

Feeding FHIR with LHC-Forms

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National Library of Medicine, NIH

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What is LHC-forms and what can it do?

LHC-Forms is Powerful https://lhncbc.nlm.nih.gov/project/lforms

- □ A fast, web based open source JavaScript program (300kB) generates live forms on-the-fly using JSON form descriptions.
- Accommodates nested groups and repeating groups of questions (e.g. Surgeon General's Family Health History).
- □ Has all of the usual form functions -- Skip logic, rich validation checks, auto complete menus, score calculation, other calculations
- ☐ Answer lists displayed as columnated grid with autocomplete functions.
- Many different layout styles and responsive design that fits any screen size.
- Some examples follow



LHC-Forms are standards oriented

- □ All LOINC 2000+ LOINC panels *are* LHC forms.
 - Same for most of NLM's Common Data Elements (CDEs) not all LOINC.
 - NIH Common Data Elements (CDE) Repository: https://cde.nlm.nih.gov/home
- Form questions modeled after to HL7 observations with data types, cardinality, units of measure for quantities and answer lists for ordinal variables.
- □ Has external (standard) vocabulary tables (e.g. RxNorm, LOINC, ICD, many genomic standards) with auto-complete service.
- LHC-Forms service (https://lhncbc.nlm.nih.gov/project/lforms) generates HL7
 v2 messages from entered data.
- □ Via SMART, can link to patient resource (now), and deliver captured data to FHIR resource(s). (Stay tuned for today's demo.)

Lots of rich form (questionnaire content) in LOINC

- Most CMS forms (OASIS, MDS, Dialysis) and CMS is organizing all of their assement instruments around LOINC (e.g. CDC birth and death certificates).
- Lots of psychosocial surveys (e.g. PROMIS, Neuro-QOL), Clinical structures, ventilator variables, 12-lead EKG, Pulmonary function tests (Mayo), cardiac echos (DICOM), Nursing instruments (ANA), Lab panels, Ophthalmology measures (NEI), etc.

Associated Tools Services

- Form builder for creating new forms and editing old ones
- Docker for delivering packages.
- JSON Schema for LHC-Forms.
 - Form: https://github.com/lhncbc/lforms-validator/blob/master/lforms-form-schema.json
 - Item: https://github.com/lhncbc/lforms-validator/blob/master/lforms-item-schema.json
- Clinical table linker- provides machinery for questions whose answers come from external tables
 - "Secret sauce": via URL, implementer can specify what fields are searched, which are returned as part of columnated grid, and which are stored in the value field as hidden variables

https://clin-table-search.lhc.nlm.nih.gov/

 Other fields in the form can use these hidden variables as answer lists, default values or help messages -- will demonstrate.

LHC-Forms Demo Screenshots

- Matrix
- Nested and repeating groups
- Score computation
- Auto-complete
- Auto defaults

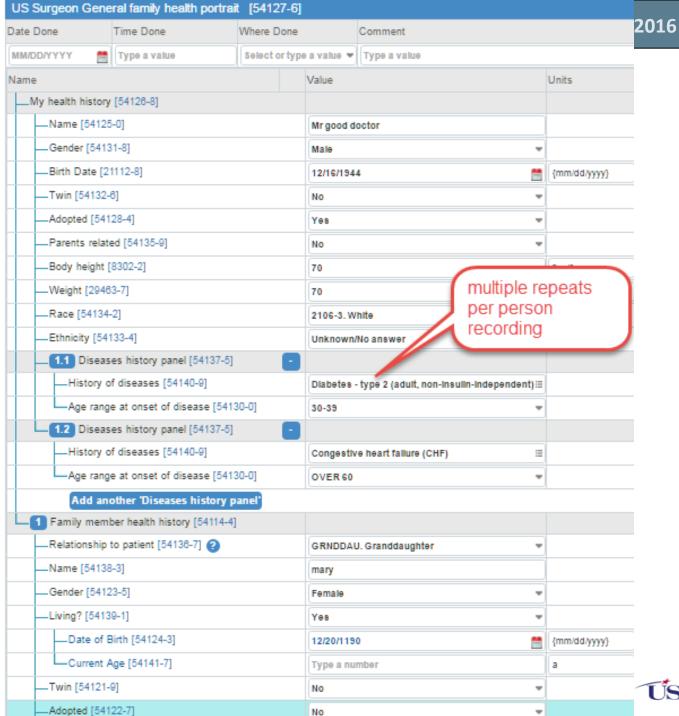


"Matrix" Legend showing PROMIS Social isolation panel

PROMIS item bank - social isolation - version 2.0 ©							
Date Done	Time Done		Where Done		Comment		
MM/DD/YYYY	Type a value		Select or type a value	•	Type a val	ue	
		Never	Rarely	Some	times	Usually	Always
People get the wrong idea about my	situation ©	0	•			•	•
I feel isolated even when I am not al	one ©	0	•			•	•
I feel that people avoid talking to me	©	0	0	(0	0
feel detached from other people ©		0	0			0	0
I feel that some of my friends avoid me ©		0	0			0	0
I feel that some of my family members avoid me ©		0	0			0	0
I feel that I am alone in my interests and ideas ©		0	0			0	0
I feel that people barely know me ©		0	0			0	0
I feel like a stranger to those around me ©		0	0	(0	0
I find that friends or relatives have di	ifficulty talking						
with me about my health							0
©							
I feel that people are around me but not with me ©		0					0
I feel isolated from others ©		0	0			0	0

Nested and Repeating Groups

Surgeon General's family health history as an LHC-Form





Survey Score Computed On-the-Fly (PHQ-4)©

Use "List" Style	Use "Table" Style	Show HL7 Message				
■ Display Question Code ■ Show Help/Description		 Keyboard Navigation On Input Fields 	Total # of Questions: 5			
Patient health qu	estionnaire 4 iter	n ©				
Date Done	Time Done	Where Done	Comment			
MM/DD/YYYY 🏥	MM/DD/YYYY Market Type a value Select or type		a value ▼ Type a value			
Name			Value			
— Feeling nervous, anxious or on edge ©			2. More than half the days	the form		
Over the past 2 weeks have you not been able to stop or control worrying			Not at all	computes the total score as		
Little interest or pleasure in doing things? ©			2. More than half the days	one answers the		
— Feeling down, depressed, or hopeless? ©			2. More than half the days	questions.		
Patient health questionnaire 4 item total score ? ©			6			



Choice menu presented as grid from NCBI's database of Genetic variations panel

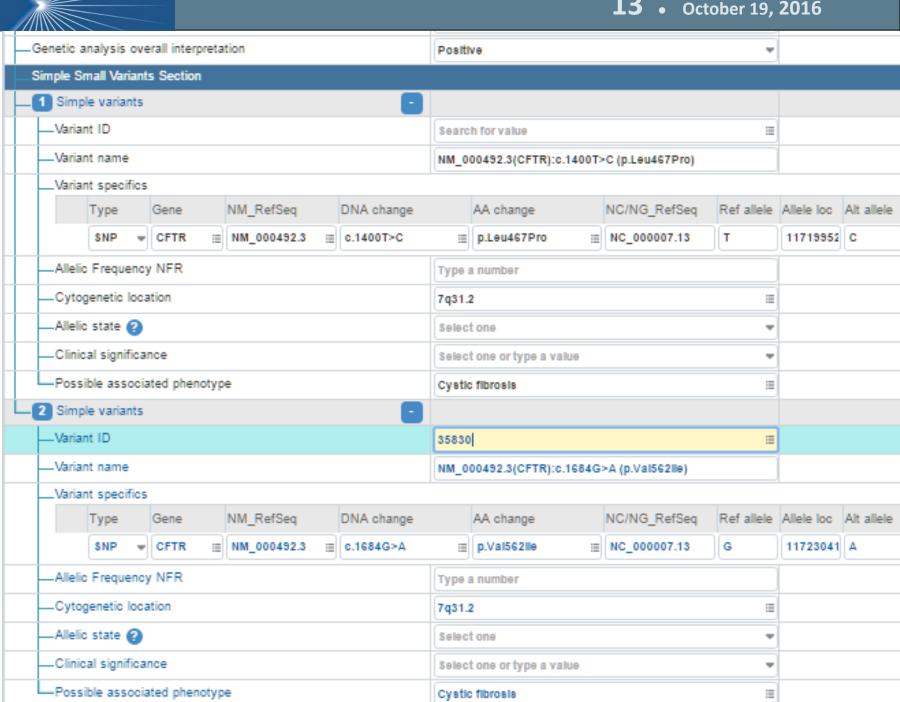
Simple Small Variants Section						
Simple genetic variant panel						
— Simple variant	bre	bre				
Transcript specification	Name	Variant ID	Phenotype			
— Gene studied	NM_015713.4(RRM2B):c.322-2A>G	5387	RRM2B-related mitochondrial disease			
— Transcript RefSeq ID	NM_000059.3(BRCA2):c.5946delT (p.Ser1982Argfs)	9325	Pancreatic cancer 2			
— DNA change c.HGVS	NM_000059.3(BRCA2):c.6275_6276defTT (p.Leu2092Profs)	9318	Breast-ovarian cancer, familial 2			
- Amino acid change p.HGVS	NM_000465.3(BARD1):c.1670G>C (p.Cys557Ser)	8045	Familial cancer of breas			
— DNA change type	NM_007194.3(CHEK2):c.470T>C (p.lle157Thr)	5591	Li-Fraumeni syndrome 2			
BNA change type	NM_007194.3(CHEK2):c.541C>T (p.Arg181Cys)	5597	Familial cancer of breas			
Amino acid change type	NM_015713.4(RRM2B):c.329G>A (p.Arg110His)	5393	RRM2B-related mitochondrial disease			
— Genomic specification	See more items (Ctl Ret)	See more items (Ctl Ret)				
— Genomic reference sequence	7 of 8692 total; 2685 bytes in 14 ms					



Automatic details from hidden fields

HL7 draft genetic test reporting form

Describes an approach being explored in HL7 Clinical Genomics work group



HL7 message generated from completion of genetics form

(only top 2/3ds showing)

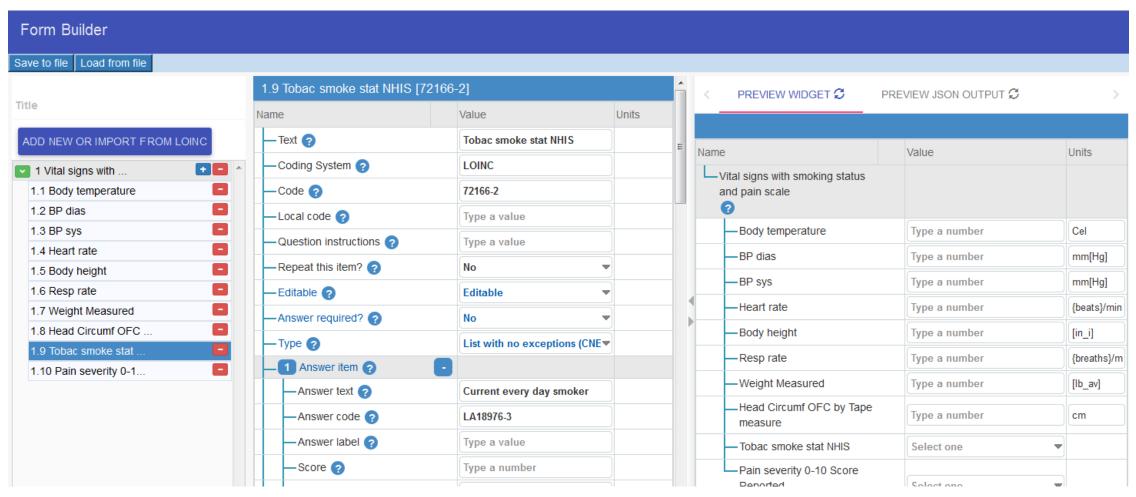
```
OBR[1]X1000-0"HL/ Genetic Test Panel for Variants - 20160322"LN]
OBX|1|CNE|XXXXX-12^Choose kind of mutations targeted^LN|1|C01^Simple variants^LN~C02^Complex
variants^LNI
OBX|2|CNE|XXXXX-10^Choose region of interest specification^LN|1|C01^Specific targeted mutations^LN|
OBX|3|CWE|51967-8^Genetic 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^\ariant ID^LN|1.1|44487^35823^LN|
OBX|2|ST|XXXXX-13^\ariant name^LN|1.1|NM_000492.3(CFTR):c.1400T>C (p.Leu467Pro)|
OBR|3|XXXX1-1^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|
OBXI9|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^\/ariant ID^LN|2.1|44494^35830^LN|
OBX|2|ST|XXXXX-13^\ariant name^LN|2.1|NM 000492.3(CFTR):c.1684G>A (p.\/al562lle)|
OBR|5|XXXX1-1"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.\/al562lle^LN|
```

ORVIGIOTIVVVVV ATANOMIO DI-CO--ALNIO A AINO GOGGOT AGI

Form Builder Demo Screenshots

LHC Form Builder

Editing LOINC: 72513-5 Vital signs with smoking status and pain scale [VSP]

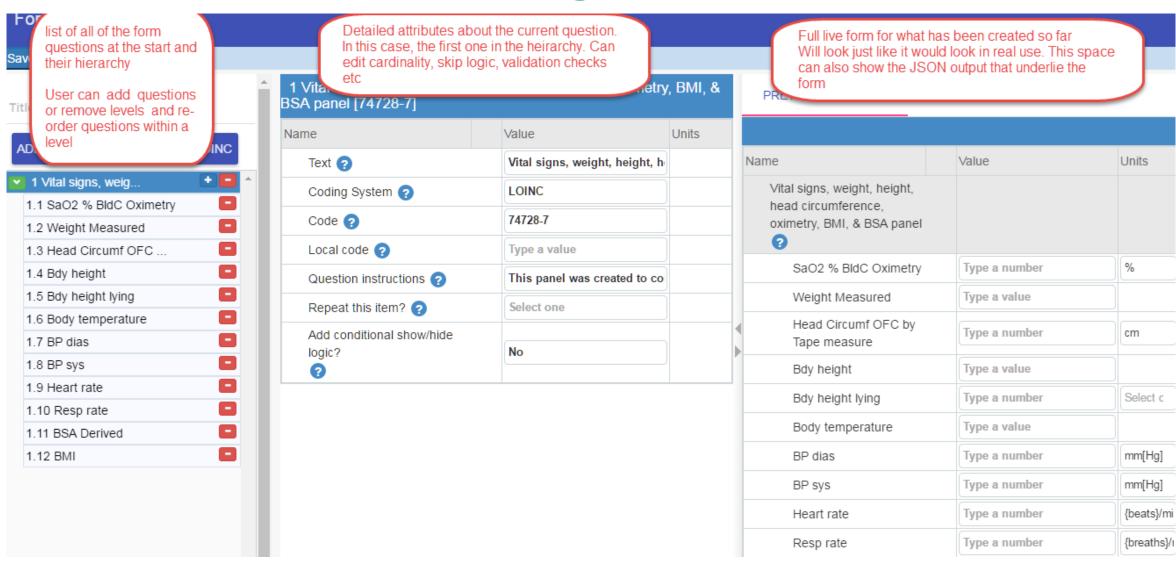








After selecting a starter form



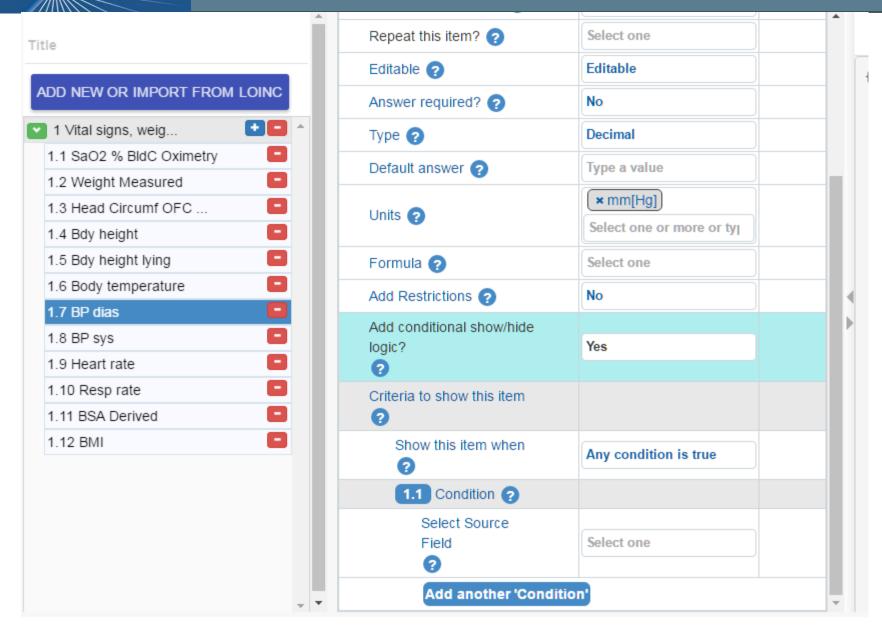








- Clicked on one variable, BP diastolic
- Shows Controls for managing cardinality
- Input required
- Data type
- Default value
- Formula
- Show/Hide rules (Skip logic)









The FHIR connection

What is working

■ Using SMART on FHIR

- Can pull up form service from https://gallery.smarthealthit.org/
 - Very fast -- all with native FHIR resources.
 - Provides an ecosystem for LOINC.

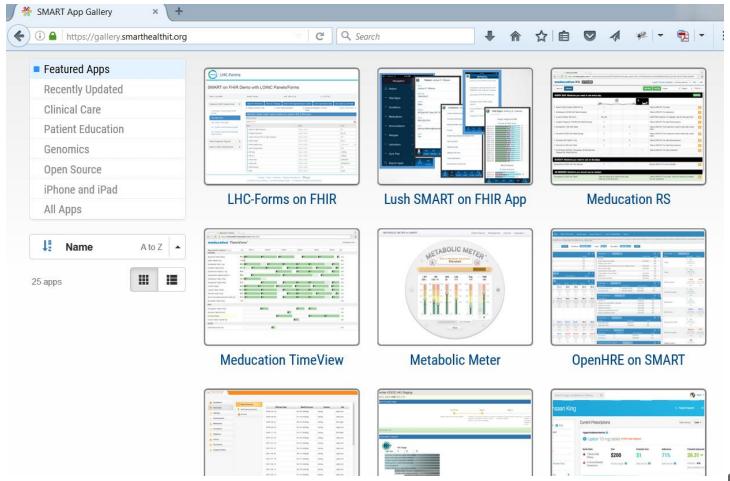
Steps

- Pick a patient from the sample patient registry file.
- Pick a form.
- Enter data.
- Store it in the Diagnostic report resource -- using related observations as needed to implement that hierarchical – and repeating – group structure
- Retrieve it and view it back in the form.
- Inspect V2 message.
- Inspect FHIR message.



LHC-Forms on FHIR

https://gallery.smarthealthit.org/

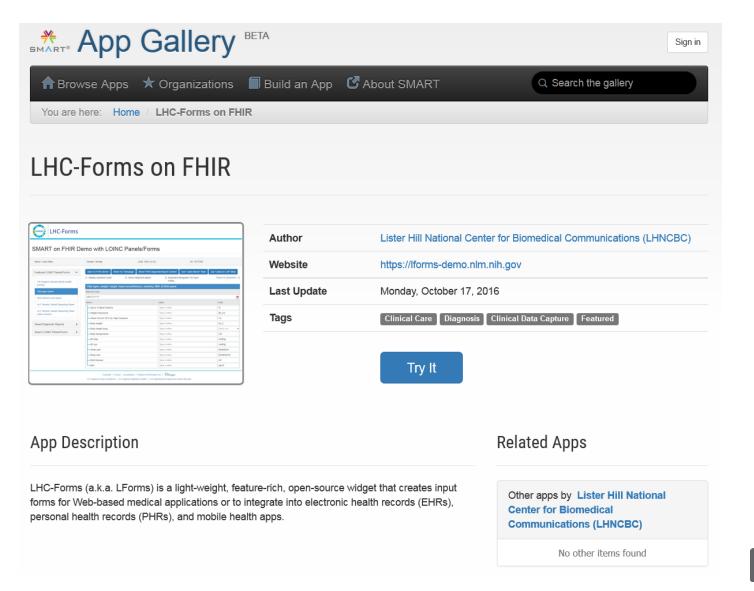






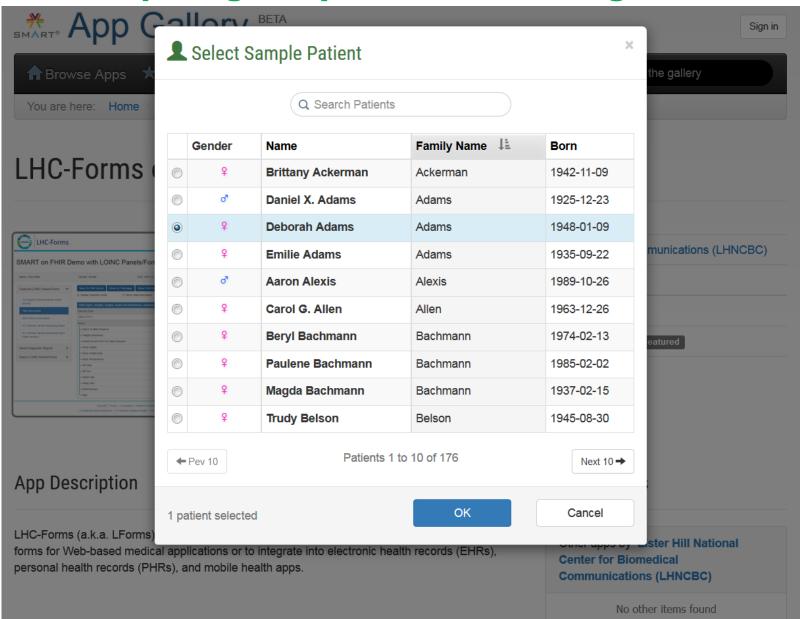


https://gallery.smarthealthit.org/





https://gallery.smarthealthit.org/







SMART on FHIR Demo with LOINC Panels/Forms

DoB: 1948-01-09 ID: hca-pat-18 Name: Deborah Adams Gender: female Featured LOINC Panels/Forms Please select a LOINC Panel/Form from left side. **US Surgeon General family** health portrait Vital signs panel Short blood count panel **HL7** Genetic Variant Reporting Panel **HL7** Genetic Variant Reporting Panel (table version) Saved Diagnostic Reports Search LOINC Panels/Forms







SMART on FHIR Demo with LOINC Panels/Forms

Save To FHIR Server Show HL7 Message Show FHIR DiagnosticReport Content Use "Label Above" Style Use "Label on Left" Show HL7 Message Display Question Code Show Help/Description Keyboard Navigation On Input Total # of Question Code Show Help/Description Fields US Surgeon General family health portrait Use "Label on Left" Show HL7 Message Show FHIR DiagnosticReport Content Use "Label on Left" Show Help/Description Keyboard Navigation On Input Total # of Question Code Show Help/Description Keyboard Navigation On Input Fields US Surgeon General family health portrait Use "Label on Left" Show HL7 Message Show FHIR DiagnosticReport Content Use "Label on Left" Show HL7 Message Show FHIR Diagnostic Reports Display Question Code Show Help/Description Keyboard Navigation On Input Total # of Question Code Show Help/Description Keyboard Navigation On Input Total # of Question Code Show Help/Description Fields US Surgeon General family health portrait Use "Label on Left" Show HL7 Message Show FHIR DiagnosticReport Content Use "Label on Left" Show Help/Description Reporting Panel Use "Label on Left" Show Help/Description Reporting Panel Use "Label on Left" Show Help/Description Reporting Panel Use "Label Above" Skyle Use "Label on Left" Show Help/Description Reporting Panel Use "Label Above" Skyle Use "Label on Left" Show Help/Description Reporting Panel Use "Label Above" Skyle Use "Label on Left" Show Help/Description Reporting Panel Use "Label Above" Skyle Use "Label on Left" Show Help/Description Reporting Panel Use "Label Above" Skyle Use "Label on Left Skyle Use "Label Above" Skyle Use "Label on Left Skyle Use "Label Above" Skyle Use "Label on Left Skyle Use "Label Above" Skyle Use "L	Name: Deborah Adams	Gender: female	DoB: 1948-01-0	9	ID: hca-pat-18	
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Short blood count panel Short blood count panel HL7 Genetic Variant Reporting Panel (table version) Name Value Units		-			gation On Input	Total # of Question
HL7 Genetic Variant Reporting Panel HL7 Genetic Variant Reporting Panel (table version) Name Name Name Type a value Select one Select one Firth Date Firth Date Name Select one Name Name Name Name Value Units Units Units Name Name Value Units Name Name Value Name Value Name Value Name Value Units Name Name Name Name Value Name Value	Vital signs panel					
HL7 Genetic Variant Reporting Panel (table version) Saved Diagnostic Reports Search LOINC Panels/Forms Search LOINC Panels/Forms MWDD/YYYY Select one —Birth Date —Twin —Adopted —Parents related —Parents related —Body height —Weight —Weight —Race —Ethnicity —Select one or more —In Jiseases history panel —History of diseases Search for value	Short blood count panel	MM/DD/YYYY				
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		— 1.1 Diseases hi	istory panel			
Age range at onset of disease Select one		—History of dise	eases	Search for value	:	
		Age range at	onset of disease	Select one		
		Family member h	nealth history			



Issues and Plans

Issues

- Observations are all packaged in the Diagnostic report resource.
- Too slow to move into observation.
- But currently no option to search by observation ID in that resource.
- To put them in the observation resource requires requesting a new observation instance ID from that resource, then tying it into the diagnostic report and then storing the observation into the observation resource. With current hardware, it can take 2 seconds per observation. Would not be tolerable to user.

Issues (2)

- Lots of challenges with complicated objects whose attributes are treated as individual fields on most real world forms.
 - Date and time usually entered separately not as one big time stamp
 - Provider ID entered separately not (usually) as a package with many separate fields.
 - Telephones etc. rarely entered with all of the paraphernalia.
 - Even quantities present problems -- easier to use string and regular expressions for many cases (Will make a value- and units object soon)

To do

- ☐ Link to provider, orders, encounter and depending on which one is chosen pull the other info from that resource.
- Solve the slow observation store problem.
- Provide report date and deal better with effective date.

URLs for exploring

(Ye Wang, Paul Lynch, Ajay Kanduru, Lee Mericle, Clem McDonald)

- Well-connected data input form (LHC-Forms)
 - Project page: https://lhncbc.nlm.nih.gov/project/lforms
 - Software download and documentation: https://github.com/lhncbc/lforms
 - Demo site: https://lhc-forms.lhc.nlm.nih.gov/
- Lister Hill Clinical Table Search Service (aka Autocompleter/Table Connector)
 - https://clin-table-search.lhc.nlm.nih.gov/
 - http://lhncbc.github.io/autocomplete-lhc
 - https://github.com/lhncbc/autocomplete-lhc
- Form Builder
 - https://lforms-formbuilder.nlm.nih.gov (lforms/demo)
- Units of measure (UCUM) validator and converter
 - http://lhncbc.github.io/ucum-lhc/
- □ LHC-Forms on FHIR https://gallery.smarthealthit.org/

