eHealth in Latin America and the Caribbean: interoperability standards review

Pan American Health Organization

World Health Organization

REGIONAL OFFICE FOR THE Americas

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Summary, objectives, recipients

Summary

Information and Communication Technology implemented in healthcare has the potential to improve the quality of care, optimize expenditure and contribute to the safety and fairness of patient care. The field of healthcare involves a high degree of information exchange among stakeholders; however, it is highly fragmented and distributed across multiple unintegrated data silos. To achieve adequate continuity of care, a continuous flow of information is required. A key aspect to accomplish this objective is to ensure the interoperability of information systems that support the health care process. The effective information exchange between stakeholders and systems can be attained through the use of standards. This report aims to describe a conceptual framework for interoperability and eHealth standards, to perform a systematic review of the literature (implementation and effective use of standards to achieve interoperability in Latin American and Caribbean countries) and, finally, to provide recommendations to achieve this objective in the region.

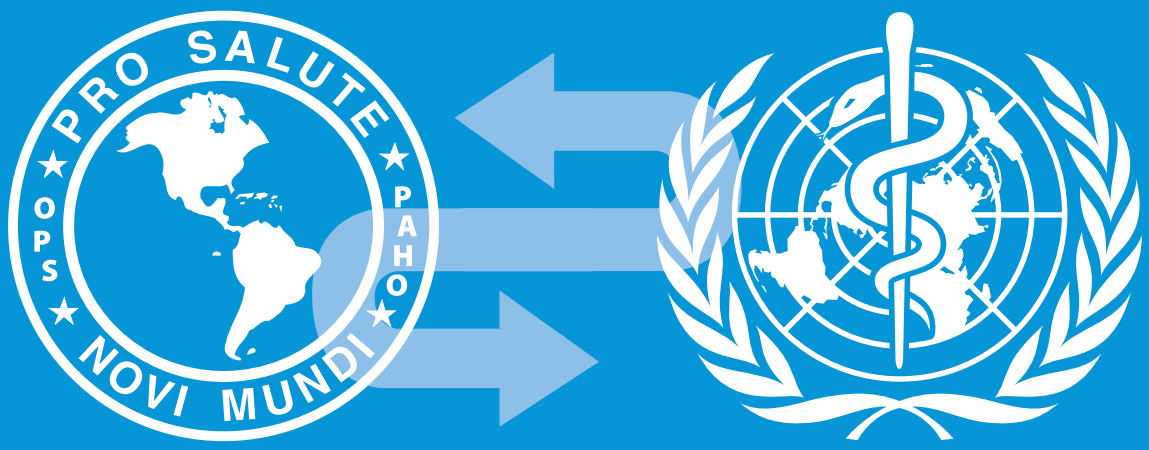
Objectives

- Describe a conceptual framework on interoperability and eHealth standards in general.
- Conduct a review of the implementation and effective use of standards to achieve interoperability in Latin American and Caribbean countries.
- Provide recommendations to achieve interoperability in eHealth in the region.

Recipients

This report is intended for managers, decision makers and implementers of Health Information Systems, and also for those members of the health team interested in the characteristics of eHealth standards and interoperability. It is expected to provide support to those involved in the design and implementation of eHealth initiatives in Latin America and the Caribbean.

Strategic actions of the Pan American Health Organization/ World Health Organization with regard to standards and interoperability



Eight agencies[1] that work in the sphere of health agreed that it is critical to strengthen the five sources of key data (health surveys, birth and death registries, censuses, information and surveillance systems, and administrative systems) and their availability, usability, accuracy, reliability, security, scalability, and sustainability for analysis, synthesis, validation, and in-country and international use of health data.[2] To achieve this strengthening, the agencies proposed four global actions: increasing the levels and efficiency of investment in health information, developing common data architecture, strengthening monitoring and evaluating performance, and expanding data access and use.

In addition, the third recommendation of the Commission on Information and Accountability for Women's and Children's Health (CoIA),[3] related to innovation, considered it fundamental to reach agreement on standards and guarantee interoperability of data between disparate information systems. This recommendation also had an impact on the need to establish common methodologies and minimum data sets to guarantee that information is collected consistently, interpreted and recorded correctly in a timely manner, and shared effectively. Finally, it indicated that national policies on the exchange of health data should guarantee data protection and data privacy, and personal consent for the control and release of data.

The use of eHealth and m-health should be strategic, integrated and support national health goals. In order to capitalize on the potential of ICTs, it will be critical to agree on technical, semantic, and electronic interoperability standards, and to ensure the actual functional interoperability of systems. Health information systems must comply with these standards at all levels, including systems used to capture patient data at the point of care. Common terminologies and minimum data sets should be agreed on so that information can be collected consistently, easily shared and not misinterpreted. In addition, national policies on health-data sharing should ensure that data protection, privacy and consent are managed consistently.[4]

As a specialized agency of United Nations (UN), the World Health Organization (WHO) recognizes the importance of standardizing health data and its importance for eHealth systems and services. Promoting health care requires the appropriate use of Information and Communications Technologies (ICTs) in order to provide skilled health services, cut costs, and achieve universal coverage of health services.[5]

For WHO and the International Telecommunication Union (ITU), standards and interoperability are a necessary component for gaining perspective on the application of ICTs to support health (eHealth at the national level).[6] Standards must be established in order to collect information systematically and facilitate the compatibility of data and terminology.

The need to address the matter of data circulation from an international standpoint was included by WHO in the report of the Secretariat on eHealth in 2005[7] and expanded in resolution

1 - Bill & Melinda Gates Foundation; GAVI; Global Fund to Fight AIDS, Tuberculosis & Malaria; UNAIDS; UNFPA; UNICEF; World Bank; and the World Health Organization.

2 - Chan M, Kazatchkine M, Lob-Levyt J, Obaid T, Schweizer J, et al. (2010) Meeting the Demand for Results and Accountability: A Call for Action on Health Data from Eight Global Health Agencies. PLoS Med 7(1): e1000223. doi:10.1371/journal.pmed.1000223

3 - World Health Organization. Keeping Promises, Measuring Results. Commission on Information and Accountability for Women's and Children's Health. Geneva, Switzerland, 2011.

4 - (Id. 3)

5 - World Health Organization. WHO Forum on Health Data Standardization and Interoperability. Geneva (Switzerland): WHO; 2013.

6 - World Health Organization, International Telecommunication Union. National eHealth Strategy Toolkit. Geneva; 2012.

7 - World Health Organization. eHealth [Internet]. 58th World Health Assembly; May 16 to 25, 2005; Geneva (Switzerland). Geneva, Swit-

WHA58.28, which urged the Member States to promote multisectoral collaboration in order to define eHealth criteria and standards based on contrasted data. This mandate also urged WHO to promote multisectoral collaboration in order to make administrative and technical solutions more compatible with ethical directives in the area of eHealth.[8]

In the Region of the Americas the eHealth Strategy and Plan of Action of the Pan American Health Organization (PAHO), approved in 2011 by the 51st PAHO Directing Council, also includes the question of standards and interoperability as a key component of eHealth.[9] This strategy and plan of action seeks to promote the sustainable development of eHealth programs and initiatives that can be expanded and made interoperable, while also contributing to the unified interoperability of health systems (organizational and technological interoperability). Furthermore, resolution CD51/13 urges the Member States to promote an internal dialogue and to coordinate efforts among ministries and other public sector institutions, as well as partnerships among the public and private sectors and civil society, in order to achieve national consensus and guarantee the exchange of knowledge regarding profitable models, ensuring the availability of standards for quality, safety, interoperability, and ethics, and respecting the principles of confidentiality of information, equity, and equality.

In 2012, the WHO Forum on Health Data Standardization and Interoperability was held with the principal objective of facilitating dialogue among organizations devoted to formulating health data standards, organizations responsible for maintaining standards, academic institutions, experts, and Member States, for the purpose of working on a road map to achieve interoperability within countries. Below are the panels that were formed, and the main conclusions for each of them are shown:[10]

1. **Essential aspects of health data standards for health care delivery.** Among the key results, Panel 1 concluded that in order to achieve semantic and syntactic interoperability, various categories of standards should be implemented as part of the general strengthening of eHealth systems and services nationally and subnationally.
2. **Country perspectives on health data standards implementation.** Panel 2 observed that it is essential to have national eHealth policies that include standardization of health information technologies.
3. **Access to health data standards.** Through the discussion in Panel 3, the forum recognized the need for a worldwide support mechanism to help the Member States, especially the low- and middle-income countries, to access and adopt standards at all levels of eHealth systems and services. In addition, science, medicine, and information technology are not static, but can, in fact be quite dynamic. Interoperability standards are necessarily evolutionary therefore (e.g., ICD-9, -10, & -11), and strategies for orderly selection, adoption, and implementation of new standards must be anticipated and supported.
4. **In-country policy and governance mechanisms for the adoption of health data standards.** Panel 4 concluded that it is essential to have a work force with the necessary health and information technology competencies for the effective application of the standards at the national and subnational levels.
5. **Innovative funding models for health data standards access and adoption.** In Panel 5 it was recognized that financing should be part of a national eHealth strategy so as to maintain implementation of the standards.

zerland: WHO; 2005 (document A58/21)

8 - World Health Organization. eHealth [Internet]. 58th World Health Assembly; May 16 to 25, 2005; Geneva (Switzerland). Geneva, Switzerland: WHO; 2005 (resolution WHA58.28)

9 - Pan American Health Organization. eHealth Strategy and Plan of Action (2012-2017) [Internet]. 51st Directing Council of PAHO, 63rd session of the Regional Committee of the WHO for the Americas; September 26 to 30, 2011; Washington (DC), United States. Washington (DC): PAHO; 2011 (document CD51/13)

10 - (Id. 5).

6. **Human capacity for health data standards implementation and maintenance.** Panel 6 revealed the importance of governments promoting the participation of academic institutions and nongovernmental organizations that work in the sphere of health with a view to formally establishing specialized training programs for current health professionals on standardization and eHealth systems.

7. **Role of development partners in health data standards implementation.** Since donors often demand that beneficiaries provide a considerable quantity of data, in Panel 7 it was suggested that the funds currently given for collecting data on paper should be redirected to financing standards-based eHealth systems.

In this same vein, in April 2013 PAHO carried out a regional technical consultation on "eHealth standardization for data exchange and interoperability" that included the participation of national authorities from Barbados, Chile, Colombia, Costa Rica, Jamaica, Mexico, and Peru. The following conclusions were reached at this forum:

- Financing long-term projects is the main challenge at the national level;
- There is a need for human resources trained to work on eHealth issues at the regional level;
- Maintaining real-time interoperability, while mindful of standards and information architecture, is a major challenge;
- A free or low cost shared server is needed for clinical terminologies and common dictionaries;
- The main reasons identified for the lack of progress are the failure to develop policies, fragmented information systems, and the lack of consistent and unified selection and application of technical and semantic interoperability standards;
- Communication is important for the social dissemination of processes and for sharing experiences regionally; and
- The value of intra- and international interoperability of health data is often transient. Though the benefits are most evident when confronting pandemic disease events like flu or Ebola, the costs to support and maintain such systems is difficult to accurately measure and share.

Aware of the need to standardize health data, both WHO and PAHO have shown their commitment in this regard by approving, during the 66th World Health Assembly in 2013, resolution WHA66.24 on "eHealth standardization and interoperability," and also by including the design of national eHealth strategies as an objective in the 2014-2019 Strategic Plan.

Resolution WHA66.24[11] urges the Member States to prepare a road map for implementing health data standards at the national and subnational levels and for ensuring the confidentiality of personal clinical data. This resolution urges WHO, within existing resources, to provide support to Member States to integrate the application and of health data standards and interoperability, and to support their promotion of the full implementation of health data standards in all eHealth initiatives.

With regard to the 2014-2019 Strategic Plan,[12] both PAHO and WHO included among their objectives the need to work on developing national eHealth strategies. For PAHO, developing and using eHealth (including health care through mobile devices, or mHealth) offers an opportunity for changing how health services are provided. Developing and implementing national eHealth strategies will be fundamental for optimizing the health benefits offered by the new information technologies.

11 - World Health Organization. eHealth [Internet]. 66th World Health Assembly; May 27, 2013; Geneva (Switzerland). Genva, Switzerland: PAHO; 2013 (resolution WHA66.24)

12 - Pan American Health Organization. Strategic Plan of the Pan American Health Organization 2014-2019 [Internet]. 52nd PAHO Directing Council, 65th session of the Regional Committee of WHO for the Americas; September 30 to October 4, 2013; Washington (DC) United States. Washington (DC): PAHO; 2013 (document 345).

In 2014 the Inter-ministerial Policy Dialogue on eHealth Standardization was held, as was the Second WHO Forum on Health Data Standardization and Interoperability, which produced major recommendations on the national context with respect to eHealth policies in relation to standardization and interoperability, namely: [13]

- Be embedded in a national health plan, and an eGovernment plan if one exists. Its view must be long term, provide continuity, and commit to long-term investment.
- Development and implementation of national eHealth policies for standardization and interoperability should be a national effort and must include stakeholders from the health sector, non-health sectors of national governments, and non-state actors;
- Be patient-centered, emphasizing service quality, equity, patient outcomes, patient safety and population outcomes;
- Be based on mutual trust and understanding and genuine collaboration between all stakeholders from lawmakers to patients, facilitated from the start by a participative approach to policy-making, and encompassing public and private partnerships where necessary;
- Support an evidence base for the socio-economic benefits of eHealth, and encompass user utility and outreach programs to ensure that all stakeholders, including patients, are aware of the use, benefit and risks of eHealth and are engaged in related discourse and decision-making, and its implementation;
- Adopt appropriate electronic Health Information Exchange (HIE) technology, including at national and subnational levels, in vertical programs, and in public and private health care facilities;
- Set health data and health IT standards to ensure interoperability at data-, device and system-levels, in a framework containing a fixed core set of maintained standards allowing for a degree of innovation outside that core set and allowing for development based on the capacity and maturity of eHealth systems and services and regulate an appropriate degree of adoption in the country context;
- Use existing international standards where possible and adapt specific standards to suit national contexts (taking necessary care to ensure interoperability and backward compatibility, as applicable);
- Provide unique identifiers for patients, health care workers and health care facilities, with verification and authentication procedures;
- Ensure the safety of interoperable medical devices, and ensure security, defining privacy and security policies addressing technology use in health care delivery;
- Build capacity from country and ministry level down to that of frontline health workers. This includes financial and academic capacity as well as technical and human resource capacity;
- Ensure good governance, balancing top-down and bottom-up approaches, encompassing: equity and accessibility; legality; user rights in line with human rights; privacy; responsibility; and accountability to citizens and to the state. Compatibility of technologies, efficiency, open dialogue and a shared vision on use of data are necessary for implementation. In monitoring compliance, clear goals and key indicators for monitoring and evaluation are needed, with mechanisms for social participation;
- Support competency-based education and capacity building in health informatics, with standardized curricula and measurable learning objectives at national and subnational levels. Train-

13 - World Health Organization. Joint Inter-Ministerial Policy Dialogue on eHealth Standardization and Second WHO Forum on eHealth Standardization and Interoperability. Geneva (Switzerland): WHO; 2014.

ing should be for the health workforce, including social workers, and should cover eHealth policy development and planning, communications and leadership as well as technical content. Training, including in-service training, can provide a valuable opportunity for partnership with academia, technical colleges and other relevant bodies;

- Encourage relevant ministries of national governments to include eHealth core competencies in job descriptions for relevant posts;

Finally, the approval in October 2014 of the PAHO "Strategy for Universal Access to Health and Universal Health Coverage,"[14] is the most recent action taken to date in the area of standardization and interoperability. This strategy indicates the need to ensure that data are high-quality, comprehensive, timely, and reliable, which includes interoperability with other offices and mechanisms, while also developing indicators to monitor and evaluate health, equity, and their determinants. Data analysis should be used to develop and guide policies and plans for moving towards universal access to health care and universal health care coverage.

Recognizing the importance of standardizing data and its relevance for eHealth systems and services, PAHO will continue working to develop a regional road map to establish standards on health data at the national and subnational levels and to guarantee the confidentiality of personal clinical information.

14 - Pan American Health Organization. Strategy for Universal Access to Health and Universal Health Coverage [Internet]. 53rd PAHO Directing Council, 66th session of the Regional Committee of WHO for the Americas; September 29 to October 3, 2013; Washington (DC) United States. Washington (DC): PAHO; 2014 (document CD53/5, Rev. 2).

eHealth Standards and Interoperability

"If you wish to converse with me, define your terms."
Voltaire

Information Technology and Communication (ICT) implemented in healthcare have the potential to improve the quality of care, optimize expenditure and contribute to the safety and fairness of patient care [1, 2]. Health care is a continuous process based on information and communication, which requires constant interaction and information exchange among the involved stakeholders, such as patients, providers, insurers and the state. It is estimated that 30 % of health-related expenditure is allocated to manage information [3]. To achieve adequate continuity of patient care, a continuous flow of information among members of the health team is required [4]. This information is highly fragmented and distributed across multiple sources acting as silos, precluding adequate availability of information to support the care process, clinical management, administrative processes and data aggregation [5]. No country is immune to this reality, affecting both developed and developing countries [6]. To achieve a smooth flow of information between silos, it is necessary to ensure the interoperability of information systems that support the care process through the use of standards [7].

The World Health Organization (WHO), through a resolution at its 66th World Assembly, called on member countries to adopt certain standards in order to achieve effective exchange of information between healthcare system agents [8]. WHO recognizes eHealth as cost- effective and secure use of ICT in healthcare and related domains including healthcare services, healthcare monitoring and healthcare documentation as well as education, knowledge and research in health [9]. EHealth is defined as an emerging field in the intersection of medical informatics, public health, and business, referring to health services and information delivered or enhanced through the Internet and related technologies. In a broader sense, the term characterizes not only a technical development, but also a state-of-mind, a way of thinking, an attitude, and a commitment for networked global thinking, to improve healthcare locally, regionally, and globally by using ICT [10].

Among the main points of the resolution on interoperability, it was established to standardize eHealth among member countries, attune policies and legislation for the effective adoption of these standards, promote collaboration with international agencies to standardize and adopt measures for innovation, development and evaluation in this domain [8].

eHealth Interoperability

There is no unique definition for the term *interoperability* (IO); it has different meanings in different contexts. The most widespread definition is the one given by the Institute of Electrical and Electronics Engineers (IEEE), which is defined as:

"... The ability or capability of two or more systems to exchange information and use the exchanged information..." [11].

This definition encompasses two distinct ideas: the first one is the exchange of information (syntactic interoperability), and the second one is that the information exchanged can be properly understood, processed and effectively used by the receiver (semantic interoperability).

In healthcare, the IO has a more specific scope and is defined as:

"... The ability of different health information systems (hospital systems, departmental systems, electronic medical records, etc.) to exchange data and use the information that has been exchanged with-

in and across organizational boundaries in order to improve the effective delivery of health care to individuals and communities ..." [12]

Interoperability Levels

Currently, there is no clear consensus on the different interoperability levels. After analyzing the reported rankings, synonymy and an obvious overlap were observed in the defined levels [13-15]; these classifications are detailed in Table 1.

Table 1: Classifications and interoperability levels

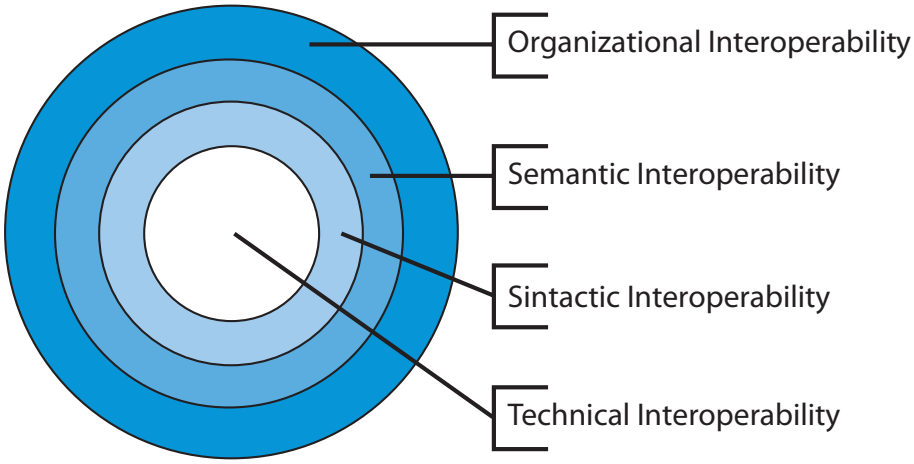
	Interoperability levels
Walker y col. [13]	**Level 1:** No electronic data. No exchange through information systems **Level 2:** Electronic transmission of not standardized information. Information cannot be manipulated. **Level 3:** Electronic transmission of organized and structured not standardized data. Interfaces are required to translate data. **Level 4:** Electronic transmission of organized and standardized data. Encoded and interpretable information by receiver and issuer.
Healthcare Information and Management Systems Society **(HIMSS)** [14]	**Foundational:** Data exchange between issuer and receiver. **Structural:** It defines structure or data format and ensures interpretation. **Semantics:** Interpretation of the meaning, allowing its use.
Health Level Seven [15]	**Technique:** Data exchange, not related to the meaning. **Semantics:** The receiver has to interpret the meaning the same way the issuer does. **Process:** Optimal integration of exchanged data with work processes.

Noting the overlap in the reviewed works, in order to classify the interoperability levels in eHealth, the classification proposed by the European Telecommunication Standards Institute (ETSI) will be used in this report [16]. This classification is also defined in another publication [17]; it includes four interoperability levels (Figure 1)

- **Technical:** generally associated with hardware and / or software components, systems and platforms that enable machines to communicate with each other. This type of interoperability often focuses on communication protocols and the necessary infrastructure to operate.
- **Syntactic:** usually related with data formats. Transferred messages by communication protocols need to have a well-defined syntax and encoding, even if they are only in a bit table format. However, many protocols transport data or content, and this can be represented by high level transfer syntax, such as HTML, XML or ASN 12 (information exchange between systems does not guarantee the proper interpretation and use of it, technical and standard issues in protocol areas and exchange formats are solved).
- **Semantic:** interoperability level associated with the contents' meaning. It refers to human interpretation of the content rather than the machine's interpretation. Therefore, interoperability at this level means that there is a common understanding among people about the meaning of the content (information) that is being exchanged (correct interpretation and the use of exchanged information is guaranteed, hence formal definitions of each entity, attribute, relationship, restriction and exchanged term are needed).
- **Organizational:** as its name suggests, it is the ability of organizations to communicate and effectively (significantly) transfer data (information), even though a variety of different information systems based on very different infrastructures are being used through different

geographic regions and cultures. Organizational interoperability depends on the technical, syntactic and semantic levels' success (systems from different areas are integrated to support distributed business processes. To achieve this, rules and business processes must be defined, as well as the actors involved in these processes, organizational objectives, the different business structures: departments, hierarchies, etc.).

Figure 1: Interoperability levels (adapted from [16])



A good analogy to understand the different interoperability levels is the use of the mail, with which we can send and receive letters and packages. If we want the letter or package to reach destination, we have to provide the name and address of the recipient. We also provide our name and address in case our package or letter delivery cannot be completed. All the postal system's logistics is equivalent to the communication protocols that enable information exchange between systems (technical interoperability). However, the delivery protocol we use does not specify the content of what we are shipping. Shipments may contain checks, bills or personal correspondence, that is to say the different types of items that can be sent (syntactic interoperability). Moreover, the content may be written in different languages, such as Japanese or English, and to understand the message content you need to have a vocabulary that both issuer and receiver know how to interpret (semantic interoperability). Last but not least, there is the ability to generate actions by the exchanged content, the letter may indicate that something must be done and its execution can be associated with organizational interoperability [18]. The sum of the different interoperability levels ensures that the information will be properly exchanged, interpreted and used among different systems, different suppliers and different technologies [19].

Benefits in eHealth Interoperability

In order to get more value (improved patient care, including safety, efficacy, and efficiency) from eHealth, interoperability is undoubtedly required. Most of the promises that are emerging from eHealth need systems to share information. These benefits can be seen at different health system levels.

At the individual and population Health Quality Benefits level, interoperability facilitates the timely exchange of all patient information among members of a care network. The availability of accurate and complete data enables participants in the healthcare continuum to be fully and accurately informed, allowing users of clinical information systems to make diagnostic and therapeutic decisions with an up-to-date comprehensive understanding of the patient, resulting in better health care [20]. This enables improved care at the moment and point of care, and provides an opportunity of potentially life-saving error-detection and intervention so that drug-allergies or contra-indications are avoided before harm occurs.

At the Health Organization Benefits level, the value of interoperability is obtained when there is a complete, timely, and accurate integration of the data between legacy computer systems, because they use different programming languages, communication protocols, operating systems, data standards, units of measurements, patient identifiers, and electronic interfaces. Such systems need to share and use the same information generated or stored in multiple locations and computers. In the past, in order to avoid error-prone manual data re-entry, unique and expensive interface programs, converters, and adapters have been required for each combination of legacy system. The creation of such unique interfaces to link each of the systems within an organization is possible, but when the number of systems that need to be connected grow, the cost and complexity grows geometrically [(5)]. The use of a consistent, standards-based interoperability protocols often allows each legacy system to be adapted with only one, or a few, standardized interfaces that are less expensive to design, implement, test, and maintain.

At a Governmental Benefits level, Public Health bases their actions on reported data by health care providers and insurers, but those parties often must manually enter information in multiple systems, and could upload it erroneously, incomplete, inaccurately, or too late to be of effective benefit [(6)]. Interoperability that is based on mutually-agreed standards offers the opportunity to replace manual data entry and incomplete and error-laden reports by timely and accurate automated reports, allowing greatly improved access to disaggregated data by multiple government agencies, care providers and insurers. Potential uses of this information include: mandatory and non-mandatory laboratory diagnostic reports (diseases of mandatory reporting to monitor seasonal diseases, antibiotic resistance, morbidity in the community), reporting of disease statistics, population-based pathology records, ad-hoc public health research, and improved disaster response (during which victims can be identified and treated according to previous data on their health records). Moreover, information could flow back to the appropriate care providers through notes on epidemic diseases and recommendations for action to health team members [(21, 22)].

Finally, from an Economic Benefits point of view, interoperability would improve health services management and lower costs [(13)]. This could be achieved, for example, by requesting less redundant studies ensuring the availability of prior results or eliminating the need of written records of patients' results to share among effectors. These benefits are also transferred to drugs prescription, imaging studies and surgical indications, as well as hospitalizations and unscheduled visits to emergency stations, limiting expenditure to a large extentt [(23-25)].

It is estimated that a fully interoperable national health system could achieve significant economic benefits, with a net saving that could reach 5% of total health expenditure [(13)], without considering indirect costs of providing better medical care and any costs related to prevented legal actions.

Barriers to achieving interoperability in eHealth

DDespite the potential benefits interoperability offers to medical care quality, it is clear that reaching this goal is not easy to achieve [(26)]. This situation is linked to the lack of proper communication and management of medical information, which is generated in large volumes and in different formats. Synonymy and polysemy are part of this problem [(27)].

One of the problems lies in selection, procurement and use of standards. In many cases, inappropriate standards are selected – or new, expensive, and often incomplete standards are "invented" -- due to lack of awareness of internationally accepted standards' existence. In others parties have misunderstood many important benefits that interoperability standards provide (as listed above). In addition to these problems, there is sometimes competition, overlap, and disagreement among available standards for the same purpose, which is detrimental to the ultimate interoperability goals [(6)].

Even when the benefits of interoperability standards are understood, hospitals are confronted with the challenging coexistence of different brands and generations of computer systems and pro-

gramming (and spoken) languages, even in the same institution. The adoption of standards is often seen as a significant effort and cost in and of itself, and it requires technological investment, specialized human resources and workflow changes [28].

For successful standards' implementation, the associated costs can be high at first, with an investment return that is not clear initially. Because the benefits are diluted among many actors over varying periods of time, but the costs are assumed by early adopters, considerable resistance and reluctance can be encountered [13]. Also, given the equalizing power and transparency that shared health information which interoperability creates among the stakeholders, it is possible that some members of the system could have conflicting interests regarding standards' implementation. For example, some participants could perceive loss of unilateral power or autonomy in an organization or health system, or an increased vulnerability to critical review and risk of litigation or punishment. These concerns can pose significant cultural obstacles to standards adoption and the desired data-driven process improvement.

Another problematic or documented barrier is the concern about data security and privacy. This concern arises from patients or other citizens who do not want to find their personal data unprotected, and from the medical team who does not want to be exposed to litigation or potential modifications of clinical records that can lead to misinterpretation or other errors. This is associated with several necessary technical, organizational, and cultural changes in order to enable secure and reliable information sharing, decreasing the perception of the need for autonomy of information islands [29].

Another factor that needs to be taken into account is the need for trained personnel to take on the challenge of implementing the necessary changes in order to adopt standards and interoperability. This concerns both a specialized staff that can integrate itself to the development, implementation, and ongoing maintenance of the interoperable systems, as well as a health team that is properly trained and motivated to accurately record data and use the generated data, reports, and other information under this new paradigm. This requires two things: to train information technology specialists in this field, and a health personnel education and credentialing process for those who lack the appropriate information technology skills.

Achieving these goals in an orderly, efficient, and affordable fashion can improve when a national health information standards implementation guide is adopted and followed [30]. However, the lack of government coordination and strategically planned digital healthcare agendas regarding standards' adoption for eHealth has been one of the most visible barriers [8, 31].

Last but not least, as mentioned above there are wide variations in computer systems and organizational cultures. Because of these challenges, improved healthcare data interoperability may expose or create an additional challenge: organizational interoperability. For example, a private hospital may not be reluctant to share patients or data with public hospitals for fear of losing patients and/or revenue. In other cases, clinical specialists with overlapping skills may fight over diagnostic and therapeutic protocols because their jurisdiction and revenue are not aligned. In order to overcome organizational interoperability, cultural and organizational changes are often required, which needs a clear commitment by health leaders to provide a fair and transparent governance basis to the project.

Conditions for achieving interoperability in eHealth

There are conditions that should be considered when defining whether the institution /region /nation are able to participate in an interoperability initiative. There are a number of objectives and questions that should be considered before deciding whether to commit and locate institutional resources for this purpose [32].

Objectives and philosophy of health information exchange: the first question that should be posed is whether interoperability is aligned with the organization's institutional and strategic objectives. This

requires a review of the mission; vision and objectives; the needs of patients, health-care providers and other system users, as well as the study of potential solutions available in both public and private spheres. The interoperability vision is to share clinical information generated electronically among providers, to capture and analyze it to improve and support decision making, public health reports, health information and patient wellness. Neither will all institutions be ready to accept this change, nor will all new participants be included in all the foreseen objectives. Instead, incremental improvements will be made or a big- bang type approach will be used.

Organizational Commitment: participation in an interoperability and standards initiative that requires devoting a significant amount of resources. This can include infrastructure, human resources, membership subscriptions and time dedication in some of the institution's key departments (pharmacy, IT, finance, medical, etc.). In addition, this can also result in earnings and productivity losses due to workflow changes in training and implementation periods.

Risk assessment: assuming this project presumes an evaluation of the risks and the impact this may have on the organization, definition of success and failure criteria, identification of potential threats in order to achieve the goal, and mitigation or assumption of weaknesses found. The cost of participation in this implementation will compete with other projects within the institution and this is important when planning resources.

Leadership and Governance: as previously mentioned, implementing standards and interoperability strategies require the organization's and leaders' commitment. These should have a balanced representation of the organization's forces (clinical, technical, administrative, legal, etc...) and should also become promoters of change.

Nationally Accepted Standards: instituting a process to certify standards is required. It should be coordinated by an independent entity to establish accepted standards and their uses in specific cases. A review of standards with national endorsement is important when considering the adoption of an interoperability initiative.

Information and Data: the value of the information that interoperates derives from the importance given by users. Understanding why and how data is used allows incorporating the interests of patients, healthcare providers and others, into the business plan. Regardless of these issues, interoperability might be established as a solution that is not used to its fullest extent.

Economics and Sustainability: it is important to assess the potential benefits of this solution given that the associated costs with implementation are usually incurred by providers. Some of these will not be economic benefits, but improvements on quality of care and patient safety. Once this objective has matured, its tangible results begin to appear, allowing the project to grow and be sustainable over time. It is also crucial to determine a national structure to support the various initiatives and maintain alignment with health priorities.

Regulations: is a relevant topic since one of the potential barriers to establish interoperability initiatives is the concern for privacy and misuse of information. A legal framework is required to accompany these initiatives to achieve greater information security and allow its effective exchange. It will be required to be modified according to regions and local existing laws.

Maturity of Interoperability initiatives: one of the dilemmas is to evaluate if the organization wishes to participate in the initiative from the beginning. This will require greater investment but, in this case, actions that will be taken into account will be shaped from the start. Another option is to wait until other initiatives mature and become operational before investing in them. Stages of maturity of interoperability initiatives go from conceptual to self-sustainability of the project.

It is important to stress the need for interoperability standards at all levels (local, regional, national), to prevent the interoperability chain from breaking. Otherwise, an integrated health information system will never be achieved [33]. The consensus on which standards to use and how to do so plays a fundamental role and the WHO and the International Telecommunication Union (ITU) generated a report to be considered in any digital eHealth agenda at government level [34].

Developing interoperability standards for eHealth

In health information systems, the first step for an interoperable system is its ability to transfer patient information from one system to another. In general, this transfer is done through a tailored and personalized interface. According to the dictionary, the term "interface" (contact surface) is defined as follows: 1. f. Inform. Physical and functional connection between two devices or independent systems.

We know that the number of (I) interfaces grows approximately as half the square of the number of systems that are integrated (I = (nx (n-1)) / 2), which leads to an exponential growth of interfaces that will have to be developed, each time a new system is integrated. The use of standards provides a solution to this problem.

The word ***"standard"*** has different definitions, it is generally considered as *"... A document adopted by consensus by a recognized entity, that provides rules, guidelines and / or features for common use, in order to obtain an optimal level of performance in a given context ..."* [35].

There are four basic mechanisms to develop a standard:

- **Ad hoc:** a group of interested people or organizations agree on the specifications of the standard. Specifications are informal but accepted by the parties. The standard DICOM is an example, as the results of the agreement between the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA).
- **De facto:** when a company dominates the market and sets the standard. Microsoft is a good example (e.g.: some web programming codes are unique to Microsoft Internet Explorer and only look good with that browser, meaning that they are incompatible with other browsers).
- **Juri or Governmental Mandate:** a government agency creates a standard and legislates its use. In Latin American countries, an example could be the death certificate.
- **Consensus:** a group of volunteer representatives of the standard's stakeholders develop it openly. An example is the standard Health Level Seven (HL7).

The following are steps to develop a standard, without taking into consideration the mechanism used to do so [36]:

- The first step consists of the **identification** of a problem. Someone realizes there is a need for a standard and recognizes that the level of technology is sufficient to support this standard.
- If the idea of starting with the standard is mature, many individuals begin with the **conceptualization**, where it is decided: What should the standard do? What will its scope be? What will the format be? Will it be based on messaging? Will data exchange begin in a query or will it be triggered by an event?
- Afterwards, the **discussion** phase begins among all stakeholders to define contents, identify critical issues and set times. During this stage all the pros and cons are reviewed. Participants will have different visions on how to solve the problem according to their experience. In order to reach agreements, the establishment of definitions for each of the used terms will be crucial.
- After having several discussions, the first **draft** is written. This is the starting point of the standard specifications and its first version. In general, the first version of the standard is written by few individuals. Afterwards, the stage of refining the standard begins. This is a complicated and laborious process since new people who were not in the initial discussion are introduced. Many organizations have an open policy and listen to anyone who joins the development process. Actually, most organizations support an open voting process, inviting interested parties to submit comments and suggestions.

- Generally, standards run through several **versions**. A critical stage in the standard's life is the early stage of implementation, where its degree of acceptance and implementation are important to reach success. The maintenance and promotion of the standard are also important to ensure its wide availability and valuation. Producing a standard costs time and money. In the United States the development of a standard by consensus is voluntary while in Europe most of the developments are funded by the government.
- **Compliance** is an important aspect of the standard, is a concept that includes its adherence or adoption and also specific agreements between users who claim that they will follow certain rules. The conformity of a document specifically identifies which data elements will be sent, when and in which format. Applications should agree on a declaration of conformity, which means that the application can generate or receive messages that meet certain guidelines or compliance profile. It is even necessary to define business rules between the parties.
- **Certification** is also an important aspect. After establishing a minimum set of tests and meeting them successfully, the certification stage is met. The use of most standards improves after a certification process through which a neutral certification entity verifies that a process or product complies with the standard correctly.

Once the standard has been developed, dissemination and implementation is usually carried out in two different ways:

- **Top Down:** when the utilization proposal comes from a central government. This facilitates interoperability.
- **Bottom Up:** when institutions are the ones adopting and spreading the standard. This is more laborious and it takes longer to reach an agreement.

International standards organizations for eHealth

There are organizations that develop standards to address certain issues within a broader framework, some organizations are specifically generated to create and publish standards, other groups are formed to coordinate the efforts of various organizations or to implement different standards. Often, the development of health standards involves technical committees within larger organizations, such as the International Organization for Standardization (ISO) and its Technical Committee 215 on Health Informatics (ISO / TC 215) or the European Committee for Standardization (CEN) and committee 251 on Health Information and Communications Technology (CEN TC/251). Here are some of the most important international standards organizations interested in eHealth interoperability.

ISO: The International Organization for Standardization (ISO)[37] is the largest standards developer and accreditor worldwide, with an international network of institutions in 163 countries. It was founded in 1947; it has published more than 19500 standards, covering most aspects of technology. With regard to health, standards are developed by the Technical Committee on Health Informatics, ISO / TC 215 [38], whose scope is: to ensure standardization in the health information field, promote interoperability between independent systems, allow information's compatibility and consistency, and reduce its duplication. The Committee has 35 country members and 23 observers, has already published 116 standards, including ISO 12967:2009 (Health Informatics Service Architecture) and ISO / TS 22220:2011 (The Identification subjects in healthcare) among others. ISO collaborates with other organizations such as HL7 and CEN, working on the development of ISO standards to receive accreditation, facilitating its international adoption.

CEN: The European Committee for Standardization (CEN) is a non-profit international organization created in 1975 aiming to remove European trade barriers (39). One of its services is to provide

a platform to develop standards and other European technical specifications. It consists of 33 country members, where their standards are national standards, reducing market conflicts for products from different countries. Health issues are addressed by CEN/TC251, which is the committee responsible for publishing standards including messaging, electronic health records and eHealth initiatives. Currently, CEN has already published 89 standards on Health Informatics [40].

- **HL7:** Health Level Seven [41] is a non-profit organization dedicated to provide a framework and standards to exchange, integrate, and retrieve electronic health information associated with the organization. HL7 was founded in 1987; it consists of more than 2300 members, 500 of whom are corporate members. The development of standards is carried out by volunteers who can participate in various working groups, under the revision of a Steering Committee. The use of these standards used to require the payment of a license, however in mid- 2013 the standards were released to the international community [42]. One of its most important products is the HL7 v2.x family, which is probably one of the most widely used at a data communication level between health information systems. Among them: information pertaining to income; discharge or transfers (ADT); laboratory requests; radiologic studies, medical reports and other [43]. Another standard developed by this organization, is the Clinical Document Architecture (CDA) based on HL7 v3, in which the structure and semantics of clinical documents such as follow-ups, discharge summaries and referrals, allow the reading of these documents by both humans and computers which will process them [44].

- **NEMA:** The National Electrical Manufacturers Association (NEMA) is an organization that brings the medical equipment industry together. It was founded in 1926 in the United States, it has over 400 members and it provides a place for the development of technical standards [45]. It is the creator of Digital Imaging and Communications in Medicine (DICOM), which is an open standard that allows standardization of digital imaging studies and communication between the radiological equipment and other health systems [46]. It has been adopted by ISO as an international standard for medical imaging [47].

- **ASTM INTERNATIONAL:** The American Society for Testing and Materials (ASTM), founded in 1898, is a scientific and technical organization responsible for the development of standards that evaluates systems, products, services and materials [48]. One of its committees, the E31 has three sub-committees and is responsible for developing standards related to health information. It has 300 members who meet biannually and have approved more than 30 health standards, including one of the most important ones, the ASTM E2369-12 (Standard Specification for Continuity of Care Record (CCR) [49]).

- **WHO:** The World Health Organization is a specialized agency of the United Nations that is concerned with international public health. Among its many responsibilities, the WHO is charge of ruling standards and regulating eHealth [50]. It publishes and maintains the ICD (International Classification of Diseases), statistical classification of terms such as diseases, symptoms, social issues, etc. [51]. Its different versions have evolved to include diagnostic, surgical and therapeutic procedures, apart from codes that combine diagnoses and symptoms in order to reduce unnecessary codes. WHO also works with the organization responsible for SNOMED-CT (IHTSDO) to allow cross-mapping between vocabularies [52].

- **IHTSDO:** The International Health Terminology Standards Development Organization (IHTSDO) [53] is an international non-profit organization established in 2007 that owns and manages the rights of SNOMED-CT (Systematized Nomenclature of Medicine - Clinical Terms). SNOMED-CT is a controlled clinical terminology, which is multilingual and it is organized in hierarchies, from general to specific, allowing a great level of detail in concept description, presenting semantic correlation between terms [54]. Among SNOMED-CT's covered topics are: signs / symptoms / diseases / interventions / procedures / observable entities / anatomical structures/ organisms/ substances and pharmacological products.

- **Regenstrief Institute:** It is a non-profit organization associated with the University of Indiana, who in 1994 started the Logical Observation Identifiers Names and Codes (LOINC) as a response to the need to share lab results with providers and health insurers [55]. It provides universal identifiers

for laboratory results and other clinical observations (vital signs, fluid balance, clinical scores, etc.). LOINC is a free tool for developers [56].

- **IHE:** Integrating the Healthcare Enterprise is an initiative by healthcare professionals and industry representatives seeking to improve the way electronic health information is shared. This is done through the standards specification and product testing to certify they meet the necessary requirements to interoperate [57]. It promotes the integration of systems through the coordinated use of existing standards to meet a certain profile which will solve clinical needs. The created profiles provide the specifications for the implementation of standards that will be used by implementation guidelines [58].

- **CDISC:** The Clinical Data Interchange Standards Consortium [59] is an open, multidisciplinary, nonprofit organization that has established standards to support the acquisition, exchange, submission and archiving of data and metadata of clinical research. It has more than 300 member organizations, including many pharmaceutical companies, HL7, HIMMS. Their standards are independent from the platforms, neutral and free, but to become a member of the consortium there is a paid membership.

- **JIC:** The Joint Initiative Council is formed by the union of different standards developing entities seeking to settle the difficulties that arise from standardization efforts [60]. This is done through coordinated plans and strategies, with an ultimate goal: to make all standards available through ISO, focusing on the resolution of overlapping or conflicting situations between two or more standards. The organizations participating in this council are ISO/TC215, HL7, CEN/TC251, CDISC, IHTSDO and GS1, being able to invite others, when appropriate, depending on the domain that is being addressed on certain specific issues.

- **IEEE:** The Institute of Electrical and Electronics Engineers is proclaimed as the largest global professional association. It is dedicated to the advance of technological innovation [61]. One section is the IEEE Standards Association (IEEE-SA), with representation in 160 countries. It aims to improve the functionality, capabilities and interoperability with a wide range of products and services. Its standards are aimed at interoperability with medical devices, for example, pulse oximeter, ECGs, implantable devices, as well as protocols to exchange information and nomenclatures. IEEE maintains relationships with other standards organizations: ISO, JIC, ITU (International Telecommunication Union) and IEC [62].

- **ITU:** The International Telecommunication Union is a specialized agency of the United Nations that is responsible for issues that concern information and communication technologies [63]. It aims to protect communication rights of all individuals. Its membership includes 193 Member States and around 700 Sector Members and Associates. It presents different sectors, including one of Standardization (ITU-T). It also works in conjunction with the WHO to provide tools to achieve implementation of eHealth standards.

- **IEC:** The International Electrotechnical Commission is a non-governmental international standards organization that prepares and publishes International Standards for all electrical, electronic and related technologies – collectively known as "electrotechnology". It was founded in 1906. It is headquartered in Geneva, Switzerland and in 82 member countries. It is a platform for companies, industries and governments to get together in order to discuss and develop standards. The Committee in charge of health specifications is the TC 62. This committee is interested in electrical equipment, electrical systems and software used in health care and its effect on patients, operators, other people and the environment, in terms of security and performance. IEC is one of the three sister organizations (IEC, ISO and ITU) that develop international standards. When required, this organizations work together to ensure that standards that are being developed fit and compliment smoothly.

- **GS1:** It is an international organization. Its Health division nucleates the pharmaceutical and medical devices industry, suppliers, customers, hospitals, government and regulatory entities [65]. Its mission is the development and implementation of global standards, particularly those related to patient safety and efficiency in the supply chain, traceability and adequate data synchronization. It works in conjunction with WHO and ISO / TC 215.

Interoperability in eHealth: Classification Standards

There are many classifications and taxonomies of standards in order to achieve interoperability in eHealth [6, 7, 34, 66], which were added in a functional classification after a revision that took place in Africa [67]. After analyzing this classification, it should be noted that several of the standards could not be classified into a single category. In Appendix A there is a detailed description of each standard mentioned in the following classification.

Messaging Standards

Messaging standards define the structure, content and data requirements of electronic messages. The message is the unit sent from one system to another. Using DICOM for digital image communication between electronic health records and means of capture is an example. Other widely used standards, to exchange information between health information systems are HL7 v2 and v3. Last but not least, NCPDP is a standard used for prescription transactions, drug dispensing and billing.

Terminology Standards

These provide a basis for a symptoms description, diagnoses and treatments common language, allowing the subsequent interpretation of information regardless of the context. There are two distinct types of standards in this field: terminologies and classifications. Terminologies allow you to assign a term to the medical act that is being done, it has defined relations and it secures a good definition of the entered term (e.g.: SNOMED-CT). Classifications allow further analysis for research, billing, management or public health. (e.g.: LOINC and ICD-10).

Documentation Standards

These determine the type of information included in a document, and its location. This should ensure consistency since data should not be misinterpreted or overlooked. They are used to specify the structure of follow ups, discharge summaries and other clinical documents. Examples of documentation standards are HL7 CDA to share clinical documents, and ASTM CCR. Using a CDA implementation profile that generates instances semantically equivalent to the CCR, the CCD was created. (Continuity of Care Document) [68].

Conceptual Standards

These allow the transmission of information among systems without losing the meaning given by the context. HL7 RIM Version 3 is a clear example, which provides an object-oriented model mapping a lot of concepts and clinical domains.

Application Standards

These define the implementation of business rules when systems interact. As an example we can cite CCOW HL7, which is used to integrate functions of different software applications so they can work in conjunction and seamlessly. With CCOW the same username and password between different applications and a common user interface to view data from a variety of sources can be used.

Architecture Standards

These generate a generic model for health information systems, allowing information sharing among organizations, defining common elements and business logic among systems. They guide the planning and design of new embedded systems and interoperability of existing systems. The most obvious example is the HISA or Architecture for Health Information Systems, prepared by the CEN, which provides an open architecture that is independent of the technical specifications and applications.

Review: Usage of standards to achieve Interoperability in eHealth in Latin America and the Caribbean

In the first section of this report, a conceptual description of interoperability in general and in eHealth was provided, particularly its levels, benefits, barriers, and recommendations, as well as the entities developing standards to achieve interoperability in the eHealth domain. Since there are clear differences in levels of development and adoption of ICT between developed and developing countries, we consider it important to know the standards penetration and its adoption in order to achieve effective eHealth interoperability in the Latin American region. This information may be useful for decision makers at government level and can serve as evidence to replicate successful cases and avoid mistakes.

Objectives

The objective of this report is to perform a systematic review of the literature so as to summarize the existing evidence on effective standards implementation to reach eHealth interoperability in Latin America and the Caribbean. Factors that may have contributed to its success or failure and its main characteristics are also reviewed.

Materials and Methods

The authors conducted a systematic review of the retrieved literature on standards implementations in order to achieve eHealth interoperability in Latin America and the Caribbean.

Data source

PubMed, IEEE Xplore, CINAHL, LILACS and Scopus are search engines that were used as sources to retrieve bibliographic references. The bibliographic search was limited to a specific date range that went from 01-01-2000 to 01-06-2015. The search of each term of the construct was performed in every field.

Inclusion Criteria

All kinds of scientific publications within the date range set, which had referred to the effective implementation or some stage of the project's development (e.g. pilot or concept tests) of any of the standards mentioned in Annex A of this report, at any level (local, regional, national), excluding those articles that only addressed technical and/or functional issues of each of the standards or its simple description, were included.

Publications were considered as valid if they were published in Spanish, Portuguese and English, provided they referred to countries of the region as sources of such implementation.

Exclusion Criteria

Those publications that did not meet the inclusion criteria or were recovered more than once in different search engines were excluded. In addition, publications that had no abstract were also excluded.

Search Strategy

The search strategy was divided into three phases with different goals and strategies.

- In the first stage, generic searches were conducted in each primary base, trying to retrieve publications on interoperability at local and regional level.
- In a second stage, the list of specific standards to be used through the domain experts' agreement was validated.
- Finally, an individual search of each standard on the list in each of the Latin American and the Caribbean countries was conducted.

First stage

First, a general search was conducted in primary bases with the intent to identify publications that addressed the use of standards at local and regional level. The search was conducted with the following terms:

- *"Healthcare interoperability" AND latin america*
- *"Healthcare interoperability" AND caribbean region*
- *"Health information exchange" AND latin america*
- *"Health information exchange" AND caribbean region*
- *"Healthcare information exchange" AND latin america*
- *"Healthcare information exchange" AND caribbean region*
- *"Healthcare data exchange" AND latin america*
- *"Healthcare data exchange" AND caribbean region*
- *"Healthcare data exchange" AND caribbean region*
- *"Electronic data interchange" AND latin america*
- *"Electronic data interchange" AND caribbean region*
- *"Healthcare interoperability standards" AND latin america*
- *"Healthcare interoperability standards" AND latin america*
- *"Standards for interoperability" AND latin america*
- *"Standards for interoperability" AND caribbean region*

To search LILACS, the following terms were used: *"Healthcare interoperability" AND" Latin America"; "Healthcare interoperability" AND "Caribbean"; "Healthcare information exchange" AND "Latin America"; "Healthcare information exchange" AND "Caribbean"; "Healthcare data exchange" AND "Latin America"; "Healthcare data exchange" AND "Caribbean"; "Healthcare interoperability standards" AND "Latin America"; "Healthcare interoperability standards" AND "Caribbean"; "Standards for interoperability" AND "Latin America"; "Standards for interoperability" AND "Caribbean".*

Second stage

Given the large amount of eHealth standards being used worldwide, it was necessary to validate a list of standards to be considered in specific searches. Based on a publication that contemplates such standards [69] and the detailed Annex [70], together with those recovered in the first stage of the search, and standards that were not contemplated by the authors of the report, a list of standards to be validated by two Latin American interoperability experts was drawn.

The result of this combination of standards was categorized according to the interoperability level (technical, syntactic, semantic and organizational) and sent to the two experts (DK and DML) blindly for validation and categorization according to these levels. Experts had to state the relevance of the standard within the domain and its corresponding level; they could also include or exclude a standard from the list according to their opinion. In cases where the two experts couldn't reach an agreement on a particular standard; one of the authors considered expert (DL) would have to define the case categorizing such standard in the appropriate level.

Third stage

Once the list of standards for interoperability in eHealth had been drawn up and validated, at this stage, a search of each of the standards in each of the countries in Latin America and the Caribbean was performed. It included the name of the standard and its acronym (if applicable), for example: (("International Statistical Classification of Diseases and Related Health Problems, Tenth Revision")) AND Argentina, plus ("ICD-10") AND Argentina.

Data Review

The papers retrieved after the third stage, were analyzed according to the main objective of this study. Four reviewers (DL, MF, AB, MGA) independently reviewed the titles and abstracts against the inclusion criteria using the EROS software, developed by the Institute for Clinical Effectiveness and Health Policy (IECS) (http://www.eros- systematic-review.org/). In cases where the criteria did not match, the discordance was solved by consensus between reviewers. In order to do this, full text version of every article was needed, except for the ones where full text versions were not available. In that case, that paper had to be excluded from the revision.

Results

Regarding the first stage of the standards search at local and/or regional level, there was no retrieval of publications mentioning different standard than those included in the list used for the categorization, performed by experts.

In the second stage, the list shown in Table 2 was obtained. This was achieved through a domain expert's consensus process who prepared the list of eHealth standards by interoperability level.

After this process, only two items on the original list (OMG and Open MRS) were removed since they did not correspond to the domain, according to the expert's consensus. This left 65 standards that were included in the conducted search during the third stage. It may be considered that CDISC and IHE are not organizations that publish "base standards" but rather "composite standards" for interoperability, as mentioned in the first section of this report; that is why they were also included in the search as well.IHE is recognized by ISO as a Standards Development Organization. (e.g., IHE's widely adopted XDS (Cross-Enterprise Document Sharing) and XDS-i (Cross-Enterprise Image Sharing) standards specify the orchestration of ASTM, DICOM, HL7, IEEE 111073, LOINC, SNOMED, and other "base standards" to achieve secure, reliable, and testable technical, syntactic, semantic, and organizational integration and interoperability.[132])

Table 2 – Standards Categorization defined through expert's consensus and number of their publications.

Standard	Interoperability Levels				Recovered items
	Technical	Syntactic	Semantic	Organizational	
ASTM Continuity of Care Record (CCR)		X	X		0
ASTM Standard Practice for Content and Structure of the Electronic Health Record (EHR)	X	X	X		0
Health Level Seven (HL7) Clinical Document Architecture (CDA) Release 2.0		X	X		4
HL7 Continuity of Care Document (CCD)		X	X		0
HL7 Communication Standard		X	X		3
National Council for Prescription Drug Programs (NCPDP) Data Dictionary			X		0
HL7 EHR System Functional Model				X	0
Digital Imaging and Communications in Medicine (DICOM)	X	X			12
HL7 Arden Syntax for Medical Logic Systems		X	X		0
HL7 Clinical Context Management (CCOW)				X	0
HL7 Version 2.5 Communication Standard		X			0
HL7 Version 2.4 Communication Standard		X			0
HL7 Version 2.3.1 Communication Standard		X			0
HL7 FHIR Fast Healthcare Interoperability Resources		X	X		0
IEEE 1073 Point of Care Medical Device Communication	X	X			0
NCPDP Batch Transaction Standard	X	X			0
NCPDP Formulary and Benefit Standard	X	X			0
NCPDP Billing Unit Standard		X	X		0
MeSH			X		0
RadLex			X		0
Alternative Billing Concepts (ABC) Codes			X		0
Clinical Care Classification (CCC) System			X		0
Current Dental Terminology (CDT)			X		0
Current Procedural Terminology (CPT)			X		0
Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV)			X		0
Global Medical Device Nomenclature (GMDN)		X	X		0
International Classification of Diseases for Oncology (ICD-O)			X		1
International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)			X		0
International Classification of Functioning, Disability and Health (ICF)			X		0
International Classification of Primary Care (ICPC)			X		2
International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10)			X		2
International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Clinical Modification (ICD-10-CM)			X		0

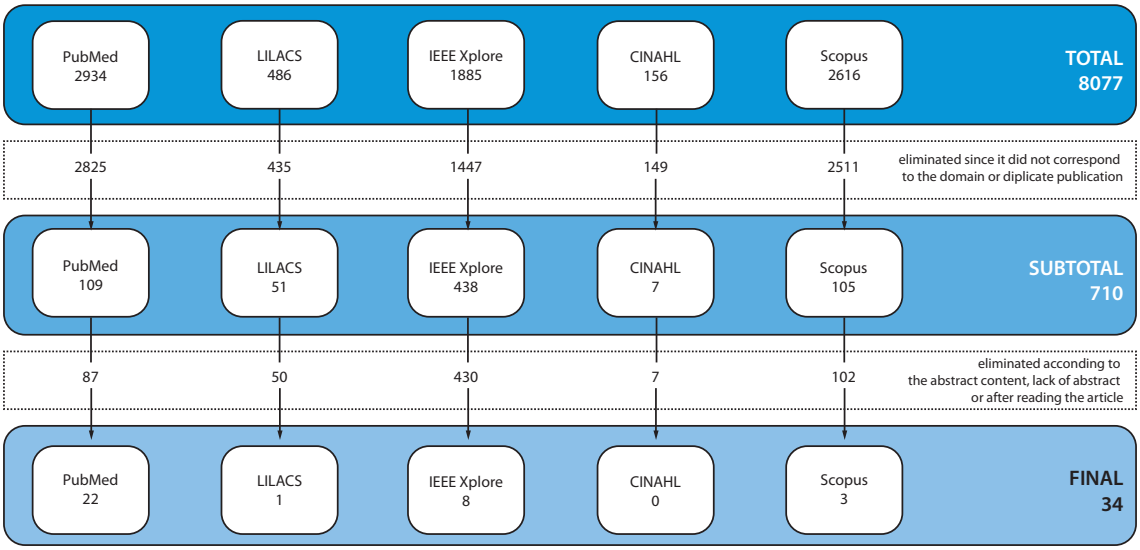
Standard	Interoperability Levels				Recovered items
	Technical	Syntactic	Semantic	Organizational	
Logical Observation Identifiers, Names and Codes (LOINC)			X		0
MEDCIN			X		0
Medical Dictionary for Regulatory Activities (MedDRA)			X		0
National Drug Code (NDC)			X		0
North American Nursing Diagnosis Association (NANDA) International Taxonomy II			X		2(*)
Nursing Interventions Classification (NIC)			X		2(*)
Nursing Outcomes Classification (NOC)			X		2(*)
Omaha System			X		0
RxNorm			X		0
Systematized Nomenclature of Dentistry (SNODENT)			X		0
Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT)			X		2
Universal Medical Device Nomenclature System (UMDNS)			X		0
Unified Medical Language System (UMLS)			X		1
United States Health Information Knowledgebase (USHIK)			X		0
Web Ontology Language (OWL)		X			0
OpenEHR		X	X		0
DRG			X		1
IHE**				X	1
ISO 13606		X	X		2
ISO 13606-1		X			0
Arden Syntax			X		0
GELLO		X			0
Guideline Interchange Format (GLIF)			X		0
Infobutton		X	X		1
ASTM Guidelines Elements Model		X	X		0
UCUM (Unified Code for Units of Measure)		X			0
RDF (Resource Definition Framework)		X			0
ITK (National Health System Interoperability ToolKit)				X	0
DEEDS (Data Elements for Emergency Department Systems)		X	X		0
WSDL (Web Service Definition Language)		X			0
CDISC (Clinical Data Interchange Standards Consortium) **	X	X			0
ATC (Anatomical Therapeutic Chemical)			X		0

(*) The same article refers to the three standards. (**) These are considered by ISO as "composite standards." But, since they are organizations that promote their integration, they fall into the standards category.

In the third stage of the search process, where the retrieval of literature on the topic, using different bases was performed, 8077 publications were initially found. After eliminating duplicates,

titles were reviewed and those that did not correspond to the domain, referring to interoperability standards for health, were excluded. A total of 710 publications were finally selected. In a first stage, from these selected publications, the abstracts were reviewed by four of the authors and those selected in this process. Also, the full text version was obtained. After reading the gathered information, 34 publications were finally included (Figure 2).

Figure 2: Flowchart of reviewed papers selection



Finally, the 34 included publications correspond to 11 of the standards on the validated list. (65 total), as shown in Table 3.

Retrieved Publications

Table 3 (below) shows the list of the publications included in the final review, with their main findings.

Table 3: publications retrieved in the review with their main findings.

Standard	Author	Country where implementation took place	Main findings
CDA	Campos F y col. [71]	Argentina	The paper communicates the experience of developing a document repository based on the use of defined standards, specifically to interoperate. Tertiary care hospital with 750 beds. The clinical data repository included about 70 million event data sets of information: 18 million clinical notes and 9,000,000 problems. The contents of each CDA generated in the EHR is based on the concept of "medical session": the natural grouping of all actions and records performed by a healthcare provider in a single encounter with a patient. Interoperability was conducted with some entities and portability was achieved electronically with 150 entities that fund patient's hospitalizations. 73 % of the monthly billing documentation is sent in cda format through optical media (CD / DVD). Depending on the ordering entity, the media may include between 1 and 1,000 documents. The average number of documents per episode of hospitalization is 112 with an average of 180 pages. As a secondary result, the implementation of a redundant EHR was achieved. This means that although the document repository is part of CDR and EHR, the documents can be accessed regardless of whether the EHR is interoperable.
	Martínez-Garbino J y col. [72]	Argentina	The paper is about the implementation of a communication system between a self-monitoring blood glucose device and an EHR. In encodes glucose levels and produces a clinical document (CDA).
	Campos F y col [133]	Argenitna	Downtime in the Electronic Health Record system is unavoidable, this paper described the development of a contingency plan ensuring patient care continuity and minimizing risks for health care delivery. Two applications were developed allowing healthcare delivery providers to retrieve clinical information using the Clinical Document Architecture Release 2 (CDA R2) document repository as the information source. This paper describes the strategy, implementation and results; and provide an evaluation of effectiveness.

Standard	Author	Country where implementation took place	Main findings
CDA	Campos F y Col [134]	Argentina	This paper describe the architecture that allows the data recorded by specialists to flow transparently to the different levels of data requirements, feeding into the EuCliD repository for worldwide, national or regional analysis. It contains the details of the observations and evolution of the disease that specialists need to provide the correct treatment and also includes a summary of the patient's EHR.
CIAP	López Osornio A y col. [73]	Argentina	The paper analyzes the variability in secondary coding process, in order to measure the quality of the process and develop an automated coding system based on the similarity of problems on previous texts. The variability index is the proportion of correct codes; they are supposed to represent all the problems in the database excluding those texts that appear only once. In our database, this index was 12.78%. To apply this information to generate an automatic encoder, a thesaurus with nearly 15,000 text groups containing a supposedly correct code was developed, relating the text written by doctors with the codes for each group A website was also developed. It allows text entry in which a standardization process and a comparison with the thesaurus can be applied; it also allows to automatically assign an icpc code in cases where coincidence was found.
	Luna D y col. [74]	Argentina	The paper assesses the reliability of the central secondary coding of medical problems by medical students and trained nurses using CIAP. 164,745 medical problems of 45,365 adult patients were coded in a period of two years (average 3.63 problems, sd: 2.69). The degree of intra-coder agreement was 97.7% (kappa: 0.97, p <0.0001). Secondary and centralized coding, when encoders use CIAP, is reliable and can be used to code medical problems.
DICOM	Andrade R y col. [75]	Brazil	The paper communicates the experience of using the mobile client/server application called "cyclops dicom pda". The use of an HTTP client application is described, using a DICOM client. The application called "cyclops pda dicom editor" generated images of 200 x 320 pixels to display them on a PDA.
	Palma A y col. [76]	Mexico	The paper analyzes the performance and implementation of a PACS called webservex developed in partnership between the Autonomous University of Querétaro and the Mexican Society of Radiology. Web-based application. RIS with MySQL database. Webservex implements three different web services: two DICOM imaging services, one for large images using MTOM encoding and one for small images using the base-64 standard. Also, both services are prepared to exchange data between original images (as when it was taken by the original device) and JPEG compressed images.
	Azpiroz Leehan J y col. [77]	Mexico	The paper refers to the implementation of a PACS system in a small provincial hospital. A web application was developed using DICOM and HL7 as standards. The need for further studies on cost / benefit to extend this implementation to health centers within the country with similar characteristics.
	Garcia Ruiz M y col. [78]	Colombia	The paper introduces mantisGRID project, an interagency initiative of Colombian academic and medical centers to provide "GRID" services for Colombia and Latin America. In its first phase, a reliable architecture was developed using OGSA-dai services and the globus toolkit, and a PHP-based web interface for running the website. The focus was put on making the mantisGRID fully compatible with both standards, HL7 and DICOM, and to ensure security and data integrity, while maintaining the confidentiality of patient data. Data transfer through the current nodes of the network is carried out safely through an application called file trower and it implements the RENATA network. The work was done with few Colombian nodes with the idea of extending the network within the country and Latin America.
	Von Wangenheim A y col. [79]	Brazil	The paper explains how to implement a system for integrating medical reports in a telemedicine network using the DICOM standard with structured vocabularies in the State of Santa Catarina in southern Brazil. The network connects 401 health institutions in 291 municipalities. A web application and a platform for smartphones were implemented in order to enable the use of DICOM SR standard, in order to obtain a minimal impact on the routine work of the doctors in the network and provide a report generation process to report electrocardiograms. We conclude that the system is reliable, efficient and compatible with the use of tools for data mining.
	García A y col. [80]	Colombia	The paper states how to apply a pilot teleradiology system in Medellin with a software with remote access enabling communication and remote interpretation of biomedical images. It was made in Colombia to assess the possibility of remote diagnosis and interpretation of resonance and tomography imaging through a VPN. When this was implemented, at the time, there were problems with the communication speed via internet (64 Kbps).

Standard	Author	Country where implementation took place	Main findings
DICOM	Prado T y Col [135]	Brazil	This paper present a new approach for the development of a data persistency layer for a Digital Imaging and Communications in Medicine (DICOM)-compliant Picture Archiving and Communications Systems employing a hierarchical data-base. This approach makes use of the HDF5 hierarchical data storage standard for scientific data and overcomes limitations of hierarchical databases employing inverted indexing for secondary key management and for efficient and flexible access to data through secondary keys. . This approach was implemented and tested using real-world data against a traditional solution employing a relational database, in various store, search, and retrieval experiments performed repeatedly with different sizes of DICOM datasets.
	Alvarez L y col. [81]	Argentina	The paper aims to reflect the work done regarding design, layout and implementation of a teleimaging network for a center of medical imaging located in the province of Santiago del Estero, Argentina. Also, it shows how the interconnection and transmission of images, to medical diagnostic centers in the provinces of Córdoba and Tucumán, was achieved through the standard DICOM. On the implementation of a medical imaging network, some aspect that are not considered for other types and needs of computer networks must be considered when dealing with medical imaging. The use of first-line equipment for basic infrastructure in the network (switches, cables, connections, servers) is recommended, since the use of this type of electronics will result in high performance. The investment in electronics for this medical imaging network was possible through a reinvestment of the budget designated for computer equipment. Not using commercial software in 95% of the computers on the network, allowed them to reinvest in non-replaceable high-performance technology.
	Gutierrez -Martinez J y col. [82]	Mexico	The paper's objective was to report the experience gained through the development and implementation of PACS services based on the standard DICOM. The system was developed through the RUP methodology, using several software engineering tools. It showed benefits associated with the use of the DICOM standard.
	Soares T y col. [83]	Brazil	The aim of this paper was to introduce a new parallel architecture designed to reduce the bottleneck of problems given when using the serial I/O architecture provided by HDF. In order to obtain better HDF's I/O access performance, an extension for the cyclopsdcmserver was implemented. This was developed by the Telemedicine Laboratory of the Federal University of Santa Catarina (Brazil), which has two main projects, the cyclopsdicomserver and MTCR (Rede Catarinense de Telemedicina) connecting various health institutions in the state of Santa Catarina. This network provides access to 10 modalities via a DICOM PACS which acquires patients' information from the cyclopsdicomserver. Writing experiments were conducted comparing serial architecture versus parallel architecture, showing a 30% improvement on this last one regarding I/O operations. Recovery time was not assessed (pending, for future studies).
	Bortoluzzi M y col. [84]	Brazil	The aim of this paper was to develop a clinical report system capable of creating reports of any medical specialty, and storing them using DICOM standards. It was developed in a community hospital in southern Brazil, the "Regional Hospital Alto Vale do Itajaí". A system that allows users to create and save report templates DICOM-compatible and use these templates to ease the process of creating structured reports was implemented. There is an increasingly evident need to use standards when writing clinical reports as more institutions develop systems and clinical reports suggest the possibility of sharing information.
	Soriano E y col. [85]	Argentina	The paper explains how to incorporate different studies in the EHR generating multiple complementary services in their original formats (images, video, audio, bookmarks, etc.) beyond the text of the report of a PACS implementation within the EHR in order to continue the implementation of other services of complementary studies.
DRG	Pino E y col. [86]	Chile	In this study, DRG was used as an estimator of the patients' complexity. The study was conducted by the intensive care unit for adults at the 'University Hospital of Concepcion, a teaching hospital in Concepcion, Chile. There is evidence that during periods of maximum demand, it makes more sense to prepare a contingency plan for rare events when DRG exceeds the unit's capacity. Equipment and personnel are key factors when facing these complex scenarios.

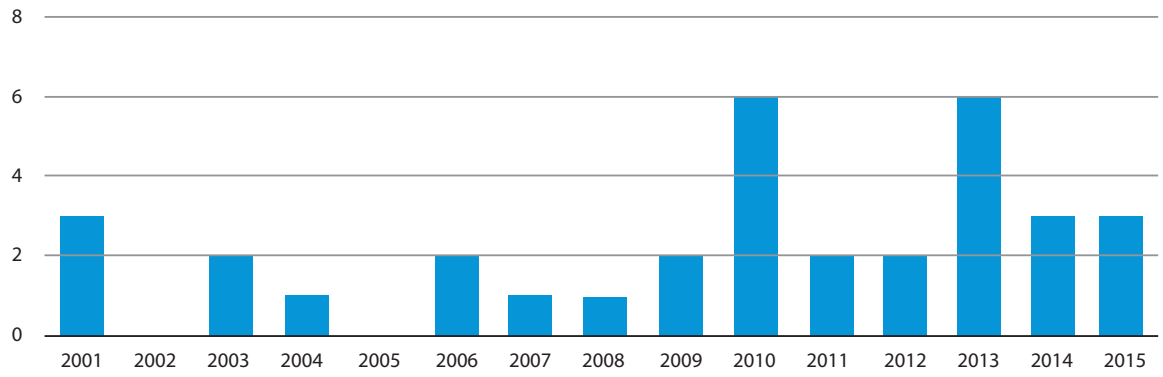
Standard	Author	Country where implementation took place	Main findings
HL7	Tachinardi U y col. [87]	Brazil	This paper describes the design and development of a system that integrates information from the patient's bedside monitors and electronic medical records using HL7. The study was conducted at the Heart Institute (Incor) of the Faculty of Medicine of the University of Sao Paulo. It has a web-based EHR. Biosignals of patients' bedside monitors were integrated using HL7 messaging through a symphonia 3 parser. The authors concluded that the project achieved its objectives and that doctors appreciate having their patients' information in a very simple way, this is especially useful for those patients in intensive care units that require special attention. The integrated nature of the system makes patient data, as well as laboratory results, easy to be accessed using a single web application.
	Cruz W y col. [88]	Brazil	A process model of integration and interoperability is presented, using information technology and communication in emergency services, implementing HL7 standard and RFID devices, as part of a platform for ubiquitous healthcare. The capacity to integrate hospital information systems is described, as well as locating, filtering and collecting information from patients and health personnel. The health development framework methodology (HDF) was used.
	Murakami A y col. [89]	Brazil	A real time glucose monitoring system for patients in the ICU was implemented. The study was conducted in the Heart Institute of Sao Paulo, Brazil. A monitor simile Holter was used. The monitor readings were transmitted via a wifi network using HL7 as the communication protocol. The results were integrated with the EHR and the bedside monitor in the ICU, in order to allow medical staff to easily access the glucose readings. These results suggest that glucose readings in real time are clinically significant and, therefore, a promising tool for the UCI.
ICD-10 ICD-O	Hernández-Avila J y col. [90]	Mexico	The aim of this study was to evaluate the development and implementation of an EHR based on ICD10 coding for the State of Colima, Mexico, and perceive its benefits and limitations. The major challenge that is faced in order to achieve a successful implementation of EHR is the resistance of physicians to use ICD-10. In this regard, physicians complained about the difficulty in identifying diseases' codes , since this task was never part of their medical education. As a solution, the IT department suggested to build a list of the most common diagnoses (reported by doctors) with their respective ICD10 codes.
	De Mello P y col. [91]	Brazil	This paper is about the implementation of a computer system to characterize the data of patients admitted to hospitals in the region of Rio de Janeiro in Brazil. The system consisted of 4 modules in which patients' patronymic data and their location were included, as well as the admission diagnosis coded with ICD10. The implementation of this system appeared to be a powerful tool for identifying the different needs of health resources and for planning. It was also a great tool to assess quality and provide useful information for epidemiological purposes.
	Oleynik M y Col [136]	Brazil	This work develops an automated classifier of pathology reports which infers the topography and the morphology classes of a tumor using codes from the International Classification of Diseases for Oncology (ICD-O). Data from 94,980 patients of the A.C. Camargo Cancer Center was used for training and validation of Naive Bayes classifiers, evaluated by the F1-score. Measures greater than 74% in the topographic group and 61% in the morphologic group are reported.
IHE	Fuentes M y col. (92)	Uruguay	It is proposed to separate the information in clinical patronymic CDA documents and reassemble them in the context of health care towards ensuring the confidentiality of the data, as the law indicates the Hospital Maciel, corresponds to a teaching hospital of the health services network of the administration of state services (ASSE). It is an adult center for tertiary care and of national reference in Uruguay. For reconciliation within clinical context, the corresponding standardized transactions were applied to the IHE's PDQ (patient demographic query) actor. With this solution the current legislation was fulfilled since it was possible to make it transparent to the user successfully.
ISO 13606	Santos M y col. [93]	Brazil	The objective is to present the modeling process of archetypes used by the health department of the state of Minas Gerais, Brazil (ses / mg), in order to build the regional health clinical record system. The architecture of the clinical record system was constructed with reference to the reference model of ISO 13606 norm. The full development of archetypes was performed in nearly 10 months and was coordinated by a team of physicians and systems analysts. Archetypes (reference terminology, domain tables and list of terms) achieved a favorable condition for the use of controlled vocabulary between the central repository and the clinical record system.
	Santos M y col. [94]	Brazil	The ISO 13606 standard was used as a starting point to build a semantic electronic health record (EHR) and to model archetypes for a central data repository. The protocol was used in the creation of a unique and public clinical data repository, available for primary care. A second instance was projected, in order to integrate the second and tertiary levels of care.

Standard	Author	Country where implementation took place	Main findings
SNOMED	Navas H y col. [95]	Argentina	This paper aims to describe the effectiveness of modeling control regulations for the post-coordination of terms when implementing an automatic system of rules defined by the terminology server SNOMED CT. The implementation of an automatic system of rules for the post-coordination of terms improves its performance as well as its interoperability with other health centers (as it was achieved in 2006 with the Nebraska Medical Center).It could also have a positive impact in education. It could improve the training of coders who are in charge of modeling terms, and thus reduce the variability between them when they are making decisions to generate post-coordinated expressions.
	Lopez Osornio A y col. [96]	Argentina	The model performance was very satisfactory considering the needs' extensibility and the creation of local subsets. Duplication of data models with SNOMED CT adds complexity to data access, but once the basic mechanisms are created, there is no impact on system performance or on the software development speed. 86% of users selected some suitable interface option.
UMLS	Miyoshi N y col. [97]	Brazil	This paper aims to describe an ontology to be used as semantic connection between two different databases in the health data integration process. The design and implementation process of an ontology-related data structure of the record of clinical follow ups, taking UMLS as reference pattern, is described. The proposed extension of the UMLS semantic network was achieved by making an initial assignment to semantic groups. The use of UMLS metathesarus was very useful to validate the ontology. In addition, this validation was also achieved by the conducted interviews with medical specialists. It was confirmed that the proposed ontology can act as a mapping tool to provide a database integration. Through this ontology, applications to acquire, store and analyze information that compose the clinical record can be built.
NANDA NIC NOC	Peres H y col. [98]	Brazil	This paper focuses on the development of an electronic nursing documentation system to evaluate adult patients, the decisions made based on nursing diagnoses, the expected outcomes and interventions. A software was developed and specially designed for two different environments (academic and professional). This software can simulate situations in order to teach or to document real patient data. A unification of the NANDA-I, NIC and NOC frameworks was performed.
	Silva Thome y Col [137]	Brazil	This work describes the applicability of the systematization of nursing care (NCS) to outpatient nursing appointments using the NANDA-I and Nursing Interventions Classification (NIC) taxonomies. Significant associations were found between the most frequently detected NDs and the most commonly prescribed interventions ($p > .05$). The NCS through the use of classification systems allows mental health nurses to better identify and assist poorly adjusted patients.
OTHERS	Borbolla D y Col [138]	Argentina	The objective of this paper is to describe the implementation and use of context aware information in Spanish from MedlinePlus embedded in a Patient Portal. Personalized information can help patients solve problems, make treatment decisions, gain confidence in their ability to care for themselves and communicate with providers. To integrate MedlinePlus information in their institutional PHR they used the HL7 Context-Aware Knowledge Retrieval Standard, also known as the Infobutton Standard. After analysing one year of use, patients accessed MedlinePlus information in Spanish in a similar rate to other personalized information generated locally. Infobuttons associated to laboratory test results were used in approximately 10% of patients portal sessions when reviewing lab results.

Publications' Characteristics

Of the 34 retrieved papers, 94% (n = 32) were published in English, while 6% (n = 2) were in Spanish. Publications in Portuguese were not included. Figure 2 shows the respective years in which the selected items were published.

Figure 3: Number of publications per year.



As for the countries in which these items were performed, 44% were conducted in Brazil (n = 15), 33% in Argentina (n = 11), 11% in Mexico (n = 4), 3% in Uruguay (n = 1), 3% in Chile (n = 1) and 7% in Colombia (n = 2).

According to the categorization of the different standards (Table 2), most of the recovered items (n = 12) refer to the DICOM standard. This standard has been identified in both the technical and syntactic level. Regarding the publications, in many cases their main objective is the communication of an integration model of the different components of the PACS and DICOM standard, rather than its implementation [75-85]. Regarding HL7 v2x standard, 3 posts were recovered. In this case, the recovered items were primarily related to implementation associated with the integration of biomedical signals (such as patient bedside monitors) and with captured data that corresponded to blood glucose monitoring and the generation of clinical documents [87-89]. It is important to clarify that many of these do not report successful implementation. Their results are unknown and the barriers encountered in the implementation are not specified.

Regarding the CDA standard, four articles were retrieved. These report the successful implementation of a repository model of clinical documents, which were generated based on the "medical session" concept. The achievement of interoperability with about 150 institutions that funded patients' hospitalization is described. This allowsdocuments to be accessed regardless of whether the EHR is interoperable or not[71]. An other article recounts the implementation of a communication system between a self-monitoring blood glucose device and the EHR [72]. And also the use of CDA R2 to maintain the availability of information during contingencies is reported [133].

Within the considered "semantic" level standards, two publications on CIAP were recovered. Both items belong to the same institution, and in them the implementation of the standard for coding medical problems is described. The use of CIAP showed good results. Coders strongly agreed [73, 74].

Two articles regarding the semantic ICD-10 standard and one related to ICD-O were also retrieved. One posted by The Mello *et al.* [91] recounts the implementation of a system dedicated to obtain clinical data on patients' admissions, at a regional level in Rio de Janeiro, using this coding system for different diseases. On the other hand, the other ICD-10 article presented the problems and barriers found during the implementation of an electronic health record based on ICD-10. It was difficult to identify diseases' codes. However, to solve this, building a list of the most common diagnoses with their respective ICD-10 codes was suggested [90]. ICD-O standard was used to develop an automated classifier of pathology reports which infers the topography and the morphology classes of a tumor.

Regarding the use of archetypes (standard ISO13606), in two articles published by Santos et al. there was a description of the modeling process of archetypes that were used by the Department of Health of Minas Gerais in Brazil for the construction of a clinical record at regional level [93, 94].

Only one publication related to the UMLS standard was retrieved [97]. It described an ontology to

be used as semantic connection between two different databases in the health data integration process.

As for the NANDA, NIC and NOC standards, two articles on the implementation of an electronic nursing documentation system (diagnoses, outcomes and interventions in adult patients) using these three coding systems were found. One describing its use in an academic setting for teaching purposes [98] and the other in the ambulatory care setting [137].

Two articles on SNOMED-CT, both coming from the same institution in Argentina, were found. One of them [96] refers to the implementation of a terminology interface using SNOMED with a very good system performance, and a proper performance for needs' extensibility and subsets creation. In another article, the implementation of an automatic system of rules for the post-coordination of terms that improves its performance as well as its interoperability with other health centers was described. Also, the article mentioned the importance that this could have in an educational level for coders' training, thus reducing the variability between them [95].

Regarding the DRG standard, just one publication was recovered [86]. It recounts the gathered experience in a University Hospital in Chile. An estimation of the complexity of the adult patients in the critical care unit using this system was performed.

IHE was the only standard categorized as "organizational". In this case, the retrieved publication was of Fuentes et al. It described the use of IHE PDQ (Patient Demographic Query) to separate the patronymic information in CDA documents, which belong to a national electronic registry of a tertiary care hospital, and store them. In addition, it was possible to regroup that information in a healthcare context, successfully obeying the legal requirements in this regard, making it transparent to the users [92].

Finally one publication commenting on the implementation of the more novel infobutton standard was retrieved. Researchers apply the standard to give context aware resources to users of a personal health record in Argentina [138].

Discussion

This second section of the report has attempted to collect published information related to the topic in question, through a systematic review. According to the used methodology, in the first stage of the local standards search process, no articles on standards with these features and that could complement the selected list to perform the search on the databases were recovered.

During the second stage, experts considered on a consensual basis to include both CDISC and IHE, understanding that even though neither of them were standards by themselves, they were considered as guides to implement them. This is currently key when using interoperability standards.

From the development and analysis of the search results, several significant points emerged. First of all, the small number of recovered articles, even though there is evidence of a clear trend towards a greater amount of publications in recent years (figure 2). Moreover, the results included articles belonging to just 6 of the 20 countries that were considered in the search process. There is also evidence that there are several articles that belong to the same groups within an institution, which probably has greater access to perform international publications than others.

Even though standards are used in eHealth, this is not usually communicated through scientific papers, which explains the low recovery of papers in the domain. The use of standards follows specific recommendations (such as coding ICD- 10 proposed by WHO member countries). Moreover, in cases where newer or recently implemented standards are being used, the search strategy might not have been wide enough to recover these types of publications. These papers usually do not appear on the databases that were used on this revision. But, more "gray literature" might have been recovered (such as post-

ers, regional communications centers, thesis, etc.) using Google Scholar for example, even though there were opinions for [99] and against [100] it. In the same way, this could explain why the vast majority of the retrieved articles were published in English (including those found in the local database of the region, LILACS), probably because most articles were from international journals. If the search had been expanded to "gray literature" the number of communicated experiences might have been greater. We believe that in cases in which it was possible to document an implementation, it had to be communicated. Global representation rather than regional representation on databases were preferred.

It is noted that the items included in the analysis refer only to 11 of the 65 standards included in the search. However, these 11 standards could be considered currently as the most important ones [3].

Another important point on the results' analysis is that in relation to the specific content of the included articles, a significant heterogeneity among these publications can be demonstrated. Most of them are scientific communications that describe standards' use. Moreover, there were several publications that simply focused on the description of a model, not carrying out the implementation of the standard in question. This raises the possibility to speculate that such implementation never existed or that once implemented, the authors did not report the experience based on the previous statements, existing evidence on the various challenges in achieving successful and sustainable implementations in developing countries [101]. Among these challenges, the difficulty presented to share resources and experiences stands out, which may partly explain the lack of publications on the topic in this region.

Finally, even though the current situation in some countries of the region [102], such as Chile [103] and Uruguay [104], and the fact that there are policies related to the incorporation of national digital agendas, this does not happen in all countries of Latin America and the Caribbean. In fact, in many cases, private institutions are the ones that develop independently in this regard [105].

In this sense, the proposed premises by the Pan American Health Organization [106], suggest the importance of incorporating these policies on national digital agendas, while highlighting the importance of the adoption of standards to achieve interoperability. Therefore we understand that the proposed Toolkit by WHO and ITU acquires a fundamental role in this regard given the absence of national policies, being possibly of great help when implementing these standards [34].

Limitations

One of the limitations mentioned before in reference to the search methodology used, is that a there could have been better utilization of grey literature (for example Google Scholar). This would have yielded a much more comprehensive search, alongside other methodologies, such as surveys and interviews as additional references for the region.

Another limitation also concerns the methodology of the review, more specifically, relating to the lack of standardization as far as the quality of the articles included in the review is concerned. As stated previously, because most publications included are descriptive in nature, it was not possible to analyze and measure conclusions objectively from the quantitative aspects, as well as perform an evaluation from the qualitative aspect of each, using some of known tools for this purpose [107], and therefore a meta-analysis could not be performed.

Recommendations

The Latin America and the Caribbean region is vulnerable to political, economic and environmental influences that create and exacerbate already existing problems, and impacting the ability of countries to provide adequate healthcare coverage for its citizens. Despite significant improvements observed over the last decade, Latin America has historically been an area with social inequities with segments of the population without access to health, while other groups have comparable health figures with the developed world. This leads to an important social gradient in health and the potential impact on the entire population (transmissible diseases, higher healthcare costs, poor management of chronic diseases, etc.) [108].

Since the advent of ICT and digitization of health, there have been many opportunities for developing countries, which have not been fully exploited, in part, because access has been limited and technology has not been well distributed. This situation has created a digital divide, which occurs between companies and organizations that use ICT and those who cannot use them [109]. eHealth is one of the positive initiatives that promise a positive impact if applied in developing countries [110]. Considering interoperability as an equalizer that allows information to be shared, this could partially remedy the breach generated by the lack of access [19].

The recommendations given to countries in order to implement interoperability through standards do not vary from the necessary recommendations to achieve a successful ICT project. In fact, they need to be framed in a sustainable eHealth strategic plan [34, 106]. The challenges that developing countries face to achieve sustainability of eHealth implementations [101] provide a framework to address the recommendations provided in this report to achieve eHealth interoperability through the use of standards:

- Resources and infrastructure.
- Development of digital agendas.
- Legal and Ethical Considerations.
- Standards for common use.
- Adequately trained workforce.
- Regional Integration.

Resources and Infrastructure

Many eHealth initiatives have been frustrated from the start due to insufficient infrastructure. However, with an adequate support, information exchange among different health organizations and across geographic boundaries can be achieved. The use of IT applications in healthcare requires a reliable network, high availability 24/7, with high speed and low latency. Internet access has improved in Latin America in recent years, but its use has been directed mainly towards production and entertainment rather than health. Broadband providers are concentrated in large cities. In rural areas, internet connections are similar to the residential ones [111]. Another potential drawback is the inadequate availability of electricity and computer components [112]. This is one of the reasons for using mobile technologies [113]. The percentage of the population with access to computers varies from nearly 50% in Uruguay to 10% in El Salvador (though these percentages may have changed after the delivery of educational policies in Argentina and Uruguay where netbooks were distributed) while the level of cellphone penetration

reached 100% in a dozen Latin American countries [114]. Other issues to consider are: user authentication mechanisms, applications and health data repositories, capable of sharing and reusing information [34].

Regarding the necessary programs and services to achieve the health system's and eHealth program's objectives, an important requirement is to identify the way in which health services could be shared electronically. This will allow an evaluation of the necessary components that need to be present in the Health System [34]. From the standards point of view, this is relevant since standards should be prioritized from the conception of an eHealth [115].

The infrastructure, training and standard selection go hand in hand with the financial plan and the implementation strategy. Funding should be aligned with the national eHealth strategy [34]. There are different suggestions given by foundations on how to finance these projects. Regarding standards, collaboration of national standardization institutions with standards creative societies is proposed, in order to procure them for free or paying a nominal fee, especially for the countries of this region [116].

The partnership among government agencies, civil and academic organizations and the health sector is presumed to increase the effectiveness and the generated impact of eHealth implementations and their accompanying standards [112]. Gathered experience within the region showed that projects often fail when fully financed externally. Interested parties usually tend to get more involved when financial risks are shared, leading to greater interest regarding the success of these projects [117]. A potential funding source comes from international nonprofit organization. These organizations are usually significantly monitored, which could provide credible and complete data regarding standards adoption. This information could also be compared among different countries. A clear example of this modality may be found in Uruguay in the computerization project of the clinical layer of a private healthcare network in the country [118].

Development of Digital Agendas

The Pan American Health Organization strongly recommends its member countries, to implement strategic planning for digital agendas at national level (106), in which a vital component is represented by standards for interoperability, as recently formulated through a resolution by WHO [8]. The proposed Toolkit by WHO and ITU acquires a fundamental role when following these recommendations and implementing these standards [34]. In the countries of the region, the current situation in this respect is dissimilar [102]. There are some good role models, such as the case of Chile [103] and Uruguay [104].

Without a doubt, there is a clear need for policies to provide a legal framework for the creation of digital agendas and to support the implementation of eHealth standards, including monitoring and evaluation of their management [119]. It is recommended to work in collaboration and with the participation of non-governmental organizations, academic institutions and the industry, since efforts based on different competences are essential to implement standards at national, regional and inter-country [116] level.

National and international implementation and financial approaches are required, particularly in this area, where economic resources of the health sector are bounded. Fortunately, there are institutions with sufficient governance to support and empower the required changes [34]. Within the legal framework, the standards' intellectual property, security and information privacy and how these issues apply in different nations are subjects that need to be evaluated [117].

Legal and Ethical Considerations

A legislation to prioritize the adoption of standards, associated with a regular review is required. The perceived loss of competitiveness by some actors in their endeavors to subscribe to the use

of standards [29] should be noted. The legal and executive environment is necessary to establish the confidence of the industry and individuals in eHealth [34]. One of the topics that complicate the adoption of standards is inherent in the sharing of sensitive information between different entities. This is why every effort to standardize must be accompanied by the protection of privacy, data integrity assessment and the development of high safety standards including access control and user authentication [120].

Another important issue to be addressed is the univocal identification of people, the Achilles' heel of information systems, which in most countries is not yet resolved and is the initial step for patient centered care [121].

Common Standards

EHealth is one of the most difficult areas to standardize. On one hand, this is because it originated from legacy systems based on proprietary technologies; on the other hand, because health standards cannot be directed to a specific area in medicine, but to different topics from patient data to medical devices [6]. The difficulty in selecting standards is partly because some of them share and overlap characteristics, others are paid and a third group corresponds to the ones that are adopted by the pressure imparted by most of the actors involved [120]. It is important that local governments make the effort to achieve the participation in Standards' International Associations, in order to mold them according to regional needs. In order to evaluate the requirements the standard must meet, there must be a consortium of users, researchers, scientists and technicians to further develop this documentation. The creation of regional and/or national autonomous multidisciplinary organizations in charge of creating, selecting, adapting, coordinating and implementing standards should be a consideration when planning any eHealth plan. When selecting a standard, different issues should be taken into consideration (language, cost, open vs. owners, organizations' workflows) [17]. A way of doing this is to be based on IHE guidelines for the adoption of health standards, which provides a framework for their coordinated use. These recommendations are focused on an interoperability needs evaluation model and its setting in different profiles [115].

Adequately Trained Workforce

One of the most complex tasks lies in human resources training to work in the creation and adaptation of standards. In Latin America there are few countries with training programs in Medical Informatics, these programs are usually short courses, master's and medical subspecialties [122]. The amount and types of professionals needed and the required skills to carry out these projects have not yet been defined. One of the training requirements is to standardize learning objectives, competencies, the required curriculum and the roles in different countries and regions [123]. This is the first step towards professional certification and accreditation of educational programs on a national level [124], involving governments, NGOs and academic centers. Training programs are also needed for other health professionals who already work in other disciplines [116, 125].

In addition to medical staff, skilled personnel needs to be trained to create eHealth policies and eHealth plans, they also need to have great communication and leadership skills, to create budgets, fund these projects and receive technical training required to implement standards [116, 125].

Due to the current lack of human resources, creating a network of centers, experienced in training professionals, is recommended. This creates a sort of social interoperability, where different organizations can consult each other and develop human resources [122].

Regional Integration

Given the previously mentioned shortcomings in infrastructure, finance and human resources, regional integration efforts are required in order to optimize efficiency in eHealth [126]. Standards should be one of the considerations to be evaluated when designing policies in eHealth in order to strengthen the region's trans-border union, such as the one being sought in the European Community [127]. These international efforts focus on certain objectives that require modification of the information's flow, collaboration between countries, process redesign and changes in organizational culture [128]. As an example of regional integration in training, there is a network of universities whose objective is to discuss the regional curriculum and to share teachers and content among network members (Red QUIPU) [122, 129]. Another example is the project of the ITU for a Pan American Telemedicine Network (PATN) including five countries, with communicated nodes via broadband or satellite internet, to handle electronic health records in real-time, teleconferencing, remote diagnosis, medical education training and teleconsultation [130].

The recommendations have been expressed in general terms, requiring potential adaptations to different local realities, without them, interoperability initiatives could be doomed to failure [112, 131].

Conclusions

One of the recommendations given by WHO / ITU in their eHealth Toolkit is to evaluate gathered experiences in other countries (both successes and failures) to understand what types of objectives are planned to be achieved with ICT. Latin American countries and their institutions use standards, this assumption is based on the observation that many nations and organizations in the region are represented in companies that elaborate standards (HL7, IEEE , ISO, etc.). From the search and evaluation of the studies found on the review, it can be concluded that in Latin America and the Caribbean interoperability and eHealth standards have not been adequately represented through scientific publications. Most of the publications are about pilots instead of sustainable and effective implementations. It can be inferred that there is a niche in the medical literature that has not been explored, which would be important to develop extensively in order to have information when generating strategies and implementation programs in these countries.

The implementation of standards is crucial to optimize eHealth resources. Expected ICT benefits would not be achieved without the standardization of most aspects of health information. This will require a national digital agenda covering the strategic adoption of eHealth standards adapted to local idiosyncrasies, with government coordination and the participation of all stakeholders.

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Annexes

Annex A: Description in eHealth Standards

Standard	Definition	Link
Unified Medical Language System (UMLS)	UMLS or Unified Medical Language System, is a set of files and software that brings together many health and biomedical vocabularies and standards to enable interoperability between computer systems. You can use the UMLS to enhance or develop applications, such as electronic health records, classification tools, dictionaries and language translators.	http://goo.gl/BDfzyI
International Classification of Diseases, Ninth Revision (ICD-9)	The International Classification of Diseases (ICD) is designed to promote international comparability in the collection, processing, classification, and presentation ofmortality statistics.	http://goo.gl/iw40qe
International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)	Based on ICD-9. ICD-9-CM is the official system of assigning codes to diagnoses and procedures associated with hospital utilization in the United States. The ICD-9 consists of a tabular list containing a numerical list of the disease code numbers in tabular form; an alphabetical index to the disease entries; and a classification system for surgical, diagnostic, and therapeutic procedures.	http://goo.gl/jY5IRC
International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10)	The ICD has been revised periodically to incorporate changes in the medical field. The Tenth Revision (ICD-10) differs from the Ninth Revision (ICD-9) in several ways although the overall content is similar: First, ICD-10 is printed in a three-volume set compared with ICD-9's two-volume set. Second, ICD-10 has alphanumeric categories rather than numeric categories. Third, some chapters have been rearranged, some titles have changed, and conditions have been regrouped. Fourth, ICD-10 has almost twice as many categories as ICD-9. Fifth, some fairly minor changes have been made in the coding rules for mortality.	http://goo.gl/HnSTBk
International Classification of Primary Care (ICPC) 1	The International Classification of Primary Care (ICPC) is a classification method for primary careencounters. It allows for the classification of the patient's reason for encounter (RFE), the problems/diagnosis managed, primary or general health care interventions, and the ordering of the data of the primary care session in an episode of care structure. It was developed by the WONCA International Classification Committee (WICC), and was first published in 1987 by Oxford University Press (OUP).	http://goo.gl/7YDM04
International Classification of Primary Care (ICPC) 2	ICPC-2 classifies patient data and clinical activity in the domains of General/Family Practice and primary care, taking into account the frequency distribution of problems seen in these domains. It allows classification of the patient's reason for encounter (RFE), the problems/diagnosis managed, interventions, and the ordering of these data in an episode of care structure.	http://goo.gl/asFMK2
Logical Observation Identifiers, Names and Codes (LOINC)	LOINC was developed to provide a definite standard to identify clinical information within electronic reports. LOINC database provides a set of universal codes and names to identify clinical and laboratory findings in the context of HL7, ASTM E1238 and CEN TC 251 posts reporting observations. One of the main objectives of LOINC is to facilitate the exchange and aggregation of results for clinical care and research. The LOINC codes are intended to identify test results or clinical observation.	http://goo.gl/m78LP7
ATC (Anatomical Therapeutic Chemical)	In the Anatomical Therapeutic Chemical (ATC) classification system, the active substances are divided into different groups according to the organ or system on which they act and their therapeutic, pharmacological and chemical properties.	http://goo.gl/Xmty67

Standard	Definition	Link
Systematized Nomenclature of Medicine (SNOMED)	Systematized Nomenclature of Medicine (SNOMED) is a systematically organized computer processable collection ofmedical terms and veterinary medicine, providing codes, terms, synonyms and definitions used in clinical documentation and reporting. SNOMED CT comprehensive coverage includes: clinical findings, symptoms, diagnoses, procedures, body structures, organisms and other etiologies, substances, pharmaceuticals, devices and specimen. It allows a consistent way to index, store, retrieve, and aggregate clinical data across specialties and sites of care.	http://goo.gl/m78LP7
Systematized Nomenclature of Medicine (SNOMED RT)	SNOMED RT (Reference Terminology) is a terminology that represents clinical concepts, useful for data analysis on the causes of diseases, patients' treatments and outcomes of medical care processes. SNOMED RT represents multiple hierarchies and incorporates description logic.	http://goo.gl/Xmty67
Systematized Nomenclature of Medicine Clinical Terms (SNOMED CT)	SNOMED CT or SNOMED Clinical Terms is a systematically organized computer processable collection ofmedical terms providing codes, terms, synonyms and definitions used in clinical documentation and reporting. SNOMED CT is considered to be the most comprehensive, multilingual clinical healthcare terminology in the world. The primary purpose of SNOMED CT is to encode the meanings that are used in health information and to support the effective clinical recording of data with the aim of improving patient care. SNOMED CT provides the core general terminology for electronic health records. SNOMED CT comprehensive coverage includes: clinical findings, symptoms, diagnoses, procedures, body structures, organisms and other etiologies, substances, pharmaceuticals, devices and specimen..	http://goo.gl/gaeyWa
Current Procedural Terminology (CPT)	The CPT code set describes medical, surgical, and diagnostic services and is designed to communicate uniform information about medical services and procedures among physicians, coders, patients, accreditation organizations, and payers for administrative, financial, and analytical purposes.	http://goo.gl/FVoJSQ
HL7 Version 2.x Communication Standard	HL7's Version 2.x (V2) messaging standard is the workhorse of electronic data exchange in the clinical domain and arguably the most widely implemented standard for healthcare in the world. This messaging standard allows the exchange of clinical data between systems. It is designed to support a central patient care system as well as a more distributed environment where data resides in departmental systems.	http://goo.gl/8c0QBl
HL7 Communication Standard, Version 3	HL7 V3 includes standards for communications that document and manage the care and treatment of patients in a wide variety of healthcare settings. As such, it is a foundational part of the technologies needed to meet the global challenge of integrating healthcare information, in areas such as patient care and public health.	http://goo.gl/jwSxsf
Digital Imaging and Communications in Medicine (DICOM)	It is a standard for handling, storing, printing, and transmitting information in medical by the DICOM Standards Committee that is formed by user organizations, vendors, government agencies and trade associations.	http://goo.gl/ElxIxF
Health Level Seven (HL7) Clinical Document Architecture (CDA) Release 2.0	CDA 2.0 supports the exchange of clinical documents such as discharge summaries and progress notes. By balancing XML, RIM, and coded vocabularies, CDA allows documents to be both feasible to be read by a machine (which allows them to be easily electronically processed) as well as by humans (so they can be retrieved and used by those who need them in a simple format). CDS documents can also be displayed using browsers or applications, for example in mobile phones.	http://goo.gl/DN0GWF
HL7 Continuity of Care Document (CCD)	El CCD Standard was developed by HL7 with consultation and advice from several members of ASTM. It originated as an alternative implementation of the ASTM CCR for those institutions or organizations that implemented the architecture of clinical documents HL7 (CDA).	http://goo.gl/cqAk1G
ASTM Continuity of Care Record (CCR)	It is a core data set of the most relevant administrative, demographic, and clinical information facts about a patient's healthcare, covering one or more healthcare encounters. It provides a means for one healthcare practitioner, system, or setting to aggregate all of the pertinent data about a patient and forward it to another practitioner, system, or setting to support the continuity of care.	http://goo.gl/omuNbK

Standard	Definition	Link
CDISC (Clinical Data Interchange Standards Consortium)	CDISC is a global, open, multidisciplinary, non-profit organization that has established standards to support the acquisition, exchange, submission and archive of clinical research data and metadata for the development of medical and biopharmaceutical products.	http://goo.gl/cqAk1G
National Council for Prescription Drug Programs (NCPDP) Data Dictionary	NCPDP was founded as the extension of a Drug Ad Hoc Committee. It specializes in the development of standards for the exchange of prescriptions and billing information.	http://goo.gl/BxnCgD
ASC X12	ASC X12 is a committee designated under the purview of DSMO. It develops uniform standards for the exchange of business transactions between industries using EDI (Electronic Data Interchange) standards. ASC X12 is a development organization accredited by ANSI standards.	http://goo.gl/q29l6K
ASTM Standard Practice for Content and Structure of the Electronic Health Record (EHR)	It Identifies the content and structure for EHR. The scope of this standard is intended to cover all types of health services including: acute care hospitals, ambulatory care, nursing institutions, tertiary centers and specialty centers.	http://goo.gl/LRntIA
HL7 Arden Syntax for Medical Logic Systems	The Arden Syntax is an ANSI-approved American National Standard language for encoding procedural medical knowledge and representing and sharing that knowledge among personnel, information systems and institutions. It assists clinicians, other health care workers and patients to make better decisions through alerts and other information interventions based on logic encoded into health knowledge bases consisting of medical logic modules (MLMs), each of which contains sufficient knowledge to make a single decision.	http://goo.gl/7vI2lB
HL7 FHIR, Fast Heatlhcare Interoperability Resources	FHIR is the latest generation of standards developed by HL7 combines the functionality of HL7 v2, v3 and CDA with WEB (XML , JSON , HTTP , etc.) standards , putting the focus on implementation. The FHIR specification is a "Draft Standard for Trial Use" (DSTU) final version is expected in 2017	http://goo.gl/7vI2lB
HL7 Clinical Context Management (CCOW)	The CCOW standard specifies architectures, interfaces between components, and data definitions in a technologically neutral way. It also maps those architectures, interfaces and definitions as clearly as possible.	http://goo.gl/XZ2ONH
IEEE 1073 Point of Care Medical Device Communication	It is a family of communications standards for medical devices which allows hospitals and other healthcare providers to achieve "plug and play" interoperability between medical devices and computerized information systems in health care, specifically targeting acute care scenarios.	http://goo.gl/vTvl4X
NCPDP Batch Transaction Standard	The NCPDP Batch Transaction Format provides practical guidelines and ensures a consistent implementation of standards for file delivery across the industry to be used between processors or pharmacies and drugstores, switches and processors.	http://goo.gl/KjWudQ
NCPDP Formulary and Benefit Standard	The NCPDP Formulary and Benefit Standard provides standards for pharmacy income beneficiaries (including health plans and pharmacy managers) to communicate necessary information to prescribers.	http://goo.gl/KjWudQ
NCPDP Billing Unit Standard	Given the high number of processors, fiscal intermediaries, administrators, Medicaid programs, the NCPDP Billing Unit Standard was created to promote a common billing language for the delivery of prescription orders.	http://goo.gl/KjWudQ
MeSH	Medical Subject Headings is a terminology used to index, catalogue and retrieve the world's medical literature. MeSH terms are arranged in a hierarchy that is not as strict as the one used by most of the other coding systems since the terms can appear in multiple places of the hierarchy.	http://goo.gl/mS4Z1U
RadLex	RadLex is a unified language of radiology terms for standardized indexing and retrieval of radiology information resources. It covers more than 30,000 terms.	http://goo.gl/LCMkbk
Alternative Billing Concepts (ABC) Codes	ABC Codes has over 4000 codes that describe what is said, done, requested, prescribed or distributed among providers of alternative medicine. The disciplines covered by this system include acupuncture, holistic medicine, massage therapy, homeopathy, naturopathy, ayurvedic medicine, chiropractic and midwifery.	http://goo.gl/4RnI1a
Clinical Care Classification (CCC) System	It is a classification system that consists of two interrelated terminologies - the CCC of Nursing Diagnoses and Outcomes and the CCC of Nursing Interventionsand Actions. Both taxonomies are classified by components, or clusters of items representing behavioral patterns, functionality, physiological or psychological care.	http://goo.gl/KttSN5

Standard	Definition	Link
Current Dental Terminology (CDT)	CDT is a coding system developed for reporting services performed by dentistry.	http://goo.gl/Q2KrqG
Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV)	DSM IV is a nomenclature to standardize the diagnostic process for patients with psychiatric disorders. It includes codes that correspond to the ICD-9-CM.	http://goo.gl/F41v4u
Global Medical Device Nomenclature (GMDN)	The Global Medical Device Nomenclature (GMDN) is a comprehensive system of internationally recognised coded descriptors in the format of preferred terms with definitions used to generically identify, describe and catalog medical devices, particularly products used in the diagnosis, prevention, monitoring, treatment or alleviation of diseases in humans.	http://goo.gl/Xhpd9H
International Classification of Diseases for Oncology (ICD-O)	CD-O is the standard tool for coding diagnoses of neoplasms in the tumor and cancer registry as well as in pathological laboratories. ICD-O is a dual classification with coding systems for both topography and morphology. Topography codes describe the site of origin of the neoplasm. It uses the same category system of 3 characters and 4 characters from the neoplasm section of ICD-10.	http://goo.gl/m6n09p
International Classification of Functioning, Disability and Health (ICF)	ICF is a classification system of health and health-related domains. These domains are classified according to individual and social perspectives in two lists: a list of body functions and structures, and a list of domains of activity and participation.	http://goo.gl/sYn6Eq
International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Clinical Modification (ICD-10-CM)	This version of the disease classification was developed by the World Health Organization. The ICD-10 is used to code and classify mortality data from death certificates, having replaced ICD-9 for this purpose as of January 1, 1999.	http://goo.gl/uQL1QI
International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Procedure Coding System (ICD-10-PCS)	ICD-10-PCS is a new procedure coding system to report procedures in institutions in USA.	http://goo.gl/Hzi9EF
MEDCIN	MEDCIN is a presentation and terminologty engine. It covers over 250,000 items that include clinical symptoms, history, physical examination, tests, diagnoses, and treatment.	http://goo.gl/LpLIhI
Medical Dictionary for Regulatory Activities (MedDRA)	MedDRA is a clinically validated international medical terminology dictionary (and thesaurus). It is expected to surpass and replace terminologies currently in use as its development progesses.	http://goo.gl/LEWqId
National Drug Code (NDC)	NDC is a coding system for pharmacies. It reports services, supplies, drugs, and biological information.	http://goo.gl/RfBjXI
North American Nursing Diagnosis Association (NANDA) International Taxonomy II	The organization of the international system of nursing diagnoses NANDA was in the beginning an alphabetical list, turning in the mid-80s to the current conceptual system that guides the classification of nursing diagnoses in a taxonomy.	http://goo.gl/yROn22
Nursing Interventions Classification (NIC)	NIC is a standarized classification of interventiones performed by nurses.	http://goo.gl/tM1GmI
Nursing Outcomes Classification (NOC)	NOC is a standarized classification of patient outcomes. It was developed to evaluate the impact of interventions performed by nurses.	http://goo.gl/Rkg22C
Omaha System	The Omaha System is a research-based, comprehensive practice and documentation standardized taxonomy or classification designed to document client care from admission to discharge.	http://goo.gl/GTIBPH
RxNorm	RxNorm is a normalized naming system for generic and branded drugs that provides standard names for clinical drugs (active ingredient, strength, dosage form) and dosage forms when being administered.	http://goo.gl/c92tFv
Systematized Nomenclature of Dentistry (SNODENT)	SNODENT is a Systematized Nomenclature of Dentistry covering dental diagnoses, signs, symptoms and discomfort.	http://goo.gl/ClYSjQ
Universal Medical Device Nomenclature System (UMDNS)	UMDNS is a standard international nomenclature and computer coding system used to facilitate the identification, processing, archiving, storage, retrieval, transfer and data communication between medical devices.	http://goo.gl/mUtlUI
United States Health Information Knowledgebase (USHIK)	USHIK is an on-line, publicly accessible registry and repository of healthcare related data, metadata, and standards. It allows loading, comparison, synchronization and harmonization of health information, values and information models in a uniform scope.	http://goo.gl/yaIjYr

Standard	Definition	Link
Web Ontology Language (OWL)	It is designed for use by applications that need to process the content of information instead of just presenting information to humans. There are three currently available OWL Lite sublanguages, OWL DL and OWL Full.	http://goo.gl/R2xuyB
OpenEHR	OpenEHR is a set of specifications defining a health information reference model, a language for building 'clinical models', or archetypes, which are separate from the software, and a query language. The architecture is designed to make use of external health terminologies, such as SNOMED CT, LOINC and ICDx.	http://goo.gl/OoIwpo
DRG	DRG is a statistical classification system of the hospitalizations of patients in different groups for billing purposes. DRG divided all possible diagnoses in more than 20 systems and over 500 groups for Medicare reimbursement.	http://goo.gl/UUSCkP
IHE	IHE is an initiative by healthcare professionals and industry to improve the way computer systems in healthcare share information. IHE promotes the coordinated use of established standards such as DICOM and HL7.	http://goo.gl/UsI2wU
ISO 13606	ISO 13606 is designed to achieve semantic interoperability in EHR communication.	http://goo.gl/oExVGA
ISO 13606-1	ISO 13606-1 specifies the communication of part or all of the electronic health record of a single identified subject of care between EHR systems, or between EHR systems and a centralized EHR data repository.	http://goo.gl/b9V0by
Arden Syntax	Arden Syntax is a standard for presentation and exchange of clinical knowledge in Medical Logic Modules.	http://goo.gl/9IsZIN
GELLO	GELLO is a standard query and expression language that provides a suitable framework for manipulation of clinical data for decision support in healthcare.	http://goo.gl/h2AsLB
Guideline Interchange Format (GLIF)	GLIF is a computer-interpretable language for modeling and executing clinical practice guidelines. GLIF supports sharing of computer-interpretable clinical guidelines across different medical institutions and system platforms.	http://goo.gl/Dc5HuQ
Infobutton	Infobutton are knowledge retrieval tools that take into consideration the context of the retrieved data.	http://goo.gl/h3hdGb
UCUM (Unified Code for Units of Measure)	The Unified Code for Units of Measure is a code system intended to include all units of measures being contemporarily used in international science, engineering, and business. The purpose is to facilitate unambiguous electronic communication of quantities together with their units.	http://goo.gl/F6gkJq
RDF (Resource Definition Framework)	RDF is a standard model for data interchange on the Web. RDF has features that facilitate data merging even if the underlying schemas differ, and it specifically supports the evolution of schemas over time without requiring all the data consumers to be changed.	http://goo.gl/eGDZBE
ITK (National Health System Interoperability ToolKit)	ITK is an open source system that provides multi platform developers a wide variety of tools for image analysis.	http://goo.gl/i3DsNX
DEEDS (Data Elements for Emergency Department Systems)	The National Center for Injury Prevention and Control (NCIPC) is coordinating a national effort to develop uniform specifications for data entered in emergency department (ED) patient records. The initial product is Data Elements for Emergency Department Systems.	http://goo.gl/676k3o
WSDL (Web Service Definition Language)	WSDL is an XML format for describing network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information.	http://goo.gl/hRRkrY

Annex B: Abbreviations and Acronyms

ABC Codes	Alternative Billing Concepts Codes
ASC X12	Accredited Standards Committee X12
ASTM CCR	Continuity of Care Record
ASTM	American Society for Testing and Materials
ATC	Anatomical Therapeutic Chemical
CCC System	Clinical Care Classification System
CEN	European Committee for Standardization
CCD	Continuity of Care Document
CDISC	Clinical Data Interchange Standards Consortium
CDT	Current Dental Terminology
CPT	Current Procedural Terminology
DEEDS	Data Elements for Emergency Department Systems
DICOM	Digital Imaging and Communications in Medicine
DRG	Diagnosis-related group
DSM-IV	Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition
GLIF	Guideline Interchange Format
GMDN	Global Medical Device Nomenclature
HIMSS	Healthcare Information and Management Systems Society
HL7 Arden Syntax for MLS	Health Level Seven Arden Syntax for Medical Logic Systems
HL7 CCOW	Health Level Seven Clinical Context Object Workgroup
HL7 CDA Release 2.0	Health Level Seven Clinical Document Architecture 2.0
HL7 Communication Standard, Version 3	Health Level Seven Communication Standard, Version 3
HL7 Version 2.x Communication Standard	Health Level Seven Version 2.x Communication Standard
ICD-9	International Classification of Diseases, Ninth Revision
ICD-9-CM	International Classification of Diseases, Ninth Revision, Clinical Modification
ICD-10	International Statistical Classification of Diseases and Related Health Problems, Tenth Revision
ICD-10-CM	International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Clinical Modification
IEC	International Electrotechnical Commission

IEEE 1073 Point of Care Medical Device Communication	Institute of Electrical and Electronics Engineers 1073 Point of Care Medical Device Communication
ICD-10-PCS	International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Procedure Coding System
ICD-O	International Classification of Diseases for Oncology
ICF	International Classification of Functioning, Disability and Health
ICPC 1	International Classification of Primary Care 1
ICPC 2	International Classification of Primary Care 2
IHE	Integrating the Healthcare Enterprise
IHTSDO	International Health Terminology Standards Development Organisation
IO	Interoperabilidad
ISO	International Organization for Standardization
ITK	National Health System Interoperability ToolKit
JIC	Joint Initiative Council
LOINC	Logical Observation Identifiers, Names and Codes
MedDRA	Medical Dictionary for Regulatory Activities
MeSH	Medical Subjects Headings
NANDA International Taxonomy II	North American Nursing Diagnosis Association International Taxonomy II
NCPDP Batch Transaction Standard	National Council for Prescription Drug Programs Batch Transaction Standard
NCPDP Billing Unit Standard	National Council for Prescription Drug Programs Billing Unit Standard
NCPDP Data Dictionary	National Council for Prescription Drug Programs Data Dictionary
NCPDP Data Dictionary	National Council for Prescription Drug Programs Formulary and Benefit Standard
NCPDP Formulary and Benefit Standard	National Drug Code
NDC	National Electrical Manufacturers Association
NEMA	Nursing Interventions Classification
NIC	Nursing Outcomes Classification
NOC	Organización Mundial de la Salud
OMS	Open electronic health record
OpenEHR	Web Ontology Language
OWL	Resource Definition Framework
RDF	Systematized Nomenclature of Dentistry
SNODENT	Systematized Nomenclature of Medicine
SNOMED	Systematized Nomenclature of Medicine Clinical Terms
SNOMED CT	Systematized Nomenclature of Medicine Reference Terminology
SNOMED RT	Tecnologías de Información y Comunicación
TIC	Unified Code for Units of Measure
UCUM	Universal Medical Device Nomenclature System

UMDNS	Unified Medical Language System
UMLS	United States Health Information Knowledgebase
USHIK	Web Service Definition Language
WSDL	Web Service Definition Language

PAHO/WHO eHealth Program

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