

# Many to One: Analysis of Information Models for Telemedicine in Patient Centric Perspective

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**Abstract:** ICT enablement of information sharing and exchange between health employees and citizens across organizations and private homes is one of the mechanisms to enhance patient empowerment. However, heterogeneity of information models and the employee-centric nature of most healthcare systems make information exchange, with a focus on the interests of patients, non-trivial. For example, it is not clear how the free-text and patient initiated interaction features of emerging patient empowering telemedicine can integrate to the many employee centric systems with heterogeneous information models.

From the perspectives of enabling patients' read/write initiatives across health related standards, from a unified interface, we conduct analysis of the following information domains that support: (A) healthcare employees and are specific to formal procedures inside a healthcare scope; (B) patient and care givers and are also specific to formal procedures in a healthcare scope; (C) any group and are outside the scope; In particular, we look at: (A) Shared Medicine Card (SMC) – a standard embedded in a Danish national service for management of citizens' medicine; (A) HL7 CDA and (B) PHMR, which are international standards for clinical document exchange; (B) Data Set for Chronically Ill (DSCI) – a national proposal for a standardized exchange of notes on e.g., lab results, diagnosis of long-term patients; C) iCalendar – international standard for calendar events.

Analysis is made with purpose of investigating requirements for the design and implementation of a patient centric information model that will enable patients to read and write information from a unified integration point or service interface and further contribute knowledge on patient empowerment through proof of concept demonstrators. In this paper the emphasis is placed on: analysis of glossary of concepts and equivalence relations for the standards. Further details on investigation of requirements for the future patient-centric model, architecture support and demonstrators can be traced at [telehealth.dk](http://telehealth.dk).

## Introduction

According to ethnographic studies on the use of telemedicine, patients who make status notes on health, have a better understanding of their health. For example, eDagbogen [1] for the pregnant woman with diabetes, allow patients to make their own status notes.

However, there is no simple way to integrate the patient centric systems like eDagbogen with the traditional medical IT systems, since there are no service interfaces from the technological perspective that could enable patients to navigate across or annotate existing heterogeneous health documents in a generic way and most of the patient involvement is framed into specific questionnaires, diaries or calendar slots of health employees. The project (telehealth.dk) aims at demonstrating opportunities of enabling patient initiated interactions e.g., generic read/write, by designing and implementing shared service interface, information model and middleware support for the above-mentioned national and international standards.

### Information Model Analysis

Investigation of information models is made through: conceptual, user/external and the computer/internal views [2]. The three-view approach, allow to better understand the purpose, strength and weaknesses of models in a patient centric perspective. XMLSpy EE was used to analyze XML schemas, instances, identify equivalence groups, user views and mappings. *Computer View*: The table below summarize on quantitative analysis of XML schemas of the domains. E.g., SMC, for exchange of medicine cards

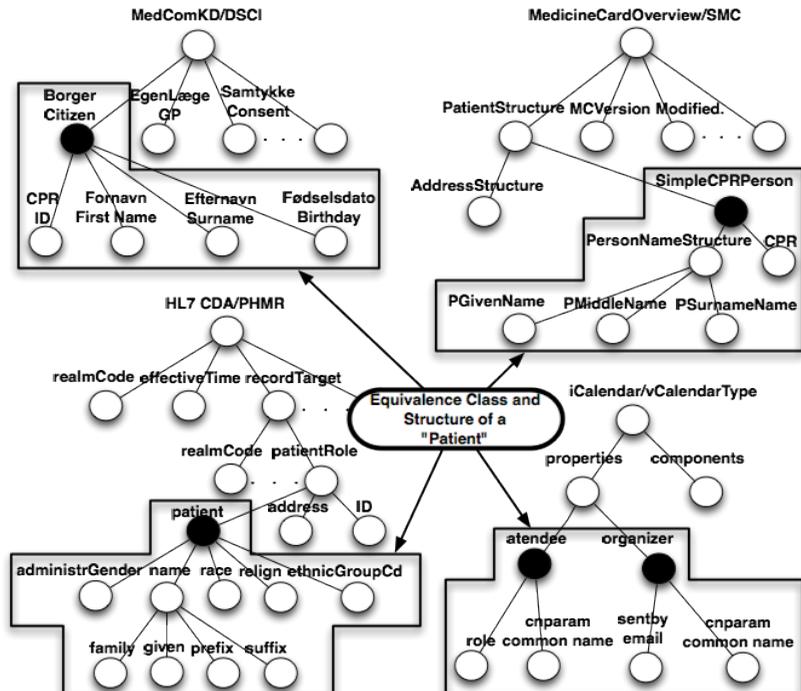
Standards/Terms	SMC	DSCI	HL7CDA	iCalendar	Total
#Elm/types	441	128	1526	309	<b>2454</b>
#XSD modules	600	1	6	9	616

and overview, uses 600 schemas to describe its domain (last row). DSCI for exchange of data of long-term patients uses a single schema (column 3). The most quantitatively heavy information model is the one of HL7 CDA/PHMR (hl7.org), which includes more than thousand terms. If the shared interface should support: navigation and search and annotation across documents, a join of all model elements, would be one approach. However, a join would result in 2454 terms, for use in the service interface. This could negatively influence the quality of meaningful navigation and search across documents, e.g. a search for “Surayya” would return a whole document, instead of parts that describe a “Patient”. Hence, we propose to identify equivalence groups for diverse information models. Note, the proposed concept, known as annotations or tagging, relies on equivalence relations between heterogeneous information models, while the support of ease of navigation relies on the tree-based structure of XML documents. Finally, the possibility of querying and getting meaningful results is based on the keywords and future evolution of groups. Next, we present a simplified view, in Backus Normal Form (BNF) of the models.

MedComKD := PersonIDCards  DataNote	HL7CDA/PHMR := Header  Body
PersonIDCards := <b>Citizen</b>   Next-of-Kin  CareGiver	Header := Title  <b>RecordTarget</b>   Author  DateT  ID  Versic
DataNote := Properties  DataSegments*	Body := Text  StructuredDataSegment
Properties := Date  Text  ResponsibleOrOrg*  ID	StructuredDataSegment := Properties  Text  StructuredDat
DataSegments := Consent  Diagnosis  Diary  Medication  C	Properties := Title  Subject  Author  DateTime  ID  Version
MedicineCardOverview := Properties  Document	iCalendar := Properties  Component*
Document := PrescriptionOverview*  MedicineCardOverview	Properties := <b>Attende</b>   <b>Organizer</b>   Categories  Class
Properties := Status  Actor*  <b>Patient</b>   Consent  Version  ID	Component := Attributes  vEvent  vJournal  vFreeBusy  vT
Status := Modified  Reviewed  Created  Paused  Suspended	

**SMC [3]** can be characterized as a document-based information model, where document status and document actors are important for the application and administration logic. Schema tree is relatively high. **DSCI [4]** is considered as a set of data segments. It starts with visit card like structures of people involved in the patient’s care and proceeds with a sequence of HL7 CDA like types for healthcare related notes: e.g., diary and lab results. A shared set of attributes: date of the note, id, responsible person and other. Schema tree is rather flat, compared to the one of SMC. **HL7 CDA/PHMR** for exchange of various clinical documents, supports a possibility of describing involved parties in the header of the message, in a fine grained role based manner: payee, authority, author, second author. The body has structured/unstructured content of health-related acts observations, notes, assessment, and administrative procedures. The structured body has nested components, with subsequent act/class codes of HL7. Header and body may force integrators create duplicate information across the document. Due to nested structure of the components, the schema tree can become high. **iCalendar**: is an international standard for managing calendar specific tasks for private and collaborative needs. It has properties of the calendar event and the components, which describe simple to complex calendar events. The structure is without deep nested components.

Once the many equivalence relations are identified into groups, one can think of new meaningful keywords for the groups or use e.g., HL7 CDA or SMC terms. An example of the identified equivalence groups, key/root nodes and candidates for structures are given in the figure below, for a “Patient”. For example, the structure of Patient may include many attributes, for future use (e.g., “religion” in HL7 is rare in Danish context) or be simple and contain few attributes (e.g., SMC). The main point is that the equivalence approach and the underlying architecture should allow the Patient structure to evolve with time. For example, the middleware based architecture allows new domain models to “attach” and contribute new information e.g., on religion based food preferences, which may further extend the structure of Patient with the “religion” attribute. Thanks to the



tree-based structure of the internal schemas and the separation of concerns of equivalence groups from keywords the future evolution of the patient centric information model can be supported. The equivalence relation can be directly translated into a single simple interface that can be used for integration of patient centric telemedicine: navigation can be done by “jumping” up and down in the BNFs, between equivalence groups. Search and annotations can be done at the identified points of the equivalence groups across the different health-related employee centric systems.

*Summary:* We identified opportunities of how ICT-based patient involvement through navigation; search and annotations, in a meaningful way across health-related models can be supported from a single interface. Concept demonstrations and architecture can be followed at [telehealth.dk](http://telehealth.dk).

## References

- [1] R Aarhus, S. Ballegaard, T. Hansen ”SundtHjem projektet” (Danish) (2009)
- [2] Y. Tina Lee ”Information Modeling: From Design to Implementation” (1999)
- [3] DSCI, MedCom ”Fælles Kroniker Data (KD) V0”
- [4] SMC, Statens Serum Institut, “Fælles Medicin Kort” at [ssi.dk](http://ssi.dk)