

# Model-Driven EHR

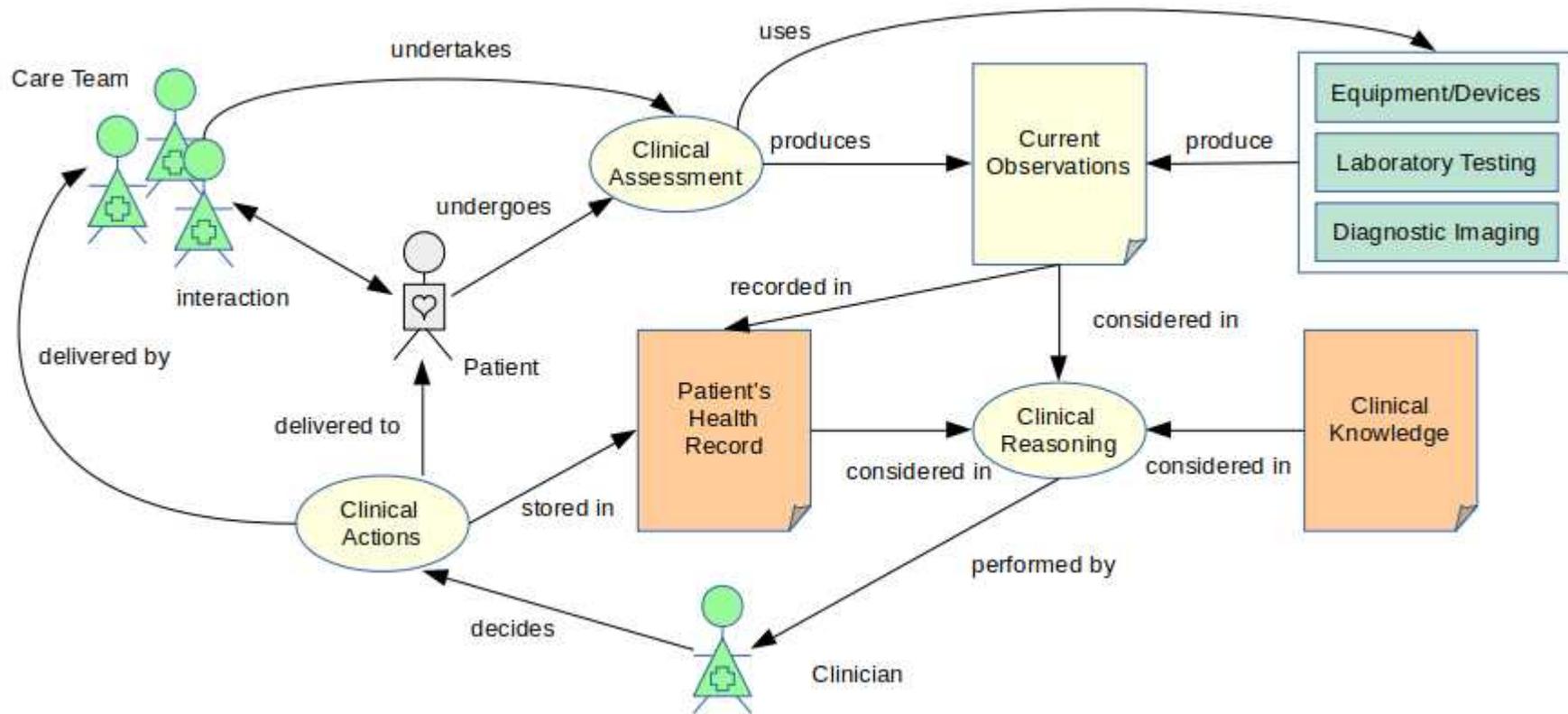


Dr John Chelsom

Director, Applied Health Informatics Program  
Fordham University

CEO  
Seven Informatics Ltd

# Clinical Decision Making



Clinical decision making is supported by information and knowledge that is managed in Clinical Information Systems

# National Agencies - Top Down

National agencies tend to favour top-down approaches to clinical systems implementation.

Particularly where these agencies provide the funding for healthcare and technology.

Top down approaches can crush the life out of the grass roots of healthcare and health information systems suppliers

- No match with requirements
- No stakeholder buy-in
- No innovation

But top down directives could also be made to give freedom to do things locally that match exactly what is required.



# Bottom-Up Can Be a Car Wreck

Allowing local decision makers complete freedom to develop and deploy clinical information systems can lead to chaos.

Complete freedom may mean

- ignoring guidelines for best practice
- missing out on economies of scale
- creating systems that cannot interoperate
- hindering the exchange of clinical information



Open standards are key to balancing top-down and bottom-up approaches, but care is needed....

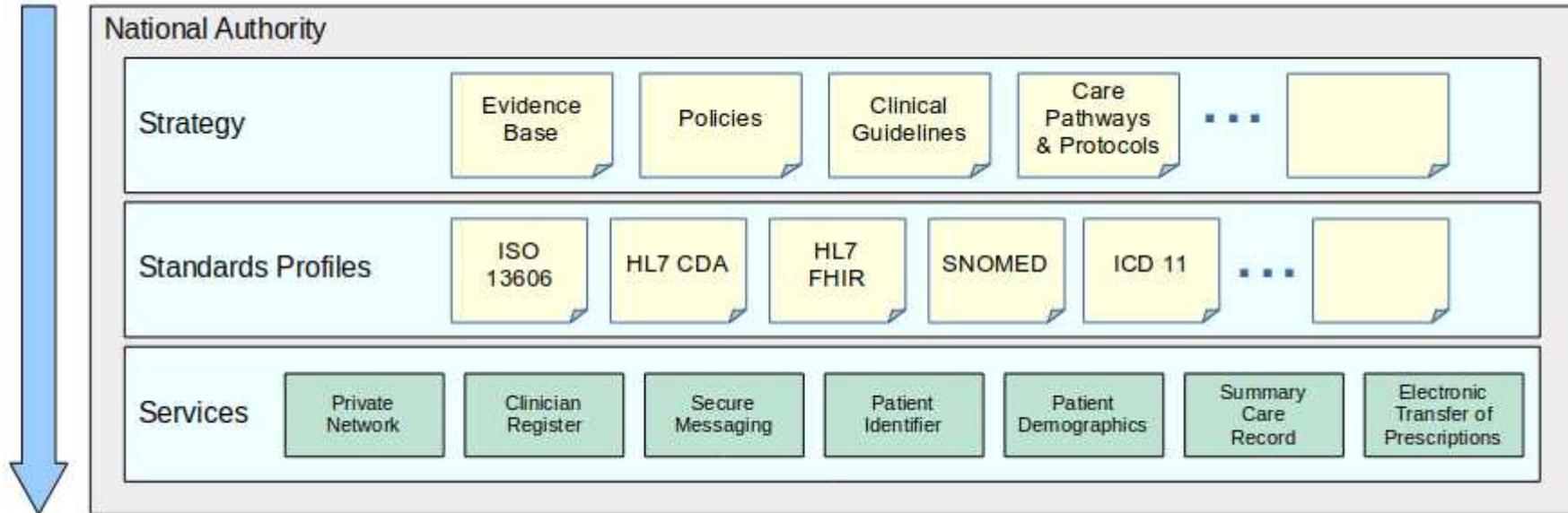


Open standards can be used to force everything to be done in the same way.

Open standards can also mean giving freedom to do things locally in a way which will allow data exchange and functional interoperability with others.



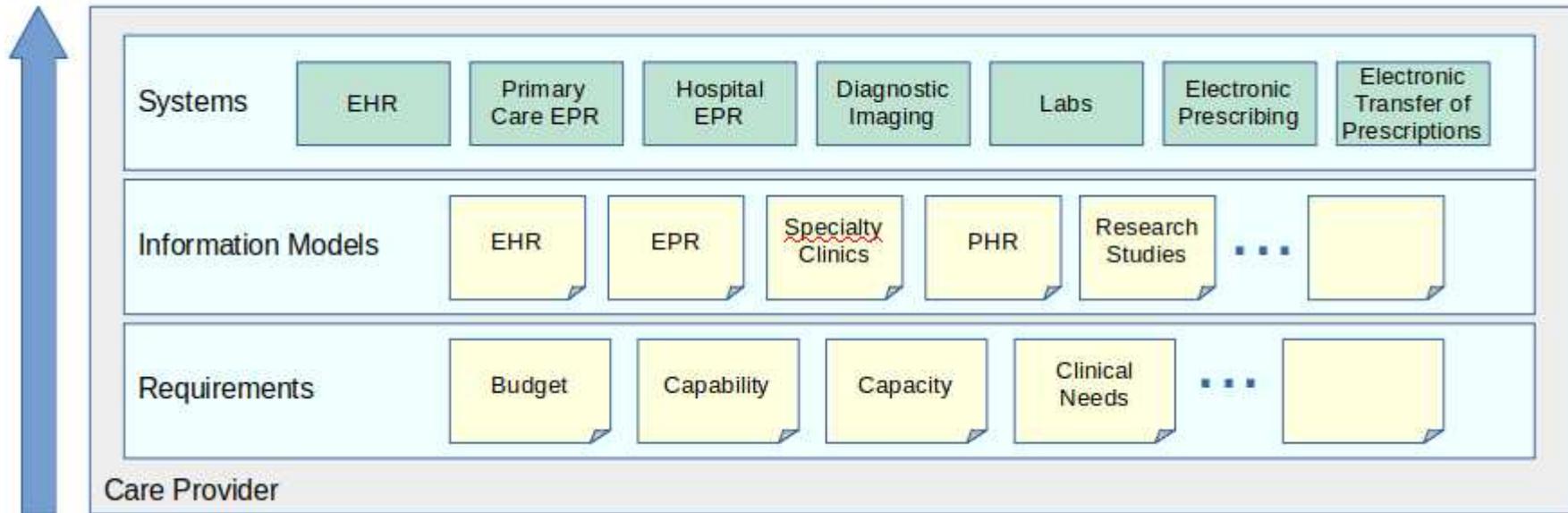
# Open Standards Deliver Top-Down



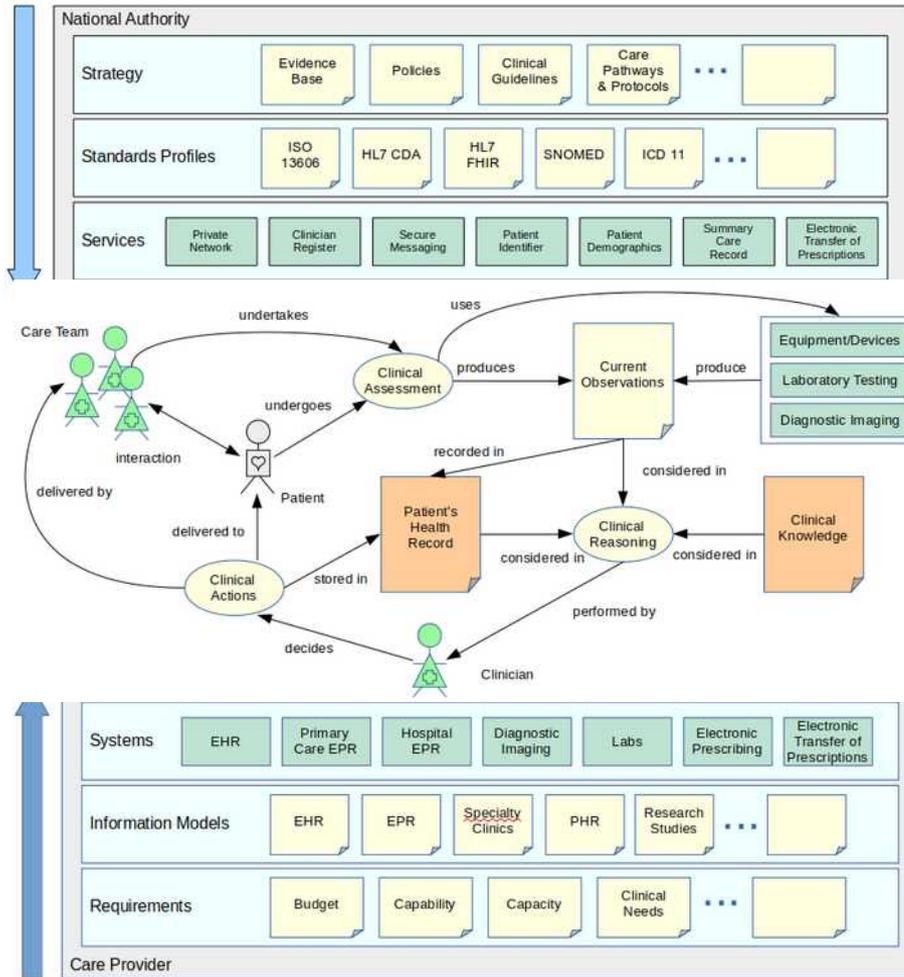
National Strategy determines the Open Standards Profiles used to define shared Clinical Information Services

# Open Standards Deliver Bottom-Up

Local Requirements drive the development of local Information Models that configure the Clinical Information Systems.



# Top-Down Meets Bottom-Up



The best top-down approach from National Agencies can meet the bottom-up implementations from Care Providers.

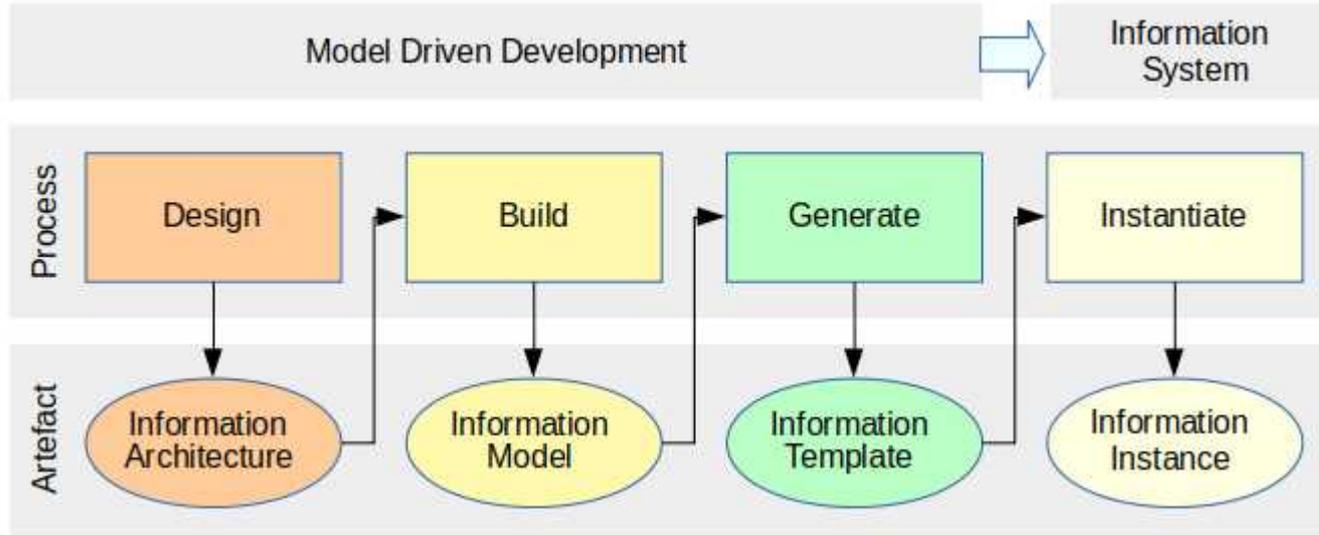
A robust framework of open standards guides the bottom-up implementation.

Evidence shows that it is difficult to 'police' adherence to those standards.

Better the carrot than the stick:

- public sector procurement and funding can require adherence to the standards
- a Government Catalogue of approved products can be maintained
- connection to national level services can mandate the use of standards
- 'payment by results' can require reporting through the national services

# Architecture and Models



Agreement (national) on the Design of a Clinical Information Architecture allows for...

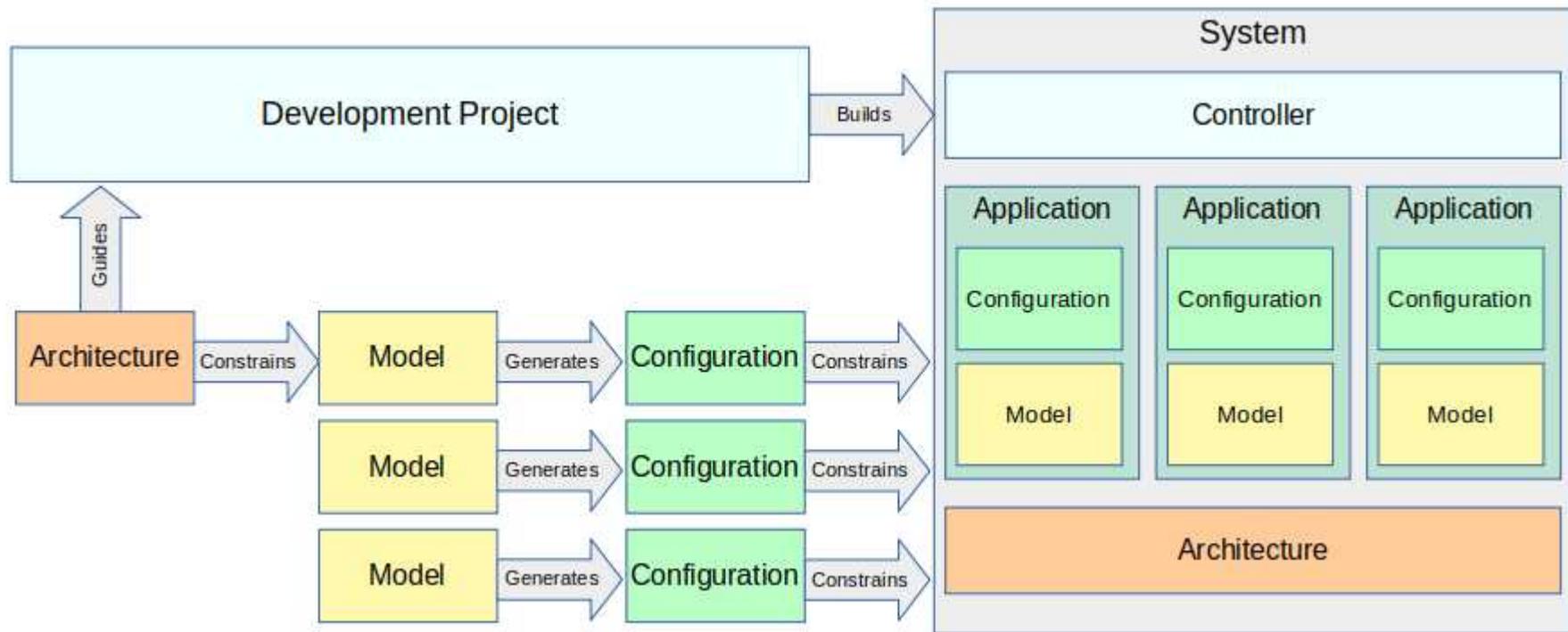
Information Models to be developed locally, which then generate the templates used to...

instantiate the Clinical Information gathered and used for clinical care and research

# Model-Driven Clinical Systems

Using the EHR framework, clinicians can develop their own clinical information models.

Then deploy them as enterprise-scale EHR, conforming to the architectural standards



# ISO 13606 Reference Model

**EHR\_EXTRACT** - The electronic health record for one person

**FOLDER** - High-level organisation of the EHR e.g. per episode, per clinical specialty

**COMPOSITION** - A clinical care session, encounter or document e.g. test result, letter

**SECTION** - Clinical headings reflecting the workflow and consultation process

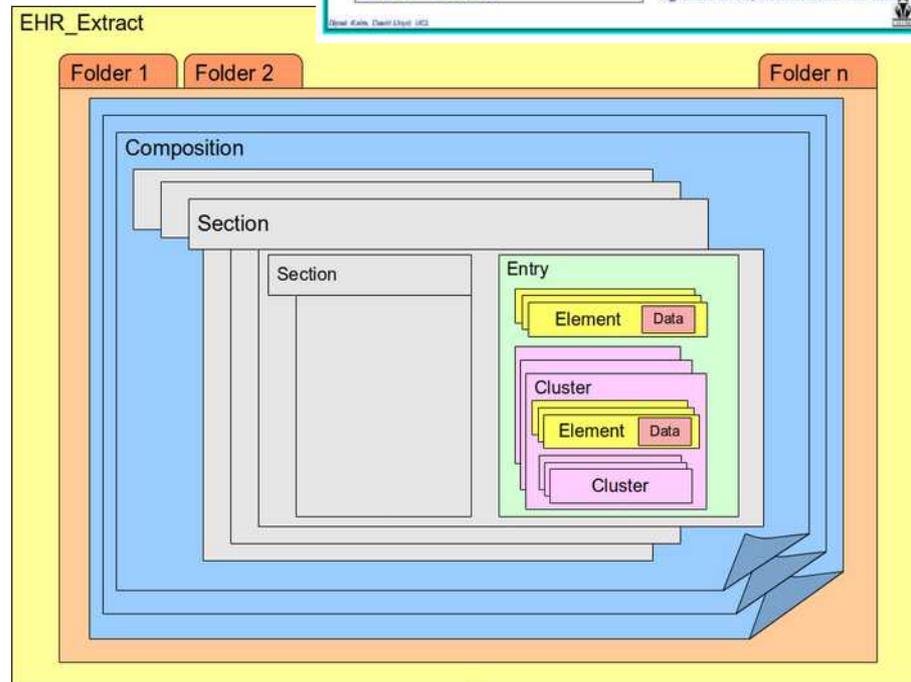
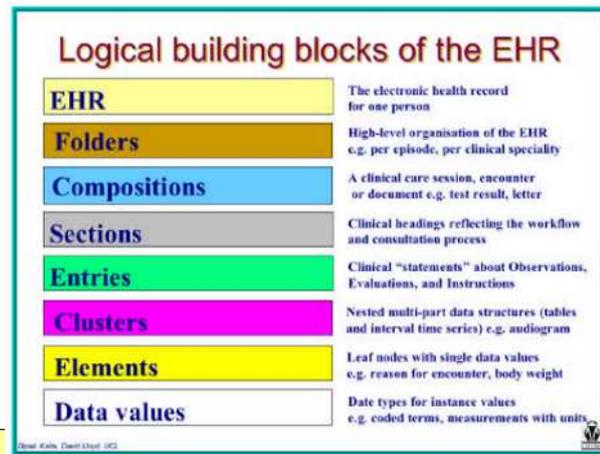
**ENTRY** - Clinical statements about Observations, Evaluations and Instructions

**CLUSTER** - Nested multi-part data structures (tables and interval time series) e.g. audiogram

**ELEMENT** - nodes with single data values e.g. reason for encounter, body weight

**DATA** - Data types for instance values e.g. coded terms, measurements with units

Kalra, D., 2006. Electronic health record standards. Yearbook of medical informatics, 15(01), pp.136-144.



# The Reference Model in Practice

The screenshot displays a patient record for Arthur (Mr) CHUMLEY-WARREN, born 13-Feb-1947 (70 years), male. The interface includes a navigation bar with 'Dashboard', 'Patient Search', 'Patient Cohort', 'Care Setting: cityEHR Feature Demo', 'Quit', 'Admin', and 'Registration'. A sidebar on the left lists various medical categories, with 'DAS 28' and 'Disease Activity Score (DAS 28)' highlighted. The main content area shows a 'Disease Activity Score (DAS 28)' form with a human silhouette and a data table.

Count	Swollen Joints	Tender Joints
23	3	1
Visual Analogue Scale	7	
DAS Score	3.52	

Annotations on the screenshot identify components of the Reference Model:

- Folder:** Points to the 'Care Setting: cityEHR Feature Demo' dropdown menu.
- Composition:** Points to the 'DAS 28' and 'Disease Activity Score (DAS 28)' items in the sidebar.
- Element:** Points to the 'DAS Score' field in the data table.
- Data:** Points to the value '3.52' in the 'DAS Score' field.
- Entry:** Points to the 'DAS Score' field in the data table.
- Section:** Points to the 'Disease Activity Score (DAS 28)' form header.
- Cluster:** Points to the 'Swollen Joints' and 'Tender Joints' fields in the data table.
- EHR\_Extract:** Points to the 'DAS Score' field in the data table.

At the bottom of the interface, it shows 'CityEHR Version Number - V1.5', 'User: cityEHR Administrator / cityEHR Feature Demo', and login information: 'Logged on: 11:26:01 on Tuesday, 1st August 2017' and 'Last logged on: 12:29:58 on Friday, 28th July 2017'.

# Model-Driven cityEHR

26-Jun-2024 - Patient Registration \* Page load time: Show ISO-13606 Show Ids ↻ ☰

**Patient Demographics**

NHS Number  Hospital Number  Overseas Patient:  Find Demographics  1234999555

Title  Forename  Surname

Sex Assigned at Birth  Gender Identity  Date of Birth

Address  Town/City

Postcode

**GP Details**

Code  Dr  Practice  Find GP

Address  Town/City

Postcode

cityEHR Version Number - V1.7-2024-05-09-01 User: cityEHR Administrator / cityEHR Feature Demo / en-gb Logged on: 12:25:40 Wednesday, 26th June 2024 Last logged on: 07:40:01 Saturday, 22nd June 2024

Here is a patient registration screen in the EHR

Compositions, with their Sections, Entries and Elements are defined in the Information Model

The Composition to gather the data is chosen in the configuration

# Supporting ISO 13606

Running cityEHR in debug mode allows viewing of the ISO 13606 structure.

The screenshot displays the 'Patient Registration' form in the cityEHR system. The form is titled '26-Jun-2024 - Patient Registration' and includes a navigation bar with options like 'Dashboard', 'Patient Search', and 'Patient Cohorts'. The main content area is divided into two sections: 'Patient Demographics' and 'GP Details'. The 'Patient Demographics' section contains fields for NHS Number (1234999555), Hospital Number (80072623), Overseas Patient (checkbox), Find Demographics (checkbox), Title (Ms), Forename (Polly), Surname (Ponsford), Sex Assigned at Birth (Female), Gender Identity (Female), Date of Birth (25-8-1950), Address (80 Spalding Way), Town/City (Southampton), and Postcode (SO8 2UF). The 'GP Details' section contains fields for Code, Dr, Practice, Find GP (checkbox), Address, Town/City, and Postcode. The form is overlaid with a complex set of colored rectangles (red, yellow, green, blue, magenta) that represent the ISO 13606 data structure. The top right of the page features a 'Quit Administration' button and the 'cityEHR' logo. The bottom of the page shows the version number (V1.7-2024-05-09-01), user information (cityEHR Administrator / cityEHR Feature Demo / en-gb), and login/logout times.

Quit Administration **cityEHR**

Dashboard Patient Search Patient Cohorts In-Tray Clinics Orders Registration

26-Jun-2024 - Patient Registration \* Page load time: Show ISO-13606  Show Ids

### Patient Demographics

NHS Number: 1234999555 Hospital Number: 80072623 Overseas Patient:  Find Demographics:

Title: Ms Forename: Polly Surname: Ponsford

Sex Assigned at Birth: Female Gender Identity: Female Date of Birth: 25-8-1950

Address: 80 Spalding Way Town/City: Southampton

Postcode: SO8 2UF

### GP Details

Code: Dr: Practice: Find GP:

Address: Town/City:

Postcode:

cityEHR Version Number - V1.7-2024-05-09-01 User: cityEHR Administrator / cityEHR Feature Demo / en-gb Logged on: 12:25:40 Wednesday, 26th June 2024 Last logged on: 07:40:01 Saturday, 22nd June 2024

# Supporting HL7 CDA

Running cityEHR in debug mode allows viewing of the HL7 CDA structure.

The screenshot displays the cityEHR interface. On the left, a form titled "26-Jun-2024 - Patient Regi" is visible, containing sections for "Patient Demographics" and "GP Details". The "Patient Demographics" section includes fields for NHS Number (12349), Title (Ms), Sex Assigned at Birth (Female), Address (80 Spa), and Postcode (SO8 2UF). The "GP Details" section includes fields for Code, Address, and Postcode. On the right, an "XML Document Viewer" window is open, displaying the XML structure of the HL7 CDA document. The XML includes namespaces for cityEHR and math, and contains elements for ClinicalDocument, patientRole, patient, providerOrganization, and assignedPerson.

```
<ClinicalDocument xmlns:cityEHR="http://openhealthinformatics.org/ehr/" xmlns:math="http://exslt.org/
<typeId root="#CityEHR:Form" extension="#CityEHR:Form:BaseRegistration"/>
<templateId root="#ISO-13606:EHR_Extract:cityEHR" extension="#ISO-13606:Folder:FeatureDemo"/>
<id root="cityEHR" extension="#CityEHR:Form:BaseRegistration"/>
<code code="" codeSystem="cityEHR" displayName="Patient Registration"/>
<effectiveTime value="2024-06-26T12:26:03.812+01:00"/>
<recordTarget>
  <patientRole>
    <id extension=""/>
    <patient>
      <name>
        <prefix/>
        <given/>
        <family/>
      </name>
      <administrativeGenderCode code="" codeSystem="" displayName=""/>
      <birthTime value=""/>
    </patient>
    <providerOrganization>
      <id extension="cityEHR" root="#ISO-13606:EHR_Extract:cityEHR"/>
      <name/>
    </providerOrganization>
  </patientRole>
</recordTarget>
<author>
  <time value=""/>
  <assignedAuthor>
    <id extension="" root="#ISO-13606:EHR_Extract:cityEHR"/>
    <assignedPerson>
      <name/>
```

cityEHR, Version Number - V1.7-2024-05-09-01 User: cityEHR Administrator / cityEHR Feature Del

# Patient Record - Based on the Model

The screenshot displays a patient record for Polly Ponsford. The top header includes the patient's name, birth date (25-Aug-1950, 73 years), and gender (Female). A navigation bar contains links for Dashboard, Patient Search, Patient Cohorts, In-Tray, Clinics, Orders, and Registration. A left sidebar lists navigation options like Events, Annotations, LifeLine, and Patient Registration (1). The main content area shows a 'Patient Registration' event from 26-Jun-2024, with a detailed view of 'Patient Demographics' and 'GP Details'. The demographics section lists NHS Number, Hospital Number, Overseas Patient status, Find Demographics status, Title, Forename, Surname, Sex Assigned at Birth, Gender Identity, Date of Birth, Address, Town/City, and Postcode. The GP Details section shows Find GP as false. A text box on the right explains that elements in the registration composition are mapped to the information required in the patient label (top left).

PONSFORD, Polly (Ms) Born: 25-Aug-1950 (73 years) Gender: Female  
Patient Id 80072623 NHS Number 1234999555

Quit Administration  
Dashboard Patient Search Patient Cohorts In-Tray Clinics Orders Registration

city EHR

Events Annotations LifeLine Hide  
Events Summaries Forms Letters Pathways Booking Ordering Show

▼ All Events (1)  
26-Jun-2024 Patient Registration  
Patient Demographics  
GP Details  
▶ Patient Registration (1)

26-Jun-2024 - Patient Registration Page load time:

**Patient Demographics**  
NHS Number 1234999555  
Hospital Number 80072623  
Overseas Patient false  
Find Demographics true  
1234999555  
Title Ms  
Forename Polly  
Surname Ponsford  
Sex Assigned at Birth Female  
Gender Identity Female  
Date of Birth 25-Aug-1950  
Address 80 Spalding Way  
Town/City Southampton  
Postcode SO8 2UF

**GP Details**  
Find GP false

Elements in the registration Composition are mapped to the information required in the patient label (top left)

cityEHR Version Number - V1.7-2024-05-09-01 User: cityEHR Administrator / cityEHR Feature Demo / en-gb Logged on: 12:25:40 Wednesday, 26th June 2024 Last logged on: 07:40:01 Saturday, 22nd June 2024

# Patient Search

Quit Administration

Dashboard Patient Search Patient Cohorts In-Tray Clinics Orders Registration

city EHR

Recent Care Team

80072623 - Ponsford

67229171 - Marston

96274917 - Wallace

24605251 - Eastman

60083743 - Ladd

12551414 - Cale

**Patient Search** Page load time:

Care Team  

Patient Id  Surname  Forename

Gender

Day of Birth  Month  Year  Date

Consultant

Enter search criteria to find patient.

cityEHR Version Number - V1.7-2024-05-09-01 User: cityEHR.Administrator / cityEHR.Feature.Demo / en-gb Logged on: 12:25:40 Wednesday, 26th June 2024 Last logged on: 07:40:01 Saturday, 22nd June 2024

Elements in the registration Composition (or any other designated Compositions) are mapped to the search terms used to find patients

# Enter Patient Data

Using any of the Compositions defined in the Information Model

PONSFORD, Polly (Ms) Born: 25-Aug-1950 (73 years) Gender: Female  
Patient Id 80072623 NHS Number 1234999555 

Quit Administration  
Dashboard Patient Search Patient Cohorts In-Tray Clinics Orders Registration

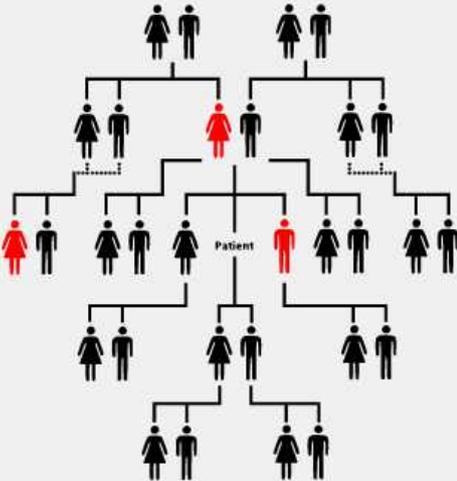
cityEHR

In Progress New Hide Events Summaries Forms Letters Pathways Booking Ordering Show

▼ cityEHR Feature Demo (26)

26-Jun-2024 - Family History \* Page load time:  Show ISO-13606  Show Ids  Highlight Entries -- None --

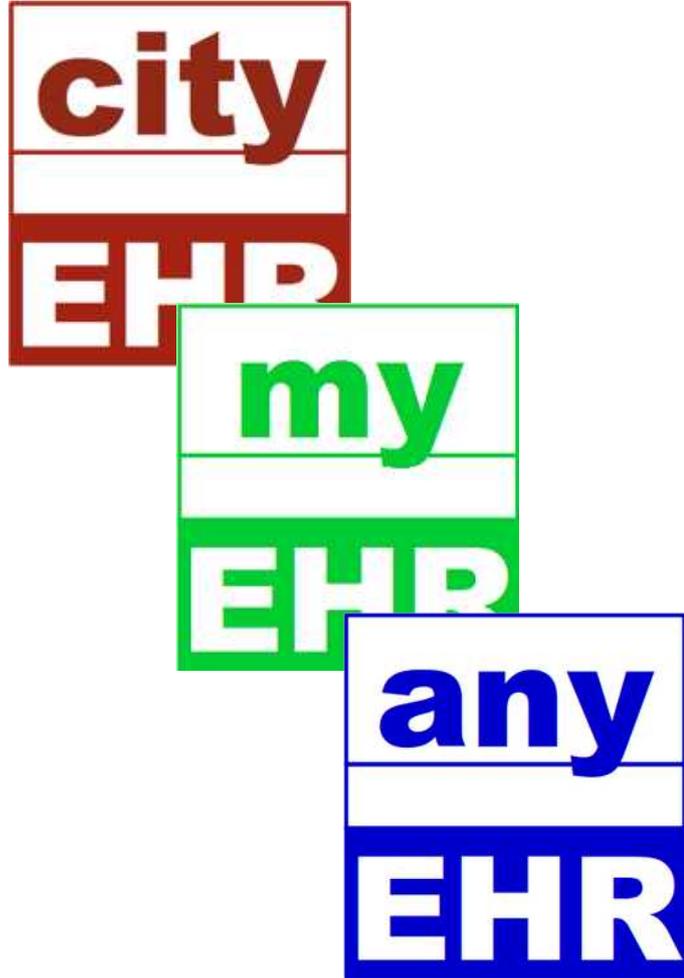
Family history 



Year of Diagnosis	Relation	General Diagnosis
<input checked="" type="checkbox"/> 1946	Mother	Blastomycosis
<input checked="" type="checkbox"/> 1978	Female Cousin On Mothers Side	Malaria
<input checked="" type="checkbox"/> 1972	Brother	Malaria

Family History  
cityEHR Version Number - V1.7-2024-05-09-01 User: cityEHR Administrator / cityEHR Feature Demo / en-gb Logged on: 12:25:40 Wednesday, 26th June 2024 Last logged on: 07:40:01 Saturday, 22nd June 2024

# cityEHR



cityEHR is an **open source** Electronic Health Records system

Implemented as an **Enterprise Java** application, accessed through a **web browser**.

Managing clinical information for patient care and research studies, using the HL7 **Clinical Document Architecture** (CDA)

Based on over ten years of **academic research**

Using **open standards** throughout - ISO 13606, HL7 CDA, ICD 11, SNOMED CT, UML, XML, OWL/XML, XForms

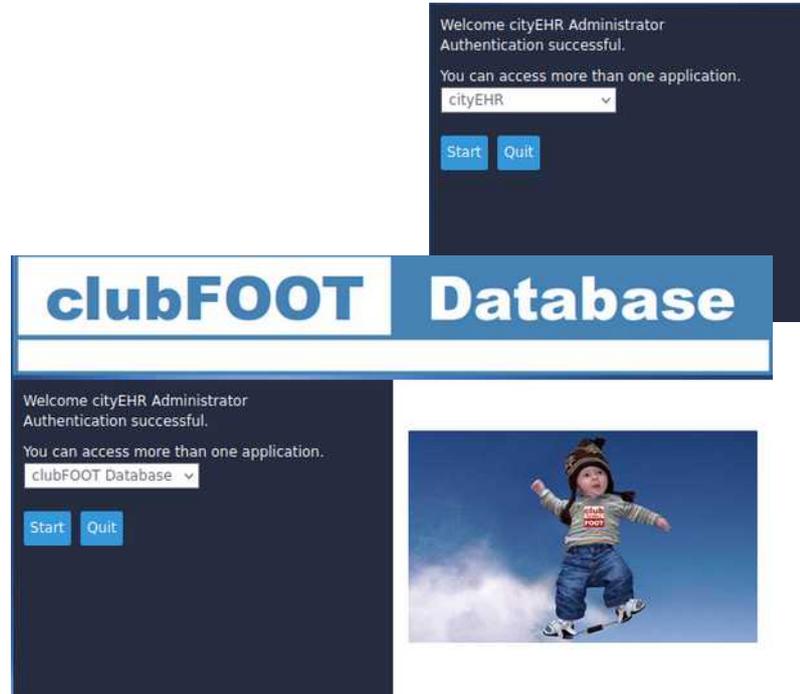
Entirely **model-driven** (using Ontology models, following the ISO 13606 standard)

**Clinician-led** - using Clinical Information Models tailored for each deployment, developed by clinicians using standard desktop tools

# Seven Informatics and cityEHR

Founded in 2013 to support the development and deployment of cityEHR

Now also delivers Fordham University's Applied Health Informatics masters program



# Global Open Source Electronic Health Records

GOSEHR was launched with the financial support of Seven Informatics and the support for Academic Research and Education Programs from Fordham University.

Partners include leading universities in the UK, Canada and Norway, together with the African Digital Health Research Institute.



Global Open Source Electronic Health Records

**FORDHAM UNIVERSITY**

THE JESUIT UNIVERSITY OF NEW YORK

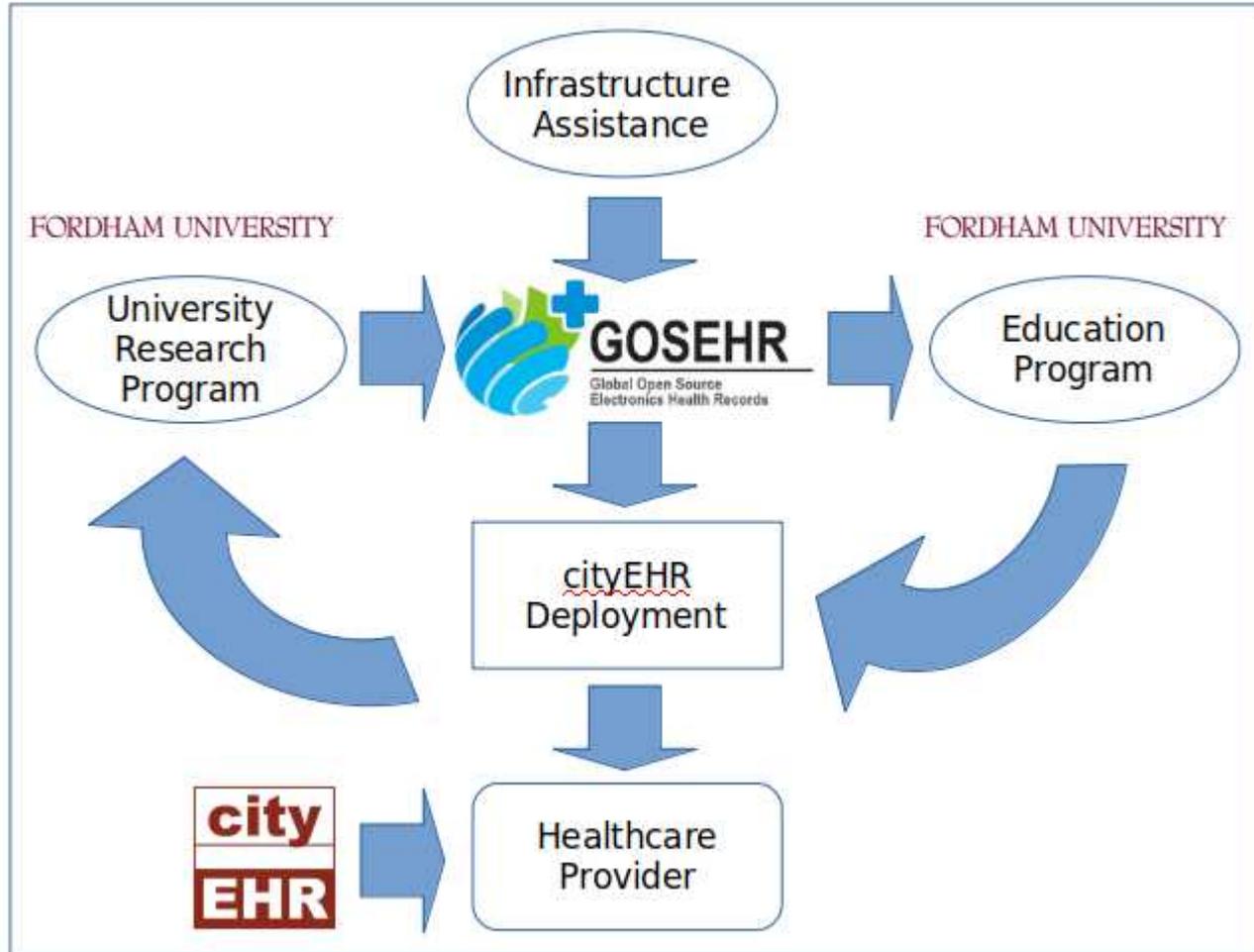
The objective of the Global Open Source Electronic Health Records initiative is to create a sustainable program for the deployment of open source EHR in participating countries, with the ultimate aims of improving patient outcomes and delivering better healthcare, within existing budget constraints.

The Initiative is bringing the benefits of open source, structured EHR systems to low-income countries, through engagement, education and research with local communities.

Partners include leading universities, healthcare providers, open source software developers, NGOs and local community companies.

<https://gosehr.org>

# GOSEHR Dimensions



Global Open Source EHR

University Research

Education and training

Deployment of EHR

Infrastructure Assistance

# GOSEHR Engagement Model

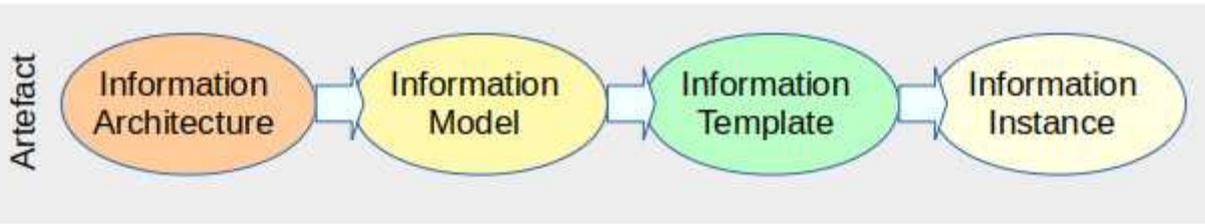


The GOSEHR Engagement Model brings together local research, systems integrators and care providers to deploy open source EHR, supported by the GOSEHR partners.

# Model-Driven EHR



Model-Driven Platform



Identifier	DisplayName	Unit	Extension	ElementType	DataType	RequiredValue	Scope
47	DiffusivityMeasure	Result		enumeratedValue	string	Optional	
48	LabTestResult	BMD	Element_Measurement	simpleType	double	Optional	
49	BMDResp	BMD		simpleType	double	Optional	
50	TScoreHip	I		simpleType	double	Optional	
51	TScoreSp	Z		simpleType	double	Optional	
52	BMDZscore	BMD		simpleType	double	Optional	
53	TScoreZscore	I		simpleType	double	Optional	
54	TScoreZscore	Z		simpleType	double	Optional	
55	BMDZscore	BMD		simpleType	double	Optional	
56	TScoreZscore	I		simpleType	double	Optional	
57	TScoreZscore	Z		simpleType	double	Optional	
58	Comments	Comments		simpleType	string	Optional	
59	ScanDate	Scan date		simpleType	date	Optional	
60	AgeAtScan	Age at scan		age	dayTimeDuration	Optional	
61	MeasurementDate	Measurement date		simpleType	date	Optional	
62	Concomitancy			enumeratedClass	string	Required	Full
63	BacterialDiagnosis	Bacterial Infection		enumeratedClass	string	Optional	Defined
64							
65							
66	InfectionSort		Element_Diagnosis	enumeratedClass	string	Optional	Defined
67	InfectionSort		Element_Diagnosis	enumeratedClass	string	Optional	Defined
68	LabTest	Test Name		enumeratedClass	string	Optional	Full
69	WebTest (CocMetals)	Test Name	Element_LabTest	enumeratedClass	string	Optional	Full
70	WebTest (Electrolytes)	Test Name	Element_LabTest	enumeratedClass	string	Optional	Full
71	WebTest (Electrolytes)	Test Name	Element_LabTest	enumeratedClass	string	Optional	Full
72	WebTest (Electrolytes)	Test Name	Element_LabTest	enumeratedClass	string	Optional	Full



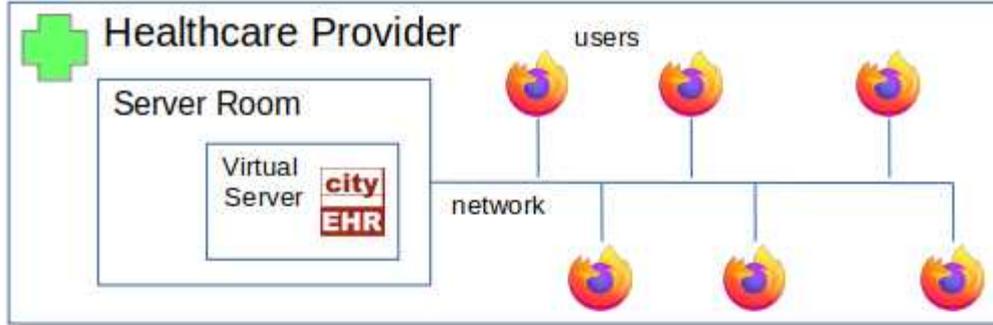
cityEHR is a model-driven platform for the development and deployment of Electronic Health Record applications.

The underlying Information Architecture is an ontology that follows the ISO 13606 and HL7 CDA standards.

Clinicians create Clinical Information Models using familiar tools, such as a spreadsheet.

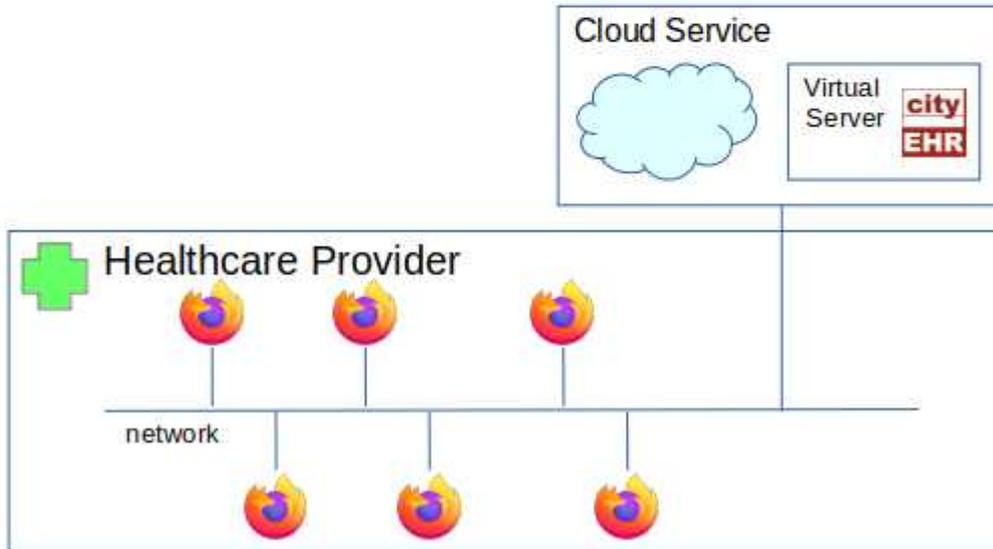
The models are imported to cityEHR and then drive the features of the EHR that are made available to clinical users.

# Deployment of cityEHR



cityEHR can be deployed within the Healthcare Provider, ideally in a secure server room using a virtual server infrastructure.

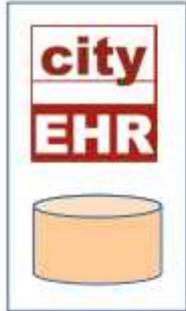
Users access the EHR using the Firefox web browser on devices connected to the network within the Healthcare Provider.



Alternatively, cityEHR can be deployed on secure private Cloud Service, accessible through the Healthcare Provider network.

The most secure way to achieve this is to set up a Virtual Private Network (VPN) between the Cloud Service and the Healthcare Provider.

# cityEHR Scalability



## Stand-alone Deployment

Built-in database  
1 to 10 users  
Up to 10,000 patients



## Deploy with External Database

External database, single instance  
1 to 100 users  
Up to 50,000 patients



## Deploy with Database Cluster

External database, multiple instances  
1 to 10,000 users  
Up to 1,000,000 patients

cityEHR is deployed on the open source eXist Native XML Database

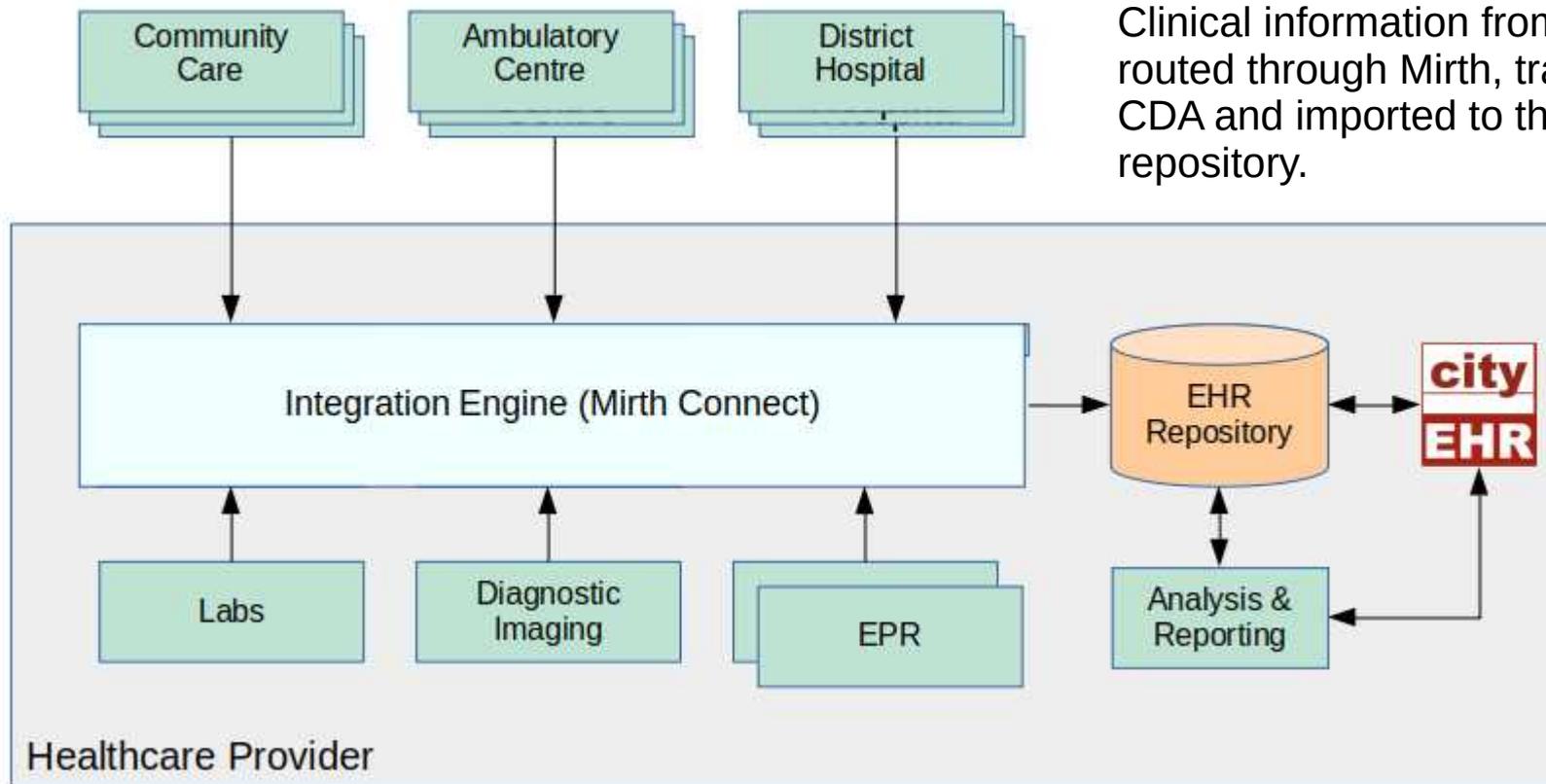
The database is built in to the cityEHR system and can be used for small scale deployments.

For larger deployments, the database can be installed on its own server, either as a single instance or as a database cluster on multiple servers.

# Integration with cityEHR

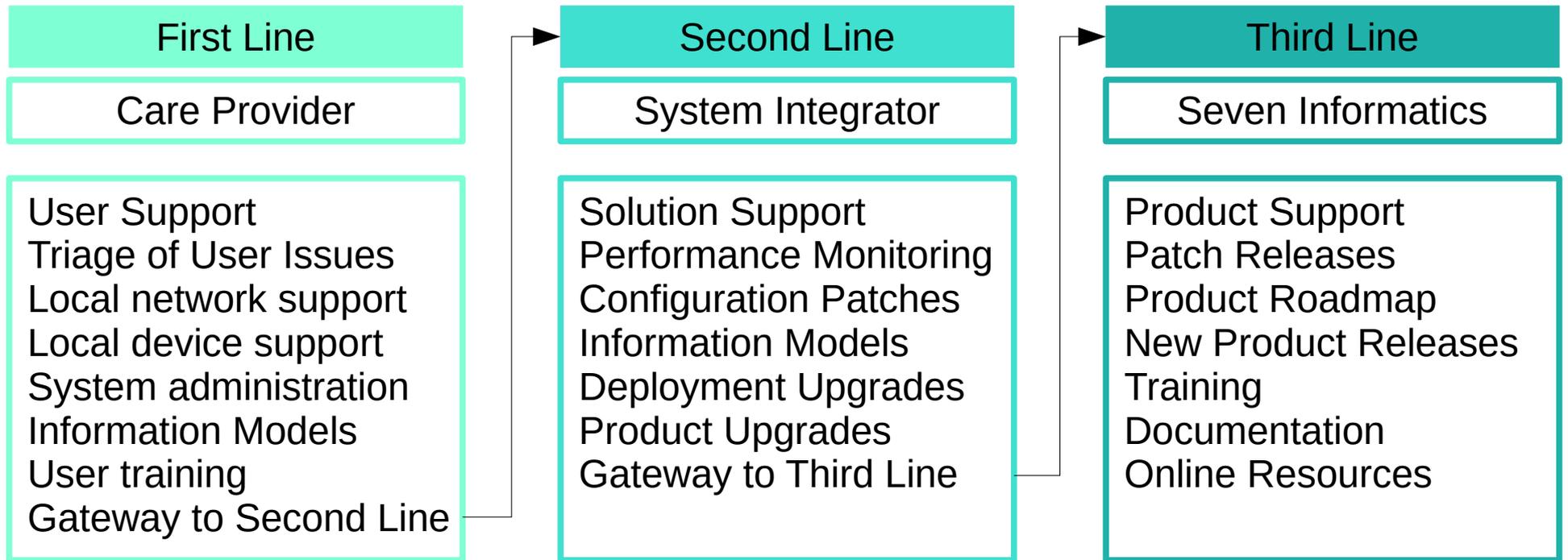
cityEHR can be deployed with the open source Mirth Connect integration engine,

Clinical information from multiple sources is routed through Mirth, transformed to HL7 CDA and imported to the cityEHR repository.



# Support and Maintenance

Blueprints for system Support and Maintenance, involving the Care Provider, Local System Integrator and Seven Informatics.



# Agile Deployment Plan

Blueprints for deployment in three phases, of three or six months, with monthly iterations, using the agile Scrum methodology.

## Phase One

### Foundation

- Local Engagement
- Project Teams
- Regulatory Approval
- Education and Training
- Deployment Plan
- Information Models
- Feasibility Prototypes

## Phase Two

### Integration

- Network
- Server Installation
- End-User Devices
- Deploy Mirth Connect
- Information Models
- Connect End Points
- Connect EHR Database
- Pilot with live data

## Phase Three

### Electronic Health Record

- Education and Training
- Mirth Connect go-live
- Deploy cityEHR
- Pilot cityEHR as Viewer
- Information Models
- Pilot cityEHR
- Refine models
- cityEHR go-live



Open Health Informatics

Standards Open Source Interfaces Processes Resources Workshops GOSEHR Summit

## Informatics Delivering Better Healthcare Outcomes

Open Health Informatics brings together Open Standards, Open Source Software, Open Systems Interfaces and Open Development Practices with the aim of delivering better healthcare outcomes.

Open Standards  
Open Source Software  
Open Systems Interfaces  
Open Development Processes

# Get Involved

[Register](#) **8th – 13th September 2024, St Edmund Hall, Oxford.**

Presented by:

FORDHAM UNIVERSITY



This one-week residential workshop will bring together participants from around the world, to learn how to configure and deploy an open source, model-driven, health electronic records system. We will use the open source cityEHR system, initially configured with example ontology models for a range of clinical services, which have been created by students at Fordham University, the University of Oxford and the University of Victoria, Canada.

## GOSEHR Summit

**An annual summit, bringing together academics, healthcare professionals, engineers and investors from around the world, presented in association with Fordham University.**

**Next Date: Saturday 5th April 2025, St Edmund Hall, Oxford.**

[Register](#)

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