SDTM-ETL 4.5 User Manual and Tutorial

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Mapping Units of Measure

Table of Contents

Introduction

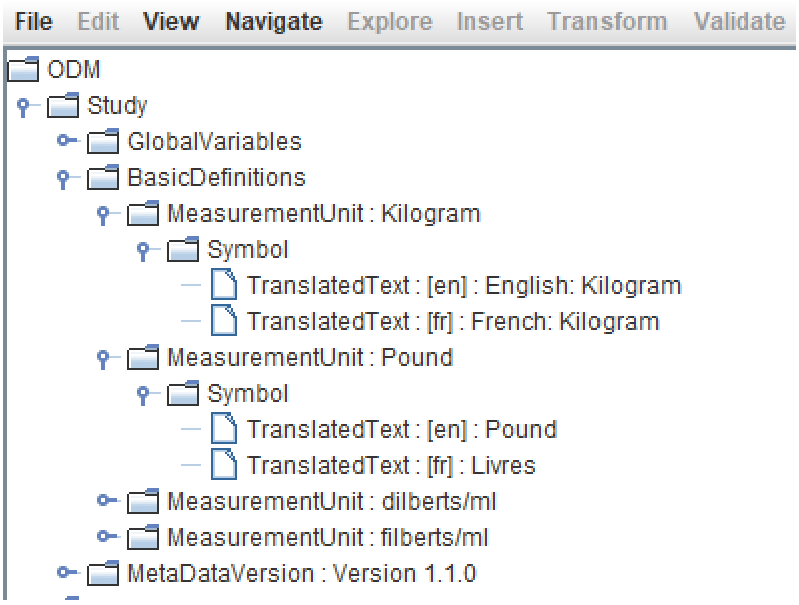
Units of measure can be handled and mapped to SDTM/SEND units of measure in different ways. Main reason is that ODM has several mechanisms to store and handle units of measure.
The classic one, but not used by many EDC systems, is to store the units in the ODM element "BasicDefinitions", and then referencing these, as well in the ODM metadata as in the clinical data, using the element "MeasurementUnitRef".
The second one is to just define the unit of measure as a data point, using "ItemDef" in the metadata, and "ItemData" in the clinical data.
And then there is UCUM (Unified Code for Units of Measure), which is used in healthcare and a standard in the medical informatics world, but unfortunately (due to the "not-invented-here syndrome) not (yet) used by CDISC.

On the SDTM/SEND side, in many cases, variables representing units of measure (e.g. –ORRESU) is under CDISC controlled terminology , i.e. having a CDISC codelist. Better were that CDISC moves to UCUM, as unit conversions can easily be automated using UCUM, which is not possible at all with CDISC units.
In some cases, one will however also want its own codes for units of measure, also on the SDTM/SEND side.

We will discuss each of these options in detail.

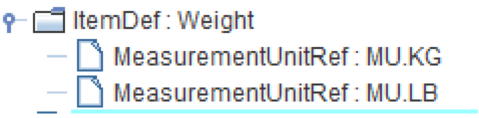
Copying ODM units of measure to SDTM/SEND define

In ODM, in some implementations, the units of measure to be used are stored in the "BasicDefinitions" element. When this is so, one will find these in the ODM tree on the left side, e.g.:



```
ODM
  Study
    GlobalVariables
    BasicDefinitions
      MeasurementUnit : Kilogram
        Symbol
          TranslatedText : [en] : English: Kilogram
          TranslatedText : [fr] : French: Kilogram
      MeasurementUnit : Pound
        Symbol
          TranslatedText : [en] : Pound
          TranslatedText : [fr] : Livres
      MeasurementUnit : dilberts/ml
      MeasurementUnit : filberts/ml
    MetaDataVersion : Version 1.1.0
```

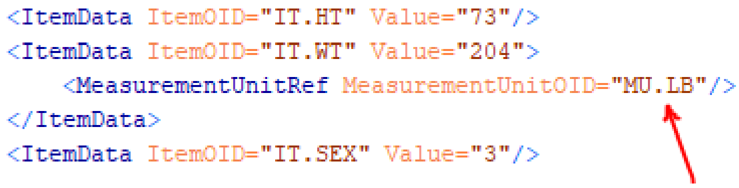
For data points that use these units, one will find a reference to them e.g.



```
ItemDef : Weight
  MeasurementUnitRef : MU.KG
  MeasurementUnitRef : MU.LB
```

Essentially meaning that, in the (e)CRF, there was a choice between using "kg" or "pounds" as the unit of measure for "weight".

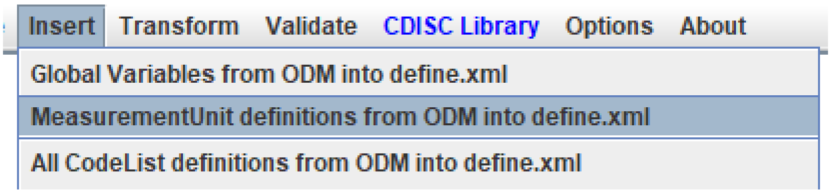
This also means that in the clinical data, one may find data points for which "kg" was used, and others for which "pounds" was used. For example:



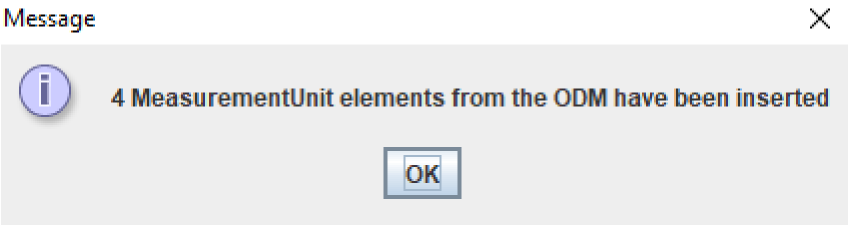
```
<ItemData ItemOID="IT.HT" Value="73"/>
<ItemData ItemOID="IT.WT" Value="204">
    <MeasurementUnitRef MeasurementUnitOID="MU.LB"/>
</ItemData>
<ItemData ItemOID="IT.SEX" Value="3"/>
```

One may now want to copy these units of measure from the ODM side to the SDTM/SEND define.xml and then transform this into a codelist. Very often, this will not be necessary, as one wants to use the already associated CDISC codelist. However, and especially in SEND, there will be no suitable associated codelist (e.g. for PK measurements) and one wants to use the units from the ODM.

To copy the units of measure from the ODM into the define.xml representing the SDTM/SEND data, use the menu "Insert - Measurement Unit definitions from ODM into define.xml":

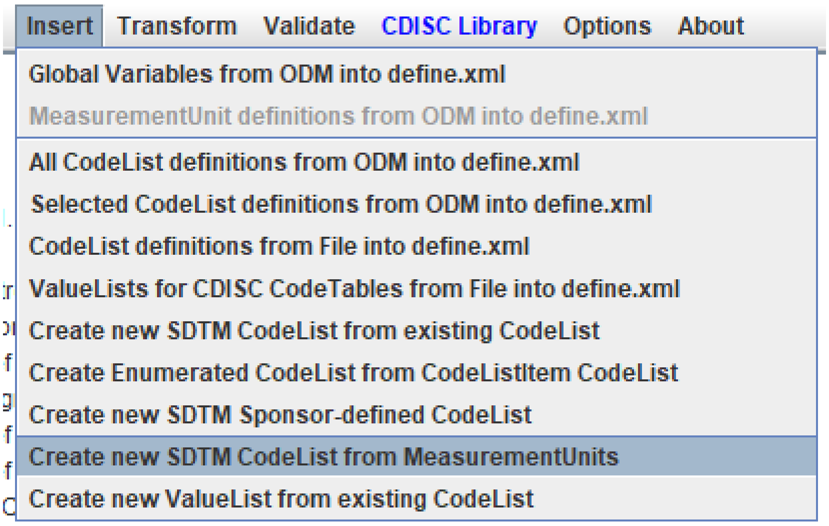

Insert
Transform
Validate
CDISC Library
Options
About
Global Variables from ODM into define.xml
MeasurementUnit definitions from ODM into define.xml
All CodeList definitions from ODM into define.xml

leading e.g. to:


Message

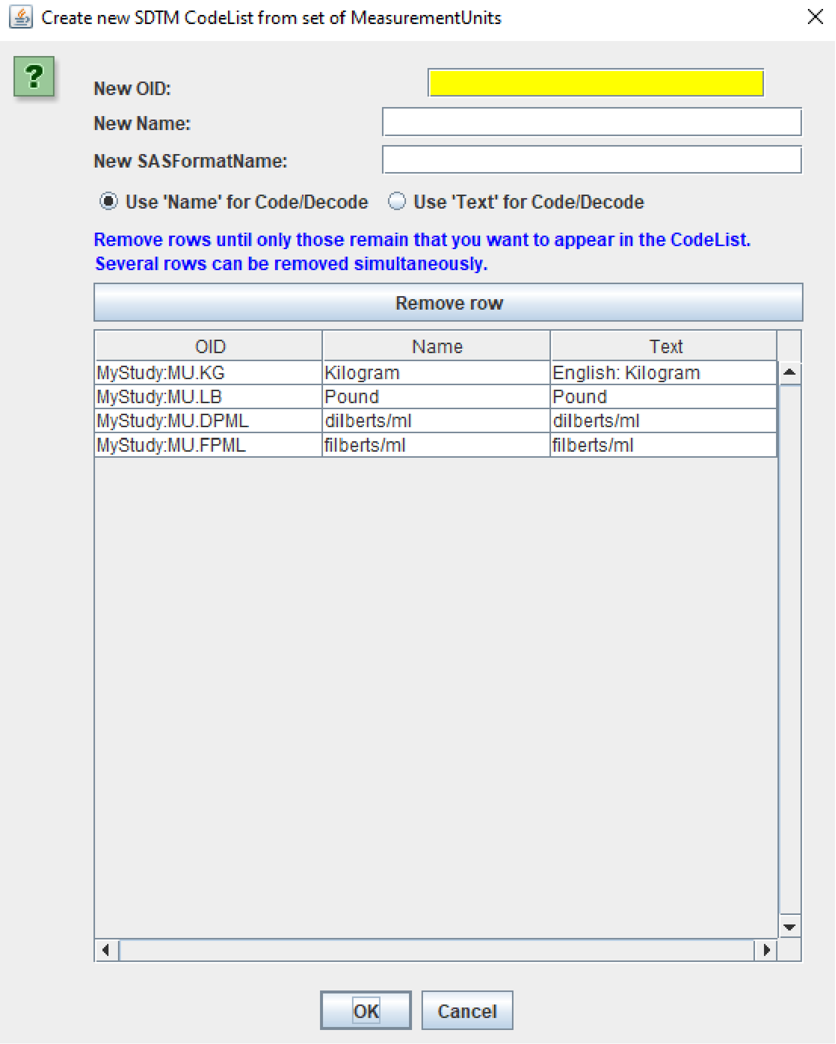
4 MeasurementUnit elements from the ODM have been inserted

As define.xml does not formally support the "BasicDefinitions" element, in most cases, one will want to transform these into an SDTM or SEND codelist.
This can be done by using the menu "Insert - Create new SDTM[1] CodeList from MeasurementUnits":


Insert
Transform
Validate
CDISC Library
Options
About
Global Variables from ODM into define.xml
MeasurementUnit definitions from ODM into define.xml
All CodeList definitions from ODM into define.xml
Selected CodeList definitions from ODM into define.xml
CodeList definitions from File into define.xml
ValueLists for CDISC CodeTables from File into define.xml
Create new SDTM CodeList from existing CodeList
Create Enumerated CodeList from CodeListItem CodeList
Create new SDTM Sponsor-defined CodeList
Create new SDTM CodeList from MeasurementUnits
Create new ValueList from existing CodeList

Which will pop up a new dialog:

[1] In the case SEND is used, the menu item will state "Create new SEND CodeList from MeasurementUnits"



Create new SDTM CodeList from set of MeasurementUnits

New OID:

New Name:

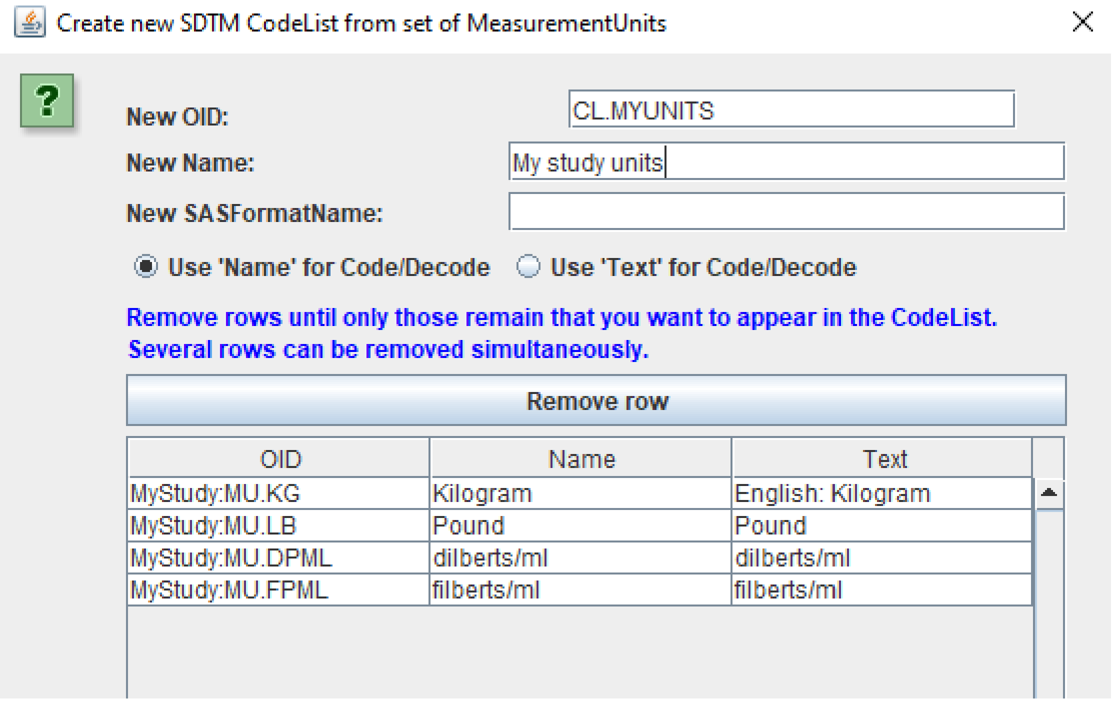
New SASFormatName:

● Use 'Name' for Code/Decode ○ Use 'Text' for Code/Decode

Remove rows until only those remain that you want to appear in the CodeList.
Several rows can be removed simultaneously.

OID	Name	Text
MyStudy:MU.KG	Kilogram	English: Kilogram
MyStudy:MU.LB	Pound	Pound
MyStudy:MU.DPML	dilberts/ml	dilberts/ml
MyStudy:MU.FPML	filberts/ml	filberts/ml

One then needs to at least fill the fields "New OID" and "New Name". For example:



Create new SDTM CodeList from set of MeasurementUnits

New OID: CL.MYUNITS

New Name: My study units

New SASFormatName:

● Use 'Name' for Code/Decode ○ Use 'Text' for Code/Decode

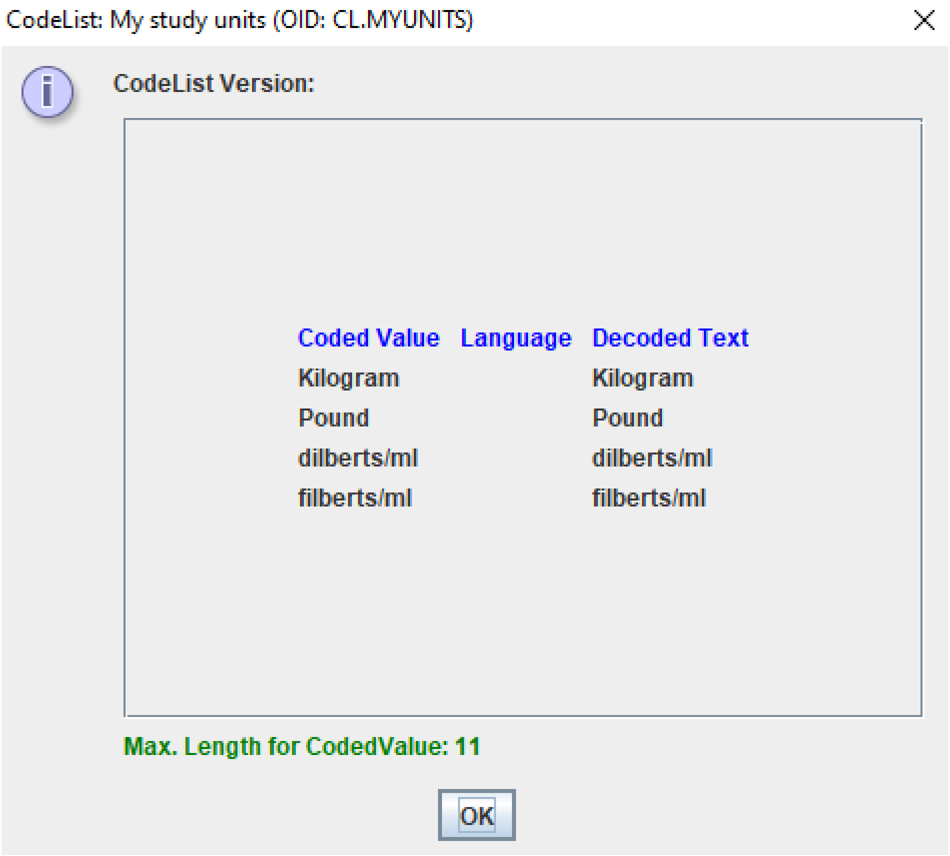
Remove rows until only those remain that you want to appear in the CodeList.
Several rows can be removed simultaneously.

OID	Name	Text
MyStudy:MU.KG	Kilogram	English: Kilogram
MyStudy:MU.LB	Pound	Pound
MyStudy:MU.DPML	dilberts/ml	dilberts/ml
MyStudy:MU.FPML	filberts/ml	filberts/ml

One can still add or remove rows in this table, and has the option to either use the value of "Name" or of "Text" to appear in the "Decode" child elements of the codelist.

After clicking OK, one can use the generated codelist, e.g. assigning it to SDTM/SEND variables.

One can also still edit it, make subset codelists (menu "Insert - Create new SDTM CodeList from existing CodeList"), or use it as a basis for other codelists.
For visualization of the generated codelist, when one has assigned it to an SDTM/SEND variable, use the menu "View - SDTM Codelist" or "View - SEND CodeList", e.g. leading to:



CodeList: My study units (OID: CL.MYUNITS)

CodeList Version:

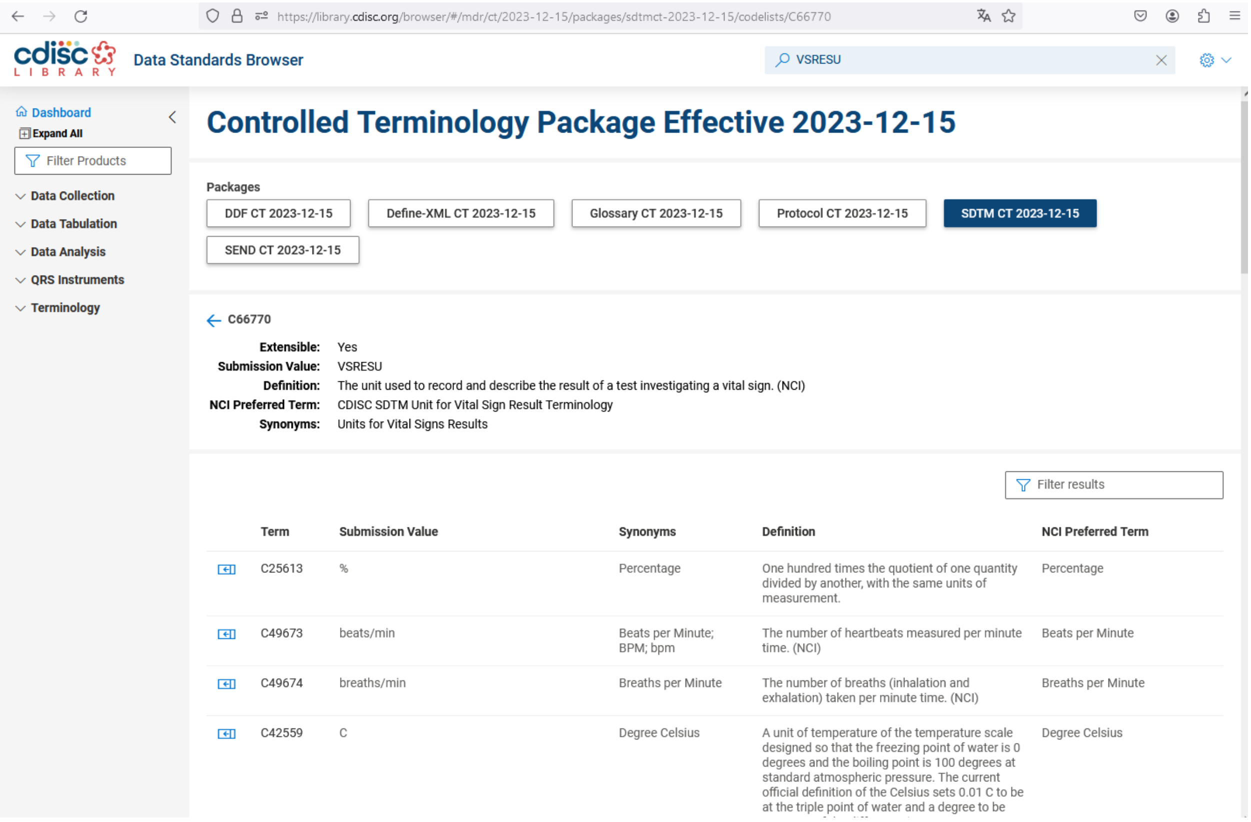
Coded Value	Language	Decoded Text
Kilogram		Kilogram
Pound		Pound
dilberts/ml		dilberts/ml
filberts/ml		filberts/ml

Max. Length for CodedValue: 11

Mapping ODM Units of Measurement to SDTM/SEND CDISC Controlled Terminology units

For EDC systems that support the "BasicDefinitions" mechanism for the units of measure in the ODM export, one can map these to the CDISC controlled terms used in SDTM or SEND directly.

Let us try to do this for VS, i.e. map the units from the ODM to the CDISC codelist VSRESU (NCI code C66770). According to the CDISC Library:



https://library.cdisc.org/browser/#/mdr/ct/2023-12-15/packages/sdtmct-2023-12-15/codelists/C66770

Controlled Terminology Package Effective 2023-12-15

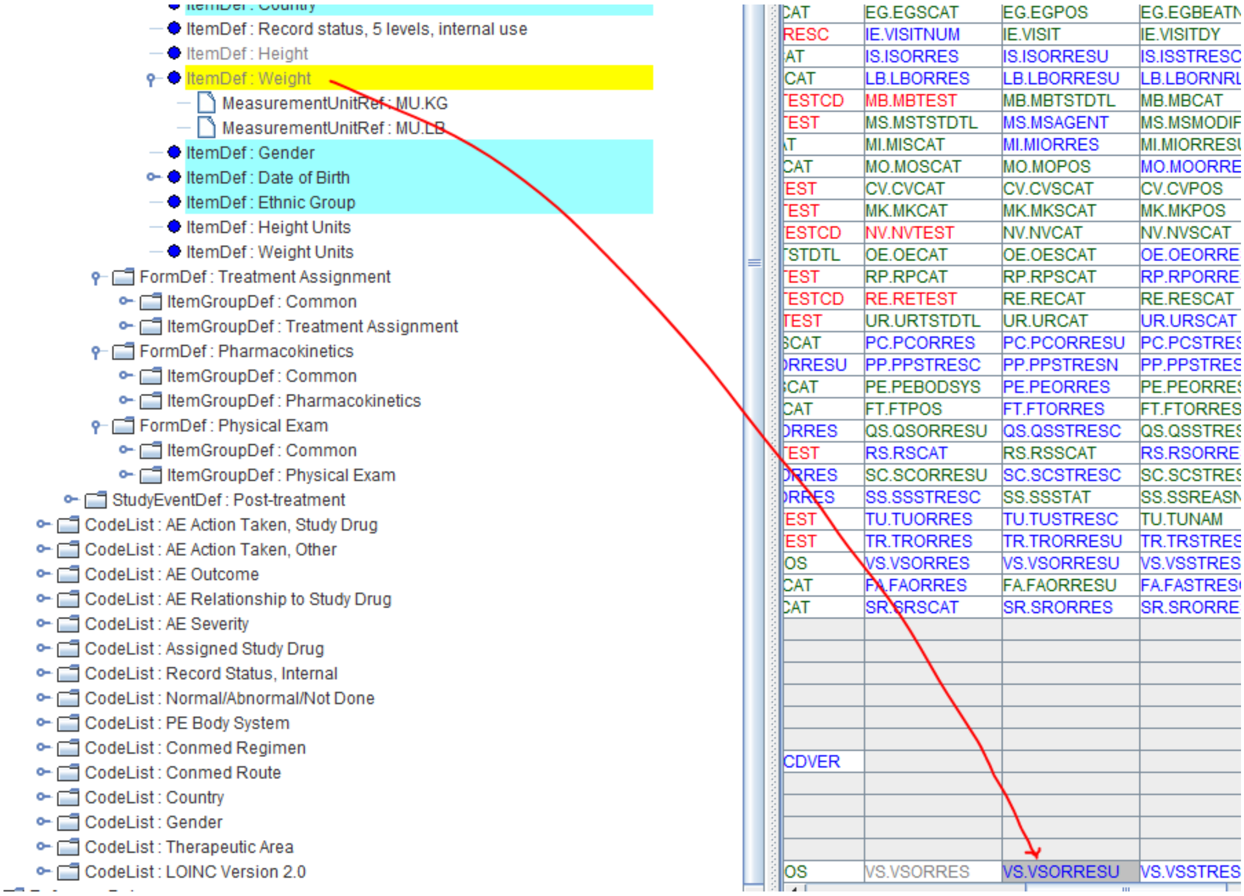
Packages

C66770

Extensible: Yes
Submission Value: VSRESU
Definition: The unit used to record and describe the result of a test investigating a vital sign. (NCI)
NCI Preferred Term: CDISC SDTM Unit for Vital Sign Result Terminology
Synonyms: Units for Vital Signs Results

Term	Submission Value	Synonyms	Definition	NCI Preferred Term
C25613	%	Percentage	One hundred times the quotient of one quantity divided by another, with the same units of measurement.	Percentage
C49673	beats/min	Beats per Minute; BPM; bpm	The number of heartbeats measured per minute time. (NCI)	Beats per Minute
C49674	breaths/min	Breaths per Minute	The number of breaths (inhalation and exhalation) taken per minute time. (NCI)	Breaths per Minute
C42559	C	Degree Celsius	A unit of temperature of the temperature scale designed so that the freezing point of water is 0 degrees and the boiling point is 100 degrees at standard atmospheric pressure. The current official definition of the Celsius sets 0.01 C to be at the triple point of water and a degree to be	Degree Celsius

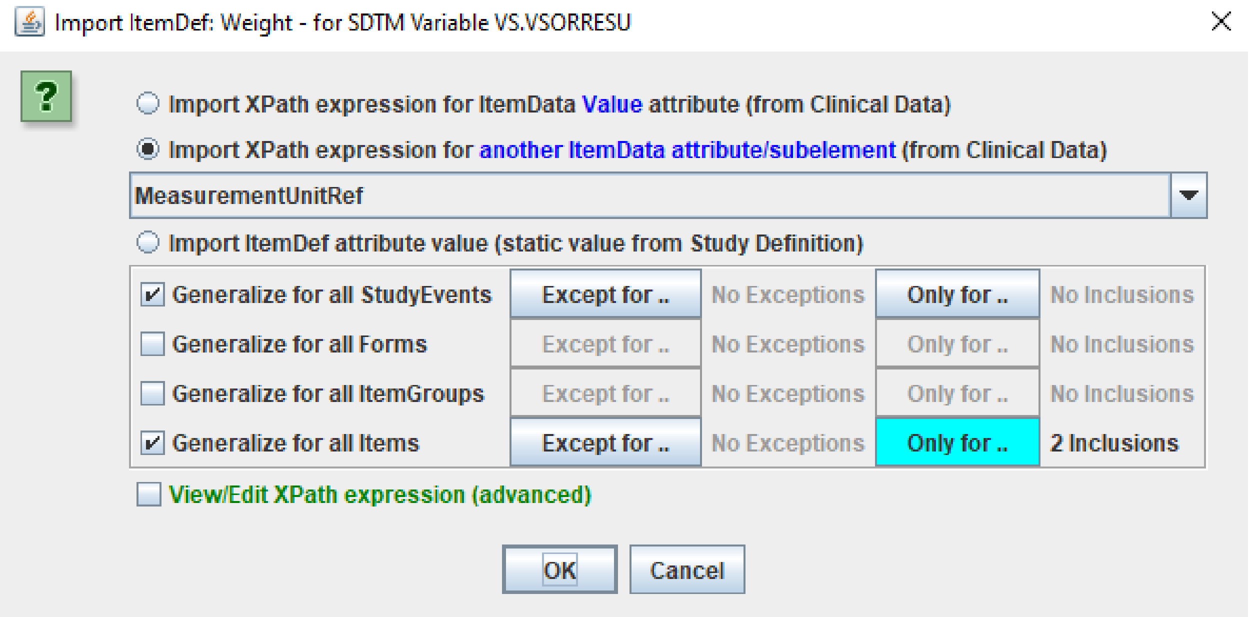
When we already have provided the mapping for VSTESTCD, VSTEST, VSORRES, we can also generate the mapping for VSORRESU.
In order to do so, just drag-and-drop from "Weight" (OID="IT.HT") to the cell VS.VSORRESU:



```
ItemDef : Country
ItemDef : Record status, 5 levels, internal use
ItemDef : Height
ItemDef : Weight
    MeasurementUnitRef : MU.KG
    MeasurementUnitRef : MU.LB
ItemDef : Gender
ItemDef : Date of Birth
ItemDef : Ethnic Group
ItemDef : Height Units
ItemDef : Weight Units
FormDef : Treatment Assignment
    ItemGroupDef : Common
    ItemGroupDef : Treatment Assignment
FormDef : Pharmacokinetics
    ItemGroupDef : Common
    ItemGroupDef : Pharmacokinetics
FormDef : Physical Exam
    ItemGroupDef : Common
    ItemGroupDef : Physical Exam
StudyEventDef : Post-treatment
CodeList : AE Action Taken, Study Drug
CodeList : AE Action Taken, Other
CodeList : AE Outcome
CodeList : AE Relationship to Study Drug
CodeList : AE Severity
CodeList : Assigned Study Drug
CodeList : Record Status, Internal
CodeList : Normal/Abnormal/Not Done
CodeList : PE Body System
CodeList : Conmed Regimen
CodeList : Conmed Route
CodeList : Country
CodeList : Gender
CodeList : Therapeutic Area
CodeList : LOINC Version 2.0
```

CAT	EG.EGSCAT	EG.EGPOS	EG.EGBEATN
RESC	IE.VISITNUM	IE.VISIT	IE.VISITDY
AT	IS.ISORRES	IS.ISORRESU	IS.ISSTRESC
CAT	LB.LBORRES	LB.LBORRESU	LB.LBORNRL
ESTCD	MB.MBTEST	MB.MBTSTDTL	MB.MBCAT
EST	MS.MSTSTDTL	MS.MSAGENT	MS.MSMODIF
T	MI.MISCAT	MI.MIORRES	MI.MIORRESU
CAT	MO.MOSCAT	MO.MOPOS	MO.MOORRE
EST	CV.CVCAT	CV.CVSCAT	CV.CVPOS
EST	MK.MKCAT	MK.MKSCAT	MK.MKPOS
ESTCD	NV.NVTEST	NV.NVCAT	NV.NVSCAT
STDTL	OE.OECAT	OE.OESCAT	OE.OEORRE
EST	RP.RPCAT	RP.RPSCAT	RP.RPORRE
ESTCD	RE.RETEST	RE.RECAT	RE.RESCAT
TEST	UR.URTSTDTL	UR.URCAT	UR.URSCAT
SCAT	PC.PCORRES	PC.PCORRESU	PC.PCSTRES
RRESU	PP.PPSTRESC	PP.PPSTRESN	PP.PPSTRES
CAT	PE.PEBODSYS	PE.PEORRES	PE.PEORRES
CAT	FT.FTPOS	FT.FTORRES	FT.FTORRES
RRES	QS.QSORRESU	QS.QSSTRESC	QS.QSSTRES
EST	RS.RSCAT	RS.RSSCAT	RS.RSORRE
RRES	SC.SCORRESU	SC.SCSTRESC	SC.SCSTRES
RRES	SS.SSSTRESC	SS.SSSTAT	SS.SSREASN
EST	TU.TUORRES	TU.TUSTRESC	TU.TUNAM
EST	TR.TRORRES	TR.TRORRESU	TR.TRSTRES
OS	VS.VSORRES	VS.VSORRESU	VS.VSSTRES
CAT	FA.FAORRES	FA.FAORRESU	FA.FASTRES
CAT	SR.SRSCAT	SR.SRORRES	SR.SRORRE
CDVER			
OS	VS.VSORRES	VS.VSORRESU	VS.VSSTRES

The "mapping wizard" dialog shows up:



Import ItemDef: Weight - for SDTM Variable VS.VSORRESU

○ Import XPath expression for ItemData Value attribute (from Clinical Data)

● Import XPath expression for another ItemData attribute/subelement (from Clinical Data)

MeasurementUnitRef

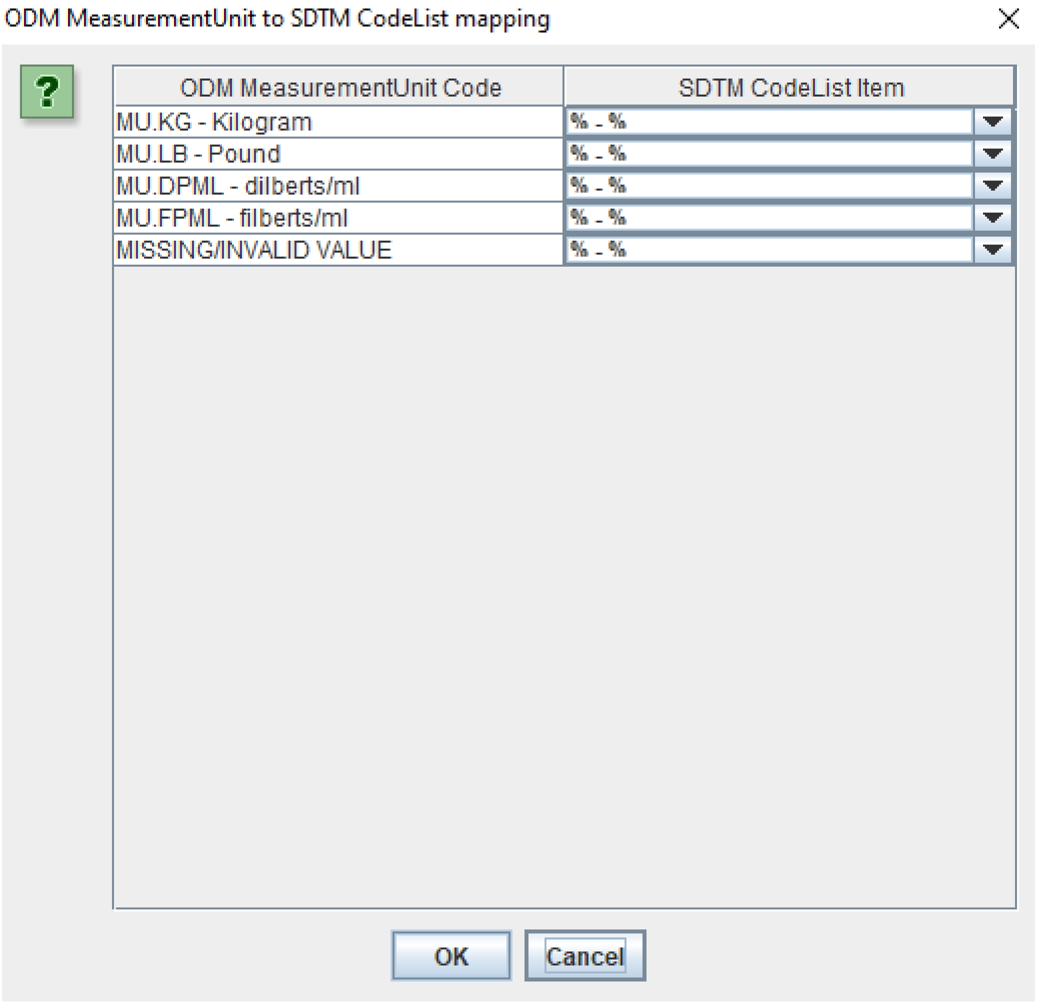
○ Import ItemDef attribute value (static value from Study Definition)

☑ Generalize for all StudyEvents	Except for ..	No Exceptions	Only for ..	No Inclusions
□ Generalize for all Forms	Except for ..	No Exceptions	Only for ..	No Inclusions
□ Generalize for all ItemGroups	Except for ..	No Exceptions	Only for ..	No Inclusions
☑ Generalize for all Items	Except for ..	No Exceptions	Only for ..	2 Inclusions

□ View/Edit XPath expression (advanced)

As the wizard sees that we have a "MeasurementUnitRef" child element on the ODM side, and we wish to map to an –ORRESU variable, it already suggests that we use the value of "MeasurementUnitRef". The "Only for …" on "Generalize for all Items" is retained from our prior mappings for VSTESTCD, VSTEST and VSORRES, as we want to limit to "Height" and "Weight" ("Gender" in the same group does not go into VS).

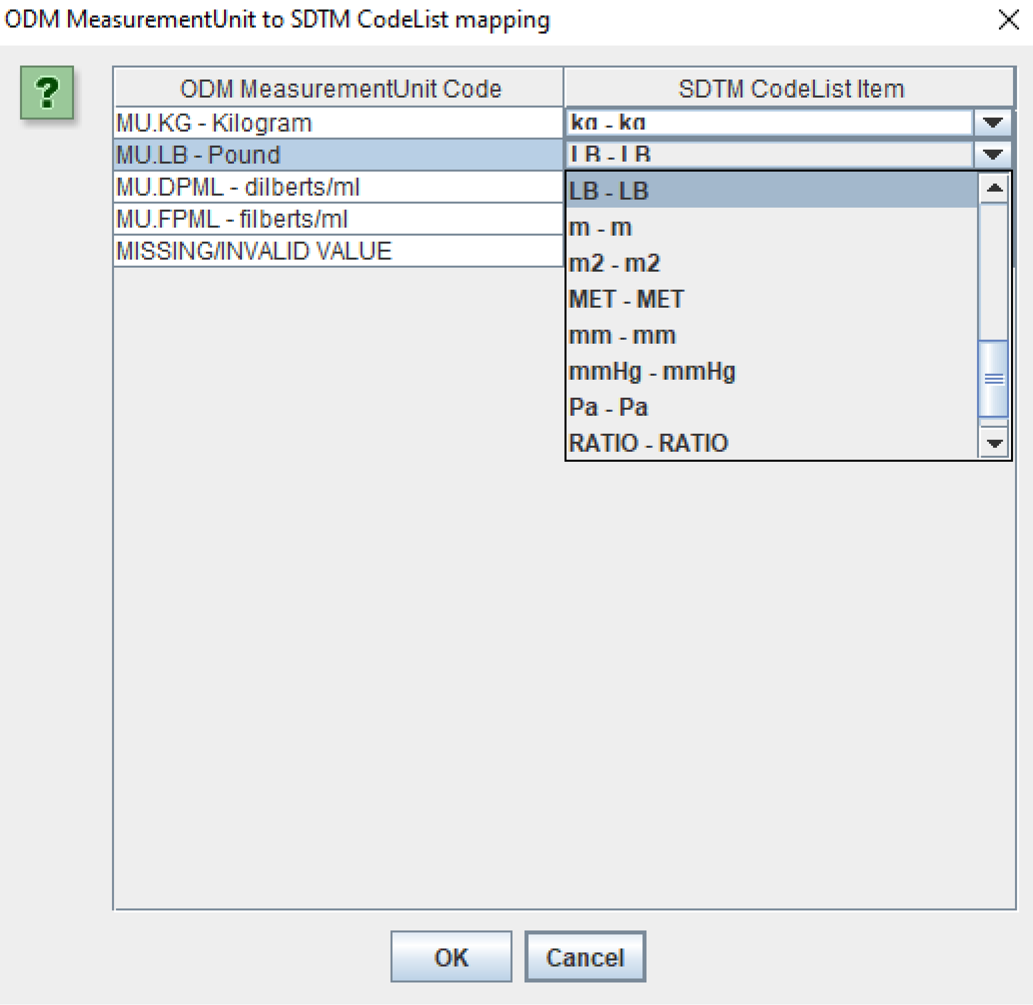
After clicking "OK" we get the part that allows us to define the mappings:



ODM MeasurementUnit to SDTM CodeList mapping

ODM MeasurementUnit Code	SDTM CodeList Item
MU.KG - Kilogram	% - %
MU.LB - Pound	% - %
MU.DPML - dilberts/ml	% - %
MU.FPML - filberts/ml	% - %
MISSING/INVALID VALUE	% - %

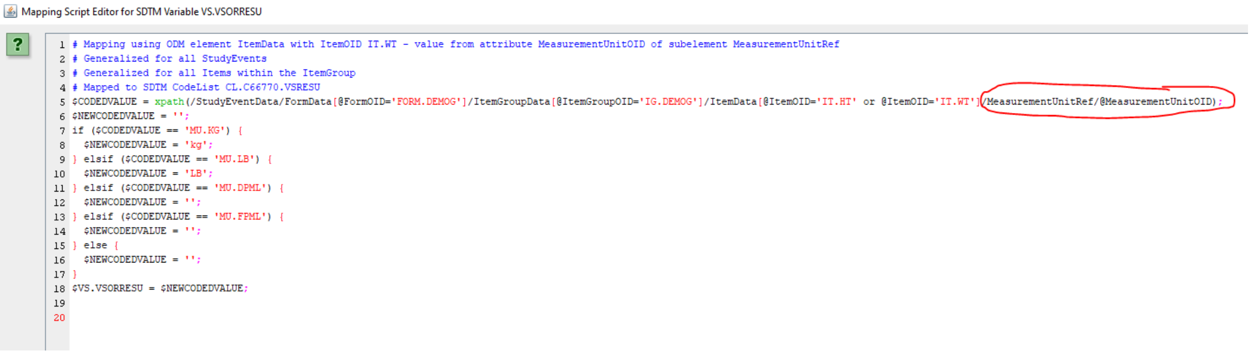
Which we then need to fill out using the dropdowns, e.g.



ODM MeasurementUnit to SDTM CodeList mapping

ODM MeasurementUnit Code	SDTM CodeList Item
MU.KG - Kilogram	kg - kg
MU.LB - Pound	LB - LB
MU.DPML - dilberts/ml	
MU.FPML - filberts/ml	
MISSING/INVALID VALUE	

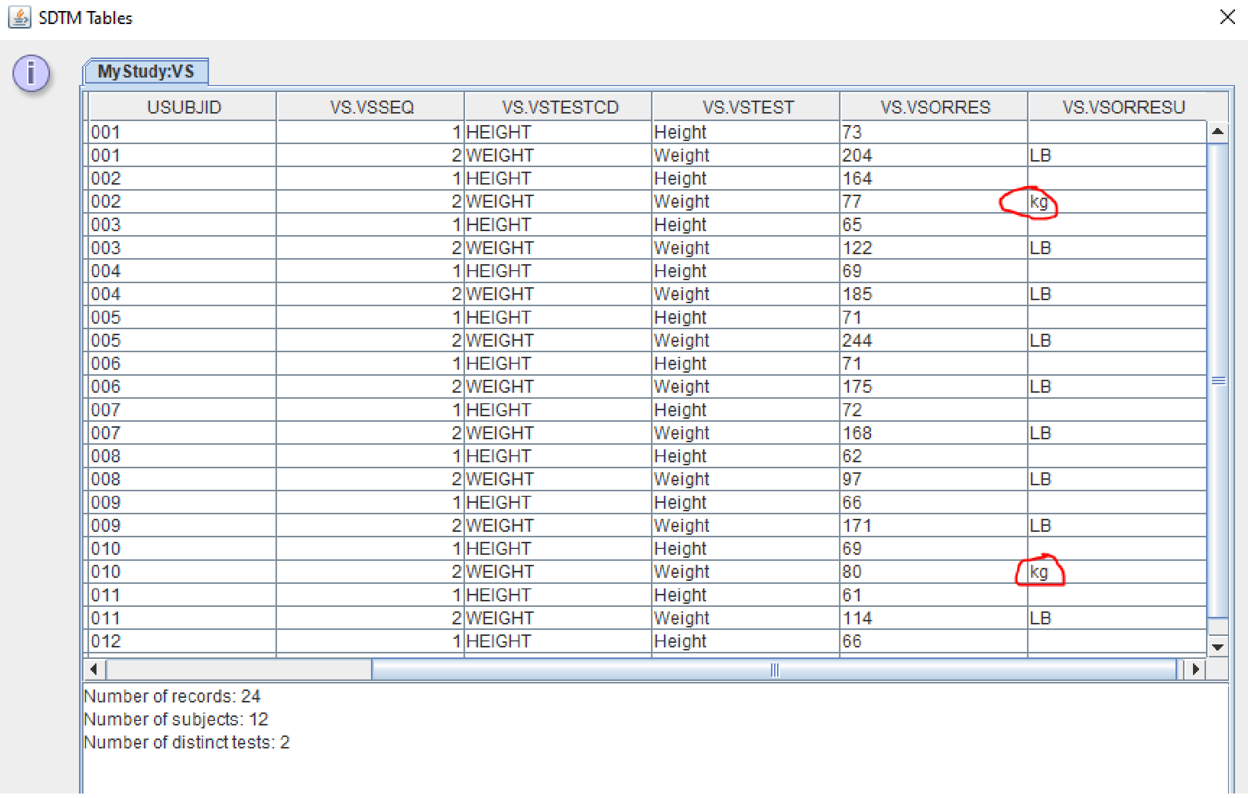
Leading to the automatically created mapping script:



Mapping Script Editor for SDTM Variable VS.VSORRESU

```
 1 # Mapping using ODM element ItemData with ItemOID IT.WT - value from attribute MeasurementUnitOID of subelement MeasurementUnitRef
 2 # Generalized for all StudyEvents
 3 # Generalized for all Items within the ItemGroup
 4 # Mapped to SDTM CodeList CL.C66770.VSRESU
 5 $CODEDVALUE = xpath(/StudyEventData/FormData[@FormOID='FORM.DEMOG']/ItemGroupData[@ItemGroupOID='IG.DEMOG']/ItemData[@ItemOID='IT.HT' or @ItemOID='IT.WT']/MeasurementUnitRef/@MeasurementUnitOID);
 6 $NEWCODEDVALUE = '';
 7 if ($CODEDVALUE == 'MU.KG') {
 8   $NEWCODEDVALUE = 'kg';
 9 } elsif ($CODEDVALUE == 'MU.LB') {
10   $NEWCODEDVALUE = 'LB';
11 } elsif ($CODEDVALUE == 'MU.DPML') {
12   $NEWCODEDVALUE = '';
13 } elsif ($CODEDVALUE == 'MU.FPML') {
14   $NEWCODEDVALUE = '';
15 } else {
16   $NEWCODEDVALUE = '';
17 }
18 $VS.VSORRESU = $NEWCODEDVALUE;
19
20
```

Notice the "/MeasurementUnitRef/@MeasurementUnitOID" in the XPath selection in line 5.
The next lines than transform the ODM unit into the SDTM unit from the CDISC VSRESU codelist.
When then executing the mappings (using "Transform - Generate Transformation (XSLT) Code for …", the final result is e.g.:



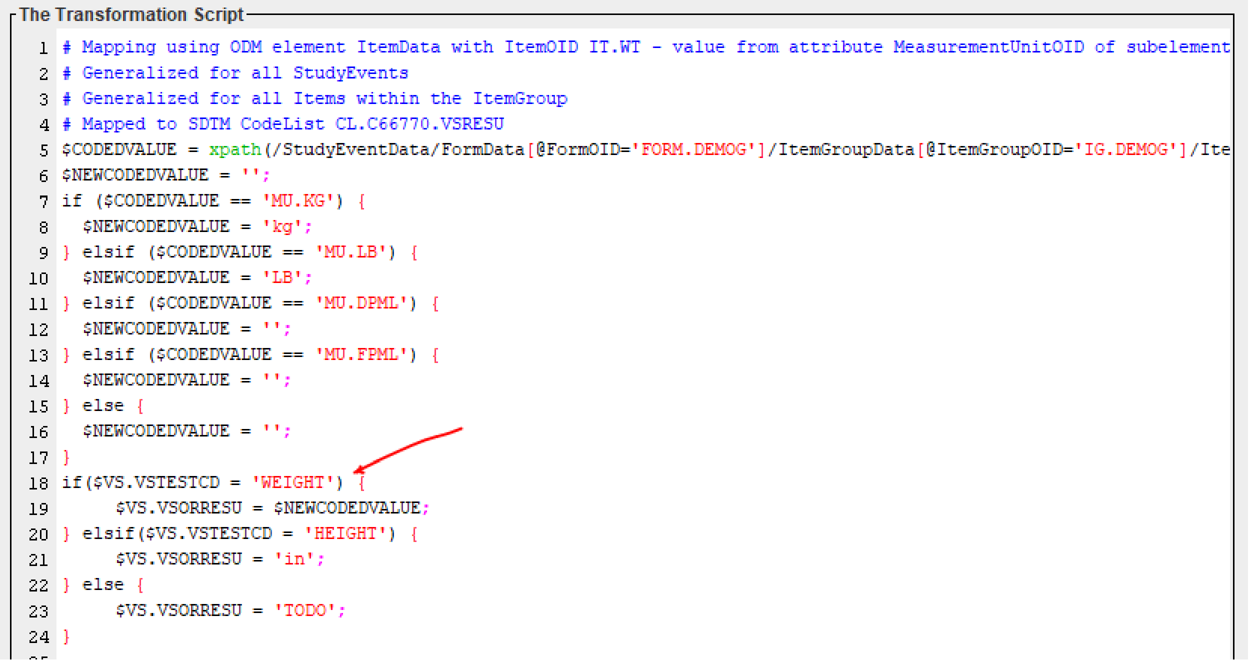
SDTM Tables

MyStudy:VS

USUBJID	VS.VSSEQ	VS.VSTESTCD	VS.VSTEST	VS.VSORRES	VS.VSORRESU
001	1	HEIGHT	Height	73	
001	2	WEIGHT	Weight	204	LB
002	1	HEIGHT	Height	164	
002	2	WEIGHT	Weight	77	kg
003	1	HEIGHT	Height	65	
003	2	WEIGHT	Weight	122	LB
004	1	HEIGHT	Height	69	
004	2	WEIGHT	Weight	185	LB
005	1	HEIGHT	Height	71	
005	2	WEIGHT	Weight	244	LB
006	1	HEIGHT	Height	71	
006	2	WEIGHT	Weight	175	LB
007	1	HEIGHT	Height	72	
007	2	WEIGHT	Weight	168	LB
008	1	HEIGHT	Height	62	
008	2	WEIGHT	Weight	97	LB
009	1	HEIGHT	Height	66	
009	2	WEIGHT	Weight	171	LB
010	1	HEIGHT	Height	69	
010	2	WEIGHT	Weight	80	kg
011	1	HEIGHT	Height	61	
011	2	WEIGHT	Weight	114	LB
012	1	HEIGHT	Height	66	

Number of records: 24
Number of subjects: 12
Number of distinct tests: 2

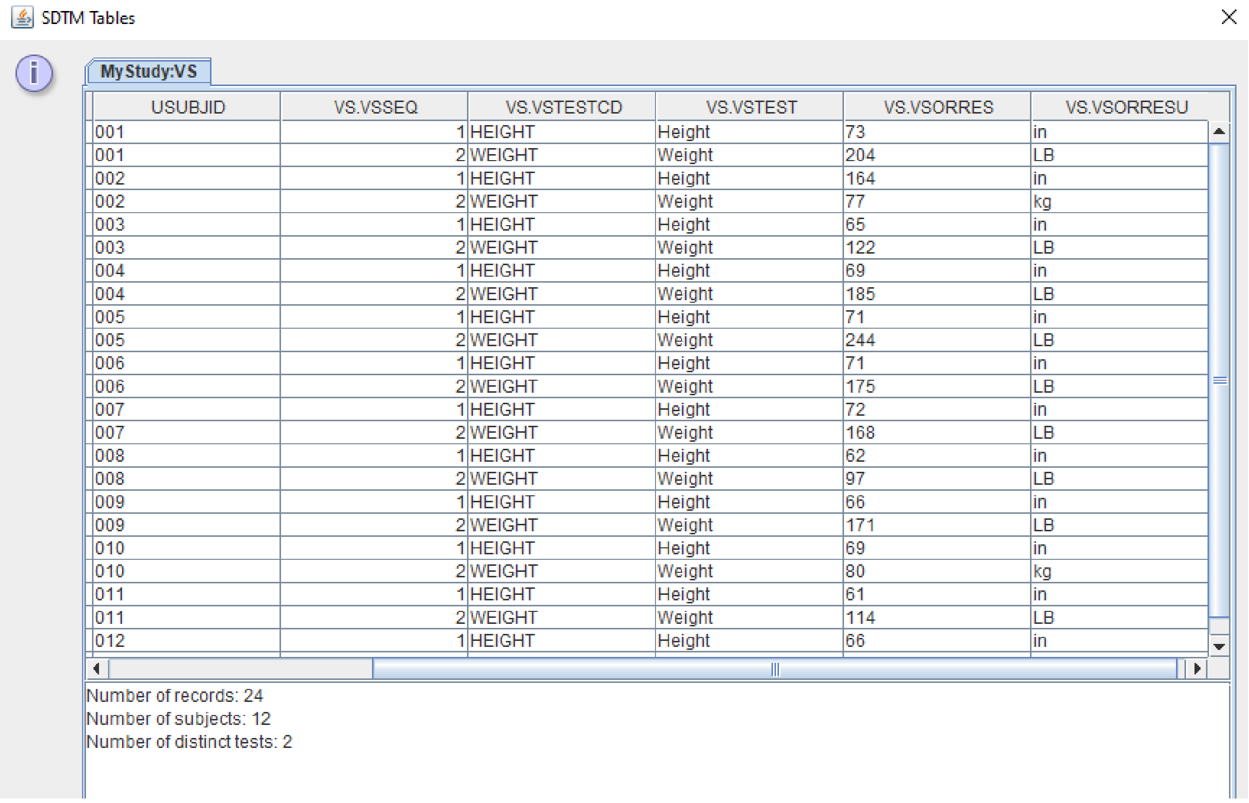
Where we see that for most subjects, weight was collected in pound (CDISC-code "LB") but for a few, weight was collected in kilograms (CDISC-code "kg").
We also see that no unit was assigned for "HEIGHT". Reason for this that there wasn't a choice for the unit for "height", but was always collected in inches (CDISC-code "in"). So we need to extend the code somewhat, and have the assignment being based on the value of VSTESTCD. For example:



The Transformation Script

```
# Mapping using ODM element ItemData with ItemOID IT.WT - value from attribute MeasurementUnitOID of subelement
# Generalized for all StudyEvents
# Generalized for all Items within the ItemGroup
# Mapped to SDTM CodeList CL.C66770.VSRESU
$CODEDVALUE = xpath(/StudyEventData/FormData[@FormOID='FORM.DEMOG']/ItemGroupData[@ItemGroupOID='IG.DEMOG']/Ite
$NEWCODEDVALUE = '';
if ($CODEDVALUE == 'MU.KG') {
  $NEWCODEDVALUE = 'kg';
} elsif ($CODEDVALUE == 'MU.LB') {
  $NEWCODEDVALUE = 'LB';
} elsif ($CODEDVALUE == 'MU.DPML') {
  $NEWCODEDVALUE = '';
} elsif ($CODEDVALUE == 'MU.FPML') {
  $NEWCODEDVALUE = '';
} else {
  $NEWCODEDVALUE = '';
}
if($VS.VSTESTCD = 'WEIGHT') {
     $VS.VSORRESU = $NEWCODEDVALUE;
} elsif($VS.VSTESTCD = 'HEIGHT') {
     $VS.VSORRESU = 'in';
} else {
     $VS.VSORRESU = 'TODO';
}
```

Essentially hardcoding that for the case of "HEIGHT", always "inches" (CDISC-code "in") needs to be assigned. This then ultimately leads to the results:

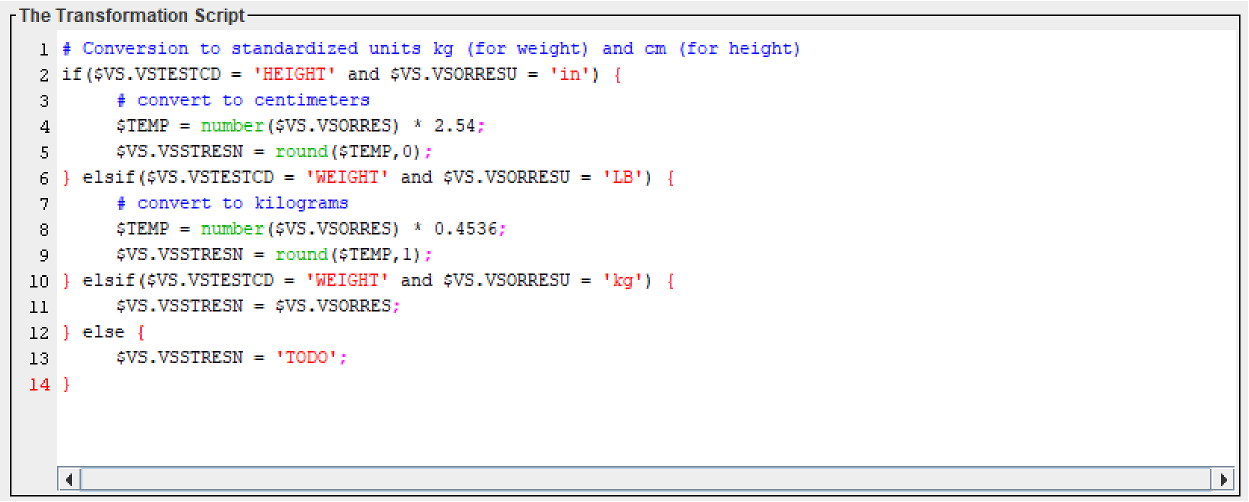


USUBJID	VS.VSSEQ	VS.VSTESTCD	VS.VSTEST	VS.VSORRES	VS.VSORRESU
001	1	HEIGHT	Height	73	in
001	2	WEIGHT	Weight	204	LB
002	1	HEIGHT	Height	164	in
002	2	WEIGHT	Weight	77	kg
003	1	HEIGHT	Height	65	in
003	2	WEIGHT	Weight	122	LB
004	1	HEIGHT	Height	69	in
004	2	WEIGHT	Weight	185	LB
005	1	HEIGHT	Height	71	in
005	2	WEIGHT	Weight	244	LB
006	1	HEIGHT	Height	71	in
006	2	WEIGHT	Weight	175	LB
007	1	HEIGHT	Height	72	in
007	2	WEIGHT	Weight	168	LB
008	1	HEIGHT	Height	62	in
008	2	WEIGHT	Weight	97	LB
009	1	HEIGHT	Height	66	in
009	2	WEIGHT	Weight	171	LB
010	1	HEIGHT	Height	69	in
010	2	WEIGHT	Weight	80	kg
011	1	HEIGHT	Height	61	in
011	2	WEIGHT	Weight	114	LB
012	1	HEIGHT	Height	66	in

Number of records: 24
Number of subjects: 12
Number of distinct tests: 2

Standardized units and UCUM

A big problem with the CDISC controlled terminology for units is that is does not allow to automate unit conversion, which is often needed for populating –STRESN variables. For example for our case, in case we want to have "cm" and "kg" for the "standardized" results, there is no other way than to hardcode the conversion factors. This means a lot of manual work. For example, for VSSTRESN, we will need a (too) long manually generated script like:

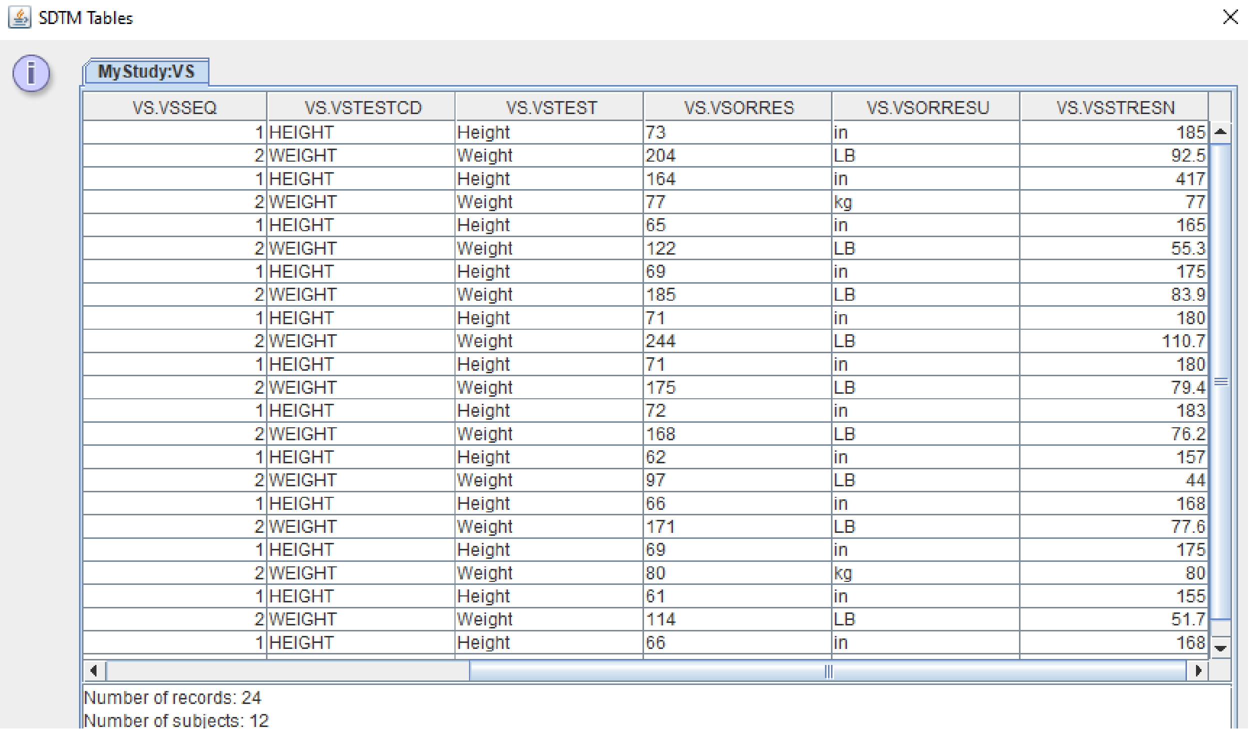


```
# Conversion to standardized units kg (for weight) and cm (for height)
if($VS.VSTESTCD = 'HEIGHT' and $VS.VSORRESU = 'in') {
     # convert to centimeters
     $TEMP = number($VS.VSORRES) * 2.54;
     $VS.VSSTRESN = round($TEMP,0);
} elsif($VS.VSTESTCD = 'WEIGHT' and $VS.VSORRESU = 'LB') {
     # convert to kilograms
     $TEMP = number($VS.VSORRES) * 0.4536;
     $VS.VSSTRESN = round($TEMP,1);
} elsif($VS.VSTESTCD = 'WEIGHT' and $VS.VSORRESU = 'kg') {
     $VS.VSSTRESN = $VS.VSORRES;
} else {
     $VS.VSSTRESN = 'TODO';
}
```

where we use rounding to an integer for conversion to centimeters and to one character after the decimal point for conversion to kilograms.

Also remark the use of the "number()" function, as in our mapping language, variable values are essentially always strings, and need to be converted to a number for mathematical operations.

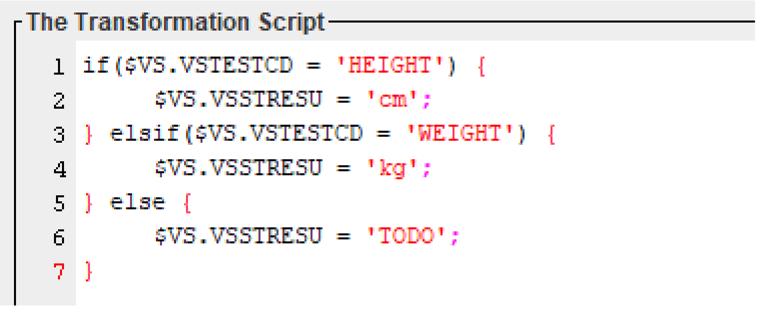
The total result then is:



VS.VSSEQ	VS.VSTESTCD	VS.VSTEST	VS.VSORRES	VS.VSORRESU	VS.VSSTRESN
1	HEIGHT	Height	73	in	185
2	WEIGHT	Weight	204	LB	92.5
1	HEIGHT	Height	164	in	417
2	WEIGHT	Weight	77	kg	77
1	HEIGHT	Height	65	in	165
2	WEIGHT	Weight	122	LB	55.3
1	HEIGHT	Height	69	in	175
2	WEIGHT	Weight	185	LB	83.9
1	HEIGHT	Height	71	in	180
2	WEIGHT	Weight	244	LB	110.7
1	HEIGHT	Height	71	in	180
2	WEIGHT	Weight	175	LB	79.4
1	HEIGHT	Height	72	in	183
2	WEIGHT	Weight	168	LB	76.2
1	HEIGHT	Height	62	in	157
2	WEIGHT	Weight	97	LB	44
1	HEIGHT	Height	66	in	168
2	WEIGHT	Weight	171	LB	77.6
1	HEIGHT	Height	69	in	175
2	WEIGHT	Weight	80	kg	80
1	HEIGHT	Height	61	in	155
2	WEIGHT	Weight	114	LB	51.7
1	HEIGHT	Height	66	in	168

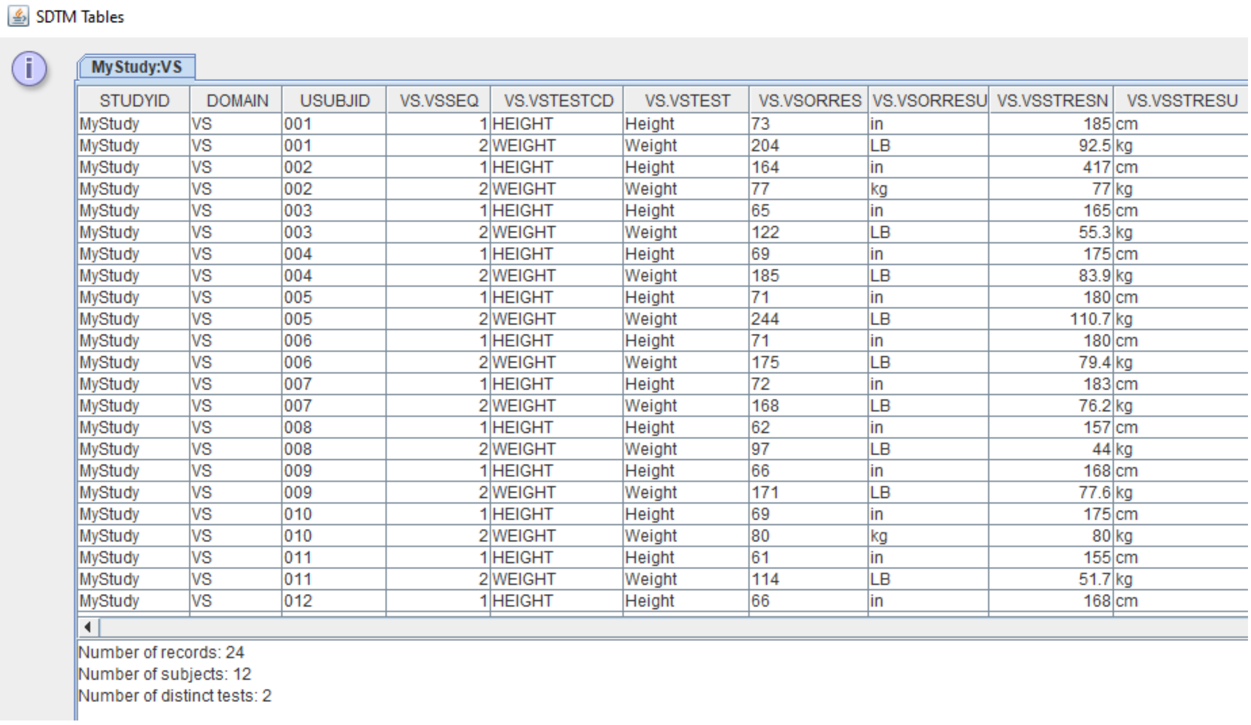
Number of records: 24
Number of subjects: 12

but we then still need to add the mapping for VSSTRESU too:



```
if($VS.VSTESTCD = 'HEIGHT') {
     $VS.VSSTRESU = 'cm';
} elsif($VS.VSTESTCD = 'WEIGHT') {
     $VS.VSSTRESU = 'kg';
} else {
     $VS.VSSTRESU = 'TODO';
}
```

and the total result being:

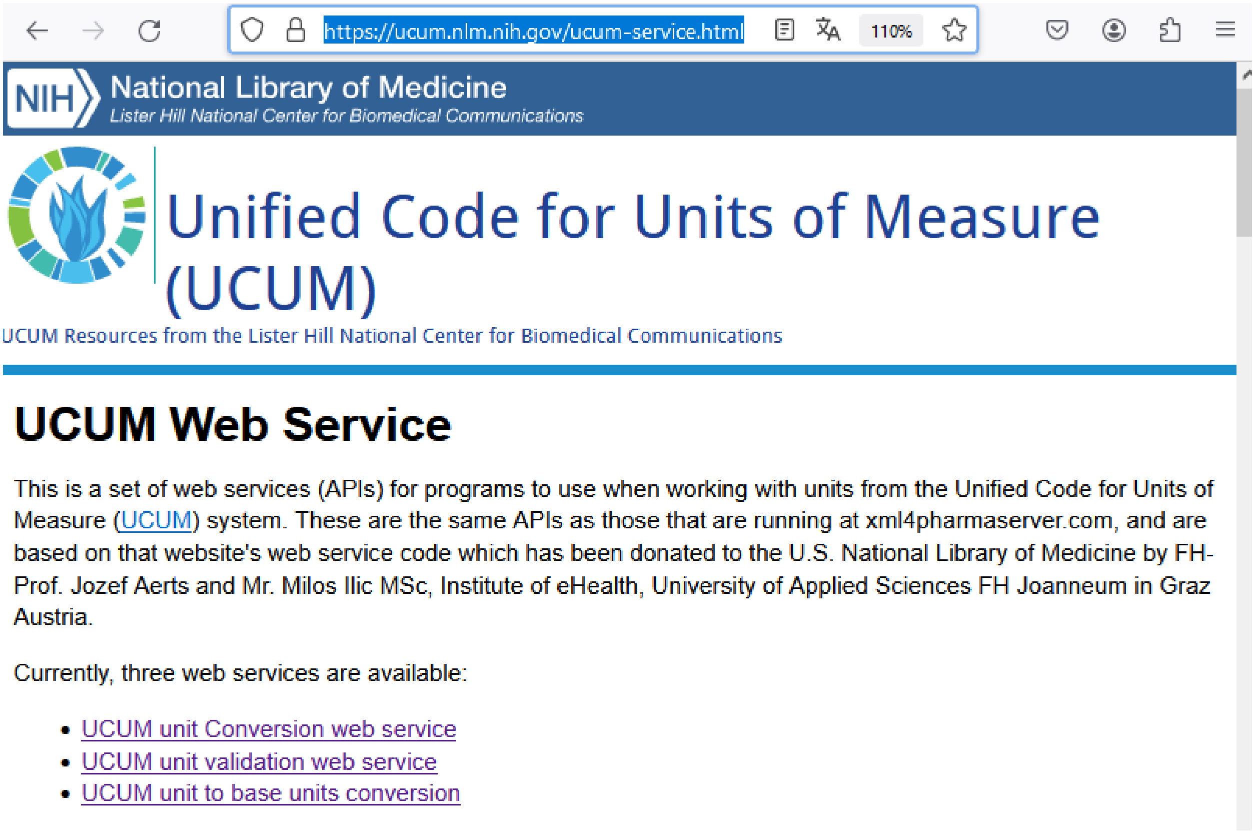


STUDYID	DOMAIN	USUBJID	VS.VSSEQ	VS.VSTESTCD	VS.VSTEST	VS.VSORRES	VS.VSORRESU	VS.VSSTRESN	VS.VSSTRESU
MyStudy	VS	001	1	HEIGHT	Height	73	in	185	cm
MyStudy	VS	001	2	WEIGHT	Weight	204	LB	92.5	kg
MyStudy	VS	002	1	HEIGHT	Height	164	in	417	cm
MyStudy	VS	002	2	WEIGHT	Weight	77	kg	77	kg
MyStudy	VS	003	1	HEIGHT	Height	65	in	165	cm
MyStudy	VS	003	2	WEIGHT	Weight	122	LB	55.3	kg
MyStudy	VS	004	1	HEIGHT	Height	69	in	175	cm
MyStudy	VS	004	2	WEIGHT	Weight	185	LB	83.9	kg
MyStudy	VS	005	1	HEIGHT	Height	71	in	180	cm
MyStudy	VS	005	2	WEIGHT	Weight	244	LB	110.7	kg
MyStudy	VS	006	1	HEIGHT	Height	71	in	180	cm
MyStudy	VS	006	2	WEIGHT	Weight	175	LB	79.4	kg
MyStudy	VS	007	1	HEIGHT	Height	72	in	183	cm
MyStudy	VS	007	2	WEIGHT	Weight	168	LB	76.2	kg
MyStudy	VS	008	1	HEIGHT	Height	62	in	157	cm
MyStudy	VS	008	2	WEIGHT	Weight	97	LB	44	kg
MyStudy	VS	009	1	HEIGHT	Height	66	in	168	cm
MyStudy	VS	009	2	WEIGHT	Weight	171	LB	77.6	kg
MyStudy	VS	010	1	HEIGHT	Height	69	in	175	cm
MyStudy	VS	010	2	WEIGHT	Weight	80	kg	80	kg
MyStudy	VS	011	1	HEIGHT	Height	61	in	155	cm
MyStudy	VS	011	2	WEIGHT	Weight	114	LB	51.7	kg
MyStudy	VS	012	1	HEIGHT	Height	66	in	168	cm

Number of records: 24
Number of subjects: 12
Number of distinct tests: 2

So, a lot of manual code, and that only for two vital signs tests!

The whole medical world is using UCUM notation for units, except for CDISC (reason: "not-invented-here syndrome). UCUM is not a "list" (CDISC-CT for units just is a list) and does, in contradiction to CDISC, allow for automated unit conversions.
There is even a free RESTful web service for it provided by the National Library of Medicine (NLM) for which the description can be found at https://ucum.nlm.nih.gov/ucum-service.html:



National Library of Medicine
Lister Hill National Center for Biomedical Communications

Unified Code for Units of Measure (UCUM)

UCUM Resources from the Lister Hill National Center for Biomedical Communications

UCUM Web Service

This is a set of web services (APIs) for programs to use when working with units from the Unified Code for Units of Measure (UCUM) system. These are the same APIs as those that are running at xml4pharmaserver.com, and are based on that website's web service code which has been donated to the U.S. National Library of Medicine by FH-Prof. Jozef Aerts and Mr. Milos Ilic MSc, Institute of eHealth, University of Applied Sciences FH Joanneum in Graz Austria.

Currently, three web services are available:

- UCUM unit Conversion web service
- UCUM unit validation web service
- UCUM unit to base units conversion

Such RESTful web services can be used in any software, even in SAS or R.

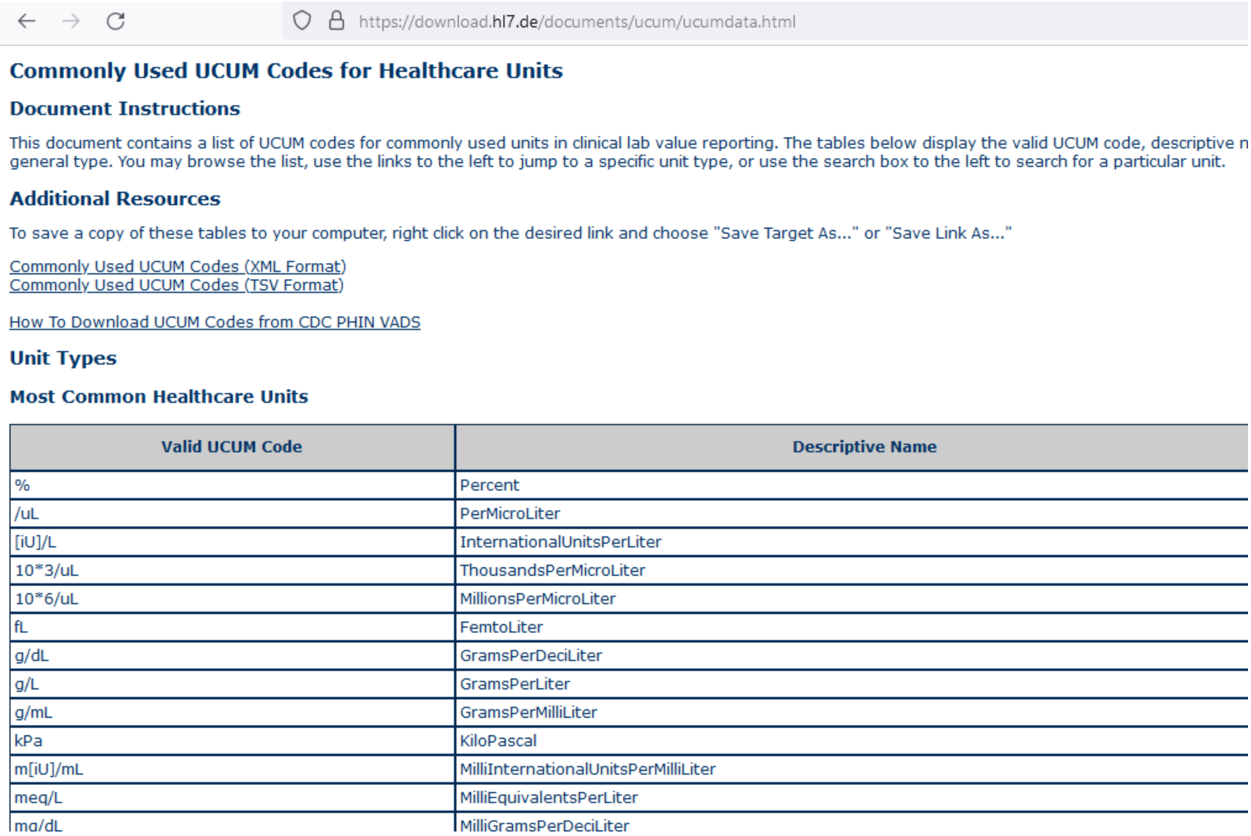
Just suppose that our collection system already uses UCUM for units, which will usually (>99%) the case when the data comes from electronic health records[2].

The UCUM notation for the above units is:

Designation	UCUM notation
centimeters	cm
inches	[in_i]
kilograms	kg
pouns	[lb_av]

Where one sees that for some cases, the UCUM notation is equal to the CDISC controlled term ("cm" and "kg") whereas it is very different for others.

A more complete oversight of "Commonly Used UCUM Codes for Healthcare Units" can be found at: https://download.hl7.de/documents/ucum/ucumdata.html



https://download.hl7.de/documents/ucum/ucumdata.html

Commonly Used UCUM Codes for Healthcare Units

Document Instructions

This document contains a list of UCUM codes for commonly used units in clinical lab value reporting. The tables below display the valid UCUM code, descriptive n general type. You may browse the list, use the links to the left to jump to a specific unit type, or use the search box to the left to search for a particular unit.

Additional Resources

To save a copy of these tables to your computer, right click on the desired link and choose "Save Target As..." or "Save Link As..."

Commonly Used UCUM Codes (XML Format)
Commonly Used UCUM Codes (TSV Format)

How To Download UCUM Codes from CDC PHIN VADS

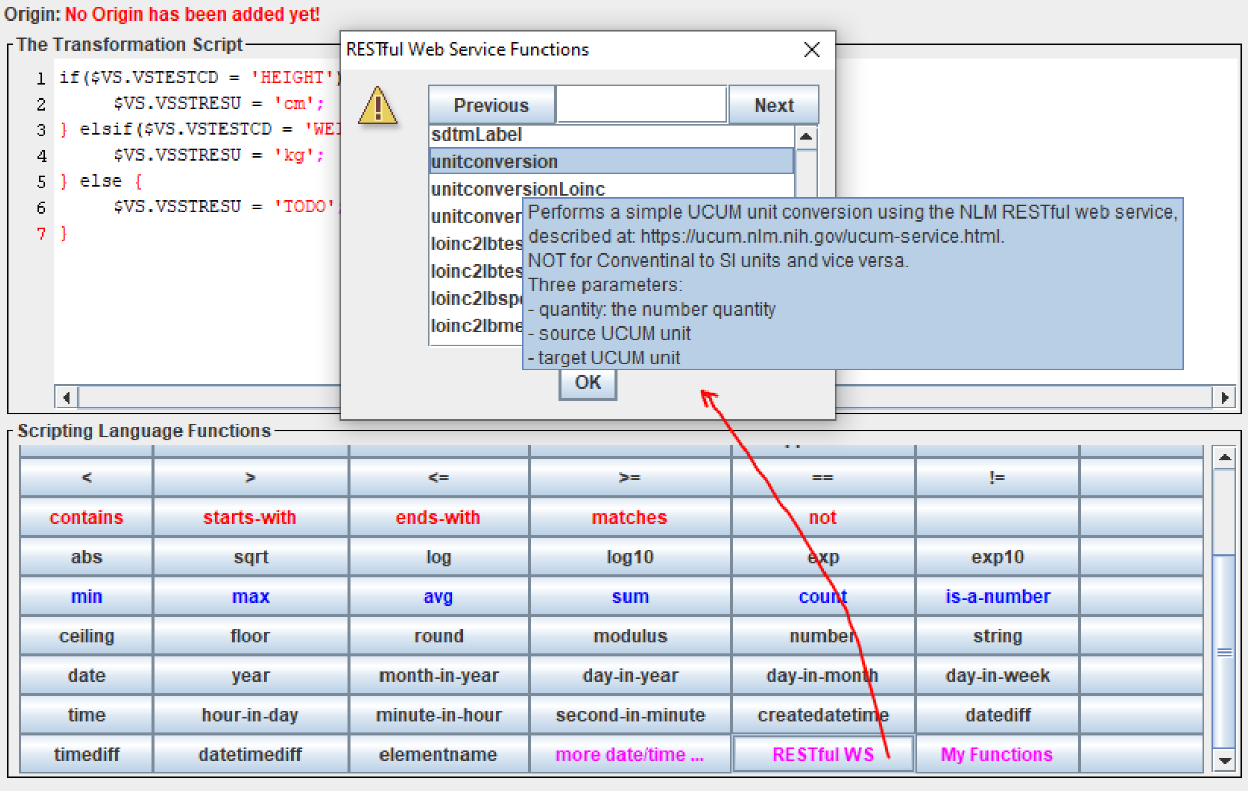
Unit Types

Most Common Healthcare Units

Valid UCUM Code	Descriptive Name
%	Percent
/uL	PerMicroLiter
[iU]/L	InternationalUnitsPerLiter
10*3/uL	ThousandsPerMicroLiter
10*6/uL	MillionsPerMicroLiter
fL	FemtoLiter
g/dL	GramsPerDeciLiter
g/L	GramsPerLiter
g/mL	GramsPerMilliLiter
kPa	KiloPascal
m[iU]/mL	MilliInternationalUnitsPerMilliLiter
meq/L	MilliEquivalentsPerLiter
mg/dL	MilliGramsPerDeciLiter

Our scripting language has a number of functions that use the NLM RESTful web service to have automated unit conversion using UCUM notation for the units.
These functions can be found when, in the mapping editor, clicking the button (located near the bottom) "RESTful WS", then popping up a list of available functions with tooltips with explanations:

[2] As well HL7 CDA as FHIR normally use UCUM notation for all units.



Origin: No Origin has been added yet!

The Transformation Script

```
if($VS.VSTESTCD = 'HEIGHT')
    $VS.VSSTRESU = 'cm';
} elsif($VS.VSTESTCD = 'WEI
    $VS.VSSTRESU = 'kg';
} else {
    $VS.VSSTRESU = 'TODO'
}
```

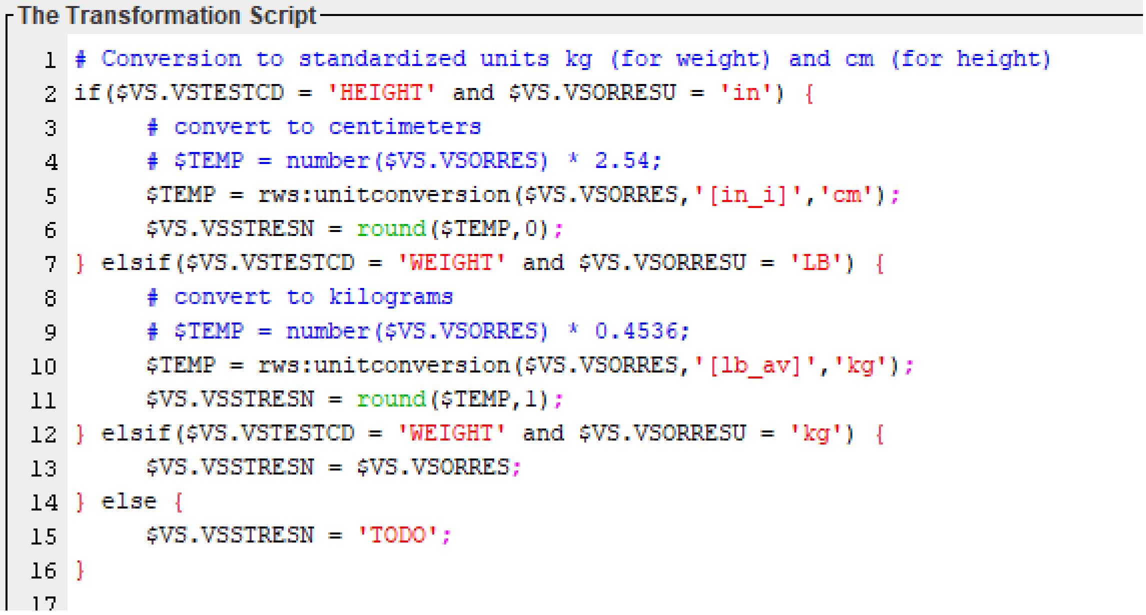
RESTful Web Service Functions

Performs a simple UCUM unit conversion using the NLM RESTful web service, described at: https://ucum.nlm.nih.gov/ucum-service.html.
NOT for Conventinal to SI units and vice versa.
Three parameters:
- quantity: the number quantity
- source UCUM unit
- target UCUM unit

Scripting Language Functions

<	>	<=	>=	==	!=	
contains	starts-with	ends-with	matches	not		
abs	sqrt	log	log10	exp	exp10	
min	max	avg	sum	count	is-a-number	
ceiling	floor	round	modulus	number	string	
date	year	month-in-year	day-in-year	day-in-month	day-in-week	
time	hour-in-day	minute-in-hour	second-in-minute	createdatetime	datediff	
timediff	datetimediff	elementname	more date/time ...	RESTful WS	My Functions	

For example, although this is fully counterproductive in this case, we could use:



The Transformation Script

```
# Conversion to standardized units kg (for weight) and cm (for height)
if($VS.VSTESTCD = 'HEIGHT' and $VS.VSORRESU = 'in') {
    # convert to centimeters
    # $TEMP = number($VS.VSORRES) * 2.54;
    $TEMP = rws:unitconversion($VS.VSORRES,'[in_i]','cm');
    $VS.VSSTRESN = round($TEMP,0);
} elsif($VS.VSTESTCD = 'WEIGHT' and $VS.VSORRESU = 'LB') {
    # convert to kilograms
    # $TEMP = number($VS.VSORRES) * 0.4536;
    $TEMP = rws:unitconversion($VS.VSORRES,'[lb_av]','kg');
    $VS.VSSTRESN = round($TEMP,1);
} elsif($VS.VSTESTCD = 'WEIGHT' and $VS.VSORRESU = 'kg') {
    $VS.VSSTRESN = $VS.VSORRES;
} else {
    $VS.VSSTRESN = 'TODO';
}
```

Using the "rws:unitconversion" function.
Essentially, doings so only makes sense when the units come in UCUM notation already in the source data.

It however shows once again that CDISC should move to UCUM notation for units instead of mandating to use it's "own invented wheel".

Conclusions

There are several possibilities for mapping units of measure from the source (ODM) to the target SDTM or SEND variables. When the units of measure are defined as datapoints (i.e. using "ItemDef"), the mapping is as for any other data point, with the difference that usually, a mapping to CDISC units will be needed, for which there is a wizard. Alternatively, the units defined in the ODM "BasicDefinitions" can be imported into the define.xml and transformed to a codelist.
When the ODM uses the "MeasurementUnitRef" mechanism for units, when doing drag-and-drop from the "ItemDef" to an SDTM/SEND cell, the software will already suggest to use the value of "ItemData/MeasurementUnitRef/@MeasurementUnitOID" that can then be mapped to CDISC units using the provided wizard.
SDTM-ETL also supports automatic unit conversion when the units are provided in UCUM notation. Due to the nature of the CDISC-CT (just lists) this is unfortunately not possible with CDISC units.