

Innovative approaches and processes for capturing expert aged care knowledge for multiple purposes

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Abstract

Residential aged care is largely considered a 'green field' with regard to Information Technology (IT). Systems that already exist usually have their own system architectures, which results in a lack of interoperability within the aged care sector as a whole. The provision, administration and funding of aged care consist of a complex and varied set of arrangements which requires an IT infrastructure that meets the needs of many stakeholders including nurses and personal carers in the aged care residential sector. These health workers must be able to comply with contemporary best practice, and meet all quality and reporting requirements. In this scenario, the implementation of Electronic Health Records (EHRs) is a key strategy for improving the quality, safety and efficiency of residential aged care delivery. The openEHR approach (<http://www.openEHR.org>) is one of the most recognised approaches for EHR systems. The definition and use of aged care openEHR Archetypes (clinical models representing semantic constructs) can contribute to interoperability of EHRs as well as various health information systems. Based on a review of scientific literature, other relevant documents and stakeholder identification and consultation, this paper describes the current state of play with regard to EHRs in residential aged care. The paper further compares openEHR archetypes, clinical guidelines, terminologies and standards as well as the processes needed for their development to enable the capturing of expert aged care knowledge for multiple purposes. It is argued that a clear process capturing expert knowledge relevant to the aged care sector is required for the purpose of automating all data capture and enabling these data to be used to support clinical practice in accordance with aged care standards as well as to meet various reporting, management, research and planning requirements. This archetype development process should be based on existing clinical guidelines and standard development processes, and enable international collaboration where possible.

Keywords: Semantic interoperability, aged care, archetypes, openEHR, electronic health records, computerised medical record systems

1. Introduction

Australia's aged care system is structured around two main forms of care delivery, residential care and care

in the community, or a combination of the two. Residential aged care is financed and regulated by the Federal Government and provided mainly by the non-government sector (by both

non-profit and for-profit providers). All levels of Government, as well as consumers and the non-government sector, have some role in funding, administering or providing aged care

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for older Australians. Consequently the provision of aged care consists of a complex and varied set of arrangements. Information transfer is slowly being computerised to various degrees although there is poor system integration between all sectors within the health industry. Anecdotal evidence indicates that most existing clinical systems in use within the aged care sector have not been developed to enable the electronic extraction of data needed to meet the Government's reporting requirements. Many information systems developed to meet such reporting requirements are not perceived as useful at the point of care. Consequently, in the majority of aged care facilities, the same data are collected and documented many times in multiple systems [1]. Furthermore, administration of the Aged Care Act 1997 tends to require a lot of paperwork to manage this sector's expected information flow between various parties. Excessive documentation was estimated to cost the aged care industry \$142 million annually. A further issue is that much of the required documentation can only be provided by registered nurses, taking them away from providing direct care to the residents [2].

Collectively the aged care sector is the ninth largest employer in Australia. There are around 55,000 admissions per year maintaining a population of around 154,000 residents in care at any one time ([3], p.13). This can only increase as the Australian Productivity Commission estimates that by 2055 around 6 percent of our population will be aged 85 years and over, compared with 1.5 percent in 2005. Residential care can consist of low or high level care although, increasingly, homes are providing care that enables residents to progress from low to high level care in one place.

Young in a recent keynote address noted [4] that the adoption and use of Information and Communication Technologies (ICT) in the aged care sector is largely a 'green field' although software that integrates all residential aged care data to meet point of care and all reporting needs is now available. Better use of such knowledge can make a substantial difference to health out-

comes. Better use of information and communication technologies can make a significant difference in a nurse's use of documentation time and hence increase the time available for direct patient care. It is important to note that currently there are no national standards that such systems need to be compliant with. As a consequence current systems usually have their own system architectures, resulting in a lack of interoperability within the aged care sector as a whole. Australia is in the process of establishing the necessary requirements to enable us to adopt and use electronic health records (EHRs); this includes the residential aged care sector. It is necessary to enable data collection once only at the source to meet nursing and personal care assistants' needs and to enable the use of these data many times for multiple purposes at various levels within the residential aged care sector. As is the case in the health industry generally, it is also highly desirable for nurses and personal care assistants to be able to comply with contemporary best practice at the point of care in the aged care residential sector, and meet all quality and reporting requirements with the support of one fully integrated information system incorporating best practice protocols. The adoption of aged care *openEHR* Archetypes (clinical models representing semantic constructs) offers nurses and personal care assistants working within the residential aged care sector an opportunity to apply their expert knowledge and have this represented in a computer-processable format based on consensus to enable improved automation of clinical care data. Ultimately this provides the opportunity for data stored in local EHRs to be included in shared and longitudinal electronic health records.

It is the aim of this paper to:

- describe the current state of play with regard to Electronic Health Records in residential aged care;
- compare *openEHR* archetypes, clinical guidelines, terminologies and standards as well as the processes needed for their development to enable

the capturing of expert aged care knowledge for multiple purposes.

2. Electronic Health Records for Residential Aged Care

As noted previously, the adoption and use of ICT in the aged care sector is largely a 'green field' [4]. One example of an EHR project related to aged care is *Healthelink*, the first pilot of an Electronic Health Record for New South Wales. This has initially been made available for people aged 65 years or more and located in certain regions of NSW [5].

With regard to further current implementations that are indirectly related to the implementation of Electronic Health Records in the aged care sector, the Aged Care Association Australia lists a number of software products at their website (<http://agedcareassociation.com.au>). One example is Lee Care Plus, a care, lifestyle and operations management program (<http://www.leetotalcare.com>). This software requires the users to enter all data once only. For example aged care specific admission and assessment data are Resident Classification Scale (RCS) compatible. These same data form the beginning of a resident's total record used to produce care plans, quality reports, 1-3 monthly care evaluations, and to meet aged care accreditation requirements, and produce any 'user specific list' or plan as required. This software consists of an interactive computer-based nursing care plan that interfaces with assessment documents. This system was developed based on design specifications provided by a nurse with high level expertise and experience with all aged care administrative requirements and their associated complexity. This is in line with Curtis' law that states, "good designs require deep application domain knowledge" ([5], p.38). In addition, the ongoing 'Hospital in the Home' program, initiated as a pilot program in 1994 by the Victorian Government (<http://www.health.vic.gov.au/hith>), and any other initiatives like this would

benefit from widespread adoption of EHRs and semantic interoperability. Before this interoperability concept is explained in more detail we need to explore what an EHR consists of.

The 2004 ISO Technical Report ISO-TR20514 [6] is the most authoritative document to describe the electronic health record (EHR) as it has been developed through international consensus. An ‘integrated care EHR’ is defined (Clause 4.6.2) as:

‘a repository of information regarding the health status of a subject of care in computer processable form, stored and transmitted securely, and accessible by multiple authorised users. It has a standardised or commonly agreed logical information model which is independent of EHR systems. Its primary purpose is the support of continuing, efficient and quality integrated health care and it contains information which is retrospective, concurrent and prospective’.

The requirements for an EHR should ensure that it can be used, shared and exchanged between clinicians of all disciplines, across all sectors of health, different countries, and despite the adoption of different models of health care delivery. It should also support additional uses of the information contained in all EHRs such as for research, epidemiology, population health, health administration, financing, and health service planning purposes. Finally, the EHR should facilitate the evolution of existing systems as well as the construction of new systems.¹

The National E-Health Transition Authority (NEHTA) in Australia defines shared Electronic Health Records (SEHRs) as “records which will contain selected health information about an individual, which can be shared between multiple points of care while maintaining high standards of privacy and security” [7]. Its focus is on e-health systems “that can securely and efficiently exchange data”. This is seen as a prerequisite to significantly im-

prove our perception about the importance of communicating clinical and administrative information between healthcare professionals. It is important to note the difference in functionality between ‘records’ and ‘systems’. Records infer storage, systems are about using stored data, information and knowledge for multiple purposes including information exchange between systems. The NEHTA Fact sheet on clinical information [8] notes that “input and ownership by clinicians is critical for the adoption of clinical information standards”. NEHTA are adopting a top-down approach for this development whereas the work discussed in this paper is one attempt towards meeting this same requirement using a bottom-up approach. Furthermore, NEHTA’s work in this area is focused on acute medical care and has little relevance to the aged care sector or nursing care at this time. However, NEHTA will ‘harness and endorse emerging technologies (such as archetypes) which can help improve or accelerate interoperability and information exchange’ ([8], p.2).

In view of these requirements, it is important that EHRs and related systems developed for Aged Care are consistent and semantically interoperable with other EHRs and related systems – so that patient information can be sent, received and used by the receiving systems within the aged care sector as required. Thus, from a technology point of view, very little should be aged care specific in our opinion – it is all about getting the domain knowledge ‘right’ for the aged care sector. That is this domain knowledge needs to be presented in a manner that reflects reality and best practice. Such domain knowledge also needs to be presented in a manner that suits daily work processes by adequately enabling the system to meet carer documentation needs. This can be achieved via Aged Care information system adoption of *openEHR* archetypes.

Processes to systematically and consistently acquire the domain knowledge in the form of clinical models representing semantic constructs (*openEHR* archetypes) and to harmonise these models with other clinical domain models can be very similar (and in fact should be) throughout the health sector. The technology used for this development is the same. Processes to develop, maintain and manage this knowledge need to be put in place (see e.g. [9] for a more in-depth discussion of this aspect).

It is our expectation that eventually all new admissions to a residential aged care facility will be accompanied by an EHR or, at the very least, significant parts thereof such as current medications. The information contained within the EHR needs to be able to be imported electronically and used by the aged care facility’s information system to ensure continuity of care with minimum effort. To realise this vision requires a contribution to the development of an IT infrastructure that meets the needs of many stakeholders. There is a need to concentrate on developing a process to identify, document, implement, manage and govern the nursing domain knowledge as well as contribute to the development of relevant international standards for all stakeholders to make the most of associated emerging technologies and EHRs.

Nurses and personal care assistants who assess residents’ care requirements constitute a major group of direct care givers in any residential aged care setting. Such direct care givers also need information about the quality and outcomes of the care they have delivered. In Australia, this must be in accordance with the administrative requirements of the Aged Care Act 1977. Providing this type of information in formats that are readily accessible, timely and understandable is increasingly important in all health care organisations. In Australia, a national

¹ As *eJHI* is a journal for all health professions and informaticians, we feel that it is appropriate to refer readers not too familiar with the concept of EHRs to the Health and Nursing Informatics Resource Centre hosted by Central Queensland University at <http://healthinformatics.cqu.edu.au/hniresources>, which, among others, aggregates resources with regard to EHRs, as well as <http://healthinformatics.cqu.edu.au/projects/openEHR/openEHRLinks.htm> for useful links to understand the *openEHR* archetype approach in more detail.

framework for clinical information capture, storage, representation and use to underpin electronic health information interchange and to facilitate semantic interoperability of clinical information across the health system is under development.

3. Ensuring Semantic Interoperability for EHRs

3.1 Electronic Health Records based on *openEHR* Archetypes

Australia is one of the countries leading activities in the field of open Electronic Health Records (EHR), namely the *openEHR* approach. The *openEHR* foundation enables the development of open specifications and software for EHR systems via a two-level modelling software engineering approach. The first level is the reference information model which is pared down to the minimum to support the medico-legal requirements and record management functions for complex EHR systems. This essentially determines the system's architecture or design and ensures that clinicians can always send information to another site and receive information, which they can read – this is called *data interoperability*. The second level involves the *openEHR* archetype methodology – a way of sharing evolving clinical information so that it can be processed without loss of meaning at the new location – enabling *semantic interoperability* between systems. The latter requires the involvement of key information users to develop the necessary information constraint models containing all the rules that determine for example a range of values, or the unit of measure to be used, to ensure data capture validity. These models represent expert information or knowledge objects known as Archetypes and provide the capacity to manage up to date clinical knowledge.

Archetypes provide a relatively simple means for clinicians to specify the

structure, content and context of clinical information without becoming involved in how information technologists might implement this within an information system. *openEHR* archetypes are formally expressed by the Archetype Definition Language (ADL) but can also be expressed in html or xml. This determines how captured clinical data can be displayed and processed by a computer. Archetypes are electronically generated documents that provide an explicit approach for clinicians to handle data in a structured and context driven manner. Archetypes describe rich information structures by indicating:

- how the information is to be expressed
- what is optional and what is mandatory
- what is a sensible value for each data element and
- any other rules that need to be expressed.

Archetypes can improve aged care by:

- standardising clinical content and enabling the data to be interchangeable between systems
- empowering residents by enabling them to switch providers more easily without the need for multiple examinations and repeated tests
- improving access to relevant residents' information both for providers as well as possibly for residents
- providing the necessary flexibility to reflect resident care preferences through the development of *openEHR* archetypes
- enabling care providers to access best practice information as part of their everyday workflow and decision-making processes at the point of care.

Another advantage of using archetypes is that computers can, at the time of data entry, validate data and alert the user to any error as archetypes control data quality through their rules to a certain extent. Sharing of information requires the adoption of standard terminology and data structures within

standard archetypes.

Typically, different systems have been designed to serve the different functions within a health care setting. We know that defining a system's technical requirements for clinical users has always been an extremely difficult task. According to Glass's law, 'requirement deficiencies are the prime source of project failures' ([10], p.16). The adoption of archetypes replaces the need for providing these detailed technical requirements. The challenge is to design systems that can serve a range of functions and/or to integrate information systems such that semantic interoperability is achieved. System integration can be technologically difficult and tends to be costly [11] unless all systems comply with the same set of messaging/communication standards that:

- support medico-legal accountability and privacy
- enable fast information retrieval
- support unambiguous clinical information representation
- ensure that the EHR contains meaningful and valid information
- enable key patient information sharing between individual care providers
- facilitate communication regarding request/instruction activation or completion in shared care environments, and
- support the ability to extend the system to meet new information requirements without having to rebuild systems.

The *openEHR* approach of two-level modelling is able to meet these needs. This requires the development of archetypes to enable reliable sharing of clinical meaning in addition to providing guaranteed data interoperability.

The adoption of archetypes within aged care provides for ease of adoption of best practice, evidence-based data collection and usage norms supporting standard national data collections, accreditation and data sharing with general practices and hospitals. This will not only significantly close the 'evidence-based gap' but also greatly reduce software maintenance

and increase interoperability. This approach also provides a fundamental ‘change agent’ for Aged Care. Further, the development of archetypes can increase the documentation consistency between aged care service providers including the acute sector caring for aged clients not yet able to be placed in a more appropriate residential aged care setting (“bed-blockers”).

3.2 Towards Nationwide Semantic Interoperability

Greater standardisation of health information and knowledge representation needs to be achieved to make better use of the data and knowledge collected by health care organisations. The achievement of semantic interoperability requires a national adoption of a key set of standards consisting of a standard information model (system architecture or design), terminology, data types, unique patient/resident identifier and a unique individual and organisational provider identifier. Standard *openEHR* archetypes include the adoption of a standard terminology and a standard set of data types. They best fit with the *openEHR* information model but can be used to enable communication between systems with different information models to a variable extent resulting in variable degrees of interoperability between systems. Terminologies and data types are now discussed in greater detail as these relate to archetype development but any further discussion about unique identifiers is outside the scope of this paper.

The adoption of a standard way to represent both the meaning of information (a ‘normative’ reference or terminology) and the known place or context enables clinicians to share information in a form that computers can understand. Archetypes define the required data structures for individual knowledge objects but the concepts included in archetypes need to be represented or ‘labelled’ in a standard way as well. This may be achieved by adopting one of more known terminologies. Many terminologies have been developed to suit a variety

of purposes. Their effectiveness relates to a balance between the number of terms (size) and the specificity or level of detail (granularity). Provision is made for either cross-referencing concepts or by adopting more than one hierarchy for some single concepts within a terminology so that data can be retrieved consistently. Mapping based on complex rules between the terminology and its ontology (a defined structure of concepts within a domain,) is a critical step in achieving consistent reporting as the context of each concept within this structure defines the meaning (semantics). Mapping is about creating a semantic link between the ontology and terminology. This requires the adoption of a health language ontology such as the Systematised Nomenclature of Medicine (SNOMED) ontology (<http://www.snomed.org>) that clearly defines the concepts, their attributes and relationships to other concepts to which various terminologies can be mapped. SNOMED-CT is structured as a multiple inheritance hierarchy of concepts. It models concepts and their relationships to each other in clinical constructs. Terminologies tend to follow a variety of different structures frequently making this mapping process a challenging task. An in-depth discussion on the relationship between *openEHR* and archetypes to clinical terminologies like SNOMED-CT can be found in [9].

Coding and classification systems help to standardise the collection of health information to suit specific purposes such as resource allocation. They aim to define specific concepts within confined contexts. Understanding context is critical to the communication of meaning or semantic value. “Any meaningful exchange of utterances depends on the prior existence of an agreed set of semantic and syntactic rules” [12]. On a lower level, data types are essential technical specifications of the way different types of data are entered and handled in information systems.

Data types are fundamental building blocks of computer software, electronic messaging, and the EHR. A data type is defined by CEN/TS14796 as a

‘set of distinct values, characterised by properties of those values and by operations on those values’. The *openEHR* set of data types are the most comprehensive and best able to accommodate clinical data. A small team of Australian experts is engaged internationally in identifying a common standard set of health data types and encouraging their adoption into international standards. The result of this work is expected to go through the ISO TC215 committee for an international ballot in the very near future. Current clinical information systems tend not to have adopted standard data models, or data types due to this lack of agreed standards. Indeed, clinical information systems tend to be vendor specific, and so data sharing between many systems is difficult if not impossible to implement.

One way of overcoming this difficulty is via the adoption of standard structured messages that are compliant with messaging standards such as those developed by the Health Level 7 (HL7) organisation (<http://www.hl7.org>) and its many international affiliates. This is most successful between two systems but very complicated when multiple systems need to be connected. It works when there are limited and pre-determined communication requirements, such as for pathology orders and results or for electronic messages for the exchange of information on drug prescription. Standards Australia has developed a number of HL7 standard implementation guidelines, see <http://e-health.standards.org.au/>.

A major infrastructure project on data definitions and standards is being managed by a number of national entities such as the Canadian Institute for Health Information (CIHI) and the Australian Institute of Health and Welfare (AIHW). Data dictionaries are one tool used to promote the standardisation of data. The Australian National Health Data Dictionary (NHDD) is a repository of data standards, including clinical data specifications. This is governed by the National Health Data Standards Committee. The AIHW have re-engineered metadata content to develop the Metadata Online Registry

(METeOR, <http://meteor.aihw.gov.au>). This registry is Australia's central repository for health, community services and housing assistance metadata, enabling all people collecting, using and exchanging data to share the same understanding of its meaning and representation.

Much standards development work is continuing internationally with considerable Australian input to enable effective electronic communication as required for widespread EHR adoption. In particular the European standard, EN-ISO 13606-1 Electronic Health Record Communication, originally a 4-part standard is now being enhanced to become a 5-part standard by adopting the *openEHR* two-level modelling approach in a limited way. Part 2: Archetype Model has been drafted and is available via the wiki established in August 2006 to facilitate the sharing of clinical information models (<http://detailedclinicalmodels.org/wiki>). This is arguably the single most important standard requiring international consensus as it defines the fundamental EHR infrastructure requirements [13]. *openEHR* uses archetypes to model the clinical content of EHRs that is completely separate from any technical design issues for an EHR system.

Through the adoption of archetypes, all clinical and other domain-specific knowledge that frequently changes now resides in archetypes outside the software. Such domain specific knowledge can be expressed and shared using the Archetype Definition Language (ADL) or html or xml. Their link to a particular data model such as the one defined by EN-ISO 13606 or by the *openEHR* foundation, provides the basis for querying information. Researchers from a number of countries are in the process of developing the necessary infrastructures enabling the design and implementation of Electronic Health Records (EHRs). This includes knowledge capture via clinical business analysis processes into computer-processable formats.

For example, Scotland is undertaking the development of a library of clinical templates for nursing in the community along with a national clinical dataset

development program. These templates are essentially information models derived from domain models; see the clinical templates website (<http://www.clintemplate.org>). Not only do these templates document the knowledge domain but they also point to the evidence base for this knowledge, as well as to recommendations for its use in practice. They include a notation about the template developer and last review date. The UK National Health Service (NHS) has established a clinical terminology service to provide support for users of SNOMED-CT and all versions of the Read codes (<http://www.connectingforhealth.nhs.uk/terminology/snomed>). Their nursing representative is a member of the SNOMED Nursing Working Group who have undertaken the mapping and managing of the American Nursing Association's (ANA) recognised standardised nursing classifications to SNOMED to provide a reference terminology. HL7 also have a project to overcome conflicting semantics between SNOMED-CT and HL7 term codes. This Terminology project is jointly sponsored by the HL7 Vocabulary Committee and SNOMED International [14].

The Netherlands, the NHS and many within the USA have adopted the HL7 version 3 communication standard and are in the process of developing and documenting care provision models relevant to specific Domain Message Information Models within which rules for messaging are applied and documented as Refined Message Information Model (R-MIM) displaying the structure of clinical messages in a colour coded model. R-MIMs are used to design messages and to explain what each HL7 message consists of. In August 2006 the Intermountain Hospital in Salt Lake City, Utah, USA took steps to establish an international repository for detailed clinical models, a generic term for clinical information models such as *openEHR* Archetypes, HL7 Templates, or Intermountain Healthcare's Clinical Elements. (<http://detailedclinicalmodels.org/wiki/index.php?title=Glossary>). Canada is another world leader with its EHRS Blueprint (Electronic Health Record

Solution Blueprint) (<http://www.infoway-inforoute.ca>) that describes the business and technical architecture of EHR solutions to be implemented across Canada. This document guides the development of EHR solutions, helps jurisdictions develop their own technical roadmaps at lower costs and is freely available from the Infoway website.

4. Development of *openEHR* Archetypes for Residential Aged Care

Generally speaking, the nursing domain knowledge is complex and applies to all areas of healthcare. Its knowledge concepts can be represented in multiple ways using any one of many terminologies or coding systems as discussed in more detail in section 4.3. Expert clinical nurses need to be able to document their application knowledge in a manner that enables system design engineers to understand the problems to be solved so that EHRs and other clinical systems meet operational clinical practice needs. Furthermore, such systems need to be able to transfer data, information and knowledge between systems without loss of meaning to compile EHRs. This is known as 'semantic interoperability' as discussed previously. In 1991, Booch formulated a hypothesis that an 'object model reduces communication problems between analysts and users' ([10], p.25). Since then this has been widely applied to design and requirements analysis. With the release of *openEHR* 1.0, there now is a common model available to solve some of the problems related to accessing information and knowledge by improving semantic interoperability between clinical systems. This can maximise the use of future electronic health records and enable the building of sustainable data collection systems that meet all users' needs.

The development of Residential Aged Care *openEHR* archetypes and the development of a standard archetype development process will inform

clinical knowledge governance as Australia moves to implement networked clinical information systems and electronic health records facilitating shared care. Expected outcomes within the residential aged care sector include making use of clinical information systems to:

- support decision making to ensure that all residents' care needs are met
- monitor organisational performance in accordance with the aged care accreditation standards as prescribed by the Australian Government
- provide the evidence to support funding claims in accordance with the Resident

Classification Scale (RCS)

- establish expert knowledge governance processes through the standardisation of aged care related archetypes, concept representation (terminology) and archetype maintenance.

The Aged Care sector has been supporting a clinical information program alongside other reforms in the aged care sector with regard to patient documentation, standards for quality of care, and claiming over several years. There have been several scoping exercises to understand the role of IT in the Aged Care process in nursing homes. It is our understanding that there is a Transition and Technology

Consultative Group operating between the Australian Department of Health and Aging (DoHA) and the Aged Care IT industry and that a current project is underway with CHIK services on "Industry readiness" for new information management systems. The context within which the latter work is occurring with some State Government and Church/Charity input in the largely privately run Aged care sector, is best described by listing the factors placing increasing pressure on them. These factors are:

- maintenance of clinical and personal care standards
- increasing age, frailty and complexity of residents
- need for avoidance of hospital

Publisher	Title	Year	URL
The Aged Care Standards and Accreditation Agency Ltd	Measurement, Data and Information for Residential Aged Care	2006	http://www.accreditation.org.au/DataMeasurementEducationPackage
Australian Government Department of Health and Ageing	Documentation and Accountability Manual	2005	http://www.health.gov.au/internet/wcms/publishing.nsf/Content/ageing-manuals-dam-damindex.htm
Australian Government Department of Health and Ageing	Residential Care Manual	2005	http://www.health.gov.au/internet/wcms/publishing.nsf/Content/ageing-manuals-rcm-rcmindx1.htm
Australian Government Department of Health and Ageing	Investing in Australia's Aged Care	2004	http://www.health.gov.au/internet/wcms/publishing.nsf/Content/health-investinginagedcare-book-index.htm
Australian Government Department of Health and Ageing	Standards and Guidelines for Residential Aged Care Services Manual	2001	http://www.health.gov.au/internet/wcms/publishing.nsf/Content/ageing-manuals-sgr-sgrindex.htm
Australian Government Department of Health and Ageing	The Guide: Implementing Occupational Health and Safety in Residential Aged Care	2000	http://www.health.gov.au/internet/wcms/publishing.nsf/Content/ageing-manuals-ohs-ohsindex.htm

Table 1: A selection of agenda items that need to be taken into account for any development of Aged Care archetypes (or comparable models) within the Australian context.

- admissions, speedy recovery and return from hospital
- ageing workforce - relatively untrained with respect to healthcare
- workforce shortages of GPs and nurses
- movement to payment systems based on patient care needs, complexity and need to assess and audit such claims
- a relative under-use of electronic information management and communication systems.

Any development of Aged Care archetypes needs to be undertaken within this context. The many stakeholders need to collaborate to ensure that an outcome that is consistent with these agendas will be achieved. For a selection of these agendas within the Australian context, refer to Table 1.

A key issue is the need to evaluate known problems with the use of Clinical Data Sets without the use of a common model like *openEHR* underpinning them (for example: incompatible basic data types and overlapping and incompatible definitions of clinical content, [15]).

To realise the described outcomes, Central Queensland University is working closely with Djerriwarrh Health Services and Austin Health, Centre for Applied Clinical Informatics, in the first instance through informal discussions, teleconferences and an analysis of relevant clinical documentation and clinical knowledge associated with assessment. This is being complemented by an extensive literature review as well as the extraction of topics from the national aged care (accreditation) outcome standards, existing legislation, and relevant documentation available online from the Australian Government Department of Health and Ageing. Advice will be sought from the Health Data Standards Committee regarding data submissions for inclusion into the National Health Data Dictionary that have significant clinical content.

The aim of this collaboration is to develop a process for capturing expert knowledge relevant to the aged care sector for the purpose of automating

all data capture and enabling these data to be used to support clinical practice in accordance with aged care standards as well as to meet various reporting, management, research and planning requirements. A solution to these problems based on *openEHR* archetypes will be explored and a detailed standard process to capture domain knowledge defined. Our focus is on archetype development to capture domain knowledge relevant to the aged care sector in a manner that will facilitate multiple uses by many stakeholders of the information and knowledge captured in this way.

Ideally, the nursing profession would develop its domain knowledge constraint models collaboratively in an *international* context through the following process (Please note that our current activities are limited to Australia):

- List aged care knowledge topics requiring archetypes (constraint models)
- List aged care related information user stakeholders
- Develop archetypes to suit topics listed and gain consensus from aged care experts such that these archetypes can meet multiple purpose national information needs
- Develop a governing process to minimise redundancy by comparing these new archetypes with existing archetypes and integrating these where necessary to suit multiple disciplines
- Deposit final aged care specific archetypes at the national standard archetype repositories once approved by relevant professional organisations representing aged care expertise

- Develop a mechanism that enables international nursing knowledge sharing via the use of an agreed standard presentation format of nursing care models.

5. Archetypes vs. Guidelines, Standards and Terminologies: A High-level Comparison of Required Processes

A process for archetype development could be based on the integration of two existing processes for capturing expert clinical knowledge. The first is the process adopted for the development of clinical practice guidelines; the second is a consensus-based standards development process. Archetypes need to be evidence-based and be adopted as a standard representation of knowledge objects. Aged care guidelines are available from a number of different sources, for example in a textbook [16] or at the Aged Care – Easy Care, Clinical Practice Guidelines website (<http://www.ciap.health.nsw.gov.au/guidelines/aged.html>).

In addition, the clinical concepts represented within archetypes need to be represented in a standard way and appropriately linked to clinical terminologies. We shall now examine these three key characteristics in sections 5.1 to 5.3.

5.1 Clinical Practice Guideline vs. Archetype development

The process of credible and usable guideline development has the follow-

Practice Guideline Development	
1.	Means for setting priorities among topics for guideline (archetype) development
2.	Procedures for securing thoughtful and useful statements of expert judgments
3.	Methods for analysing and rating scientific evidence
4.	Mechanisms for identifying and evaluating inconsistent or conflicting guidelines

Table 2: Procedural and Methodological Issues

ing attributes: clarity, multidisciplinary, schedule review and documentation ([17], p.29). The US Institute of Medicine's Committee on Clinical Practice Guidelines identified six procedural and methodological issues needing particular attention ([17], p.201). Four of these apply equally to the development of archetypes; see Table 2 for details.

The National Health and Medical Research Council (NHMRC) recommends that guidelines

"should be developed by a multidisciplinary guideline development committee, the initial task of which is to determine the need for and scope of the guidelines, define the purpose and target audience and identify the health outcomes that will improve as a result of their implementation" ([18] p.1)

Another main principle noted was that guidelines need to be based on the best available evidence, thus any development committee needs to locate the best available evidence. Both the multidisciplinary approach and use of evidence apply to archetype development. The NHMRC has produced a handbook detailing how to review evidence as part of their handbook series on preparing clinical practice guidelines. However, the clinical knowledge represented in archetypes differs from practice guideline representation. Clinical practice guidelines require evidence about appropriate interventions to solve specific clinical problems, whereas archetypes require evidence about the fundamental knowledge object, including the specifics detailing how each aspect of an intervention is undertaken and documented. Archetypes require evidence associated with far more detailed concepts such as rules, measurement ranges, data types, presentation formats, most appropriate data representation (terminology, codes), ontology, data to be included to assist decision making, data integrity constraints and allowed units with associated numeric ranges. Examples are the use and documentation of the Barthel index or the Apgar score or various aspects of drug administration or pain management. Archetypes are content models defined in terms of domain base concept models.

According to Leslie and Heard [19], the information in each archetype should be able to be interpreted in isolation and be as complete as possible to suit multiple sectors, purposes and priorities. Developing or building archetypes consists of the following collaborative processes:

- Brainstorm.
- Consider the clinical concept from all angles.
- Source all possible content such as datasets, the Internet, textbooks/publications, other clinical experts.
- Produce a mindmap.
- Organise by focusing on the identification of data elements, protocol, state, allowable events, pathway steps, concepts needing coding/terminology.
- Re-use existing archetypes where possible.
- Map to existing archetypes.
- Combine multiple archetypes within larger composite archetypes or templates.
- Overlapping concepts, where possible, should be resolved into a set of archetypes which do not overlap. This may require the specialisation of some archetypes.

5.2 Standards Development Process vs. Archetype Standards Development

Standards Australia defines a standard as:

"a published document which sets out specifications and procedures designed to ensure that a material, product, method, or service is fit for its purpose and consistently performs in the way it was intended. Standards establish a common language which defines quality and establishes safety criteria. Standards and conformance are keys used to ensure the quality and consistency of physical, chemical, and biological measurements throughout Australian society and the economy" (<http://standards.org.au/cat.asp?catid=2>).

The development of a new standard or the revision, amendment or with-

drawal of an existing standard can be triggered by a source external to any accredited standards development organisation, such as any government, industry, trade association, professional body, consumer organisation or an individual. Such proposals may or may not proceed through Standards Australia, depending upon their likely contribution to the relevant industry, employment, safety, health or efficient use of resources, their appropriateness, political, social or commercial considerations, likely legislative links, and harmonisation potential as well as internal capacity ([20], p.8). The actual development is an open, transparent consensus-based process undertaken by an expert working group or technical committee (TC) consisting of members who collectively provide balanced representation of the broadest spectrum of interests. A first draft, based on sound industrial and scientific experience, is made available for public comment. Responses are then considered by the TC and, if necessary, modifications are made prior to going through a ballot process to demonstrate substantial agreement. Standards are published once accepted. Most are voluntary although many are mandatory as a result of legislative inclusion. Professional and other bodies can be recognised as accredited standards development organisations which are not required to have procedures and structures identical to Standards Australia. However, the standards development process needs to be able to demonstrate "the same credibility, by ensuring balanced representation on committees, transparency and openness in the application of procedures, and decisions by agreed consensus" ([20], p.16) in accordance with the processes adopted by Standards Australia.

Such a development process is yet to be established for archetype standardisation. To enable the processing and analysis of health records inside any one system in an environment where such records originate from heterogeneous record sources, rich semantic interoperability between systems is essential, according to Beale and Kalra [21]. Such interoperability is necessary so that

the record content can be confidently used by clinical applications, within messages, for decision support, public health and research. This requires the development and use of consistent and rigorous archetypes that standardise the clinical content of all EHR Entries. Such archetypes need to be designed optimally for each clinical area and be consistent across authoring teams. Archetype development must be coordinated through “Domain Knowledge Governance” defined as “comprising all tasks related to establishing or influencing formal and informal organisational mechanisms and structures in order to systematically influence the building, dissemination, and maintaining of knowledge within and between domains” [22]. Archetypes that reflect the knowledge of specific clinical knowledge domains can only be defined and maintained by the profession that specialises in that area of practice.

Most of the archetypes suitable for the aged care sector have to be built by a relatively small group of expert clinicians. Other groups of clinicians can then easily extend and adapt these archetypes to their needs. The *openEHR* Archetype Editor was built as a tool to support the domain experts’ development of archetypes. This editor provides an easy-to-use graphical user interface. As a consequence, clinical domain experts can and need to take charge of managing their domain knowledge. However, as argued initially in [22], archetype development and maintenance has to be systematically organised - through the adoption of systematic domain knowledge governance. This has recently been supported by Australia’s National E-Health Transaction Authority (NEHTA), stating that ‘undisciplined creation and application of archetypes threatens the goal of semantic interoperability’ [23]. It needs to be transparent, repeatable in a hierarchical organisational model and with agreement at every level, led by a multidisciplinary team of experts, in-

clude formal quality control measures, and provide references where appropriate. Domain knowledge governance will ensure that archetypes will meet the information needs of the various areas. Redundancy is minimised and semantic interoperability vastly increased.

Once a set of archetypes has been drafted, national consensus needs to be gained through the relevant professional organisations with the responsibility for governing the relevant domains. Initial drafts need to be evaluated via the conduct of interviews with experts and multidisciplinary focus group discussions. This needs to be followed up with a national Delphi study of aged care experts to agree on the key clinical concepts to be included in aged care information systems and EHRs. The Delphi technique will allow us to elicit information and judgements from a greater number of experts to reach consensus. The principles identified then need to be incorporated into the management framework so that clinical experts can *systematically* develop archetypes that fit all clinical domains.

For all this, an archetype ontology is required to map individual archetypes to a generic knowledge framework. To support domain knowledge governance with information technology, the Web Ontology Language (OWL) [24] and the Protégé OWL Plug-In were used to develop and maintain an Archetype Ontology which provides the necessary meta-information on archetypes for Domain Knowledge Governance as detailed previously. In addition, we used Borland JBuilder X® as Integrated Development Environment, Java™ Servlet 2.3 Technology, and Apache Tomcat 4.1.31 as servlet container.

This archetype ontology includes information such as the EHR class of the archetype (for example: Observation, Evaluation, Instruction), the purpose of the archetype (for example Chronic Disease Management), or the age group of the patient to which the archetype is applicable. Some of this

information, such as the EHR class, is expressed within the archetype itself. Other information, such as the age group, can only be formally expressed in the Protégé knowledge base. In addition, the domain such as residential aged care to which the archetype is relevant is included.

Based on this ontology, one of the authors (SG) in collaboration with Ocean Informatics developed a web-based Archetype Finder² to support the user in easily locating and accessing archetypes. This user interface is generically built based on the archetype ontology, i.e. changes in structure and content of the archetype ontology are immediately reflected in the Archetype Finder without modifications to the software. After specifying the requested properties of archetypes, the Archetype Finder searches the ontology and presents an overview of all matching archetypes. Usage experience in Australia shows that the Archetype Finder is one of the fastest ways to locate and access archetypes. This Archetype Finder is currently being expanded into a comprehensive Archetype Repository and will also include further mechanisms to support Domain Knowledge Governance with a clear process for authoring, updating, managing, and disseminating knowledge in archetypes as well as archetype version control. This aspect is discussed in more detail in [9].

5.3 Archetypes vs. Clinical Concept Representation and Clinical Terminologies

Terms within an archetype can be bound to or constrained by any number of terminologies or, if highly specific to the archetyped concept, they can be specified within the archetype itself. In contrast to terminologies, archetypes specify groups of data that are whole, discrete, highly related and clinically meaningful concepts like a blood pressure measurement consisting of the diastolic and systolic blood pressure, but also of any other information relevant for the interpretation

² The Archetype Finder is available online at <http://www.archetypes.com.au>

of the readings, such as the position of the patient during the blood pressure measurement [9].

SNOMED-CT has been endorsed by NEHTA as the national core terminology to be adopted. Thus, there is a need to translate or map all concepts included in archetypes to SNOMED-CT terms where possible and identify gaps. Australia's adoption of this terminology allows for inclusion at the national (and enterprise) level of additional concepts and terms as "SNOMED local extensions". Such extensions may be the addition of occasional missing concepts, additional descriptors or terms for existing concepts or could represent entire terminology areas where SNOMED is lacking. A current consultancy project is underway to determine the suitability of SNOMED-CT as a clinical terminology resource for Australian Government-funded aged care services.

Every health professional has command of a body of knowledge that needs constant updating. Professional organisational intellect is said to operate at four levels that increase in value. This intellect relates to: cognitive knowledge (know what), advanced skills (know how), systems understanding (know why) and self-motivated creativity (care why), where the last level is needed for people to adopt change [25]. Knowledge represents intellectual assets that are of primary importance in the safe provision of quality health care. The dimensions of knowledge generation and its management have huge implications for the health industry. Knowledge management requires the adoption of a set of processes that enable the creation, capture, organisation, sharing, dissemination and use of knowledge, including the use of data mining tools.

Models of clinical or other domain-specific concepts like archetypes need to adopt a standard set of terms to represent all concepts contained within each knowledge model. These terms can come from any number of terminologies. Such models specify groups of data that are discrete, highly related and clinically meaningful. They define the business rules (constraints) for valid values and they use terminol-

ogy to identify components within a model. They enable information to be specified in a far more complex form than is possible in message structures. In addition, they can evolve over time yet remain standardised. There is no need to only use one terminology as the term that best describes the relevant concept is adopted within the model by formally expressing the combination (context) of data. Such knowledge models and the concepts identified within them can be represented in a variety of ways.

The term 'ontology' in the field of health concept representation describes how these concepts and the reality they attempt to describe are to be represented. For example, terminologies, classifications, knowledge bases, nomenclatures etc are all examples of attempts to represent an ontology (Australian Standard AS 5021 - 2004). Ideally, an ontological approach is used to write up archetypes such that they accurately reflect domain knowledge. Such knowledge needs to be based on evidence or best practice although it can include 'tacit' knowledge acquired by experts and agreed to by consensus. A good example of this is the work undertaken in the European based WISECARE project [26].

The authors suggest that the current full draft international ISO standard - integration of a reference terminology model [27] for nursing - be used as the basis for such a framework, as this provides the conceptual structures as represented in a reference terminology model. This standard consists of reference terminology models for nursing diagnosis and nursing actions and reflects attempts at harmonisation with evolving terminology and information model standards outside the domain of nursing.

6. Discussion and Conclusion

The aged care sector is characterised as consisting of a complex, resource intensive, highly regulated and challenging working environment. The availability of detailed and clinically

relevant information is essential for many clinical care and resource allocation decisions that affect the quality of patient and residential aged care. Cost-effective, high-quality residential aged care is information intensive and dependant on the availability and use of timely, quality information. In this context, the implementation of EHRs is a key strategy for improving the quality, safety and efficiency of residential aged care delivery. The diversity and complexity of clinical data imposes a significant need and challenge for semantic interoperability of various computer systems.

A framework must be in place for developing, managing and maintaining archetypes and identifying those that are applicable nationally. Overlapping archetypes and therefore redundancy needs to be kept to a minimum. For this, multidisciplinary teams need to be established in order to ensure that those archetypes meet the needs of as many clinical groups as possible. Funding is needed to replace clinical staff while they are engaging in this process. This process is expected to be very time consuming as staff need a fair amount of education prior to being able to fully engage in archetype development and the number of archetypes needed to meet all Aged Care information requirements. Our approach as described can be viewed as an in-depth business analysis for developing a national information system that contains health information about the residential aged care population. This study will provide clear directions for clinicians to identify their information needs for EHR developments. Meeting these needs is expected to minimise the risk of resident safety and health IT system failure by reducing the "rationality-reality gap" between information system user needs, and those needs actually met by these systems.

The proposed archetype management framework will facilitate the development of future information systems and optimise electronic health records within the aged care sector. It will enable electronic health records to accurately and comprehensively document residential aged care and support clinical

cal decision-making. It will also enable the discovery of new clinical knowledge to improve safe and individual care and result in cost savings by streamlining residential care processes avoiding unnecessary procedures.

Our results will enable software developers to develop the technical infrastructure for electronic health record systems, while domain experts provide the content they need for safe care delivery. Obviously, as clinical domains and specialities overlap significantly, domain experts need guidance in the process of developing a whole repository of archetypes: Archetypes have to be standardised as much as necessary while allowing for as much flexibility as possible. Once an archetype is defined, it should be submitted to the Clinical Review Board of *openEHR*, as archetype development should be coordinated to avoid incompatible archetypes for the same concept by systematic Domain Knowledge Governance and to obtain semantically interoperable systems. Only then can overlapping concepts or otherwise incompatible archetypes be avoided. As each archetype forms a clearly defined semantic unit that expresses one clinical concept, archetypes enable knowledge to be governed within clearly defined boundaries.

To the best of our knowledge, this study is the first of this type in Australia and the world. This is expected to provide solutions for healthcare professionals to have access to accurate and comprehensive information available at the point of care. The resulting new framework for the identification of standardised clinical data needed to support decision-making and the transferability across other clinical knowledge domains is expected to benefit many. It will facilitate an optimum use of information systems, including clinical knowledge discovery that can be adopted by clinicians in any practice setting. The key innovation of this study is that it enables clinicians as healthcare professionals to actively and systematically engage in content definition of electronic health records without recourse to the technical jargon used by software developers. This is crucial since clinicians

are often reluctant to engage in any aspects of their work related to technology due to the mismatch with the patient care delivery approach. Until now, content of an electronic health record for clinicians and technology development were invariably mixed up.

Applications using the results of this work are expected to be able to electronically transfer, share, exchange and meaningfully use all captured aged care information within decision support systems, enable the mapping to an electronic knowledge base, facilitate regulatory reporting, undertake population surveillance, evaluate clinical practice and analyse outcomes by entering data once only and enabling its use many times to meet multiple information needs at various locations via semantic system interoperability.

The research will have ramifications both nationally and internationally as this research team is a primary contributor to the international detailed clinical models (archetype development) group established in August 2006 (http://www.detailedclinicalmodels.org/wiki/index.php?title=Main_Page). The purpose of this group is to facilitate the sharing of clinical information models. The real world experiences encountered by all members of this group are shared via a mailing list, teleconferences, meetings and this wiki webpage so that we continue to learn from each other. We avoid re-inventing the wheel by sharing our work. With Australia being one of the most prominent international players in the field of electronic health records, this group enables international knowledge transfer to be realised.

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