Exchanging care records using HL7 V3 care provision messages

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▶ Additional material is published online only. To view please visit the journal online (http://dx.doi.org/10.1136/amiajnl-2013-002264).

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Received 13 August 2013
Revised 30 March 2014
Accepted 1 April 2014
Published Online First 19 April 2014

ABSTRACT

Objective This paper describes Health Level 7 (HL7) V.3 Care Transfer, Care Record Query, and Care Record messages. This is the core of the Care Provision Domain in the HL7 standard which became normative at the end of 2012 and is an American National Standards Institute (ANSI)-approved HL7 standard.

Background and significance Using a message is somewhat different from the approach offered in the current HL7 Clinical Document Architecture (CDA). The overall advantage is human-to-human communication and system-to-system processing of structured data through electronic messages, supporting continuity of care and interactive structured data exchange through querying.

Materials and methods The Care Provision Domain Model in HL7 was developed based on use cases from several projects internationally. Use case and information analysis, model building, HL7 consensus methods (eg, working group meetings), conference calls, balloting, a draft standard for trial use, pilot implementations, and subsequent evaluation were applied.

Results The membership and pilot implementers gave feedback to improve the draft standard. After the formal ballot process, HL7 membership accepted it as a normative standard and it is now ANSI approved. The Care Provision Domain Model defines the structure (data exchanged) and dynamics (workflow and communications) of the Care Record, Care Record Query, and Care Transfer.

Discussion and conclusions The HL7 V3 Care Provision Domain differs from the HL7 CDA regarding support of the dynamics of care (eg, for continuity of care) as provided through a series of interactions and queries, but is similar with respect to the data and their organization.

OBJECTIVE

The need to exchange patient data for care provision has existed for almost 30 years.[1] Health Level 7 (HL7) V.2 (V2), an early standard first released in 1987 and under continuous development since, is designed to assist the proper transfer of data from one system to another.[1] Currently, HL7 V.3 (HL7 V3) is being developed.[1 2] HL7 V3 is based on the HL7 Reference Information Model (RIM), a set of object-oriented class diagrams with attributes[1–4] facilitating consistent specification of HL7 domain models and message models.[1 2] Despite consistency on the level of detail, the number of classes in the RIM (about 50) supports many variations. Current initiatives within HL7 focus on harmonizing the various domains and message models. The Clinical Statement Pattern is considered the core model for clinical content and allows expression of any clinically relevant phenomenon in the various HL7 messages and documents.[1] A clinical statement is 'an expression of a discrete item of clinical, clinically related or public health information that is recorded because of its relevance to the care of a patient or other entities. Clinical or public health information can be expressed with different levels of granularity and therefore the extent and detail conveyed in a single statement may vary.'[5] Early adopters found domain coverage, process support, and care transition responsibilities successfully supported, but the correct message to exchange care records, or parts, was not available and exchange was limited to documents.

A typical HL7 V3 message consists of structural and dynamic components.[1] The structures consist of Domain Message Information Models (DMIMs) covering clinical domains such as Clinical Genomics and Pharmacy. When a domain is described in the V3 RIM classes, everything necessary for that particular specialty is specified. DMIMs allow a medication order for Pharmacy to be distinguished from a laboratory result message for Orders. The dynamic part describes the use cases for a specific message, the care processes, and the interactions between humans and between systems. The dynamics are represented by Trigger Events (TE) referring to the situation triggering the healthcare professional or system to send a message, interactions (IN) specifying who is communicating with whom, Refined Message (RM) types defining the specific messages exchanged, and the Application Roles (AR) that must be fulfilled to correctly carry out the data exchange.[1]

HL7 standards materials from England, Australia, and the Netherlands informed the development of the Care Provision Domain Model (CPDM) and influenced its inclusion in the HL7 V3 standards.[6–8] In particular, messages for continuity of care were created and included a transfer request, acceptance, query, and care record message. In addition, the hand-over responsibilities of professionals in the chain of care, across institutions, were carefully analyzed. A set of interactions allowing for careful and legally sound care coordination and hand-off of responsibilities is crafted into the CPDM message set. This is built upon clinical use cases from various projects in the areas of stroke, youth healthcare, diabetes care, aged care, and perinatology.[6 7]

The Clinical Document Architecture (CDA) is a HL7 standard defining the structure of clinical documents. These documents are persistent and contain patient information from a specific time frame for human-to-human communications. They

To cite: Goossen W, Langford LH. *J Am Med Inform Assoc* 2014;**21**:e363–e368.

are often used for referral letters, discharge summaries, and reports among others. In the USA, the EHR Testing and Certification Criteria for Stage 2 of the Centers for Medicare and Medicaid Services (CMS) EHR Incentive Program calls for data exchange to deploy CDA-based specifications.[11 12] Although CDA-based data exchanges are used worldwide,[9 10] there are advantages to using HL7 V3 messages. Advantages of HL7 V3 messages include a querying mechanism and the full dynamics of messages allowing support of continuous care by professionals across multiple systems, locations, and institutions. Although the CDA and CPDM have the Clinical Statement Pattern in common, allowing structural data elements, templating (as reusable fragments), and organization into sections to be consistent between these two systems, there are also important differences between the CDA document and CPDM V3 messages. One difference is that the CDA is aimed primarily at human-to-human communication, although it has become more machine-readable with each revision, in particular at level 3 where the clinical statements are handled. HL7 V3 messages are primarily aimed at system-to-system electronic communication, ensuring a receiving application handles data exchange in a semantic interoperable manner. Style sheets allow a HL7 V3 message to be read by humans. A second difference is that the CDA provides 'a snapshot in time' and is often recognized as a legal document. HL7 V3 messages allow individual data to be validated, through a unique identifier per instance, but in most jurisdictions cannot be a legal document, and proof of sending and receiving depends on systems' log files. Perhaps the biggest difference between the CPDM and CDA is that the CPDM supports the dynamic communication required in areas such as care planning. In contrast to the CDA, the CPDM offers dynamic and real-time collaboration support for professionals working as a team in continuous care while using different applications and even when working in different care settings.

The purpose of this paper is to report on HL7 CPDM development and the derived HL7 V3 message topics for Care Transfer, Query, and Care Record.

BACKGROUND AND SIGNIFICANCE

Need for HL7 V3 Care Transfer, Query, and Care Record messages

Currently in healthcare, there is a need to exchange health-related data for clinical care, quality measures, and research.[1 6 7 9–11 13–15] Early attempts resulted in unique interfaces that are not standards based, leading to higher costs, inconsistencies in data, and over time, loss of system transparency. The standardized approach to healthcare data exchange has many benefits. The importance and relevance of the HL7 V3 messages is demonstrated through several use cases describing the need for exchanged messages supporting transfer of care, querying of records, and continuity of care.

The need expressed in concrete care situations

Work in the Netherlands found the perinatology domain was well suited for using HL7 V3 messaging for exchanging necessary information through the chain of care.[6] HL7 V3 includes RIM capabilities for standardizing data structures and differentiation between data and dynamic models (processes and communications), core parts of the perinatology domain. Example use cases used in the perinatology project informing the CPDM are:

- Referral from a general practitioner to a midwife or specialist
- Transfer requests from a midwife to an obstetrician
- Discharge letter from a specialist back to the general practitioner or midwife
- Authorized querying of the sender's electronic health record (EHR) by the specialist.

The need to reuse the referral message was demonstrated by the use case describing the obstetrician's need to refer the newborn baby to the pediatrician.[6] This included reuse of several data elements from the prenatal, labor, delivery, and maternal postpartum record, but personalized to the neonate, with data pertaining to the situation following the birth. This led to a list of concrete use cases, which have been abstracted to transfer, referral, acceptance, care record exchange, and care record querying.

Use cases from other projects include:

- Referral request from a hospital to various nursing homes
- Continuity of care messages from a hospital to a nursing home
- Authorized querying for additional patient data
- Joint care for patients with chronic conditions and sharing data.

MATERIALS AND METHODS

HL7 V3 CPDM development

Review of the Dutch project use cases concerning stroke and heart failure indicated the same message structures and dynamics would be valid and useful for supporting continuity of care in other clinical domains.[16] In addition to base structures and responsibilities of transfer and record exchange, many data elements are identical between domains (eg, blood pressure, weight), while some data elements are different but the underlying structure is not (eg, assessment scales). Since HL7 uses external codes to identify the variables and answers, the same message content structures could be used in the various clinical domains.[16] To accommodate such reuse, the modelers used an existing HL7 V3 structure called a 'choice box' (figure 1).

When applying the classes from the RIM, it is possible to use a variable set of data without having to model every data element. The choice box allows pertinent data to be defined and wrapped in the choice box structure. In a CDA or message, a high level class (such as the Document Class or the Care Provision Class) can point to the choice box. At implementation, any type of class in the choice box can be used and instantiated for one data element. For instance, the Observation Class can be used in the CDA or HL7 V3 message for weight, heart rate, diastolic blood pressure, total Apgar score, and so on.

In implementations, the same construct could be used for recording Apgar score in perinatology[6] or the Glasgow Coma Scale in stroke care.[16] This approach applies in many clinical domains and allows a wide variety of consistent clinical data in the same message structure.[16]

Evolution of the CPDM

The CPDM materials were developed to contain a domain model and several topics including Care Transfer, Care Record, Care Record Query, and assessment scales. The membership decided by ballot that the materials were informative in 2005–2006

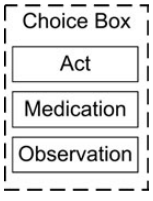

Figure 1 Choice box construct.

leading to a Draft Standard for Trial Use (DSTU) for the core materials in early 2007. When the DSTU was set to expire due to the low number of implementations 2 years later, the National IT Institute for Healthcare in the Netherlands (Nictiz), a user of the DSTU, requested an extension, which was granted until 2011.

An evaluation was carried out in 2010 among three pilot users: Nictiz, Ontario Health, Canada, and Integrating the Healthcare Enterprise (IHE).[17] Changes were made to the CPDM and message models based on the evaluation and 4 years of experience. One important change requested was harmonization of the Clinical Statement.[5] This harmonization allows even more clinical content reuse from message to document and vice versa.

Two more projects contributed useful comments. The German Verband der Hersteller von IT-Lösungen für das Gesundheitswesen (VHitG, the German association for IT vendors in healthcare), in cooperation with HL7 Germany, specified order messages based on patient care transfer requests and contributed to the follow-up work for the Assessment Scale topic. Norway brought comments about inconsistencies in the Encounter Class between the CPDM and Patient Administration Domain Model. The core CPDM materials underwent changes in 2011 and were balloted at normative level in May and September 2012, confirming their status as a finalized standard. The resulting standards are implemented in practice, recognized by the American National Standards Institute (ANSI), and published in the HL7 2013 Normative Edition.[18] Additional details on the evaluation and ballot comments in the period 2007–2012 are available in a supplementary online file.

RESULTS

Evaluation of the DSTU of the CPDM

Evaluation of the DSTU of the CPDM was carried out in 2010 using a multi-method approach.[17] The methods utilized included interviews using a semi-structured questionnaire[17] as well as processes in place for HL7 membership to report experiences through the DSTU comment pages[1] or submit change requests through the formal ballot procedures. Each submitted comment is addressed and only after all have been handled to the satisfaction of the submitter can the standard move to the normative stage.

Core components: structure of the CPDM

Figure 2 summarizes the normative CPDM.

The Care Provision Act (#1) links through participations to #2, involved entities and their roles. Care Act Relationship (#3) links #1 to #4, the Clinical Statement with the choice of Act classes. Relationship (#5) distinguishes the subject of some data from the target of care (ie, the subject fetus of a pregnant woman as the record target for whom data are exchanged).

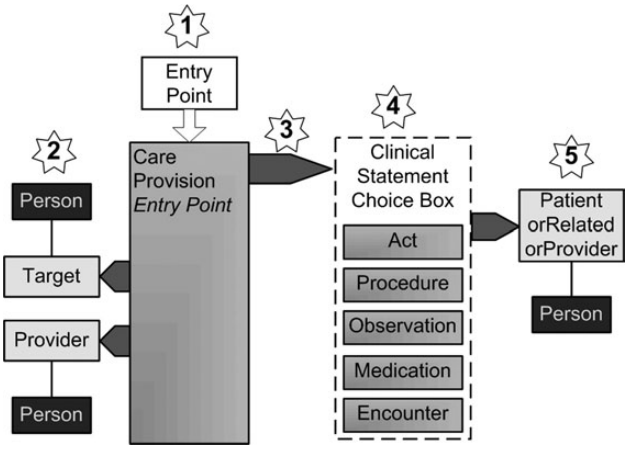

Figure 2 Care Provision Domain (CPDM) model summary.

Core structural components of the CPDM include (1) responsibility of care, (2) transfer of care, (3) allowance of attached data, and (4) allowance for data to be organized. The essential concept in the CPDM is the responsibility for care provision. The scope of the CPDM includes all the information needed for decisions to be made by any care provider or team of care providers. This includes the patient who is considered both a subject of care and a provider (eg, for self-care and self-management).

The purpose of the CPDM is to facilitate the continuity of care. The CPDM handles the transfer of responsibility and updating of pertinent information between collaborating care providers. For each type of care record exchange, a Query or Query Profile definition exists in the CPDM. It is important to note that both the data required in transfer (the structural component) and the processes of transferring (ie, interactions that create a full dynamic two-way communication) are included in this standard. Management plans (eg, clinical pathways) for the subjects may be included in a CPDM message as various 'Acts.' (In HL7 all activities are called Acts). The 'Act of Care Provision' is the recording of the responsibility for care including management, assessment, diagnosis, treatment, and care.[1 18] Different message formats for almost identical data exchanges are problematic for implementers. The CPDM can also be used to exchange data for quality reporting and submissions to national registries, as is illustrated by The Netherlands Perinatal Registry (PRN).[19]

Dynamics in the CPDM

The principle in CPDM modeling is that patient-centered care can be documented and exchanged among all involved providers.[18] This allows for real-time continuity of care on a continuous and ongoing basis and with a myriad of parties involved.[18] HL7 specifies storyboards with interactions depicting the many ways the messages can be applied. Figure 2 illustrates how some CPDM interactions facilitate continuity of care. Each communication is called an interaction.

Figure 3 depicts the CPDM interactions supporting referrals and care record exchanges between care professionals.[1 18]

Each interaction includes the RIM-based artifacts and their identifiers.[1 18] REPC is the internal HL7 code for Care Provision, UV represents Universal Domain, AR is Application Role (ie, the behavior of the applications communicating), TE is the trigger event (ie, the human initiated or computer initiated event starting the interaction and data communication), and IN is the interaction. QUPC is the Query for Patient Care domain and RM stands for the RM or the specific message for this function. This diagram shows the referral request, referral acceptance, query for additional information, and sending of a record (summary) back to the requesting provider after a referral is completed. These artifacts allow a fully automated process to take place, removing the burden of manual interference.

Implementation in XML

To implement these structural and dynamic CPDM materials, a set of HL7 V3 RIM-based XML (eXtended Markup Language) standards has been created. The XML for the CPDM domain includes wrappers for the dynamics of the communication and messages for the exchange of the clinical content.[1 18] It further consists of a series of CPDM XML schemas to verify if a CPDM message has the appropriate structure. For Care

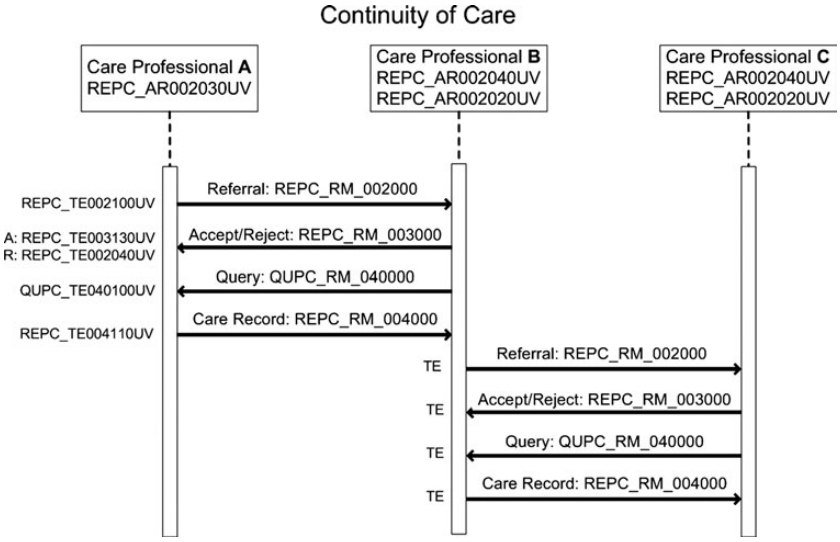

Figure 3 Care Provision Domain Model (CPDM) interactions for referrals and care record exchange. AR, Application role; IN, Interaction; QUPC, Query for Patient Care domain; REPC, internal HL7 code for Care Provision; RM, Refined Message; TE, Trigger Event; UV, Universal Domain.

Provision, the XML message holds data about the receiver, receiver application, sender, sender application, target of care (subject of data), the Care Provision Act, and the relevant data specified according the Clinical Statement. The Care Record message allows for any composition of clinical data and can represent (through use of the Organizer Class) any grouping or ordering of data. Hence, it can represent all sections like the CDA, dedicated ordering such as in the continuity of care document (CCD), or even the ISO 13606 ordering of the record, folders, compositions, sections, and entries.[13–15] The CPDM also contains the HL7 RIM-based details for all data such as the code system used, the type of class, date/time, etc. Figure 4 shows core XML content of the Care Record message from the perinatology project representing the clinical statement for highest blood pressure during pregnancy as an example.

Actual use

HL7 does not have processes or maintain metrics on implementation of standards that have been finalized and promoted to normative status. However, the first author's personal experiences reveal some indicators of implementation and scale of use. One implementation in progress is the application of the Care Record message to exchange data between source systems and a clinical data warehouse and to exchange data between a hospital and home care for oncology nursing.[20] This is a development project involving one hospital and one home care agency.

Figure 4 XML fragment of the Care Record message, indicating one unique care provision event, and an excerpt of some Clinical Statement-based data. XML, eXtended Markup Language.

```
<CareProvisionEvent classCode="PCPR" moodCode="EVN">
  <templateId root="2.16.840.1.113883.2.4.6.10.90.50"/>
      <id root="2.16.840.1.113883.2.4.99.23444.6" extension="cp16645"/>
       <statusCode code="active"/>
            <effectiveTime>
                  <low value="20130603"/>
            </effectiveTime>
    <subject typeCode="SBJ">
      <patient classCode="PAT">
       <!-- Item: 10 - SocialSecurityNumber -->
       <id root="2.16.840.1.113883.2.4.6.3" extension="100202020"/>
                <addr>
                   <postalCode>12008</postalCode>
                </addr>
                <statusCode code="active"/>
                <patientPerson classCode="PSN" determinerCode="INSTANCE">
                   <name use="L">
                      <given>Francesca</given>
                      <family qualifier="SP">Johnson</family>
                   </name>
                   <birthTime value="20110801"/>
                </patientPerson>
             </patient>
          </subject>
          <!—Item example - Highest diastolic blood pressure -->
          <pertinentInformation3 typeCode="PERT" contextConductionInd="true">
             <observation classCode="OBS" moodCode="EVN">
                <code code="X_IVDIASTPREG" codeSystem="2.16.840.1.113883.6.1"/>
                <value xsi:type="IVL_PQ">
                   <high value="95" unit="mm[Hg]"/>
                </value>
             </observation>
          </pertinentInformation3>
       <!-- rest of the message content starts here-->
       <!-- rest of the message content ends here-->
</CareProvisionEvent>
```

A larger scale implementation is the use of a derivate message from the Care Record (supporting vaccine prescriptions) for the transfer of records from one childcare agency to another.[21] These messages are implemented in the child healthcare records of three vendors, allowing health professionals responsible for the transfer to send the Care Record adapted message. This pilot implementation has the potential to expand to up to 50 Dutch organizations for preventive healthcare and conservatively could result in 25 000 uses of the HL7 V3 Care Records adaptation annually.

For perinatology, midwives use the highest number of HL7 V3 CDA and Care Record messages in the Netherlands. About 100–200 midwife practices had implemented the Care Record message by 2011.[22] Currently, many thousands of messages are sent annually. This number is growing, but no recent details are publicly available. In the near future it is expected that 95% of birth-related data will be sent to The Netherlands Perinatal Registry using a Care Record message.[6 19] Ongoing projects include the use of the same Care Record message for patient care transfers in acute perinatal care situations. However, no numbers are available at the moment. The Care Record for the perinatal registry is implemented by two of three vendors providing systems for midwives which allow them to send Care Record messages themselves.

DISCUSSION

HL7 messages are often criticized as being time consuming to implement. The CPDM is no different from other HL7 V3 domains. However, some aspects warrant consideration. HL7 is a standard built on actual implementations, so real-world experiences are fed back to the developers with changes applied during development and the ballot process. The DSTU is an important mechanism applying the standard in practice. This allows for missing parts of the standard to be revealed and improvements made, and provides an estimated time for implementation and testing prior to the normative version. In addition, an implementation specification is being developed that retains the large investments in HL7 V3, in particular the modeling, but speeds up implementation. This work is called FHIR (Fast Health Interoperable Resources)[23] for which a first DSTU has been issued. The HL7 FHIR team and CPDM developers are currently working on FHIR resources (the implementation specifications) for several areas of the CPDM. It can be envisioned that, when FHIR matures, the full CPDM will be implementable via this novel approach.

The participants implementing the CPDM DSTU materials have contributed significantly to the availability of a set of messages ready for use in controlled practice pilot environments. The Care Record Topic has been proven to work for continuity of care in several real-world environments and thousands of messages have been sent. Care Record users included hundreds of care professionals using their EHR system in day-to-day care. The Transfer Topic and Care Record Query Topic messages have all been updated according to the experiences with the Care Record but they have themselves not been tested in practice. A large-scale evaluation among health professionals using the Care Record message would be advisable. This proposed evaluation could be carried out in the Netherlands but could also include other sites where the Care Record message is used. Nictiz has carefully tested the use of the Care Record message, with dedicated data for the domains, through a series of conformance tests and certification. This, however, is not the case for the Care Record Query or for the Care Transfer messages, both of which need to be implemented and tested. In particular, the latter must be tested for its ability to support the hand-over of responsibility for the care of a patient. This is particularly important because it is one advantage the message has over a document.

Not all existing structures in the CPDM can be described here. The domain model and three core topics (Transfer, Query, Care Record) are the basis of the CPDM and if these are implemented, then all other topics such as assessment scales, care plan, allergy, and intolerance can also be implemented. Detailed clinical model examples to populate the Care Record are under development and further refinement, and will become available in the near future.[23] These are very granular and depend on the generic message structures of the four core topics.

Replacement of the choice box with the Clinical Statement provides huge advantages. The Clinical Statement structure allows the exchange of fully text-based records, fully structured records, and anything in between as combinations of structured data and free text. One advantage is that the CPDM, for the data definitions (or free text labels), is now 100% consistent with the CDA. This allows each system to use the detailed specifications of the other system, such as use of the CDA sections in the Care Record, use of the Assessment Scale from the CPDM in the CDA, or reuse of each other's Detailed Clinical Models and their HL7 V3 templates. This also applies to RIM, data types, etc. Use of the Clinical Statement in the CPDM makes it simpler for implementers who now have to deal with only one version for all of these concepts.

The biggest difference between the CPDM and CDA is that the CPDM supports the dynamic communication required in areas such as the care plan. The CPDM offers dynamic and real-time collaboration when the team is working jointly in continuous care, even when they are using different applications. The definition of CPDM message implementations can be evidence based and demonstrates best practice.[2 5 8 12] Although messages have a brief temporal existence, each incoming message can be stored for logging purposes in the EHR.

In the early days, V3 messages were segmented, but now, due to the Clinical Statement, all record sections and organizers developed for the CDA can be fully (re)used in the Care Record message, allowing a complete record exchange for reading and for full computer processing, longitudinal records, querying, decision support, and clinical data warehouse functions. This confers a huge advantage on the CPDM over the CDA for some applications.

CONCLUSION

The HL7 V3 Care Record is a flexible message structure allowing exchange of a full Care Record. It allows dynamic data exchange for a multidisciplinary team ensuring real-time continuity of care. The Care Record can be exchanged as a push message or follow the pull mechanism using the Care Record Query. The CPDM further allows for electronic support of a Care Transfer handshake.

The Care Record message has been implemented in an IHE Patient Care Coordination framework in Ontario Health, Canada, in Norway and Germany, and in several clinical domains in the Netherlands. The CPDM is useful in situations where responsibilities are handed over and especially when the dynamics of care processes need support. This is in contrast to the 'snapshot approach' of the older methods of exchanging documents with the HL7 V3 CDA.[9 10] Now that the CPDM is normative, the focus can move to supporting completion of clinical requirements, expressing these in the various formats as templates or detailed clinical models, and then selection of the best format for the exchange: document, message, or web service.

To conclude, the CPDM offers a structurally and dynamically subset of messages in HL7 V3, tested in actual clinical practice implementations. It is a normative standard through its HL7 membership level balloting and ANSI approval. The CPDM supports continuity of care through referrals, health information exchange and in the future, self-care management when patients are using personal health records to author clinical data and collaborate in their own care.

Acknowledgements We wish to thank the HL7 membership who participated in the various ballot rounds for this domain, and the other co-chairs, modeling facilitators, publishing facilitators, and users of this standard, in particular IHE Patient Care Coordination, Ontario Health, The Netherlands Perinatal Registry (PRN), and Nictiz who all contributed to its generation and completion.

Collaborators This work is based on the efforts of the Health Level 7 Patient Care Working Group.

Contributors The first author wrote the manuscript and is responsible for the integrity of this work as a whole, from inception to published article. The second author provided substantive editing and clarification of mentioned concepts.

Funding The project is based purely on volunteer work at the HL7 International standards organization. Work on the Dutch applications of the CPDM described in the paper was carried out by consultants who were paid by the organizations concerned. Evaluation of CPDM in 2010 was partly funded by Nictiz.

Competing interests None.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement The paper summarizes the Care Provision Domain in Health Level 7. The complete standard can be obtained through http://www.hl7.org.

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