Building a Smart Container for VistA
Lessons Learned

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1. Introduction

During the period of March to May, 2012 a prototype Smart Container for VistA was developed by the team of George Lilly, CIO of WorldVistA and Rob Tweed, the creator of EWD, and Joseph Del Molin of eCology who provided project coordination. The work was done in collaboration with the Harvard Smart Project with funding from the ONC via the Harvard Smart project.

The project objective was to demonstrate that a Smart Container for VistA was feasible and to gauge the level of effort to create one. Also, to provide a public demonstration of the VistA Smart Container and publicly available source code and servers that would allow developers to create Smart Applications using VistA.

The VistA Smart Container was demonstrated at the June 5, 2012 VistA Community Meeting at George Mason University. Since then, it has been demonstrated at several other forums, including NHS Hack day in England and at the Seattle VistA Expo in September. Further demonstrations are planned.

The software has been released publicly under a GPL version 2 or greater license and can be found on the WorldVistA trac server at this address:

https://trac.opensourcevista.net/browser/smart

The VistA Smart Container has also been included fully configured in the latest dEWDrop 3 virtual machine, which allows developers to use it right away without the effort of installation and configuration. The dEWDrop virtual machine can be downloaded free of charge from the Fourth Watch Software website at this address:

http://www.fourthwatchsoftware.com/

The prototype implements the following Smart clinical domains:

- Demographics
- Problems
- Medications
- Lab Results

This paper is in partial fulfillment of the Smart/ONC contract and relates the experiences we had in trying to map the VistA data elements to the Smart data model.
2. Approach

The server side of the Smart Container is written in Mumps. The front end of the Smart Container is written in javascript and Mumps using EWD. Why Mumps? It is a very efficient and productive language for doing this kind of mapping work and most importantly, it is the native language of VistA. When the Mumps routines are put together into a package, they can be easily added to any VistA system without the addition of any other subsystem for data transformation. In addition, the Smart Container was implemented as a standard VistA RPC, allowing it to be easily accessed by any external system using a standard VistA interface.

Several months before the start of the project, the first version of the Fileman Triple Store was released. It provides the ability to represent triples in Fileman and to import triples as RDF, JSON, and Mumps arrays. We used the triple store for the Smart Container. The Smart Container generates triples, stores them into the triples store, and then renders the Smart RDF from the stored triples. The Fileman Triple Store can be found here: https://trac.opensourcevista.net/browser/fmts It is also discussed in its own google group here: https://groups.google.com/forum/?fromgroups#!forum/fileman-triple-store

The clinical values used in the Smart Container are obtained from the xml output of the VistA NHIN package. Below is a sample output. The Smart Container makes an internal Mumps RPC call to obtain the xml and parses it and turns it into a more easy to use Mumps array.

```xml
<results total='13' >
<patient>
<address streetLine1='635 Big Sky Ln' city='BIXBY' stateProvince='OKLAHOMA' postalCode='74008' />
<bid value='A1117' />
<dob value='2531016' />
<exposures>
<exposure value='AO' />
</exposures>
</facilities>
<facility code='050' name='VOE OFFICE INSTITUTION' />
<families>
<familyName value='ALLEN' />
<fullNames value='ALLEN, JASON RYAN' />
<gender value='M' />
<givenNames value='JASON RYAN' />
{id value='6' />
<lrdfn value='49' />
<maritalStatus value='N' />
<religion value='6' />
<sc value='0' />
:ssn value='111111117' />
</supports>
</address streetLine1='635 Big Sky Ln' city='BIXBY' >
```
<problem>
<entered value='3110504' />
<facility code='100' name='VOE OFFICE INSTITUTION OLD' />
<iCD value='496.' />
<iD value='45' />
<location value='ZZ*DR OFFICE' />
<name value='Chronic Obstructive Pulmonary Disease' />
<provider code='76' name='VAN NESS, NANCY' />
<removed value='0' />
<sc value='0' />
<status value='A' />
<unverified value='0' />
<updated value='3110504' />
</problem>

<lab>
<collected value='3120425.231037' />
<comment xml:space='preserve'>GPLTEST SMART Report Released Date/Time: Apr 25, 2012@23:11</comment>
<facility code='100' name='VOE OFFICE INSTITUTION OLD' />
<groupName value='CH 0425 5' />
<iD value='CH;6879573.768963;67008' />
<labOrderID value='118' />
<localName value='HDLCHLS' />
<loinc value='2085-9' />
<orderID value='855' />
<result value='45' />
<resulted value='3120425.231116' />
<sample value='SERUM' />
<specimen code='0X500' name='SERUM' />
<status value='completed' />
<test value='HDL CHOLESTEROL' />
<type value='CH' />
<vuid value='4662693' />
</lab>
<lab>
<collected value='3120425.230609' />
<comment xml:space='preserve'>~For Test: CHOLESTEROL ~GPLTEST SMART Report Released Date/Time: Apr 25, 2012@23:07</comment>
<facility code='100' name='VOE OFFICE INSTITUTION OLD' />
<groupName value='CH 0425 3' />
<iD value='CH;6879573.769391;12' />
<labOrderID value='103' />
<localName value='CHOL' />
<loinc value='2093-3' />
<low value='120 ' />
<orderID value='852' />
<result value='163' />
<resulted value='3120425.230719' />
<sample value='SERUM' />
</lab>
<dose dose='0' units='mg Tab|1 tablet' route='by mouth' schedule='as directed' />
</doses>

<facility code='050' name='VOE OFFICE INSTITUTION' />
<form value='CAP,EC' />
{id value='2N;O' />

<name value='FREE TXT DRUG CAP,EC' />
<ordered value='3110504.18382' />
<orderingProvider code='76' name='VAN NESS,NANCY' />
<sig xml:space='preserve'>Azithromycin 250 mg Tab|1 tablet BY by mouth as directed</sig>
<start value='3110504.1733' />
<status value='active' />
<type value='OTC' />
<vaType value='N' />
</med>

<dose dose='0' units='.' route='inhale' schedule='as directed' />
</doses>

<facility code='050' name='VOE OFFICE INSTITUTION' />
<form value='CAP,EC' />
{id value='3N;O' />

<name value='FREE TXT DRUG CAP,EC' />
<ordered value='3110504.18501' />
<orderingProvider code='76' name='VAN NESS,NANCY' />
<sig xml:space='preserve'>Albuterol Sulfate 2.5 mg/3 mL (0.083 %) Neb Solution|1 mL BY inhale as directed</sig>
<start value='3110504.1755' />
<status value='active' />
<type value='OTC' />
<vaType value='N' />
</med>

<dose dose='0' route='inhale' schedule='as directed' />
</doses>

<facility code='050' name='VOE OFFICE INSTITUTION' />
<form value='CAP,EC' />
{id value='4N;O' />

<name value='FREE TXT DRUG CAP,EC' />
<ordered value='3110504.190648' />
<orderingProvider code='76' name='VAN NESS,NANCY' />
<sig xml:space='preserve'>Atrovent HFA 17 mcg/Actuation Aerosol Inhaler|1 puff BY inhale as directed</sig>
<start value='3110504.1811' />
<status value='active' />
<type value='OTC' />
<vaType value='N' />
</med>
<med>
<doses>
<dose dose='0' route='by mouth' schedule='DAILY' />
</doses>
<facility code='050' name='VOE OFFICE INSTITUTION' />
<form value='TAB' />
<id value='5N;O' />
<name value='WARFARIN 3MG TAB' />
<ordered value='3110622.165848' />
<orderingProvider code='63' name='KING,MATTHEW MICHAEL' />
<products>
$product code='94514' name='WARFARIN 3MG' role='D' >
<class code='ANTICOAGULANTS' />
<vaGeneric code='865' name='WARFARIN' vuid='4019972' />
<vaProduct code='4659' name='WARFARIN NA 3MG TAB' vuid='4005206' />
</product>
</products>
<sig xml:space='preserve'>Warfarin 3 mg Tab| 1 tablet BY by mouth DAILY</sig>
<start value='3110622.160507' />
<status value='active' />
<type value='OTC' />
<vaType value='N' />
</med>
<med>
<doses>
<dose dose='0' route='by mouth' schedule='DAILY' />
</doses>
<facility code='050' name='VOE OFFICE INSTITUTION' />
<form value='TAB' />
<id value='6N;O' />
<name value='WARFARIN 3MG TAB' />
<ordered value='3110622.165848' />
<orderingProvider code='63' name='KING,MATTHEW MICHAEL' />
<products>
$product code='94514' name='WARFARIN 3MG' role='D' >
<class code='ANTICOAGULANTS' />
<vaGeneric code='865' name='WARFARIN' vuid='4019972' />
<vaProduct code='4659' name='WARFARIN NA 3MG TAB' vuid='4005206' />
</product>
</products>
<sig xml:space='preserve'>Warfarin 3 mg Tab| 1 tablet BY by mouth DAILY</sig>
<start value='3110622.160548' />
<status value='active' />
<stop value='3110622.170517' />
<type value='OTC' />
<vaType value='N' />

This XML is transformed to a more usable Mumps array. The array indexes are derived from the XML tags:

```mumps
G("allergy",1,"adverseEventType@value")="D"
G("allergy",1,"comments.comment@commentText")="active"
G("allergy",1,"comments.comment@commentType")="O"
G("allergy",1,"comments.comment@entered")=3110622.163636
G("allergy",1,"comments.comment@enteredBy")="KING,MATTHEW MICHAEL"
G("allergy",1,"comments.comment@id")=1
G("allergy",1,"drugIngredients.drugIngredient@name")="CEPHALEXIN"
G("allergy",1,"drugIngredients.drugIngredient@vuid")=4018891
G("allergy",1,"entered@value")=3110622.1636
G("allergy",1,"facility@code")="050"
G("allergy",1,"facility@name")="VOE OFFICE INSTITUTION"
G("allergy",1,"id@value")=51
G("allergy",1,"localCode@value")="1495;PS(50.416,""
G("allergy",1,"mechanism@value")="ALLERGY"
G("allergy",1,"name@value")="CEPHALEXIN"
G("allergy",1,"reactions.reaction@name")="HIVES"
G("allergy",1,"severity@value")="SEVERE"
G("allergy",1,"source@value")="O"
G("allergy",1,"vuid@value")=4018891
G("lab",1,"collected@value")=3120425.231037
G("lab",1,"comment")="GPLTEST SMART Report Released Date/Time: Apr 25, 2012@23:11"
G("lab",1,"comment@xml:space")="preserve"
G("lab",1,"facility@code")=100
G("lab",1,"facility@name")="VOE OFFICE INSTITUTION OLD"
G("lab",1,"groupId@value")="CH 0425 5"
G("lab",1,"id@value")="CH;6879573.768963;67008"
G("lab",1,"labOrderID@value")=118
G("lab",1,"localName@value")="HDLCHLS"
G("lab",1,"loinc@value")="2085-9"
G("lab",1,"orderID@value")=855
G("lab",1,"result@value")=45
G("lab",1,"resulted@value")=3120425.231116
G("lab",1,"sample@value")="SERUM"
G("lab",1,"specimen@code")="0X500"
G("lab",1,"specimen@name")="SERUM"
G("lab",1,"status@value")="completed"
G("lab",1,"test@value")="HDL CHOLESTEROL"
G("lab",1,"type@value")="CH"
G("lab",1,"vuid@value")=4662693
G("lab",2,"collected@value")=3120425.230609
G("lab",2,"comment")="--For Test: CHOLESTEROL --GPLTEST SMART Report Released Date/Time: Apr 25, 2012@23:07"
G("lab",2,"comment@xml:space")="preserve"
G("lab",2,"facility@code")=100
```
G("lab",2,"facility@name")="VOE OFFICE INSTITUTION OLD"
G("lab",2,"groupName@value")="CH 0425 3"
G("lab",2,"high@value")=" 200"
G("lab",2,"id@value")="CH;6879573.769391;12"
G("lab",2,"labOrderID@value")=103
G("lab",2,"localName@value")="CHOL"
G("lab",2,"loinc@value")="2093-3"
G("lab",2,"low@value")="120"
G("lab",2,"orderID@value")=852
G("lab",2,"result@value")=163
G("lab",2,"resulted@value")=3120425.230719
G("lab",2,"sample@value")="SERUM"
G("lab",2,"specimen@code")="0X500"
G("lab",2,"specimen@name")="SERUM"
G("lab",2,"status@value")="completed"
G("lab",2,"test@value")="CHOLESTEROL"
G("lab",2,"type@value")="CH"
G("lab",2,"units@value")="mg/dL"
G("lab",2,"vuid@value")=4662777
G("lab",3,"collected@value")=3120425.223729
G("lab",3,"comment")="-For Test: HIGH-SENSIVITY C-REACTIVE PROTEIN ~GPLTEST
SMART Report Released Date/Time: Apr 25, 2012@22:42"
G("lab",3,"comment@xml:space")="preserve"
G("lab",3,"facility@code")=100
G("lab",3,"facility@name")="VOE OFFICE INSTITUTION OLD"
G("lab",3,"groupName@value")="CH 0425 1"
G("lab",3,"high@value")=" 3"
G("lab",3,"id@value")="CH;6879573.776271;1006"
G("lab",3,"labOrderID@value")=94
G("lab",3,"localName@value")="HS-CRP"
G("lab",3,"loinc@value")="30522-7"
G("lab",3,"low@value")="0"
G("lab",3,"orderID@value")=850
G("lab",3,"result@value")=2.9
G("lab",3,"resulted@value")=3120425.224231
G("lab",3,"sample@value")="SERUM"
G("lab",3,"specimen@code")="0X500"
G("lab",3,"specimen@name")="SERUM"
G("lab",3,"status@value")="completed"
G("lab",3,"test@value")="HIGH-SENSIVITY C-REACTIVE PROTEIN"
G("lab",3,"type@value")="CH"
G("lab",3,"units@value")="mg/L"
G("lab",3,"vuid@value")=4673029
G("med",1,"doses.dose@dose")=0
G("med",1,"doses.dose@route")="Oral"
G("med",1,"doses.dose@schedule")="Select Frequency"
G("med",1,"doses.dose@units")=" mg Tab| 1 Add'l Sig"
G("med",1,"facility@code")="050"
G("med",1,"facility@name")="VOE OFFICE INSTITUTION"
G("med",1,"form@value")="TAB"
G("med",1,"id@value")="1N;0"
G("med",1,"name@value")="ATORVASTATIN TAB"
G("med",1,"ordered@value")=3110429.123852
G("med",1,"orderingProvider@code")=77
G("med",1,"orderingProvider@name")="LILLY,GEORGE"
G("med",1,"products.product.class@code")="ANTILIPEMIC AGENTS"
G("med",1,"products.product.vaGeneric@code")=3382
G("med",1,"products.product.vaGeneric@name")="ATORVASTATIN"
G("med",1,"products.product.vaGeneric@vuid")=4024041
G("med",1,"products.product.vaProduct@code")=12595
G("med",1,"products.product.vaProduct@name")="ATORVASTATIN CA 10MG TAB"
G("med",1,"products.product.vaProduct@vuid")=4012960
G("med",1,"products.product@code")=94208
G("med",1,"products.product@name")="ATORVASTATIN 10MG"
G("med",1,"products.product@role")="D"
G("med",1,"sig")="Lipitor 10 mg Tab| 1  Add'l Sig BY Oral Select Frequency"
G("med",1,"sig@xml:space")="preserve"
G("med",1,"start@value")=3110429.1145
G("med",1,"status@value")="active"
G("med",1,"stop@value")=3110504.13373
G("med",1,"type@value")="OTC"
G("med",1,"vaType@value")="N"
G("med",2,"doses.dose@dose")=0
G("med",2,"doses.dose@route")="by mouth"
G("med",2,"doses.dose@schedule")="as directed"
G("med",2,"doses.dose@units")=" mg Tab| 1 tablet"
G("med",2,"facility@code")="050"
G("med",2,"facility@name")="VOE OFFICE INSTITUTION"
G("med",2,"form@value")="CAP,EC"
G("med",2,"id@value")="2N;O"
G("med",2,"name@value")="FREE TXT DRUG CAP,EC"
G("med",2,"ordered@value")=3110504.18382
G("med",2,"orderingProvider@code")=76
G("med",2,"orderingProvider@name")="VAN NESS,NANCY"
G("med",2,"sig")="Azithromycin 250 mg Tab| 1 tablet BY mouth as directed"
G("med",2,"sig@xml:space")="preserve"
G("med",2,"start@value")=3110504.1733
G("med",2,"status@value")="active"
G("med",2,"type@value")="OTC"
G("med",2,"vaType@value")="N"
G("med",3,"doses.dose@dose")=0
G("med",3,"doses.dose@route")="inhale"
G("med",3,"doses.dose@schedule")="as directed"
G("med",3,"doses.dose@units")=" ."
G("med",3,"facility@code")="050"
G("med",3,"facility@name")="VOE OFFICE INSTITUTION"
G("med",3,"form@value")="CAP,EC"
G("med",3,"id@value")="3N;O"
G("med",3,"name@value")="FREE TXT DRUG CAP,EC"
G("med",3,"ordered@value")=3110504.18501
G("med",3,"orderingProvider@code")=76
G("med",3,"orderingProvider@name")="VAN NESS,NANCY"
G("med",3,"sig")="Albuterol Sulfate 2.5 mg/3 mL (0.083 %) Neb Solution| 1 mL BY inhale as directed"
G("med",3,"sig@xml:space")="preserve"
G("med",3,"start@value")=3110504.1755
G("med",3,"status@value")="active"
G("med",3,"type@value")="OTC"
G("med",3,"vaType@value")="N"
G("med",4,"doses.dose@dose")=0
G("med",4,"doses.dose@route")="inhale"
G("med",4,"doses.dose@schedule")="as directed"
G("med",4,"facility@code")="050"
G("med",4,"facility@name")="VOE OFFICE INSTITUTION"
G("med",4,"form@value")="CAP, EC"
G("med",4,"id@value")="4N; O"
G("med",4,"name@value")="FREE TXT DRUG CAP, EC"
G("med",4,"ordered@value")=3110504.190648
G("med",4,"orderingProvider@code")=76
G("med",4,"orderingProvider@name")="VAN NESS, NANCY"
G("med",4,"sig")="Atrovent HFA 17 mcg/Actuation Aerosol Inhaler| 1 puff BY inhaler as directed"
G("med",4,"sig@xml:space")="preserve"
G("med",4,"start@value")=3110504.1811
G("med",4,"status@value")="active"
G("med",4,"type@value")="OTC"
G("med",4,"vaType@value")="N"
G("med",5,"doses.dose@dose")=0
G("med",5,"doses.dose@route")="by mouth"
G("med",5,"doses.dose@schedule")="DAILY"
G("med",5,"facility@code")="050"
G("med",5,"facility@name")="VOE OFFICE INSTITUTION"
G("med",5,"form@value")="TAB"
G("med",5,"id@value")="5N; O"
G("med",5,"name@value")="WARFARIN 3MG TAB"
G("med",5,"ordered@value")=3110622.165848
G("med",5,"orderingProvider@code")=63
G("med",5,"orderingProvider@name")="KING, MATTHEW MICHAEL"
G("med",5,"products.product.class@code")="ANTICOAGULANTS"
G("med",5,"products.product.vaGeneric@code")=865
G("med",5,"products.product.vaGeneric@name")="WARFARIN"
G("med",5,"products.product.vaGeneric@vuid")=4019972
G("med",5,"products.product.vaProduct@code")=4659
G("med",5,"products.product.vaProduct@name")="WARFARIN NA 3MG TAB"
G("med",5,"products.product.vaProduct@vuid")=4005206
G("med",5,"products.product@code")=94514
G("med",5,"products.product@name")="WARFARIN 3MG"
G("med",5,"products.product@role")="D"
G("med",5,"sig")="Warfarin 3 mg Tab| 1 tablet BY by mouth DAILY"
G("med",5,"sig@xml:space")="preserve"
G("med",5,"start@value")=3110622.160507
G("med",5,"status@value")="active"
G("med",5,"type@value")="OTC"
G("med",5,"vaType@value")="N"
G("med",6,"doses.dose@dose")=0
G("med",6,"doses.dose@route")="by mouth"
Warfarin 3 mg Tab| 1 tablet BY by mouth DAILY
From this mumps array, triples are formed according to the Smart data model and then rendered as rdf. Examples of each type are shown in the sections that follow.
3. Demographics

All of the fields in demographics mapped directly from the NHIN xml output except the following:

sex - Sex is given as M or F in VistA, must be male or female for Smart
Date of Birth - all dates in VistA are in fileman format. The Smart date format is different and requires special transformations. An example is 1988-01-03, the zeros are required to keep the dates in sort order even though they are strings

Triples:

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>PREDICATE</th>
<th>OBJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>nodeID:163928854</td>
<td>rdf:type</td>
<td>v:Home</td>
</tr>
<tr>
<td>nodeID:163928854</td>
<td>v:locality</td>
<td>BIXBY</td>
</tr>
<tr>
<td>nodeID:163928854</td>
<td>v:postal-code</td>
<td>74008</td>
</tr>
<tr>
<td>nodeID:163928854</td>
<td>v:region</td>
<td>OKLAHOMA</td>
</tr>
<tr>
<td>nodeID:163928854</td>
<td>v:street-address</td>
<td>635 Big Sky Ln</td>
</tr>
<tr>
<td>nodeID:627173842</td>
<td>rdf:type</td>
<td>v:Name</td>
</tr>
<tr>
<td>nodeID:627173842</td>
<td>v:additional-name</td>
<td>RYAN</td>
</tr>
<tr>
<td>nodeID:627173842</td>
<td>v:family-name</td>
<td>ALLEN</td>
</tr>
<tr>
<td>nodeID:627173842</td>
<td>v:given-name</td>
<td>JASON</td>
</tr>
<tr>
<td>nodeID:825405422</td>
<td>dcterms:identifier</td>
<td>6</td>
</tr>
<tr>
<td>nodeID:825405422</td>
<td>dcterms:title</td>
<td>VistA Patient Record 6</td>
</tr>
<tr>
<td>nodeID:825405422</td>
<td>rdf:type</td>
<td>rdf:type</td>
</tr>
<tr>
<td>nodeID:825405422</td>
<td>sp:system</td>
<td>VistA Patient Record</td>
</tr>
<tr>
<td>nodeID:835095016</td>
<td>rdf:type</td>
<td>v:Tel</td>
</tr>
<tr>
<td>nodeID:835095016</td>
<td>rdf:value</td>
<td>333-333-3334</td>
</tr>
<tr>
<td>vistaSmart:6/patient</td>
<td>foaf:gender</td>
<td>male</td>
</tr>
<tr>
<td>vistaSmart:6/patient</td>
<td>rdf:type</td>
<td>sp:Demographics</td>
</tr>
<tr>
<td>vistaSmart:6/patient</td>
<td>sp:belongsTo</td>
<td>vistaSmart:6/patient</td>
</tr>
<tr>
<td>vistaSmart:6/patient</td>
<td>sp:medicalRecordNumber</td>
<td>nodeID:825405422</td>
</tr>
<tr>
<td>vistaSmart:6/patient</td>
<td>v:adr</td>
<td>nodeID:163928854</td>
</tr>
<tr>
<td>vistaSmart:6/patient</td>
<td>v:bday</td>
<td>1953-10-16</td>
</tr>
<tr>
<td>vistaSmart:6/patient</td>
<td>v:n</td>
<td>nodeID:627173842</td>
</tr>
<tr>
<td>vistaSmart:6/patient</td>
<td>v:tel</td>
<td>nodeID:835095016</td>
</tr>
</tbody>
</table>

RDF:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
  <rdf:Description rdf:nodeID="iDPsDPss635992783">
    <rdf:type rdf:resource="http://www.w3.org/2006/vcard/ns#Tel"/>
    <value xmlns="http://www.w3.org/1999/02/22-rdf-syntax-ns#">333-333-3334</value>
  </rdf:Description>
  <rdf:Description rdf:nodeID="iDPsDPss675298425">
    <rdf:type rdf:resource="http://www.w3.org/2006/vcard/ns#Home"/>
    <locality xmlns="http://www.w3.org/2006/vcard/ns#">BIXBY</locality>
    <postal-code xmlns="http://www.w3.org/2006/vcard/ns#">74008</postal-code>
  </rdf:Description>
</rdf:RDF>
```
<rdf:RDF>
  <rdf:Description rdf:nodeID="iDPsDPss769124988">
    <identifier xmlns="http://purl.org/dc/terms/">6</identifier>
    <title xmlns="http://purl.org/dc/terms/">VistA Patient Record 6</title>
    <system xmlns="http://smartplatforms.org/terms#">VistA Patient Record</system>
  </rdf:Description>
  <rdf:Description rdf:nodeID="iDPsDPss960163516">
    <additional-name xmlns="http://www.w3.org/2006/vcard/ns#">RYAN</additional-name>
    <family-name xmlns="http://www.w3.org/2006/vcard/ns#">ALLEN</family-name>
    <given-name xmlns="http://www.w3.org/2006/vcard/ns#">JASON</given-name>
  </rdf:Description>
  <rdf:Description rdf:about="https://smart2.vistaewd.net/vista/smart/records/6/patient">
    <gender xmlns="http://xmlns.com/foaf/0.1/">male</gender>
    <medicalRecordNumber xmlns="http://smartplatforms.org/terms#" rdf:nodeID="iDPsDPss769124988"/>
    <bday xmlns="http://www.w3.org/2006/vcard/ns#">1953-10-16</bday>
    <adr xmlns="http://www.w3.org/2006/vcard/ns#" rdf:nodeID="iDPsDPss675298425"/>
    <n xmlns="http://www.w3.org/2006/vcard/ns#" rdf:nodeID="iDPsDPss960163516"/>
    <tel xmlns="http://www.w3.org/2006/vcard/ns#" rdf:nodeID="iDPsDPss635992783"/>
  </rdf:Description>
</rdf:RDF>
4. Problems

All of the fields in problems mapped directly from the NHIN xml output except the following:

SNOMED code - Problems in VistA are coded with ICD9. We added a mapping file donated by Conor Dowling to the triple store that maps some ICD9 codes to SNOMED. the file is posted here:

https://trac.opensourcevista.net/svn/smart/trunk/data/icdToSNOMEDCG.zip in cases where there was no map, we delivered the ICD9 code

Analysis of our test patients regarding the coding of problems:

Total number of patients: 178
Total number of problems: 180
Total number of problems with snomed codes: 138
Percentage of problems with SNOMED codes: 76%

Triples:

<table>
<thead>
<tr>
<th>SUBJECT</th>
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<th>OBJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td>nodeID:322421093</td>
<td>dcterms:title</td>
<td>Diabetes Mellitus without mention</td>
</tr>
<tr>
<td></td>
<td></td>
<td>of Complication, type II or unspecified type</td>
</tr>
<tr>
<td>nodeID:322421093</td>
<td>rdf:type</td>
<td>sp:CodedValue</td>
</tr>
<tr>
<td>nodeID:322421093</td>
<td>sp:code</td>
<td>snomed:443694000</td>
</tr>
<tr>
<td>nodeID:521484640</td>
<td>dcterms:title</td>
<td>Essential Hypertension</td>
</tr>
<tr>
<td>nodeID:521484640</td>
<td>rdf:type</td>
<td>sp:CodedValue</td>
</tr>
<tr>
<td>nodeID:521484640</td>
<td>sp:code</td>
<td>snomed:59621000</td>
</tr>
<tr>
<td>nodeID:540863376</td>
<td>dcterms:title</td>
<td>Other and unspecified hyperlipidemia</td>
</tr>
<tr>
<td>nodeID:540863376</td>
<td>rdf:type</td>
<td>sp:CodedValue</td>
</tr>
<tr>
<td>nodeID:733217502</td>
<td>dcterms:title</td>
<td>Coronary Atherosclerosis of Native Coronary</td>
</tr>
<tr>
<td>nodeID:733217502</td>
<td>rdf:type</td>
<td>Vessel</td>
</tr>
<tr>
<td></td>
<td>sp:code</td>
<td>snomed:233817007</td>
</tr>
<tr>
<td>snomed:233817007</td>
<td>dcterms:identifier</td>
<td>233817007</td>
</tr>
<tr>
<td>snomed:233817007</td>
<td>dcterms:title</td>
<td>Coronary Atherosclerosis of Native Coronary</td>
</tr>
<tr>
<td>snomed:233817007</td>
<td>rdf:type</td>
<td>Vessel</td>
</tr>
<tr>
<td>snomed:233817007</td>
<td>sp:code</td>
<td>snomed:233817007</td>
</tr>
<tr>
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<td>dcterms:identifier</td>
<td>443694000</td>
</tr>
<tr>
<td>snomed:443694000</td>
<td>dcterms:title</td>
<td>Diabetes Mellitus without mention</td>
</tr>
</tbody>
</table>

18
of Complication, type II or unspecified type

http://purl.bioontology.org/ontology/SNOMEDCT

55822004

Other and unspecified hyperlipidemia

http://purl.bioontology.org/ontology/SNOMEDCT

59621000

Essential Hypertension

http://purl.bioontology.org/ontology/SNOMEDCT

nodeID:733217502

nodeID:540863376

nodeID:322421093

nodeID:521484640

nodeID:322421093
Essential Hypertension

Diabetes Mellitus without mention of Complication, type II or unspecified type,

Coronary Atherosclerosis of Native Coronary Vessel

Other and unspecified hyperlipidemia
rdf:nodeID="iDPsDPss782573457"/>
<startDate xmlns="http://smartplatforms.org/terms#">2011-06-24</startDate>
</rdf:Description>
</rdf:RDF>
5. Medications

We only processed Outpatient meds for the first version of the Smart Container. Inpatient meds were skipped.

All of the fields in medications mapped directly from the NHIN xml output except the following:

- RxNorm - VistA meds are coded with VUIDs. We used a mapping file in VistA to map the VUID codes to RxNorm.
- Units and Values in VistA do not conform to the Smart standards, and we did not find a way to map them to Smart terminologies, we delivered what VistA stores. However, it might be possible to develop a mapping, perhaps based on the type of medication.

Analysis of Medication Form, Dose, Schedule, and Route in test patients.

Outpatient Medications in dEWDrop

Total number of patients: 178
Total number of medications: 258
Total number of outpatient medications: 35
Percentage of outpatient medications: 13%
FORM("")=1
FORM("CAP,ORAL")=2
FORM("INHALANT")=2
FORM("INHL,ORAL")=2
FORM("OINT,TOP")=1
FORM("SUSP,ORAL")=2
FORM("TAB")=22
FORM("TAB,CHEWABLE")=2
FORM("TAB,SA")=1
DOSE(2)=3
DOSE(2.5)=2
DOSE(3)=2
DOSE(10)=4
DOSE(20)=3
DOSE(75)=1
DOSE(80)=2
DOSE(81)=2
DOSE(100)=1
DOSE(200)=2
DOSE(250)=1
DOSE(300)=1
DOSE(500)=1

23
DOSE("0.1")=1
DOSE("0.2")=1
DOSE("1 PUFF")=2
DOSE("2 PUFFS")=2
DOSE("5 ML")=2
DOSE("A SMALL AMOUNT")=1
DOSE("UNKNOWN")=1
UNITS("MG")=27
UNITS("UNKNOWN")=8
SCHED("BID")=12
SCHED("BID PRN")=3
SCHED("ONCE")=1
SCHED("Q12H")=1
SCHED("Q2-4H")=1
SCHED("Q8H")=1
SCHED("QAM")=3
SCHED("QD")=11
SCHED("QHS")=1
SCHED("UNKNOWN")=1
ROUTE("UNKNOWN")=35

Non-VA Medications in dEWDrop

Total number of patients: 178
Total number of medications: 258
Total number of non-VA medications: 142
Percentage of non-VA medications: 55%
FORM("CAP,EC")=29
FORM("CAP,ORAL")=3
FORM("EXTRACT")=6
FORM("INHALANT")=3
FORM("INHL,ORAL")=3
FORM("INJ,SOLN")=2
FORM("PWDR,RENST-ORAL")=3
FORM("TAB")=82
FORM("TAB,EC")=2
FORM("TAB,SA")=9
DOSE(0)=114
DOSE(1)=1
DOSE(2.5)=1
DOSE(5)=1
DOSE(8)=3
DOSE(10)=4
DOSE(20)=2
DOSE(40)=1
DOSE(325)=2
DOSE("UNKNOWN")=13
UNITS(" 1")=8
UNITS(" 2")=1
UNITS(" mEq Oral Packet| 1 unit")=1
UNITS(" mEq Tab| 1 tablet")=1
UNITS(" mcg/Actuation Aerosol Inhaler| 1 puff")=2
UNITS(" mcg/Actuation Aerosol Inhaler| 2 gm")=1
UNITS(" mcg/Actuation Aerosol Inhaler| 2 puff")=4
UNITS(" mg Tab| 1 Add'l Sig")=3
UNITS(" mg Tab| 1 tablet")=25
UNITS(" mg-5")=1
UNITS(" mg/5 mL Oral Susp| 2.5 mL")=1
UNITS(" mg/5 mL Oral Susp| 5 mL")=1
UNITS("")=1
UNITS(".1 mg Tab| 1 tablet")=7
UNITS(".2 mg Tab| 1 tablet")=1
UNITS("IV")=2
UNITS("MCG/INHL")=1
UNITS("MG")=15
UNITS("PO")=1
UNITS("TKN")=5
UNITS("UNKNOWN")=60
SCHED("BID")=25
SCHED("BID PRN")=1
SCHED("DAILY")=62
SCHED("NOW")=1
SCHED("Q4h")=4
SCHED("Q4h PRN")=2
SCHED("Q6H PRN")=1
SCHED("Q6h")=3
SCHED("Q8h")=2
SCHED("QAM")=1
SCHED("QD")=13
SCHED("QID")=6
SCHED("Select Frequency")=3
SCHED("TID")=2
SCHED("UNKNOWN")=8
SCHED("as directed")=3
SCHED("in A.M.")=5
ROUTE("UNKNOWN")=142

IV Medications in dEWDrop

Total number of patients: 178
Total number of medications: 258
Total number of IV medications: 5
Percentage of IV medications: 1%
FORM("")=5
DOSE("UNKNOWN")=5
UNITS("UNKNOWN")=5
SCHED("Q24H")=1
SCHED("Q8H")=2
SCHED("UNKNOWN")=2
ROUTE("UNKNOWN")=5

Inpatient Medications in dEWDrop

Total number of patients: 178
Total number of medications: 258
Total number of Inpatient medications: 76
Percentage of Inpatient medications: 29%
FORM("CAP,ORAL")=7
FORM("INHALANT")=4
FORM("INHL,ORAL")=2
FORM("INJ")=1
FORM("INJ,PWDR")=6
FORM("INJ,SOLN")=6
FORM("SUSP,ORAL")=3
FORM("TAB")=40
FORM("TAB,EC")=1
FORM("TAB,SA")=4
FORM("TAB,SUBLINGUAL")=2
DOSE(2)=7
DOSE(2.5)=1
DOSE(3)=3
DOSE(5)=10
DOSE(10)=3
DOSE(20)=2
DOSE(25)=3
DOSE(30)=3
DOSE(75)=5
DOSE(100)=6
DOSE(250)=1
DOSE(325)=3
DOSE(650)=2
DOSE(1000)=5
DOSE("0.1")=7
DOSE("0.125")=1
DOSE("0.4")=2
DOSE("200MG/5ML")=1
DOSE("UNKNOWN")=11
UNITS("GM/1VIAL")=1
UNITS("MCG/INHL")=4
UNITS("MCG/SPRAY")=1
UNITS("MEQ")=3
UNITS("MG")=55
UNITS("UNKNOWN")=7
UNITS("UNT/1ML")=5
SCHED("BID")=15
SCHED("NOW")=5
SCHED("PRN")=2
SCHED("Q12H")=3
SCHED("Q2-4H")=1
SCHED("Q24H")=13
SCHED("Q4H")=1
SCHED("Q4H PRN")=7
SCHED("Q6H")=3
SCHED("Q6H PRN")=2
SCHED("Q8H")=2
SCHED("QD")=16
SCHED("QD PRN")=3
SCHED("STAT")=2
SCHED("UNKNOWN")=1
ROUTE("UNKNOWN")=76

Triples:

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<th>OBJECT</th>
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<td>nodeID:251667904</td>
<td>dcterms:title</td>
<td>ATORVASTATIN TAB</td>
</tr>
<tr>
<td>nodeID:251667904</td>
<td>rdf:type</td>
<td>sp:CodedValue</td>
</tr>
<tr>
<td>nodeID:251667904</td>
<td>sp:code</td>
<td>rxnorm:617314</td>
</tr>
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<td>sp:unit</td>
<td>UNKNOWN</td>
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<td>nodeID:482950547</td>
<td>sp:value</td>
<td>0</td>
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<tr>
<td>nodeID:513189765</td>
<td>sp:ValueAndUnit</td>
<td>nodeID:577056569</td>
</tr>
<tr>
<td>nodeID:528278275</td>
<td>sp:unit</td>
<td>mg Tab</td>
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<tr>
<td>nodeID:528278275</td>
<td>sp:value</td>
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<tr>
<td>nodeID:577056569</td>
<td>sp:unit</td>
<td>Oral</td>
</tr>
<tr>
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<td>sp:value</td>
<td>Select Frequency</td>
</tr>
<tr>
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<td>sp:ValueAndUnit</td>
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<td>sp:ValueAndUnit</td>
<td>nodeID:482950547</td>
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<tr>
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<td>WARFARIN 3MG TAB</td>
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<td>sp:CodedValue</td>
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<td>sp:code</td>
<td>rxnorm:855320</td>
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<tr>
<td>rxnorm:855320</td>
<td>sp:unit</td>
<td>by mouth</td>
</tr>
<tr>
<td>nodeID:993436766</td>
<td>sp:value</td>
<td>DAILY</td>
</tr>
<tr>
<td>rxnorm:617314</td>
<td>rxnorm:617314</td>
<td>617314</td>
</tr>
<tr>
<td>rxnorm:617314</td>
<td>dcterms:title</td>
<td>ATORVASTATIN TAB</td>
</tr>
<tr>
<td>rxnorm:617314</td>
<td>rdf:type</td>
<td>smartplatforms.org/terms/codes/RxNorm_Semantic</td>
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</table>
RDF:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
  <rdf:Description rdf:nodeID="iDPsDPss282620764">
    <ValueAndUnit xmlns="http://smartplatforms.org/terms#" rdf:nodeID="iDPsDPss771302706"/>
  </rdf:Description>
</rdf:RDF>
```
ATORVASTATIN TAB

1 tablet BY mouth DAILY

1 Add'l Sig BY Oral

Select Frequency
6. Lab Results

All of the fields in labs mapped directly from the NHIN xml output except the following:

- Loinc codes - VistA supports Loinc codes, and where they were present, we delivered them as output. Where there were no Loinc codes, we skipped the lab result, because we could not figure a way to provide a smart output.

Analysis of our test patients regarding LOINC coding:

Total number of patients: 178
Total number of lab results: 411
Total number of lab results with loinc codes: 224
Percentage of lab tests with loinc codes: 54%

Triples:

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<th>OBJECT</th>
</tr>
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<td>dcterms:identifier</td>
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<tr>
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<td>HDL CHOLESTEROL</td>
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<tr>
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<td>rdf:type</td>
<td>sp:Code</td>
</tr>
<tr>
<td>loinc:2093-3</td>
<td>sp:system</td>
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<td>dcterms:title</td>
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<tr>
<td>loinc:30522-7</td>
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<td>dcterms:identifier</td>
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</tr>
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<td>dcterms:title</td>
<td>HIGH-SENSIVITY C-REACTIVE PROTEIN</td>
</tr>
<tr>
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<td>sp:Code</td>
</tr>
<tr>
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<td>sp:ValueAndUnit</td>
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<td>sp:unit</td>
<td>HDL CHOLESTEROL</td>
</tr>
<tr>
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<td>sp:value</td>
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</tr>
<tr>
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<td>CHOLESTEROL</td>
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<td>sp:CodedValue</td>
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<tr>
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<td>sp:code</td>
<td>loinc:2093-3</td>
</tr>
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<td>sp:Attribution</td>
</tr>
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<td>nodeID:158083727</td>
<td>sp:startDate</td>
<td>2012-04-25</td>
</tr>
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</tr>
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<td>nodeID:508295096</td>
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<td>sp:Attribution</td>
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</table>
HDL CHOLESTEROL

High-Sensitivity C-Reactive Protein

mg/dL

subject

predicate

object

valueAndUnit

value

unit

mg/dL

163

nodeID:603258303

nodeID:606788887

nodeID:606788887

nodeID:606788887

nodeID:616271691

mg/dL

nodeID:606788887

nodeID:606788887

nodeID:606788887

nodeID:616271691

subject

predicate

object

valueAndUnit

value

unit

mg/dL

200

nodeID:603258303

nodeID:606788887

nodeID:606788887

nodeID:606788887

nodeID:616271691

mg/dL

nodeID:606788887

nodeID:606788887

nodeID:606788887

nodeID:616271691

subject

predicate

object

valueAndUnit

value

unit

mg/dL

200

nodeID:603258303

nodeID:606788887

nodeID:606788887

nodeID:606788887

nodeID:616271691

mg/dL

nodeID:606788887

nodeID:606788887

nodeID:606788887

nodeID:616271691

subject

predicate

object

valueAndUnit

value

unit

mg/dL

200

nodeID:603258303

nodeID:606788887

nodeID:606788887

nodeID:606788887

nodeID:616271691

mg/dL

nodeID:606788887

nodeID:606788887

nodeID:606788887

nodeID:616271691

subject

predicate

object

valueAndUnit

value

unit

mg/dL

200

nodeID:603258303

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nodeID:616271691

mg/dL

nodeID:606788887

nodeID:606788887

nodeID:606788887

nodeID:616271691

subject

predicate

object

valueAndUnit

value

unit

mg/dL

200

nodeID:603258303

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nodeID:606788887

nodeID:606788887

nodeID:616271691

mg/dL

nodeID:606788887

nodeID:606788887

nodeID:606788887

nodeID:616271691

subject

predicate

object

valueAndUnit

value

unit

mg/dL

200

nodeID:603258303

nodeID:606788887

nodeID:606788887

nodeID:606788887

nodeID:616271691

mg/dL

nodeID:606788887

nodeID:606788887

nodeID:606788887

nodeID:616271691

subject

predicate

object

valueAndUnit

value

unit

mg/dL

200

nodeID:603258303

nodeID:606788887

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nodeID:606788887

nodeID:616271691

mg/dL

nodeID:606788887

nodeID:606788887

nodeID:606788887

nodeID:616271691

subject

predicate

object

valueAndUnit

value

unit

mg/dL

200
RDF:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<rdf:RDF xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#">
  <rdf:Description rdf:about="http://purl.bioontology.org/ontology/LNC/2085-9">
    <identifier xmlns="http://purl.org/dc/terms/">2085-9</identifier>
    <title xmlns="http://purl.org/dc/terms/">HDL CHOLESTEROL</title>
    <rdf:type rdf:resource="http://smartplatforms.org/terms#Code"/>
    <system xmlns="http://smartplatforms.org/terms#" rdf:resource="http://loinc.org/codes/"/>
  </rdf:Description>
  <rdf:Description rdf:about="http://purl.bioontology.org/ontology/LNC/2093-3">
    <identifier xmlns="http://purl.org/dc/terms/">2093-3</identifier>
    <title xmlns="http://purl.org/dc/terms/">CHOLESTEROL</title>
    <rdf:type rdf:resource="http://smartplatforms.org/terms#Code"/>
    <system xmlns="http://smartplatforms.org/terms#" rdf:resource="http://loinc.org/codes/"/>
  </rdf:Description>
  <rdf:Description rdf:about="http://purl.bioontology.org/ontology/LNC/30522-7">
    <identifier xmlns="http://purl.org/dc/terms/">30522-7</identifier>
    <title xmlns="http://purl.org/dc/terms/">HIGH-SENSIVITY C-REACTIVE PROTEIN</title>
    <rdf:type rdf:resource="http://smartplatforms.org/terms#Code"/>
    <system xmlns="http://smartplatforms.org/terms#" rdf:resource="http://loinc.org/codes/"/>
  </rdf:Description>
</rdf:RDF>
```
<valueAndUnit xmlns="http://smartplatforms.org/terms#" rdf:nodeID="iDPsDPss963601236"/>
</rdf:Description>
<rdf:Description rdf:nodeID="iDPsDPss536704371">
<rdf:type rdf:resource="http://smartplatforms.org/terms#ValueAndUnit"/>
<unit xmlns="http://smartplatforms.org/terms#">mg/dL</unit>
<value xmlns="http://smartplatforms.org/terms#">200</value>
</rdf:Description>
<rdf:Description rdf:nodeID="iDPsDPss558098398">
<rdf:type rdf:resource="http://smartplatforms.org/terms#QuantitativeResult"/>
<valueAndUnit xml.:http://smartplatforms.org/terms#" rdf:nodeID="iDPsDPss912964037"/>
</rdf:Description>
<title xmlns="http://purl.org/dc/terms/">CHOLESTEROL</title>
</rdf:Description>
<rdf:Description rdf:nodeID="iDPsDPss684965313">
<rdf:type rdf:resource="http://smartplatforms.org/terms#Attribution"/>
<startDate xmlns="http://smartplatforms.org/terms#">2012-04-25</startDate>
</rdf:Description>
<rdf:Description rdf:nodeID="iDPsDPss805024399">
<rdf:type rdf:resource="http://smartplatforms.org/terms#ValueRange"/>
<maximum xmlns="http://smartplatforms.org/terms#" rdf:nodeID="iDPsDPss536704371"/>
<minimum xmlns="http://smartplatforms.org/terms#" rdf:nodeID="iDPsDPss183485436"/>
</rdf:Description>
<rdf:Description rdf:nodeID="iDPsDPss816211098">
<rdf:type rdf:resource="http://smartplatforms.org/terms#ValueAndUnit"/>
<unit xmlns="http://smartplatforms.org/terms#">mg/L</unit>
<value xmlns="http://smartplatforms.org/terms#">0</value>
</rdf:Description>
<rdf:Description rdf:nodeID="iDPsDPss864181975">
<rdf:type rdf:resource="http://smartplatforms.org/terms#ValueAndUnit"/>
<unit xmlns="http://smartplatforms.org/terms#">mg/dL</unit>
<value xmlns="http://smartplatforms.org/terms#">163</value>
</rdf:Description>
<rdf:Description rdf:nodeID="iDPsDPss901763418">35</rdf:Description>