Continuity of Care with HL7 v3 Care Record for Oncology Nursing

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Abstract. The Clinical Data Warehouse needs to meet three functions: reporting quality indicators, clinical research, and continuity of care. This paper reports on one function, namely the development and testing of data exchange for continuity of nursing care for oncology patients. The proof of principle was carried out using system analysis, requirements setting, system design, system development and experiment with the application of Health Level 7 version 3 Care Record electronic message. A successful testing of the Care Record message was conducted, using a case based data-subset for oncology nursing care including personal data, pain, weight and vital signs, among others. Conclusion: The development illustrated that the system components facilitate electronic data exchange from hospital to home care, allowing home care nurses to use received clinical data in their local system. In an incremental approach this data exchange can be enhanced to meet all data and all systems requirements.

Keywords. electronic patient record, discharge summary, continuity of care, standards, HL7, nursing discharge message

Introduction

A joint project to develop and use a Clinical Data Warehouse was carried out between Isala Clinics, Icare Homecare, and Windesheim lectorate ICT innovations in health care, all based in Zwolle, the Netherlands [1]. The Clinical Data Warehouse (CDWH) should meet requirements to facilitate continuity of care from hospital to home care, collection of data for nursing quality indicators, and collection of data for clinical research, all deploying appropriate consent and data security procedures [1]. The project was carried out in an incremental approach during 2 and a half year, ending December 2013. Subprojects included (1) the determination of the data that needed to be exchanged for continuity of oncology nursing care between hospital and home care, (2) data standardization of the data using unified terminology and Detailed Clinical Models (DCM) [2], (3) determining a DCM based Extract, Transform and Load procedure for getting data from various sources into the CDWH, (4) developing an architecture for the CDWH storage and governance, (5) develop the CDWH and identifying data marts for each use / reuse of clinical data, (6) develop a data mart for determining nursing quality indicators, (7) develop a data mart for research data, and (8) develop a data mart for the data exchange for continuity of care from Isala Clinics to Icare Homecare for oncology patients with esophagus carcinoma or stomach carcinoma. All phases where accompanied with a legal underpinning with following regulations and determining consent and taking data protection measures. The purpose

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Nursing Informatics 2014
K. Saranto et al. (Eds.)
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of this paper is to report on the analysis, design, development and testing of the Health Level 7 version 3 Care Record message [3,4] for a subset of oncology nursing care data, as determined by the nurses from hospital and home care.

1. Methodology and materials

Due to the complexity of these sub-projects, a strict architectural design was developed in project four and deployed [5], which include high levels of standardization which were strictly maintained. The overall CDWH architecture is explained in Goossen et al, 2013 [1] This project phase used a multiple stages extraction, exchange and import mechanism for the data flow, as illustrated in figure 1. The HL7 v3 Care Record options for nursing have been explored before and were used as the basis for this phase of the project [3,4]

In the first project, the participating nurses determined a set of around 100 data elements which would be required for continuity of care. Each data element was reviewed and uniquely coded and specified, using the DCM approach [2]. This lead in project two to about 9 DCM’s available at the time this continuity of care message was designed. More DCM will follow in a later stage, allowing an agile approach to the message development. One advantage of the DCM method is the high level of involvement of clinicians, specifying up to the most detailed characteristics of their data requirements and offering precise coding. This process makes life of the systems analysis and developer and tester easier through better communication.

Another advantage of the resulting DCM is that they can easily be reused in other projects, in the CDWH project it is foreseen that the DCM for pain scale, malnutrition and infection can be used for continuity of care, from hospital to home care and vice versa, and for the quality indicators that need to be reported at the national level. Given the fact that oncology care is likely to last up to two years with frequent transfers of responsibility and updates from hospital to home vice versa, the snapshot approach of the HL7 Clinical Document Architecture [6], was considered insufficient. The HL7 v3 Care Record message in contrast allows for a flexible data contents, making an agile approach feasible, also allowing quick results for the whole of the dataflow (Figure 1), enhancing it in follow up cycles in which DCM based data are added incrementally. An approach not taken before, most projects deploying Care Record specified first all relevant data in depth and completed full specification before putting it to the test. Further, the HL7 v3 Care Record message [3,4] was developed with input from the Dutch national ICT institute, making the materials such as implementation guides, and Dutch adjustments readily available. The Health Level 7 Care Record message consists of three major areas: the header contains the meta data about the message, date, time,
purpose, type of interaction. Next, the communicating systems, both sending and receiving, are identified, as are parts of their respective organizations. The third component holds the so called payload, which is the identifiers and personal data for patient (subject) and provider (professional), and the clinical content, in this case the nursing data for oncology care as specified in the DCM collection.

To store the clinical oncology data in the CDWH, a database product named MGRID is used for project 5. MGRID is a database specifically designed for integration with HL7v3. The internal table structure of MGRID is based on the HL7 v3 Reference Information Model, and data types [4]. To extract the required oncology nursing data from the CDWH, and to properly exchange them, two interfaces were designed in this project eight, one for each side of the connection. The data extracted from the CDWH are inserted in the Care Record message, and next transported over a secure network through the open source Mirth Connect software. The first interface is built upon the CDWH database and is responsible for the generation and the exchange of the HL7v3 Care Record message. The second interface supports the receiving system and is responsible to receive and acknowledge receiving the Care Record messages, and to interpret the contents of the message. Subsequently it will interpret the received data and transforms them into the valid and accessible eXtended Markup Language (XML) format for import into the receiving system called ONS. To develop both interfaces, two agile sprints were finalized in which each interface was created based on design, develop and deliver phases. Each interface has gotten its own set of requirements that describe its behavior.

2. Results

In this project eight, the first set of results includes the requirements for the interfaces. The sending system is created using Mirth Connect open source software, which serves as the message broker for the CDWH. Mirth Connect controls all interfaces from CDWH to external systems and has functionality to extract DCM based clinical data from MGRID, generate an HL7v3 Care Record message from this, and to send it to the receiving system. Mirth Connect allows for later plug-ins to be added and has a clear graphical user interface. Table 1 illustrates the requirements for Mirth Connect linked to the CDWH to fulfill the role as sender. For the proof of principle we have applied patient cases, which were developed by the nurses from hospital, home care and nurse students, to reflect a realistic and complete set of data.

<table>
<thead>
<tr>
<th>Table 1. Requirements for Mirth Connect as the sending system from CDWH</th>
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<tbody>
<tr>
<td>Requirements Mirth Connect</td>
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<tr>
<td>The application must get the requested data from the database.</td>
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<tr>
<td>The application must fill a HL7v3 Discharge Summary (Care Record) with the requested data.</td>
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<tr>
<td>The application must send the generated HL7v3 Discharge Care Record to the receiving application.</td>
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<tr>
<td>The application must wait for an acknowledgement of the receiving application.</td>
</tr>
<tr>
<td>If the application does not receive an acknowledgement, resend the generated HL7v3 Discharge Summary.</td>
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</tbody>
</table>

Within the proof of principle the sender CDWH, through Mirth Connect, sends the HL7 v3 Care Record message with nursing oncology data through a network to an
external system. For the proof of principle, this is not a secure line, however, in next proof of concept phase, it will be send through encrypted connections. For the proof of principle a laptop was used to install the Java parser that serves as HL7v3 interface to the receiving application ONS. The receiving application, i.e. the HL7v3 Parser (converter), has been coded in the Java programming language by the first author of this paper. The Java parser transforms the HL7v3 message into localized XML that can be imported into ONS and then presented in its note fields. This is based on an ONS XML schema. Table 2 illustrates the requirements for the receiving system.

Table 2. Requirements for a Java Parser serving as the HL7 v3 message converter for the receiving system ONS

<table>
<thead>
<tr>
<th>Requirements Java Parser to XML</th>
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<tbody>
<tr>
<td>• The application must ‘listen’ to incoming HL7v3 Care Record messages.</td>
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<tr>
<td>• The application must validate the incoming HL7v3 Discharge Summary (Care Record).</td>
</tr>
<tr>
<td>• The application must generate an XML file which can be read by the receiving application ONS.</td>
</tr>
<tr>
<td>• The application must validate the XML file for ONS.</td>
</tr>
<tr>
<td>• The application must send an acknowledgement to the CDWH when the HL7 v3 Care Record message has been received.</td>
</tr>
<tr>
<td>• The application must facilitate the uptake of the XML file by ONS as receiving system.</td>
</tr>
</tbody>
</table>

The reliability of the connection, required to have control over receiving the message and accepting responsibility for care based on it, is guaranteed through interactions and a condition (Figure 2). This set of interactions to guarantee the connection enforces this through an acknowledgement of receiving a message. HL7 v3 Care Record messages each get a unique identifier, so even if more messages are send, the acknowledgement will pertain to each single message through this identifier. In practice this means that the CDWH, after sending the HL7 v3 Care Record through Mirth Connect, waits 10 seconds for the acknowledgement. If the acknowledgement is not received within this conditional time frame, the message will be resend. This way the reliability of the electronic communication can be guaranteed and care professionals can depend on it.

In project six of the CDWH project a working prototype of the CDWH was delivered. In the CDWH one dedicated data mart has been defined for the continuity of care for oncology patients from Isala Clinics to Icare homecare. The data mart contains the subset of relevant oncology care data and the consent of the patient for the electronic exchange [1]. The CDWH proves able to generate HL7v3 Care Records and send them from Isala Clinics through a network to the receiving system at Icare Homecare. The receiving ONS system at Icare Homecare was able to import the XML content and present this to the nurses in the notes fields of the system. This proofs the principle that the full range of electronic communication is possible from nurses generating hospital care data, storing these in the CDWH, extracting the required data from CDWH, generate the HL7 v3 Care Record message, electronically send it to the recipient, parsing that in the format for the receiving system and presenting the results to the receiving nurses.

The requirements for both interfaces of the connection, i.e. the Mirth Connect interface and the Java Parser for the receiver application were tested. The Mirth Connect configuration met 89% of the requirements during the acceptation tests [7].
The remaining 11% could be explained through a known bug in Mirth Connect, known and reported in the Mirth Connect community. A workaround was used for this.

Mirth Connect offers entry fields in the application in which JavaScript code can be entered to realize the desired behavior, such as transforms. This cannot be done with the graphical user interface. Interpreting JavaScript through Mirth Connect is not flawless, leading to some unexpected behavior by Mirth Connect. We recommend to use, were possible, the graphical user interface or one of the available plug-ins legitimized by the Mirth Connect community. Figure 3 contains a snippet of the HL7v3 Care Record message with data from the CDWH database.

```xml
<organizer classCode="CATEGORY" moodCode="EVN">
  <templateId root="9CE7270C-FF7E-40ed-997F-C58AE2503603"/>
  <effectiveTime>
    <value="20130619"/>
  </effectiveTime>
  <code code="363808001" codeSystem="2.16.840.1.113883.6.96" codeSystemName="SCT" displayName="body weight measure">
    <component typeCode="COMP">
      <!-- BodyWeight templateID from the DCM body weight from HL7 international-->
      <observation classCode="OBS" moodCode="EVN">
        <templateId root="9AA5439F-5FCE-4e75-A6BE-5E47B88DA1D0"/>
        <codeCode="27113001" codeSystem="SCT" codeSystemName="SnomedCT" displayName="BodyWeight />
        <value code="255395001" codeSystem="SCT" codeSystemName="BodyWeightValueOrigin" displayName="" unit="kg" value="78" xsi:type="PQ"/>
      </observation>
    </component>
  </code>
</organizer>
```

Figure 3: Snippet of the HL7 v3 Care Record message illustrating the body weight of 78 kg.
The receiving application met 96% of the requirements [7]. During the import of the XML file into the receiving ONS application one issue came forward, making the import not completely successful. For the identification of some data elements an identifier is used, which must meet an ONS internal standard. This standard for identifiers is missing in the ONS documentation of Icare Homecare and was therefore not included in the HL7v3 Parser. This issue is documented and will be solved in the next iteration of the project. Except this issue, a complete and valid XML import file was generated, meeting all other requirements for the ONS application and containing all oncology data that were send by the HL7v3 Care Record message. See Figure 4 for a snippet of the generated XML.

```
<content>
  <note>
    <mutationAction>1</mutationAction>
    <id>0.8897768625167299</id>
    <content>null
      templateId root: 9AA5439F-5FCE-4e75-A6BE-5E47B88DA1D0
code code: 27113001
codeSystem: SCT displayName: BodyWeight
templateId root: 9AA5439F-5FCE-4e75-A6BE-5E47B88DA1D0
code code: 8867005
    </content>
  </note>
</content>
```

Figure 4: Snippet generated XML file for ONS receiving system

### 3. Conclusion

Generally spoken, this eighth iteration of the CDWH project to get data from CDWH at Isala Clinics into the HL7 v3 Care Record message and into the Icare Homecare ONS receiving application for the purpose of continuity of nursing care for oncology patients was successful. However, there are some points of discussion that need to be taken into account. The CDWH is not auto-filled with data from source systems, requiring the use of case based data in this phase. Although, through the input of the practicing nurses, the relevance of the cases data is very high, it is recommended to redo the test with real patient data from the CDWH. Secondly, next phase of the CDWH project should work on obtaining data electronically in the DCM format from the source systems in Isala Clinic (project 3). Thirdly, the agile approach to create the HL7 v3 Care Record is novel. It means that only a small start set with the data specified in seven DCMs were used. Although this number is sufficient for the proof of principle to exchange nursing data from hospital to home care, it is not meeting the full set of requirements that nurses defined. More agile sprints, including subsequent DCMs, are required to get to the full care record exchange. Fourth issue is that to keep the scope of the agile sprints limited, there has been given no attention to the format the data are presented in the receiving application ONS. Currently it does include XML tags, which the nurses do not want to see. For next phase an XML style sheet is recommended that hides the complexity of the file, and only shows from Figure 4 the bodyweight and 78 kg.

The issues that came forward during the proof of principle were related to a known bug in Mirth Connect, solvable via use of a plug in, and the missing documentation of the identifiers in the ONS specifications. The first issue was solved in the project, the second one will be solved in next round. The project required a close cooperation between the Nursing students and the IT-students and their teachers, which lead to a
high quality demonstration environment for the nursing data, the standards based DCM, the CDWH, the data marts and, in particular for this project phase, for the exchange of oncology data for continuity of nursing care. Errors which are likely to occur in multidisciplinary teams have to a large extend been prevented using standards as DCM and HL7 v3 Care Record.

References


