the type of software license used to collect or host the data. The **open data movement** advocates for making data, usually at an aggregate level, available publicly. Many governments and organizations have joined this movement, including Kenya, the United Kingdom, the **United States**, **and others**.

Open standards are public standards developed (or approved) and maintained via a collaborative and consensus-driven process. These standards can be used in both OSS and proprietary software to facilitate interoperability and data exchange among different products or services and are intended for widespread adoption. In health care there are many, and sometimes **conflicting, standards** for health data as well as their transport and security, among others. The more well-known include ICD and SNOMED for clinical data and HL7 version 2 and Fast Health Interoperability Resources (FHIR) for transport.

Overview of OSS in Health

Open source projects have been developed for almost every domain of health care in both high- and low-resource settings. This includes health reporting systems (DHIS2), human resource management (iHRIS), imaging (dcm4che), laboratory (Bika, OpenE-LIS), research (i2b2), mobile data collection (CommCare, Medic Mobile, Open Data Kit), disaster management (Ushahidi), interoperability (Nextgen, OpenHIE), and EHRs. All the systems above have been used at hundreds, if not thousands, of health care sites.

The use and adaptation of existing open source systems such as these is limited in Latin America and the Caribbean (LAC); instead many public institutions build EHRs or public health information systems from scratch. But building from scratch has several disadvantages, including:

1 Having to recreate the basic functionality, such as users, permissions, and data models, required in every system

2 Underestimating the complexity of the problem, so the project may go over budget, take longer than expected, or fail to provide all the expected functionalities

3 Having a permanent dependency on the original developers. Whether the developers work for a vendor or the institution itself, there is usually little to no knowledge transfer beyond the original developer or group of developers. As a result, the institution or company becomes dependent on the original developer(s) to make any change to the system, which can result in high vendor charges or an inability to modify the system if the internal programmer(s) leave

Given the World Health Organization's finding that funding is the largest limitation of implementing national EHR systems, the duplication of effort required to build a model from scratch is even more of a problem.[2]

Two of the many examples of EHRs developed by IT departments of Ministries of Health (MOHs) in LAC are described here. These have been selected for no other reason than that the authors know of them.

- SIAP (Comprehensive Patient Care System) is a health information system for managing the medical records of patients in health facilities run by the MOH of El Salvador. It was developed by the MOH's Information and Communications Technologies Directorate (DTIC). SIAP has 7 modules (patient identification, medical appointments, clinical follow-up, pharmacy, laboratory, digital signatures, and digital imaging) and has been partially implemented in 30 national hospitals and 12 health facilities.[3]

- e-SUS Hospitalar is a hospital information system developed by Brazil's MOH using mixed technologies (OSS and proprietary), although all the code developed will have the GNU open source license.

Such systems have been built throughout LAC even though many countries in the region, and worldwide, have policies to promote the use of OSS in the public sector. In LAC , at least 11 countries have passed 31 legal mandates on the use of OSS from 2000 to 2010. For comparison, Europe passed 126, while the United States passed 16. A few examples include:

- Bolivia's approval in 2017 of Supreme Decree No. 3251, which made the implementation of electronic government, free software, and open standards official for all institutions of the Government of Bolivia.

- Ecuador in 2008 approved National Decree No. 1014, adopting OSS as law. The modifications made in 2017 emphasized national software production but maintained the preference for public institutions to acquire free software.

- Brazil's government, for approximately 13 years until 2016, had promoted public institutions' use of open source rather than proprietary software as long as they had similar functionality. Despite the change in OSS policy, the government created and still maintains a nationwide repository of open source projects (Software Publico Brasileiro) that public institutions can download from.

- Uruguay's law No. 19.179, passed in 2014, promotes OSS use in government institutions.

[2] World Health Organization. 2016. *Global Diffusion of eHealth: Making Universal Health Coverage Achievable*. Geneva, Switzerland: World Health Organization., page 99
[3] RELACSIS-OPS Red. Identificador Único de Pacientes | El Salvador. Health & Medicine. Retrieved from https://www.slideshare.net/RELACSISRed/identificador-nico-de-pacientes-el-salvador

Open Source Electronic Health Record (EHR) Systems

There are over 30 open source EHR systems worldwide that have been designed for different purposes and settings. Some systems were designed for specific countries, such as **OSCAR** for Canada, **OpenMAXIMS** and **Ripple** for the United Kingdom. Others are focused on specific medical specialties, such as **Open Dental** for dentists, **Odoo Medical** for primary care, and **OpenEyes** for ophthalmology. Here we review five systems designed for worldwide use that have been adopted in at least four countries:[4,5]

1

OpenMRS is a community-driven EHR platform supporting over 8.7 million active patients in 3,307 sites across over 64 countries.[6] There are at least **five national implementations** with hundreds of sites each, including in Kenya, Mozambique, the Philippines, and Uganda. OpenMRS follows international standards, such as FHIR, is modular so functionality can be added through modules (like apps on an iPhone or Android phone), and has customizable forms and a data dictionary. It is meant for a clinical implementation and has practice management functionality.

2

Bahmni consists of OpenMRS for clinical functionality, OpenELIS for laboratory management, dcm4chee for imaging, and OpenERP/odoo for practice management and logistics. It is implemented in over eight countries and has a **list of vendors or implementation partners** that can be hired to provide implementation and ongoing support.

4 Syzdykova A, Malta A, Zolfo M, Diro E, Oliveira JL Open-Source Electronic Health Record Systems for Low-Resource Settings: Systematic Review, JMIR Med Inform 2017;5(4):e44, **https://medinform.jmir.org/2017/4/e44**

5 Aminpour F, Sadoughi F, Ahamdi M. Utilization of open source electronic health record around the world: A systematic review. J Res Med Sci. 2014;19(1):57-64.

6 National OpenMRS implementations. (2018, March 14). Retrieved May 24, 2019, from OpenMRS Talk website: **https://talk.openmrs.org/t/national-openmrs-implementations/16533/2**

3   **GNU Health** is an EHR and laboratory management system that has been adopted by the United Nations University and is an official project of GNU. GNU Health has been implemented in at least four countries, but precise data on uptake is not available. Though it has functionality for many areas of a hospital, GNU Health's forms and data dictionary cannot be modified.

4   **OpenVistA** and **WorldVistA**, based off of the VistA hospital system developed by the US Department of Veterans Affairs, are in use in more than 140 hospitals. These systems have all necessary features for a complex hospital system, including functionality for EHRs, financials, laboratories, radiology, pharmacies, and population health. Though the systems are used mostly in the United States, they have also been implemented in Egypt, Finland, Germany, and Mexico.

5   **OpenEMR** is one of the only open source EHRs certified by the Office of the National Coordinator (ONC) of the US Department of Health and Human Services. It is downloaded more than 7,000 times per month and has functionality for a patient portal, patient scheduling, EHRs, billing, and reports. OpenEMR has certified vendors in 13 countries including **Argentina, the United Kingdom, and the United States**.

Benefits of Open Source EHRs versus Proprietary EHRs

To more closely understand the pros and cons of the two types of systems, Table 1 lists the key similarities and differences between them.

Table 1. Key Similarities and Differences between Open Source and Proprietary EHRs

Similarities (same for both systems)

- Require planning before implementation (cost estimation, processes standardization, etc.)
- Require implementation (software customization, training of personnel, server setup, etc.)
- Require maintenance after implementation (software, creating and training new users, etc.)
- Require data and information security measures to prevent data leaks and other IT security threats
- Require a legal framework (patient data confidentiality, security, interoperability, etc.)

Differences

Open source EHRs	• Client can make improvements independent of vendor • Client can implement it without vendor • Client can use system if vendor contract ends • Client can look and try out system before implementation without vendor assistance • Client can get service from many vendors • Client can add functionality through source code updates and modifications
Proprietary EHRs	• Company that owns software decides who can provide services, such as implementation or support • Client is unable to improve or update software until vendor releases a new version • Client may need vendor support to implement/customize functionality • Vendor may limit free trials to a few days • Vendor have multitude of business licensing models with variability in subscription terms and maintenance

In general, OSS provides more power and options to the customer because the customer owns not only its own data, but also the system itself, which has many advantages.[7] Table 2 describes advantages and disadvantages of each type of system.

Table 2. Major Advantages and Disadvantages of Open Source and Proprietary EHRs		
	Advantages	Disadvantages
Open source EHRs	• Very easy to acquire and test before implementation • Less vendor lock, meaning they aren't required to use the EHR vendor for all changes to the system • More control over data • Reduced development and configuration costs • Increased interoperability • Most solutions include open and international standards	• Lack of IT support in some regions • Increased customization usually required • Software updates (including security updates) may depend on other users to build them and therefore may take longer • Indemnification and liability risks are not covered if do not have a vendor
Proprietary EHRs	• Simpler license and ownership choices • More likely to find a vendor to provide technical support, updates, and maintenance	• Dependent on vendor for all modifications • Potential for artificial monopoly in countries and regions since there is one vendor

The discussion that follows further explains the advantages of open source EHR systems.

>> Reduced Vendor Lock

Because modifications to an EHR system tend to be complex, many vendors of proprietary EHRs are known for charging high fees for this work, increasing their fees once the system has been implemented, or providing poor service. With an open source EHR system, the customer can choose whether to use a vendor or internal IT people to modify the system. If a vendor is chosen, the customer has more control over the vendor because the customer can change vendors without also losing the system.[8] That said, given the complexities of maintaining a functioning EHR system, changing vendors is not easy either. For example, there may not be another vendor in the region for the system, or customizations or missing documentation would make changing vendors difficult. Despite these constraints, the use of open source EHRs provides more leverage to hospitals, governments, and other consumers in a market that is highly controlled by EHR companies.

This is even more important for national or regional implementations where a MOH, for example, chooses a single system and by default creates a regulatory monopoly. If the system is not open source, the cost of changing the system is so high that the vendor

7 https://www.pcworld.com/article/209891/10_reasons_open_source_is_good_for_business.html

8 Goulde, M., and M. Holt. 2006. *Open Source Software: A Primer for Health Care Leaders*. California HealthCare Foundation.

is practically irreplaceable. There have been many cases of vendors using this position to their favor.

As an example, consider the situation if two countries implement a national EHR system, with Country A using a proprietary system and Country B using open source tools to build their own. Country A has to pay the vendor for each update, and only the vendor can modify the functionality. As a result, Country A has to pay any fee set by the vendor. Country B is able to change or update its EHR system according to its budget and can use a vendor or an in-house IT team to make modifications.

>> Increased Control of Data

Customers of open source systems can have more say and control over how the data are stored and used. This facilitates, for example, the development or use of complementary programs to access that data for in-house reporting.

A problem that arises frequently in proprietary EHR systems is that the customer lacks control of features, such as reporting functions, in the system. This was the case in Chile, for the proprietary system Rayen by Saydex, where health centers had to pay every month to get their monthly report with updated data. A similar problem is that proprietary EHR customers cannot change the content of the report even if it is discovered that the report no longer fits the client's needs.

With OSS, a customer can modify functionality independent of the vendor to extract and view their data. So if the customer wants to examine specific data to determine how to better meet patients' need or other purposes, the customer has the option of doing it themselves and not necessarily rely on the vendor as with many proprietary systems. All of this, however, is dependent on the customer having the appropriate technical access to their system.

Two more examples[9] of typical problems with proprietary EHR systems follow:

1	**The Chilean MOH installed a proprietary immunization information system in 2010, which had been developed by a local software company based on technical requirements provided by the National Immunization Program and implemented on the company's servers. The MOH signed an agreement to pay a monthly fee for access to the system and run reports that were created at the start of the project. Because the MOH did not have direct access to the database or data, any additional reports needed, and any software updates incurred an additional charge.**
2	**The Panamanian MOH uses a national EHR system, SEIS, using proprietary software. MOH personnel can run existing reports in the EHR but cannot create new reports. To address this limitation, the MOH created a separate data warehouse and business intelligence (BI) tool to create new reports.**

>> Reduced Developmental Costs and Flexibility to Expand

Given that OSS is free to download and try for any length of time and proprietary software, if the vendor allows, often has short test periods, OSS systems have less risk. Furthermore, if the open source system has many organizations continually improving it by developing it, then the customer may get that additional functionality without having to pay for its development. Additionally, OSS systems have the benefit of allowing the customer to choose who builds additional functionality for them, so they are not bound to their current vendor.[10]

EHR systems are complex and have a high failure rate, but they are also an essential part of the workflow. Because of this, changing EHR systems is expensive and getting it right the first time is difficult. Thus, organizations should want to have a system that they can modify and expand with as little cost as possible and a vendor who is flexible. Both of these occur more easily with open source EHR systems. To modify the system, for example, if the code is open source, the customer has options as to who develops it whether internally, through their vendor, or another vendor. Also, given that the customer has more options and is not locked into a contract with one vendor, the vendor has to be more flexible.

[9] Taken from interviews with Government personnel.
[10] Goldwater, Jason C et al. 2013 "The use of open source electronic health records within the federal safety net." Journal of the American Medical Informatics Association: JAMIA vol. 21,2: 280-4

>> Increased Innovation

OSS promotes innovation because organizations can build applications on top of existing EHR system. OpenMRS is a good example. It has **dozens of add-on applications**, dozens of local start-ups in multiple countries to provide implementation services and to add functionality on top of it. For example, in Chile, one company implemented an automated diabetes management system using OpenMRS.

>> Increased Interoperability

Though both open and proprietary systems can use open standards, open source systems are more likely to use these standards. This is, in part, because people who work with OSS systems tend to be in favor of open standards, whereas proprietary vendors have a commercial interest in keeping clients from changing to another system. Proprietary vendors therefore tend to be wary of **open standards**.[11,12] A **review paper** found that proprietary issues were in the top three reasons for lack of interoperability, after privacy and sustainability.[13]

[11] Reynolds, C.J., and J.C. Wyatt. 2011. "Open Source, Open Standards, and Health Care Information Systems." *J Med Internet Res* 13(1): e24.

[12] Hammond, W.E. 2005. The Making and Adoption of Health Data Standards *Health Affairs* 24(5)

[13] Wua, H., and E.M. LaRueb. 2017. "Linking the Health Data System in the U.S.: Challenges to the Benefits." *International Journal of Nursing Sciences* 4(4): 410–417.

Disadvantages of Open Source EHRs versus Proprietary EHRs

>> ## Lack of Vendors

The major problem for implementing any of the available open source EHR systems in LAC is the lack of organizations that are able to provide implementation and support services for them. Some open source systems have vendors that provide fee-based support services, though most do not. Therefore organizations using them must rely on having internal IT personnel and the system's community to resolve their problems. This means that OSS system vendors will not have the same access to most services that a proprietary vendor handles, including adding features, installing software fixes, and maintenance.

>> ## Customization Required When Compared to Locally Built EHRs

Like any international proprietary EHR, an open source EHR tends to require more customizations to local requirements, such as national identifiers, local names, and processes, the first time it is installed. This is because these systems were designed to be implemented in many countries, therefore are more flexible and require more customization. For this reason, some countries have opted to build their own software from scratch. However, building from scratch requires an even higher level of in-country support in terms of development, maintenance, and time.

>> ## Complexity

Proprietary software is easier to understand because it behaves more like most goods that people are already familiar with. There is a single owner of the good, and that owner—and only that owner—can sell their good. OSS is based on the principle that software can be shared with near-zero cost for the benefit of many people by allowing them all to use the same good, which is impossible with many physical goods. As an example, if an organization chooses an open source EHR system, none of the organizations and people who have worked on that system receive payment. This process is the opposite of what happens with most medical equipment, devices, or other health goods. However, this situation makes it more complicated to understand and, along with other reasons, means less uptake.

Total Cost
of Ownership

It is difficult to measure the total cost of ownership (TCO) of an EHR system and even more difficult to compare the TCO of open source versus proprietary EHR systems. This is mostly due to the lack of public data on the costs of EHR projects. In one US state, a multiple-hospital **VistA-based EHR network was implemented** for one-tenth the price of a proprietary EHR network in another hospital network in the same state (US$9 million versus US$90 million for seven to eight hospitals in each system).[14]

The table below describes the components of total cost of ownership that each type of software will have. This **spreadsheet** can also help calculate the total cost of ownership. For OSS, there are separate columns for calculating costs with a software vendor and without one, as would be the case if relying on in-house IT support.

14 *"Ten Fold (10X): Is There Really an Order of Magnitude Difference?"* Crossover Health, 2009, xo.crossoverhealth.com/ten-fold-10x-is-there-really-an-order-of-magnitude-diffe-rence/.

	Proprietary Software	OSS with vendor	OSS without vendor
Startup costs			
• Upfront software cost	Depends on the vendor	None	None
• Customization	Done by vendor. May require less customization if already have an implementation in the country	Should be done by vendor. May require less customization if already have an implementation in the country	Done by in-house staff, if needed
• Training	Done by vendor		Done by in-house staff, if needed
• Data migration	Done by vendor, if needed	Done by vendor or in-house staff	Done by in-house staff, if needed
Operational costs			
• Licenses	Depends on vendor	None	None
• On-going training	Can be done by vendor or in-house staff		Done by in-house staff
• Maintenance; patches	Developed and installed by vendor	Developed by community, vendor, or in-house staff; installed by vendor or in-house staff	Developed by community or in-house staff; installed by in-house staff
• Data center; hardware	Usually maintained by vendor	Maintained by vendor or in-house staff	Maintained by in-house staff
• Enhancements	Developed and implemented by vendor	Developed by community, vendor, or in-house staff; installed by vendor or in-house staff	Developed by community or in-house staff; installed by in-house staff

Deciding between an Open Source and Proprietary EHR

>> Building your own EHR or having staff provide technical support

If your organization has decided to build its own EHR system or have its IT staff provide technical support for a system that will be built, using an open source EHR system as a starting point is the most logical choice. Most, if not all, open source EHR systems have already established the basic functionality required for a good system. This includes creating users, permissions, and reports. Additionally, many have created flexible frameworks to customize the system to the needs of the organization. In general, these functionalities have been tested over many years by different organizations to ensure they work, and it is harder to justify the expense involved in recreating them for the new system. OpenMRS has spent at least US$8 million creating its system, and that money does not need to be spent again to reinvent the wheel.

The main reasons organizations give for creating their own EHR systems are 1) they do not have programmers who know the OSS or open source language, or 2) their needs are so specific that they are not met by any open source EHR. In the authors' combined 30 years of experience in EHRs in Africa, Latin America, and the United States, the vast majority of projects that created their own systems for these reasons ended up not being able to create the desired functionality within time limits or budget constraints. The majority of teams designing systems vastly underestimate the complexity of creating an EHR system, and failure rates for EHR system implementations have been estimated at 20 to 50 percent in the United States.[15]

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[15] Keshavjee K, Bosomworth J, Copen J, et al. Best practices in EMR implementation: a systematic review. *AMIA Annu Symp Proc.* 2006;2006:982.

>> Choosing Vendors

If the organization would like a vendor, then it should decide between the advantages of having a vendor of an open source or proprietary EHR.

The important factors in selecting the type of vendor are choosing between the simpler and more commonly used processes of choosing a proprietary software vendor versus the flexibility an open source EHR including being able to different vendors, owning the system, and the other advantages described in Section 6. As discussed early, avoiding vendor lock is especially important when selecting a national system, as this can create an artificial monopoly and potentially give a vendor too much leverage.

There are few, if any, open source EHR vendors in Latin America, so finding one may require contacting open source vendors from other parts of the world or inviting local companies to provide services. This will probably add time to the process of choosing an EHR system and vendor, but doing so will provide many benefits later on, including reducing maintenance costs, having a greater ability to negotiate with vendor, and increasing innovation.

Additional Resources

American Medical Association's digital leadership in health resources: https://www.ama-assn.org/delivering-care/digital-health-leadership

Gould, M, and E. Brown. 2006. *Open Source Software: A Primer for Health Care Leaders*. Oakland, CA, United States: California HealthCare Foundation. https://www.chcf.org/wp-content/uploads/2017/12/PDF-OpenSourcePrimer.pdf

Houngbo, P.Th., H.L.S. Coleman, M. Zweekhorst et al. 2017. "*A Model for Good Governance of Healthcare Technology Management in the Public Sector: Learning from Evidence-Informed Policy Development and Implementation in Benin.*" *PLOS ONE* January 5. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0168842.