

On-the-Fly Data Capture Tooling for FHIR/HL7 V2

Paul Lynch, Ye Wang, Ajay Kanduru, Xiaocheng Luan, Lee Mericle, Shennon Lu, and
Clement McDonald

Lister Hill Center, National Library of Medicine, NIH

Presented by Clem McDonald, Paul Lynch, Ye Wang, and Ajay Kanduru

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Why we built a general forms system

Database systems as a motivating example

- In the 70's pre database systems, I started developing medical record software.
- We had to build a separate data structure for each kind of data, e.g. patient registry, prescriptions, the structures only existed in the programs and were held hostage by them.
- Had to write separate programs for storing data and for reporting content of each such data using these software data structures.
- Then came database systems.
- They magic they provided was the stored data structure definition.
- They freed the data structure from the programs.

Motivating example 2

- The programs then read the data structure from the database definition. This made it easier to keep different programs aligned and modify them.
- Also made it feasible to develop general tools, like report generators, and data input tools, because they would just read the data definition and create a new personality for each data definition.

Motivating example 3

- We developed our own sort-of-relational database system in the mid 70's.
- The software work that remained was development of data entry forms, data display forms and special routines process the data that was entered.
- We thought that for sure, the industry would develop a stored form definition equivalent of stored database definitions and eliminate a big chunk of the remaining work of developing clinical applications X-forms looked like the answer, but it didn't happen.

So we built our own

- In the Mid 80's we started building a PC based physician order entry and decision support work station called the Gopher. Wrote it in Revelation (a Pick operating system), which had its own built in database system.
- It was the basis of many papers in the New England Journal and JAMA including one that showed that such systems save money.
- To ease development we developed our own forms generator.
- All we had to do was record the attributes that applied to the form, over all, and the attributes (data type, answer lists, etc.) for each question/variable on the form AND a software routine that defined the next action to be performed.

Our own form development experience

- This made software development fast and “easy”. We could respond overnight to changes needed as we deployed.
- The form “became” the application - Enter something then do something (Where the do was a routine that would take actions such as store the data, run an arbitrary routine, create a flowsheet,) and all master files, reminder rules etc. were maintained through forms.

Rev - N

TEST4, PATIENT 9999-4 F I DAILY ORDERS Ord 140K .00s y 05/12/14 11:42AM Page 1 of 4

1. Patient ID	2. Date	3. Time	4. Pt's Ward	5. Bed#	6. Doctor ID
9999-4	12 MAY 2014	11:34AM	ER	EXAM03	WARVEL, JEFF

7. Main Problem
parotid mass

8. Any Orders

9. Rx Orders			10. Test Orders			11. Other Orders		
1.			1.			1.		
2.			2.			2.		
3.			3.			3.		
4.			4.			4.		
5.			5.			5.		

Main Problem choices
TEST4's active problems

1) Abdominal Pain	25) Essential HTN Malignant
2) Acute Pancreatitis	26) HIV Positive
3) CHF	27) Myocardial Infarct Acute
4) Diabetes Mellitus	28) Acute Pancreatitis
5) Elbow Fx	29) Pneumonia
6) Hip Pain	30) R/o MI
7) Periodic Gyn Exam	31) Sepsis
other DX options	32) Shock
8) AIDS	33) Syncope
9) Abdominal Pain	34) TB Active
10) Ascites	35) Deep Vein Thrombosis
11) Asthma	36) Unstable Angina
12) CHF	37) UTI
13) Cirrhosis of Liver	38) Weight Loss
14) Coma	
15) COPD Exacerbation	
16) Coronary Artery Disease	
17) Stroke	
18) Delirium Tremens	
19) Diabetic Ketoacidosis	
20) Diarrhea	
21) Drug Overdose	
22) Foot Ulcer(s)	
23) EtOH Abuse	
24) GI Bleed	

Use RESTORE (Ctrl-F2) to restore cleared text.

2461A03E [] WISHARD INQ_INFO

Patient input

Welcome to Wishard Memorial Hospital
 Software Copyright 2004 by Regenstrief Institute
 'Help'=help, 'Backout/ESC'=quit, 'Enter/DO'=next screen.

Patient Institution: WISHARD
 Patient MRN or NAME: _____
 Test(s) to Retrieve: ALL
 Date(s) to Retrieve: ALL
 System(s) to Search: _____

OBSERVATIONS

- 1) Recent_results
- 2) WMH inpatient flousheet
- 3) WMH longterm flousheet
- 4) Global Flousheet
- 5) Specialty Abstract
- 6) Nurse/PA/PT/OT/Diet Note
- 7) Letter/Form/Consent
- 8) Psych Evaluation Note
- 9) Cytology Reports
- 10) Dischrg Sum/Admissn H&P
- 11) Cardiology Reports
- 12) Uascular Lab Reports
- 13) GI Procedures
- 14) Neurology Reports
- 15) Operative Report
- 16) Radiology & Nuclear Med
- 17) Surgical Pathology
- 18) Visit/Procedure/Gopher
- 19) Progress Notes
- 20) Reference Lab Info
- 21) Scanned Documents

Press F10 for more choices

Next stage

- We build some tools for a PHR at NLM
- Those tools evolved into LHC-Forms
 - A form generator that could make every LOINC panel into an on-the-fly data capture form.
 - It could convert a form definition into an working web form in an instant.
 - It has lots of sophisticated form capabilities including tie-ins to the most common external coding systems.

Impediments

- It was not a standard.
- Users could stitch such forms into their web pages, but it had no natural usage ecosystem.
- Real users of the form would have to figure out how to tie to a patient registry, orders, provider tables, authentication, etc. Tall barriers to its use.

Then along came FHIR

- FHIR eliminated these impediments.
- FHIR SDC is a “standard” which our tools could implement and render as executable forms.
- SMART on FHIR provided a real world ecosystem of authentication tools, patient registries etc., in which LHC forms could live and be useful. So we support SMART on FHIR and LHC-Forms lives on its App gallery - <https://apps.smarthealthit.org/>.
- We also built tools that can interact directly with FHIR servers and can use native Google and Facebook logons for authentication. Ye Wang will show you the details later.

Forms definitions

- FHIR forms
 - FHIR Questionnaire - defines a simple questionnaire without special features such as skip logic.
 - FHIR SDC Questionnaire – an extension on Questionnaire, with lots of additional features like skip logic, more sophisticated error checking, etc.
- IHE
 - Has an SDC form - but it is different from, and formulated in a more complicated fashion than the FHIR SDC form
https://ihe.net/uploadedFiles/Documents/QRPH/IHE_QRPH_Suppl_SDC.pdf
- LHC-Forms has a native form definition based on LOINC panels which we can transform into either of the FHIR Questionnaires and possibly into IHE questionnaire in future.

Introduction & Overview

- Goals and rationale for standards-based data capture
- LOINC panels/Forms – provide 2000 pre-built forms
- Form fields can be tied to External look up tables (coding FHIR systems/master files)
- Can define form in
 - Spreadsheet specification
 - Through form builder program (will present)
- Can generate FHIR SDC form definition
- SDC Questionnaire specification
- Can deliver completed form as
 - FHIR QuestionnaireResponse
 - FHIR DiagnosticReport

Brief over view of FHIR forms

- Questionnaire/QuestionnaireResponse
 - A resource for storing form definitions themselves
 - Questionnaire - <https://www.hl7.org/fhir/questionnaire.html>
 - Questionnaire, structured data capture (SDC) - <https://www.hl7.org/fhir/DSTU2/sdc/questionnaire-sdc.html>
 - Questionnaire response a resource for storing the content of a completed form
 - For Questionnaire - <https://www.hl7.org/fhir/questionnaireresponse.html>
 - For Questionnaire SDC - <http://hl7.org/fhir/us/sdc/sdc-questionnaireresponse.html>
- DiagnosticReport
 - With standard codes for the variables also *possible* to generate a FHIR DiagnosticReport bundle directly from data capture forms

LHC tools you will hear about today

- LHC Clinical Table Search Service (CTSS)
 - Provides Autocomplete (and soon simple Lucene Search) for commonly needed codes systems such as ICD diagnoses, US national provider files (NPI), Rx.norm drug ingredients, LOINC test and measure terms
 - Includes some secret sauce
 - Can be tied into LHC form fields, used directly off LHC web site, or tied into user application
- LHC-Forms - form definitions and the widget
- LHC-Forms Builder - a tool to create LHC-Forms
 - LHC-Forms can also be defined/edited directly in their native forms (JSON) or via a spread sheet definition
- UCUM - units validator & converter

Secret Sauce in Clinical table linker

- Via the URL, users can specify what fields in the external table are searched, and which answers are returned as part of selection grid, and which are stored in the index value field as hidden variables
- Other fields in the form can use these hidden variables as answer lists, default values, or help messages.
- Explore the tables we have created so far at:
<https://clin-table-search.lhc.nlm.nih.gov/>
- Tables include IDC9, ICD10, genetic tables (ClinVar, dbSNP, etc.), RxTerms, NPI (coming soon), etc.

LHC-Forms: Short Introduction

- Strong tie to Meaningful Use standards
 - Coding systems LOINC, RxNorm, Snomed CT, Standard genetic coding systems, UCUM
 - All LOINC panels are also LHC-Forms
- Outputs : FHIR DiagnosticReport, FHIR QuestionnaireResponse, V2 message, JSON

Lots of rich survey instruments and assessments available as LOINC forms > 2000 and thus LHC forms

- Most CMS clinical forms (OASIS, MDS 3.0 nursing home assessments, dialysis reports) are represented as LOINC panels/forms.
 - CMS is unifying all of its assessments as LOINC forms with LOINC codes—some which will use the LOINC codes for existing CMS data items where possible and obtain new ones when needed.
- CDC standard forms for birth and death certificates are LOINC forms
- Lots and lots of psychosocial surveys
 - PHQ, PROMIS
 - Lots of clinical test panels and nursing assessment forms
 - Ventilator variables, 12 lead EKG, Pulmonary function tests (Mayo), cardiac echoes (DICOM), Lab panels, Ophthalmology measures (NEI), etc.

LHC-Forms Builder: Short Introduction

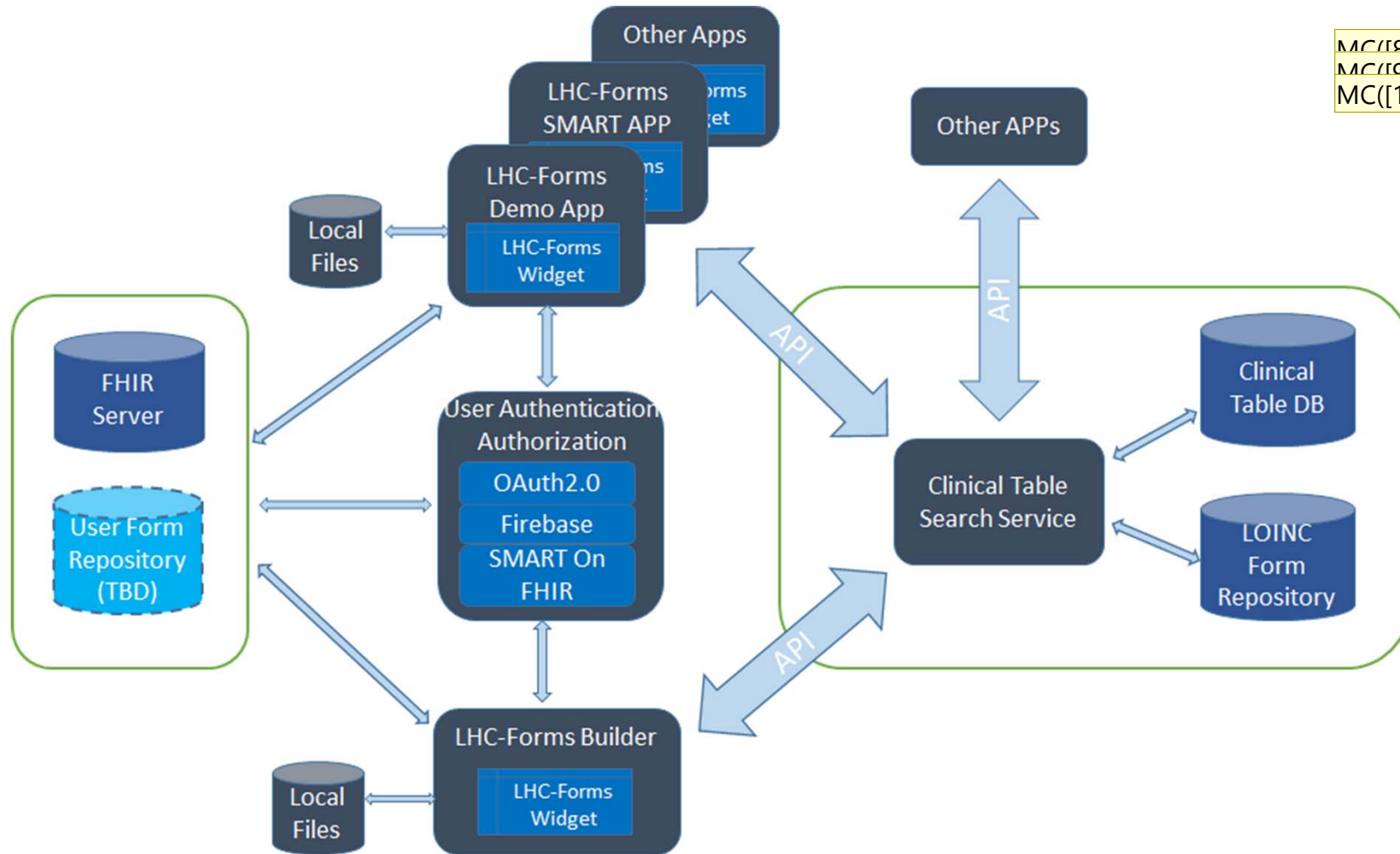
- Website: <https://lhc-formbuilder.lhc.nlm.nih.gov/>
- Can start with one or more existing LOINC panels, and add to or edit it.
- Can start from scratch using existing LOINC variables or user invented variable.
- JSON Schema defined for validating forms.
- Docker implementation of one of our applications, plan to support Docker for all of them.

UCUM-LHC: Unit Validation and Conversion

- For “Unified Code for Units of Measure” (UCUM)
- Website: <https://ucum.nlm.nih.gov/ucum-lhc/>
- Library can be downloaded from GitHub or installed with “bower”
- Library supports:
 - Validation of unit expressions
 - Conversion of values between different unit expressions
- Unit codes in UCUM are not always what one would expect, but there are synonyms
 - Some UCUM syntax is not in common vernacular, e.g. [lb_av], but synonyms ([lb_av] = pounds) will guide the users
- Some special syntax: “.” = multiplication, * = exponentiation

Overall Technology

- Mixture of Web widgets and applications, namely: Clinical Table Search Service, Form Builder, UCUM validator
- All software - applications and widgets - are written in JavaScript
- Most of development uses Google AngularJS
- All data (including form definition and content of populated form) is represented as JSON
- Most content stored in Elastic Search (with Lucene)
<https://www.elastic.co/>
- Size of LHC forms renderer that loads into browser – about 300K



MC(I)8
MC(I)9
MC(I)10

Slide 23

MC([8 could you put numbers on the four things we are countnig as "tools" in the previous slide. Would like to be able to refecenc them by number. But... I only count three Also can I say that the API is the same general structure -in all of the instances shwoing on the grap

McDonald, Clem (NIH/NLM/LHC) [E], 9/12/2017

MC([9 Finally is the LOINC form repository just all of teh LOINC terms and panels or is soemthing seperate.

McDonald, Clem (NIH/NLM/LHC) [E], 9/12/2017

MC([10 Instead of other APPs better say, Your Apps or something

McDonald, Clem (NIH/NLM/LHC) [E], 9/12/2017

Some example forms as preview



Surgeon Generals family health history as an LHC-Form

Multiple levels of nesting -
 A person can have many diagnoses with dates AND many relatives who also have many diagnoses and dates

US Surgeon General family health portrait [54127-6]

Date Done	Time Done	Where Done	Comment
MM/DD/YYYY	Type a value	Select or type a value	Type a value
Name	Value	Units	
My health history [54126-8]			
Name [54125-0]	Mr good doctor		
Gender [54131-8]	Male		
Birth Date [21112-8]	12/16/1944	{mm/dd/yyyy}	
Twin [54132-6]	No		
Adopted [54128-4]	Yes		
Parents related [54135-9]	No		
Body height [8302-2]	70		
Weight [29483-7]	70		
Race [54134-2]	2106-3. White		
Ethnicity [54133-4]	Unknown/No answer		
1.1 Diseases history panel [54137-5]			
History of diseases [54140-9]	Diabetes - type 2 (adult, non-insulin-independent)		
Age range at onset of disease [54130-0]	30-39		
1.2 Diseases history panel [54137-5]			
History of diseases [54140-9]	Congestive heart failure (CHF)		
Age range at onset of disease [54130-0]	OVER 60		
Add another 'Diseases history panel'			
1 Family member health history [54114-4]			
Relationship to patient [54136-7]	GRNDDAU. Granddaughter		
Name [54138-3]	mary		
Gender [54123-5]	Female		
Living? [54139-1]	Yes		
Date of Birth [54124-3]	12/20/1190	{mm/dd/yyyy}	
Current Age [54141-7]	Type a number	a	
Twin [54121-9]	No		
Adopted [54122-7]	No		

multiple repeats per person recording

Can enter multiple fields in one field (or as separate fields illustrated with PHR)

Medications assessed [51963-7]

* Ampicillin * coumarin

Search for or type values

Gene(s) assessed [48018-6]

* CFTR * AAGAB * FDXACB1

Search for values

make multiple sections in one field. Remove them by clicking on x

PHQ-9 Depression survey with score computed on the fly

As an LHC-Form

PHQ-9 quick depression assessment panel [44249-1] ©

Date Done	Time Done	Where Done	Comment
MM/DD/YYYY	Type a value	Select or type a value	Type a value
Name	Value	Units	
<input type="checkbox"/> Over the last 2 weeks, how often have you been bothered by any of the following problems? [44257-4] ©			
<input type="checkbox"/> Little interest or pleasure in doing things? [44250-0] ©	1. Several days		
<input type="checkbox"/> Feeling down, depressed, or hopeless? [44255-8] ©	2. More than half the days		
<input type="checkbox"/> Trouble falling or staying asleep, or sleeping too much [44259-0] ©	1. Several days		
<input type="checkbox"/> Feeling tired or having little energy [44254-1] ©	1. Several days		
<input type="checkbox"/> Poor appetite or overeating [44251-7] ©	1. Several days		
<input type="checkbox"/> Feeling bad about yourself-or that you are a failure or have let yourself or your family down [44258-2] ©	1. Several days		
<input type="checkbox"/> Trouble concentrating on things, such as reading the newspaper or watching television [44252-5] ©	0. Not at all		
<input type="checkbox"/> Moving or speaking so slowly that other people could have noticed. Or the opposite-being so fidgety or restless that you have been moving around a lot more than usual [44253-3] ©	0. Not at all		
<input type="checkbox"/> Thoughts that you would be better off dead, or of hurting yourself in some way [44260-8] ©	1. Several days		
Patient health questionnaire 9 item total score [44261-8] ? ©	8		{score}
<input type="checkbox"/> How difficult have these problems made it for you to do your work, take care of things at home, or get along with other people? [89722-7] ? ©	Select one		

form adds up the score for the answers given

<https://lhc-forms.lhc.nlm.nih.gov/>

Secret sauce : Code stored in one field can generate code answer lists for succeeding fields- to be illustrated on the PHR form

Enter Lasix oral and get selection menu of available pill sizes


-	Z-PAK (Pack)	q	Stopped	▼	mixed Pack	tal
-	Beclomethasone (Nasal)	q	Active	▼	40 mcg/puff Metered dose sp	1 p
-	LA SIX (Oral Pill)	q	Active	▼	Select one or type a value	Ty

Add another 'Medications'

Allergies and Other Dangerous Reactions


Name	action
------	--------


1: 20 mg Tab
2: 40 mg Tab
3: 80 mg Tab




Secret sauce: record for Id in one field generates defaults for others


Before

Genetic variant coding system [02122-0]  Discrete genetic variant

Discrete genetic variant [81252-9] 


Transcript specification 


Gene studied	Transcript RefSeq ID	DNA change c.HGVS	Amino acid change p.HGVS	DNA change type	Amino acid change type
<input type="text" value="Search for or type a value"/>	<input type="text" value="Search for or type a value"/>	<input type="text" value="Search for or type a value"/>	<input type="text" value="Search for or type a value"/>	<input type="text" value="Select one or type a value"/>	<input type="text" value="Select one or type a value"/>

Genomic specification 


Genomic reference sequence	Genomic DNA change (gHGVS)	Genomic ref allele	Genomic allele start-end	Genomic alt allele
<input type="text" value="Search for or type a value"/>	<input type="text" value="Type a value"/>	<input type="text" value="Type a value"/>	<input type="text" value="Type a value"/>	<input type="text" value="Type a value"/>

After

Discrete genetic variant [81252-9] 

Transcript specification 

Gene studied	Transcript RefSeq ID	DNA change c.HGVS	Amino acid change p.HGVS	DNA change type	Amino acid change type
CFTR	NM_000492.3	c.1373G>T	p.Gly458Val	SNV	Select one or type a value

Genomic specification 

Genomic reference sequence	Genomic DNA change (gHGVS)	Genomic ref allele	Genomic allele start-end	Genomic alt allele
NC_000007.13	Type a value	G	117188858^117188858	T

Choices of combo boxes, radio buttons, check boxes and grids when appropriate

Braden scale skin assessment panel

Date Done: MM/DD/YYYY Time Done: Type a value Where: Select

Name

- Sensory perception Braden Scale
 Completely
 No impairment
- Moisture exposure Braden Scale
 Constantly moist
 Very moist
 Occasionally moist
 Rarely moist
- Physical Activity Braden Scale
 Bedfast
 Chairfast
 Walks occasionally
 Walks frequently
- Physical mobility Braden Scale
 Completely immobile
 Very limited
 Slightly limited
 No limitation
- Nutrition Intake Pattern Braden Scale
 Very poor
 Probably inadequate
 Adequate
 Excellent
- Friction+Shear Braden Scale
 Problem
 Potential problem
 No apparent problem

Braden Scale Total Score: Type a value {score}

Pressure ulcer risk Braden Scale
 Very high
 High
 Moderate
 Mild
 No risk

Display format: In 6 columns

gear gives choice of combo box or buttons and the

gear clicked

Responsive design-example from HL7 V2 genetics reporting form


Wide screen

select one or type a value

Full narrative report [51969-4]

Variant ISCN [81291-7]

Versions of Coding Systems [divider04t]

Human reference sequence assembly [62374-4] 

<input type="radio"/> NCBI35	<input type="radio"/> NCBI36
<input type="radio"/> GRCh37	<input type="radio"/> GRCh38
<input type="radio"/> OTHER: <input type="text"/>	


HGVS version [ID] [81303-0]

dbSNP version [Num] [81415-7]

Skinny screen

Variant ISCN [81291-7]

Versions of Coding Systems [divider04t]

Human reference sequence assembly [62374-4] 

<input type="radio"/> NCBI35	<input type="radio"/> NCBI36
<input type="radio"/> GRCh37	<input type="radio"/> GRCh38
<input type="radio"/> OTHER: <input type="text"/>	

HGVS version [ID] [81303-0]

Making Applications from forms – Implemented PHR close to what it was in previous Ruby on Rails applications (will demo)

Save To File Use "Label Above" Style Use "Label on Left" Style Show HL7 Message

Display Question Code Show Help/Description Keyboard Navigation On Input Fields Total # of Questions: 44

Personal Health Record

Medical Conditions

Medical condition	Status	Started	Stopped	Description/Comment
Chest pain	🔍 Active	04/20/2016	MM/DD/YYYY	Sounds anginal. Worrse with exertion, but young and no family history
Pneumonia - bronchial	🔍 Inactive	03/17/2017	04/22/2016	Treated wish Zpack on ambulatorybais
Hay fever (allergic rhinitis)	🔍 Active	03/20/2012	MM/DD/YYYY	Every spring
bac	🔍 Select one or	MM/DD/YYYY	MM/DD/YYYY	Type a value

Add another 'Medical Conditions'

Medications

Medication name	Status	Strength	Instructions	Started	Stopped	Why stopped	Resupply
Z-PAK (Pack)	🔍 Stopped	mixed Pack	take until gone	03/17/2016	04/22/2016	Finished the prescription	MM/DD/YYYY
Beclomethasone (Nasal)	🔍 Active	40 mcg/puff Metered dose sp	1 puff twice day in season	03/20/2012	MM/DD/YYYY	Select one or type a value	MM/DD/YYYY

Add another 'Medications'

Allergies and Other Dangerous Reactions

Name	Reaction	Started	Comment
Pollen	🔍 Sneezing or stuffy nose	03/15/2017	Worse when maple trees bloom
Select one or type a value	🔍 Select one or type a value	MM/DD/YYYY	Type a value

Add another 'Allergies and Other Dangerous Reactions'

Choices of combo boxes, radio buttons, check boxes and grids when appropriate

Braden scale skin assessment panel

Date Done: MM/DD/YYYY Time Done: Type a value Where: Select

Name

- Sensory perception Braden Scale
 Completely
 No impairment
- Moisture exposure Braden Scale
 Constantly moist
 Very moist
 Occasionally moist
 Rarely moist
- Physical Activity Braden Scale
 Bedfast
 Chairfast
 Walks occasionally
 Walks frequently
- Physical mobility Braden Scale
 Completely immobile
 Very limited
 Slightly limited
 No limitation
- Nutrition Intake Pattern Braden Scale
 Very poor
 Probably inadequate
 Adequate
 Excellent
- Friction+Shear Braden Scale
 Problem
 Potential problem
 No apparent problem

Braden Scale Total Score: Type a value {score}

Pressure ulcer risk Braden Scale
 Very high
 High
 Moderate
 Mild
 No risk

Combo box Radio buttons
Display format: In 6 columns

gear gives choice of combo box or buttons and the

gear clicked



HL7 message generated from completion of genetics form- only top 2/3ds showing (Hand out)

```

OBR|1|X1000-0^HL7 Genetic Test Panel for Variants - 20160322^LN|
OBX|1|CNE|XXXXX-12^Choose kind of mutations targeted^LN|1|C01^Simple variants^LN~C02^Complex
variants^LN|
OBX|2|CNE|XXXXX-10^Choose region of interest specification^LN|1|C01^Specific targeted mutations^LN|
OBX|3|CWE|51967-8^Genetic disease assessed^LN|1|C0010674^Cystic fibrosis^LN|
OBX|4|CNE|48002-0^Genomic source class^LN|1|LA6683-2^Germline^LN|
OBX|5|CNE|48018-6^Gene(s) examined^LN|1|1884^CFTR^LN|
OBX|6|CNE|51968-6^Genetic analysis overall interpretation^LN|1|LA6576-8^Positive^LN|
OBR|2|XXXXX-9^Simple variants^LN|
OBX|1|CNE|XXXXX-5^Variant ID^LN|1.1|44487^35823^LN|
OBX|2|ST|XXXXX-13^Variant name^LN|1.1|NM_000492.3(CFTR):c.1400T>C (p.Leu467Pro)|
OBR|3|XXXXX-1^Variant specifics^LN|
OBX|1|CNE|XXXXX-19^Type^LN|1.1.1|SNP^SNP^LN|
OBX|2|CNE|48018-6^Gene^LN|1.1.1|44487^CFTR^LN|
OBX|3|CNE|48013-7^NM_RefSeq^LN|1.1.1|44487^NM_000492.3^LN|
OBX|4|CNE|41103-3^DNA change^LN|1.1.1|44487^c.1400T>C^LN|
OBX|5|CNE|48005-3^AA change^LN|1.1.1|44487^p.Leu467Pro^LN|
OBX|6|ST|XXXXX-17^NC/NG_RefSeq^LN|1.1.1|NC_000007.13|
OBX|7|ST|69547-8^Ref allele^LN|1.1.1|T|
OBX|8|ST|X0029^Allele loc^LN|1.1.1|117199525|
OBX|9|ST|69551-0^Alt allele^LN|1.1.1|C|
OBX|3|CWE|X1001-0^Cytogenetic location^LN|1.1|44487^7q31.2^LN|
OBX|4|CWE|X1002-0^Possible associated phenotype^LN|1.1|C0010674^Cystic fibrosis^LN|
OBR|4|XXXXX-9^Simple variants^LN|
OBX|1|CNE|XXXXX-5^Variant ID^LN|2.1|44494^35830^LN|
OBX|2|ST|XXXXX-13^Variant name^LN|2.1|NM_000492.3(CFTR):c.1684G>A (p.Val562Ile)|
OBR|5|XXXXX-1^Variant specifics^LN|
OBX|1|CNE|XXXXX-19^Type^LN|2.1.1|SNP^SNP^LN|
OBX|2|CNE|48018-6^Gene^LN|2.1.1|44494^CFTR^LN|
OBX|3|CNE|48013-7^NM_RefSeq^LN|2.1.1|44494^NM_000492.3^LN|
OBX|4|CNE|41103-3^DNA change^LN|2.1.1|44494^c.1684G>A^LN|
OBX|5|CNE|48005-3^AA change^LN|2.1.1|44494^p.Val562Ile^LN|
OBX|6|ST|XXXXX-17^NC/NG_RefSeq^LN|2.1.1|NC_000007.13|

```



Clinical Table Search Service

Presenter: Paul

Clinical Table Search Service: Introduction

- <https://clin-table-search.lhc.nlm.nih.gov/>
- Purpose: A web service for auto-completing selection lists used in filling in forms
 - Example use: A field with a list of drug names that auto-completes as you type
- Provides access to pre-defined 20+ data tables, e.g.:
 - Medical conditions
 - ICD-10-CM
 - Drug names (and associated strength/form lists)
 - LOINC questions (with coded answer lists, and forms)
 - UCUM (Unified Codes for Units of Measure) -- for lists of units
 - National Provider Index (doctors and practices)
 - Genetic tables (ClinVar, COSMIC, snps, etc.)

Clinical Table Search Service: Introduction

- Definition: “A **web service** is a [service](#) offered by an electronic device to another electronic device, communicating with each other via the [World Wide Web](#).” (Source: [Wikipedia](#))
- Output is intended for programs, not people
- A program sends a URL to the web service, perhaps with a query, and gets back data (typically XML or JSON)
- For the Clinical Table Search Service (CTSS):
 - a JavaScript program in a webpage sends a URL with what the user typed, and
 - gets back a JSON structure with data for matching items that can be shown in a list and selected.

Clinical Table Search Service: Introduction

Web service example:

- URL sent by program: <https://clin-table-search.lhc.nlm.nih.gov/api/conditions/v3/search?terms=arm>
- Returned data (hard to read, but not by a program):

```
[7,["2958","29959","23374","9917","9918","9893","9909"],null,[["Arm pain"],["Shoulder or upper arm injury"],["Elbow pain"],["Shoulder strain"],["Shoulder sprain"],["Humerus fracture"],["Biceps tendon rupture"]]]
```

Clinical Table Search Service: Introduction

- Usages:
 1. AJAX calls from external software to the APIs for our tables
 2. LHC-Forms can use the CTSS for auto-completing lists from any of the pre-defined tables.
 3. Stand alone searches off our web site (to see what's there, using the demos on the documentation pages)
- Hands-on exercise at end of this section:
 - We'll modify some starting code to create an auto-completing field
 - We'll add some code to auto-populate an adjacent field with data from the selected item
 - If you get stuck, there is a functioning parallel example with a different API that you can modify.

Clinical Table Search Service: Introduction

- Each data table has its own set of fields
 - Example: The medical conditions table has codes, a primary name, a consumer name, and a synonyms field.
- The service allows you to specify, via the URL:
 - Which fields to search
 - Which field(s) you want returned as:
 - a code field for the record
 - fields to display in columns of the user choice grid, e.g. patient name AND address
 - extra fields of data (returned as a hash for later use, e.g. by LHC-Forms as defaults, menus, help text, etc., for subsequent fields.)
 - More on this later

Clinical Table Search Service: Introduction

- Early in its history and still a pilot
- Have not advertised or promoted
- Content is updated on a monthly basis (except dbVar)
 - Data update date for each table is shown on main page
- In use by several production websites and (probably) apps. As of 2017/12:
 - 67 referring sources (using or linking to us)
 - 12% direct access (e.g. non-web programs)

Clinical Table Search Service: Website

- <https://clin-table-search.lhc.nlm.nih.gov/>
- Documentation and demos of the web service
- Main page shows list of data tables
 - Clinical/administrative tables in first half
 - Genetic tables grouped together in second half of page
- Link to detailed documentation for each table on left
 - Individual page per table also defines the fields in each table and provides details for how to construct query URLs
 - Also includes information on the data source and processing we performed
- Center column of web page grid has input field for demonstrating the autocomplete search of that table plus:
 - Link to source code for demo autocompleter
 - Link to a page per table for customizing the search & display fields



Clinical Table Search Service

A web API service for use with autocomplete-lhc & LHC-Forms

Clinical Table Search Service (formerly "lforms-service") is a web service which software programs can use for querying clinical data tables. The API for each table is designed to work with our form field autocompletion package, but can be used by other programs as well. Please [let us know](#) if there are other clinical data tables you would like to see here.

Connectable Clinical Tables

What follows is a list of currently available tables with links to instructions for the APIs for programmatic access, and an example autocompleter for each table which uses that table's API.

Some of the data sets that we serve are stable (e.g., ICD-9-CM), while others are updated more frequently (e.g., ClinVar). We strive to keep our data up-to-date with respect to the data sources; in most cases it should be less than a month behind. Please refer to the "Details" column below for more information on a specific API's data version or date.

Table Description	Try It	Details
ICD-10-CM	<input type="text" value="Code or name"/> Source code Customize	From CDC Data version: 2018
ICD-9-CM diagnoses	<input type="text" value="Code or name"/> Source code Customize	From CMS Data version: 32 (2014-10-01)
ICD-9-CM procedures	<input type="text" value="Code or name"/> Source code Customize	From CMS Data version: 32 (2014-10-01)
LOINC questions and forms Contains over 2000 medical forms and their associated questions)	<input type="text" value="LOINC item"/> Source code Customize	From LOINC. Note that use of LOINC is subject to the LOINC Terms of Use and in some cases additional copyrights . Form definitions for the forms can also be retrieved and rendered with the LHC-Forms display widget. Data version: 2.61 (2017-06-23)
Major surgeries and implants About 280, hand-edited with synonyms; a Regenerief Institute derivative	<input type="text" value="Procedure"/> Source code Customize	From the NLM PHR & Regenerief Institute Data version: 2017-10-31
Medical conditions Over 5000, hand-edited with synonyms; a Regenerief Institute derivative	<input type="text" value="Condition"/> Source code Customize	From the NLM PHR & Regenerief Institute Data version: 2017-10-31
NPI - individuals	<input type="text" value="Provider name or NPI"/> Source code Customize	National Provider Identifier (NPI) records for individuals, from CMS Data version: 2017-12-12
NPI - organizations	<input type="text" value="Provider name or NPI"/> Source code Customize	National Provider Identifier (NPI) records for organizations, from CMS Data version: 2017-12-12
Prescribable drug ingredients A subset of RxTerms/RxNorm ingredients	<input type="text" value="Ingredient"/> Source code	From RxTerms/RxMix Data version: 201801
RxTerms drug names & strength lists	<input type="text" value="Drug name"/> Source code	From RxTerms

Clinical Table Search Service: Website

- Overview of some Data Tables
 - Most popular (December)
 - [Medical conditions](#): Hand-edited with synonyms; a Regenstrief Institute derivative. Usage = 63%
 - [ICD-10-CM](#): Usage = 19%
 - [RxTerms](#): Drug names & strength lists, derived from RxNorm. Usage = 12%
 - [UCUM](#): Unified Codes for Units of Measure. Usage = 3%
 - Also have [LOINC](#) terms, along with form definitions (more later)
 - Can retrieve answer lists for LOINC questions

Clinical Table Search Service: Medical Conditions

- Medical conditions (>5000) list originated from Regenstrief Institute
- Content selected for importance and most carry synonyms as well as associated billing codes and links to MedlinePlus
- Medical conditions table fields
 - Display-text fields: `primary_name`, `consumer_name`
 - Code fields: `key_id`, `icd10cm_codes` (CSV), `icd10cm` (JSON), `term_icd9_code`, `term_icd9_text`
 - `word_synonyms` - synonyms for any word in the term
 - `synonyms` - for the term as a whole
 - `info_link_data` - links to MedlinePlus
- Not all fields are populated for every record
 - `key_id`, our internal ID, exists for every record, as do the display-text fields.
 - Can specify a preferentially ordered list of codes to return

<https://clin-table-search.lhc.nlm.nih.gov/apidoc/conditions/v3/doc.html>

Clinical Table Search Service: ICD-10-CM and ICD9_CM

- ICD-10-CM - a medical coding system for classifying diagnoses and reasons for visits (>71,000 terms) – Required for billing since 2015
- Not as useful for problems as the Medical conditions table because
 - Terms are sometimes quite long
 - Not consumer oriented
- ICD-9 CM –shorter table used for almost 2 decades before ICD10 introduced

<https://clin-table-search.lhc.nlm.nih.gov/apidoc/icd10cm/v3/doc.html>

Clinical Table Search Service: RxTerms

- RxTerms is derived from RxNorm (>9000 terms)
 - Intended for prescription writing in two steps. Enters drug name and route- e.g., Oral penicillin, in first field, and then pick delivery form and strength in a 2nd field that displays only the choices that apply to that drug
- RxTerms table fields
 - DISPLAY_NAME - The drug name and route combination
 - STRENGTHS_AND_FORMS - A (JSON) list of strength and form combination strings (e.g., "2mg Tab") for the drug.
 - RXCUIS- These are codes for the DISPLAY_NAME + strength-form combination (so one for each STRENGTHS_AND_FORMS entry)
 - DISPLAY_NAME_SYNONYM - Synonyms for aiding searching
 - In RxTerms this is specific to a strength as well as a name, but we did not preserve that association.

<https://clin-table-search.lhc.nlm.nih.gov/apidoc/rxterms/v3/doc.html>

Clinical Table Search Service: LOINC

- LOINC - a universal code system for medical tests and measurements, from Regenstrief Institute (>84,000 terms)
 - Contains coded questions with coded answers lists
 - Questions are organized into forms (e.g. lab panels), which can be retrieved as JSON structures
- LOINC table fields:
 - text - The text of the question or form name
 - LOINC_NUM - The LOINC code of the question or form
 - datatype - Indicates whether it is a list, a string, a number, etc.
 - units - For numeric data types, this will a list of units (usually just one)
 - answers - The coded answer list for list datatypes
- <https://clin-table-search.lhc.nlm.nih.gov/apidoc/loinc/v3/doc.html>

Clinical Table Search Service: Demo page

- <https://clin-table-search.lhc.nlm.nih.gov/demo.html>
- Useful for seeing the contents of the data tables in response to autocompletion.
- Can select which fields are searched and which are displayed
- Can switch between data tables
- Shows the URL used for the selected search and display fields

Clinical Table Search Service: Demo page

Autocompletion Demo for the Alleles API

This page allows you to try the [Alleles API](#) and see the effects of different choices for search and display fields (specified with the "sf" and "df" query string parameters, as described on the [API documentation page](#)) on returned data, which is shown in the autocompletion list below.

Example autocompleter

The following autocompleter was constructed using the fields specified below.

[Show developer info](#)

Database:

The "Search" checkboxes control which data fields the autocompleter searches, and the "Display" checkboxes control which data fields show up in the autocompletion list. If none are checked, a default selection will be used.

Field	Search	All	Default	Display	All	Default	Description
AlternateAllele	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The value of the AlternateAllele field in the source file.
AlternateAllele_lbl	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The value of the AlternateAllele field in the source file, but prefixed with "Alt=".
AlleleID	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The ID of the allele as taken from the AlleleID column of the source file.
AminoAcidChange	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	This is the amino acid change (starting with "p.") parsed from the Name field.
Chromosome	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The chromosome number, taken from the Chromosome field in the source file, but prefixed with "chr".
ChromosomeAccession	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The chromosome accession number, taken from the ChromosomeAccession field in the source file.
Cytogenetic	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The cytogenetic location of the allele, taken from the "Cytogenetic" field in the source file.
dbSNP	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The "rs" ID number from dbSNP, taken from the "RS# (dbSNP)" field in the source file.
GeneID	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The gene ID from NCBI's gene database.
GeneSymbol	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	This is the GeneSymbol field listed in the source file. It is the symbol for the gene that overlaps the variant.
GenomicLocation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	This is an HL7-style concatenation of the Start and Stop fields, i.e., Start*Stop.
hgnc_id	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	A unique ID provided by the HGNC for each gene with an approved symbol. Although standard HGNC IDs are of the format HGNC:n, where n is a number, we have removed the "HGNC:" prefix, so that these values are just numbers.
HGVS_c	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The "HGVS (c.*)" field from the source file. (The "RefSeq cDNA-based HGVS expression".)
HGVS_p	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	The "HGVS (p.*)" field from the source file. (The "RefSeq protein-based HGVS expression".)
Name	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	This is the "Name" field (a description of the allele) from the source file.

Clinical Table Search Service: Demonstrations

- <https://clin-table-search.lhc.nlm.nih.gov/>
 - Example query for the medical conditions API
 - Base URL for API + “terms” parameter with user input
- <https://clin-table-search.lhc.nlm.nih.gov/api/conditions/v3/search?terms=heart>



- Format of URL is the same for each data table
- URL contains an API version number to provide stability for existing users when we change features.

Clinical Table Search Service: Demonstrations

- Example output for the medical conditions API
<https://clin-table-search.lhc.nlm.nih.gov/api/conditions/v3/search?terms=heart>
- Returns a JSON structure, designed for compactness

Available result count



Array of condition codes



Placeholder for extra data about each record



- [32,["2212","365","2895","8411","3978","3867","8777"],null,[["Coronary artery disease (CAD)"],["Congestive heart failure (CHF)"],["Palpitations"],["Atrial myxoma"],["Heart murmur"],["Heart attack (myocardial infarction)"],["Sinoatrial block"]]]



Array of display strings, corresponding to codes

Clinical Table Search Service: Configuration

- API Parameters
 - terms (required, added by autoCompleter)
 - maxList (desired number of results)
 - sf = “search fields”
 - df = “display fields”
 - cf = “code field”
 - ef = “extra fields”
 - q = a query string to further constrain results (Lucene syntax)

Clinical Table Search Service: Configuration

- Example using query parameters:

[https://clin-table-search.lhc.nlm.nih.gov/api/conditions/v3/search?
sf=consumer name,synonyms&df=consumer name,icd10cm codes
&terms=ar](https://clin-table-search.lhc.nlm.nih.gov/api/conditions/v3/search?sf=consumer name,synonyms&df=consumer name,icd10cm codes&terms=ar)



search query
(autocompletion)



search fields



display fields (to be
shown to the user)

- When not supplied, default settings are used for sf & df

Clinical Table Search Service: Autocomplete-lhc

- Autocompletion package written for the format output by CTSS
 - <https://lhncbc.github.io/autocomplete-lhc/>
 - Can also use CTSS with other autocompleters or on its own
 - Advantage: No need to write code to parse the output
 - Pre-built, ready-to-use version hosted on CTSS website:
 - <https://clin-table-search.lhc.nlm.nih.gov/autocomplete-lhc-versions>
- Demo of RxTerms API & autocomplete-lhc
 - <https://plnkr.co/edit/sVFMu8v3ZINJMMu6bfhW>
 - Uses autocomplete-lhc hosted on CTSS website
 - Just a few lines of code create an auto-completing field hitting CTSS

Clinical Table Search Service: Autocomplete-lhc

- Features (demo at <http://lhncbc.github.io/autocomplete-lhc/>)
 - Built-in notion of coded list items (but codes are optional)
 - Provides methods for retrieving the “extra” data for a selected item
 - Optionally numbered lists, and can pick by number
 - Longer lists handled with a “see more” link and two-column flow
 - Supports a table-format (multi-fielded list items) with column headings
 - Long lists can be broken up with non-clickable heading items
 - Comes with an AngularJS directive
 - Accessible to screen readers

Clinical Table Search Service: Exercise

- Build a units (UCUM) lookup showing the unit code and its name.
- Template: <https://jsfiddle.net/lforms/rgt28krv/>
- Steps:
 1. Look at example of an NPI lookup: <https://jsfiddle.net/lforms/01gwLmpb/>
 2. Look at <https://clin-table-search.lhc.nlm.nih.gov/apidoc/ucum/v3/doc.html> for field names for the UCUM code and name.
- Extra credit: Fill in a form field for the unit's "LOINC property"
 1. Look at an NPI example: <https://jsfiddle.net/lforms/fa96usvf/>
 2. Add an input field for "LOINC property"
 3. Add a the listener for selection events on the unit field to assign the corresponding loinc_property value to its input field

Clinical Table Search Service: Exercise

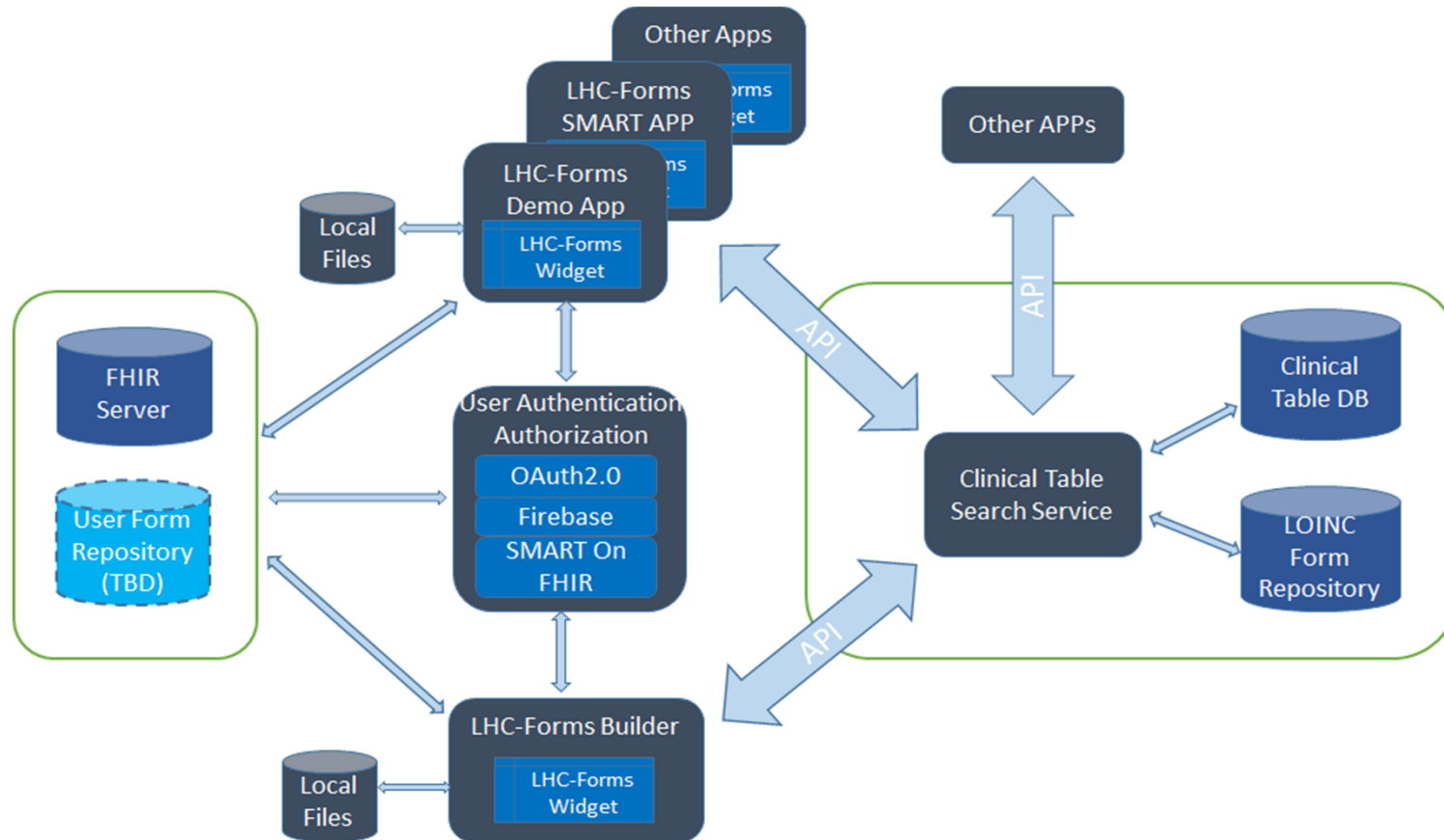
- Answers:

<https://jsfiddle.net/lforms/eutkj3fs/>

LHC-Forms: An Intelligent Form Widget

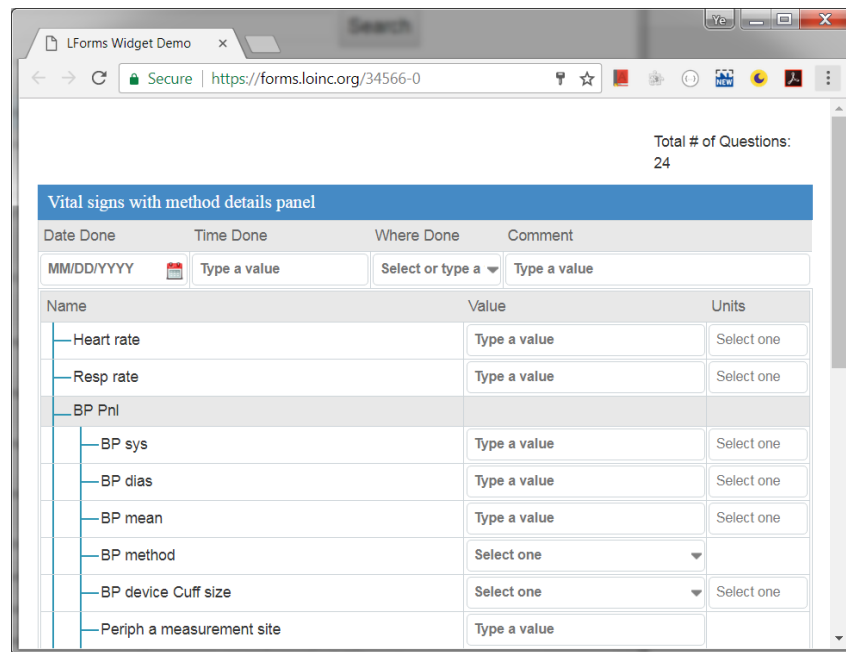
- A widget developed in JavaScript for web, mobile and desktop Apps
 - AngularJS
 - NodeJS
 - JSON
- Advanced features
 - Skip Logic
 - Repeats
 - Display control
 - Search field/autocomplete
 - Formula/calculation method
 - Data restrictions/validations
 - Data control
 - Customizable templates
- Data exports
 - HL7 v2
 - FHIR DiagnosticReport
 - FHIR Questionnaire
 - FHIR QuestionnaireResponse

LHC-Forms: System Design



Five sites where LHC-Forms is implemented

Regenstrief LOINC website (1)



The screenshot shows a web browser window with the URL <https://forms.loinc.org/34566-0>. The page title is "LForms Widget Demo". The main content area displays a form titled "Vital signs with method details panel" with a "Total # of Questions: 24". The form includes a table with columns for "Name", "Value", and "Units".

Name	Value	Units
Heart rate	Type a value	Select one
Resp rate	Type a value	Select one
BP Pnl		
BP sys	Type a value	Select one
BP dias	Type a value	Select one
BP mean	Type a value	Select one
BP method	Select one	
BP device Cuff size	Select one	Select one
Periph a measurement site	Type a value	

<https://search.loinc.org>

- Logical Observation Identifiers Names and Codes (LOINC) is a common language (a set of identifiers, names, and codes) for identifying health measurements, observations, and documents.
- Clicking on a link button for LOINC items that are forms or panels yields a LHC form based on that panel
- Login is required.

NIH common data elements (CDE) website (2)

The screenshot shows a web browser window titled "NIH CDE Repository" with the URL "https://cde.nlm.nih.gov/form/public/html/f/ormsRender.html?tinyid...". The page displays a "Patient Safety Event Report - Hospital: Medication or Other Substance - Version 1.2". The form includes fields for "Date Done", "Time Done", "Where Done", and "Comment". Below these is a table with columns "Name", "Value", and "Units". The form contains several questions, such as "Event ID:", "Initial Report Date (HERF Q1):", and "What type of medication/substance was involved?". The "What type of medication/substance was involved?" question has a list of radio button options including Medications, Nutritional products, Medical gases, Radiopharmaceuticals, Drug-drug, drug-food, or adverse drug reaction, Biological products, Expressed human breast milk, Contrast media, Patient food, and Other substance.

- The NIH Common Data Elements (CDE) Repository has been designed to provide access to structured human and machine-readable definitions of data elements.
- Forms at CDE has an option to be displayed by LHC-Forms widget.

<https://cde.nlm.nih.gov>

Presenter: Ye

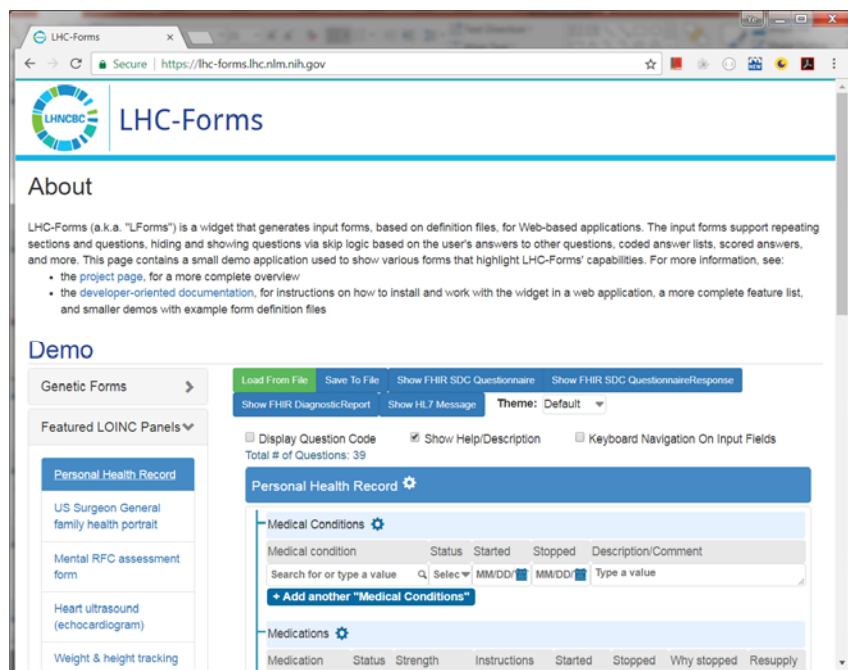
NLM's RxTerms website (3)

The screenshot shows a web browser window titled "RxTerms Demo" with the URL "https://rxterms.nlm.nih.gov". The page header includes the NLM logo and "Unified Medical Language System". The main content area is titled "RxTerms Demo Form" and contains instructions for using the form. Below the instructions is a form with three columns: "Drug Name", "Strength", and "RxCUI". The "Drug Name" column has a search box with "Search for value" and a dropdown menu. The "Strength" column has a "Select one" dropdown. The "RxCUI" column has a "Type a value" text input. There is an "Add another 'Prescription entry'" button below the form. At the bottom, there is a note about the demo using the Clinical Table Search Service web API and the autocomplete-lhc package.

- RxTerms is a drug interface terminology derived from RxNorm (the U.S. terminology standard for clinical drugs) which can be easily used for prescription writing or medication history recording.
- A demo application for searching RxTerms is implemented in LHC-Forms

<https://rxterms.nlm.nih.gov>

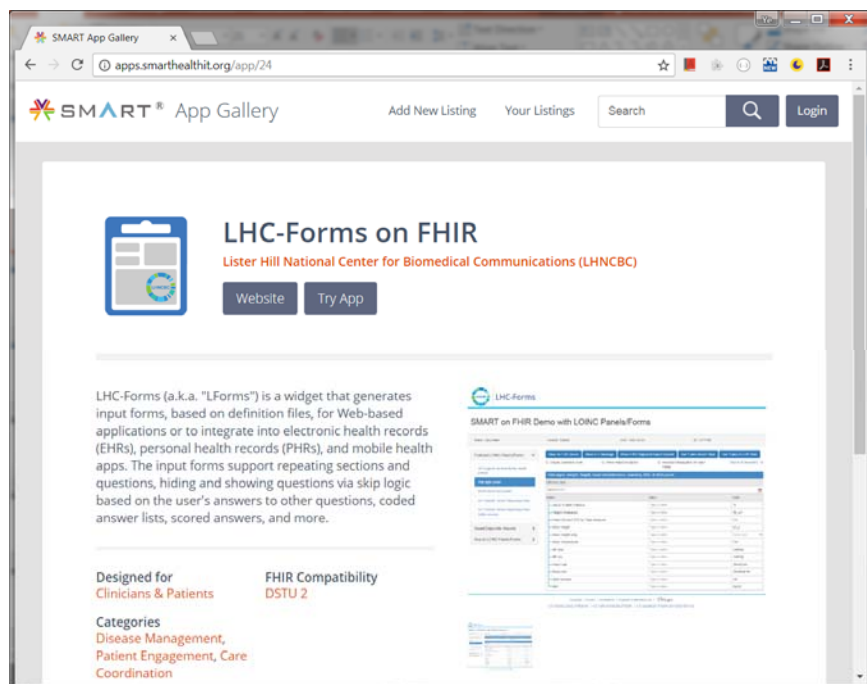
LHC's website (4)



<https://lhc-forms.lhc.nlm.nih.gov>

- A public demo site that contains an application to show various forms that highlight LHC-Forms' capabilities.
- A demo application (/demo-app) utilizes a HAPI FHIR server and Google Firebase service.

SMART on FHIR platform (5)



<http://apps.smarthealthit.org/>

- SMART Health IT is an open, standards based technology platform that enables innovators to create apps that seamlessly and securely run across the healthcare system (<https://smarthealthit.org/an-app-platform-for-healthcare/about/>)
- A registered app utilizes SMART On FHIR platform.

LHC-Forms in operation

- Surgeon General's Family History
- PHQ-9
- Personal Health Record
- Clinical genomics HL7 V2 report
- Large CMS form

LHC-Forms and FHIR

LHC-Forms and FHIR Questionnaire

- Most common features are compatible.
 - Form structure, code, name, data types and etc.
 - Most FHIR Questionnaire resources could be loaded into LHC-Forms widget and displayed as actionable forms
 - LHC-Forms form definition data can be exported as FHIR Questionnaire
 - And User data can be exported as FHIR QuestionnaireResponse
- LHC-Forms has some advanced features
 - Skip logic, Display control and etc. support more functions
 - Formula, Data control and etc. are not available in FHIR Questionnaire yet.
 - Would lead to some extensions in Questionnaire
- There are a list of fields in Questionnaire are not yet supported in LHC-Forms

LHC-Forms Features (1)

Features	LHC-Forms	Questionnaire	SDC Questionnaire
Name	name, question	name, title; text	name, title; text
Code	code, codeSystem; questionCode, questionCodeSystem	code (Coding)	code (Coding)
Copyright	copyrightNotice	copyright	copyright
Section/Item	item.items	item.item	item.item
Question cardinality	questionCardinality	-	questionnaire-minOccurs, questionnaire-maxOccurs
Question repeats	questionCardinality	repeats	repeats
Answer cardinality	answerCardinality	-	-
Answer repeats	answerCardinality	-	-
Answer required	answerCardinality	required	required

LHC-Forms Features (2)

Features	LHC-Forms	Questionnaire	SDC Questionnaire
Answer list	answers	option, options	option, options
Search field/autocomplete	externallyDefined	options	options
Data types	dataType	type	type
Unit list	units	-	questionnaire-unit
Readonly/editable	editable	readOnly	readOnly
Skip logic	skipLogic	enabledWhen	enabledWhen
Coding instructions/helps	codingInstructions, codingInstructionsFormat	-	entryFormat
Calculation method/formula	calculationMethod	-	-
Default/Initial value	defaultAnswer	initial[x]	initial[x]

LHC-Forms Features (3)

Features	LHC-Forms	Questionnaire	SDC Questionnaire
Display control	displayControl	-	questionnaire-itemControl, questionnaire-choiceOrientation
Data control	dataControl	-	-
Restrictions/validations	restrictions (minExclusive, minInclusive, maxExclusive, maxInclusive, length, minLength, maxLength, pattern)	maxLength	maxLength, minLength, regex, minValue, maxValue, maxDecimalPlaces, maxSize,
Display template	template, templateOptions	-	-

LHC-Forms specs:

https://github.com/lhncbc/lforms/blob/master/form_definition.md

Questionnaire Fields not supported in LHC-Forms

- Form Level:

- experimental
- purpose
- lastReviewDate
- useContext
- contact
- publisher
- approvalDate
- effectivePeriod
- jurisdiction

- Item Level:

- definition
- prefix



Data Types

Data Types	QuestionnaireItem Type	LHC-Forms dataType	
Group	group	SECTION	
Display	display	TITLE	
Question	question	(item)	
Boolean	boolean	BL	not fully supported yet
Decimal	decimal	REAL	
Integer	integer	INT	
Date	date	DT	
Date Time	dateTime	DTM	not supported yet
Time	time	TM	
String	string	ST	
Text	text	TX	
Url	url	URL	
Choice	choice	CNE	
Open Choice	open-choice	CWE	
Attachment	attachment	BIN	not supported yet

Additional Data Types in LHC-Forms

Data Types		LHC-Forms dataType	
Numeric Range		NR	
Date - Year		YEAR	
Date - Month		MONTH	
Date - Day		DAY	
Email		EAMIL	
Phone		PHONE	
Ratio		RTO	not supported yet

LHC-Forms Advanced Features

LHC-Forms Advanced Features

- <http://lhncbc.github.io/lforms/demos.html>
 - Repeats
 - Skip Logic
 - Formula/calculationMethod
 - Restriction/validation
 - dataControl
 - displayControl
 - Autocomplete --Search field & Answer list
 - template & templateOptions

LHC-Forms Features: Repeats (1)

The screenshot displays a form with two identical sections, labeled 1.1 and 1.2. Each section is titled 'Your diseases history' and includes a minus sign in a blue square on the right. Section 1.1 has a 'Disease or Condition' dropdown menu with 'Blood Clots' selected and an 'Age at Diagnosis' dropdown menu with '20-29' selected. Section 1.2 has a 'Disease or Condition' dropdown menu with 'Select one' selected and an 'Age at Diagnosis' dropdown menu with 'Select one' selected. Below the second section is a blue button with a plus sign and the text '+ Add another "Your diseases history"'. A vertical line on the left side of the form indicates the repetition of the sections.

- A section or an item could have multiple instances on the form.

LHC-Forms Features: Repeats (2)

```
{  
  questionCardinality: {"min": "1", "max": "*"}  
}
```


LHC-Forms Features: Skip Logic (1)

Source #1 (ALL)	1
Source #2 (ALL)	2
Shown when 'Source #1 (ALL)' == 1 AND Shown when 'Source #2 (ALL)' == 2	Type a number
Source #1 (ANY)	1
Source #2 (ANY)	3
Shown when 'Source #1 (ANY)' == 1 OR Shown when 'Source #2 (ANY)' == 2	Type a number

- A feature that controls if an item or a section is shown on a form based on the current values of other items.
- Support <, >, =, >=, <=
- Support AND, ANY

LHC-Forms Features: Skip Logic (2)

```
// skip logic, with logic ALL
{ "questionCode": "sIALLSource1", "dataType": "INT", "question": "Source #1
(ALL)" },
{ "questionCode": "sIALLSource2", "dataType": "INT", "question": "Source #2
(ALL)" },
{ "questionCode": "sIALLTargetItem", "dataType": "INT", "question": "Shown
when 'Source #1 (ALL)' == 1 AND Shown when 'Source #2 (ALL)' == 2 ",
  "skipLogic": {
    "conditions": [
      {"source": "sIALLSource1", "trigger": {"value": 1}},
      {"source": "sIALLSource2", "trigger": {"value": 2}}],
    "action": "show",
    "logic": "ALL" },
},
```

LHC-Forms Features: Skip Logic (3)

```
// skip logic, with logic ANY
{ "questionCode": "sIANYSource1", "dataType": "INT", "question": "Source #1
(ANY)" },
{ "questionCode": "sIANYSource2", "dataType": "INT", "question": "Source #2
(ANY)" },
{ "questionCode": "sIANYTargetItem", "dataType": "INT", "question": "Shown
when 'Source #1 (ANY)' == 1 OR Shown when 'Source #2 (ANY)' == 2 ",
  "skipLogic": {
    "conditions": [
      {"source": "sIANYSource1", "trigger": {"value": 1}},
      {"source": "sIANYSource2", "trigger": {"value": 2}},
    ],
    "action": "show",
    "logic": "ANY"},
}
```

LHC-Forms Features: Skip Logic (4)

Skip Logic Source (repeating) #2 ?

2

1 A Repeating Section

Skip Logic Source (repeating) #1 ?

3

T2: Shown when 'Skip Logic Source (repeating) #2' == 2

Type a number

T3: Shown when 'Skip Logic Source (repeating) #1' <= 5

T4: Shown when my section header is shown

Type a number

- Decedents are controlled by ancestors or siblings.
- Children cannot control parents.
- If a parent item is shown, all decedents are shown, unless they are controlled by other skip logic rules.

LHC-Forms Features: Skip Logic (5)

```
"items": [  
  { "questionCode": "X-001",  
    "question": "Favorite dessert (try ice cream)",  
    "dataType": "ST" },  
  { "questionCode": "X-002",  
    "question": "Ice cream flavor?",  
    "dataType": "ST",  
    "skipLogic": {  
      "conditions": [  
        { "source": "X-001",  
          "trigger": { "value": "ice cream" }  
        },  
      ],  
      "action": "show"  
    }  
  ]  
}]
```

LHC-Forms Features: Skip Logic (6)

```
{ "questionCode": "X-006",  
  "question": "What is your favorite food? (shown if previous is > 10)",  
  "dataType": "REAL",  
  "skipLogic": {  
    "conditions": [{  
      "source": "X-005",  
      "trigger": {  
        "minExclusive": "10"}  
    }],  
    "action": "show"}  
}
```

LHC-Forms Feature: calculationMethod (1)

Glasgow coma scale (with score rules)

Date Done	Time Done	Where Done	Comment
MM/DD/YYYY	Type a value	Select or type a value	Type a value

Name	Value	Units
GCS eye	1. No eye opening - 1	
GCS motor	2. Extension to pain - 2	
GCS verbal	4. Confused - 4	
GCS total	7	{score}

- Pre-built Functions, such as TOTALSCORE, BMI.
- Calculate value for an item based on other items' values

Present

LHC-Forms Features: calculationMethod (2)

```
{ "questionCode": "9270-0",
  "dataType": "CNE",
  "question": "GCS verbal",
  "answers": [
    {"label": "1", "code": "LA6557-8", "text": "No verbal response (>2 yrs); no vocal response (<=2 yrs)",
"score": 1, "other": null},
    {"label": "2", "code": "LA6558-6", "text": "Incomprehensible sounds", "score": 2, "other": null},
    {"label": "3", "code": "LA6559-4", "text": "Inappropriate words", "score": 3, "other": null},
    {"label": "4", "code": "LA6560-2", "text": "Confused", "score": 4, "other": null},
    {"label": "5", "code": "LA6561-0", "text": "Oriented", "score": 5, "other": null}
  ]
},
{ "questionCode": "9269-2",
  "question": "GCS total",
  "calculationMethod": {
    "name": "TOTALSCORE"
  }
}
```


LHC-Forms Feature: calculationMethod (3)

```
{ "questionCode": "8302-2",  
  "question": "Height",  
  "dataType": "REAL",  
  "units": [  
    {"name": "inches", "default": true}, {"name": "centimeters"}  
  ],  
},  
{ "questionCode": "29463-7",  
  "question": "Weight",  
  "dataType": "REAL",  
  "units": [  
    {"name": "lbs", "default": true}, {"name": "kgs"}  
  ],  
},  
{ "questionCode": "39156-5",  
  "question": "Body mass index (BMI) [Ratio]",  
  "calculationMethod": {  
    "name": "BMI",  
    "value": ["29463-7", "8302-2"]  
  }  
}
```

LHC-Forms Feature: restrictions/validation (1)

INT with maxInclusive restrictions

- "INT with maxExclusive restrictions" must be a value less than 10.

10

REAL with minInclusive restrictions

- Validation is applied to dataTypes automatically.
- Additional restrictions are available to check numeric values, string size, and patterns.

LHC-Forms Features: restrictions/validation (2)

```
{ "questionCode": "int1",  
  "dataType": "INT",  
  "question": "INT with maxExclusive restrictions",  
  "restrictions": {"maxExclusive": 10}  
}
```

LHC-Forms Features: dataControl (1)

RxTerms Demo

L Prescription entry

Drug Name	Strength	RxCUI
Vitamin K 1 (OraQ	1 mg Cap	1089780

+ Add another "Prescription entry"

- An attribute of an item, such as “answers”, “units”, tool tips, could be reset based on another item’s value.
- It supports a direct copy of the attribute value, new construction of an object or an array.


LHC-Forms Features: dataControl (2)

```
"dataControl": [{  
  "source": {  
    "sourceType": "INTERNAL",  
    "sourceItemCode": "nameAndRoute"  
  },  
  "construction": "ARRAY",  
  "dataFormat": {  
    "code": "value.data.RXCUIS",  
    "text": "value.data.STRENGTHS_AND_FORMS"  
  },  
  "onAttribute": "answers"  
}]
```

LHC-Forms Features: dataControl (3)

```
"dataControl": [{  
  "source": {  
    "sourceType": "INTERNAL",  
    "sourceItemCode": "strengthAndForm"  
  },  
  "construction": "SIMPLE",  
  "dataFormat": "value.code",  
  "onAttribute": "value"  
}]
```


LHC-Forms Features: displayControl (1)

Question #1 

Select one

Question #2 

Answer 1 Answer 2
 Answer 3 Answer 4

Question #3 


Answer 1 Answer 2 Answer 3 Answer 4


Question #4 

Answer 1 Answer 2
 Answer 3 Answer 4


```
"displayControl": {  
  "answerLayout": {  
    "type": "COMBO_BOX"}}  
"displayControl": {  
  "answerLayout": {  
    "type": "RADIO_CHECKBOX",  
    "columns": 2}}  
"displayControl": {  
  "answerLayout": {  
    "type": "RADIO_CHECKBOX",  
    "columns": 4}}  
"displayControl": {  
  "answerLayout": {  
    "type": "RADIO_CHECKBOX",  
    "columns": 2}}
```

LHC-Forms Features: displayControl (2)


1 A repeating group with horizontal layout 

Question #1 


Select one ▼

Question #2 

Select one ▼

Question #3 

Select one ▼

Question #4 

Select one or more ▼

```
"displayControl": {"questionLayout": "vertical"}
```



LHC-Forms Features: displayControl (3)

- A group with matrix layout (non-repeating) ? ⓘ ⚙

	Answer 1	Answer 2	Answer 3	Answer 4
Question #1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Question #2	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Question #3	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Question #4	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

```
"displayControl": {"questionLayout": "matrix"}
```

LHC-Forms Features: displayControl (4)

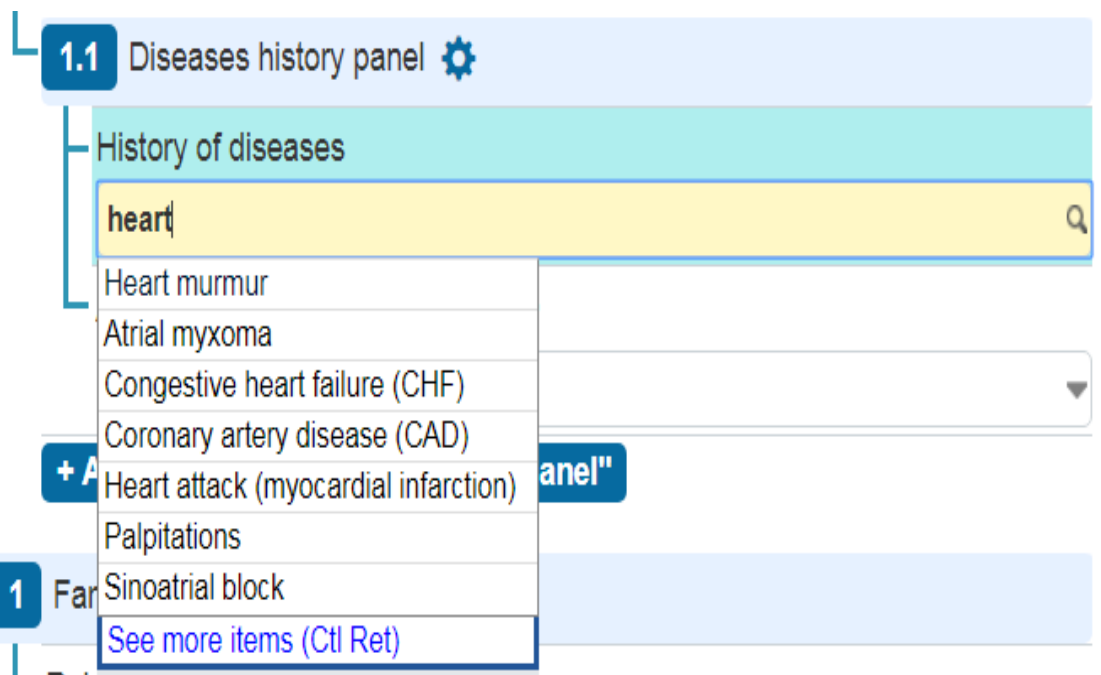
A repeating group with horizontal layout 

Question #1	Question #2	Question #3	Question #4
Select one ▼	Select one ▼	Select one ▼	Select one or more ▼

+ Add another "A repeating group with horizontal layout"

```
"displayControl": {"questionLayout": "horizontal"}
```

LHC-Forms Features: Autocomplete—Search Field (1)

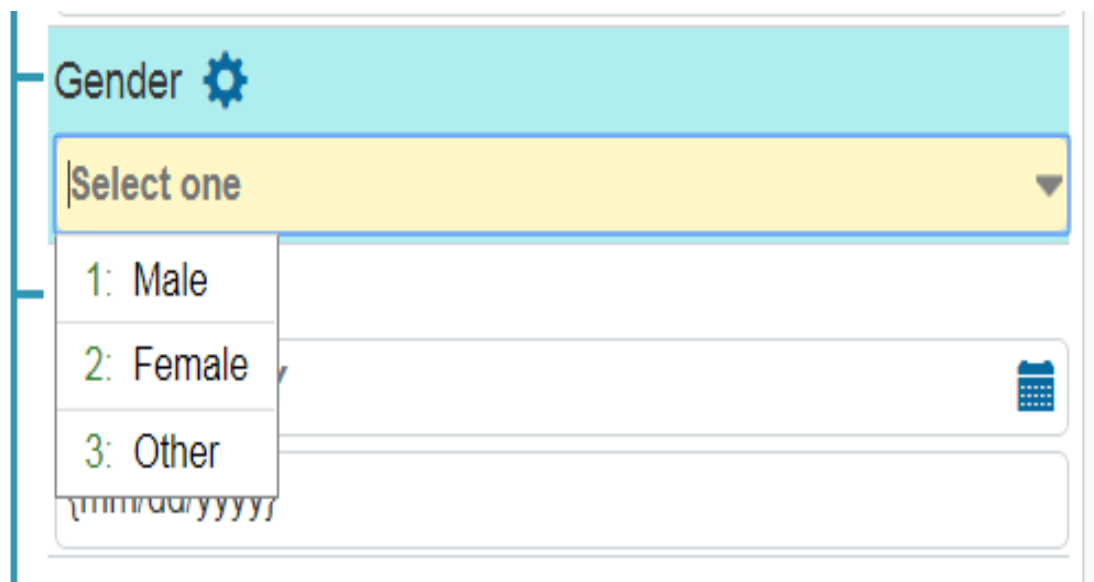


- Uses autocomplete-lhc widget
- Uses LHC CTSS search service

LHC-Forms Features: Autocomplete—Search Field (2)

```
{ "questionCode":"54116-9",  
  "dataType":"CNE",  
  "question":"History of diseases",  
  "externallyDefined": "https://clin-table-search.lhc.nlm.nih.gov/api/conditions/v3/search"  
}
```

LHC-Forms Features: Autocomplete—Answer List (1)



The screenshot shows a form field for "Gender" with a gear icon. Below the field is a dropdown menu with a yellow background and a downward arrow. The dropdown is open, showing three options: "1: Male", "2: Female", and "3: Other". Below the dropdown is a text input field with a calendar icon on the right. The text input field contains the text "11/11/2011".

- Uses autocomplete-lhc widget

LHC-Forms Features: Autocomplete—Answer List (2)

```
{ "questionCode":"54123-5",  
  "dataType":"CNE",  
  "question":"Gender",  
  "answers":[  
    {"label":null,"code":"LA2-8","text":"Male","other":null},  
    {"label":null,"code":"LA3-6","text":"Female","other":null},  
    {"label":null,"code":"LA46-8","text":"Other","other":null}]  
}
```

LHC-Forms Features: template & templateOptions

showQuestionCode
showCodingInstruction
tabOnInputFieldsOnly
hideFormControls
hideUnits
showFormOptionPanel
showFormOptionPanelButton
allowMultipleEmptyRepeatingItems
allowHTMLInInstructions
useAnimation
defaultAnswer
displayControl
viewMode
defaultAnswerLayout
showFormHeader
formHeaderItem

LHC-Forms specs:

https://github.com/lhncbc/lforms/blob/master/form_definition.md

LHC-Forms: Exporting data

- Available functions:
 - LForms.Util.**getUserData**(...) -- returns user data with options to include form definition data.
 - LForms.Util.**getFormData**(...) -- returns the form definition with user data. It has everything needed to redisplay the form in its filled-in state.
 - LForms.Util.**getFHIRData**(...) -- returns FHIR Questionnaire, QuestionnaireResponse or DiagnosticReport resources.
 - LForms.Util.**getHL7Data**(...) -- returns HL7 v2 OBR and OBX segment data.
- Documentation
 - <http://lhncbc.github.io/lforms/index.html#retrieving-user-entered-data>

LHC-Forms: Installation for Development

- Install as a bower package
 - bower is a package manager for web application development (<https://bower.io/>)
 - “bower install lforms”
- Pre-built, ready-use packages on CTSS website (<https://clin-table-search.lhc.nlm.nih.gov/lforms-versions>)
 - Download the package
 - Include the package in webpages directly
 - Documentations: <http://lhncbc.github.io/lforms/>

LHC-Forms: Resources

- LHC-Forms Project website
<https://lhncbc.nlm.nih.gov/project/lhc-forms>
- LHC-Forms public demo application
<https://lhc-forms.lhc.nlm.nih.gov/>
- Github pages
<https://github.com/lhncbc/lforms>
<http://lhncbc.github.io/lforms/>

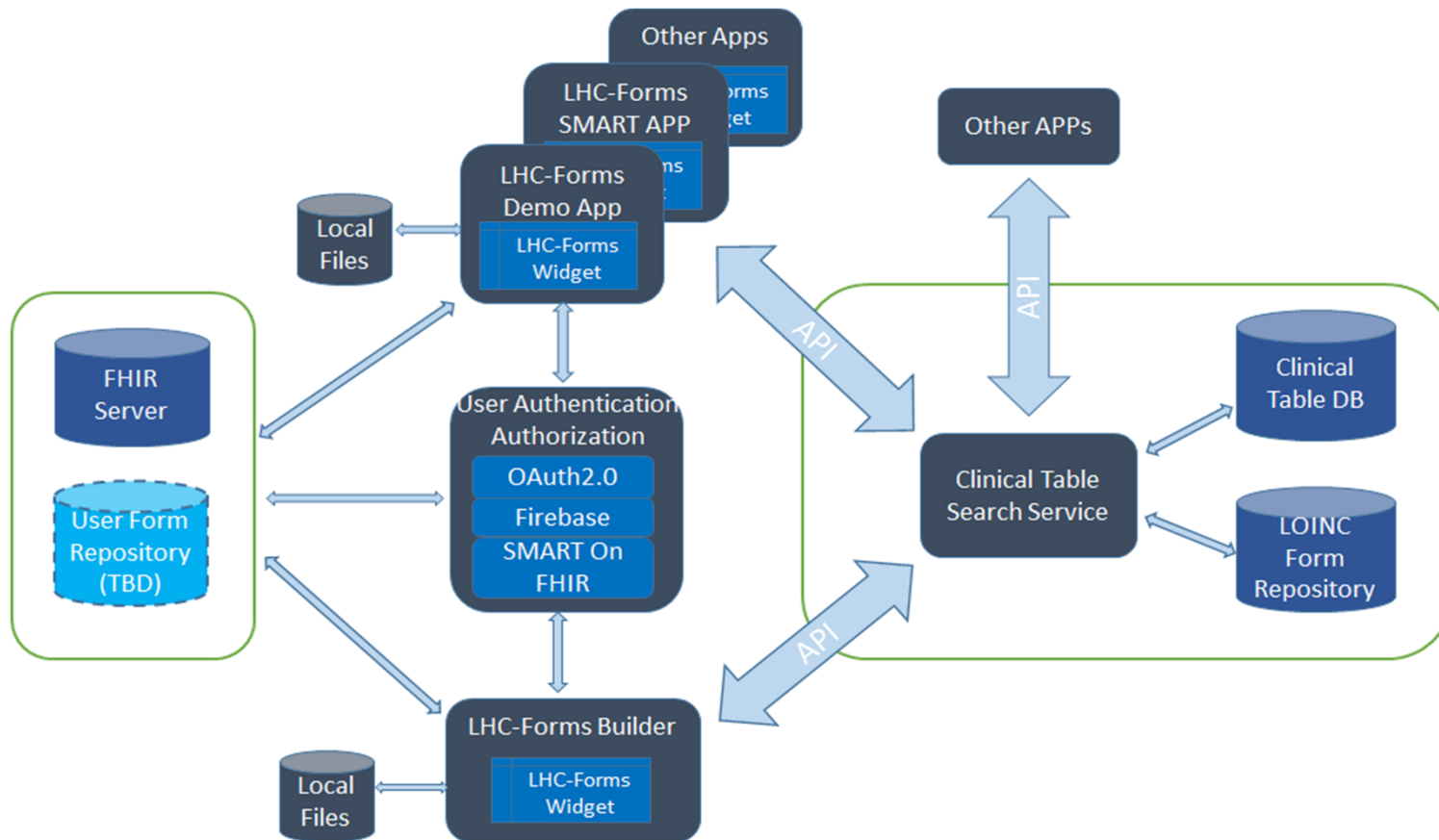
LHC-Forms: Exercise (1)

- LHC-Forms feature demo on Github
 - <http://lhncbc.github.io/lforms/demos.html>
- LHC-Forms demo website
 - <https://lhc-forms.lhc.nlm.nih.gov/>
- LHC-Forms on FHIR SMART app
 - <https://apps.smarthealthit.org/app/24>

LHC-Forms: Exercise (2)

- A demo application with Form builder and Demo app:
 - LHC-Forms form builder, to create/edit forms
 - LHC-Forms demo-app, to use those forms for user input data
 - Forms are stored as FHIR Questionnaire in a HAPI FHIR server
 - User data are stored as FHIR QuestionnaireResponse in the same HAPI FHIR server
 - User authentication/authorization is handled by Google firebase
- LHC-Forms Form Builder
 - <https://lhc-formbuilder.lhc.nlm.nih.gov/>
 - requires login: lforms/demo
- LHC-Forms FHIR Demo App
 - <https://lhc-forms.lhc.nlm.nih.gov/demo-app>

LHC-Forms: System Design



LHC-Forms Builder

Presenter: Ajay

LHC-Forms Builder: Demo

- Website: <https://lforms-formbuilder.nlm.nih.gov/>
- Builds forms for the LHC-Forms render, and can import or export
- Can import or export FHIR Questionnaires
- Currently behind a password, but we hope to remove that soon
- Can start with one or more existing LOINC panels, and add to or edit it.
- Can start from scratch, and import LOINC questions (with their answer lists) to make new panels

LHC-Forms Builder: Demo

LHCNBC | Form Builder for LHC-Forms/FHIR questionnaire

Export | Import

FormName
Family Health History

ADD NEW OR IMPORT FROM LOINC

BUILD BASIC PROPERTIES | BUILD ADVANCED PROPERTIES | PREVIEW

- Initially, it starts out empty
- Click here to get started
- ...or here to resume from a saved form



Form Builder for LHC-Forms/FHIR Questionnaire

SIGN IN

Export Import

Form Name: **NewLForm**

ADD NEW OR IMPORT FROM LOINC

- 1 US Surgeon Genera...
 - 1.1 My health history
 - 1.1.1 Name
 - 1.1.2 Gender
 - 1.1.3 Birth date
 - 1.1.4 Twin
 - 1.1.5 Adopted
 - 1.1.6 Parents related
 - 1.1.7 Body height
 - 1.1.8 Weight
 - 1.1.9 Race
 - 1.1.10 Ethnicity
 - 1.1.11 Diseases history ...
 - 1.1.11.1 History of diseases
 - 1.1.11.2 Age range at onse...
 - 1.2 Family member hea...
 - 1.2.1 Relationship to n

BUILD BASIC PROPERTIES BUILD ADVANCED PROPERTIES

1 US Surgeon General family health portrait [54127-6]

Name	Value
Text* ?	US Surgeon General family health portrait
Coding system ?	<input checked="" type="radio"/> LOINC <input type="radio"/> Custom
Code* ?	54127-6
Local code ?	Type a value
Question instructions [1] ?	Type a value
Repeat this item? [1] ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Section ?	<input checked="" type="radio"/> Yes <input type="radio"/> No

PREVIEW WIDGET LHC-FORMS OUTPUT FHIR

NewLForm

US Surgeon General family health portrait

- My health history
 - Name: Type a value
 - Gender: Select one
 - Birth date: Type a number {mm/dd/yyyy}
 - Twin: Select one
 - Adopted: Select one
 - Parents related: Select one
 - Body height

- 1. SDC extension to FHIR Questionnaire
- 2. LHC-Forms extension to FHIR Questionnaire

Presenter: Ajay

Form structure pane

Form item editor

Form preview pane



Form Item Editor

Fields without foot notes are defined in Standard FHIR Questionnaire

Fields with * are required

Fields with foot note [1] are SDC extensions to FHIR Questionnaire

Fields with foot note [2] are LHC-Forms extensions to FHIR Questionnaire

BUILD BASIC PROPERTIES
BUILD ADVANCED PROPERTIES

Code* ?	54125-0
Local code ?	Type a value
Question instructions [1] ?	Type a value
Repeat this item? [1] ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Editable ?	<input type="radio"/> Read only <input checked="" type="radio"/> Editable <input type="radio"/> Read only for existing data, otherwise editable
Answer required? ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Type ?	String
Default answer ?	Type a value
Score calculation method [2] ?	<input checked="" type="radio"/> None <input type="radio"/> TOTAL SCORE <input type="radio"/> BMI

1. SDC extension to FHIR Questionnaire
2. LHC-Forms extension to FHIR Questionnaire

LHC-Forms Builder: Demo

The screenshot shows the LHC-Forms Builder interface. At the top, there are tabs for 'Export' and 'Import'. Below that, the form name is 'Family Health History'. A blue button labeled 'ADD NEW OR IMPORT FROM LOINC' is highlighted with a red arrow. A red text box above the button says 'Clicking here brings up new item dialog'. To the right, a dialog box titled 'Add new or import from LOINC' is open. It has two radio buttons: 'New item' (unselected) and 'Import from LOINC' (selected). Below this is a section titled 'Select type' with two radio buttons: 'Panel' (selected) and 'Question' (unselected). At the bottom of the dialog, there is a search bar, an 'Import' button, and a 'CANCEL' button. A red arrow points from the 'Panel' option in the dialog to a text box on the left.

Clicking here brings up new item dialog

Two kinds of items: panels & questions

- Panels contain questions and other panels

LHC-Forms Builder: Demo

Add new or import from LOINC

New item Import from LOINC

Select type

Panel
 Question

surge|

54127-6 - US Surgeon General family health portrait
75621-3 - TNM pathologic staging after surgery panel

2 of 2 total; 145 bytes in 17 ms

Autocompleting to bring in a LOINC panel 

LHC-Forms Builder: Demo

The form structure pane allows for drag & drop rearranging of items, including making one item a child of another.



Family Health History

ADD NEW OR IMPORT FROM LOINC

- 1 US Surgeon Genera...
 - 1.1 My health history
 - 1.1.1 Name
 - 1.1.2 Gender
 - 1.1.3 Birth Date
 - 1.1.4 Twin
 - 1.1.5 Adopted
 - 1.1.7 Body height
 - 1.1.6 Parents related
 - 1.1.8 Weight
 - 1.1.9 Race
 - 1.1.10 Ethnicity
 - 1.1.11 Diseases history ...
 - 1.1.11.1 History of diseases
 - 1.1.11.2 Age range at onse...
 - 1.2 Family member hea...
 - 1.2.1 Relationship to p...
 - 1.2.2 Name
 - 1.2.3 Gender
 - 1.2.4 Live...

LHC-Forms Builder: Demo

The screenshot displays the LHC-Forms Builder interface. On the left, a tree view shows the structure of a form titled "Family Health History". The tree includes a main section "1 US Surgeon General..." and a sub-section "1.1 My health history". Under "1.1 My health history", there are ten items: "1.1.1 Name", "1.1.2 Gender", "1.1.3 Birth Date", "1.1.4 Twin", "1.1.5 Adopted", "1.1.6 Body height", "1.1.7 Parents related", "1.1.8 Weight", "1.1.9 Race", and "1.1.10 Ethnicity". Below these is "1.1.11 Diseases history ..." which has two sub-items: "1.1.11.1 History of diseases" and "1.1.11.2 Age range at onset...". At the bottom of the tree is "1.2 Family member hea..." with a sub-item "1.2.1 Relationship to p...". A red arrow points from the "1.1.1 Name" item in the tree to a context menu that is open over it. The context menu contains the following options: "Insert an item **before**...", "Insert an item **after**...", "Insert a **child** item...", "Move this **before**...", "Move this item **after**...", "Make this a **child** of...", and "Remove this item". In the background, a "BUILD BASIC PROPERTIES" dialog box is visible for the "1.1.1 Name" item, showing a "Name" field with the value "1.1.1 Name [Modified_541]".

Each item also has a context menu:

- Allows movement of items without drag and drop (for accessibility)
- Allows creation or import of new questions and panels next to that item
- Allows deletion of item
 - ... currently without any pesky warnings to get in your way

LHC-Forms Builder: Demo – Item Properties

The item editing pane (the middle section) is divided into “basic” and “advanced” properties, to reduce the complexity for simple use case.

- Both sections and questions can repeat

- For sections, question options are hidden

BUILD BASIC PROPERTIES BUILD ADVANCED PROPERTIES

1.1.11 Diseases history panel [54137-5]

Name	Value
Text* ?	Diseases history panel
Coding system ?	<input checked="" type="radio"/> LOINC <input type="radio"/> Custom
Code* ?	54137-5
Local code ?	Type a value
Question instructions [1] ?	Type a value
Repeat this item? [1] ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Section ?	<input checked="" type="radio"/> Yes <input type="radio"/> No

1. SDC extension to FHIR Questionnaire
2. LHC-Forms extension to FHIR Questionnaire

LHC-Forms Builder: Demo – Item Properties

Advanced properties for a section item:

- The complexities of the first three options are hidden until you select “Yes”.

BUILD BASIC PROPERTIES
BUILD ADVANCED PROPERTIES

Advanced

Name	Value
Add restrictions ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Add conditional show logic? ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Create data from other items? ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
[2] ?	
Copyright Notice ?	<input type="text" value="Type a value"/>

1. SDC extension to FHIR Questionnaire
 2. LHC-Forms extension to FHIR Questionnaire

LHC-Forms Builder: Demo – Item Properties

“Conditional show logic” (i.e. skip logic) allows set conditions under which the section or question will be shown.

- Multiple conditions can be used
- Select another question whose value triggers the showing of this item
- Specify the value or range that is required to show this item.

Advanced

Name	Value
Add conditional show logic? ?	<input checked="" type="radio"/> Yes <input type="radio"/> No
Criteria to show this item ?	
Show this item when ?	<input checked="" type="radio"/> Any condition is true <input type="radio"/> All conditions are true
1.1 Condition ?	
Select Source Field ?	1.1.8. Weight
1.1.1 Numerical range ?	
Select conditional operator ?	<input checked="" type="radio"/> > <input type="radio"/> >= <input type="radio"/> < <input type="radio"/> <= <input type="radio"/> =
Value for the condition ?	1000
+ Add another "Numerical range"	
+ Add another "Condition"	

LHC-Forms Builder: Demo – Item properties

For items that are questions rather than sections, more options open up.

The screenshot displays the LHC-Forms Builder interface. On the left, a tree view shows the form structure under 'NewLForm'. The selected item is '1.1.4 Twin'. The main panel shows the 'BUILD BASIC PROPERTIES' tab for this item. The properties are as follows:

Name	Value
Text*	Twin
Coding system	<input checked="" type="radio"/> LOINC <input type="radio"/> Custom
Code*	54132-6
Local code	Type a value
Question instructions [1]	Type a value
Repeat this item? [1]	<input type="radio"/> Yes <input checked="" type="radio"/> No
Section	<input type="radio"/> Yes <input checked="" type="radio"/> No
Editable	<input type="radio"/> Read only <input checked="" type="radio"/> Editable <input type="radio"/> Read only for existing data, otherwise editable
Answer required?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Type	List with no exceptions (CNE)

“Section” is set to “No”
• Implies question

LHC-Forms Builder: Demo – Item properties

Options for questions allow control of:

- Whether an question's value is read-only
- Whether the answer is required
- Can select the data type for a question, which restricts the allowed input.
- Lists Can either allow free text or not (CWE vs CNE)
- List answers:
 - Can have “labels” (e.g. “a”, “b”) which appear with the answer text
 - Can have an “other” option which allows entry of a separate free text answer
 - Can have “scores” which are summed

The screenshot shows the 'BUILD BASIC PROPERTIES' tab of the LHC-Forms Builder. The 'Type' dropdown is set to 'List with no exceptions (CNE)'. A red arrow points from the text 'List answers:' in the list to this dropdown menu.

Property	Value
Section	<input type="radio"/> Yes <input checked="" type="radio"/> No
Editable	<input type="radio"/> Read only <input checked="" type="radio"/> Editable <input type="radio"/> Read only for existing data, otherwise editable
Answer required?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Type	List with no exceptions (CNE)
1 Answer item	1: Boolean (Yes/No) [-]
Answer text	2: Clock time
Answer code	3: Date
Answer label	4: Date time
Score	5: Decimal
Specify with free text	6: Email
2 Answer item	7: Integer
Answer text	8: List with no exceptions (CNE) [-]
Answer code	9: List with exception (CWE)
Answer label	10: Phone
Score	11: Ratio
	12: String
	13: URL
	14: Year

LHC-Forms Builder: Demo – Item properties

More on lists:

- Can allow multiple answers
- Can have a default answer
- Can be accessed via a URL which supports autocompletion (in autocomplete-lhc format).

The “Score calculation method” shown here is actually for numeric fields, but sums the scores associated with entered answers to list questions.

The screenshot displays a configuration panel for an 'Answer item'. The panel includes the following fields and options:

- Answer text**: No
- Answer code**: LA32-8
- Answer label**: Type a value
- Score**: Type a number
- Specify with free text**: Yes No
- + Add another "Answer item"** (button)
- Allow multiple answers? [2]**: Yes No
- Default answer**: Type a value
- URL for externally defined answer list**: Type a value
- Score calculation method [2]**: None TOTAL SCORE BMI

LHC-Forms Builder: Demo – Item Properties

Under “Advanced”, there are two new properties which apply to questions.

“Restrictions” allows you to restrict permitted input for the question.

- Minimum/maximum
- Number of characters
- Pattern matching
- Multiple restrictions can be added

The screenshot shows the 'Advanced' properties panel in the LHC-Forms Builder. The 'Restrictions' section is highlighted with a red arrow. A dropdown menu is open, showing options: 1: >, 2: >=, 3: <, 4: <=, 5: Length, 6: Minimum length, 7: Maximum length, 8: Pattern. The 'Add restrictions' checkbox is checked.

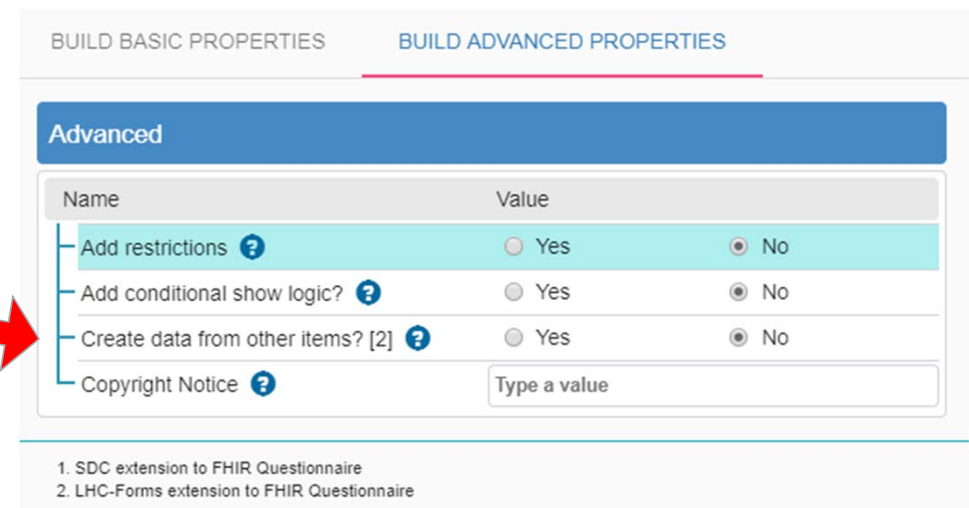
Name	Value
Add restrictions ?	<input checked="" type="radio"/> Yes <input type="radio"/> No
1.1 Restriction ?	
Type ?	Select one
Value ?	
+ Add another "Restriction"	
Add conditional show logic? ?	<input type="radio"/> No <input checked="" type="radio"/> No
Create data from other items? [2] ?	<input checked="" type="radio"/> No <input type="radio"/> No
Copyright Notice ?	

1. SDC extension to FHIR Questionnaire
2. LHC-Forms extension to FHIR Questionnaire

LHC-Forms Builder: Demo – Item Properties

Under “Advanced”, there are two new properties which apply to questions.

“Create data from other items” is the data control feature we discussed which allows one field to control another field’s content. The user interface here is not quite right yet, but we hope to fix that soon.



The screenshot shows the 'Advanced' properties tab in the LHC-Forms Builder. It contains a table with the following properties:

Name	Value
Add restrictions ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Add conditional show logic? ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Create data from other items? [2] ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Copyright Notice ?	<input type="text" value="Type a value"/>

Below the table, there are two footnotes:

1. SDC extension to FHIR Questionnaire
2. LHC-Forms extension to FHIR Questionnaire

LHC-Forms Builder: Demo – Item properties

- All items (sections and panels) are required to have a code.
- Imported LOINC questions or panels start out having LOINC codes.
- When a LOINC item is changed, its code and its parent sections' codes are changed to make it clear that the item is no longer the standard coded item from LOINC.

1.1.11 Diseases history panel [Modified_54137-5]

Name	Value
Text* ?	Diseases history panel
Coding system ?	<input type="radio"/> LOINC <input checked="" type="radio"/> Custom
Code* ?	Modified_54137-5
Local code ?	Type a value
Question instructions [1] ?	Type a value
Repeat this item? [1] ?	<input type="radio"/> Yes <input checked="" type="radio"/> No
Section ?	<input checked="" type="radio"/> Yes <input type="radio"/> No

1. SDC extension to FHIR Questionnaire
2. LHC-Forms extension to FHIR Questionnaire



Form Builder for LHC-Forms/FHIR Questionnaire

SIGN IN

Export Import

Form Name: **NewLForm**

ADD NEW OR IMPORT FROM LOINC

- 1 US Surgeon Genera...
- 1.1 My health history
 - 1.1.1 Name
 - 1.1.2 Gender
 - 1.1.3 Birth date
 - 1.1.4 Twin
 - 1.1.5 Adopted
 - 1.1.6 Parents related
 - 1.1.7 Body height
 - 1.1.8 Weight
 - 1.1.9 Race
 - 1.1.10 Ethnicity
 - 1.1.11 Diseases history ...
 - 1.1.11.1 History of diseases
 - 1.1.11.2 Age range at onse...
- 1.2 Family member hea...
 - 1.2.1 Relationship to p

BUILD BASIC PROPERTIES BUILD ADVANCED PROPERTIES

1 US Surgeon General family health portrait [Modified_54127-6]

Name	Value
Text*	US Surgeon General family health portrait
Coding system	<input type="radio"/> LOINC <input checked="" type="radio"/> Custom
Code*	Modified_54127-6
Local code	Type a value
Question instructions [1]	Type a value
Repeat this item? [1]	<input type="radio"/> Yes <input checked="" type="radio"/> No
Section	<input checked="" type="radio"/> Yes <input type="radio"/> No

1. SDC extension to FHIR Questionnaire
2. LHC-Forms extension to FHIR Questionnaire

PREVIEW WIDGET LHC-FORMS OUTPUT FHIR OUTPUT

NewLForm

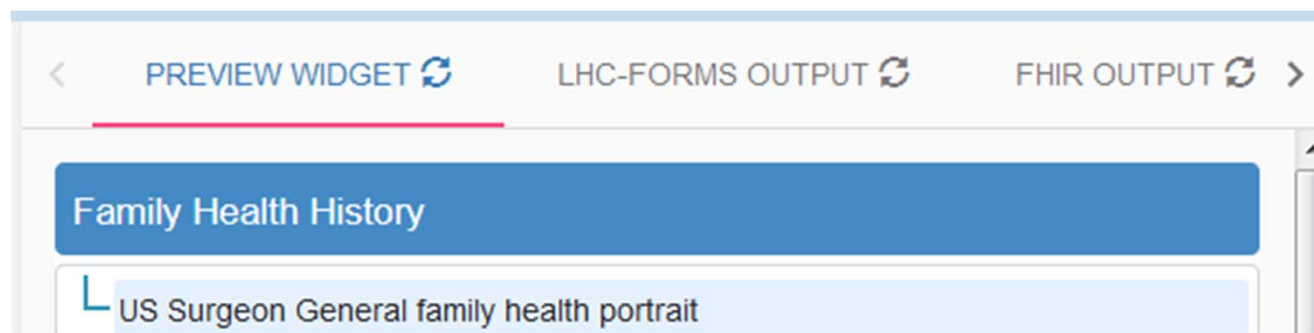
- US Surgeon General family health portrait
 - My health history
 - Name: Type a value
 - Gender: Select one
 - Birth date: Type a number {mm/dd/yyyy}
 - Twin: Select one
 - Adopted: Select one
 - Parents related: Select one
 - Body height

Form preview pane

Presenter: Ajay

LHC-Forms Builder: Demo – Preview Pane

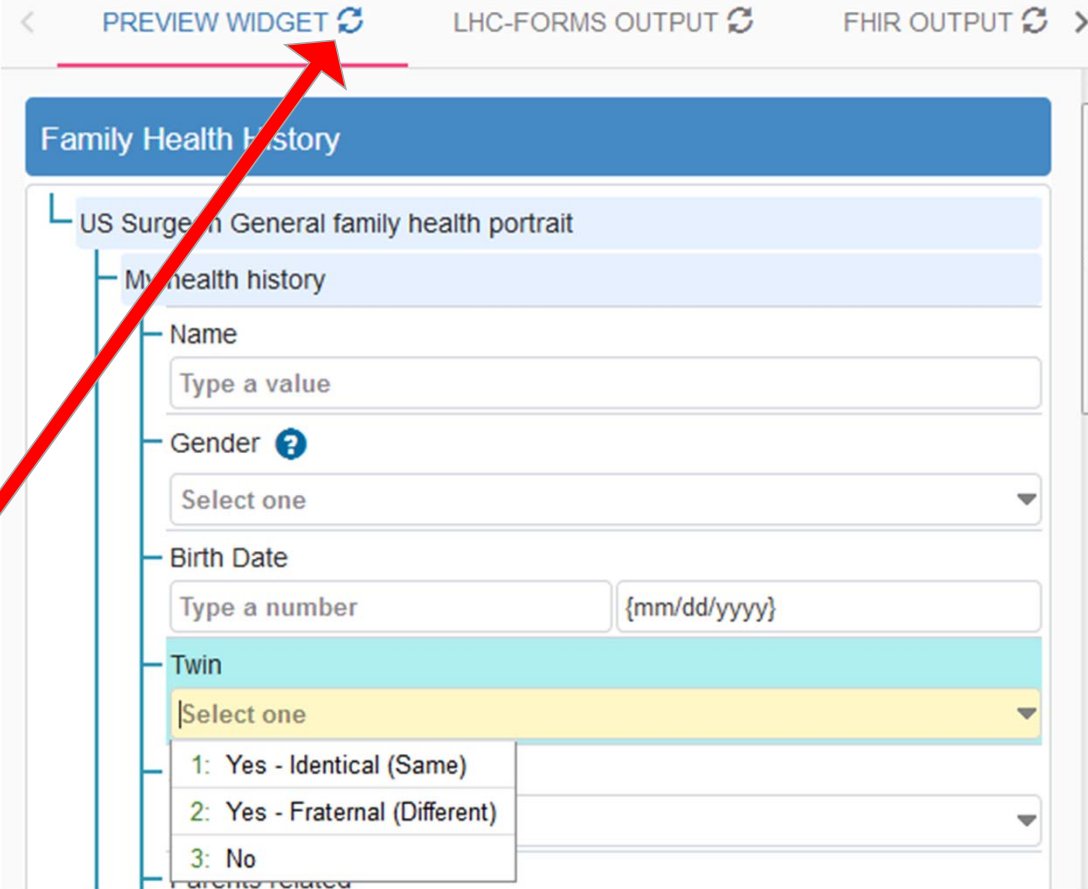
The preview pane has three tabs at top that control which type of preview is shown.



LHC-Forms Builder: Demo – Preview Pane

The “Preview Widget” tab shows a working preview of the form using the LHC-Forms rendering widget.

It does not update in response to every key stroke, so sometimes you might need to use the refresh button to see the latest changes you have made.



The screenshot displays the 'Preview Widget' tab of the LHC-Forms Builder. The form is titled 'Family Health History' and is a 'US Surgeon General family health portrait'. The form fields include:

- Name: Type a value
- Gender: Select one (with a help icon)
- Birth Date: Type a number (with a date format placeholder {mm/dd/yyyy})
- Twin: Select one (with a dropdown menu showing options: 1: Yes - Identical (Same), 2: Yes - Fraternal (Different), 3: No)

A red arrow points from the text 'to use the refresh button' to the refresh icon (a circular arrow) next to the 'PREVIEW WIDGET' tab label.

LHC-Forms Builder: Demo – Preview Pane



The screenshot shows a web interface with two tabs: "PREVIEW WIDGET" and "LHC-FORMS OUTPUT". The "LHC-FORMS OUTPUT" tab is active and displays a JSON definition for a form widget. The JSON includes details for two questions: "US Surgeon General family health portrait" and "My health history".

```
{
  "type": "LOINC",
  "code": null,
  "name": "Family Health History",
  "items": [
    {
      "question": "US Surgeon General family health portrait",
      "questionCodeSystem": "Custom",
      "questionCode": "Modified_54127-6",
      "questionCardinality": {
        "min": "1",
        "max": "1"
      },
      "header": true,
      "editable": "1",
      "answerCardinality": {
        "min": "0",
        "max": "1"
      },
      "dataType": "ST",
      "items": [
        {
          "question": "My health history",
          "questionCodeSystem": "Custom",
          "questionCode": "Modified_54126-8",
          "questionCardinality": {
            "min": "1",
            "max": "1"
          }
        }
      ]
    }
  ]
}
```

The “LHC-Forms Output” tab shows preview of the JSON LHC-Forms definition.

LHC-Forms Builder: Demo – Preview Pane

```
< DGET ↻ LHC-FORMS OUTPUT ↻ FHIR OUTPUT ↻
{
  "resourceType": "Questionnaire",
  "status": "draft",
  "date": "2017-09-12T18:47:19-04:00",
  "version": "2.56",
  "meta": {
    "profile": [
      "http://hl7.org/fhir/us/sdc/StructureDefinition/sdc-questionna
    ]
  },
  "title": "Family Health History",
  "name": "Family Health History",
  "identifier": [
    {
      "system": "http://loinc.org",
      "value": null
    }
  ],
  "code": [
    {
      "system": "http://loinc.org",
      "code": null,
      "display": "Family Health History"
    }
  ],
  "subjectType": [
    "Patient",
    "Person"
  ],
}
```

The “FHIR Output” tab shows preview of the JSON FHIR Questionnaire definition.

LHC-Forms Builder: Demo – Saving & Loading

At the top of the form are buttons that open menus for savings (Export) and loading (Import).



- Each menu gives two options:
 - local file
 - FHIR server
- Save to a local file often
 - Currently reloading the page does not warn you that you'll lose any changes!

LHC-Forms Builder: Exercise

- Use the form builder to:
 1. Build a form
 2. Save the definition to a FHIR server as a Questionnaire
- Use the LHC-Forms demo app to:
 1. Load the saved form
 2. Fill it out
 3. Save the response to a FHIR server as a QuestionnaireResponse

Unified Code for Units of Measure (UCUM)

Presenter: Paul

UCUM-LHC: Unit Validation and Conversion

- For “Unified Code for Units of Measure” (UCUM)
- Website: <https://ucum.nlm.nih.gov/ucum-lhc/>
- Library can be downloaded from GitHub or installed with “bower”
- Library supports:
 - Validation of unit expressions
 - Conversion of values between different unit expressions
- Unit codes in UCUM are not always what one would expect, but there are synonyms
- Some special syntax: “.” = multiplication, * = exponentiation

UCUM-LHC: Demo

- Demo of library at <https://lhncbc.github.io/ucum-lhc/demo.html>
- Validation of individual expressions
- Batch validation of expressions in a spreadsheet file
- Conversion from one expression to another

UCUM-LHC: Demo

Units of Measure (UCUM) Validator and Converter
A demonstration site for the LHC UCUM service

LHC UCUM Validator and Converter

Validator **Converter**

UCUM Unit Expression Validation

Validate unit expressions one at a time

Enter or select a unit expression to be validated: Press tab or return to validate the expression

If you are not finding a unit that you think should be there, check the advanced search options to see if you should add a category (or categories) to the search.

[Show advanced search options](#)

[Show entry hints](#)

Validate all unit expressions in a CSV file

We can validate unit expressions in a comma separated values file on your system.

- Use the browse button below to select the file.
- You will then be asked for the name of the column that contains the expressions to be validated. (Your file must include column headers).
- A copy of your file will be created that includes three additional columns at the end, confirming what expression was validated, the validation results, and any relevant notes.
- You will be asked where you want the file saved. You may change the name of the output file at that time.

[Browse...](#) No file selected.

About the LHC UCUM Library

- Here is a [description](#) of the LHC UCUM Software Library.
- The code is available from the [GitHub code repository](#).

- Demo has separate tabs for validating and converting
- Top part of page has section for validating individual UCUM unit expressions.
- Lower part of page has an option for validating a spreadsheet containing UCUM expressions in a column.
 - Results are appended in a new column and the revised spreadsheet is returned.

UCUM-LHC: Demo

Validate unit expressions one at a time

Enter or select a unit expression to be validated: Press tab or return to validate the expression

If you are not finding a unit that you think should be the

[Show advanced search options](#)


m is a valid unit expression.

cs_code	name	guidance
m	meter	unit of length = 1.09361 yards
m2	square meter	unit often used to represent body surface area
m[H2O]	meter of water column	
m[Hg]	meter of mercury column	
mA	milliampere	unit of electric current

- Unit expression components (e.g. “kg” and “m”) autocomplete as you type, to aid in learning UCUM.

UCUM-LHC: Demo

Validate unit expressions one at a time

Enter or select a unit expression to be validated: 
the expression

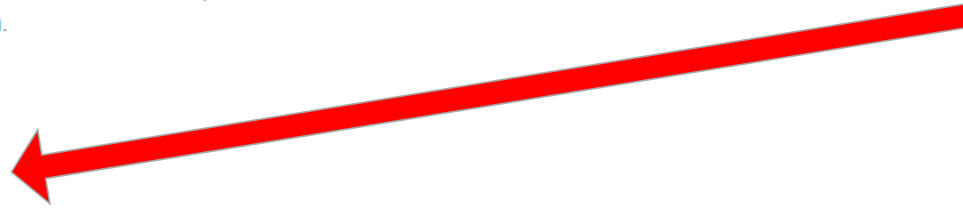
If you are not finding a unit that you think should be there, check the advanced search category (or categories) to the search.

Show advanced search options

kg.m/s is a valid unit expression.

Show entry hints

After expression is entered, hitting tab or return will cause the expression to be checked, and the result will appear below.



UCUM-LHC: Demo

Validate unit expressions one at a time

Enter or select a unit expression to be validated:

the expression

If you are not finding a unit that you think should be there, click the advanced category (or categories) to the search.

Hide advanced search options

Limit search to units in selected categories:

Clinical Use Nonclinical Use Constants Obsolete

Select unit fields to display:

cs_code name guidance category synonyms loinc_property source

- “Advanced tab provides options for:
- Narrowing type of units that appear in the autocompletion list
 - Selecting fields that display in the autocompletion table

UCUM-LHC: Converter Demo

Convert values from one UCUM unit to another

Enter or select a valid UCUM code for the unit you want to convert: UCUM codes are

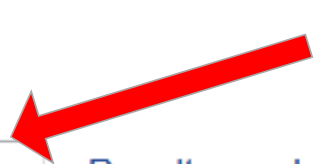
Starting expression



If you are not finding a unit that you think should be there, check the advanced search options to see if you should add a category

Show advanced search options

Magnitude in starting units



Enter the numeric value you want to convert: Result rounded to decimal digits.

Enter or select the unit that you want to convert to: Ending expression



Convert

10 kg.m = 1000000.00 g.cm Result



UCUM-LHC: Code

- Code can be installed as a bower package: `bower install ucum-lhc`
- Can also link to the library on our demo site, or download it:
 - <https://lhncbc.github.io/ucum-lhc/dist/ucum-lhc.min.js>
- Example usage:

```
<script src="https://lhncbc.github.io/ucum-lhc/dist/ucum-lhc.min.js"></script>
<script>
  var utils = ucumPkg.UcumLhcUtils.getInstance();
  var resultObj = utils.validateUnitString('m2/g4');
</script>
```
- Experiment here: <https://jsfiddle.net/lforms/y6kde2xd/>

UCUM Web Service

- For validating and converting without using our JavaScript library
- Programs can send URL requests with units to validate or convert and get a XML, JSON, or plain text responses back.
- <https://ucum.nlm.nih.gov/ucum-service.html>
- These APIs were donated by Jozef Aerts of XML4Pharma
- Examples:
 - [https://ucum.nlm.nih.gov/ucum-service/v1/ucumtransform/1/from/\[in_i\]/to/cm](https://ucum.nlm.nih.gov/ucum-service/v1/ucumtransform/1/from/[in_i]/to/cm)
 - <https://ucum.nlm.nih.gov/ucum-service/v1/isValidUCUM/mm>