The Value of Clinical Information Models and Terminology for Sharing Clinical Information

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Abstract—**This paper reports from the national strategy for OpenEHR adoption in Northern Norway Regional Health Authority encouraged by the unfolding of a national repository for OpenEHR archetypes and a national initiative to integrate clinical terminologies. The paper contributes to a qualitative longitudinal interpretive study with an effort to increase the possibility to obtain semantic interoperability (towards integrated care) and discusses SNOMED-CT and other relevant clinical terminology and Clinical Information Models (CIMs) such as OpenEHR archetypes. Terminology and archetypes are used to structure the EPR two-folded, and we discuss a general use of information models to increase interoperability extensively. A two-folded use of terminology where terminology is integrated in archetypes, or where terminology is used to structure the EPR system while using the hierarchical model of the terminology is discussed. Secondly, we discuss for what purpose OpenEHR is the choice of CIM to succeed in Norwegian healthcare.**

Keywords-eHealth medical records; electronic health records; web technology; e-health; interoperability; semantics; integrated care; OpenEHR; terminology; classification systems

I. INTRODUCTION

The increased focus on process-oriented systems across different health care organizations presupposes standardization in the form of shared terminologies and information models to enable semantic interoperability. Terminology standards have significant importance in modern medicine, and have been used to structure clinical information for different purposes [1]. Such standards also have the potential of supporting nursing terminologies such as International Classification of Nursing Practice (ICNP) or Nursing Intervention Classification (NIC) and The North American Nursing Diagnosis Association (NANDA) [2][3]. These standards have been developed, and used, to ensure consistency of meaning across time and place. On one level, nursing classifications enable day-to-day planning for local users (Primary use) where clinical terminology is used to structure information (standardized care-plans) using diagnosis and interventions from NIC and NANDA, for example. In practice, this will generate an automatic and reliable use of terminology for information that is sent and received between systems or health care deliverers. Examples of terminologies are the International Classification of Diseases (ICD), Systematized Nomenclature of Medicine Clinical Terms (SNOMED-CT), and International Classification of Nursing Practice (ICNP) [4][5][6].

Clinical Information Models (CIMs) [7] are models specified in some clinical information standard to express the clinical data entities processed by Health Information Systems (HIS). CIMs are used to appropriately maintain the consistency of clinical information structures inside a HIS, and to enable semantic interoperability across different systems and organizations. This makes CIMs a basic component for the appropriate management of patient data [8]. Moreover, with recent advances in data reuse strategies, CIMs are also playing an important role in defining the clinical information structures needed for secondary use of data [9][10].

OpenEHR is one of the specifications available to define CIMs. It relies on a meta-model based on reference model and constraint mechanisms to define formal specifications of CIMs called archetypes. Archetypes are information elements of clinical concepts where observations, options, instructions, and actions form the iterative process of treatment and care [11]. When using archetypes with a terminology binding, it becomes possible to make Electronic Patient Record (EPR) systems content structured in a multilevel modelling approach enabling semantic interoperability and the reuse of data. Using OpenEHR archetypes with a terminology binding it is possible to structure Electronic Patient Record (EPR) information models in a standard way. This enables semantic interoperability among HIS compliant with such standard [12].

For more than a decade, national initiatives towards shared and integrated care have been a focus area for the Norwegian health authorities [13][14]. This especially emphasizes the need to organize the clinical content of the EPR system in a more structured manner, to ensure interoperability across heterogeneous practices. Such need for contents organization is due to an increasing demand for rapid feedback on results, and an urge to compare organizational and / or clinical data. Structured data will allow clinicians to categorize variables in order to build meaningful reports, to extract data for quality registers and reuse EHR data in clinical research.

The definition of archetypes requires governance organizations that coordinate their definition on a broad scale. In Norway, the national initiative that deals with the contents

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organization has gradually gained a foothold. The OpenEHR architecture has been used to build a national repository, a.k.a. Clinical Knowledge Manager (CKM), of common Clinical Information Models. CIMs are defined collaboratively in the CKM as OpenEHR archetypes to provide vendors a library of common formal models to build their clinical information systems on. CKM archives information about how new archetypes are translated, modelled, and shared, and is planned to contain between 1000 and 2000 archetypes. The target is to build an open source repository of clinical content, based on the OpenEHR clinical information model. A precondition for success is that clinicians agree on the content of each archetype in the CKM consensus processes. Clinicians from the four Regional Health Authorities are active contributors in the process of developing archetypes. This process has been coordinated by the national editorial group, and the National Administration Office of Archetypes (NRUA).

This paper describes the national work accomplished to support the new two-levelled modelling of EPR systems with focus on the development of clinical value. We describe the work performed in: a) CIMs definition as archetypes by multidisciplinary teams of information architects and clinicians; b) the evaluation of the adequacy of adopting SNOMED-CT as reference terminology to annotate CIM. Based on this we present the following research questions: How interconnected is the choice of OpenEHR as clinical information model when the purpose is to have a library of clinical data to share between systems and healthcare levels? What is the adequacy of adopting clinical terminology to annotate any CIM?

The rest of the paper is structured as follows. In section two, we introduce the qualitative method used in the study, in section three we describe the value of information models, clinical terminology, the specifics of OpenEHR, and the national work towards the use of archetypes to structure the content of EPR systems. In section four the models used, and actions considered are discussed, and section five concludes based on the findings in the previous section.

II. MATERIALS AND METHODS

The research presented herein has mainly been developed in the North Norwegian Regional Health Authority in coordination with NRUA, and the Norwegian Directorate of Health. Interpretive and ethnographically oriented qualitative methods have been applied, grounded in participation and contribution in the work accomplished [15]. Analysis of longitudinal research is a continuous and iterative process with an ever-changing intensity. The fieldwork has focused on the regional/national work accomplished, and, secondly, the forthcoming process where numerous archetypes will be tested as structured elements in the new process oriented EPR system. During the last seven years several meetings, courses, and workshops with focus on archetypes and terminology have been covered by observations, document analysis, and interviews. Conversations, discussions, reflections, and debates from these meetings are the foundation of this work. The observations and description of on-going work has been followed by the interviews with members of the regional and national initiatives. This includes six interviews on the archetype governance, 10 interviews and 180 hours of observations on the use of clinical terminology, conversations with end users of the CKM while guiding them to become users, and participants in national discussions on the consensus of archetypes. The interviews includes as said 10 clinicians, doctors and nurses that are active users of the CKM. The process of educating them to become CKM users has given valuable knowledge on how to develop the learning and recruitment strategies.

TABLE I. AN OVERVIEW OF THE DATA COLLECTION

Data source	
Interviews with contributors to the work with archetypes, and the development of new EPR.	18 open ended interviews
Participatory observation	180 hours
Participation in meetings, workshops, and informal discussions.	300 hours
Document studies: Documents from the CKM, concerning archetypes in general.	

III. RESULTS

During the last three years, the use of OpenEHR archetypes has grown with focus on a national anchorage in Norwegian healthcare. The initiative has developed through national ICT, and an EPR vendor that holds more than 80 % of the secondary healthcare EPR systems. From the outset, a national collaborating group is working, in coordination with the aforementioned vendor, to build a national repository of archetypes. Simultaneously, such work contributes to the development of a structured EPR system that is based on OpenEHR technologies. Still, OpenEHR is only one of several comprehensive information models for standardizing and sustaining clinical content for health care.

At the same time, the Norwegian Directorate of Health has put focus on clinical terminology, and has engaged clinicians nationwide to explore the integration of SNOMED-CT in the existing ICT portfolio.

A. The value of Clinical Information Models

The future of Norwegian healthcare depends upon communication between ICT systems of different vendors, and between the primary and specialist health systems. The national CKM will contain the reference archetypes and guidelines to help implementers in the adoption of OpenEHR and terminologies. This makes the Norwegian CKM unambiguously unique based on the grade of consensus. In order to define CIMs that are general enough to be applied in different organizations and systems, it is necessary to define them as a collaborative effort among domain experts. The environments to carry out this work are the so called CKMs. The definition of CIMs typically encompasses two main tasks. The first is the specification of the information structure in a clinical information standard such as OpenEHR. The second is the binding of the meaningful sections of the CIM to a terminology to attach unambiguous standard descriptions to them. In the last decade, the work

of initiatives to model CIMs is leading to the definition of an extensive catalogue of models publically available, upon which clinical systems implementations can be based. Nowadays, there is a considerable diversity in the standards and approaches available to define CIMs. Although most editorial teams follow similar steps, there is no published unified methodology or guideline for their definition [7]. The scope of modelling initiatives varies significantly from the local to the international level. For example, the international CKM and the Clinical Information Model Initiative (CIMI) define CIMs at an international level; the Norwegian CKM defines them at a national level; and the Intermountain Clinical Element Models (CEMs), were defined at intra-organizational level. The work in parallel of different initiatives has led to semantically equivalent models expressed in different information standards, a.k.a. iso-semantic models.

B. The use of terminology to standardize local practice

Since 2005, one of the largest hospitals in Norway, Akershus University Hospital, has used an EPR that includes a module for nursing. Along the lines of standardization, the nursing care plan, including nursing classification systems were viewed as a mean for making nursing work more effective and offering quality assurance. The classification systems are ICT-based standards integrated with the care plan. The diagnoses are represented by the international classification system NANDA, consisting of 206 nursing diagnoses [6]. The interventions are represented by the NIC system, consisting of 486 interventions. Care plans are increasingly made to replace the use of free text in the documentation, foremost to establish a common, formalized language based on the best practices. Free text documentation is whatever information the nurses share about the patient in the EPR in addition to, or without, writing formalized care plans. However, the implementation of the EPR led to a systematic use of standardized care plans. The care plan has been organized in such a manner that each diagnosis, dimension, and action is firmly attached to the plan with a start and a stop date. When standardizing these plans, the nurse can easily choose several actions from a predefined list for the applicable diagnosis. By doing this, the nurse saves time, while the standardized sentences work as a quality indicator. The purpose of using terminology as a primarily means to standardized EPR systems is challenging, still terminology has been used to structure an unstructured EPR system with success.

C. Clinical terminology, the national strategy

Terminology offers a common vocabulary for national health authorities, local researchers, and quality registers. All in all, this means that in addition to being a storing device for free text data the EPRs are capable of encoding commonly occurring data using fixed lists of multiple choices for certain purposes. Thus, data becomes more comparable and computable than free text would be. Some key examples may be found through the global World Health Organization (WHO)-based ICD. There are also terminological standards for more specific domains, such as the ICF (International Classification of Functioning, Disability and Health) for rehabilitation. In the case of ICD-9 and -10, which has been used in Norwegian healthcare systems from their origin, the primary target could have been achieved: If the clinicians had used the diagnosis codes from ICD-10 to categorize the subscription of patients in the EPR, it would clearly be of primary use (Clinical IT Manager). On the contrary, it is difficult for clinicians to be explicit and specific early in the trajectory of the patient, since diagnosis change throughout the patient pathway. Diagnosis change and the IT systems in use need to track and categorize these changes logically to support the activity coding of clinical work. The coding of activities reflects the focus of the clinical pathway, not the diagnosis of the patient. In this sense, the archetypes become valuable: as a quality assurance of the completeness of the clinical terminology, to direct the clinical content of the EPR systems and other integrated systems, and to identify relevant information and give the clinicians access to this information. On the contrary, to the local level the patient pathways fixed to clinical ICD diagnosis probably need to be determined on a national level, and based on national directives. A member of the regional archetype group stated *"The archetype is not annotated but this is a subset of the SNOMED concepts available for severities. As a maximum data set, the archetype should not restrict the "standard" set of terms agreed in terminologies. However, before doing so, I think that the implications in term of SNOMED licenses should be considered very carefully."* For instance, clinical pathways for cancer diagnosis are today organized from national cancer groups that have resulted in national guidelines that easily could be followed and connected to already existing "Pakkeforløp" standardized packages to monitor that cancer patients receive the right treatment at the applicable time. Large scale Infrastructure projects, with increasingly more focus on integrated care, put pressure on the Norwegian Directorate of Health to focus on clinical terminologies and archetypes. Recently, there has been a growing activity in the section of e-health towards increased focus on terminologies such as SNOMED-CT, and ICF, and how terminology and archetypes fit together. A selected number of personnel has, through the last 6 months, gathered resource personnel from all over the country. These are clinicians and health informatics with special interest in the use of clinical terminology. The work started in November 2015 with the purpose to map SNOMED-CT towards the most commonly used EPR functions. At the same time ICNP will be piloted in the primary healthcare services, this has been organized by the Norwegian Nursing Association that has translated the terminology, and it is acknowledged by the Norwegian Directorate of Health. SNOMED-CT and ICNP are both discussed in the new national project. Other Scandinavian countries such as Sweden and Denmark have earlier allocated significant resources both to translate and get SNOMED-CT operational for clinical practice.

The national project has focused on SNOMED-CT; should Norway become an organized user of SNOMED? How is the coverage of SNOMED-CT for the content of the

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clinical pathway? How is the integration of SNOMED-CT solved technically? The last question includes the use of archetypes, but also the possibility to use SNOMED directly to structure EPR content using the hierarchical model?

D. The national governance of archetypes

NRUA was established in 2013 by the National ICT with the goal of producing high quality archetypes. The NRUA has assigned six full/part time associates with an increasing number of collaborators in the Regional Health Authorities. There are between two and three members from each of the four regions. As an example, there is an increasing number of members from the North Norwegian Health Authority, one physician with special interest in health informatics, one nurse with a PhD in information Systems, one ICT-advisor, two PhD students in part time possitions and one project manager from the regional ICT development program where the new process oriented EPR is developed. NRUA also cooperates closely with global connections such as the founder of archetypes, the international governed repository, and vendors that cooperate with the Norwegian vendor. The vendors are important contributors with a mutual interdependency. In all, the governance work is important in local, national, and global environments. The overall goal with NRUA is to coordinate the development and use of archetypes on a national level, both handling translations of international archetypes as well as handling local initiatives. It is called "Do-ocracy" where doers make the decisions, but where the reviews are initiated by the Editorial Group which also covers the recruitment of the reviewers to the national Clinical Knowledge Manager. The further approval is done by the Editorial Group if the requirements are met. The requirements are factors such as the right number of clinical specialists for the right archetype (national level) where all four regions are included. One of the leaders of the international CKM stated, "*the collaboration between the international and the Norwegian CKM is unique and all activities with archetypes in Norway is followed by the international society and vice versa."* She continued by saying, *"neither the CKM nor the consensus process is perfect and adjustments will be necessary along the way. Changes can be related to open-Source and Web based CKM/process where everything is stored open and is constantly evolving."*

Since the beginning in January 2014, NRUA first focused on the translation of already existing archetypes and observation-archetypes like blood pressure, body weight, nutritional risk, height, and temperature. During this period of time, national consensus has for instance been reached for the archetype Blood pressure, Screening of Nutritional Risk, and Body weight. In 2015 and the beginning of 2016 more complex archetypes like Evaluation and Cluster archetypes has been defined. Clinicians have been invited to participate through the national CKM after coordination between the regional groups and the secretariat at NRUA. Archetypes are used as standards for the clinical content of the EPR and it was important for clinicians to have an essential role in defining and designing them. One clinician said: "*It is crucial to include clinicians in this work; they have the clinical knowledge and know what is important to focus on, for the archetypes to be useful standards for clinical work."* The same clinician commented, "*If others than clinicians design the archetypes, it will be troublesome to get clinicians to accept and use them*. Other archetypes were also considered, all based on regional programs or initiatives such as a specific nursing registration scheme in the West Norway Regional Health authority, archetypes for national clinical registers, archetypes ordered by clinical work-groups with focus on the development of the new EPR system, and a number of archetypes ordered by cooperating vendors on a global level. In total, 39 archetypes have been approved in national consensus processes, and more than 100 archetypes are in process. The first archetype that reached national consensus was the Observation archetype for blood pressure; The clinical value of this archetype consists of all possible clinical values for data (systolic), state (score), events (24 hour blood pressure), protocol (Type of equipment). The archetypes in process are of different classes, observations, Actions, Compositions, Evaluations, and Clusters.

E. Terminology binding of archetypes

A key aspect of archetypes is that they can be annotated with terminological codes. Archetypes can be tagged with SNOMED-CT codes adding a standard term to each of the sections and nodes of the archetype. This includes, the archetype name to recognize it over organizational or even national borders. In turn, the information becomes interoperable for multiple purposes, and over several boundaries. This makes it essential that standardized terminologies for different domains can be integrated either in the archetype or in the EPR system. The use of a terminology like SNOMED-CT, which is widely exploited, increases the semantic interoperability on several levels, both for primary and for secondary use. The tag/code of the SNOMED-CT is enclosed in different systems and formats such as Medical Technical equipment for use in Medical Chart systems, and clinical specialist systems all bound to integrate with the EPR system of choice. This makes the terminology a mediator both on the national and global level. As an example; the Electronic Chart systems used in Norway/Europe are mostly based on structured data elements with a CIM, and the system needs to integrate structured elements from integrated systems to visualize the patient pathway, and for process and decision support. The integration with co-existing EPR systems is especially important. Medication, laboratory results, and the care plan have to be integrated in the same view to visualize the pathway. The Chart systems have a CIM for structured data elements that differs from the OpenEHR/archetype CIM intended to be used in Norway, and mapping between them demands unknown resources. In practice SNOMED-CT or other terminology can connect variables from the two systems to avoid problems with the mediation between the two different reference models if both CIM had included terminology. An internationally viable terminology like SNOMED-CT will make it possible to communicate information globally as long as it is implemented. When a patient contracts an illness when traveling abroad, healthcare personnel could get access to vital information by using the tags of SNOMED-CT to vital parameters in for instance a core

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health record. For secondary purposes, SNOMED-CT codes increases the scope and interoperability for clinical research, where a clinical trial could attract research communities outside the consisting parameters.

IV. DISCUSSION

Terminology standards are used on a daily basis in health care work. Still, we know little about the processes of how these terminologies come into being, and how they are co-constructed with daily work, (for further information on: how clinical terminologies are used to categorize/structure nursing diagnosis and interventions in a standardized nursing plan in Norwegian healthcare refer to [16]; the use of medical diagnosis through the use of ICD-9 to categorize medical diagnosis refer to [4]). On the contrary, structured data for secondary purposes has gained more attention, both for the use of archetypes and terminology (See [3]). Structured EPR data will make it possible for clinicians to categorize variables to build meaningful reports, to extract data for quality registers, and for clinical research. Structured data elements will also make it possible to organize information that supports process and decision support inside an integrated EPR portfolio, and the use of OpenEHR will support clinicians with a more open, adaptive, and collaborative system, which enables modelling of clinical content. Structured data, OpenEHR based, and tagged with Clinical terminology codes is opening new possibilities to obtain integrated care. Information becomes standardized and understandable between heterogeneous local practices, such as different wards in the same hospital, nationally through the repository of archetypes, and globally through primary or secondary use of terminology and archetypes. Further, the use of clinical terminology increases the semantic interoperability to integrate different CIMs. The portfolio of different EPR systems in Norwegian health care for instance needs to communicate structured information. This regards both information between integrated systems at the hospital (between the EPR and the electronic chart system), and between EPR systems in the specialist and primarily health care services.

A. Primary use of terminology

The integration of clinical terminology for use in EPR systems to support clinical practice has proven difficult to accomplish. With the use of archetypes, and a national governance of clinical variables through a common repository for structured data elements, there are future advantages of both semantic and interoperable character. Earlier research elaborates on how the categorical use of clinical terminology to structure nursing diagnosis and interventions in standardized nursing plans has been a success for increased quality and efficiency. However, the use of clinical terminology to categorized clinical documentation for enabling process- and decision support in the EPR portfolio is limited. In this sense, clinical terminology is used to support the primary health care process giving semantic meaning to the content of the clinical processes. The use of standardized nursing plans at a large scale in a Norwegian hospital showed clear advantages both for quality and efficiency. Furthermore, when information is tagged with the purpose to categorize such as with ICD-10 and medical diagnosis, the same information becomes available for secondary purposes. On the next level, any of these tagged nodes of information could be recirculated. Archetype based elements such as blood pressure, pulse, temperature, and laboratory data can also be used for primary purposes. Local, regional, or national coordinated process - and decision support will in the future be based on templates where these variables are put together, where mathematical matrixes calculate the risk for a given condition/disease. The national repository of archetypes is structured and standardized so that terminology could become superfluous. For instance, an archetype for use in a national clinical register is harvested from different EPR systems and the nodes used, such as diastolic and systolic for blood pressure, are prefixed in a template that is produced for the register. In this sense, the archetype could be used to solve a given interoperability challenge. Under conditions where the terminology was lacking, the structure, the semantics, and the demarcation of the archetype would cover the national requirements, but all global advantages would be absent.

B. Secondary use of terminology

At the same time as the primary information becomes interoperable, both as single archetype/terminology or intervened, the information becomes semantically interoperable for use in secondary settings. As an illustration, all information that is tagged with the nursing classification ICNP, both diagnosis and interventions, becomes sharable for secondary use. All the nursing diagnosis and interventions would be an object for clinical research on a national or global level which is a relatively unexploited research arena. For patient safety when traveling abroad, specialists need to view the core health record written in another language. For this setting, the terminology for earlier diagnosis and interventions could be compared and used for treatment and care. Another secondary use purpose is the integration between the functioning EPR system and various specialist systems and medical chart systems. The structured medical chart system has for instance a CIM that differ a lot from OpenEHR. To integrate values from the two systems clinical terminology as SNOMED-CT can be used as a mapping device. When all the systems are based on structured variables it becomes important that data elements with different reference models can be shared and recognized between them. For instance, the care plan is intended to be an interdisciplinary tool for categorizing documentation in the EPR. For this to become a success it would be important that structured information from other applications is used in the care plan even if the master system for the information is for instance the medical chart.

Equal for both cases is that information used for any given purpose on a local or national level can be reused with another purpose both locally, nationally, and globally. For the archetypes that are approved in the national governance processes, increasingly in number, and in the end a repository that includes a number of archetypes that support clinical work there will be a possibility for a terminology binding. An increasing number of archetypes, more than 1000 will in the end be accessible in an open repository, and each arche-

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type that is translated or modelled will be compared or reviewed with the purpose of being added to the global repository. For instance, the process of getting consensus on the observation archetype blood pressure started with a translation of the global standard, and ended with a new version that also is planned for the global or international repository.

C. The clinical information model

The diversity in standards, scope and methodology complicates the decision about adopting one standard or another for the definition of CIMs since it will influence the systems that can be deployed in the health network. Now, the preferred standards to define clinical models according to the literature are OpenEHR/ISO13606 archetypes, followed by HL7 templates. Therefore, in the near future it is expected to find an ecosystem where implementations based on different standards coexist. This may add a burden for those implementers that need to adapt from one standard to another. However, it is important to notice that the most valuable resource of a CIM is not the technical specification, but the conceptual model that it contains. The reason is that a CIM defines a way of combining clinical concepts together to build more complex conceptual structures beyond providing a format to express clinical information. For example, the archetype OpenEHR-EHR-CLUSTER.symptom_sign.v1 aggregates several granular concepts such as Body site, Episodicity, Impact etc. to build the more complex entity Symptom/Sign. This aggregation of concepts is more evident when the CIM is annotated with an international terminology. Reaching a consensus about the conceptual model of the CIM is the task that consumes most of the efforts of editorial teams since they need to coordinate professionals from different domains. Nevertheless, if the modelling work is appropriately performed, the conceptual model will be equivalent in most iso-semantic models.

As a consequence, once CIMs are defined in a particular standard, the conceptual model is clear and can be transformed to other representations/standards. In fact, that is the approach of openCIMI initiative which pursues the definition of CIMs that can be expressed in several formats such as CEMs, HL7 CDA or OWL by defining transformation functions among them. These transformations, although complex, are technical tasks that can be accomplished with much less effort than the definition of stable conceptual models. Transformations among standards vary in complexity, and the easiest case is the transformation from OpenEHR to ISO13606 that can be fully automated. In more difficult scenarios, the EU project SemanticHealthNet has provided insights to define an ontology based on the CIM conceptual model that allows the access to equivalent information hosted in repositories expressed with disparate information standards [16].

V. CONCLUSION

Currently several standards and terminologies are available for the specification and annotation of CIMs respectively. openEHR, HL7 CDA and ISO 13606 are examples of standards to define CIMs which in most cases are annotated with standard terminologies to enable their interoperability across systems.

With the parallel national initiatives running at this time in different countries, it is starting to become visible how the organization and size of countries influences their standardization efforts. On one hand, large countries with very heterogeneous health networks are aiming for the adoption of standards that allow sharing EHR information documents extracts. That is the case of Spain with ISO 13606 [17] or the US with HL7 CDA [18][19].

On the other hand, Norway is heading to the adoption of a nationwide EHR information architecture with openEHR that defines not only some relevant CIMs but the whole EHR information structure. Three are the factors that have influenced this direction of work. The first is the homogeneity in the market since only one vendor represents 80% of the market share in hospital. The second is the close collaboration between vendors and health authorities; this allows coordinating the definition of the whole information model of new systems. The third, and most determinant, is the body of knowledge already available in the international CKM that has fed the national CIMs definition pipeline with existing archetypes. This has accelerated their validation at a national level avoiding their definition from scratch.

At the moment, the Norwegian eHealth strategy has established a multidisciplinary community of vendors, governmental agencies and health organizations collaborating in order to define a nation-wide EPR information architecture. The knowledge management framework of OpenEHR supports to manage the national CKM. The OpenEHR governance model and the collaboration between the international and Norwegian CKM teams are proving to be effective to manage the definition of CIMs for the national eHealth strategy. On the technical side, the rich reference model provided by OpenEHR acts as a powerful modelling tool for the definition of CIMs. On the organizational side, the collaborative environment provided by the CKM is allowing to ensure the validity of the CIMs generated. As a result the National eHealth Department is providing the health informatics community a body of standard clinical models which allows implementers and researchers to define standard interoperable implementations on them.

The semantic interoperability gained from the use of both terminology and OpenEHR archetypes separately is a highly valuable asset. For instance, earlier studies in Norway have showed that clinical terminology has the potential to structure information of unstructured EPR systems. The ongoing national work also suggests that the combined use of archetypes and terminology further increases the semantic interoperability for connecting EPR systems on different layers of healthcare. Using for instance SNOMED "non-hierarchical" to tag the nodes of archetypes is interesting, and could be an integration advantage for vendors. It is a fact that both subjects complement each other's capacity to reach semantic interoperable.

Another "feature" that could increase the semantic interoperability is the growing possibility to use different Clinical Information Models to extract and share information from the National repository of archetypes/ clinical variables

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and content. The Government and the National e-health administration has decided to use different ICT systems in the primarily and specialist healthcare for several years to come. This requires a possibility to use clinical content from the national repository using another CIM specification standard than OpenEHR to extract and use semantic interoperable information. In this sense, the clinical model defined by an archetype can be represented in another standard by defining transformation rules among OpenEHR and the other standard. This way, the archetype-based repository becomes the reference common information 'ontology' or conceptual model used by different vendors regardless the standard, classes, and model they implemented.

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