

# Electronic Health Records for Cardiovascular Medicine

Sofia Ouhbi<sup>1</sup>, Ali Idri<sup>1</sup>, Jose Luis Fernández-Alemán<sup>2</sup>, Ambrosio Toval<sup>2</sup> and Halima Benjelloun<sup>3</sup>

**Abstract**—Nowadays, many cardiology health care centers and hospitals adopt new technologies to improve interaction with their patients. The Electronic Health Records (EHR) offer health care centers and institutions the possibility to improve the management of their patients' health data. Currently, many physicians are using EHRs to improve health care quality and efficiency. A large number of companies have emerged to provide hospitals with the opportunity to adopt EHRs within a health care platform proposing different functionalities and services which achieve certain certification criteria. This paper identifies the current list of certified EHRs for cardiovascular medicine and assesses the specifications of the EHRs selected. The result of this paper may assist EHR seekers for cardiovascular medicine in their tasks.

## I. INTRODUCTION

Cardiovascular disease is one of the leading death causes and disability in the world [1], [2]. This chronic ailment can be better understood by analyzing data from health records [3]. The usage of health records has been strongly advocated by health care professionals and institutes to improve health care quality [4]. Different types of health records exist, such as electronic health record (EHR) and personal health record (PHR). PHR is a private application through which a patient may access, manipulate and keep tracking of his/her health information [5], [6]. The PHR can include data entered by the patient and/or from other sources such as laboratories, and electronic medical records (EMRs) or EHRs. The EHR is maintained by a health care organization or institution in which authorized clinicians can enter and manage a patient's health-related information. The usage of an EHR can be tremendously beneficial for a health care center, and can lead to [7]: potential productivity, financial improvement, quality of care improvement, rapid and remote access to patient information, easier chronic disease management, and improved continuity of care.

Many health care institutions promote the adoption of EHRs, such as the Health Information Technology for Economic and Clinical Health (HITECH) Act which supports a meaningful usage of EHRs by hospitals and clinicians through Medicare and Medicaid incentive payments to physicians and hospitals [8]. The American college of cardiology (ACC) highly encourages health care centers to choose an EHR certified by the Certification Commission for health

care Information Technology (CCHIT) [9]. CCHIT is a recognized certification body for EHRs and their networks, and an independent, voluntary, private-sector initiative. CCHIT has developed a set of testing criteria, which include functionality, security and interoperability measures for EHRs [10]. The benefit of a CCHIT-certified EHR is that the user knows the application will meet certain standards [9]. Moreover, a hospital can use a certified EHR technology to: improve quality, safety and efficiency. Also to maintain privacy and security of patient health information [8].

The aim of our paper is to list, to analyze and to assess the current CCHIT-certified EHRs which may be used in cardiology health center and hospitals. The search of these EHRs has been addressed through the use of the CCHIT Website [10]. A data extraction form has been designed to extract the specification of the EHRs selected. Moreover, each EHR selected has been assessed through a quality assessment (QA) process.

This paper is structured as follows. Section II describes the research method that was used in this paper. Section III shows the main results of the data collected and discusses the main findings of this study. Finally, Section IV presents our conclusions and further work.

## II. METHOD

This section describes the method used to search for, analyze and assess the EHRs for cardiovascular medicine.

### A. Review and Protocol

In this paper, some quality reporting guidelines, set out by the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) group [11], were followed. Before beginning the search for EHRs and the data extraction, a review protocol was developed in which each step was described, including eligibility criteria.

### B. Eligibility Criteria

The following inclusion criteria (IC) were used:

- IC1: EHRs which are CCHIT-certified.
- IC2: EHRs for cardiovascular medicine.

### C. Information Source

The CCHIT Website [10] was used as an information source for our research. This Website contains information related to the use and the creation of EHRs. *EHR Scope* [12] which is an online database dedicated to helping physicians and medical professionals find an EHR, was also used to get more information about the CCHIT-certified EHRs for cardiovascular medicine.

<sup>1</sup>Software Project Management research team, ENSIAS, Mohammed V University, Souissi Rabat, Morocco ouhbisofia@gmail.com, idri@ensias.ma

<sup>2</sup>Dept. Informatica y Sistemas, University of Murcia, Murcia, Spain aleman@um.es, atoval@um.es

<sup>3</sup>Autonomic Nervous System research team, Faculty of Medicine, Mohammed V University, Souissi Rabat, Morocco benjellounhalima@gmail.com

#### D. EHRs Selection and data collection process

The EHRs selection was organized according to the following phases: (1) The search for EHRs in the CCHIT Website [10]. (2) The selection of the EHRs found based on eligibility criteria IC1 and IC2. (3) The exploration of each EHR Website in order to identify and analyze its specifications. (4) The exploration of search engines in order to retrieve more information concerning the EHRs selected. The above activities were carried out independently by one author. Any discrepancies were resolved by the rest of authors. Data collection was carried out by using a data extraction form. Each EHR was assessed by one author to explore its specifications.

#### E. Data Items

We designed a template with the data that should be extracted from each EHR. The fields were chosen based on the specification provided by a typical EHR [13]. The data collected were tabulated to show:

- *General*: Link of the EHR.
- *EHR certification type* [10]: Ambulatory EHR [14], Long Term and Post Acute Care (LTPAC) EHR [15], Inpatient EHR [16], Emergency Department EHR [17], or Behavioral Health EHR [18].
- *Architecture supported* [10]: Web Services, Client/Server, Mobile Devices, or Thin Client.
- *Development tools*.
- *Platform* [12].
- *Recommendation*. The recommendations, appearing in the description of the EHR, that have been followed during the development of the EHR. These recommendations can be provided by: Health Insurance Portability and Accountability Act (HIPAA), Health Level Seven (HL7) standard, or other standards.
- *Certification program*. Other certification than CCHIT, for example from: Office of the National Coordinator (ONC)-authorized certification program which qualifies providers for federal incentive payments, or Surescripts certification program for software used by prescribers, pharmacies and payers for access to three core services.
- *CCHIT Usability Rating* [10]. It is scored out of 5.
- *Mobile usage*. Mobile applications for the EHR.
- *Interoperability*. The possibility to exchange information with other parties.

#### F. Quality Assessment

We evaluated each EHR using QA questions for each item:

- QA1 Has the EHR been certified more than once?
- QA2 Has the EHR a good CCHIT usability review (above 3)?
- QA3 Can the user access the EHR via a mobile device?
- QA4 Does the EHR support interoperability with other sources?

The questions were scored as follows:

- Yes = “1 point”. If the EHR provides this characteristic.
- No = “0 point”. If the EHR does not provide this characteristic.

- “-” = “0 point”. If no information has been specified in the description of the EHR.

### III. RESULTS AND DISCUSSION

#### A. EHRs Selection

A total of 22 EHRs were selected from 77 EHRs which are CCHIT-certified. 55 EHRs were discarded since they did not meet the IC2. Figure 1 shows the process of the EHRs selection.



Fig. 1. PRISMA Flow Diagram

#### B. Data collection and quality evaluation of the EHRs

Table I shows the classification of the EHRs selected. This classification is based on the calculation of the QA score of each EHR. The average QA score for EHRs is 2.95 of 4 which indicates a good level of quality. *Sunrise Ambulatory Care 2011 Suite 5.5* [19], *SuccessEHS 6.1* [20] and *PrimeSuite 2011* [21] are ranked among the best in our QA and according to CCHIT, they provide the user with a high usability level. In contrast, *NetSolutions 6.4.7* achieved the lowest score (1 out 4). 64% of the EHRs selected have not mentioned in their Websites the tools which have been used in their development. The majority of the EHRs which have mentioned this information were developed by using .NET platform and SQL for accessing and manipulating databases. All the EHRs selected offer interoperability with other entities such as laboratories and pharmacies.

#### C. The specifications of the selected EHRs

Figure 2 presents an overview of this study’s results. According to CCHIT, 45% of the EHRs selected support web services architecture, 36% support client/server architecture and 18% support thin client architecture. 73% of the EHRs selected are ambulatory EHRs while the rest is LTPAC EHRs. The nature of services required for cardiovascular medicine should be provided by LTPAC EHRs. Thus, LTPAC EHRs are expected to be more available than ambulatory EHRs. It could be hard to meet CCHIT requirements certification for LTPAC EHRs which may explain this result. Windows platform is the most platform deployed by the EHRs selected, followed by Macintosh platform and Unix/Linux platform. 41% of the EHRs selected have not mentioned in their description any specific recommendation followed in their development. The rest of EHRs selected have mainly followed recommendations from HIPAA and recommendations from HL7 for Continuity of Care Document (CDD) or in general. Cross-references taxonomy can be applied to ensure that EHRs used in cardiology comply with HIPAA and HITECH to avoid penalties and lost reputation [41]. 91% of the selected EHRs have received an extra certification from ONC. In addition to ONC and CCHIT certifications, the

TABLE I  
CCHIT-CERTIFIED EHRs FOR CARDIOVASCULAR MEDICINE

EHR product	Certification type	Architecture supported	Development tools	Platform	Regulations	(QA1) Other certification program	(QA2) CCHIT Usability Rating	(QA3) Mobile usage	(QA4) Interoperability	QA Score
Sunrise Ambulatory Care 2011 Suite 5.5 [19]	Ambulatory	Thin Client	SQL	Windows, Mac, UNIX/Linux	-	Yes (ONC)	Yes (5)	Yes	Yes	4
SuccessEHS 6.1 [20]	Ambulatory	Thin Client	-	Windows, Mac, UNIX/Linux	HL7 CCD	Yes (ONC)	Yes (5)	Yes	Yes	4
PrimeSuite 2011 [21]	Ambulatory	Client/server	.NET	Windows	HL7 CCD	Yes (ONC)	Yes (5)	Yes	Yes	4
iPatientCare 10.8 [22]	Ambulatory	Web Services	.NET, Microsoft Visual Studio, SQL	Windows, Mac, UNIX/Linux	HL7 CCD	Yes (ONC)	Yes (4)	Yes	Yes	4
ChartPlus EHR 1.0 [23]	Ambulatory	Web Services	-	-	-	Yes (ONC)	Yes (4)	Yes	Yes	4
NexTech Practice 2013 10.8 [24]	Ambulatory	Client/server	-	Windows	HIPAA	Yes (ONC)	Yes (4)	Yes	Yes	4
American Medical Software-EMR 22 [25]	Ambulatory	Client/server	SQL	Windows	HL7, HIPAA	Yes (ONC)	Yes (5)	No	Yes	3
Medicat 2011 10.0 [26]	Ambulatory	Client/server	-	Windows	HIPAA	Yes (ONC)	Yes (5)	No	Yes	3
Centricity Practice Solution 9.5 [27]	Ambulatory	Client/server	-	Windows	-	Yes (ONC)	Yes (5)	No	Yes	3
Aprima 2011 [28]	Ambulatory	Client/server	-	Windows, Mac	-	Yes (ONC)	Yes (5)	No	Yes	3
NextGen Ambulatory EHR 5.6 SP1 [29]	Ambulatory	Client/server	-	Windows	-	Yes (ONC)	Yes (5)	No	Yes	3
LeonardoMD Virtuoso 1.0 [30]	Ambulatory	Web Services	Microsoft Visual Studio, SQL	-	HIPAA	Yes (ONC)	Yes (4)	No	Yes	3
Cehrur 10.8 [31]	Ambulatory	Web Services	.NET	Windows	-	Yes (ONC)	Yes (4)	No	Yes	3
2011 Waiting Room Solutions Web Based EHR [32]	Ambulatory	Web Services	-	Windows	-	Yes (ONC)	Yes (4)	No	Yes	3
HealthMEDX Vision 7.1.10 [33]	LTPAC	Web Services	-	Windows, UNIX/Linux	HIPAA HL7 CCD	Yes (ONC)	-	Yes	Yes	3
Answers EHR Autumn 2011 [34]	LTPAC	Thin Client	-	Windows	HIPAA	Yes (ONC)	-	Yes	Yes	3
NDoc 12.11 [35]	LTPAC	Web Services	-	Windows	-	Yes (ONC)	-	No	Yes	2
CentriHealth Individual Health Record (IHR) 2011.1 [36]	Ambulatory	Web Services	-	Windows, Mac, UNIX/Linux	-	Yes (ONC and Surescripts)	-	No	Yes	2
Pro-Filer 2012 [37]	Ambulatory	Thin Client	-	-	HL7	Yes (ONC)	-	No	Yes	2
Optimus EMR 7.5.4.3 [38]	LTPAC	Web Services	-	Windows	HL7, HIPAA	No	-	Yes	Yes	2
ECS-Electronic Chart and Financial System Version 9 [39]	LTPAC	Client/server	SQL	-	HL7	Yes (ONC)	-	No	Yes	2
NetSolutions 6.4.7 [40]	LTPAC	Web Services	.NET, SQL	-	HL7 CCD	No	-	No	Yes	1

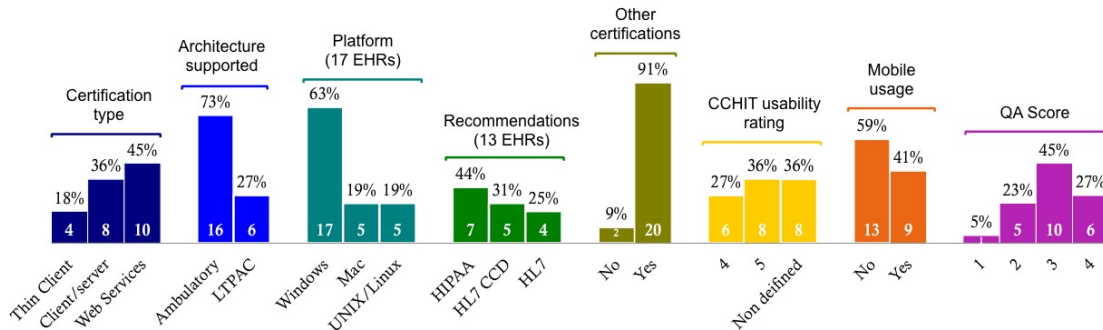


Fig. 2. An overview of the results

EHR *CentriHealth Individual Health Record (IHR) 2011.1* [36] has been also certified by Surescripts. 36% of the EHRs selected have received a very good rating from CCHIT about their usability. While 27% of the EHRs selected received a good rating. This review was not available for the remaining EHRs selected. Usability is a quality characteristic in ISO/IEC 9126 and was renamed in ISO/IEC 25010 as Operability. It represents the ease of use and user interface characteristics among other sub characteristics. 41% of the EHRs selected can be accessible via smartphones. The majority of this application are running on iOS smartphones [20], [24], [33]. Other EHRs, in addition to iOS, are running also on Android smartphones [19], [21], [34]. Only one EHR [22] runs on Windows smartphones besides iOS smartphones. The EHR mobile usage is expected to increase in the near future due to the increasing usage of smartphones all over the world.

#### D. Limitations

This study may have several limitations such as: the search was limited to CCHIT-certified EHRs which may have omitted other EHRs for cardiovascular medicine which might have been relevant to this study. The QA process could include criteria which have advantaged some EHRs from others. Adding more criteria may lead to different result in the QA score classification.

#### IV. CONCLUSIONS

This paper analyzed and assessed the specifications of 22 CCHIT-certified EHRs for cardiovascular medicine. An extraction form has been defined to assist EHR stakeholders for cardiovascular medicine to select the CCHIT-certified EHR that best fits their needs. EHR designers have also been given the opportunity to benchmark from other EHRs that have received good usability review from CCHIT. Our

findings show that not all EHRs provide information concerning their development tools or the recommendations followed in their realization. All the EHRs selected are interoperable with other health parties. Studies on EHR for other medical modalities can be conducted using the criteria presented in this study by changing the IC2 to another particular modality. We trust that our research may help practitioners to discover the available CCHIT-certified EHRs for cardiovascular medicine. In future work, we intend to analyze the specification to realize an EHR for cardiovascular medicine. Also, a study of the cardiology EHR privacy and security requirements [42], [43] is planned to be done.

#### ACKNOWLEDGMENT

The mobility grant of Sofia Ouhbi is financed by the Mediterranean Office for Youth. This research is part of the GEODAS-REQ project (TIN2012-37493-C03-02) financed by both the Spanish Ministry of Economy and Competitiveness and European FEDER funds.

#### REFERENCES

- [1] D. L. Hoyert and J. Xu, "Deaths: preliminary data for 2011," *National vital statistics reports*, vol. 61, no. 6, pp. 1–51, 2012.
- [2] N. J. Pagidipati and T. A. Gaziano, "Estimating deaths from cardiovascular disease: a review of global methodologies of mortality measurement," *Circulation*, vol. 127, no. 6, pp. 749–756, 2013.
- [3] N. Ramakrishnan, D. Hanauer, and B. Keller, "Mining electronic health records," *Computer*, vol. 43, no. 10, pp. 77–81, 2010.
- [4] M. N. Walsh, N. M. Albert, A. B. Curtis, M. Gheorghiane, J. T. Heywood, Y. Liu, M. R. Mehra, C. M. O'Connor, D. Reynolds, C. W. Yancy *et al.*, "Lack of association between electronic health record systems and improvement in use of evidence-based heart failure therapies in outpatient cardiology practices," *Clinical cardiology*, vol. 35, no. 3, pp. 187–196, 2012.
- [5] J. L. Fernández-Alemán, C. L. Seva-Llor, A. Toval, S. Ouhbi, and L. Fernández-Luque, "Free Web-based Personal Health Records: An Analysis of Functionality," *Journal of medical systems*, vol. 37, no. 6, pp. 1–16, 2013.
- [6] I. Carrion, J. Fernandez Aleman, and A. Toval, "Personal health records: New means to safely handle health data?" *Computer*, vol. 45, no. 11, pp. 27–33, Nov. 2012.
- [7] (2014, March) American Academy of Family Physicians. [Online]. Available: <http://www.aafp.org/home.html>
- [8] *Electronic Medical Records/Health Information Technology: Background Information and Resources*, Society for vascular surgery ed., SVS Clinical Practice Council, 2013.
- [9] (2014, March) Choosing an EHR. American College of Cardiology Foundation. [Online]. Available: <http://www.cardiosource.org/Advocacy/Health-IT.aspx>
- [10] (2014, March) Certification Commission for Healthcare Information Technology. [Online]. Available: <http://www.cchit.org>
- [11] A. Liberati, D. G. Altman, J. Tetzlaff, C. Mulrow, P. C. Gtzsche, J. P. Ioannidis, M. Clarke, P. Devereaux, J. Kleijnen, and D. Moher, "The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration," *J. of Clinical Epid.*, vol. 62, no. 10, pp. 1–34, 2009.
- [12] (2014, March) EHR Scope. [Online]. Available: <http://www.ehrscope.com/>
- [13] J. C. Crosson, P. A. Ohman-Strickland, D. J. Cohen, E. C. Clark, and B. F. Crabtree, "Typical electronic health record use in primary care practices and the quality of diabetes care," *The Annals of Family Medicine*, vol. 10, no. 3, pp. 221–227, 2012.
- [14] (2014, March) CCHIT Certified 2011 Ambulatory EHR Certification Criteria. The Certification Commission for Health Information Technology. [Online]. Available: [www.cchit.org/ambulatory-ehr](http://www.cchit.org/ambulatory-ehr)
- [15] (2014, March) CCHIT Certified 2011 Long Term and Post Acute Care (LTPAC) Criteria. The Certification Commission for Health Information Technology. [Online]. Available: [www.cchit.org/long-term-and-post-acute-care-ehr](http://www.cchit.org/long-term-and-post-acute-care-ehr)
- [16] (2014, March) CCHIT Certified 2011 Inpatient EHR Criteria. The Certification Commission for Health Information Technology. [Online]. Available: [www.cchit.org/inpatient-ehr](http://www.cchit.org/inpatient-ehr)
- [17] (2014, March) CCHIT Certified 2011 Emergency Dept Criteria. The Certification Commission for Health Information Technology. [Online]. Available: [www.cchit.org/emergency-department-ehr](http://www.cchit.org/emergency-department-ehr)
- [18] (2014, March) CCHIT Certified 2011 Behavioral Health Criteria. The Certification Commission for Health Information Technology. [Online]. Available: [www.cchit.org/behavioral-health-ehr](http://www.cchit.org/behavioral-health-ehr)
- [19] (2014, March) Sunrise Ambulatory Care 2011 Suite 5.5. Eclipsys Corporation. [Online]. Available: <http://ehr-software.findthebest.com/1/232/Sunrise-Ambulatory-Care>
- [20] (2014, March) SuccessEHS 6.1. SuccessEHS. [Online]. Available: <http://www.successehs.com/what/products/ehr-emr-and-practice-management-solution.htm>
- [21] (2014, March) PrimeSuite 2011. Greenway Medical Technologies, Inc. [Online]. Available: [www.greenwaymedical.com/solutions/prime-suite/](http://www.greenwaymedical.com/solutions/prime-suite/)
- [22] (2014, March) iPatientCare 10.8. iPatientCare, Inc. [Online]. Available: <http://www.ipatientcare.com>
- [23] (2014, March) Chartplus EHR 1.0. BIT Healthcare, Inc. [Online]. Available: [www.medicalrecords.com/mrcbase/emr/chartplus-ehr](http://www.medicalrecords.com/mrcbase/emr/chartplus-ehr)
- [24] (2014, March) NexTech Practice 2013 10.8. NexTech Systems Inc. [Online]. Available: <http://www.nextech.com>
- [25] (2014, March) American Medical Software-EMR 22. American Medical Software. [Online]. Available: <http://americanmedical.com/products/electronic-medical-records>
- [26] (2014, March) Mediat 2011 10.0. Mediat, LLC. [Online]. Available: <http://www.mediat.com/solutions/electronic-health-records>
- [27] (2014, March) Centricity Practice Solution 9.5. GE Healthcare. [Online]. Available: [www.gehealthcare.com/centricitypracticesolution](http://www.gehealthcare.com/centricitypracticesolution)
- [28] (2014, March) Aprima 2011. Aprima Medical Software, Inc. [Online]. Available: <http://www.aprima.com/ehr-features>
- [29] (2014, March) NextGen Ambulatory EHR 5.6 SP1. NextGen Healthcare. [Online]. Available: <http://www.nextgen.com/Products/ambulatory/EHR/EHR.aspx>
- [30] (2014, March) LeonardoMD Virtuoso 1.0. LeonardoMD, Inc. [Online]. Available: <http://www.leonardomd.com>
- [31] (2014, March) Cehrus 10.8. PracticeMax, Inc. [Online]. Available: <http://www.practicemax.com/our-technology/ehrpms-solutions/cerhus/?subpagetabs=0>
- [32] (2014, March) 2011 Waiting Room Solutions Web Based EHR and Practice Management System 4.0. Waiting Room Solutions. [Online]. Available: [www.waitingroomsolutions.com](http://www.waitingroomsolutions.com)
- [33] (2014, March) HealthMEDX Vision 7.1.10. HealthMEDX, LLC. [Online]. Available: [www.healthmedx.com](http://www.healthmedx.com)
- [34] (2014, March) Answers EHR Autumn 2011. AOD Software. [Online]. Available: <http://www.aodsoftware.com/solutions/clinical/>
- [35] (2014, March) NDoc 12.11. Thornberry Ltd. [Online]. Available: [www.thornberryltd.com](http://www.thornberryltd.com)
- [36] (2014, March) Centrihealth Individual Health Record (IHR) 2011.1. CentriHealth, Inc. [Online]. Available: <http://www.centrihealth.com/index.php>
- [37] (2014, March) Pro-Filer 2012. CoCENTRIX, Inc. [Online]. Available: [www.unicaresys.com](http://www.unicaresys.com)
- [38] (2014, March) Optimus EMR 7.5.4.3. Optimus EMR, Inc. [Online]. Available: [www.optimusemr.com](http://www.optimusemr.com)
- [39] (2014, March) ECS - Electronic Chart and Financial System Version 9. American Data (1984 Systems Inc.). [Online]. Available: [www.american-data.com](http://www.american-data.com)
- [40] (2014, March) NetSolutions 6.4.7. NTT Data Long Term Care Solutions, Inc. [Online]. Available: [www.nttdataltc.com](http://www.nttdataltc.com)
- [41] J. C. Maxwell, A. I. Antón, P. Swire, M. Riaz, and C. M. McCraw, "A legal cross-references taxonomy for reasoning about compliance requirements," *Requirements Engineering*, vol. 17, no. 2, pp. 99–115, 2012.
- [42] S. Gritzalis and L. Liu, "Requirements engineering for security, privacy and services in cloud environments," *Requirements Engineering*, vol. 18, no. 4, pp. 297–298, 2013.
- [43] C. Kalloniatis, H. Mouratidis, and S. Islam, "Evaluating cloud deployment scenarios based on security and privacy requirements," *Requirements Engineering*, vol. 18, no. 4, pp. 299–319, 2013.